Office of the Associate Administrator
for Commercial Space Transportation (AST)
Federal Aviation Administration (FAA)
Department of Transportation (DOT)

VOLUME 1:
FINAL ENVIRONMENTAL ASSESSMENT FOR A LAUNCH OPERATOR LICENSE FOR SEA LAUNCH LIMITED PARTNERSHIP

July 20, 2001
FINAL

Prepared by
ICF Consulting, Inc.

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

Responsible FAA Official	Date
Herbert Bachner	7/19/01

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LIST OF ACRONYMS AND ABBREVIATIONS

ACS	Assembly and command ship
AIP	Accident Investigation Plan
AST	Office of the Associate Administrator for Commercial Space Transportation
CDF	Charles Darwin Foundation
CDIAC	Carbon Dioxide Information Analysis Center
CDRS	Charles Darwin Research Station on Environmental Quality
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
cm	Centimeter
CO	Carbon monoxide
CO_2	Carbon dioxide
COMSTAC	Commercial Space Transportation Advisory Committee
CUPA	Certified Unified Program Agencies
dB	Decibels
DM-SL	Block DM-Sea Launch is the upper stage of the Zenit-3SL launch vehicle
DOT	U.S. Department of Transportation
E	East
EA	Environmental Assessment
E_c	Expected casualty
EEZ	Exclusive Economic Zone
EIS	Environmental Impact Statement
EMPP	Environmental Monitoring and Protection Plan
E.O.	Executive Order
EPA	U.S. Environmental Protection Agency
EPCRA	Emergency Planning and Community Right to Know Act
EST	Eastern Standard Time
FAA	Federal Aviation Administration
FAO	Food and Agriculture Organization
FONSI	Finding of No Significant Impact
ft	Feet
GEO	Geosynchronous earth orbit
GSO	Geosynchornous orbit
H_2	Hydrogen
H_2O	Water
HAT	High altitude tropical
HF	High Frequency
IIP	Instantaneous Impact Point
ILL	Impact Limit Lines
ILV	Zenit-3SL integrated launch vehicle
in	Inch
IUCN	International Union for Conservation of Nature and Natural Resources
kg	Kilogram
km	Kilometer
LEO	Low earth orbit
lb	Pound
LOL	Launch operator license
LOX	Liquid oxygen
LP	Launch platform
m	Meters
MARPOL	International Convention for the Prevention of Pollution from Ships
MEO	Medium earth orbit
mi	Mile
mm	Millimeter
MMH	Monomethylhydrazine
mph	Miles per hour
m/s	Meters per second
N	North
N_2	Nitrogen
N/A	Not applicable
N_2O_4	Nitrogen tetroxide
NEPA	National Environmental Policy Act
NIMA	National Imagery and Mapping Agency
NMFS	National Marine Fisheries Service
NO_X	Nitrogen oxides
O_3	Ozone molecule
OMB	Office of Management and Budget
OSHA	Occupational Safety and Health Administration
pH	Measure of acidity and/or alkalinity
RP-1	Kerosene fuel
S	South
sec	Second
SLLP	Sea Launch Limited Partnership
SPREP	South Pacific Regional Environmental Programme

SCAQMD	South Coast Air Quality Management District
UDMH	Unsymmetrical dimethylhydrazine
UN	United Nations
UNESCO	United Nations Educational, Scientific, and Cultural Organization
U.S.C.	United States Code
USCG	U.S. Coast Guard
USFWS	U.S. Fish and Wildlife Service
USSC	U.S. Space Command
W	West
WCMC	World Conservation Monitoring Center
WR	Written Reevaluation

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EXECUTIVE SUMMARY

ES. 1 INTRODUCTION

This Environmental Assessment (EA) evaluates the potential environmental effects of the license applicant's proposed action wherein the Federal Aviation Administration (FAA) Associate Administrator for Commercial Space Transportation (AST) would issue an launch operator license (LOL) or launch-specific licenses to Sea Launch Limited Partnership (SLLP). If issued, the LOL would allow SLLP to conduct up to eight commercial launches per year for five years without obtaining a separate license for each launch as long as there is no change in the launch parameters or in the anticipated environmental impacts. These launches would all be equatorial and would use azimuths between 82.6° and 97.4°, inclusive, originating from the SLLP Launch Platform (LP) at 0° latitude and 154° West (W) longitude, which is 425 kilometers (km) (266 miles (mi)) from Kiritimati (Christmas Island) in the Kiribati Island Group in the Pacific Ocean. This EA also addresses the proposed issuance of a launch-specific license for the launch of a Galaxy IIIC payload as well as other launch-specific licenses for launches within the proposed azimuth range and other specified launch parameters should the LOL not be issued or be delayed.

ES. 2 BACKGROUND

The SLLP project is an international commercial space launch project owned and operated jointly by Boeing Commercial Space Company of the United States, RSC Energia of Russia, KB Yuzhonoye and PO Yuzhmash of Ukraine, and Moss Maritime a.s. of Norway. The project's main assets are a seagoing mobile launch platform (LP), assembly and command ship (ACS), Home Port facilities in Long Beach, California, and the Zenit-3SL. The FAA issued a Final Environmental Assessment for the Sea Launch Project on February 11, 1999 (February 11, 1999 EA). This EA addressed the environmental impacts associated with SLLP's proposal to launch one demonstration payload and one satellite during the first year of operation and up to a maximum of six launches per year, using an azimuth of 88.67°, originating from the LP at 0° latitude and 154° W longitude. SLLP has conducted seven launches to date under seven individual launch licenses.

ES. 3 PURPOSE AND NEED FOR THE LICENSE APPLICANT'S PROPOSED ACTION

Access to space has become increasingly important for the deployment of satellites used for scientific research, communications, and multimodal transport navigation systems. Given the infrastructure and technology development costs associated with launching and deploying satellites, the Federal Government has been responsible for the majority of launches. However, with the increasing demand for access to space, especially for communications satellites, commercial launch companies have begun to offer launch services to meet this demand.

The purpose of the license applicant's proposed action as defined in 49 U.S.C. Subtitle IX – Commercial Space Transportation, ch. 701, Commercial Space Launch Activities, 49 U.S.C. §§ 70101-70121 is to:

- Promote economic growth and entrepreneurial activity through use of the space environment for peaceful purposes;
- Encourage the U.S. private sector to provide launch vehicles, reentry vehicles, and associated services by simplifying and expediting the issuance of licenses;

- Provide FAA oversight and coordination of licensed launches and to protect the public health and safety, safety of property, and national security and foreign policy interests of the U.S.; and
- Facilitate the strengthening and expansion of the U.S. space transportation infrastructure.

The need for the license applicant's proposed action is to expedite the FAA's licensing process, while still assuring public safety and proper environmental review. Such an expedited process will promote the entrepreneurial activity of a licensed launch provider. The proposed LOL would cover multiple launches using the same infrastructure at the same launch location through a range of launch azimuths without the need to re-evaluate license applications for individual launches unless conditions or operations change or an unforeseen environmental impact is discovered. The proposed LOL would allow SLLP to conduct up to eight launches per year for five years, for a maximum of 40 launches. The proposed LOL would allow SLLP to launch on exact equatorial azimuths (e.g., 90 °), which are optimal for GSO launches in terms of fuel efficiency, payload weight, and satellite life span.

ES. 4 THE LICENSE APPLICANT'S PROPOSED ACTION DEFINED

The FAA is evaluating the license applicant's proposed action, which would specifically authorize SLLP to:

- Conduct up to eight launches per year over a five-year period, for a maximum of 40 launches;
- Use a launch site at 0° latitude and 154°W longitude;
- Launch along a range of launch azimuths from 82.6° to 97.4°, inclusive;
- Use a Zenit-3SL launch vehicle; and
- Transport specified classes of payloads.

The FAA is also evaluating the possibility of issuing a launch-specific license to SLLP for the launch of Galaxy IIIC, as well as other potential launch-specific licenses (not to exceed eight per year) as necessary should the proposed LOL not be issued or be delayed. The proposed launch-specific licenses would authorize the SLLP to conduct specific launches:

- From a launch site at 0° latitude and 154°W longitude;
- On a launch along an azimuth of 90.00°;
- Using a Zenit-3SL launch vehicle; and
- Transporting specified classes of payloads.

ES.4.1 ALTERNATIVES INCLUDING NO ACTION AND THE ALTERNATIVES EVALUATION PROCESS

The FAA considered six alternatives in addition to the license applicant's proposed action. These alternatives included issuing the LOL with various changes in the launch parameters:

- Alternative with Up to 12 Launches Per Year. This alternative evaluates increasing the annual number of launches up to a maximum of 12 per year;
- Alternative with a Range of Azimuths Between 70° and 110°. This alternative considers a wider range of azimuths, those from 70° to 110°, inclusive, identified as feasible for GSO launches;
- Alternative with Avoidance of National Parks and National Reserves. This alternative would involve launching along a range of azimuths between 82.6° and 97.4° but would avoid specific azimuths within this range that would overfly any National Park or National Reserve;
- Alternative with Avoidance of the Oceanic Islands. This alternative would involve launching along a range of azimuths between 82.6° and 97.4° but would avoid any azimuth that would overfly any of the Oceanic Islands; and
- Alternative with Avoidance of the Galapagos Islands. This alternative would involve launching along a range of azimuths between 82.6° and 97.4° but would avoid any azimuths that overfly the Galapagos Islands Group; and
- No Action Alternative.

The FAA completed a thorough and objective review of reasonable alternatives to the license applicant's proposed action. The Council on Environmental Quality (CEQ) regulations require that the agency look at "reasonable" alternatives to a proposed action. With that standard in mind, the FAA did not evaluate in detail those alternatives that showed no possibility of meeting the purpose and need of the license applicant's proposed action, as described previously. The following criteria were used to determine whether alternatives were reasonable to evaluate in detail in the EA:

- Promote economic growth and entrepreneurial activity through use of the space environment for peaceful purposes;
- Encourage U.S. private sector to provide launch vehicles, reentry vehicles, and associated services by simplifying and expediting the issuance of licenses;
- Provide FAA oversight and coordination of licensed launches and to protect the public health and safety, safety of property, and national security and foreign policy interests of the US; and
- Facilitate the strengthening and expansion of the U.S. space transportation infrastructure.

Based on the evaluation of alternatives using the above screening criteria and the requirements of the National Environmental Policy Act (NEPA), the following alternatives were evaluated in detail in the EA:

- License Applicant's Proposed Action,
- Alternative with Avoidance of the Oceanic Islands,
- Alternative with Avoidance of the Galapagos Islands, and
- No Action Alternative.

ES. 5 THE AFFECTED ENVIRONMENT

The launched vehicle would proceed east on a single trajectory, on an azimuth between 82.6° and 97.4°, over the equatorial Pacific Ocean and South America. The area potentially affected by the proposed launches includes all land and water between 7.4° N and 7.4° S of the equator and between the launch location and the eastern coast of South America. Beyond this point the payload would be orbital and no further environmental effects on land or water are expected to occur (see Figure ES-1). This area encompasses approximately 9 million km^2 (3.5 million mi^2) of the equatorial Pacific Ocean and 5 million km^2 (1.9 million mi^2) of South America. The vast majority of the marine area is deep, open portions of the Pacific Ocean, although the proposed range of flightpaths include overflight of the Galapagos Islands, Cocos Island, and Malpelo Island. Further east, the area of the South American flyover encompasses several ecosystems, including Pacific coastal lowlands, the Andean mountain range, and much of the Amazon River basin.

ES.5.1 OCEANIC ISLANDS

The Oceanic Islands within the overflight zone of the proposed project include sensitive ecosystems of international importance. Cocos Island, governed by Costa Rica, is located approximately 500 km (312 mi) west of the Pacific coast of Costa Rica, and is approximately 2 km (1.2 mi) long and 1 km (0.6 mi) wide. A protected National Park, Cocos Island was added to the United Nations Educational, Scientific, and Cultural Organization (UNESCO) World Heritage List in 1997 and was subsequently designated a Wetland of International Importance (RAMSAR, 1998). Malpelo Island, governed by Colombia, lies approximately 450 km (281 mi) west of Colombia in the equatorial Pacific Ocean and is approximately 2.2 km (1.4 mi) long and 0.8 km (0.5 mi) wide.

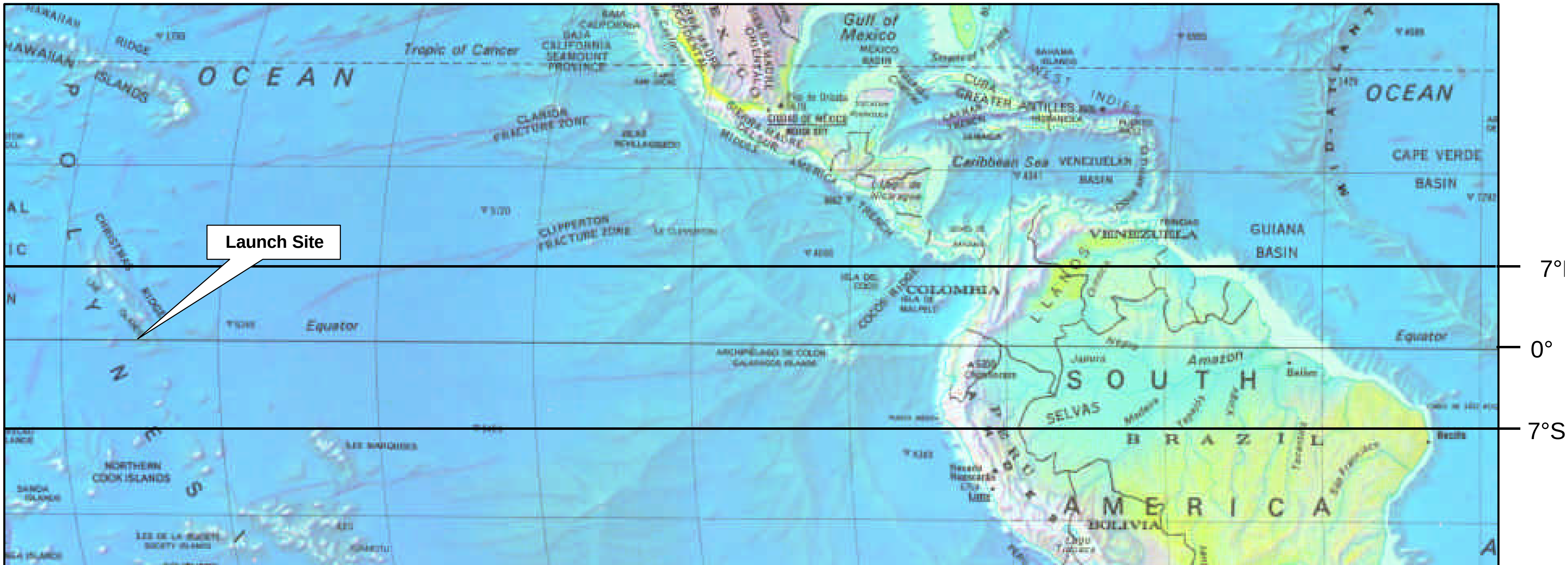
ES.5.2 GALAPAGOS ISLANDS

The Galapagos Islands, a province of the Republic of Ecuador, consist of 120 islands, rocks, and islets with a total land area of about 8,000 km^2 (3090 mi^2) in the eastern Pacific Ocean, 1,000 km (625 mi) west of the mainland. In 1959 Ecuador designated 97 percent of the land area of the Galapagos as a national park, and in 1986 established the Galapagos Marine Resources Reserve to protect the waters around the archipelago. The Galapagos Islands have also been recognized internationally as a Man and Biosphere Reserve and as a World Heritage Site by UNESCO. Ecuador manages the islands through the Galapagos National Park Service.

ES.5.3 SOUTH AND CENTRAL AMERICA

The portion of South America and Central America within the affected environment includes all of Ecuador, Surinam, and French Guiana, and portions of Colombia, Venezuela, Peru, Brazil, Guyana, and Panama. This region generally consists of three geographical areas traversing from west to east: the pacific coastal lowlands, the Andean mountain range (including high elevation valleys and plateaus), and the eastern lowlands (including much of the Amazon River basin).

Figure ES-1
Affected Environment - From Launch Site to Eastern South America (7º north to 7º south)



0 1,000 2,000 3,000
Scale in Kilometers (Approx.)

Source: Rand McNally Atlas of the World.

ES. 6 ENVIRONMENTAL CONSEQUENCES

ES.6.1 LICENSE APPLICANT'S PROPOSED ACTION

ES.6.1.1 Successful Flight

Stage I and II flight would occur over open ocean areas. In this respect, the environmental effects associated with Stage I and II components and their operation during a successful flight along any azimuth in this license applicant's proposed action would be the same as those evaluated in Sections 4.3.2 and 4.5.5 of the February 11, 1999 EA. These effects include:

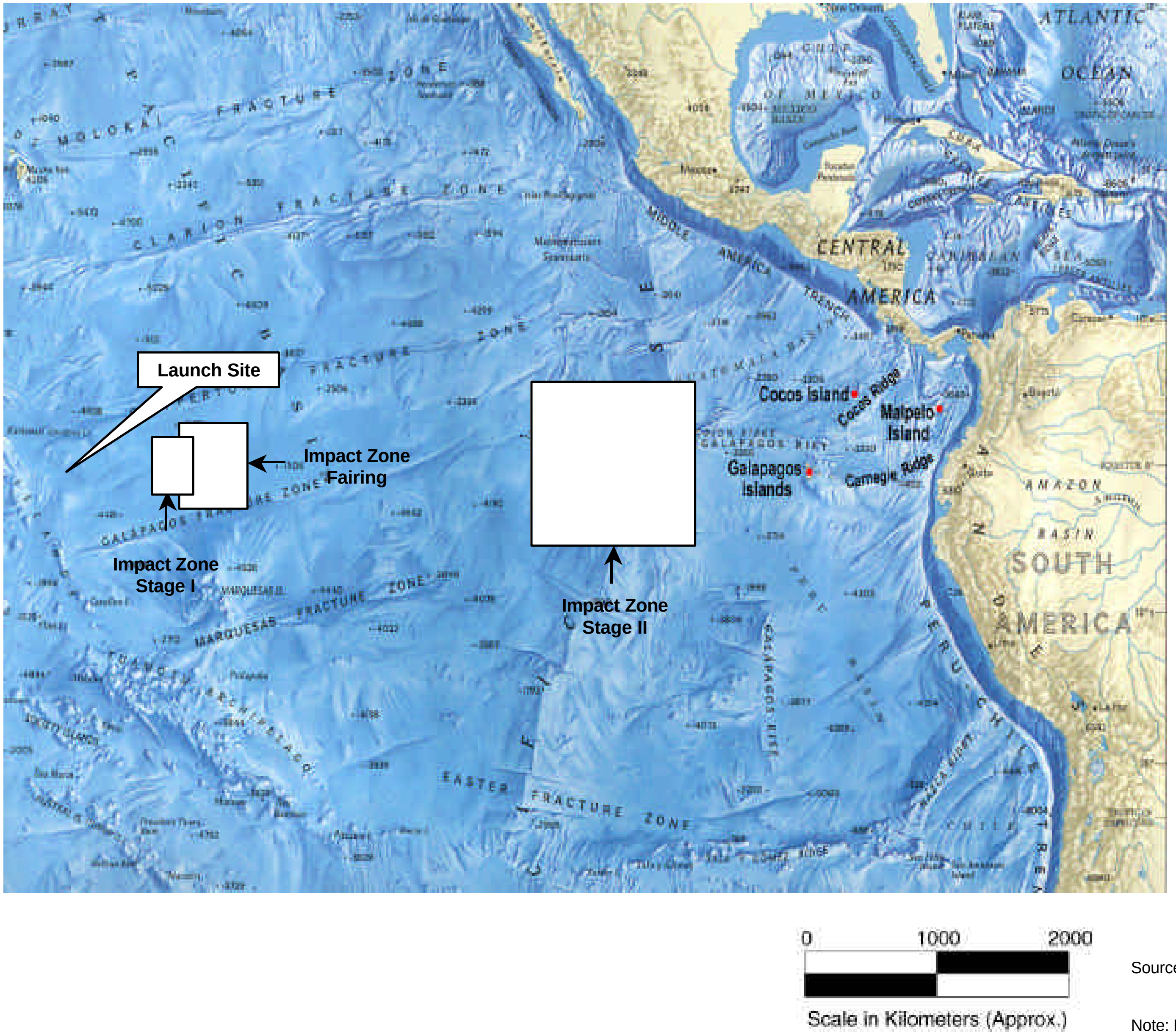
- Spent stages, fairing, and sleeve adapter (i.e., connection between Stage II and the Upper Stage) deposition in the ocean;
- Combustion emissions released to the atmosphere;
- Residual propellants released from spent stages to the atmosphere and ocean; and
- Risk of spent stages, fairing or sleeve adapter falling on a marine organism, ship, fishing vessel, or aircraft.

Geology, Oceanography, and Atmospheric Processes

As shown in Figure ES-2, Stage I and fairing impact zones overlap slightly, and jointly form a rectangle of approximately 480 km (north to south) by 600 km (east to west) (300 by 375 mi). These impact zones are located in water 2,000 to 4,000 meters (m) (1.2 to 2.5 mi) deep. The Stage II impact zone is approximately 1,270 km (790 mi) by 1,320 km (820 miles). The water depth in this area is approximately 3,900 m (2.4 mi). The deposition of spent stages and the fairing in these areas would be inconsequential relative to natural geologic processes in the region.

The open ocean environment within the proposed range of azimuths is largely uniform in terms of oceanic and atmospheric processes, with biological characteristics (e.g., plankton biomass) primarily varying with nutrient and mineral levels (Barber, et al., 1996). The spent stages and fairing pieces from any launch within the proposed range of azimuths would fall into undifferentiated deep, open waters of the tropical equatorial Pacific Ocean, far away from any Oceanic Islands or continental landmass (see Tables ES-1 and ES-2).

Figure ES-2
Impact Zones for Stage I, Stage II, and Fairing



Source: National Geographic Society.
Mercator Projection,

Note: Depths are in meters.

TABLE ES-1. IMPACT ZONES FOR SPENT STAGES AND FAIRING

Flight Element		Open Ocean Impact Zone		
Component	**Mass in kilogram (kg) pounds (lbs)**	**Latitude**	**Longitude**	**Area in square kilometer (km^2) square mile (mi^2)**
Stage I	36,500 (80,300)	2ºSouth (S) to 2ºNorth (N)	147.7ºW to 145.5ºW	107,000 (41,800)
Fairing halves*	2,400 (both) (5,280)	2.2ºS to 2.2ºN	146.6ºW to 142.2ºW	240,000 (93,800)
Stage II and sleeve adapter	11,515 (25,333)	6ºS to 6ºN	116.6ºW to 105.1ºW	1,680,000 (660,000)

* Data shown are for the potential 5-m (16.5 foot (ft)) fairing

TABLE ES-2. SHORTEST EXPECTED DISTANCES BETWEEN LANDMASSES AND ZENIT-3SL INTEGRATED LAUNCH VEHICLE (ILV) STAGE IMPACT ZONES

Landmass (Country)	Distance Between Landmass and Stage I Impact Zone (km (miles))	Distance Between Landmass and Fairing Impact Zone (km (miles))	Distance Between Landmass and Stage II Impact Zone (km (miles))
Kiritimati Island (Kiribati)	1,073 (667)	1,196 (743)	4,526 (2,813)
Malden Island (Kiribati)	841 (523)	954 (593)	4,255 (2,644)
Hatutu Island (France)	1,027 (638)	660 (410)	2,651 (1,648)
Clipperton Island (France)	4,108 (2,553)	3,748 (2,329)	476 (296)
Cocos Island (Costa Rica)	6,487 (4,032)	6,120 (3,804)	1,994 (1,239)
Galapagos Islands (Ecuador)	5,971 (3,711)	5,605 (3,483)	1,483 (922)
Malpelo (Colombia)	7,091 (4,407)	6,724 (4,179)	2,649 (1,646)

Given the expanse of the open ocean area within each impact zone, the environmental effect of stage and fairing deposition is minimal. For any individual launch, only 0.00003 percent, 0.000003 percent, and 0.000001 percent of the impact zone area would be affected by the Stage I, fairing, and Stage II depositions, respectively.

Residual propellants would be released as spent ILV components fall into the ocean. Residual LOX would dissipate immediately upon release. Residual kerosene would be dispersed into a mist during descent, and all but the largest droplets would evaporate within a few minutes. The environment would recover from the effects of the residual propellants and return to its natural condition within a few days.

Impacts on Biological Communities and Commercial Activities

Potential effects of successful launches on biological communities and commercial activities are limited to noise effects associated with the launch, and spent stages and fairings falling on a marine organism, ship, fishing vessel, or aircraft. Steady noise from pre- and post-launch operations (e.g., from ship engines) may reach 70 decibels (dB). Research indicates this level of noise would not have a detrimental affect on animals. Above the surface, launch noise could reach 150 dB at 378 m (1240 ft) which corresponds to 75 dB at the same distance below the surface.

There is a remote possibility that spent stages or the fairing may fall on a marine organism, ship or fishing vessel, or aircraft. As a mitigation measure, SLLP gives advance notice for each launch to the FAA (Central Altitude Reservation Function), the U.S. Coast Guard (USCG; 14th District), the National Imagery and Mapping Agency (NIMA), and the U.S. Space Command (USSC). To coordinate air, marine, and space traffic, these organizations issue necessary information, including notices, through well-established channels. For vessels without receiving equipment (expected to be limited to those operating out of Kiribati ports), standard notices are delivered by fax to Kiribati government authorities and regional fishing fleet and tour operators for distribution and posting.

ES.6.1.2 Possible Mission Failures

The FAA identified several failure scenarios based on previous experience with launches. A failed mission can occur at the LP, during Stage I or Stage II flight, or during Upper Stage flight. In most cases, a failure would result from a detected deviation between the programmed flight path parameter (e.g., pitch, yaw, roll) and the actual flight parameters as monitored by ILV sensors. If flight deviations exceed established limits, the thrust termination system would terminate the flight. A thrust termination system is a type of flight safety system. Flight safety systems provide a means of control during flight to prevent a launch vehicle and any component, including any payload, from reaching any populated or other protected area in the event of a launch vehicle failure. A flight safety system includes the hardware and software used to protect the public in the event of a launch vehicle failure and the functions of any flight safety system crew.

Failure at the Launch Platform Scenario

A failure at the LP would likely result in a cascading explosion of all ILV propellants. The explosions would scatter pieces of the ILV, and perhaps pieces of the LP, as far as three km (two mi) away (the LP is designed to survive an explosion of the fully fueled launch vehicle). A smoke plume would rise and drift downwind some distance before dissipating. In the course of about one minute, the entire matter and energy of the ILV would be dispersed on the LP and in the environment in a relatively concentrated area of the ocean. Potential environmental effects would include intense heat generated at the ocean surface; debris and noise released during the explosion; emissions released to the atmosphere; and the subsequent cleanup needed on the LP. Despite this intense, short-term, and localized disruption, there would be no discernible long-term impact to the environment.

Launch Abort Scenarios

There is also the potential for a launch abort at the LP (i.e., when a countdown is interrupted or no launch occurs, which is technically not a failure). In general, a launch would be aborted if equipment malfunctions or unresolved deviations of ILV parameters occur just before launch. Due to the inherent complexity of the ILV, a deviation in any number of factors could trigger an abort, and the extent to which propellants need to be safeguarded would vary based on the time prior to launch that the abort occurs. In all cases, however, the resulting contingency measures initiated by SLLP would follow established routines to stabilize the ILV on the LP. A worst-case abort, which would occur within three seconds prior to launch, involves the largest quantities of propellant and the most detailed contingency measures. An abort scenario would involve draining small quantities of propellant into the flame bucket where it would evaporate due to wind effects. In addition, the pyrophoric fluid that initiates kerosene ignition would be burned according to SLLP's operating procedures. The ILV would be returned to a horizontal position in the LP hanger, and the propellant reservoirs from the Stage I engine would be drained into containers for later disposal at the Home Port as a hazardous waste.

Failure During Stage I and II Flight Over Open Ocean Scenario

Failure during Stage I and II flight could occur in two ways: explosive failures or thrust termination failures. The mass and character of hazardous material (including the various propellants) and debris that would reach the ocean would depend on the type and time of failure during a launch (i.e., the longer the flight before failure, the less propellant would be onboard the ILV and available to potentially reach the ocean surface). An ILV failure within the first 20 seconds of flight where the stages fall intact and rupture on the surface is the worst case scenario. A failure at this stage of flight would put all unexpended propellants, other hazardous materials, and ILV hardware into the environment in a more concentrated area than would occur during a successful flight. In general, debris from a failure during Stage I and II flight would fall into the deep waters of the open ocean far from Oceanic Islands.
The primary effects of a failure during flight are:

- Release of emissions to the atmosphere.
- Release of propellants and other hazardous material to the ocean.
- Risk of Stage I or II debris falling on marine organisms, marine vessels, or aircraft.

Explosive versus Thrust Termination Failures

Explosive failures (marked by the sudden destruction of propellants and the ILV during flight) would result in the scattering of ILV parts and the immediate consumption of most if not all of the hazardous materials incorporated by or contained in those parts. In contrast, thrust termination failures (i.e., one in which a deviation in flight triggers engine cutoff) would result in the ILV losing upward and forward momentum and falling toward Earth. In this case, an ILV early in Stage I flight would likely fall intact and rupture on the ocean surface, while later in Stage I flight and during all of Stage II flight, the ILV would begin to tumble within seconds and break up due to stresses on the structure. Explosions may also occur during thrust termination if, as the ILV breaks up, flammable materials become exposed to hot engine parts and ignite. If an explosion does not occur, the extent to which ILV materials would reach the Earth's surface would depend on the altitude and speed of the ILV at the time of thrust termination.

Failure During Upper Stage Flight Over the Ocean, Oceanic Islands, or South America Scenario

Possible failure during flight of the Upper Stage could conceivably occur at any point as the Upper Stage progressively transits over the open ocean, the Oceanic Islands, and the northern part of South America. Given the speed and altitude of the Upper Stage during this period, a failure during any point would result in most of the material components and all of the propellants being heated in the atmosphere and vaporized or burned from frictional effects before reaching the Earth's surface. Approximately 42 components from the Upper Stage and payload would survive reentry friction and reach the Earth's surface. These objects range from 0.04 m (0.13 ft) to 1.2 m (3.9 ft) in size, and 0.3 kg (0.7 lbs) to 90 kg (205 lbs) in mass. The actual amount of debris that survives would depend on the time of failure during the flight (i.e., more debris would survive a failure that occurs earlier during the flight).

An Upper Stage failure has the potential to affect the open ocean, with the impacts being similar to those described above for Stage I and Stage II failures, except that most of the material components and all of the propellant in both the Upper Stage and payload would likely vaporize or burn. Only inert materials, such as durable metals in engine components and batteries, are expected to reach the Earth's surface.

In the unlikely event of an Upper Stage failure, the potential impacts would be small but could occur from debris impacting marine organisms, corral reef communities, terrestrial communities on Oceanic Islands, Central or South American habitats, and vessels, aircraft, or humans. Table ES-3 summarizes the possible types of failures and their consequences under several different failed mission scenarios.

ES.6.2 ALTERNATIVE WITH AVOIDANCE OF OCEANIC ISLANDS

Under this alternative, only azimuths between 82.6° to 83.28°, 84.50° to 85.07°, 86.36° to 88.80° and 92.89° to 97.40° would be used. The environmental impacts would be the same as for the license applicant's proposed action except for the impacts to Oceanic Islands and the corresponding portions of South America which would not be overflown in this alternative action.

Upper Stage and payload flight would progressively transit over open ocean waters and the northern part of South America. Upper Stage flight during a successful mission would have no effect on the ocean or land environments or the lower atmosphere because its operation occurs at very high altitudes. The impacts of failure during Upper Stage flight for this alternative would be the same as those for the license applicant's proposed action with the exception that no Stage I or II impact would occur on or near the Oceanic Islands.

ES.6.3 ALTERNATIVE WITH AVOIDANCE OF THE GALAPAGOS ISLANDS

Under this alternative, only azimuths between 83.60° to 86.80° and 92.89° to 97.40° would be used. The environmental impacts would be the same as for the license applicant's proposed action except for the impacts to the Galapagos Islands and the corresponding portions of South America which would not be overflown in this alternative action.

Upper Stage and payload flight would progressively transit over open ocean waters, the Oceanic Islands (excluding the Galapagos Islands), and the northern part of South America. Upper Stage flight during a successful mission would have no effect on the ocean or land environments of the lower atmosphere because its operation occurs at very high altitudes. The impacts of failure during Upper Stage flight for this alternative would be the same as those for the license applicant's proposed action with the exception that no impact would occur on or near the Galapagos Islands.

ES.6.4 NO ACTION

Under the No Action alternative FAA would not issue an LOL or launch-specific license for Galaxy IIIC to SLLP. SLLP would continue to prepare and submit launch-specific applications for individual licenses to launch up to six satellites per year within the launch parameters addressed in the February 11, 1999 EA. Home Port operations would continue at their present level. If a customer requires a different launch azimuth, SLLP would prepare individual environmental analyses and documentation to support launch-specific applications and submit the documentation to the FAA for review.

TABLE ES-3. SUMMARY OF FAILURE SCENARIOS AND ASSOCIATED ENVIRONMENTAL IMPACTS

Failure Scenarios	Impact Area	Failure Rate	Environmental Impact
During initial Stage I Flight	Launch region	3 x 10^{-18}/seconds (sec)	• ILV impacts open ocean virtually intact (Thrust Termination Failure), or in pieces (Explosive Failure) • Maximum quantity of propellants (e.g., kerosene) released and dispersed in the topmost ocean layer • Inert ILV fragments settle on ocean floor • Very low probability of debris falling on vessels (fishing, shipping, or air traffic) as well as marine organisms
During Stage I Flight	Downrange area of 800 km (500 mi)	26.94x 10^{-5}/sec	• ILV (less most Stage I propellants) impacts open ocean after tumbling and fragmentation or explosion • Propellants (e.g., kerosene) released and dispersed in atmosphere through evaporation, residual reaching the topmost ocean layer (or combustion if Explosive Failure) • Inert ILV fragments settle on ocean floor • Very low probability of debris falling on vessels (fishing, shipping, or air traffic) as well as marine organisms
During Stage II Flight	Downrange area beyond 4,600 km (2,900 mi)	28.65x 10^{-5}/sec	• Fragments of the ILV (less Stage I) surviving descent, impact open ocean • Propellants (e.g., kerosene) released and dispersed in atmosphere through evaporation, no propellant expected to reach the topmost ocean layer • Inert ILV fragments settle on ocean floor • Very low probability of debris falling on vessels (fishing, shipping, or air traffic) as well as marine organisms
During Upper Stage Flight Over Ocean Waters	Downrange area beyond 4,600 km (2,900 mi) affecting shipping	6.28 x 10^{-5}/sec	• Fragments of the Upper Stage (ILV less Stages I and II) surviving descent, impact open ocean • Propellants (e.g., kerosene) released and dispersed in atmosphere through evaporation, no propellant expected to reach the topmost ocean layer • Inert ILV fragments settle on ocean floor • Low probability of debris falling on vessels (fishing, shipping, or air traffic) or marine organisms
During Upper Stage Fight Over an Oceanic Island	Potentially populated areas	6.28 x 10^{-5}/sec	• Fragments of the Upper Stage surviving descent, impact terrestrial ecosystems or shallow, near-island ocean • Propellants (e.g., kerosene) released and dispersed in atmosphere through evaporation, no propellant expected to reach the ocean or land • Low probability of debris falling on vessels (fishing, shipping or air traffic) as well as on land or marine organisms
During Upper Stage Flight in vicinity of Panama Canal shipping	Western approaches to Panama Canal affecting shipping	6.28 x 10^{-5}/sec	• Fragments of the Upper Stage surviving descent, impact terrestrial ecosystems or coastal area • Propellants (e.g., kerosene) released and dispersed in atmosphere through evaporation, no propellant expected to reach the ocean or land • Low probability of debris falling on vessels (shipping) or land or marine organisms
During Upper Stage Flight Over South America	Potentially populated areas	6.28 x 10^{-5} /sec	• Fragments of the Upper Stage surviving descent, impact terrestrial ecosystems • Propellants (e.g., kerosene) released and dispersed in atmosphere through evaporation, no propellant expected to reach land • Low probability of debris falling on land organisms, including people

The launch-specific application and license process would be repeated approximately every 60 days, as warranted by commercial demand, requiring more processing time which could affect SLLP's launch schedule. SLLP's launch capacity could be underutilized, and it might be partially constrained in meeting the needs of its customers.

ES.7 CUMULATIVE IMPACTS

Cumulative impacts to the environment result from incremental effects of the license applicant's proposed action combined with other past, present, and reasonably foreseeable actions in the area. This EA focuses on the cumulative impacts associated with eight SLLP launches per year for five years, or a maximum of 40 proposed launches, over the broader range of azimuths of the license applicant's proposed action. Given the isolated location of the *launch site*, there is a lack of *other* past, present or reasonably foreseeable actions in the area that might, in combination with SLLP's actions, cumulatively impact the open ocean environment.

In general, the effects of the license applicant's proposed action would occur on a regional scale. No larger global impacts are expected to occur, mainly because of the small amounts of debris, hazardous material, and atmospheric emissions produced by the ILV relative to the scale of natural processes in the Pacific Ocean and anthropogenic activities (e.g., power generation) worldwide.

The cumulative effects for each phase of the launch operation are discussed below.

ES.7.1 HOME PORT

Other than the increase in the number of launches requiring processing, operations at the Home Port would be the same as those evaluated in the February 11, 1999 EA. The higher rate of throughput of both payload processing and marine vessel activity would remain within the capacity and regulatory approvals of all Home Port facilities, which were designed by SLLP to handle eight launches per year. Using unsymmetrical dimethylhydrazine (UDMH) in the Upper Stage would not create a new impact resulting from Home Port operations as SLLP will modify and comply with all Federal, state, and local permit requirements. In addition, scrubbers specifically designed to capture UDMH vapors have been installed at the Home Port facilities.

ES.7.2 PRE-LAUNCH

Transit of the LP and ACS from Home Port to the launch site would be like any normal maritime shipping and would be subject to U.S., United Nations (UN), and other international rules and regulations. The two additional round-trip transits by the ACS and LP per year would not contribute significantly to marine vessel traffic on the Pacific Ocean.

The pre-launch operations would be the same as those evaluated in the February 11, 1999 EA. No cumulative effects are expected from pre-launch operations.

ES.7.3 LAUNCH

Repeated launches over the Pacific Ocean present the potential for cumulative impacts, which may be one of two types:

- Effects of debris blown into the ocean, and
- Effects of heat and noise on marine mammals.

ES.7.3.1 Potential Effects of Debris Blown into the Ocean

The launch may blow some scattered debris into the ocean, although experience from launches to date has shown that little to no material has been lost. The increase in the number of flights would possibly result in more debris entering the ocean environment; however, the volume of material remains very small relative to the scale of the east central Pacific Ocean.

ES.7.3.2 Potential Effects of Heat and Noise on Marine Mammals

The energy from heat and sound at launch would have only a momentary impact on the ocean, and would be dissipated within minutes, leaving no lasting or cumulative impact. Environmental monitoring activities have occurred immediately before and after each launch. No impacts to the local marine environment have been observed during the monitoring efforts.

ES.7.4 SUCCESSFUL FLIGHT OVER THE OPEN OCEAN, OCEANIC ISLANDS, AND SOUTH AMERICA

It should be noted that although the license applicant's proposed action includes launches on a range of azimuths from 82.6º to 97.4º, actual flights would likely be along a more narrow band of azimuths, likely focused around 90º. Accordingly, cumulative impacts from successful missions over the five years of the license applicant's proposed action would be expected along a more concentrated area of the open ocean (i.e., into smaller spent stage deposition areas).

ES.7.4.1 Spent Stages and Fairing Debris, including Hazardous Materials

Of all the impacts listed above for successful launches, the stage and fairing debris would be the only launch byproduct that would remain in the environment for a long period of time. Stage I would be expected to occasionally break up upon descent, while Stage II is expected to always break up during its descent from a high altitude. For both stages, the debris would fall into the open ocean environment where surviving objects would cool and sink almost immediately upon reaching the water surface with the exception of the fairing pieces.

From a cumulative impact perspective, the amount of debris is negligible when compared to the expanse of the equatorial Pacific Ocean. To evaluate cumulative impacts, a worst case scenario would be that all 40 launches would use the same azimuth. This hypothetical scenario further assumes that the deposited stage and fairing debris do not overlap (i.e., the flattened stage debris sinks to the bottom of the ocean without overlapping with previously deposited stage debris), only 0.00015 percent of the ocean floor in the impact zones would be affected by the 40 launches. Even with this hypothetical worst case scenario, the resulting impact to the regional seafloor would be insignificant.

ES.7.4.2 Residual Propellants Released from the Spent Stages to the Ocean and Atmosphere

During each launch, the kerosene would evaporate and degrade relatively quickly. Specifically, almost 95 percent of any kerosene released from spent stages would evaporate and be dispersed as smog by reacting with solar energy and dissipated into the environment through natural processes. The remaining kerosene on the ocean surface would be dispersed by turbulence in the top few meters of the ocean, and be degraded to carbon dioxide (CO_2) and water (H_2O) through photochemical oxidation and microbial degradation within days of the initial release (Doerffer, 1992; National Research Council, 1985; Rubin, 1989; ITOPF, 2001; and EPA, 1999).

LOX released to the environment as the spent stages break up during descent or on the ocean surface would instantaneously vaporize upon being exposed to ambient pressure and temperature. Accordingly, the ocean environment would essentially return to pre-launch conditions within a few days and long before the next launch would occur (45 days later under the license applicant's proposed action).

ES.7.4.3 Emissions to the Atmosphere

The proposed launches would affect the atmosphere due to the combustion of propellants, with the associated generation of gas, vapor, and particulate matter emissions, and the physical passage of the ILV through the atmosphere. Total annual and cumulative (i.e., from 40 launches) emissions by altitude are provided in Table ES-4.

TABLE ES-4. TOTAL ANNUAL AND CUMULATIVE EMISSIONS FOR EIGHT LAUNCHES A YEAR

Atmospheric Layer	Altitude* Range (km (mi))	Annual Propellant Consumed (kg (lbs))	Annual Emission Products Assuming Eight Launches in kg (lbs)				
			CO**	CO_2	H_2	H_2O	N_2
Lower Troposphere	0.0-2.0 (0.0-1.2)	493,712 (1,086,166)	136,264 (299,781)	215,256 (473,563)	3,456 (7,603)	138,736 (305,219)	0
Free Troposphere	2.0-10.0 (1.2-6.2)	552,800 (1,216,160)	152,576 (336,667)	241,024 (530,253)	3,872 (8,518)	155,336 (341,739)	0
Stratosphere	10.0-51.0 (6.2-32)	1,270,648 (2,795,425)	350,696 (771,531)	554,000 (1,218,800)	8,896 (19,571)	357,056 (785,523)	0
Mesosphere and Thermosphere	51.0-292 (32-182)	997,576 (2,150,667)	271,896 (598,171)	444,064 (976,940)	7,928 (17,442)	273,808 (602378)	290 (640)
	Annual (8 Launches) Total	3,314,736 (7,248,418)	911,432 (2,009,156)	1,454,344 (3,199,110)	24,152 (53,134)	924,936 (2,034,859)	290 (640)
	Cumulative 5-Year (40 Launches) Total	16,573,680 (36,242,090)	4,557,160 (10,045,780)	7,271,720 (15,995,550)	120,760 (265,670)	4,624,680 (10,174,295)	1,450 (3,200)

* Altitude ranges are rounded to the nearest km.

** Carbon monoxide (CO), carbon dioxide (CO_2), hydrogen (H_2), water (H_2O), nitrogen (N_2)

Global warming and ozone depletion could be cumulative effects of the license applicant's proposed action. However, the contribution of these emissions is negligible when compared to other global sources, natural or man-made. The greatest risk for adverse atmospheric impacts due to ILV emissions would be in the area of ozone layer destruction. The ILV does not release chlorine or chlorine compounds (which contribute to ozone destruction) in or below the stratosphere, and the SLLP impact in this regard would not be significant.

ES.7.5 POST-LAUNCH

After a successful launch, the crew would reoccupy and clean the LP in preparation for transit to the Home Port. Any debris would be collected and handled onboard as solid waste for later disposal at Home Port. The amount of solid waste is insignificant and would not present any adverse cumulative effects as part of the overall waste stream managed while at sea and properly disposed of when the vessels return to the Home Port.

ES.7.6 Multiple Launch Failures in a Single Year in the Same Area

From a cumulative impact perspective, the most significant adverse environmental effect associated with the license applicant's proposed action would be the failure of multiple launches in a single year along the same azimuth in close proximity to one another. In considering a scenario that would result in a worst-case cumulative impact, two consecutive failures that affect the same geographic area are evaluated. Considering several (i.e., more than two) consecutive mission failures, however, is not practical since such a circumstance would challenge the continued viability of the SLLP launch concept.

ES.7.6.1 Time Period Between Launches Following a Failure for An Investigation

Considering multiple, successive failures as a hypothetical worst case, and given the mandatory investigation process, the two successive failures would occur many months apart. For both safety and commercial reasons, launches would not be resumed until the cause of the failure is determined and corrected to the satisfaction of the FAA and SLLP.

ES.7.6.2 Failure Scenarios Affecting the Ocean

Even under the worst-case scenario where the entire amount of propellants and other hazardous materials on the ILV are released directly to the ocean, the ocean environment would recover to natural conditions within a week. The subsequent launch, allowing for the amount of time required for mandatory investigation, would not occur until four to 12 months later. Therefore, no cumulative impact would occur as a result of successive, worst-case failures, even those that happen to affect the same area of the ocean because the amount of time between possible launch failures would allow the ocean environment time to fully recover.

ES.7.6.3 Failure Scenarios Affecting the Oceanic Islands or Central or South American Landmasses

The Oceanic Islands and Central or South America could only be affected by a failure during Upper Stage flight (any failures earlier in flight would only affect the ocean environment). An Upper Stage failure could be the result of either thrust termination or explosion. Both of these types of failures would have the same environmental effects and therefore are collectively considered the worst-case scenario in terms of Oceanic Islands or Central or South American effects.

A possible failure during Upper Stage flight would result in most of the ILV components and all of the propellants and other hazardous materials being heated in the atmosphere and vaporized or burned from frictional effects before reaching the Earth's surface due to the speed and altitude of the Upper Stage at this point in flight. The surviving debris, which would cool during the descent through the lower atmosphere, is highly unlikely to be hot enough to pose a risk of fire. The only potential adverse effects from the components would be the physical damage associated with striking individual terrestrial plant or animal species.

If debris struck an animal, it could be injured or killed. There is an extremely remote chance that an individual of a threatened or endangered species could be hit by falling debris. Should such harm occur, an individual's replacement in terms of population dynamics would depend on the individual species' abundance, reproduction characteristics, and recruitment success.

These additional cumulative impacts would likely be minor, with the exception of any endangered species that may be hit. The probability of these components falling on the Galapagos Islands, for example, is very low (i.e., 0.00067), and the probability of striking an endangered species would be even more remote.

ES.8 ENVIRONMENTAL MONITORING AND PROTECTION PLAN (EMPP)

The EMPP is an evolving document of mitigation measures, incorporating improvements identified by the FAA, SLLP, or suggested by the public. The plan consists of four elements:

- Visual observation for species of concern.
- Remote detection of atmospheric effects during launch.
- Collection of surface water samples to detect possible launch effects.
- Notification to mariners and air traffic.

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1.0 *PURPOSE AND NEED FOR THE LICENSE APPLICANT'S PROPOSED ACTION*

1.1 INTRODUCTION

This Environmental Assessment (EA) evaluates the potential environmental effects of this project pursuant to Executive Order (E.O.) 12114 on the Environmental Effects Abroad of Major Federal Actions, whose implementation is guided by the National Environmental Policy Act (NEPA) of 1969, as amended (42 United States Code (U.S.C). § 4321 *et seq*.), and the implementing regulations of the President's Council on Environmental Quality (CEQ; 40 Code of Federal Regulations (CFR) 1500-1508). This document incorporates by reference a prior EA prepared by the Federal Aviation Administration (FAA) dated and referred to as the February 11, 1999 EA, and is included as Appendix A of this document.

The proposed Federal action is to issue a launch operator license (LOL), and a launch-specific license for the Galaxy IIIC mission or other launch-specific licenses should the launch operator license be delayed or not issued, as described in Section 1.2. The purpose of the license applicant's proposed action is to fulfill the mandate of 49 United States Code (U.S.C). Subtitle IX – Commercial Space Transportation, ch. 701, Commercial Space Launch Activities, 49 U.S.C. §§ 70101-70121 and is more fully described in Section 1.3. The need for the license applicant's proposed action is also described more fully in Section 1.3. Section 1.4 presents, briefly, the background of the project, including the Federal government role, prior environmental analyses and documents, and public involvement. That section concludes with a roadmap for the remainder of this EA.

1.2 PROPOSED FEDERAL ACTION

The Federal action is for the FAA, Office of the Associate Administrator for Commercial Space Transportation (AST) to issue an LOL to Sea Launch Limited Partnership (SLLP) that would authorize SLLP to conduct launches from one launch site, within a range of launch parameters, of specific launch vehicles, transporting specified classes of payload. (See 14 CFR. 415.3(b)). The proposed LOL would authorize SLLP to:

- Conduct up to eight launches per year over a five-year period, for a maximum of 40 launches;[a]

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[a] Even under an LOL, a license applicant must provide the FAA with launch specific information. This will permit the FAA to have continuing oversight over SLLP operations. See 14 CFR 415.73 Continuing Acceptance of License Applications; Application for Modification of License. In accordance with 14 CFR 415.79, not later than 60 days before each flight conducted under a launch operator license, a licensee shall provide the FAA the following launch specific information:
1. payload information contained in 14 CFR 415.59;
2. flight information, including launch vehicle, planned flight path, including staging and impact locations, and on-orbit activity of the launch vehicle including payload delivery point(s); and
3. mission specific launch waivers, approved or pending, from a federal launch range from which the launch will take place, that are unique to the launch and may affect public safety.

Not later than noon, eastern standard time (EST), 15 days before each licensed flight a licensee shall submit to the FAA a completed Federal Aviation Administration/U.S. Space Command (FAA/USSPACECOM) Launch Notification Form (Office of Management and Budget (OMB) No. 2120-0608).

- Use a launch site at 0° latitude and 154° W longitude;
- Launch along a range of azimuths from 82.6° to 97.4°, inclusive[b];
- Use a Zenit-3SL launch vehicle; and
- Transport specified classes of payloads.

Any change to these LOL parameters would require additional environmental and safety analyses.

The FAA is also evaluating the possibility of issuing a launch-specific license to SLLP for the launch of Galaxy IIIC, as well as other potential launch-specific licenses (not to exceed eight per year) as necessary should the proposed LOL not be issued or be delayed. The proposed launch-specific licenses would authorize the SLLP to conduct specific launches:

- From a launch site at 0° latitude and 154°W longitude;
- On a launch azimuth within a range from 82.6° to 97.4°, inclusive;
- Using a Zenit-3SL launch vehicle; and
- Transporting specified classes of payloads.

The launch site location, launch vehicles, and classes of payloads that would be authorized under the proposed launch-specific licenses would be identical to the launch site location, launch vehicles, and classes of payloads that would be authorized under the proposed LOL. In addition, the launch azimuths that would be authorized under the launch-specific licenses would fall within the launch azimuth range that would be authorized under the LOL. Finally, the number of launch-specific licenses that would be issued per year would not exceed the number of the launches that would be authorized annually under the LOL (i.e., eight per year). The conduct that would be authorized under the proposed LOL and launch-specific licenses is identical, only the license application process would differ. Therefore, discussions and analyses of potential environmental impacts of the LOL and the launch-specific licenses are addressed together. Throughout the document, when the license applicant's proposed action is discussed, while emphasis is placed on the launch operator license, it should be understood that the launch-specific licenses are included in the license applicant's proposed action.

To obtain a launch license (either launch-specific or a launch operator license), an applicant must obtain policy and safety approvals from the FAA. Requirements for obtaining these approvals are contained in 14 CFR 415 Subpart B (Policy Review and Approval), Subpart C (Safety Review and Approval for Launch From a Federal Launch Range, including the calculation of acceptable flight risk), and Subpart F (Safety Review and Approval for Launch From a Launch Site not Operated by a Federal Launch Range). Other requirements include payload determination (14 CFR 415 Subpart D), financial responsibility (14 CFR 415.83, Subpart E) and environmental review (14 CFR 415 Subpart G).

A launch licensee shall report a launch accident, launch incident, or a mishap that involves a fatality or serious injury (as defined in 49 CFR 830.2) immediately to the FAA Washington Operations Center and provide a written preliminary report in the event of a launch accident or launch incident, in accordance with the accident investigation plan (AIP) submitted as part of its license application under 14 CFR 415.41.

[b] Within this range of azimuths, launches on azimuths of 83.28° to 84.50° have Impact Limit Lines (ILL) that overlay Cocos Island, 85.07° to 86.36° have ILL that overlay Malpelo Island, and 86.80° to 92.89° have ILL that overlay the Galapagos Island group. ILL are defined as the debris dispersion area where, with a statistical confidence of 99.67%, all the stages from successful flight as well as any material from a failure would impact. See Sections 2.3.4 and 2.3.5 below.

1.3 PURPOSE AND NEED FOR THE LICENSE APPLICANT'S PROPOSED ACTION

Access to space has become increasingly important for the deployment of satellites used for scientific research, communications, and multimodal transport navigation systems. Given the infrastructure and technology development costs associated with launching and deploying satellites, the Federal Government has been responsible for the majority of launches. However, with the increasing demand for access to space, especially for communications satellites, commercial launch companies have begun to offer launch services to meet this demand.

The purpose of the license applicant's proposed action as defined in 49 U.S.C. Subtitle IX – Commercial Space Transportation, ch. 701, Commercial Space Launch Activities, 49 U.S.C. §§ 70101-70121 is to:

- Promote economic growth and entrepreneurial activity through use of the space environment for peaceful purposes;
- Encourage the U.S. private sector to provide launch vehicles, reentry vehicles, and associated services by simplifying and expediting the issuance of licenses;
- Provide FAA oversight and coordination of licensed launches and to protect the public health and safety, safety of property, and national security and foreign policy interests of the U.S.; and
- Facilitate the strengthening and expansion of the U.S. space transportation infrastructure.

The need for the license applicant's proposed action is to streamline the FAA's licensing process while still assuring public safety and proper environmental review. Such a streamlined process will promote the entrepreneurial activity of a licensed launch provider. The proposed LOL would cover multiple launches using the same infrastructure at the same launch location through a range of launch azimuths without the need to re-evaluate license applications for individual launches unless there are changes in the license applicant's proposed action, environmental impacts or conditions of approval. The proposed LOL would allow SLLP to conduct up to eight launches per year for five years, for a maximum of 40 launches. The proposed LOL would allow SLLP to launch on exact equatorial azimuths (e.g., 90^{o}), which are optimal for geosynchronous orbit (GSO) launches in terms of fuel efficiency, payload weight, and satellite life span.

1.4 BACKGROUND

1.4.1 Federal Government Role

The purpose of 49 U.S.C. Subtitle IX – Commercial Space Transportation, ch. 701, Commercial Space Launch Activities, 49 U.S.C. §§ 70101-70121 is to promote, encourage, and facilitate the growth of the U.S. commercial space transportation industry. The U.S. Department of Transportation (DOT) was designated as the lead agency for licensing and regulating all U.S. commercial launch operations to ensure that they are conducted safely and responsibly. In November 1995, these responsibilities were delegated from the Office of the Secretary of Transportation to the FAA.

1.4.2 Prior Environmental Analyses

The FAA previously analyzed the environmental effects of licensed launch operations and launches in the Programmatic Environmental Assessment of Commercial Expendable Launch Vehicle Programs (February 1986).

The Final Environmental Assessment for the SLLP Program dated February 11, 1999 (February 11, 1999 EA), described proposed launches and alternatives, the affected environment, potential environmental impacts, and environmental mitigation measures for the launches of one demonstration payload and one commercial satellite in the first year of operation, and six per year thereafter along a single launch azimuth. It included an Environmental Finding, which concluded that licensing the proposed launches was not a major Federal action that would significantly affect the quality of the human environment, and that preparation of an Environmental Impact Statement (EIS) was not required (see Appendix C). The FAA also prepared additional documents, including Written Reevaluations (WR) and findings, for two individual launches with azimuths that differed from that evaluated in the February 11, 1999 EA and for the use of UDMH and nitrogen tetroxide (N_2O_4) in the Upper Stage for Mission 6R (see Appendix D).

1.4.3 History of the License Applicant's Proposed Project

The SLLP project is an international commercial space launch project owned and operated jointly by Boeing Commercial Space Company of the United States, RSC Energia of Russia, KB Yuzhonoye and PO Yuzhmash of Ukraine, and Moss Maritime a.s. of Norway. The project's main assets are a seagoing mobile launch platform (LP), assembly and command ship (ACS), Home Port facilities in Long Beach, California, and the Zenit-3SL. The project is intended to place payloads in orbit from a launch site in the east central Pacific Ocean at 0° latitude and 154° W longitude.

On March 27, 1999, SLLP successfully completed its first demonstration payload launch (referred to as Mission 1), that confirmed the design and operation of the complete SLLP system. On October 9, 1999, commercial operations of SLLP officially began with the launch of DIRECTV 1-R, a direct broadcast satellite (Mission 2). Mission 3, for an ICO communication satellite, involved a nonequatorial launch azimuth (i.e., 135°) that was not evaluated in the February 11, 1999 EA. Therefore, a WR of the potential environmental effects of the launch along this azimuth was prepared for Mission 3 (see Appendix D). The WR findings were used by FAA in issuing a license for this mission. On March 12, 2000, SLLP launched the ICO communications satellite. Because of a malfunctioning propulsion valve, however, the flight was terminated before reaching orbit—approximately eight minutes after liftoff—by automatic on-board safety systems. On July 28, 2000, again using an equatorial launch azimuth as evaluated in the February 11, 1999 EA, SLLP successfully sent into orbit a PanAm Sat communications satellite (Mission 4). On October 21, 2000, SLLP successfully sent into orbit Thuraya-1, a mobile communications satellite (Mission 5). Because Mission 5 also involved an azimuth not evaluated in the February 11, 1999 EA (i.e., 83.28° rather than 88.67°), a WR was prepared to determine whether the license applicant's proposed action conformed to the plans and projects analyzed in the earlier EA; whether the data and analyses in the earlier EA were still valid; and whether all pertinent conditions and requirements of the prior approval were or would be met in the new action. The first attempted launch of XM-1, a radio communications satellite ended in a launch abort (Mission 6). This launch was successfully carried out on May 8, 2001 (Mission 6R). A WR was prepared for Mission 6R which addressed the impact of using 7 to 13 gallons of unsymmetrical dimethylhydrazine (UDMH) fuel along with N_2O_4 oxidizer, imported from Russia as the propellants for the Upper Stage (see Appendix E). On March 18, 2001, using an equatorial launch azimuth as evaluated in the February 11, 1999 EA, SLLP successfully sent into orbit XM-2, a radio communications satellite (Mission 7).

1.4.4 Relationship Between this EA and the February 11, 1999 EA

This document incorporates by reference the February 11, 1999 EA. The February 11, 1999 EA considered the license applicant's proposed action of issuing launch licenses for two SLLP launches, a demonstration launch carrying a simulated payload and a launch to deploy a satellite, and also considered the potential environmental impacts of up to six launches per year along the 88.67° azimuth. The environmental impacts of specific launch licenses issued for launches along this azimuth were analyzed in the February 11, 1999 EA.

The license applicant's proposed action in this EA would use the Home Port facilities; conduct the same pre-launch operations; use the same launch vehicle and launch site (0° latitude and 154°W longitude); and would conduct the same post-launch operations as evaluated in the February 11, 1999 EA. These aspects of the license applicant's proposed action are the same as those addressed in the February 11, 1999 EA. This EA incorporates by reference the February 11, 1999 EA, which is accessible at the FAA web site (http://ast.faa.gov) and is included as Appendix A of this document. This EA focuses on potential impacts of the license applicant's proposed action and the cumulative impacts of the launches that could occur as a result of issuing an LOL.

1.4.5 Public Involvement

The FAA issued a proposed Environmental Finding Document, finding no significant impact for the draft version of the February 11, 1999 EA, which was made available for public review from April 23 to May 26, 1998. The FAA also met with representatives of the Governments of Ecuador, Kiribati, Australia, and New Zealand, and with representatives of the South Pacific Regional Environmental Programme (SPREP). Additional meetings with representatives of SPREP and the Government of Ecuador have been held periodically to discuss upcoming launches and longer-term plans, such as the application for an LOL. A draft of this EA was offered for public comment and announced in the U.S. *Federal Register*.

1.4.6 Roadmap for this EA

This EA is structured as follows:

- Introduction and description of the purpose and need for the license applicant's proposed action (Section 1.0).
- Description of the license applicant's proposed action and other alternatives, including No Action (Section 2.0).
- Description of the environment that could be affected by the license applicant's proposed action (Section 3.0).
- Evaluation of the environmental effects associated with the license applicant's proposed action and reasonable alternatives, including No Action (Section 4.0).

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2.0 DESCRIPTION OF LICENSE APPLICANT'S PROPOSED ACTION AND ALTERNATIVES

2.1 SCREENING CRITERIA

For this EA, the FAA considered screening criteria to evaluate the license applicant's proposed action and reasonable alternatives to that action. The screening criteria are based on the purposes established in 49 U.S.C. Subtitle IX – Commercial Space Transportation, ch. 701, Commercial Space Launch Activities, 49 U.S.C.§70101-70121, as follows:

- To promote economic growth and entrepreneurial activity through use of the space environment for peaceful purposes.

- To encourage the United States private sector to provide launch vehicles, reentry vehicles, and associated services by simplifying and expediting the issuance and transfer of commercial licenses; and facilitating and encouraging the use of Government-developed space technology.

- To provide FAA oversight and coordination of commercial launch activities and to protect the public health and safety, safety of property, and national security and foreign policy interests of the United States.

- To facilitate the strengthening and expansion of the United States space transportation infrastructure, including the enhancement of United States launch sites and launch-site support facilities, and development of reentry sites, with Government, State, and private sector involvement, to support the full range of United States space-related activities.

These criteria are applied in Section 2.6 to evaluate the reasonableness of the license applicant's proposed action and potential alternatives.

2.2 LICENSE APPLICANT'S PROPOSED ACTION

The license applicant's proposed action would be for the FAA to issue a launch operator license (LOL) to SLLP. The proposed license would authorize SLLP to:

- Conduct up to eight launches per year over a five-year period, for a maximum of 40 launches;
- Use a launch site at 0° latitude and 154° W longitude;
- Launch along a range of azimuths from 82.6° to 97.4°, inclusive[a];
- Use a Zenit-3SL launch vehicle; and
- Transport specified classes of payloads.

Any change to these proposed LOL parameters would require additional environmental and safety analyses.

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[a] Within this range of azimuths, launches on azimuths of 83.28° to 84.50° have Impact Limit Lines (ILL) that overlay Cocos Island, 85.07° to 86.36° have ILL that overlay Malpelo Island, and 86.80° to 92.89° have ILL that overlay the Galapagos Island group. Impact Limit Lines are defined as the debris dispersion envelope where, with a statistical confidence of 99.67%, all the stages from successful flight as well as any material from a failure would impact. See Sections 2.3.4 and 2.3.5 below.

The license applicant's proposed action would also include having the FAA issue a launch-specific license to SLLP for the launch of Galaxy IIIC, as well as other potential launch-specific licenses (not to exceed eight per year) as necessary should the proposed launch operator license not be issued or be delayed. The proposed launch-specific licenses would authorize the SLLP to conduct specific launches:

- From a launch site at 0° latitude and 154° W longitude;
- On a launch azimuth within a range from 82.6° to 97.4°, inclusive;
- Using a Zenit-3SL launch vehicle; and
- To transport specified classes of payloads.

The launch site location, launch vehicles, and classes of payloads that would be authorized under the proposed launch-specific licenses would be identical to the launch site location, launch vehicles, and classes of payloads that would be authorized under the proposed LOL. In addition, the launch azimuths that would be authorized under the launch-specific licenses would fall within the launch azimuth range that would be authorized under the LOL. Finally, the number of launch-specific licenses that would be issued per year would not exceed the number of the launches that would be authorized under the LOL per year (i.e., eight per year). The conduct that would be authorized under the LOL and launch-specific licenses is identical, only the license application process would differ. Therefore, discussions and analyses of potential environmental impacts of the proposed LOL and launch-specific licenses are addressed together. Thus, throughout the document, when the license applicant's proposed action is discussed, while emphasis is placed on the launch operator license, it is understood that the launch-specific licenses are included in the license applicant's proposed action.

The present Zenit-3SL configuration uses Russian-produced kerosene and liquid oxygen (LOX) for the propulsion of Stages I and II and the Upper Stage or Block DM-SL. Attitude control systems of the Upper Stage currently use a propulsion system of monomethylhydrazine (MMH) and nitrogen tetroxide (N_2O_4). Other propellants that may be used during the five-year period covered by the LOL are also considered in the license applicant's proposed action. Specifically, unsymmetrical dimethylhydrazine (UDMH) is considered as a potential substitute for MMH in the Upper Stage attitude control system. The environmental consequences of this substitution are discussed in Section 4.1.1.3 (Sections 4.2.1.3 and 4.3.1.3 for alternatives) and Appendix E of this EA. UDMH and MMH are both hydrazine fuels (a type of launch vehicle and spacecraft fuel used in hypergolic propellant systems) that have different chemical and physical parameters (e.g., boiling point, specific gravity, vapor pressure, and flash point). The two fuels, however, are similar in terms of their reactivity, products of combustion (based on N_2O_4 as an oxidizer), exposure limits, and United Nations (UN) and United States Department of Transportation (DOT) hazard classification. The environmental consequences from the use of UDMH specific to the Upper Stage would be similar to those of MMH.

In addition, U.S.-produced kerosene or the Russian-produced kerosene substitute Boktan may be used instead of the Russian-produced kerosene for propulsion. Section 4.1.1.3. (Sections 4.2.1.3 and 4.3.1.3 for alternatives) and Appendix E of this EA compare these products. A full operational evaluation of Boktan has not yet been completed, but preliminary analysis indicates that physical and safety parameters of the three products are similar and the environmental consequences from the use of Boktan would be similar to those of both U.S. and Russian produced kerosene. Should SLLP decide to use Boktan at some point in the future, proper environmental analysis will be conducted as appropriate.

The commercial satellites to be launched—for telecommunication, observational, navigational, and scientific purposes—are propelled by systems employing hydrazine, MMH, N_2O_4, xenon ion propulsion, and/or electrical propulsion. Satellite systems are provided to SLLP fully contained (i.e., assembled, fueled and containerized) by the manufacturer.

Under the license applicant's proposed action and the other alternatives analyzed in this EA, each launch would involve maintenance and preparation of equipment at the Home Port in California, transit of the ACS and LP (with the launch vehicle onboard) to 0° latitude (on the Equator) and 154° W longitude, pre-launch preparations, launch and flight, and post-launch operations and monitoring. These procedures are briefly described in Sections 2.2.1 through 2.2.5.

2.2.1 Home Port

The Home Port is located on the former Long Beach Naval Station in Long Beach, California. The Home Port provides the facilities, equipment, supplies, personnel, and procedures necessary to receive, transport, process, test, and integrate the satellite payload and its associated support equipment with the launch system. It also serves as the home base for launch operations.

The three launch vehicle stages, the payload fairing, and the payload adapter are transported to the Home Port where they are processed, integrated with the spacecraft (forming the Integrated Launch Vehicle or ILV), and prepared for ocean transport. The ILV, personnel, and propellants (including kerosene and LOX) are transported onboard the LP and the ACS to the launch location. During transport to the launch site, the ILV electrical systems are checked and charged, and launch command processes and contingency measures are rehearsed.

The design, permitting, construction, and operation of the Home Port was evaluated in the February 11, 1999 EA (which addressed up to six launches per year, after the initial two launches). In preparing this EA, a verification of Home Port operations was conducted and several differences related to design, permitting and operation have been identified. This new information has been included in this document as Appendix B and updates the information in Appendices A and B of the February 11, 1999 EA, which is included in its entirety as Appendix A of this document.

The use of UDMH will not create new impacts from Home Port operations as SLLP will modify and comply with all Federal, State, and local permit requirements prior to UDMH arrival on-site. In addition, scrubber filters have been installed at the Home Port to prevent release of UDMH vapors.

The following documents need to be amended prior to UDMH arrival on-site at Home Port:

1. Hazardous Material Inventory Emergency Planning and Community Right to Know Act (EPCRA), Long Beach Department of Health, Certified Unified Program Agencies (CUPA)
2. Business Emergency Plan, Long Beach Fire Department
3. Operations Manual for the Transfer of Hazardous Material in Bulk, U.S. Coast Guard (USCG)
4. Integrated Contingency Plan, Environmental Protection Agency (EPA), Occupational Safety and Health Administration (OSHA), California OSHA
5. California Offshore Emergency Service (COES), USCG

The following document will need to reflect the change in 2002:

1. Annual Emissions Inventory (Year 2001), South Coast Air Quality Management District (SCAQMD)

The following document will not require changes because thresholds are not exceeded:

1. Risk Management Plan, Long Beach Department of Health (CUPA)

Scrubber filter elements have been specifically designed, constructed, and delivered to SLLP to capture and neutralize vapors from UDMH. Following approval of the use of UDMH, these scrubbers will be installed at the SLLP facilities.

Substituting Russian Grade N_2O_4 for U.S. Grade N_2O_4 will not affect Home Port operations or permitting.

2.2.2 Pre-Launch

In the hours prior to launch, the LP is ballasted to a more stable, semi-submerged position. 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 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 kilometer (km) (three miles (mi)) away. Pre-launch operations are the same under the license applicant's proposed action as those described in the February 11, 1999 EA, Section 4.3.1.

2.2.3 Launch and Flight

Once the pre-launch preparations are complete, the launch and flight phase of the mission begins. The launch vehicle (the Zenit-3SL) uses kerosene and LOX as primary propellants. Prior launches have used Russian-produced kerosene for propulsion. U.S.-produced kerosene as well as a Russian-produced kerosene substitute called Boktan are being evaluated for future use. Testing will be conducted and if found suitable, these propellants may be used in future missions. Available data on Boktan, and U.S.-produced and Russian-produced kerosene are provided in Appendix E of this EA.

First-stage flight of the mission begins in international waters at 0° latitude and 154°W longitude and transits eastward over the equatorial Pacific Ocean. Stage and fairing separations occur as described in Table 2-1 and shown in Figure 2-1. The areas of stage and fairing deposition are outside the area included in the *Convention for the Protection for the Natural Resources and Environment of the South Pacific Region.* (See Section 4.1.1.2 of this EA for more detail.)

TABLE 2-1: IMPACT ZONES FOR STAGES AND FAIRING

Flight Element	Latitude (degrees)	Longitude (degrees)
Stage I	2 S to 2 N	147.7 W to 145.5 W
Fairing halves	2.2 S to 2.2 N	146.6 W to 142.2 W
Stage II	6 S to 6 N	116.6 W to 105.1 W

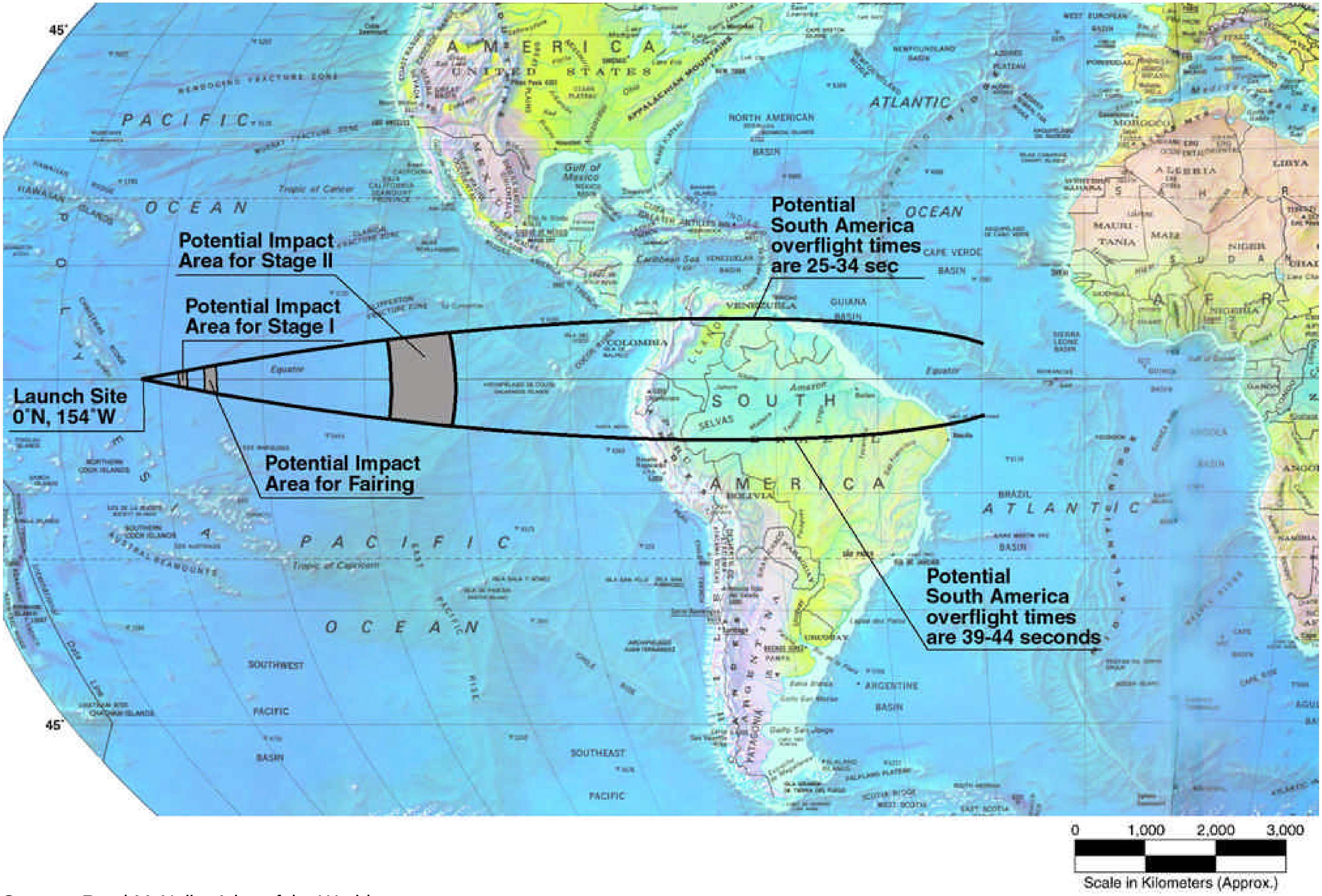
Based on the launch industry's experience with composite fairings, the two halves of the SLLP fairing would break up during descent and upon impact with the ocean surface. Prior SLLP launches have used a payload fairing with a 4.2 meter (m) (13.9 feet (ft)) diameter. This EA addresses the use of a larger fairing, up to 5.0 m (16.5 ft) in diameter, which would allow for maximum payload size and weight (Figure 2-1 and Table 2-1 are based on the 5.0 m fairing). Should SLLP propose to use a fairing larger than 5.0 m at some point in the future, proper environmental analysis will be conducted as appropriate. Under normal operating and contingency conditions, impacts from the stages and fairing would occur well outside the 200-nautical mile Exclusive Economic Zones (EEZs) of all countries in the area.

The Upper Stage begins powered flight over international waters and propels the satellite payload toward South America. Transit time across South America would range from 25 to 44 seconds (sec), depending on the azimuth of the launch. Once orbital, the Upper Stage separates from the payload, reorients, and executes an approximately 300 second burn to ensure that the Upper Stage does not affect the payload; this maneuver also provides for a safe storage orbit. MMH and N_2O_4 were used in all missions except 6R, which used UDMH and N_2O_4. Other materials may be used in the future after operational evaluation. Data on UDMH are provided in Appendix E of this EA.

The payload is moved and oriented into final position by its own propulsion system. The payloads use primarily hydrazine, MMH, UDMH, and N_2O_4 for propulsion. Other systems that may be used for propulsion, after evaluation and approval by FAA include xenon ion propulsion and electrical propulsion.

The release of any emissions from these later on-orbit maneuvers would occur well above the stratosphere and would not pose any significant environmental effects. Similarly, destruction of these propellants during a failure would be complete and incidental to the failure event.

Figure 2-1
Launch Operator License Groundtrack Corridor
(for 82.6 to 97.4 Launch Azimuths)



Source: Rand McNally, Atlas of the World.

Table 2-2 summarizes potential mission characteristics.

TABLE 2-2: POTENTIAL MISSION SUMMARY CHARACTERISTICS

Mission Element	*Characteristic*
Payload	Commercial satellite
Launch vehicle	Zenit-3SL
Launch site	0° latitude, 154° W longitude
Launch azimuth	82.6°to 97.4°, inclusive
Stages I, II, fairing impact zones	Deep and open ocean, limited vessel traffic, low biological productivity; *see Table 2-1 and Figure 2-1*
Overflight zone	Islands in eastern Pacific, including Galapagos Islands, Cocos Island, and Malpelo Island; portions of South and Central America

2.2.4 Post-Launch

After the launch, crews reoccupy the LP. In preparation for transit back to the Home Port, the crews collect any debris for examination, and subsequently wash and repaint the deck of the LP. The post-launch operations associated with the license applicant's proposed action are the same as that described in Section 4.3.3 of the February 11, 1999 EA. Debris would be disposed of in accordance with the International Convention for the Prevention of Pollution (in compliance with MARPOL 73/78) or brought back to Home Port for proper disposal. Monitoring activities are also conducted post-launch in compliance with the Environmental Monitoring and Protection Plan discussed in detail in Section 4.6.

2.2.5 Failure Scenarios

There are several possible failed mission scenarios considered in this EA:

- Explosion on the LP (impacts are discussed in Sections 4.1.2.1, 4.2.2.1, and 4.3.2.1 of this EA);
- In-flight failures of Stage I or Stage II (resulting from either an explosion or thrust termination) over the open ocean, (impacts are discussed in Sections 4.1.2.2, 4.2.2.2, and 4.3.2.2);
- In-flight failures of the Upper Stage (resulting from either an explosion or thrust termination) over the open ocean, Oceanic Islands, or South America (impacts are discussed in Sections 4.1.2.3, 4.2.2.3, and 4.3.2.3); and
- The cumulative failure of a number of launches in a single year along the same azimuth or azimuths in close proximity to one another (impacts are discussed in Sections 4.1.4.6, 4.2.4.6, and 4.3.4.6).

The failure scenarios, including multiple failures affecting the same area, generally involve the loss and return to Earth of some or virtually all of the ILV's components and hazardous materials.

This EA also addresses the scenario, in which the pre-launch process is interrupted moments before launch, resulting in a postponed or aborted launch. In this case, either the countdown is re-started, perhaps one to four days later, and the ILV is launched, or the ILV is stowed in the LP hanger, and the LP and ACS return to Home Port. While this scenario is not technically a failure, it is appropriate to consider possible effects to the environment from such an occurrence.

2.3 ALTERNATIVES CONSIDERED

This section discusses the alternatives to the license applicant's proposed action considered by the FAA and identifies reasonable alternatives considered in detail using the screening criteria described above in Section 2.1. For each alternative, unless otherwise stated, the Home Port, pre-launch, launch and flight, post launch, and possible failure scenarios will be the same as those described in Sections 2.2.1, 2.2.2, 2.2.3, 2.2.4, and 2.2.5, respectively. Alternatives that were previously considered in the February 11, 1999 EA, Section 2.2, are described in Section 2.4 of this EA.

Five alternatives to the license applicant's proposed action are identified for consideration in this EA. Each alternative still entails the proposed issuance of an LOL to SLLP (with the exception of the No Action Alternative). To this end, all aspects of each alternative (e.g., ILV and propellants) remain the same as the license applicant's proposed action except as specifically identified below.

2.3.1 Alternative Allowing up to 12 Launches Per Year

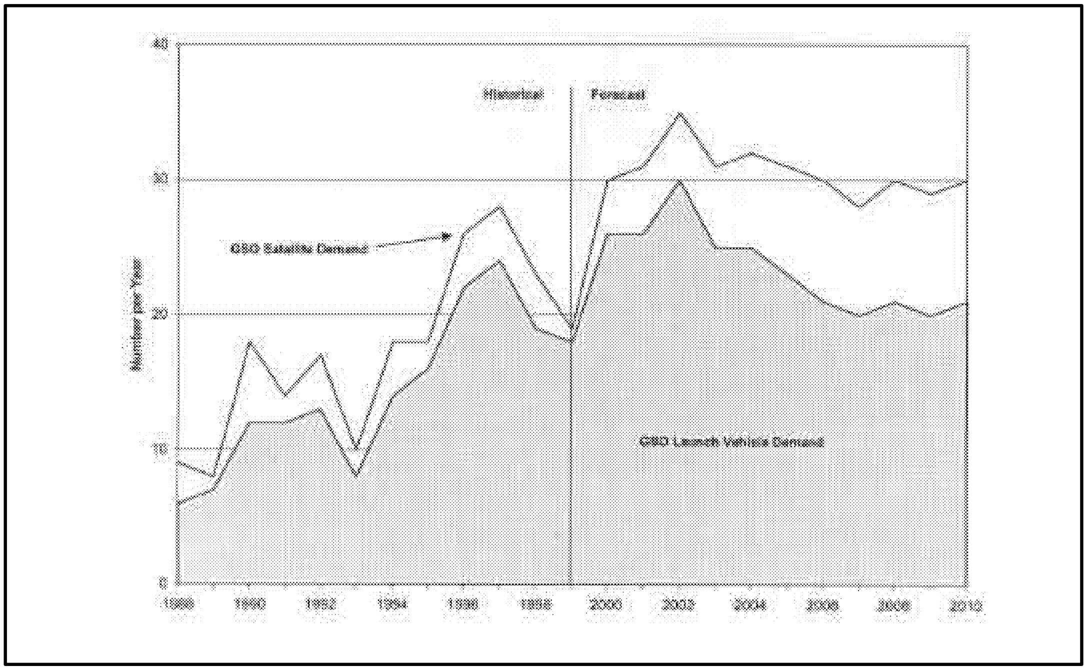
This alternative would involve the proposed issuance of an LOL to SLLP that would allow up to 12 launches per year as opposed to up to eight launches per year in the license applicant's proposed action.

The FAA and the Commercial Space Transportation Advisory Committee (COMSTAC) routinely evaluate the general market for satellite and launch demand. Figure 2-2 shows past launch data and the FAA's current projection of future demand for geosynchronous orbit (GSO) satellite launch services. As SLLP's launch system is particularly suited for launching heavy satellites, SLLP has identified GSO satellites to be the primary driver of its commercial operations.

As Figure 2-2 indicates, GSO launch vehicle demand is projected to range from 20 to 30 launches per year over the next decade. The FAA's market forecast for non-geostationary orbits (e.g., low-earth orbit (LEO), medium-earth orbit (MEO)) shows a major decline of proposed systems to be launched in non-geostationary orbits—a projected reduction of almost 40 percent (COMSTAC, 2000). Therefore, the FAA forecasts that most launches in the near future will be for GSO satellites.

SLLP has indicated that 12 launches per year was the most launches that it could reasonably be expected to conduct, based on operational considerations to date. All other aspects of this alternative (e.g., ILV and propellants) would remain the same as the license applicant's proposed action.

FIGURE 2-2: HISTORICAL AND FORECASTED DEMAND FOR GSO LAUNCHES



Source*: 2000 Commercial Space Transportation Forecasts*, Federal Aviation Administration's Associate Administrator for Commercial Space Transportation and the COMSTAC, May 2000.

2.3.2 Alternative with a Range of Azimuths Between 70° and 110°

This alternative would entail the proposed issuance of an LOL to SLLP with an increased range of azimuths from the 82.6° to 97.4° in the license applicant's proposed action to the 70° to 110°. All other aspects of this alternative (e.g., ILV and propellants) would remain the same as the license applicant's proposed action.

The range of possible azimuths is between 0° and 360° (i.e., the ILV theoretically could be launched in any direction from the launch site). Launches with azimuths between 180° and 360° would generally be going west or counter to the Earth's rotation and would therefore not be practical. Inclined azimuths (defined herein as 0° to 70° and 110° to 180°) would require extensive maneuvers of heavier satellites to move them into their final geosynchronous orbit. This would result in an increased transit time and fuel use, and pose an additional risk of failure or anomalies due to the required multiple firings of the Upper Stage to reach proper orbit. The increased risk of failures would likely cause orbital debris, which is hazardous to other spacecraft. Therefore, these azimuths are generally riskier, and are not considered feasible for GSO. Thus, only azimuths between 70 ° to 110° are a potentially feasible range of azimuths for GSO.

2.3.3 Alternative with Avoidance of National Parks and National Reserves

This alternative would involve the proposed issuance of an LOL to SLLP for the range of azimuths between 82.6° to 97.4°, but would require avoidance of specific azimuths within this range that would overfly any Nation's national parks or national reserves. There are 31 national parks or national reserves—five of which are on the UNESCO World Heritage Site List (Hammond, 1996; UNESCO, 2001) that could be potentially affected by launches in the proposed range of azimuths. The following azimuths would not require a direct launch vehicle overflight of a national park or a national reserve:

- 85.50º to 85.67º
- 92.90º to 93.25º
- 93.83º to 94.75º
- 96.68º to 97.40º

If ILL were considered, no azimuth in the range of 82.6º to 97.4º would be permissible under this alternative. All other aspects of this alternative (e.g., ILV and propellants) would remain the same as the license applicant's proposed action.

2.3.4 Alternative with Avoidance of the Oceanic Islands

This alternative would involve the proposed issuance of an LOL to SLLP for the same range of azimuths as the license applicant's proposed action (i.e., 82.6º to 97.4º), but would require avoidance of any azimuths that overfly any of the Oceanic Islands (i.e., Galapagos Islands, including the 40-mile marine sanctuary extending from all islands; Cocos Island; and Malpelo Island). The following azimuths would (see Figure 2-3) not involve overflight of any of the Oceanic Islands (including the ILL debris dispersion overlay)[b]:

- 82.60º to 83.28º
- 84.50º to 85.07º
- 86.36º to 86.80º
- 92.89º to 97.40º

Consequently, launches along azimuths ranging from 83.28º to 84.50º, 85.07º to 86.36º, and 86.80º to 92.89º would not be allowed under this alternative. All other aspects of this alternative (e.g., ILV and propellants) would remain the same as the license applicant's proposed action.

2.3.5 Alternative with Avoidance of the Galapagos Islands

This alternative would involve the proposed issuance of an LOL to SLLP for the same range of azimuths as the license applicant's proposed action (i.e., 82.6º to 97.4º), but would require avoidance of any azimuths that overfly the Galapagos Island group (including the 40-mile marine sanctuary extending from all islands). The following azimuths would (see Figure 2-4) not involve overflight of any of the Galapagos Islands (accounting for the ILL overlay)[Ibid.]:

- 82.60º to 86.80º
- 92.89º to 97.40º

Consequently, launch azimuths ranging from 86.80º to 92.89º would not be allowed under this alternative. All other aspects of this alternative (e.g., ILV and propellants) would remain the same as the license applicant's proposed action.

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[b] It should be noted that ILLs associated with an azimuth of 88.67º, in fact, would overlay Wolf and Darwin Islands of the Galapagos Island group. This azimuth was fully evaluated in the February 11, 1999 EA, and subsequent Environmental Finding and has been included in SLLP launch-specific licenses.
Ibid.

2.4 PREVIOUSLY CONSIDERED ALTERNATIVES

The alternatives discussed below were considered in the February 11, 1999 EA, Section 2.2, and were eliminated from further consideration and analysis at that time.

2.4.1 Alternative Launch Vehicle

Two launch vehicles, the Zenit and the Cyclone, were available and considered viable candidates at the time the SLLP project was initiated (see Section 2.2.1 of the February 11, 1999 EA). During that consideration, the Cyclone's payload capacity was determined to be too small to handle projected customer demand. In addition, the Zenit launch vehicle system allows for horizontal integration, processing, and transport of the launch vehicle stages and payload, while the Cyclone launch vehicle does not. This feature was deemed essential for an ocean-based launch location because it would allow the ILV to remain in a safe and stable horizontal position during transport.

In addition to cost, efficiency, and market advantages, the Zenit and Upper Stage operating systems, staffing requirements, and propellant characteristics were considered favorable in terms of possible risk to SLLP operating personnel 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. Furthermore, the integration of these alternative launch vehicles with other SLLP launch infrastructure had not been tested or proven safe and reliable.

Therefore, only the Zenit and Upper Stage satisfied all payload, operational, and safety criteria. The ACS and the LP have been configured to accommodate these systems.

The ACS and LP were designed to accommodate the Zenit-3SL. Due to engineering design requirements specific to the Zenit-3SL, the use of other launch vehicles on SLLP's ACS and LP is not feasible.

These considerations regarding the launch vehicle and Upper Stage remain valid for the license applicant's proposed action and alternatives in this EA.

Figure 2-3
License Applicant's Proposed Action with Avoidance of Oceanic Islands

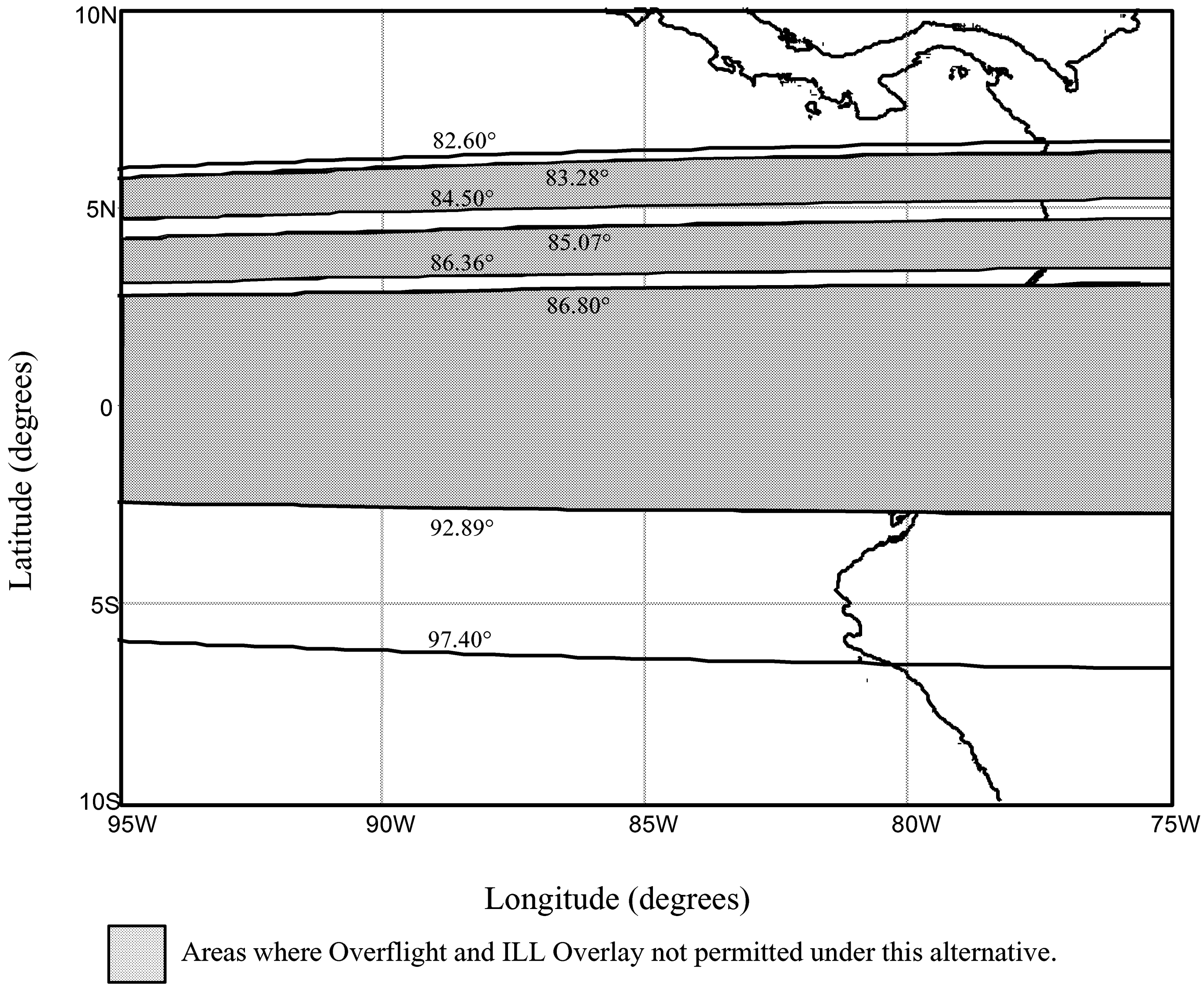
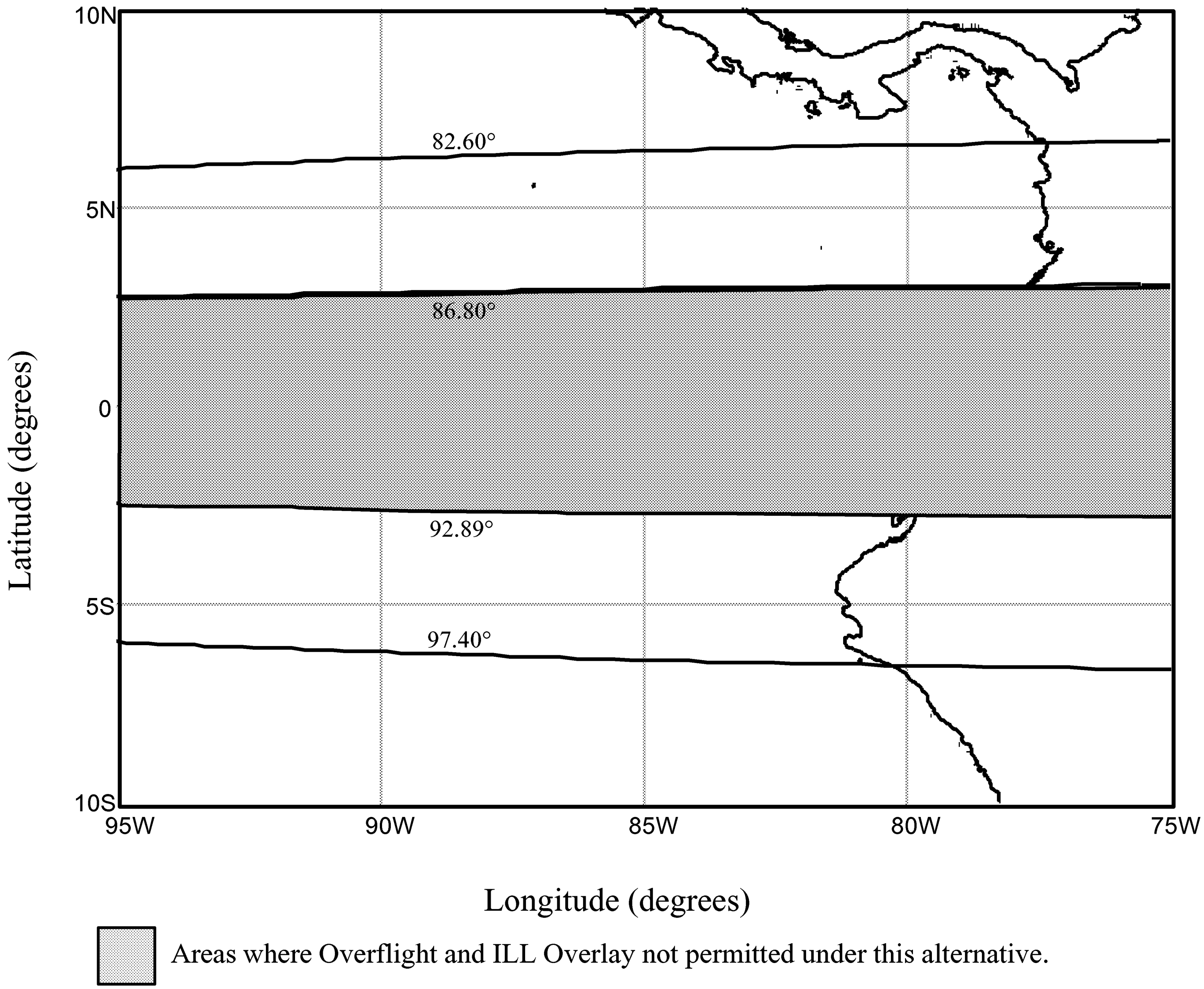


Figure 2-4
License Applicant's Proposed Action with Avoidance of Galapagos Islands



2.4.2 Use of an Alternative Launch Location

Alternative launch locations were previously considered by evaluating public safety, environmental protection, weather conditions, distance from commercial activities (e.g., fishing, recreation, shipping, and air traffic), and proximity to sovereign territories. It was concluded in the February 11, 1999 EA, Section 2.2.2, that these criteria indicated a launch location on the Equator in the east central Pacific Ocean would be most feasible.

For purposes of this EA, these criteria remain relevant and indicate a launch location at or near the Equator in the east central Pacific Ocean as optimal. The recommended launch site at 0° latitude and 154° W longitude is sufficiently distant from any populated areas (i.e., it is over 6,800 km [4,300 miles] from the Galapagos Islands, which are the closest inhabited areas along the flight path). This site was selected, in part, to ensure that spent stage and fairing deposition would only occur in the open ocean to minimize risk to human populations. The launch location also minimizes risk to wildlife populations that are similarly concentrated on land or in coastal waters.

2.5 NO ACTION ALTERNATIVE

Under the No Action alternative, the FAA would not issue an LOL for eight launches per year for five years, for a maximum of 40 launches, for azimuths from 82.6° and 97.4°, inclusive. Because SLLP is a foreign entity controlled by a United States citizen, it must obtain a launch license from the FAA. Thus, under the no action alternative, SLLP would need to continue to apply for launch-specific licenses for each proposed launch (up to six launch-specific licenses per year, or an average of one application every 60 days)[c]. For each proposed launch that would use an azimuth different from that considered in the February 11, 1999 EA, the FAA would need to consider the environmental effects and prepare the appropriate environmental documentation.

2.6 ALTERNATIVES EVALUATED DURING SCREENING PROCESS

2.6.1 Screening Methodology

The FAA completed a thorough and objective review of reasonable alternatives to the license applicant's proposed action. CEQ regulations require that an agency look at "reasonable" alternatives to the license applicant's proposed action. With that standard in mind, the FAA did not evaluate in detail those alternatives that showed no possibility of meeting the purpose and need of the license applicant's proposed action, as described in Section 1.3.

The screening methodology utilizes an evaluation process formulated to concentrate on the purpose and need for the license applicant's proposed action and the reasonableness of the alternatives. Alternatives that do not meet the purpose and need were eliminated from further consideration. Alternatives that meet the purpose and need were considered in detail. An evaluation of each alternative in terms of the screening criteria is provided below.

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[c] An individual who is a United States citizen or an entity organized or existing under the laws of the United States or any state must obtain a license to launch a launch vehicle outside of the United States or a license to operate a launch site outside of the United States. 14 CFR 413.3 (c).

2.6.1.1 License Applicant's Proposed Action

- *Promote economic growth and entrepreneurial activity through use of the space environment for peaceful purposes:* The license applicant's proposed action would promote entrepreneurial activity because it would provide a range of azimuths deemed necessary to meet predicted market demand for GSO launches. The ability to launch on a directly equatorial azimuth (i.e., 90º) would be unique worldwide and would offer commercial satellite customers a highly desirable launch option.

  A 90º azimuth is cost-effective and poses less risk of failure as it eliminates the need for maneuvers to remove orbital inclination. GSO satellites that are launched directly into an equatorial transfer orbit do not need to expend fuel to remove orbit inclination (they do however, expend some fuel, to raise their orbit to their final locations). Procedures associated with removing orbital inclination increase the time used by the satellite to reach its final orbit, by as much as a few weeks, resulting in additional cost and lost revenues for the satellite owner. The fuel expended to remove orbital inclination also shortens the useful life of the functioning satellite by approximately 10 to 15 percent for heavy payloads (Gailey, 2001). In addition, the maneuvers required to remove the orbital inclination of heavy payloads are more complex than those required to raise the orbit, and, therefore, increase the risk of an on-orbit anomaly or failure and orbital debris.

- *Encourage the U.S. private sector to provide launch vehicles, reentry vehicles, and associated services by simplifying and expediting the issuance of licenses:* The license applicant's proposed action would encourage the private sector to provide launch vehicles and launch services by providing a long-term license that would simplify and expedite licensing. The issuance of an LOL would allow SLLP to conduct up to eight launches within specific launch parameters per year for five years. It would reduce the amount of time needed to prepare, submit and review license applications by allowing a more efficient licensing process while still assuring safety and environmental review.

  The option of issuing an LOL, as opposed to requiring a launch-specific license for every launch, provides advantages both to the FAA and the licensee. Although the resources spent to prepare and review an LOL application are likely to be greater than those required for a launch-specific license, this type of license will ultimately result in cost and schedule savings by reducing the number of applications that the FAA must review and that a commercial entity with an active launch schedule must submit. 64 Fed. Reg. 19,594, 19,595; Apr. 21, 1999.

- *Provide FAA oversight and coordination of licensed launches and to protect the public health and safety, the safety of property, and U.S. national security and foreign policy interests of the U.S.:* The license applicant's proposed action requires FAA oversight through the LOL licensing process, which includes both safety and environmental reviews. Additionally, pursuant to FAA regulations, SLLP will be required to notify the FAA of each specific launch and to provide launch-specific information should the FAA issue the proposed LOL (see14 CFR 415). Should any of the proposed LOL parameters change, the FAA would require additional environmental and safety documentation and analyses. The SLLP launch infrastructure and operating procedures to be used under the license applicant's proposed action have been successful in six missions to date. The FAA has closely monitored all missions and SLLP's operations have resulted in no health or safety issues and the results of the environmental monitoring program have confirmed that the environmental impacts of the earlier missions have been insignificant.

The license applicant's proposed action also is consistent with U.S. national security and foreign policy interests. Reliable access to space, as provided under the license applicant's proposed action, promotes U.S. national security. National Space Policy, Fact sheet, Space Transportation (Sept. 19, 1996). Moreover, the SLLP launch procedures incorporate U.S. Government approved national security safeguards. The proposed SLLP launches are consistent with U.S. treaty obligations, including the Convention for the Protection of the Natural Resources and Environment in the South Pacific Region (done November 24, 1986; entered into force August 22, 1990) and the Agreement Establishing the South Pacific Regional Environment Programme (done June 16, 1993; entered into force August 21, 1995).

- *Facilitate the strengthening and expansion of the U.S. space transportation infrastructure:* The license applicant's proposed action strengthens and expands U.S. space transportation infrastructure by facilitating the use of an ocean-based launch site in addition to the traditional land-based U.S. Federal launch facilities. SLLP is the only equatorial launch site offered by a U.S. launch services provider. Thus, the license applicant's proposed action would expand U.S. space transportation infrastructure options for potential customers by providing an additional launch site choice.

The license applicant's proposed action satisfies all of the screening criteria and will, therefore, be analyzed in this EA. The license applicant's proposed action includes the possibility of the FAA issuing a launch-specific license to SLLP for the launch of Galaxy IIIC, as well as other potential launch-specific licenses (not to exceed 8 per year) as necessary should the proposed LOL not be issued or be delayed. The conduct that would be authorized under the proposed LOL and launch-specific licenses is identical, only the license application process would differ. Therefore, discussions and analyses of potential environmental impacts of the proposed LOL and the proposed launch-specific licenses are addressed together. Throughout the document, when the license applicant's proposed action is discussed, while emphasis is placed on the launch operator license, it is understood that the launch-specific licenses are included in the license applicant's proposed action.

2.6.1.2 Alternative Allowing up to 12 Launches per Year

- *Promote economic growth and entrepreneurial activity through use of the space environment for peaceful purposes:* This alternative would promote entrepreneurial activity by providing a range of azimuths sufficient to allow SLLP to meet projected market demand for GSO launches.

- *Encourage the U.S. private sector to provide launch vehicles, reentry vehicles, and associated services by simplifying and expediting the issuance of licenses:* This alternative would encourage the private sector to provide launch vehicles and services in the same manner as the license applicant's proposed action discussed above.

- *Provide FAA oversight and coordination of licensed launches and to protect the public health and safety, the safety of property, and U.S. national security and foreign policy interests of the U.S.:* This alternative would be reviewed for safety purposes through the FAA's licensing process. Any changes to SLLP's operations would need FAA's approval (i.e., the FAA is the authority for commercial launch licenses and will not license any launch that does not demonstrate a requisite level of safety and required environmental review).

- *Facilitate the strengthening and expansion of the U.S. space transportation infrastructure:* Although this alternative would appear on its face to expand U.S. space transportation infrastructure in that it would increase the use of an ocean-based launch site in addition to traditional land-based U.S. Federal and commercial launch facilities, SLLP does not currently have the infrastructure to support this schedule. SLLP currently does not have the infrastructure or operating procedures in place to support this level of launch activity without fundamental changes. For example, the LP would not have time to travel to and from the launch site to support an accelerated schedule. Thus, the turnaround time to process launches this frequently would require a transfer of the launch vehicle from the ACS to the LP somewhere near the launch site. This required change in infrastructure and operating procedures has not been examined; at this time, it is untested and has not been proven to be reliable or safe. Accordingly, this alternative, at this time, cannot facilitate the strengthening or expansion of U.S. space transportation infrastructure.

Therefore, this alternative has been dismissed because it does not meet all of the screening criteria.

2.6.1.3 Alternative with a Range of Azimuths Between 70° and 110°

- *Promote economic growth and entrepreneurial activity through use of the space environment for peaceful purposes:* This alternative might promote entrepreneurial activity by permitting more azimuths than were contemplated under the license applicant's proposed action in addition to permitting the range of azimuths between 82.6° and 97.4°.

  However, entrepreneurial launch activity, such as the SLLP project, will be promoted only to the extent that customer demand exists for the proposed launch services. The commercial launch industry is driven by the demands of satellite manufacturers and owners for the cost-effective delivery of the satellites to specific and well-defined orbits that are useful for the services that their companies provide. Accordingly, it is critical for launch service providers to provide service offerings that meet market requirements. At this time there appears to be limited demand projected for launches at slightly inclined attitudes, i.e., ranging from 70° to 82.6° and 97.4° to 110°. Therefore, because no market exists for this alternative, it does not meet the intent of promoting economic growth.

  In addition, this alternative would—for certain azimuths—require additional fuel expenditures and potentially risky on-orbit maneuvers that could lead to other problems (e.g., failures with increased orbital debris). The use of certain slightly inclined azimuths would require extensive, additional maneuvers to move satellites into their final GSO. Procedures associated with removing orbital inclination increase the time used by the satellite to reach its final orbit, by as much as a few weeks, resulting in increased cost and lost revenues for the satellite owner. The fuel expended to remove orbital inclination also shortens the useful life of the functioning satellite by approximately 10 to 15 percent for heavy payloads (Gailey, 2001). This alternative would not promote economic growth and entrepreneurial activity in the same manner as the license applicant's proposed action.

- *Encourage the U.S. private sector to provide launch vehicles, reentry vehicles, and associated services by simplifying and expediting the issuance of licenses:* This alternative would encourage the private sector to provide launch vehicles and services in the same manner as the license applicant's proposed action.

- *Provide FAA oversight and coordination of licensed launches and to protect the public health and safety, the safety of property, and U.S. national security and foreign policy interests of the U.S.:* This alternative would be reviewed for safety purposes through the FAA's licensing process.

- *Facilitate the strengthening and expansion of the U.S. space transportation infrastructure:* This alternative would strengthen and expand the U.S. space transportation infrastructure to the same extent as the license applicant's proposed action.

This alternative would not promote economic growth and entrepreneurial activity for all the azimuths in the proposed range. Further, the additional maneuvers required to move satellites into their final GSO, while they are not as extreme as for a fully inclined azimuth (see Section 2.3), would still increase risk of a failure or anomaly. Such a failure or anomaly could create orbital debris. Moreover, this alternative would not provide advantage to commercial customers beyond the license applicant's proposed action. Consequently, this alternative was not evaluated further.

2.6.1.4 Alternative with Avoidance of National Parks and National Reserves

- *Promote economic growth and entrepreneurial activity through use of the space environment for peaceful purposes:* This alternative would promote entrepreneurial activity through the use of space for peaceful purposes. However, it involves a restricted range of azimuths compared to the license applicant's proposed action that would limit commercial flexibility to meet market demand. Avoiding overflights of all national parks and reserves within the azimuth range of 82.6º to 97.4º would only leave 2.16º of the range available for commercial use. There are no potential azimuths in the 82.6º to 97.4º range that would avoid concern regarding national parks and reserves when ILLs are taken into account.[d]

- *Encourage the U.S. private sector to provide launch vehicles, reentry vehicles, and associated services by simplifying and expediting the issuance of licenses:* Issuing an LOL to allow SLLP to conduct up to eight launches per year for five years, would simplify and expedite commercial launch licensing. However, an LOL for such a narrow range of azimuths would mean that SLLP would still have to obtain a launch-specific license for each launch along any azimuth outside the narrow range identified that would avoid overflights.

- *Provide FAA oversight and coordination of licensed launches and to protect the public health and safety, the safety of property, and U.S. national security and foreign policy interests of the U.S.:* This alternative would be reviewed for safety purposes through the FAA's licensing process.

- *Facilitate the strengthening and expansion of the U.S. space transportation infrastructure:* This alternative would strengthen and expand the U.S. space transportation infrastructure to the extent that it would provide for the use of an ocean-based launch site in addition to traditional land-based U.S. Federal launch facilities.

This alternative does not meet the screening criteria, is not considered feasible and will not be evaluated further in this EA. The restricted range of azimuths compared to the license applicant's

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[d] It should be noted that FAA has licensed other SLLP missions where the ILLs overlay environmentally sensitive areas.

proposed action that would limit commercial flexibility to meet market demand. The narrow range of azimuths proposed under this alternative would severely restrict commercial operations and would not simplify or expedite the FAA's licensing of commercial launches.

2.6.1.5 Alternative with Avoidance of the Oceanic Islands

- *Promote economic growth and entrepreneurial activity through use of the space environment for peaceful purposes:* This alternative would promote entrepreneurial activity in that it would provide a range of azimuths sufficient for SLLP to meet a portion of the projected GSO launch market demand. However, this alternative would preclude azimuths that require overflight of the Galapagos Islands, Malpelo Island and Cocos Island, and therefore GSO launches would require limited maneuvers with some risk involved, to remove orbital inclination. These maneuvers would further require additional fuel consumption and transit time for the payload to reach its final orbit. While this is not optimal, it would still allow a range of azimuths and provide for greater opportunity for entrepreneurial activity than SLLP's currently authorized operations.

- *Encourage the U.S. private sector to provide launch vehicles, reentry vehicles, and associated services by simplifying and expediting the issuance of licenses:* This alternative would encourage the private sector to provide launch vehicles and services through a simplified and expedited licensing procedure. This proposed alternative would involve the issuance of an LOL that would allow SLLP to conduct up to eight launches per year for five years for the general range of azimuths identified in the license applicant's proposed action with the exception of those azimuths that would require overflight of the Galapagos Islands, Malpelo Island, and Cocos Island. Such an LOL would relieve SLLP of having to apply for individual launch-specific licenses along the approved azimuth ranges in the LOL, thus simplifying and expediting the licensing process. SLLP would still have to pursue launch-specific licenses for proposed launches along any azimuth outside this range.

- *Provide FAA oversight and coordination of licensed launches and to protect the public health and safety, the safety of property, and U.S. national security and foreign policy interests of the U.S.:* This alternative would be reviewed for safety purposes through the FAA's licensing process.

- *Facilitate the strengthening and expansion of the U.S. space transportation infrastructure:* This alternative strengthens and expands U.S. space transportation infrastructure in the same manner as the license applicant's proposed action.

This alternative, even though not optimal from an operating flexibility standpoint, satisfies the screening criteria and is therefore considered a reasonable alternative to analyze in this EA.

2.6.1.6 Alternative with Avoidance of the Galapagos Islands

- *Promote economic growth and entrepreneurial activity through use of the space environment for peaceful purposes:* This alternative would promote entrepreneurial activity in that it would provide a range of azimuths sufficient for SLLP to help meet most projected GSO launch market demand. This alternative would preclude azimuths that require overflight of the Galapagos Islands, and therefore GSO launches would require limited maneuvers with some additional risk, to remove orbital inclination. These maneuvers would require additional fuel consumption and transit time for the payload to reach its final orbit.

- *Encourage the U.S. private sector to provide launch vehicles, reentry vehicles, and associated services by simplifying and expediting the issuance of licenses:* This alternative would encourage the private sector to provide launch vehicles and services through a simplified and expedited licensing procedure. This proposed alternative would involve the issuance of a LOL that would allow SLLP to conduct up to eight launches per year for five years along a range of azimuths similar to the license applicant's proposed action but excluding those requiring overflight of the Galapagos Islands. This alternative would relieve the license applicant and the FAA from conducting the launch-specific license application process for proposed launches within the LOL-specified azimuth ranges.

- *Provide FAA oversight and coordination of licensed launches and to protect the public health and safety, the safety of property, and U.S. national security and foreign policy interests of the U.S.:* This alternative would be reviewed for safety purposes through the FAA's licensing process.

- *Facilitate the strengthening and expansion of the U.S. space transportation infrastructure:* This alternative would strengthen and expand the U.S. space transportation infrastructure in the same manner as the license applicant's proposed action discussed above.

This alternative, even though not optimal from an operating flexibility standpoint, satisfies the screening criteria and is therefore considered a reasonable alternative to analyze in this EA.

2.6.2 Alternatives Studied in Detail

Based on the screening process described above, three alternatives are identified as reasonable (i.e., satisfy the screening criteria defined in Section 2.1) and are evaluated in detail in this EA. These alternatives are:

- License applicant's proposed action – issuance of a LOL for up to eight launches per year for five years with launch azimuths between 82.6° and 97.4° and a launch-specific license for one mission with a launch azimuth of 90° (Galaxy IIIC);
- Alternative with avoidance of the Oceanic Islands; and
- Alternative with avoidance of the Galapagos Islands.

Based on the requirements of E.O. 12114 as guided by NEPA, the EA also evaluates the No Action alternative.

Each of these alternatives is evaluated in Section 4 of this EA.

3.0 AFFECTED ENVIRONMENT

3.1 OVERVIEW

Under the license applicant's proposed action and the alternatives, all launches would originate from the SLLP LP in the Pacific Ocean, 425 km (266 mi) southeast of Kiritimati (Christmas) Island of the Kiribati Island Group, at 0° latitude and 154° W longitude. The launch location is the same as described in Sections 2.1 and 3.0 of the February 11, 1999 EA (see Appendix A). This EA discusses the area potentially affected by the license applicant's proposed action and the reasonable alternatives to that action.

For purposes of this EA, the affected environment is based on an area defined on and above the Earth's surface by the proposed azimuth range of 82.6° to 97.4°. The affected environment would include the geographic area extending from the LP to the east coast of South America, beyond which the payload would be orbital and no further effects on land or water are expected to occur. The area potentially affected by the proposed launches includes all land, water, and the atmosphere between 7.4° N and 7.4° S of the equator and between the launch location and the eastern coast of South America (see Figure 3-1). This area encompasses approximately nine million km^2 (3.5 million mi^2) of the equatorial Pacific Ocean and five million km^2 (1.9 million mi^2) of South America. The vast majority of the marine area is deep, open portions of the Pacific Ocean, though the proposed range of flightpaths includes overflights of the Galapagos Islands, Cocos Island, and Malpelo Island. Further east, the area of the South American flyover encompasses several ecosystems, including Pacific coastal lowlands, the Andean mountain range, and much of the Amazon River basin.

In previous missions orbit parameters were known in detail, in advance, and were evaluated on a mission-specific basis, which included delineation of ILL. ILLs are based on a statistical analysis showing where, with greater than 99.67 percent certainty (i.e., based on three standard deviations or 3 σ), Zenit-3SL stages and debris from a failed mission would fall. In considering the potential impacts of possible failure scenarios, the ILLs for the outer most azimuths of the proposed 82.6° to 97.4° range have been calculated and are used to set the "boundaries" of the potentially impacted ocean and landmass areas given the range of potential missions that could be carried out under the license applicant's proposed action.

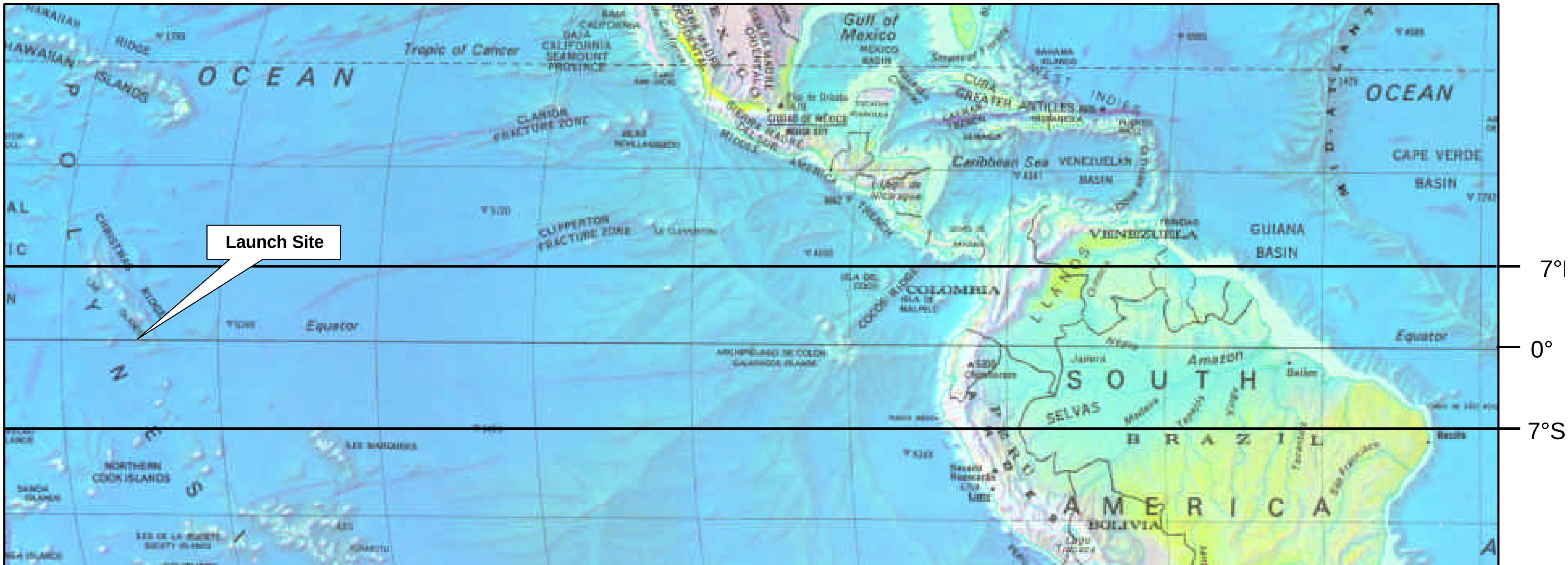
This section of the EA is organized according to geographic area and describes existing or baseline environmental conditions for the open ocean, Oceanic Islands, and continental South America. It should be noted that for the 83° azimuth, the ILL overlays a small portion of Central America; however, this landmass would not be overflown by the ILV and would only be potentially of concern given a failure of the Upper Stage as discussed in Section 4.

3.2 GEOGRAPHIC AREAS

3.2.1 Open Ocean

Approximately nine million km^2 (3.5 million mi^2) of open ocean are included within the affected environment. This section provides an overview of the geology, atmospheric processes, oceanography, biological communities, and commerce of the equatorial Pacific Ocean. Other aspects of the affected environment — such as visual resources, social conditions, and cultural

Figure 3-1
Affected Environment - From Launch Site to Eastern South America (7° north to 7° south)



0 1,000 2,000 3,000

Scale in Kilometers (Approx.)

Source: Rand McNally Atlas of the World.

resources — are not applicable because there are no human inhabitants of this area and it is the site of occasional commercial shipping or fishing.

3.2.1.1 Geology

The lithosphere in the equatorial Pacific region is broken up into roughly two dozen plates, which create various features on the ocean floor, such as ridges, trenches, and volcanoes. The region east of the launch location consists of three main tectonic plates: the Nazca Plate, moving east toward the South American Plate; the Cocos Plate, moving north; and the Pacific Plate, moving west. The Galapagos Spreading Center — also known as the Galapagos Rift — located just north of the Galapagos Archipelago, is a mid-ocean ridge formed by the edges of plates moving away from each other. The rift has a major transform fault located just north of the Galapagos Islands at 91° W. A major subduction zone, where the plates discussed above are colliding, is located along the west coast of Central and South America, and is marked by deep trenches and overlying chains of volcanoes (Clapperton, 1993). The movement of the Nazca Plate produced a chain of seamounts known as the Carnegie Ridge. A second seamount chain, the Cocos Ridge, extends northeast from the Galapagos Spreading Center (see Figure 3-2).

3.2.1.2 Atmospheric Processes and Conditions

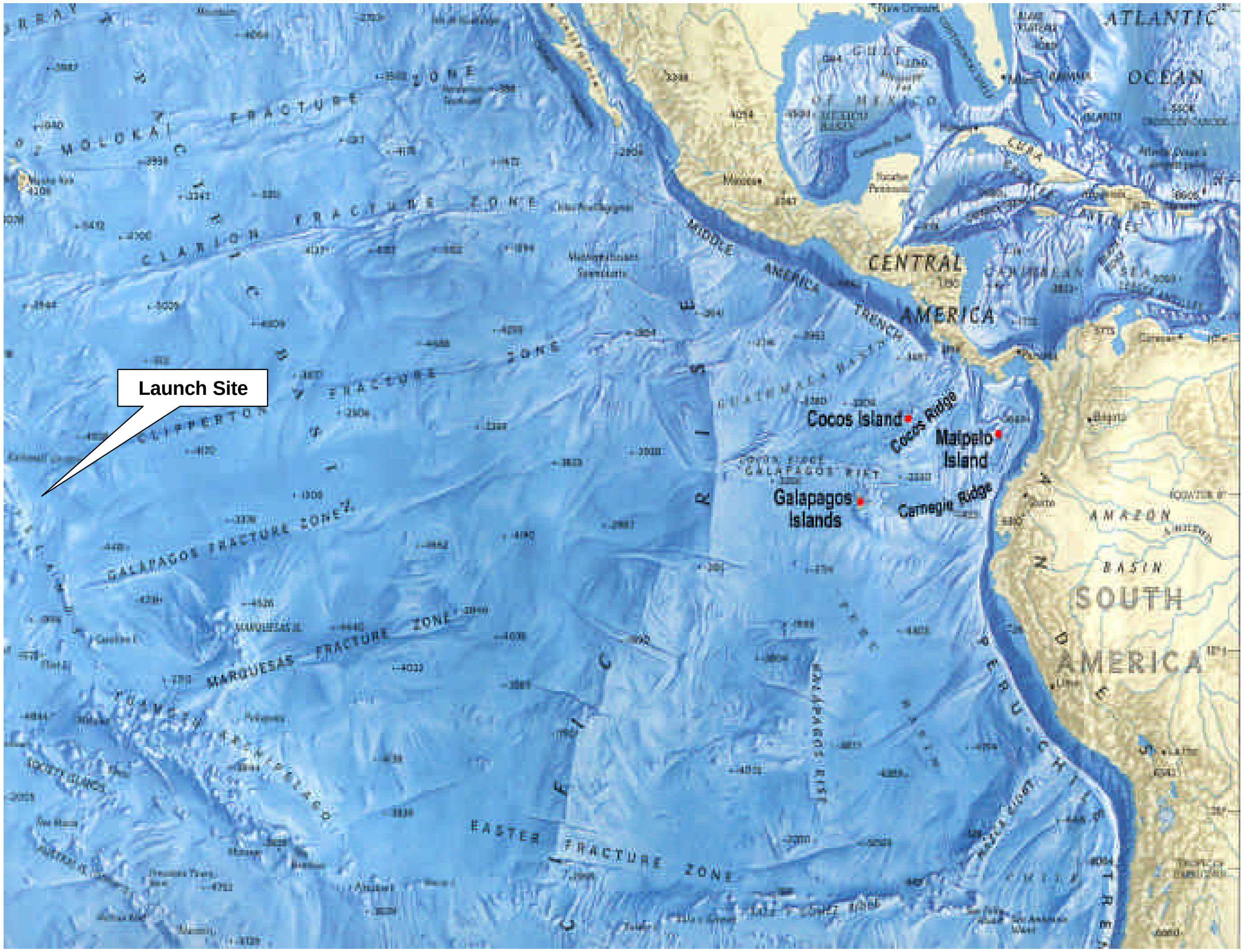
In the eastern portion of the Pacific, the atmosphere and ocean continually interact in physical and chemical cycles. Ocean surface temperatures play a large role in atmospheric conditions. A daily cycle of solar heat drives convective mixing. Convective mixing occurs as a result of changes in water stability, i.e., when surface water becomes denser than subsurface water an unstable condition exists. In this case the surface water sinks and the subsurface water rises to the surface thus creating a mixing effect. In addition, regional trade winds from the east push equatorial surface water into a mound in the west-equatorial Pacific Ocean which affects atmospheric conditions. 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 pressure 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. The El Nino effect includes an extreme decline in ecosystem productivity along the coast of South America, and great fluctuations in heat transfer and molecular exchange between the ocean and the atmosphere throughout the Pacific region (Lukas, 1992). El Nino has little effect on ecosystem productivity in the ocean waters of the launch location and range.

It has been estimated that these processes in the equatorial Pacific region annually cycle 3×10^{11} kilogram (kg) (7×10^{11} pounds (lbs)) of carbon dioxide (CO_2) between the ocean and atmosphere, and about the same amount of particulate carbon settles to the deep ocean waters per year to be replaced by upwelling and the westward equatorial current. (Murray, 1994).

Atmospheric Layers

The atmosphere can be classified into five layers or strata. From the ocean moving upward they are 1) the atmospheric boundary layer or lower troposphere, 2) the free troposphere, 3) the stratosphere, 4) the mesosphere, and 5) the thermosphere (also called the ionosphere). The troposphere is the lowest part of the atmosphere and represents the portion Figure 3-2 of the atmosphere where the frictional effects of the Earth's surface may be substantial.

Figure 3-2
Ocean Floor of the Affected Environment



Source: National Geographic Society
Mercator Projection,

Note: Depths are in meters.

It extends from the surface to approximately 2 km (1.2 mi) above sea level, although the actual height is a function of surface roughness and temperature gradient.

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, can be taken to be approximately 2 to 10 km (1.2 to 6.2 mi). 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 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.

The stratosphere is that part of the atmosphere from approximately 10 to 50 km (6.2 to 31 mi) 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 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. It is estimated that approximately 3.5×10^8 kg (7.7×10^8 lbs) of ozone are formed and destroyed daily by natural processes in the stratosphere (Manahan, 1994). An 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 destruction of the ozone layer is due in part to the placement of certain chemicals into the stratosphere, primarily as a result of human activities, that serve to catalyze these reactions leading to the destruction of ozone.

Above the stratosphere, the mesosphere extends from approximately 50 to 85 km (31 to 53 mi). Characteristic of the mesosphere is a drop in temperature with an increase in altitude, 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.

3.2.1.3 Baseline Noise Conditions

Baseline or ambient noise levels on the ocean surface—not including localized noise attributed to shipping—is a function of local and regional wind speeds. Studies of ambient noise of the ocean have found that the sea surface is the predominant source of noise, and that the source is associated with the breaking of waves (Knudsen, et al., 1948). Wave breaking is further correlated to wind speed, resulting in a relationship between noise level and wind speed (Cato, et al., 1994).

Typical wind speeds for the eastern portion of the Pacific Ocean range from 2 to 13.5 meters/second (m/s) (5 to 30 miles per hour (mph); National Imagery and Mapping Agency (NIMA), 1998, and Cato, et al., 1994). These wind speeds correspond to a noise level range of approximately 55 decibel (dB) to 68dB. At the launch location, the predominant wind speed throughout the year is approximately 8 m/s (18 mph) (NIMA, 1998). This wind speed corresponds to an ambient noise level of 64 dB. Moving eastward from the launch site to the Oceanic Islands, the dominant wind speed decreases from about 8 m/s to roughly 5 m/s (18 mph to 12 mph). Near the Oceanic Islands, the predominant wind speed is approximately 5 m/s

(12 mph) (NIMA, 1998), corresponding to an ambient noise level of 60 dB. Observed seasonal changes in winds usually do not include changes in wind speed but rather wind direction (NIMA, 1998). Storms and other weather events, however, would increase localized wind speed, and therefore would increase the noise level for the duration of that weather event.

3.2.1.4 Oceanography

Open ocean currents in the equatorial Pacific region are driven by the wind and rotation of the Earth (see Figure 3-3). Waters along the coast of South America flow north and west and are referred to as the South Equatorial Current. This current brings relatively cool, high salinity, nutrient-rich waters north from near Antarctica. Waters along the coast of Central America flow south and west and are referred to as the North Equatorial Current. This current brings relatively warm, nutrient-poor, and low salinity waters south.

Between the westerly flowing North and South Equatorial Currents, the surface Equatorial Countercurrent and the subsurface Cromwell Current both flow east, forming a transition zone. Depending on the season, this zone is commonly formed between the latitudes of 2° N and 1° S, which encompasses the Galapagos Islands. Strong vertical mixing occurs along the equator in the region of the Galapagos Islands because of the Equatorial Countercurrent and the upwelling of cool, nutrient-rich waters, which is caused by upward deflection of the subsurface Cromwell Current (Graham, 1975) and divergence in the surface wind field (Figure 3-4). This vertical mixing — together with the presence of shallow water and islands — allows for high biological productivity in the Galapagos region, (Wooster and Hedgpeth, 1966), and abundant marine life.

Coastal upwelling also occurs along the coast of South America, resulting in the biologically active coastal areas that support commercial fisheries (Figure 3-4). Coastal upwelling is common along the margins of continents, where wind conditions are such that adjacent surface waters are carried out to the open ocean via Ekman Transport (wind-driven transport of surface water away from a continental mass).

3.2.1.5 Biological Communities

Three distinct biological communities can be distinguished within the open equatorial Pacific Ocean: marine, hydrothermal vent, and coral reef. Hydrothermal vents are cracks along a rift or ridge in the deep ocean floor that spew water heated to high temperatures by the magma under the Earth's crust. These areas support species that are abnormally large in size given the depths of the vents. These communities are described below.

Figure 3-3
Currents Around the Major Oceanic Islands in the Tropical Pacific Ocean

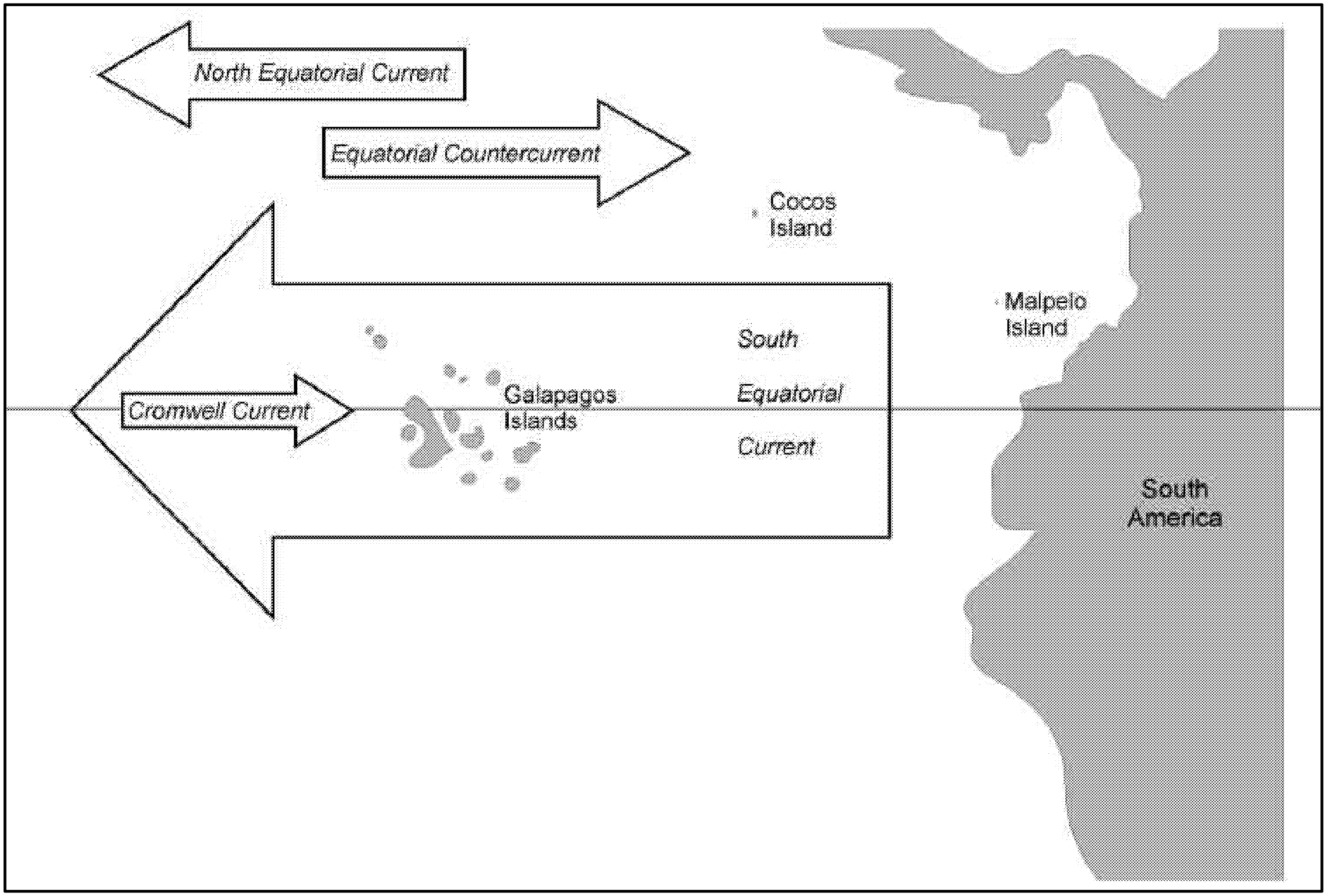
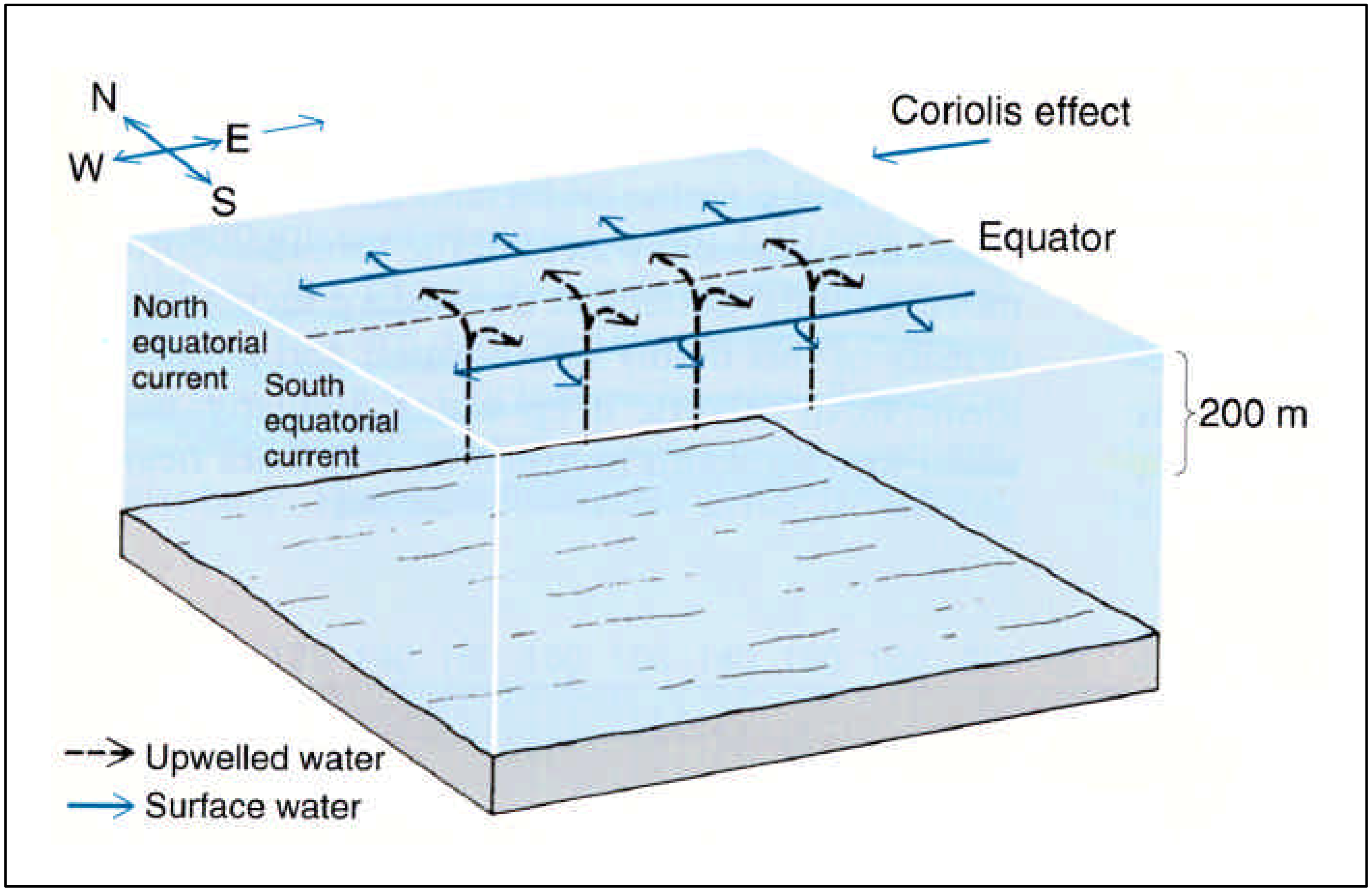


Figure 3-4
Equatorial Upwelling



Marine

Marine species diversity varies throughout the equatorial Pacific region because of the distinct differences in oceanographic processes (e.g., water temperature, and upwelling, as described in Section 3.2.1.3). The marine environment can be divided into the north, south, and transitional ecoregions, which are occupied by distinct groups of marine species.

In the north ecoregion, the North Equatorial Current transports tropical warm waters throughout the year (mean temperature of 20° C or 68° F). This current directly affects the northern Galapagos Islands, the only truly tropical region in the Galapagos, which exhibit high marine species diversity. Common species include the hammerhead shark (*Sphyrna lewini*), reef whitetip shark (*Triaendon obesus*), yellow fin tuna (*Thunnus albacares*), many species of pelagic (i.e., open ocean) fish, and shrimp.

The south ecoregion is dominated by the convergence of the Equatorial Countercurrent and the South Equatorial Current (see Figure 3-3), which — along with mixing winds — causes upwelling of cold (averaging around 15° C or 59° F), nutrient-rich waters. Marine diversity and productivity are high in such areas. Most of the marine species found in these waters originated in the cold waters of the Peruvian and Chilean Coasts. Characteristic species include a diverse variety of shorefish, an abundance of Peruvian anchoveta (*Engraulis ringens*) and pilchard (*Sardinops sagox sagap*), the Galapagos penguin (*Spheniscus mendiculus*), and the Galapagos shark (*Carcharhinus galapagensis*), which are attracted to the upwelled, nutrient-rich waters and corresponding food sources.

The transitional ecoregion is affected by cold water upwellings from the south and warm tropical waters from the north. This region is characterized by species from both the north and south regions, varying according to seasonal water temperature (Darwin Foundation, 2000). During the southern winter, this ecoregion experiences upwellings of cold water; during the southern summer, it experiences influxes of tropical waters.

The marine fauna in the Galapagos, Cocos, and Malpelo Island regions is similar with respect to species composition, with the exception of roughly 60 endemic or native species of shorefish that are restricted to individual islands within the Galapagos and Cocos Islands. No endemic species are known to occur at Malpelo Island (World Conservation Monitoring Center (WCMC), 2000). The marine fauna includes seven species of dolphins, seven species of sharks, four species of rays, and over 600 species of mollusks (WCMC, 2000). Roughly 298 fish species in 88 families have been recorded in the region. Shorefish exhibit high rates of endemism (approximately 23 percent) (Wolda, 1985).

Several species of migratory fish, reptiles, and mammals are found throughout these three marine ecoregions at various times of the year, including tuna, sea turtles, and whales.

Hydrothermal Vent

Diverse biological communities are associated with hydrothermal vents that occur along the Galapagos Rift spreading center. The organic content of the water in these areas is roughly 500 times greater than the normal bottom environment and four times greater than in typical surface waters (Thurman, 1988). Water temperatures in the immediate area of the vents range from 8° to 12° C (46° to 54° F), while the normal sea bottom temperature at this depth is usually 2° C (36° F).

These vent communities consist of unusually large organisms for these depths, with the most prominent members being pogonaphoran worms (*Rifta pachyptila*) with tubes over 1 m (3.3 ft) long, and giant clams (*Calyptogena magnifica*) over 25 centimeter (cm) (10 inch (in)) in length (Thurman, 1988).

The warm water that flows from the hydrothermal vents is rich in hydrogen sulfide. Chemosynthetic bacteria, which form the base of the food chain, use the energy released by their oxidation of hydrogen sulfide to fix carbon dioxide into organic matter. This process allows the bacteria to replace photosynthetic phytoplankton as the primary producers of organic matter in the otherwise desolate regions of the deep ocean (Thurman, 1988).

Coral Reef

Coral reefs in the eastern Pacific are poorly developed and have low species diversity when compared with those of the central and western Pacific (Glynn and Ault, 2000). This is primarily attributable to the lower water temperatures of the eastern Pacific, where ocean temperatures average 3° C (5° F) cooler than in the western Pacific (Durham, 1966), and to a relative lack of underwater platforms on which reefs can form. Corals in this area do not generally form true reef frameworks, but instead attach themselves to existing underwater structures (e.g., walls of underwater volcanoes). In a few locations, corals of the genus *Pocillopora* form reef-like frameworks (Durham, 1962).

Forty-four species of stony corals have been recorded in the Galapagos, 31 from Cocos, and seven from Malpelo (Glynn and Ault, 2000; Durham, 1962). In total, 52 species are known from these areas, with seven species common to all three island groups (Table 3-1).

The fringing reefs of Cocos Island are some of the more extensive and rich in the eastern equatorial Pacific (though still much less diverse than in the central or western Pacific). This diversity may be attributed to their location in the consistently warm waters of the north ecoregion (Guzman and Cortes, 1992; Durham, 1992). Twenty-eight species of corals are found in the Cocos reefs, the most abundant being *Porites californica* (Guzman and Cortes, 1992). Other common species include *Pocillopora robusta,* which occurs in small scattered patches at depths of one to eight meters, and *Tubastrea aurea,* which is common at various depths. The 1982-1983 El Niño phenomenon seriously affected the coral reefs of Cocos Island, causing about 90 percent of the coral to die. Although there are signs of recovery of the coral communities, it is evident that the intense feeding of sea urchins has weakened the coral foundation (de Alessi, 1997).

The Malpelo coral reef community contains seven species, none of which are endemic. Although coral growth is dense, no true coral reef is formed. The coral is interspersed among large barnacle clusters on the steeply sloping submerged walls of the volcano (Birkeland et al., 1985). At Malpelo, corals occur to depths of 30 m (100 ft); coral growth at this depth is attributed to the clear water around the island (Birkeland et al., 1985).

TABLE 3-1. STONY CORAL SPECIES OF THE GALAPAGOS, COCOS, AND MALPELO ISLANDS

Scientific Name	Location	Scientific Name	Location
Astrangia dentata	Cocos	*Pavona clivosa*	Galapagos
Astrangia eguatorialis	Galapagos	*Pavona explanulata*	Cocos
Astrangia gardnerensis	Galapagos	*Pavona gigantea*	Galapagos, Cocos
Astrangia hondaensis	Galapagos, Cocos	*Pavona maldirensis*	Galapagos, Cocos
Balanophyllia galapagensis	Galapagos	*Pavona ponderosa*	Cocos
Balanophyllia osburni	Galapagos	*Pavona varians*	Galapagos, Cocos, Malpelo
Carpophyllia diomedae	Galapagos	*Pavona varifae*	Cocos
Cindocora debilis	Galapagos, Cocos	*Pacillopora capitata*	Galapagos, Cocos
Cycloseris curvata	Galapagos, Cocos	*Pocillopora damicornis cespitosa*	Galapagos
Cycloseris elegans	Galapagos	*Pocillopora damicornis*	Galapagos, Cocos
Cycloseris mexicana	Galapagos, Cocos	*Pocillopora elegans*	Galapagos, Cocos, Malpelo
Desmophyllum galapagense	Galapagos	*Pocillopora eydouxi*	Galapagos, Cocos, Malpelo
Diaseris distorta	Galapagos, Cocos	*Pocillopora inflata*	Galapagos
Endopachys vaughani	Galapagos, Cocos	*Pocillopora meandrina*	Galapagos, Cocos
Flahellum daphnense	Galapagos	*Pocillopora verrucosa*	Galapagos, Cocos, Malpelo
Gardineroseris phamlota	Galapagos, Cocos, Malpelo	*Porites excavata*	Cocos
Kionotrochus avis	Galapagos	*Porites lobata*	Galapagos, Cocos, Malpelo
Kionotrochus hoodensis	Galapagos	*Psammocora brighami*	Galapagos
Leploseris digitata	Cocos	*Psammocora profundacella*	Galapagos, Cocos
Leploseris popvrucea	Cocos	*Psammocora stellata*	Galapagos, Cocos
Leploseris scabra	Galapagos, Cocos	*Psammocora superficialis*	Galapagos, Cocos
Lophosmilla wellsi	Galapagos	*Ralanophyllia osburni*	Galapagos
Madraeis asperula	Galapagos	*Ralanophyllia scheeri*	Cocos
Madraeis sp.	Galapagos	*Sphenotrochus hancocki*	Galapagos
Mudrepora galapagensis	Galapagos	*Thecopsammia pourtalesi*	Galapagos
Pavona clavus	Galapagos, Cocos, Malpelo	*Tubastrea tenuilamellosa*	Galapagos, Cocos

3.2.1.6 Threatened and Endangered Species

International lists of threatened, endangered, and vulnerable species and special habitats were consulted in addition to lists maintained by the U.S. Fish and Wildlife Service (USFWS) and the National Marine Fisheries Service. Lists are maintained by international conservation organizations, including the International Union for Conservation of Nature and Natural Resources (IUCN) and the WCMC. The most comprehensive of these lists is the IUCN Red List of Threatened Animals (IUCN, 2000).

Table 3-2 lists threatened, endangered, or vulnerable, species of reptiles, birds, and mammals that could occur within the affected environment, as well as their listing agency or organization and their current status.

TABLE 3-2. THREATENED AND ENDANGERED* SPECIES THAT COULD OCCUR WITHIN THE AFFECTED ENVIRONMENT

Scientific Name	Common Name	Listing Agency/ Organization	Current Listing Status	Occurrence Within Study Area
Reptiles				
Conolophus pallidus	Barrington land iguana	USFWS, IUCN	Vulnerable	Oceanic Islands
Geochelone elephantopus abingdoni	Pinta Galapagos giant tortoise	USFWS, IUCN, WCMC	Extinct in the Wild	Oceanic Islands
Geochelone elephantopus becki	Galapagos giant tortoise	USFWS, IUCN, WCMC	Vulnerable	Oceanic Islands
Geochelone elephantopus chathamensis	Galapagos giant tortoise	USFWS, IUCN, WCMC	Vulnerable	Oceanic Islands
Geochelone elephantopus darwini	Galapagos giant tortoise	USFWS, IUCN, WCMC	Endangered	Oceanic Islands
Geochelone elephantopus elephantopus	Galapagos giant tortoise	USFWS, WCMC	Endangered	Oceanic Islands
Geochelone elephantopus ephippium	Galapagos giant tortoise	USFWS, IUCN, WCMC	Extinct in the Wild	Oceanic Islands
Geochelone elephantopus guntheri	Galapagos giant tortoise	USFWS, IUCN, WCMC	Endangered	Oceanic Islands
Geochelone elephantopus hoodensis	Galapagos giant tortoise	USFWS, IUCN, WCMC	Critically endangered	Oceanic Islands
Geochelone elephantopus microphyes	Galapagos giant tortoise	USFWS, IUCN, WCMC	Vulnerable	Oceanic Islands
Geochelone elephantopus phantastica	Galapagos giant tortoise	USFWS, WCMC	Endangered/possibly extinct	Oceanic Islands
Geochelone elephantopus porteri	Galapagos giant tortoise	USFWS, IUCN, WCMC	Endangered	Oceanic Islands
Geochelone vicina	Iguana Cove Tortoise	IUCN	Endangered	Oceanic Islands
Geochelone elephantopus vandenburghi	Galapagos giant tortoise	USFWS, IUCN, WCMC	Vulnerable	Oceanic Islands
Lepidochelys olivacea	Olive Ridley sea turtle	USFWS	Endangered	Oceanic Islands, open ocean
Chelonia mydas	Green turtle	USFWS, IUCN	Endangered	Oceanic Islands, open ocean
Eretmochelys imbricata	Hawksbill sea turtle	USFWS, IUCN	Critically endangered	Oceanic Islands, open ocean
Amblyrhynchus cristatus	Galapagos marine iguana	IUCN, WCMC	Vulnerable	Oceanic Islands, open ocean
Dermochelys coriacea	Leatherback turtle	USFWS, IUCN	Critically endangered	Oceanic Islands, open ocean

Scientific Name	Common Name	Listing Agency/ Organization	Current Listing Status	Occurrence Within Study Area
Conolophus subcristatus	Galapagos land iguana	IUCN	Vulnerable	Oceanic Islands
Mammals				
Nesoryzomys fernandinae	Fernandina rice rat	IUCN	Vulnerable	Oceanic Islands
Physeter catodon	Sperm whale	USFWS	Endangered	Open ocean
Orcinus orca	Killer whale	IUCN	Lower risk	Open ocean
Globicephalia macrorhynchus	Pilot whale	USFWS, IUCN	Lower risk	Open ocean
Megaptera novaeangliae	Humpback whale	USFWS, IUCN	Vulnerable	Open ocean
Balaenoptera physalus	Finback whale	USFWS, IUCN	Endangered	Open ocean
Balaenoptera musculus	Blue whale	IUCN	Endangered	Open ocean
Balaenoptera borealis	Sei whale	USFWS, WCMC	Endangered	Open ocean
Balaenoptera acutorostrata	Minke whale	USFWS, IUCN	Lower Risk	Open ocean
Stenella coeruleoalba	Striped dolphin	WCMC	Lower risk	Open ocean
Zalophus californianus wollebaeki	Galapagos sea lion	IUCN	Vulnerable	Oceanic Islands, open ocean
Arctocephalus galapagoensis	Galapagos fur seal	IUCN	Vulnerable	Oceanic Islands, open ocean
Birds				
Spheniscus mendiculus	Galapagos penguin	USFWS	Endangered	Oceanic Islands
Oceanodroma castro	Band-rumped storm petrel	USFWS	Critical	Oceanic Islands
Pterodroma phaeopygia	Dark-rumped petrel	IUCN	Critically endangered	Oceanic Islands
Buteo galapagoensis	Galapagos hawk	USFWS, IUCN	Vulnerable	Oceanic Islands
Phalacrocorax harrisi	Flightless cormorant	IUCN	Endangered	Oceanic Islands
Nesomimus trifasciatus	Floreana mockingbird (Charles mockingbird)	IUCN	Endangered	Oceanic Islands
Laterallus spilonotus	Galapagos Rail	IUCN	Vulnerable	Oceanic Islands
Larus fuliginosus	Lava gull	IUCN	Vulnerable	Oceanic Islands
Camarhynchus pauper	Medium tree-finch	IUCN	Vulnerable	Oceanic Islands
Camarhynchus heliobates	Mangrove finch	IUCN	Critically endangered	Oceanic Islands

Scientific Name	Common Name	Listing Agency/ Organization	Current Listing Status	Occurrence Within Study Area
Coccyzus ferrugineus	Cocos Island cuckoo	IUCN	Vulnerable	Oceanic Islands
Nesotriccus ridgwayi	Cocos Island flycatcher	IUCN	Vulnerable	Oceanic Islands
Pinaroloxias inornata	Cocos Island finch	IUCN	Vulnerable	Oceanic Islands

* For an explanation of listing status categories, see Appendix F.

Note: This table includes current threatened and endangered species listing information from the IUCN database (http://www.redlist.org/programme.html). The species list and listing categories were adopted by IUCN Council effective January 2001. This list includes listed species of reptiles, birds, and mammals that occur on the Galapagos Islands, Cocos Island, and Malpelo Island, and in the surrounding oceanic environment. This list does not include mainland- or coastal- Ecuador species. The IUCN lists over 150 total species for the Galapagos Islands, Cocos Island, and Malpelo Island.

3.2.1.7 Commerce

The equatorial Pacific is used by both commercial shipping and fishing vessels and is overflown by aircraft. These commercial uses of the open ocean portion of the affected environment are discussed below.

Shipping

In terms of commercial shipping, Figure 3-5 shows a sea-lane chart that identifies the affected environment. The area is primarily used as a shipping route for vessels from or to the Panama Canal and ports along the Pacific coast of the United States, Hawaii, Tahiti, and South America, including Callao (Ecuador) and Iquique (Chile).

It is difficult to estimate potential shipping traffic on any given day. Shipping data from the Panama Canal are useful in assessing the relative magnitude of traffic in the overflight area. The Panama Canal is designed to handle 50 ships per day, the maximum number of daily transits was 65.[1] In 1998 there was an average of 35.7 daily transits.[2] The U.S. Gulf/East Coast to Asia and Europe to the West Coast of the United States and Canada are the major trade routes using the Panama Canal. These shipping routes are downrange of launches using the extreme lower azimuths (i.e., 83^{o} to 84^{o}). Table 3-3 lists the Panama Canal shipping routes and tonnage that routinely pass through the affected environment. Approximately 26 percent of the total tonnage shipped through the Panama Canal uses routes downrange of the launch. Some other route categories — such as “round the world” (at 20,250 thousand tons) and “all other routes, not otherwise classified” (at 17,621 thousand tons), which total an additional 17 percent of the tonnage shipped through the Panama Canal — may also pass through the affected environment. Therefore, using tons shipped as a surrogate for vessel traffic — 26 to 43 percent of Panama Canal traffic, or 10 to 17 vessels per day (26 to 43 percent of 40 daily transits) — may be in transit through the affected environment in route to or from the Panama Canal.

TABLE 3-3. PANAMA CANAL SHIPPING TRAFFIC

Panama Canal Traffic by Route	**Tons (‘000s)**
East Coast U.S. – West Coast South America	21,711
East Coast U.S./Canada – Oceania	5,157
Europe – West Coast South America	16,518
Europe – Oceania	2,653
South America Intracoastal	6,709
West Indies – West Coast South America	3,053
TOTAL	55,801

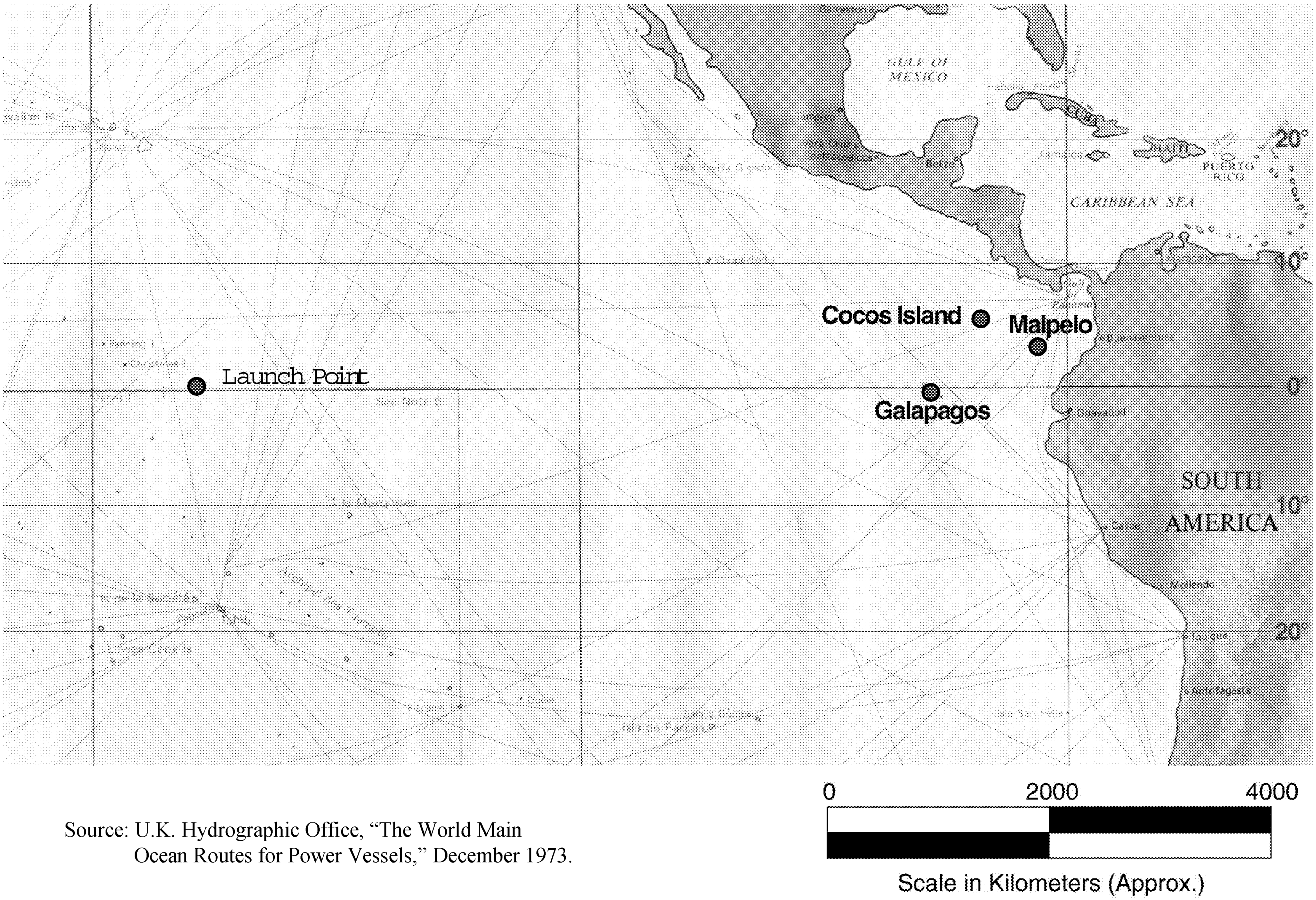
Source: http://www.orbi.net/pancanal/proposal/htraffic.htm

Commercial Fishing

Commercial fishing occurs within the affected environment, primarily by national fleets operating within their EEZs and territorial waters or by land-based foreign fleets operating under a license

[1] http://www.eia.doe.gov/emeu/cabs/panama.html
[2] http://www.eia.doe.gov/emeu/cabs/panama.html

Figure 3-5
Shipping Lanes of Equatorial Pacific Ocean



Source: U.K. Hydrographic Office, "The World Main Ocean Routes for Power Vessels," December 1973.

or fisheries agreement with a coastal nation. Within the affected environment, commercial fishing is most active south of the equator in the area influenced by the South Equatorial Current, which generates cold, nutrient-rich upwellings. These waters sustain the Peruvian anchoveta (*Engrautis ringens*) fishery, which is the largest single species fishery in the world (Food and Agriculture Organization (FAO), 1997). The area north of the equator, off the coast of northern Ecuador and Colombia, is affected by the North Equatorial Current, which has a relatively low productivity compared to the upwelling areas to the south. Commercial fisheries in this area include shrimp, small coastal pelagic species (i.e., herring), and large tropical migratory species such as yellow fin tuna (*Thunnus albacares*) and eastern Pacific bonito (*Sarda chiliensis*).

This area has experienced large fluctuations in fish production and major shifts in species composition over the past several decades. Much of this variability in abundance and composition is caused by changing environmental conditions, such as El Niño, that affect nutrient-bearing currents.

Based on overly-optimistic perceptions of fish abundance during productive years, fisheries expanded rapidly and catches exceeded sustainable levels, which contributed to major population declines (FAO, 1997). The collapse in fishery populations presents social and economic implications at the national, regional, and international levels. The southeast Pacific fishing industry is a major contributor to world fish production (accounting for almost 22 percent of the 1994 world marine fish production) (FAO, 1997). Most of the commercial fishery species in the region are considered to be fully to overly exploited (FAO, 1997).

Commercial fisheries are concentrated along the relatively narrow (maximum width 120 km or 75 mi) (FAO, 1997) continental shelf along the Pacific coast of South America. Areas suitable for bottom trawling are found off the coasts of Ecuador and northern Peru. As fishery stocks have become depleted closer to the South American coast, commercial fishing pressures have increased around the Oceanic Islands. In the 1980s, the lobster population was over exploited to the extent that the entire fishery was closed for two years, during which time there was a significant increase in the sea cucumber (*Sticopus fuscus*) harvest.

Some purse seining for tuna and long-lining for tuna, billfish, and shark occurs in and around the Galapagos. Ecuador's Congress passed the Special Law of Galapagos in 1998, and approved the Galapagos Marine Reserve Management Plan in 1999, both of which prohibit commercial fishing within 65 km (40 mi) of the coast of the Galapagos Islands. However, the constitutionality of the law is being challenged, and commercial fishing has not significantly decreased (Charles Darwin Research Station (CDRS), 2000).

Cocos Island is located in the less productive north ecoregion and is not subject to the same fishing pressures as the Galapagos Islands. Nevertheless, the Costa Rican Government has included the marine ecosystems up to a distance of 15 km (9 mi) around the island as part of a national park. The entire area was declared a zone of "absolute protection," where extraction of marine resources is banned (UNESCO, 2000). Although some commercial fishing traffic enters the 15-km (9-mi) zone, park rangers patrol the area.

Commercial fishing around Malpelo Island is limited. It has no specified zones for protection of marine ecosystems.

Commercial Air Traffic

The FAA National Ocean Service maps of commercial airline flight paths over the Pacific Ocean (Figure 3-6) indicate that four major air routes, from Los Angeles and San Francisco and one route from Hawaii, cross the affected environment. These major air routes intersect potential SLLP flight paths close to the launch site (all west of approximately 135^{o} W longitude). East of 135^{o} W longitude, which includes the majority of the airspace within the affected environment, is categorized as uncontrolled. This area includes potential SLLP flight paths over the open ocean and Oceanic Islands.

3.2.2 Oceanic Islands

The Oceanic Islands occurring within the overflight zone of the proposed project include the Galapagos Islands, Cocos Island, and Malpelo Island. This section provides an overview of the geology, atmospheric processes, biological communities, and social and economic conditions of these Oceanic Islands. The proposed project does not affect other aspects of the environment, such as noise and visual resources because the launch vehicle would not be audible or visible at the islands.

The Galapagos Islands (Figure 3-7) consist of 120 islands, rocks, and islets in the eastern Pacific Ocean, with a total land area of about 8,000 km^2 (3,100 mi^2). The Galapagos are a province of the Republic of Ecuador and are located 1,000 km (625 mi) west of the mainland. Cocos Island is located approximately 500 km (312 mi) west of the Pacific coast of Costa Rica. It is approximately 2 km (1.2 mi) long and 1 km (0.6 mi) wide (Figure 3-8). Cocos Island is governed by Costa Rica and is protected as a national park. Malpelo Island lies approximately 450 km (281 mi) west of Colombia in the equatorial Pacific Ocean. It is approximately 2.2 km (1.4 mi) long and 0.8 km (0.5 mi) wide. Malpelo Island is governed by Colombia (Figure 3-9).

3.2.2.1 Geology

As with most islands in the equatorial Pacific, the three Oceanic Island groups are volcanic in origin. These islands, many of which are the summits of volcanoes, are the product of mantle plumes (molten rock) that have risen from the Earth's interior (Steadman, 1988). These volcanoes formed under the sea and then broke through the ocean floor, growing in size and eventually emerging from the surface of the water to become islands. The Galapagos Islands rise from the Galapagos Platform, located at the intersection of the Cocos and Carnegie submarine ridges (Wooster and Hedgpeth, 1966). Cocos Ridge extends northeastward toward Costa Rica, with a depth of less than 2,200 m (6,600 ft); and Carnegie Ridge extends eastward to Ecuador and Peru, with a depth of less than 2,600 m (7,800 ft; see Figure 3-3). Cocos Island is the only portion of the Cocos Ridge to appear above sea level. Malpelo Island, located between the Cocos and Carnegie Ridges, rises from the Malpelo Ridge (Meschede, 1998).

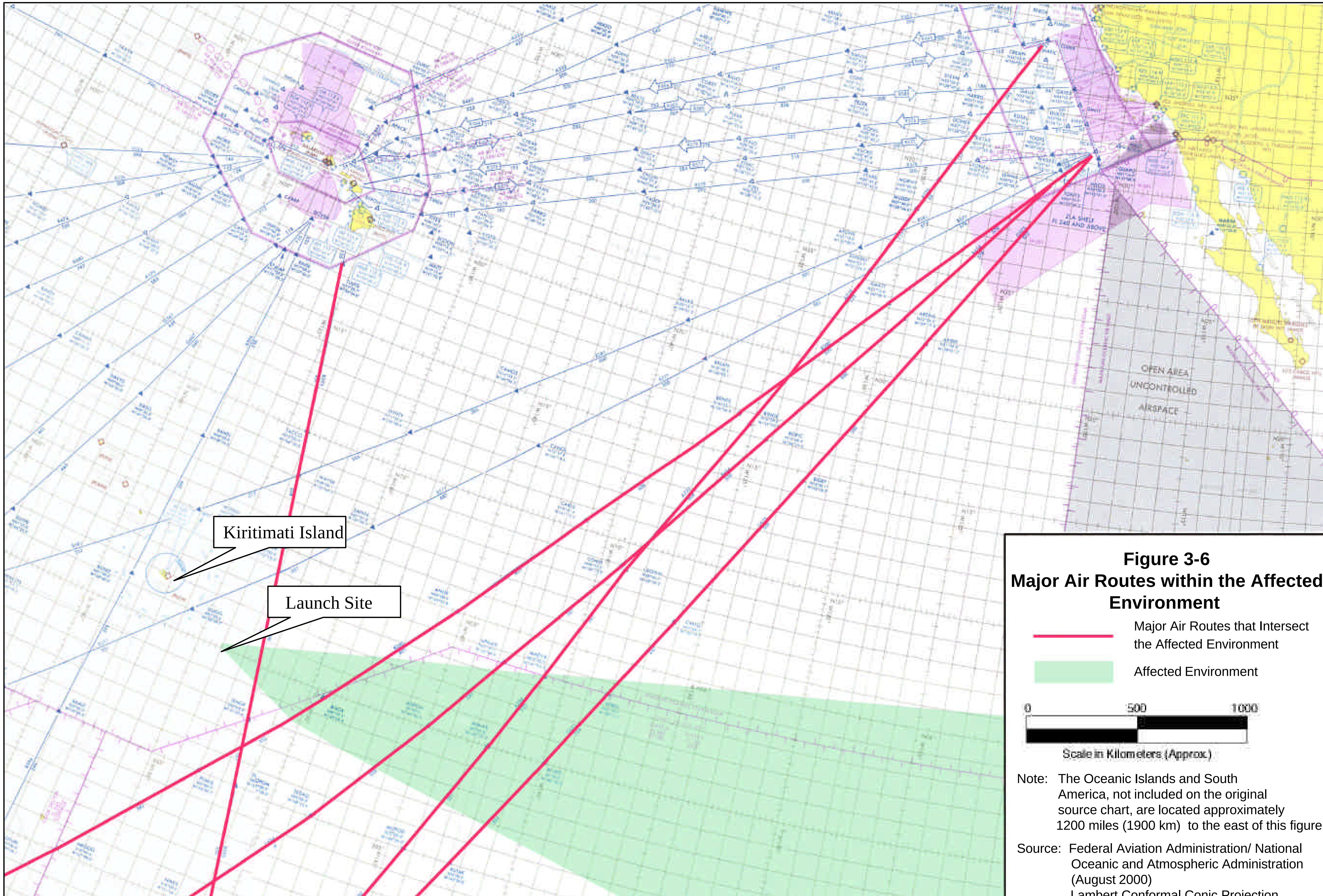


Figure 3-6
Major Air Routes within the Affected Environment

Note: The Oceanic Islands and South America, not included on the original source chart, are located approximately 1200 miles (1900 km) to the east of this figure.

Source: Federal Aviation Administration/ National Oceanic and Atmospheric Administration (August 2000)
Lambert Conformal Conic Projection

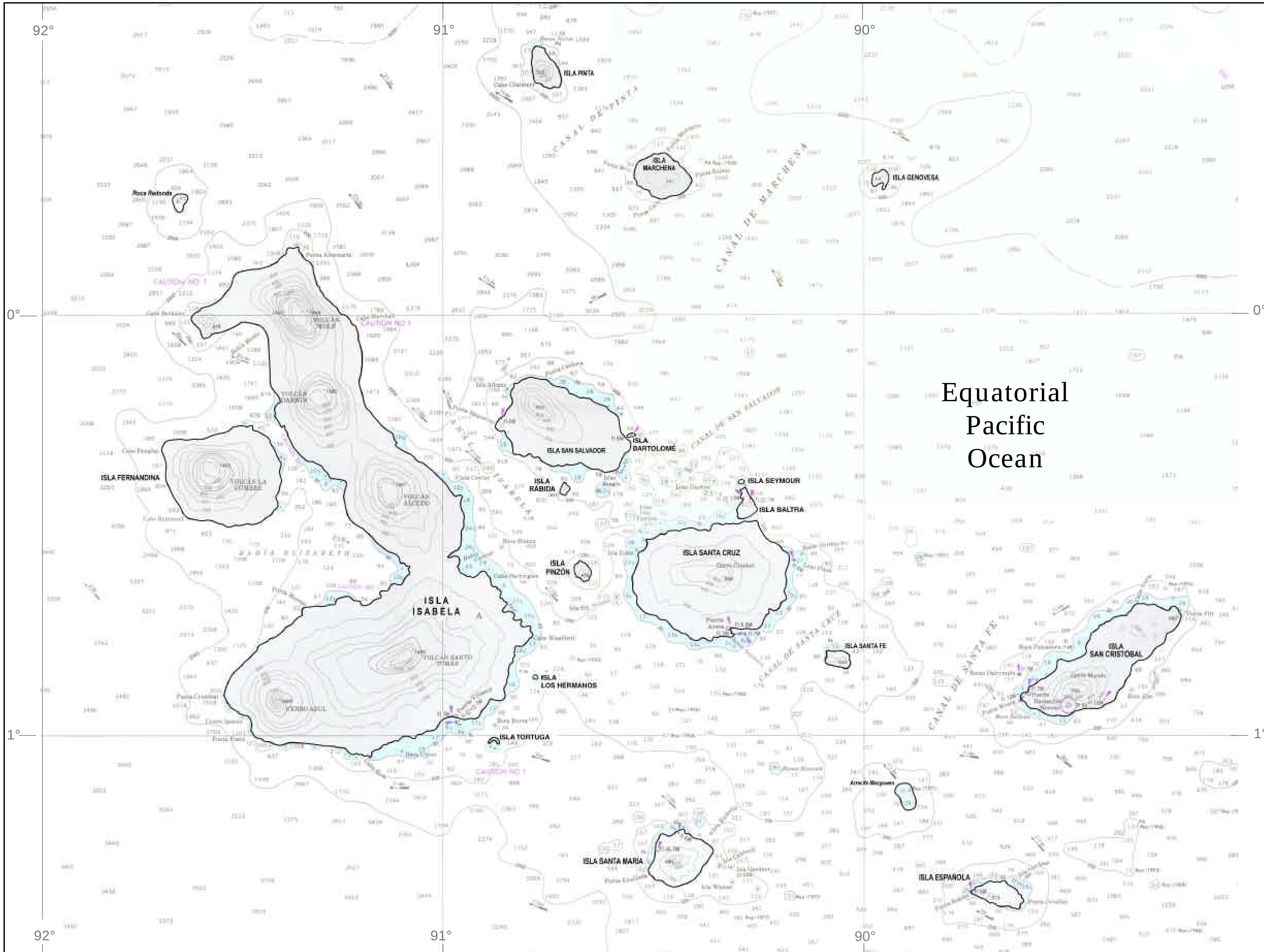


Figure 3-7
Galapagos Islands and Surrounding Waters

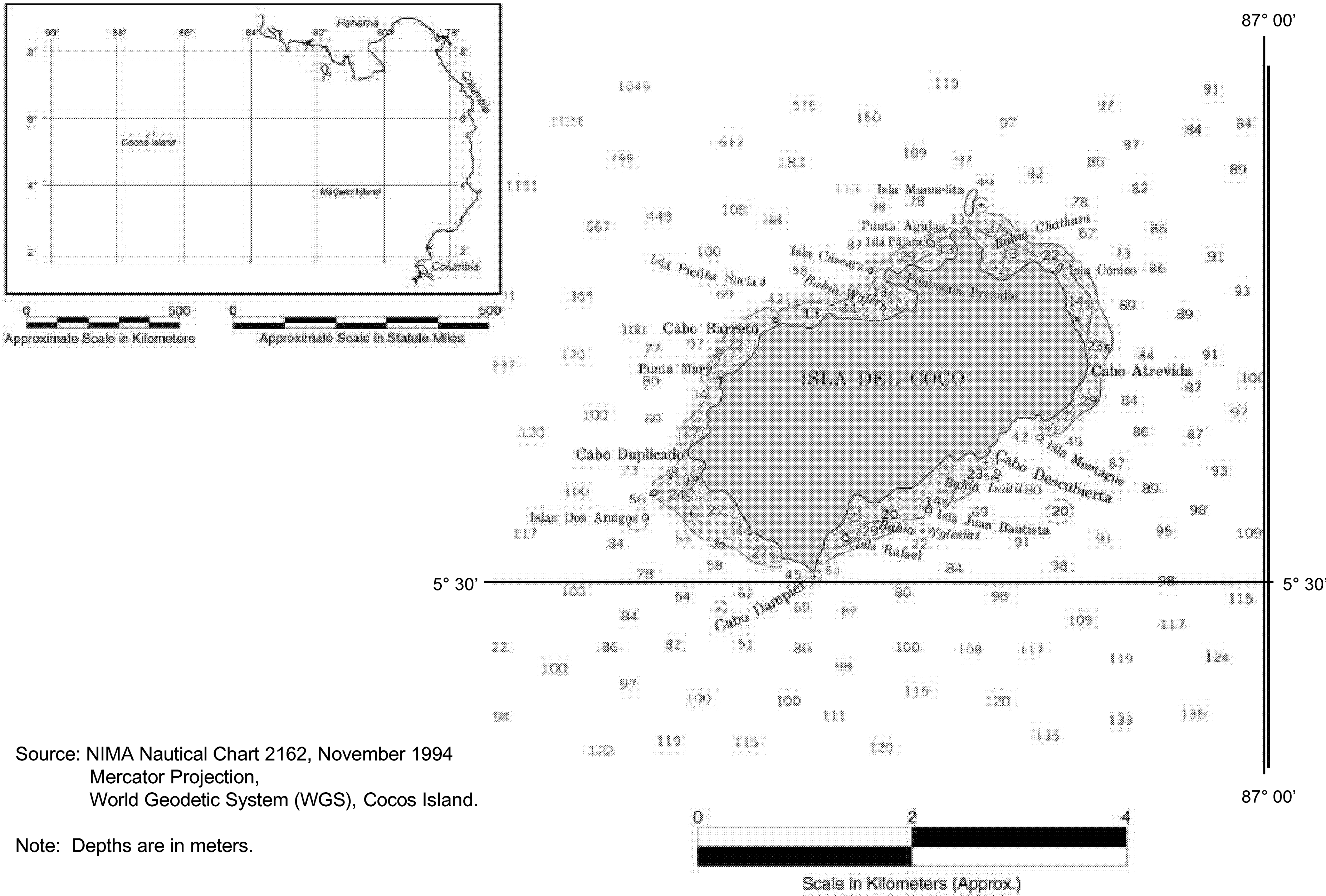
Source: Mercator Projection, World Geodetic System (WGS), Galapagos Islands.

Note: Depths and elevations are in meters.

0 30 60

Scale in Kilometers (Approx.)

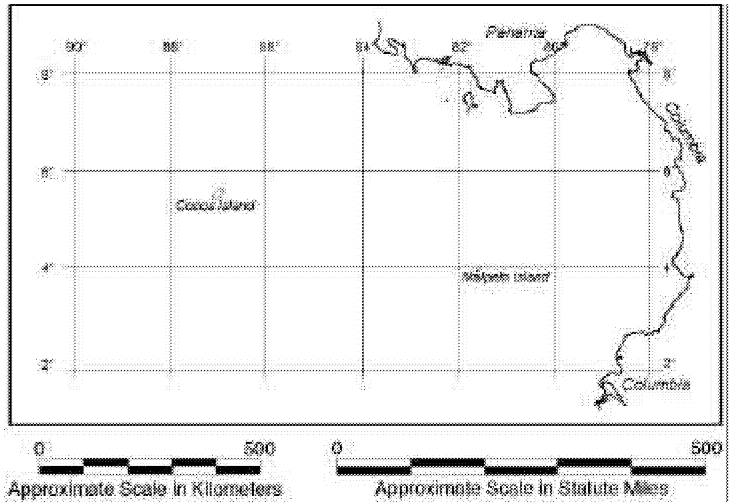
Figure 3-8
Cocos Island and Surrounding Waters

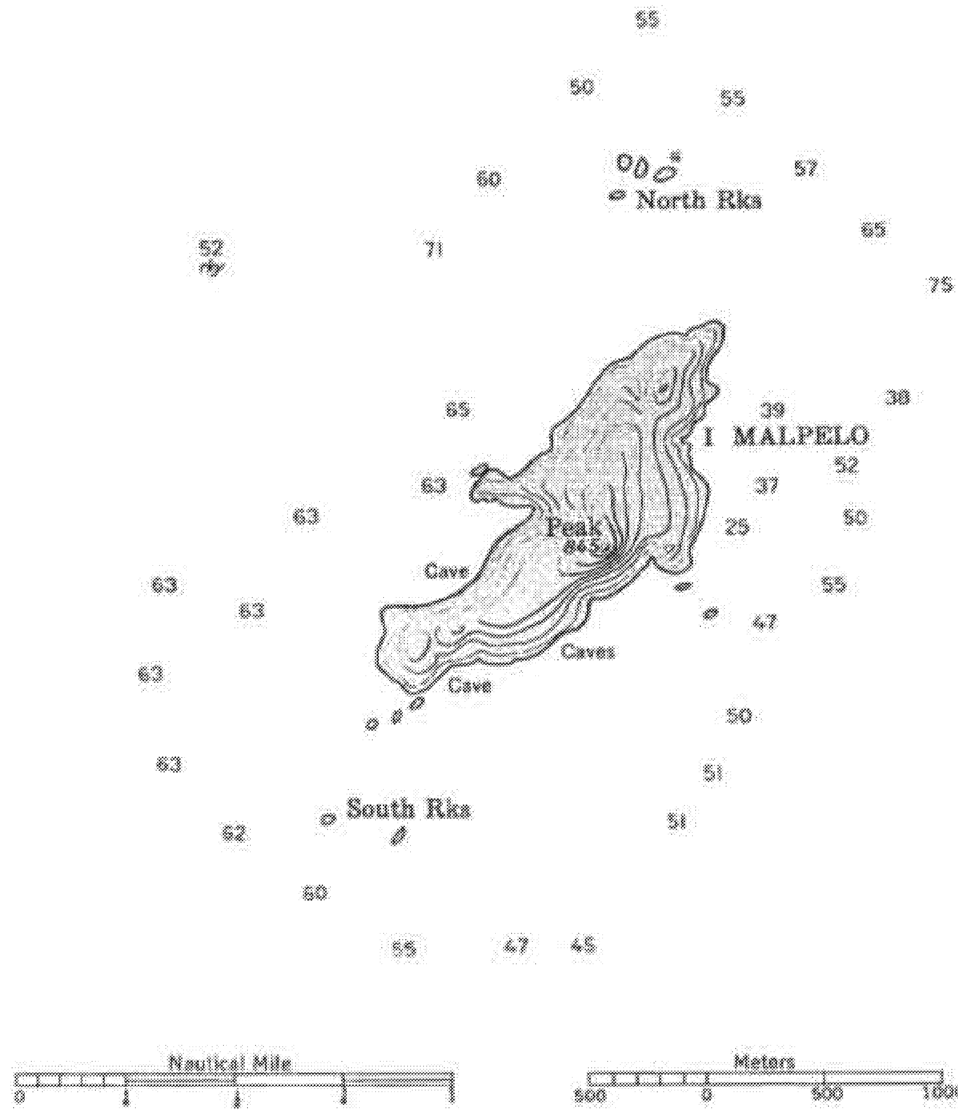


Source: NIMA Nautical Chart 2162, November 1994
Mercator Projection,
World Geodetic System (WGS), Cocos Island.

Note: Depths are in meters.

Figure 3-9
Malpelo Island and Surrounding Waters





Source: NIMA Nautical Chart 2162, November 1994

Peak, Lat. 3 59' 07" N., Long. 81 35' 40" W.

Note: Depths are in fathoms.

Galapagos Islands

Typical landscape features of the Galapagos Islands include crater lakes, fumaroles, lava tubes, sulfur fields, and a variety of lava and other volcanic materials such as pumice, ash, and tuff. As a result of their volcanic origin, the Galapagos Islands are composed almost exclusively of basalt. In geological terms, the Galapagos Islands are young, with the oldest islands being roughly three to four million years old (Williams, 1966). The larger islands typically consist of one or more sloping shield volcanoes, culminating in collapsed craters or calderas.

Minor volcanic eruptions and earthquakes are common in the Galapagos Islands. During the last 200 years, over 50 eruptions have been recorded from eight of the Galapagos volcanoes (Goff et al., 1999). The volcanoes are classified as shield volcanoes; they typically measure from 15 to 30 km (9.4 to 18.7 mi) across the base, with slopes gradually becoming steep upward to the rims of deep summit calderas with terraced walls (Wallace, 1966). The most active volcanoes are Fernandina and Isabela, the highest and westernmost islands in the Galapagos (Williams, 1966). The most recent eruptions occurred on Fernandina in 1995 and on Isabela in 1998. The least active volcanoes, and possibly the oldest, are Santa Maria, Espanola, and San Cristobal, the southeasternmost islands in the Galapagos.

Cocos Island

Cocos Island is approximately 2 km (1.2 mi) long and 1 km (0.6 mi) wide. It is located at the center of the volcanic Cocos Ridge, which runs from the Galapagos Islands to the Middle American Trench, southeast of Costa Rica. The island consists of basaltic rock and tuffacious breaches affected by trachytic intrusions. The jagged coast is lined with underwater caves and cliffs as high as 183 m (600 ft). The underwater profile consists of stepwise shelves with almost no intertidal zone and a shallow submerged fringing reef, which culminates in sand and rubble at the edge of a trench that is several hundred meters deep.

Malpelo Island

Malpelo Island is volcanic in origin. The present island is the remnant of a larger geologic structure. Malpelo is approximately 2.2 km (1.4 mi) long and 0.8 km (0.5 mi) wide and reaches a maximum height of 845 m (2,790 ft) above sea level. Wave action has eroded the island and formed steep cliffs (typically ranging from 60 to 230 m [200 to 760 ft] above sea level) and sea caves along its shoreline (Stead, 1975). Several types of igneous rocks are present on Malpelo Island, including dacite, trachyte, tuff, basalt, and andesite. Up to an elevation of 210 to 240 m (690 to 790 ft), the island is mostly trachyte, with lesser amounts of dacite and tuff. The higher elevations are covered by an andesite cap. Soil is scarce on the island and is completely absent at elevations below 90 m (300 ft) due to steep slopes and severe wave action (Stead, 1975).

3.2.2.2 Atmospheric Processes and Conditions

Atmospheric conditions and processes are the same as described in Section 3.4 of the February 11, 1999 EA and are incorporated by reference. (See Appendix A.)

3.2.2.3 Biological Communities

The three Oceanic Island groups lie at the convergence of several major ocean current systems of the equatorial Pacific (see Section 3.2.1.3). This location explains the variety of marine life and a climate that is classified as subtropical even though the islands are located near the equator. Table 3-4 provides information on the 22 primary islands within the three island groups. This section describes the terrestrial biological communities of the Galapagos, Cocos, and Malpelo islands.

Galapagos

Ecuador designated 97 percent of the land area of the Galapagos as a national park in 1959. In 1986, the Galapagos Marine Resources Reserve was established to protect the waters around the archipelago. The UNESCO recognized the Galapagos Islands as a Man and Biosphere Reserve and as a World Heritage Site. Ecuador manages the islands through the Galapagos National Park Service. The Charles Darwin Research Station (CDRS), which is operated by the Charles Darwin Foundation (CDF), carries out scientific research and assists the park service in managing the islands.

Table 3-4 lists terrestrial biological communities for 20 of the 120 Galapagos Islands. These 20 islands contain significant or unique biological communities. The remaining 100 islands are rocky projections that primarily support only nearshore algal communities or are only transiently used by fauna.

Approximately 625 species and subspecies of plants are native to the Galapagos Islands, of which 36 percent (225 species) are endemic. An additional 250 nonnative plant species have been introduced by human inhabitants. Vegetation can be divided into six zones, which are limited by elevation, moisture, and level of soil development (Schofield, 1984):

1) The Littoral Zone consists of Mangrove swamps of *Rhizophora mangle*, *Avicennia germinans*, and *Sesuvium sp.*
2) The Dry Zone is the most abundant habitat in the Galapagos Islands. It is located immediately inland from the coastal zone. Principal species characteristic of this zone are the cacti *Brachycereus sp*., *Jasminocerus thouarsii*, *Opuntia sp*., and *Croton scouleri*. These species represent the only type of vegetation present on small islands of low elevation.
3) The Transition Zone consists of mixed shrub and forested habitat. A characteristic species is the palo santo tree (*Bursera sp.*).
4) The Scalesia Zone — similar to wet tropical forest — is dominated by *Scalesia sp*. and *Pisonia floribunda*.

TABLE 3-4. CHARACTERISTICS OF OCEANIC ISLANDS

Island	Location	Primary Habitats and Significant Natural Features	Characteristic Species	Major Human Activities
Galapagos Islands				
Pinta	0.55°N 90.75°W	Summit is 850 m (2,800 ft) above sea level and has no caldera. Island is characterized by young lavas and cinder cones. Introduction of goats to the island caused much ecological damage, and vegetation is sparse.	Once had a large tortoise population that was decimated by fishermen. One Pinta tortoise remains and is the last known individual of this species.	Uninhabited
Isabela	0.60°S 91.15°W	Largest island in the Galapagos, accounting for half of the total land mass. Has five active volcanoes and Darwin's Salt Lake Crater.	Flightless cormorant, Galapagos penguin, blue-footed booby, masked booby, marine turtles, sea lions.	Inhabited Cattle herding (300 head)
Santa Fè	0.95°S 90.12°W	Oldest island in the Galapagos. Has a sheltered bay, steep cliffs, and an area of Opuntia cactus. Eroded volcanic cones called "cerros" mark the youngest parts of the island. Other features include spatter cones, pit craters, and small calderas.	Sea lion, Galapagos white-tipped shark, marine turtle, Galapagos hawk, frigatebird, pelican, swallow-tailed gull, mockingbird.	Uninhabited Visited by tourists
Bartolomè	0.25°S 90.50°W	Evokes a lunar landscape of cones and craters. Stark and dry, only the occasional prickly pear, lava cactus, or Scalesia bush. Lies opposite of Sullivan Bay. Pinnacle Rock is one of the best known landmarks of this island.	No information available.	Uninhabited
Marchena	0.33°N 90.50°W	With Pinta and Genovesa, Marchena forms the northern trio of islands just above the equator. A large shield volcano of which only the upper 343 m (1,130 ft) is above sea level.	Southern Martin, small tree finch, large tree finch, Marchena lava lizard	Uninhabited Marchena is closed to tourists; however, divers frequent the surrounding waters.

Island	Location	Primary Habitats and Significant Natural Features	Characteristic Species	Major Human Activities
Santa Maria	1.25°S 90.45°W	Beach, enclosed lagoon, forest. The terrain rises and falls in proliferation of volcanic cones. The western part of the island consists of bare lava flows and a black sand beach. In the northeastern portion of the island is Punta Cormorant's lagoon. An imploded volcano, Devil's Crown, lies just off the coast of the main island.	Sea lion, marine turtle, ghost and sally lightfoot crabs. Flamingo and several other bird species feed in the lagoons and ponds.	Inhabited The first inhabited island of the Galapagos (since 1807). Cattle farming (300 head).
San Cristobal	0.80°S 89.45°W	Home to the capital and administrative center of the Galapagos Islands, Puerto Baquerizo Moreno. Provides habitat for five endemic species (three reptiles, two birds)	Tuberculated leaf-toed gecko, San Cristóbal leaf-toed gecko, San Cristóbal lava lizard, San Cristóbal snake, red bat, paint-billed crake, Galápagos barn owl, San Cristóbal vermilion flycatcher, San Cristóbal mockingbird, vegetarian finch.	Inhabited Airport located on the island. Puerto Baquerizo Moreno is the oldest settlement in the Galapagos.
Culpepper	1.65°N 92.00°W	Encircling reef extends 400 m (0.25 mi).	Largest breeding colony of sooty tern in the Galapagos, large cactus finch.	Uninhabited Inaccessible due to absence of landing areas. Protected as a natural area by the Ecuador Government.
Daphne Major/Minor	0.40°S 90.35°W	Sparsely vegetated by herbaceous and shrub vegetation. Two small craters host thousands of nesting blue-footed boobies. Consists of 3 islets.	Swallow-tailed gull, brown noddy, blue-footed booby, masked booby, red-billed tropicbird	Uninhabited
Pinzon	0.70°S 90.70°W	18-km^2 (7 mi^2), 458-m (1,510 ft) volcano peak, entirely cliff bound. Provides habitat for one endemic reptile species.	Pinzón lava lizard, Slevin's snake.	Uninhabited

Island	Location	Primary Habitats and Significant Natural Features	Characteristic Species	Major Human Activities
Espanola	1.45°S 89.67°W	Punta Suarez has 30-m (100 ft) high cliffs that provide nesting habitat for many seabird species. Gardner Bay provides feeding habitat for many bird species and beach habitat for sea lions and marine iguanas. Encircling reefs extend 400 m (0.25 mi).	Masked booby, blue-footed booby, Galapagos dove, hooded mockingbird, cactus finch, warbler finch, waved albatross, sea lion, marine iguana, lava lizard.	Uninhabited One of the most visited islands due the variety of animals. Landing point is Punta Suarez.
Santa Cruz	0.60°S 90.35°W	The central island in the Galapagos and home to the main port, Puerto Ayora, and the Charles Darwin Research Station. Highly diverse flora and fauna. Mangrove forest, arid forest dominated by polo santo trees and prickly pears, Miconia shrubland. Tortoise reserve at Parte Alta twin craters. The island's peak is at 900 m (2,970 ft) above sea level. Cow pastures and small plantations in the island interior.	Galapagos tortoise, red bat, lava lizard, mockingbird, ground finch, vermilion flycatcher.	Inhabited Puerto Ayora, the largest town in the Galapagos, is the main tourist destination in the islands.
San Salvador	0.25°S 90.75°W	The shoreline of Perto Egas characterized by cliffs of hard volcanic ash. Primary habitat is polo santo forest. Feral goats have consumed most of the vegetation, turning much of the land into an open savannah. A salt crater, Sugarloaf volcano (390 m or 1,290 ft), is located in James Bay. Sullivan Bay is known for its conical volcano.	Fur seal, flamingo, masked booby, pelican, feral goat.	Uninhabited Commercial attempts to extract minerals from the salt lake crater failed. Today, only a few roads and abandoned buildings remain.
Rabida	0.42°S 90.72°W	A small island 2 km (1.2 mi) in width and 400 m (0.25 mi) at its highest point. Known for its unusual red-colored beaches. Vegetation consists of Opuntia cactus, polo santo trees, and shrubland.	Sea lion outhaul area, flamingo, penguin. Nine of 13 species of finch occur here.	Uninhabited Visited by tourists
Wenman	1.38°N 91.82°W	Rocky, barren island.	Seabird nesting area.	Uninhabited Inaccessible due to the absence of landing sites.

Island	Location	Primary Habitats and Significant Natural Features	Characteristic Species	Major Human Activities
Fernandina	0.35°S 91.55°W	The westernmost island of the Galapagos and one of the most volcanically active. One of the newest of the Galapagos volcanoes, evident by the lack of erosion and bareness of vegetation. Young mangrove forest is the primary habitat. Rocky shores, black sand beaches, and frequent volcanic upheavals. The main volcano is 1,500 m (4,950 ft) high with a diameter of 6.5 km (4 mi), depth of 800 m (2,640 ft), and a 910 m (3,000 ft) deep caldera.	Heron, yellow warbler, pelican, frigatebird, mangrove finch, petrel, shearwater, Galapagos penguin, fur seal, flightless cormorant, vegetarian finch, sharp-beaked ground finch, Galápagos barn owl, black rail, large Fernandina rice rat, Slevin's snake, Galápagos lava lizard, Galapagos leaf-toed gecko. Feral goats and rats.	Inhabited Visited by tourists; landing point is called Punta Espinosa.
Seymour	0.40°S 90.25°W	No information available.	Known for its large nesting colony of great and magnificent frigatebirds. The blue footed booby, land iguana, swallow-tailed gull, pelican, and red-billed tropicbird also nest here.	Uninhabited
Plaza Sur	0.60°S 90.10°W	Smallest of the 13 large islands. Dry sandy land.	Sea lion, land iguana, marine iguana.	Uninhabited Visited by tourists
Baltra	0.45°S 90.25°W	Approximately 100 m (330 ft) above sea level.	Land iguana, marine iguana, marine turtle.	Inhabited Airport located on the island
Genovesa	0.35°N 89.97°W	A small island (10 km^2, or 3.9 mi^2) in the shape of a horseshoe. One of the most pristine islands of the Galapagos group. Polo santo trees on the cliffs are a major breeding site for water and land birds. The island's interior, Darwin Bay, an imploded volcano, is the dominant natural feature. Encircling reefs are present.	Important breeding site for marine, land, and water birds, including red-footed booby, masked booby, frigatebird, wandering tattler, turnstone, whimbrel, lava gull, yellow-crowned heron, lava heron, black-crowned night heron, finch, Galapagos mockingbird, and Galapagos dove. One reptile species, a subspecies of marine iguana.	Uninhabited Visited by tourists (particularly birders).

Island	Location	Primary Habitats and Significant Natural Features	Characteristic Species	Major Human Activities
Cocos Island				
	5.55°N 87.00°W	Coastline is irregular, with cliffs rising almost vertically to 200 m (660 ft). Inland terrain is mountainous with numerous rivers and streams. Primary habitats include a herbaceous zone and a montane cloud forest zone. Two bays (Bahi`a Wafer and Bahi`a Chatham). Largest watercourses are the Genio and Pittier Rivers. Highest peak (Cerro Iglesias) is 634 m (2,090 ft).	High numbers of endemic plant and animal species. 87 bird species have been recorded, including 3 endemic (Cocos Island cuckoo, Cocos Island flycathcer, and Cocos Island finch); 2 endemic reptiles (Anolis lizard and gecko). Feral pigs, goats, and cats are the only terrestrial mammals.	The Government of Costa Rica took official possession of Cocos in 1869. After two unsuccessful attempts to colonize the island, it has remained free of permanent human intervention except for 10-15 resident park rangers.
Malpelo Island				
	4.00°N 81.58°W	400 m (1,320 ft) long and 545 m (1,800 ft) wide. Highest peak is 350 m (1,150 ft) above sea level. Flora limited to lichens and fern.	Anolis and anguid lizards, 10 species of birds. Masked booby and swallow-tailed gull nesting site. Large migrations of hammerhead and whale sharks occur just offshore.	Island has fewer than 10 Colombian Coast Guard employees; otherwise, it is uninhabited. Colombia has nearly completed the processes for designating Malpelo as a nature reserve.

Source: United Nations Environmental Program, UN System-Wide Earthwatch Web Site; WCMC, 2000; Gorman and Chorba, 1985; Wolda, 1985; Slud, 1967.

5) The Miconia Zone commonly referred to as the shrub zone — is found primarily on Santa Cruz. It is characterized by dense, monotypic stands of cacaotillo shrubs (*Miconia robinsoniana*).
6) The Fern-Sedge Zone covers the summit areas of the larger islands, where moisture is retained in temporary pools and Sphagnum moss. Endemic tree ferns (*Cyathea weatherbyana*) and various grass and sedge species occupy collapsed lava tubes and other small potholes.

Because the Galapagos Islands have always been separated from the mainland, the plants that occur there arrived by long distance dispersal. Most of the plant species were derived from South America, with some from Mexico and Central America (Schofield, 1984). Historically, birds are believed to be the major source of plant dispersal in the Galapagos, with wind and ocean currents having a minor influence. In modern times, humans have introduced approximately 250 plant species to the Galapagos Islands (Schofield, 1984). Several of these introduced plants have dramatically changed the landscape of the islands. Large areas of all of the inhabited islands have been invaded by guayaba (*Psidium guajava)* and elephant grass (*Pennisetum sp*.), which, in many areas, have completely replaced native vegetation. Orange and lemon trees are widespread in the Scalesia zones of San Cristobal and Santa Maria, often excluding the native *Scalesia* and *Pisonia* species.

Table 3-5 provides information on the common reptiles and birds that occur on the Galapagos Islands. Except for two species of marine tortoises, all of the reptile species are endemic. These include the Galapagos giant tortoise (*Geochelone)*, with 11 subspecies on different islands; two species of land iguanas; one species of marine iguana; three species of snakes; and several species of *Tropidurus* lizards and *Phyllodactilus* geckos. The native avifauna includes 57 residents, of which 26 (46 percent) are endemic and 31 are regular migrants. Endemic bird species include 13 species of finch (collectively known as Darwin's finches), eight species of seabirds, and five species of land birds. Six indigenous mammal species are found on the islands: the Galapagos fur seal, Galapagos sea lion, two species of rice rat, and two species of bat. There are roughly 1,000 insect species, 50 spiders, and 60 land snail species documented in the region, some of which are endemic to individual islands (WCMC, 2000). Sally lightfoot crab (*Graspus graspus)* is a characteristic shoreline species on all islands within the Galapagos.

Cocos Island

Although Cocos Island has a less diverse flora than that of the Galapagos Islands, it has a similar percentage of endemic species [35 percent (70 species) of vascular plants compared with 36 percent on the Galapagos]. The flora of Cocos Island consists of 235 vascular and 137 nonvascular plants (Fournier, 1966). Two plant zones are found on the island (Gomez, 1975):

- A coastal, mostly herbaceous, Littoral Zone, which rises between 0 to 50 m (0 to 165 ft), with two habitat types: the *Annona glabra* swamp and the firm terrain with various species of flowering plants.
- A montane cloud forest zone (Mountainous Zone), which grows to 100 m (330 ft). The predominant tree species include the endemic species *Huriki sacglottis holdridgei*, *Ocotea insularis*, and *Cecropia pittieri*. Undergrowth in the forest is dense with *Hypolitrum amplum* and several species of ferns (Dauphin, 2000).

TABLE 3-5 COMMON BIRD AND REPTILE SPECIES OF THE GALAPAGOS, COCOS, AND MALPELO ISLANDS

Latin Name	English Name	Distribution	Endemic
Reptiles			
Geochelone elephantopus	Galápagos tortoise (12 subspecies)	All major islands except Genovesa, Marchena, Culpepper, Wenman; extinct on Santa Maria, Santa Fé, Rábida, and perhaps Fernandina.	X
Chelonia mydas agassizii	Green turtle	Widespread throughout the Galapagos (endemic subspecies).	X
Phyllodactylus tuberculosus	Tuberculated leaf-toed gecko	San Cristóbal	X
Phyllodactylus gilberti	Wenman leaf-toed gecko	Wenman	X
Phyllodactylus leei	San Cristóbal leaf-toed gecko	San Cristóbal	X
Phyllodactylus barringtonensis	Santa Fé leaf-toed gecko	Santa Fé	X
Phyllodactylus galapagoensis	Galapagos leaf-toed gecko	Santa Cruz, Daphne Major, San Salvador, Pinzón, Crowley, Tortuga, Isabela, Fernandina	X
Phyllodactylus sp.	Rábida leaf-toed gecko	Rábida	X
Phyllodactylus bauri	Baur's leaf-toed gecko	Española, Gardner near Española, Santa Maria, Gardner near Santa Maria, Enderby, Champion	X
Sphaerodactylus pacificus	Gecko	Cocos	X
Phyllodactylus sp.	Gecko	Malpelo	
Norops townsendi	Anolis lizard	Cocos	X
Anolis agassizi	Anolis lizard	Malpelo	
Celestus hancocki	Anguid lizard	Malpelo	
Tropidurus pacificus	Pinta lava lizard	Pinta	X
Tropidurus duncanensis	Pinzón lava lizard	Pinzón	X
Tropidurus habelii	Marchena lava lizard	Marchena	X
Tropidurus bivittatus	San Cristóbal lava lizard	San Cristóbal	X
Tropidurus delanonis	Española lava lizard	Española, Gardner near Espanola	X
Tropidurus grayii	Floreana lava lizard	Santa Maria, Gardner near Santa Maria, Caldwell, Enderby, Champion	X
Tropidurus albemarlensis	Galápagos lava lizard	Santa Fé, Santa Cruz, San Salvador, Rábida, Isabela, Fernandina	X

Latin Name	English Name	Distribution	Endemic
Conolophus subcristatus	Land iguana	Santa Cruz	X
Conolophus pallidus	Santa Fé land iguana	Santa Fé	X
Amblyrhynchus cristatus	Marine iguana	Throughout the Galapagos on all major islands	X
Alsophis biserialis eibli	San Cristóbal snake	San Cristóbal	X
Alsophis biserialis hoodensis	Española snake	Española, Gardner near Española	X
Alsophis dorsalis dorsalis	Galápagos snake	Santa Fé, Santa Cruz, Baltra, San Salvador, Rábida	X
Alsophis Dorsalis helleri	Isabela snake	Isabela, Tortuga	X
Alsophis dorsalis occidentalis	Fernandina snake	Fernandina	X
Alsophis slevini slevini	Slevin's snake	Pinzón, Isabela, Fernandina	X
Alsophis slevini steindachneri	Steindachner's snake	Santa Cruz, Baltra, San Salvador, Rábida	X
Pelamis platurus	Yellow-bellied sea snake	Widespread throughout Galapagos	X
Seabirds			
Spheniscus mendiculus	Galapagos penguin	Throughout the Galapagos	X
Diomedea leptorhyncha	Waved albatross	Nearly endemic, but also breeds in small numbers on Isla La Plata, off Ecuador.	
Pterodroma phaeopygia phaeopygia	Dark-rumped petrel	Throughout the Galapagos	Endemic subspecies
Puffinus lherminieri subalaris	Audubon's shearwater	Throughout the Galapagos	Endemic subspecies
Oceanites gracilis galapagoensis	White-vented storm petrel	Throughout the Galapagos	Endemic subspecies
Oceanodroma tethys tethys	Wedge-rumped storm petrel	Throughout the Galapagos	Endemic subspecies
Oceanodroma castro	Band-rumped storm Petrel	Throughout the Galapagos	Endemic subspecies
Phaethon aethereus mesonauta	Red-billed tropicbird	Throughout the Galapagos	Endemic subspecies
Pelecanus Occidentalis urinator	Brown pelican	Throughout the Galapagos	Endemic subspecies

Latin Name	English Name	Distribution	Endemic
Sula nebouxii excisa	Blue-footed booby	Throughout the Galapagos	Endemic subspecies
Sula dactylatra granti	Masked booby	Throughout the Galapagos	Endemic subspecies
Sula sula websteri	Red-footed booby	Throughout the Galapagos	Endemic subspecies
Phalacrocorax harrisi	Flightless cormorant	Throughout the Galapagos	X
Fregata minor ridgwayi	Great frigatebird	Throughout the Galapagos, Cocos	X
Fregata magnificens	Magnificent frigatebird	Throughout the Galapagos	X
Haematopus palliatus galapagensis	American oystercatcher	Throughout the Galapagos	Endemic subspecies
Larus fuliginosus	Lava gull	Throughout the Galapagos	X
Larus Furcatus	Swallow-tailed gull	Nearly endemic to Galapagos, but also breeds on Malpelo	X
Sterna fuscata crissalis	Sooty tern	Throughout the Galapagos, large breeding colony on Culpepper	X
Anous stolidus galapagensis	Brown noddy	Throughout the Galapagos	Endemic subspecies
Anous stolidus ridgwayi	Noddy	Malpelo	
Anous minutus diamesus	Black noddy	Malpelo	
Actitis macularia	Spotted sandpiper	Malpelo	
Heteroscelus incanus	Wandering tattler	Malpelo	
Waterbirds			
Ardea herodias cognata	Great blue heron	Throughout the Galapagos	Endemic subspecies
Ardea alba egretta	Great egret	Throughout the Galapagos	Endemic subspecies
Ardeola sundevalli	Lava heron	Throughout the Galapagos	X
Ardeola striata cf. Striata	Striated heron	Throughout the Galapagos	X
Nyctanassa violacea pauper	Yellow-crowned night heron	Throughout the Galapagos	Endemic subspecies
Laterallus jamaicensis spilonotus	Black rail	Santa Cruz, Baltra, San Salvador, Pinta, Isabella, Fernandina	Endemic subspecies
Neocrex erythrops	Paint-billed crake	San Cristóbal, Santa Maria, Santa Cruz, Isabella	Endemic subspecies

Latin Name	English Name	Distribution	Endemic
Gallinula chloropus (cachinnans or pauxilla)	Common gallinule	Throughout the Galapagos	Endemic subspecies
Himantopus himantopus mexicanus	Common stilt	Throughout the Galapagos	Endemic subspecies
Phoenicopterus ruber glyphorhynchus	Greater flamingo	Throughout the Galapagos	Endemic subspecies
Anas bahamensis galapagensis	White-cheeked pintail	Throughout the Galapagos	Endemic subspecies
Land Birds			
Buteo galapagoensis	Galápagos hawk	Throughout the Galapagos, except for Genovesa, Wenman, Culpepper	X
Falco peregrinus	Peregrine falcon	Throughout the Galapagos, Malpelo, Cocos	
Zenaida galapagoensis	Galápagos dove	Throughout the Galapagos	X
Coccyzus melacoryphus	Dark-billed cuckoo	Throughout the Galapagos	X
Tyto punctatissima	Galápagos barn owl	San Cristóbal, Santa Cruz, San Salvador, Isabela, Fernandina	X
Asio flammeus galapagoensis	Short-eared owl	Throughout the Galapagos	Endemic subspecies
Pyrocephalus nanus	Galápagos vermilion flycatcher	Throughout the Galapagos, except for San Cristóbal	X
Pyrocephalus dubius	San Cristóbal vermilion flycatcher	San Cristóbal	X
Myiarchus magnirostris	Large-billed flycatcher	Throughout the Galapagos	X
Progne concolor	Southern Martin	Throughout the Galapagos, except for Genovesa, Marchena, Pinta, Wenman, Culpepper, Malpelo	X
Mimus parvulus	Galápagos mockingbird	Throughout the Galapagos, except for San Cristóbal	X
Mimus melanotis	San Cristóbal mockingbird	San Cristóbal	X
Mimus macdonaldi	Española mockingbird	Española	X
Mimus trifasciatus	Floreana mockingbird	Champion, Gardner near Santa Maria	X
Dendrocia petechia aureola	Yellow warbler	Throughout the Galapagos	X
Geospiza nebulosa	Sharp-beaked ground finch	Santa Maria, Santa Cruz, San Salvador, Isabela, Fernandina, Pinta	X

Latin Name	English Name	Distribution	Endemic
Geospiza fuliginosa	Small ground finch	Throughout the Galapagos, except for Genovesa, Culpepper, Wenman	X
Geospiza fortis	Medium ground finch	Throughout the Galapagos, except for Genovesa, Wenman	X
Geospiza magnirostris	Large ground finch	Throughout the Galapagos, except for Española, Culpepper	X
Geospiza scandens	Small cactus finch	Throughout the Galapagos, except for Española, Fernandina, Genovesa, Culpepper, Wenman	X
Geospiza conirostris	Large cactus finch	Española, Genovesa, Culpepper, Wenman	X
Geospiza crassirostris	Vegetarian finch	San Cristóbal, Santa Maria, Santa Cruz, Isabela, Fernandina, Pinta	X
Geospiza parvula	Small tree finch	Throughout the Galapagos, except for Española, Genovesa, Marchena, Culpepper	X
Geospiza pauper	Medium tree finch	Santa Maria	X
Geospiza psittacula	Large tree finch	Throughout the Galapagos, except for Española, Genovesa, Marchena, Culpepper, Wenman	X
Geospiza pallida	Woodpecker finch	Throughout the Galapagos	X
Geospiza heliobates	Mangrove finch	Isabela, Fernandina	X
Geospiza olivacea	Warbler finch	Throughout the Galapagos	X
Coccyzus ferrugineus	Cocos Island cuckoo	Cocos	X
Nesotriccus ridgwayi	Cocos Island flycatcher	Cocos	X
Pinaroloxias inornata	Cocos Island finch	Cocos	X
Icterus pectoralis	Spot-breasted oriole	Cocos	
Hirundo rustica ethrogaster	Barn swallow	Malpelo	

Source: WCMC, 2000; Steadman and Zousmer, 1988; Gorman and Chorba, 1985; Wolda, 1985; Slud, 1967.

Table 3-5 provides information on the common birds and reptiles that occur on Cocos Island. The fauna on Cocos includes 87 bird species, three of which are endemic species listed as endangered: the Cocos Island cuckoo (*Coccyzus ferrugineus*), Cocos Island flycatcher (*Nesotriccus ridgwayi*), and Cocos Island finch (*Pinaroloxias inornata*; Slud, 1967). Several seabird breeding colonies exist on the surrounding emerged rocks, including the red-footed booby (*Sula sula*), brown booby (*S. leucogaster*), great frigatebird (*Fregata minor*), white tern (*Gingis alba*), and common noddy (*Anous stolidus*). Two species of endemic reptiles are found on the island: the *anolis* lizard (*Norops townsendii*) and a gecko (*Sphaerodactylus pacificus*).

The only terrestrial mammals on the island are introduced pigs, goats, and cats. Over 362 species of insects have been documented on Cocos, including 64 endemic species. The endemic spider (*Wendilgarda galapagensis)* expresses habitat selection and web building behavior that differs from other species of its genus in Central and South America (Eberhard, 1989).

Cocos Island was added to the UNESCO World Heritage List in 1997 and was subsequently designated a Wetland of International Importance (RAMSAR, 1998).

Malpelo Island

Because soil is scarce on Malpelo Island, there are few suitable substrates for plant life. Consequently, plant species are dominated by lichens (71 species) and bryrophytes (113 species), which grow on the island's volcanic surface. The only vascular plant known to occur on Malpelo is a species of fern (*Pityrogramma dealbata*).

Correspondingly, the resident terrestrial faunal diversity of Malpelo Island is low. Ten species of birds are present (three land birds and seven seabirds), two species of lizards (*Anolis agassizi* and *Celestus hancocki*), one species of gecko (*Phyllodactylus sp.*), one land crab (*Gecarcinus malpilensis*), and 37 species of invertebrates (Abele, 1985; Wolda, 1985). Table 3-5 provides information on the common reptiles and birds that occur on Malpelo Island. None of these species are endemic to Malpelo; they are found throughout the equatorial Pacific region. There are no terrestrial mammals on the island. The masked booby (*Sula dactylatra granti*) and swallow-tailed gull (*Creagrus furcatus*) have significant breeding colonies (more than 50 pairs) on the island and its surrounding rocks (Pitman et al, 1995).

3.2.2.4 Social and Economic Conditions

Galapagos Islands

The Galapagos had no aboriginal inhabitants and was discovered in 1535 by Tomas de Berlanga, the Bishop of Panama. During the 17th and 18th centuries, buccaneers used the islands as a staging post, stocking up on water and giant tortoises. During the 19th century, whalers and fur sealers further exploited the islands for ship stores. Ecuador annexed Galapagos in 1832, and small colonies were gradually established on several of the islands (Galapagos Conservation Trust, 2000). In 1959, the Government of Ecuador declared 97 percent of the Island Group a national park, with the remainder available for the resident population.

Until the 1970s, there were no more than 1,000 residents on the Galapagos. They were primarily involved in subsistence fishing activities. From 1974 to 1999, tourism contributed to an influx of immigrants from the mainland, which caused the Galapagos population to rise from approximately 3,500 to 16,184 (Ecuadorian National Census and Statistics Institute, 2000). Population on the islands increased at a rate of 7.8 percent from 1990 to 1995, with only 1.7 percent due to natural increases and 6.1 percent due to immigration from the mainland (UNESCO, 2000).

Over 80 percent of the population lives on the islands of Santa Cruz, San Cristobal, Isabela, and Santa Maria. The capital is Puerto Baquerizo Moreno on San Cristobal Island, though the largest town is Puerto Ayora on Santa Cruz Island. Largely because of tourism, these two islands have experienced the greatest population growth over the past 10 years. The Government of Ecuador, as part of the Special Law of Galapagos, limits permanent resident status to Ecuadorians who have been on the islands for five years or more. UNESCO projects the population of the Galapagos Islands to grow to 20,000 people by 2003, 40,000 people by 2015, and 80,000 people by 2027 (UNESCO, 2000).

Tourism, which has dramatically increased since the 1970s from nearly none to more than 70,000 visitors annually, is the primary source of revenue for the islands. Tourism activities include wildlife observation, scuba diving, and snorkeling. The upgrade of two airports on San Cristobal and Baltra in the 1980s allowed for the landing of larger capacity jet aircraft. Some of those living on the islands, however, still depend on subsistence fishing for food and income. These fishermen use lines and nets, and dive for lobster. The number of local subsistence fishermen in the Galapagos has increased from less than 200 in 1971 to roughly 800 in 1999 (UNESCO, 2000).

The Galapagos Islands, because of unique flora and fauna, support an active scientific research program. The CDRS is based on Santa Cruz Island and is jointly supported by the Government of Ecuador, IUCN, and UNESCO, with additional funding from a variety of European and U.S. conservation bodies and from private donors.

Cocos Island

The Government of Costa Rica took official possession of Cocos Island in 1869. After two unsuccessful attempts at colonization, the island has never sustained a permanent population. The island was declared a national park in 1978. Its only inhabitants are 10 to 15 park rangers who reside there for short periods of time (WCMC, 2000). Visitors (mainly divers) are allowed on the island for day hikes, but not for overnight stays. The nearby reefs are a popular diving destination, with an average of 1,100 visitors per year (UNESCO, 2000). Scientific research has been extensive, including studies of land birds, island flora, biogeographic affinities of insects, and the impacts caused by introduced pigs and tourism. There are no facilities for researchers other than the lodges for rangers.

Malpelo Island

Until recently, Malpelo Island, governed by Colombia, was uninhabited and seldom visited. In 1986, the Colombia Coast Guard established a station on Malpelo Island, which usually has a staff of fewer than 10 people (WCMC, 2000). No significant tourism industry exists on the island. Because of a lack of a diversified fauna and animal population, there are no known scientific research activities at Malpelo Island at this time. The endemic lizard population has been studied on various occasions since the 1970s. There are no facilities for researchers on the island.

3.2.3 South America

Although continental South America is outside the predicted impact zone of stage and fairing debris, Section 3.2.3 provides a brief overview of the affected environment between 7.4° N and 7.4° S of the equator (see Figure 3-1). The upper-stage and payload would cross this area of continental South America at an altitude of over 180 km (112 mi).

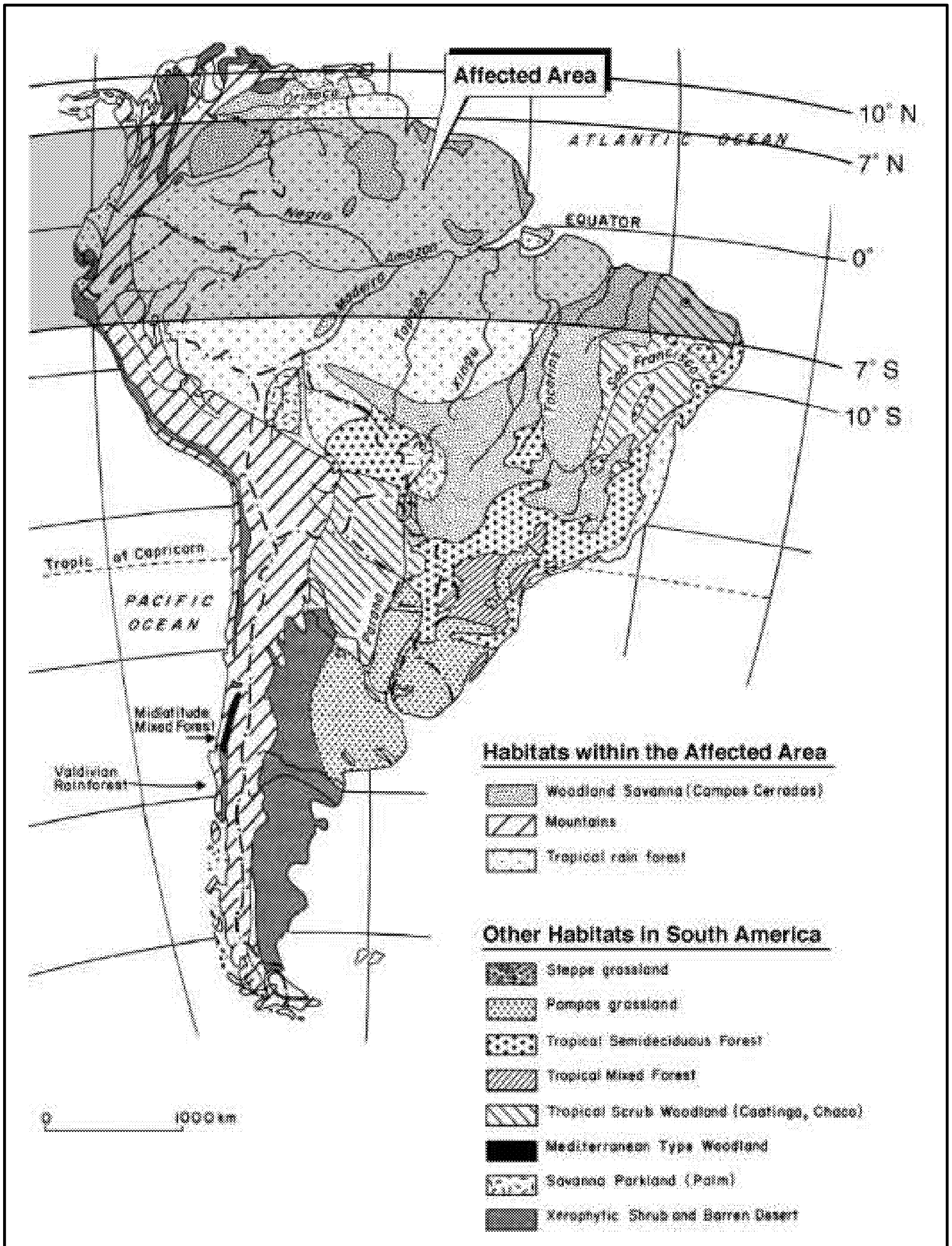
The portion of South America and Central America within the affected environment includes all of Ecuador, Surinam, and French Guiana, and portions of Colombia, Venezuela, Peru, Brazil, Guyana, and Panama. There are 29 national parks or national reserves—three of which are on the UNESCO World Heritage Site List—located within this affected environment (Hammond, 1996; UNESCO, 2001). The portion of South America within the affected environment generally consists of three geographical areas traversing from west to east: the Pacific coastal lowlands, the Andean mountain range (including high elevation valleys and plateaus), and the eastern lowlands (including much of the Amazon River Basin; see Figure 3-10). Each of these areas is described below in terms of geology, biological communities, and demographics. The proposed project would not affect other aspects of the environment—such as atmospheric conditions, aesthetics, noise, socioeconomics, and cultural resources—because the payload would cross South America at an altitude of over 180 km (112 mi), which is above the mesosphere (see discussion in Section 3.4 of the February 11, 1999 EA).

3.2.3.1. Pacific Coast and Coastal Lowlands

The Pacific coastline is generally steep and rocky, but is interspersed with sandy beaches, barrier islands, and brackish lagoons. The flat coastal lowlands variably extend 16 to 160 km (10 to 100 mi) inland from the Pacific coast to the foothills of the Andes. The northern part of these coastal lowlands in Colombia and northern Ecuador is covered by tropical rainforest, which transitions to relatively arid conditions in southern Ecuador and northern Peru (Clapperton, 1993).

These lowland forests support a diversity of animal life, including anteaters, sloths, several monkey species, tapirs, peccaries, deer, and large rodents such as agoutis, pacas, and capybaras. Large carnivores, such as pumas and jaguars, are increasingly rare.

Figure 3-10
Major Natural Vegetation Zones of South America



Source: Clapperton, 1993.

The coastal lowlands — with their hot and humid climate, dense rainforests, infertile soils, and rocky coastline — are sparsely populated. One major exception is Guayaquil, Ecuador's largest city, which has a population of over 2 million and is located at one of the few natural harbors along South America's Pacific coast.

3.2.3.2. Andean Mountain Range

Tectonic forces formed the Andean mountain range when the spreading Atlantic seafloor thrust the South American plate up and over the eastern margin of the Nazca and Caribbean plates. As is common along the margins of tectonic plates, the Andean mountain range includes numerous volcanoes and is commonly subject to earthquakes. Pre-Cretaceous metamorphic and plutonic rocks characterize the underlying geology. The Andes are among the world's youngest mountain ranges and among the highest, reaching elevations above 6,000 m (19,800 ft) (Clapperton, 1993).

Plant life in the Andean Mountains is strongly influenced by elevation and precipitation. Many species are specific to relatively narrow altitudinal bands. Alpine rain tundra forms at the highest elevations below the snow line and is dominated by lichens and bryophytes. A subalpine rain zone has three main vegetation types: tussock grassland, cushion plants and other low-growing species, and bamboo. Montane rainforest is found at lower elevations [(below approximately 3,500 m (11,500 ft)] and in the valleys. Subtropical rainforest occurs below elevations of 2,200 m (7,200 ft), with very high species diversity (Clapperton, 1993). Figs, laurels, palms, and wild avocado are common canopy trees.

The faunal species distribution in this region is related to altitudinal vegetation zones. At the highest elevations, mountain tapir, puma, guinea pig, and Andean fox are common. At lower elevations, spectacled bear, jaguar, ocelot, and various deer species are present. Over 1,500 species of birds are found in the Andean region, including toucans, hummingbirds, and songbirds (Ridgely, R.S., 1994; Altman A., 2000).

Despite their high elevations, the fertile valleys of the Andean region are the primary centers of population and economy. In this area of South America, alluvial soils found along principal river valleys and soils of volcanic origin are exceptionally productive and support agriculture, especially coffee farming. Major cities include Bogota (pop. 6.0 million), Medellin (pop. 2.0 million), and Cali (pop. 2.0 million) in Colombia and Quito in Ecuador (pop. 1.4 million).

3.2.3.3. Eastern Lowlands

The eastern lowlands form the majority of the Amazon River Basin and extend eastward from the foothills of the Andes (generally below 1,000 m or 3,300 ft) nearly to the Atlantic Ocean. This region consists of gently undulating topography in the west transitioning to relatively flat topography in the east along the Amazon River. A large freshwater sea occupied these lowlands during the Pliocene Epoch (5.3 to 1.6 million years ago). An outlet to the Atlantic was subsequently established, and the Amazon and its tributaries formed in the former seafloor (Bigarella and Ferreira, 1985).

The Amazon River drains approximately 6 million km^2 (2.3 million mi^2) and is the largest river in the world in terms of volume. Most of the rivers that drain the eastern Andes are tributaries to the Amazon, including the Putumayo, Japura, Maranon, and Negro rivers. The basin experiences high rainfall for most of the year, with precipitation averaging approximately 3,000 millimeters (mm) (119 in) annually (Salate, 1985). Around June, the Amazon overflows its banks, floods over 64,000 km^2 (25,000 mi^2) of land referred to as the varzea, and deposits nutrients that enrich the alluvial soils. The remaining portion of the Amazon basin is referred to as terra firme or upland areas.

These eastern lowlands are dominated by tropical rainforest, or selva (Pires and Prance, 1985). The Amazon rainforest is incredibly complex and has among the highest biodiversity anywhere in the world. Approximately 25 percent of the world's primary forests are located within the confines of the Amazon basin. The rainforest is composed of several layers. In the canopy, enormous trees such as the rubber tree, silk-cotton, Brazil nut, sapucaia, and sucupira reach heights in excess of 67 m (220 ft). Two or three layers of smaller shade-tolerant trees are found below the canopy, including palms, myrtles, laurels, figs, mahogany, and rosewoods. Throughout the canopy and subcanopy are many epiphytes, such as orchids and bromeliads, ferns, and mosses. A network of woody vines called lianas links the entire forest. Over 2,500 species of trees alone are found in the Amazon.

The rainforest also provides habitat for a diverse array of animal species (Junk and de Silva, 1997). Many of the mammals are arboreal and live in trees, such as monkeys and sloths. Other mammals include the tapir, the white-lipped peccary, several species of deer, and many rodents. Carnivores include jaguar, ocelot, pumas, coati, and weasels. The Amazon basin is rich in bird life, with parrots, macaws, hoatzins, woodpeckers, parakeets, many species of waterbirds, and ground-dwelling birds such as tinamous and quail (Petermann, 1997). Insects represent the largest percentage of Amazonian organisms, with more than 8,000 species classified (including mosquitoes, black flies, beetles, cicadas, spiders, and butterflies) and likely many more yet unidentified.

The Amazon and its tributaries support over 2,500 species of fish, including pirarucu, various catfish, and piranha (Junk, et al., 1997). Crocodiles, manatees, freshwater dolphins, and several aquatic mammals such as the capybara, are all found in and along the Amazon's rivers.

Most of this region is sparsely populated. The few inhabitants are generally confined to small settlements at the foot of the Andes, along the banks of the main rivers, and along the Atlantic coast. New roads extending from the Andes encourages colonization. Major cities in the rainforest include Iquitos (pop. 280,000) in Peru and Manaus (pop. 1.0 million) in Brazil. Major port cities along the Atlantic coast include Belem (pop. 1.5 million) and Macapa (pop. 89,000) in Brazil, Cayenne (pop. 38,000) in French Guiana, Paramaribo (pop. 216,000) in Surinam, and Georgetown (pop. 250,000) in Guyana.

3.3 LEGAL FRAMEWORK

The legal framework is the same as described in Section 3.6 of the February 11, 1999 EA and is incorporated by reference. (See Appendix A.)

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4.0 ENVIRONMENTAL CONSEQUENCES

This section of the EA evaluates the environmental effects of the license applicant's proposed action and each of the alternatives identified for further analysis in Section 2.6. Section 4.1 evaluates the environmental effects of the license applicant's proposed action. Section 4.2 evaluates the environmental effects of the alternative with avoidance of the Oceanic Islands. Section 4.3 evaluates the environmental effects of the alternative with avoidance of the Galapagos Islands. Section 4.4 evaluates the environmental effects of the No Action alternative.

4.1 ENVIRONMENTAL EFFECTS OF LICENSE APPLICANT'S PROPOSED ACTION

This section of the EA evaluates the environmental effects of the license applicant's proposed action. To frame this discussion, SLLP operations are broadly grouped into five phases - Home Port, pre-launch, launch, successful flight (separated into Stages I, II, and Upper Stage), and post-launch. Possible failed mission scenarios at the LP, and during flight of Stages I and II and the Upper Stage are discussed. SLLP payloads (i.e., commercial satellites), which would be loaded with propellants and sealed at Home Port, are not addressed because they become operational only when in orbit at an altitude over 35,000 km (21,700 mi). Environmental effects of payloads are discussed only with regard to possible failed mission scenarios.

As detailed in Section 2.2 of this EA, the license applicant's proposed action is for the FAA to issue an LOL for up to eight launches per year for a period of five years up to a maximum of 40 launches. These launches would be conducted over a range of azimuths (82.6^o to 97.4^o, inclusive) using a specified launch vehicle at a specified launch location for specific payload types. In general, the reader is referred to the February 11, 1999 EA, Section 4.3 for a discussion of the primary environmental impacts of the proposed project during operations at Home Port, pre-launch, launch and post-launch operations, and failure scenarios.

Impacts attributable to the range of azimuths, which affect both successful flight and the possible failure scenarios, are discussed below in Sections 4.1.1 and 4.1.2. Possible cumulative impacts attributable to the license applicant's proposed action are discussed in Section 4.1.3. The discussion of cumulative effects also considers, as a worst-case situation, the possible failure of successive launches that affect the same geographic area. Section 4.1.4 addresses other environmental concerns, such as socioeconomic considerations.

4.1.1 Environmental Effects of Successful Flight

4.1.1.1 Home Port

Under the license applicant's proposed action the environmental effects associated with the preparation of the ACS, LP, and ILV for transit to the launch site are equivalent to those described in Section 4.5.3 and Appendix A of the February 11, 1999 EA. Section 4.1.3 of this EA addresses cumulative environmental impacts associated with the license applicant's proposed action at Home Port.

The use of UDMH during operations at SLLP Home Port will require SLLP to modify Federal, state, and local regulatory documentation prior to the use of UDMH. The following documents needed to be modified:

1. Hazardous Material Inventory, (EPCRA) Long Beach Department of Health (CUPA)
2. Business Emergency Plan, Long Beach Fire Department

3. Operations Manual for the Transfer of Hazardous Material in Bulk, (USCG)
4. Integrated Contingency Plan, (EPA), (OSHA), California OSHA,
5. California Offshore Emergency Service (COES), (USCG)

The following document which will be published in 2002, will reflect emission changes occurring in 2001:

1. Annual Emissions Inventory (Year 2001), (SCAQMD)

The following document will not require changes because regulated thresholds would not be exceeded:

1. Risk Management Plan, Long Beach Department of Health, (CUPA)

Scrubbers are the components of scrubber filters specifically designed and constructed to capture and neutralize UDMH vapors. These filters have been installed at the Home Port facility.

4.1.1.2 Pre-launch, Launch, and Stage I and II Flight Over Open Ocean

Propellant loading would occur after arrival at the launch location. This would result, under normal operations, in an incidental loss of kerosene and LOX vapors, which would dissipate immediately in the atmosphere over the Pacific Ocean. Up to 125,000 liters (33,000 gallons) of freshwater from a tank on the LP would be sprayed into the LP's flame bucket to absorb energy during the initial fuel burn. The heat of the ILV exhaust would evaporate approximately 80 percent of this water, while the remainder would be dispersed by the force of the launch and settle on the ocean surface as spray or mist. This small volume of heated freshwater would cool to ambient ocean temperatures within minutes with no significant adverse effects on any marine life.

The ILV would be launched from the LP and Stage I and II flight would occur over open ocean areas. In this respect, the environmental effects associated with Stage I and II components and their operation during a successful launch along any azimuth in the license applicant's proposed action would be the same as those evaluated in Sections 4.3.2 and 4.5.5 of the February 11, 1999 EA. These include:

- Spent stages, fairing, and sleeve adapter (i.e., connection between Stage II and the Upper Stage) deposition in the ocean,
- Combustion emissions released to the atmosphere,
- Residual propellants released from spent stages to the atmosphere and ocean, and.
- Possibility of spent stages, fairing or sleeve adapter falling on a marine organism, ship, fishing vessel, or aircraft.

Section 3.2 of the February 11, 1999 EA categorized the affected environment in terms of geology, atmospheric processes, oceanography, biological communities (including marine, hydrothermal vent, coral reef, and threatened and endangered species), and commercial operations (including shipping, fishing, and air traffic). The following discussion categorizes the expected environmental effects in the same manner.

Geology

As shown in Figure 4-1, Stage I and fairing impact zones overlap slightly, and jointly form a rectangle of approximately 480 km (north to south) by 600 km (east to west) (300 by 375 mi). These impact zones are located between the Clipperton Fracture Zone and the Galapagos Fracture Zone in the eastern-equatorial

Pacific Ocean in water 2,000 to 4,000 m (1.2 to 2.5 mi) deep. The Stage II impact zone is approximately 1,270 km (790 mi) by 1,320 km (820 miles) located just west of the Galapagos Rift. The water depth in these areas is approximately 3,900 m (2.4 mi). Given the geologic setting, the deposition of spent stages and the fairing in these areas would be inconsequential relative to expanse of the open ocean environment and natural geologic processes in the region.

Oceanography and Atmospheric Processes

The open ocean environment within the proposed range of azimuths is largely uniform in terms of oceanic and atmospheric processes, with biological characteristics (e.g., plankton biomass) primarily varying with nutrient and mineral levels (Barber, et al., 1996). The spent stages and fairing pieces from any launch within the proposed range of azimuths would fall into undifferentiated deep, open waters of the tropical equatorial Pacific Ocean, far away from any Oceanic Islands or continental land mass (see Tables 4-1 and 4-2 and Figure 4-1).[a]

TABLE 4-1. IMPACT ZONES FOR SPENT STAGES AND FAIRING

Flight Element		Open Ocean Impact Zone		
Component	**Mass in kg (lbs)**	**Latitude**	**Longitude**	**Area in km^2 (mi^2)**
Stage I	36,500 (80,300)	2ºS to 2ºN	147.7ºW to 145.5ºW	107,000 (41,800)
Fairing halves*	2,400 (both) (5,280)	2.2ºS to 2.2ºN	146.6ºW to 142.2ºW	240,000 (93,800)
Stage II and sleeve adapter	11,515 (25,333)	6ºS to 6ºN	116.6ºW to 105.1ºW	1,680,000 (660,000)

* Data shown are for the potential 5-m (16.5 ft) fairing

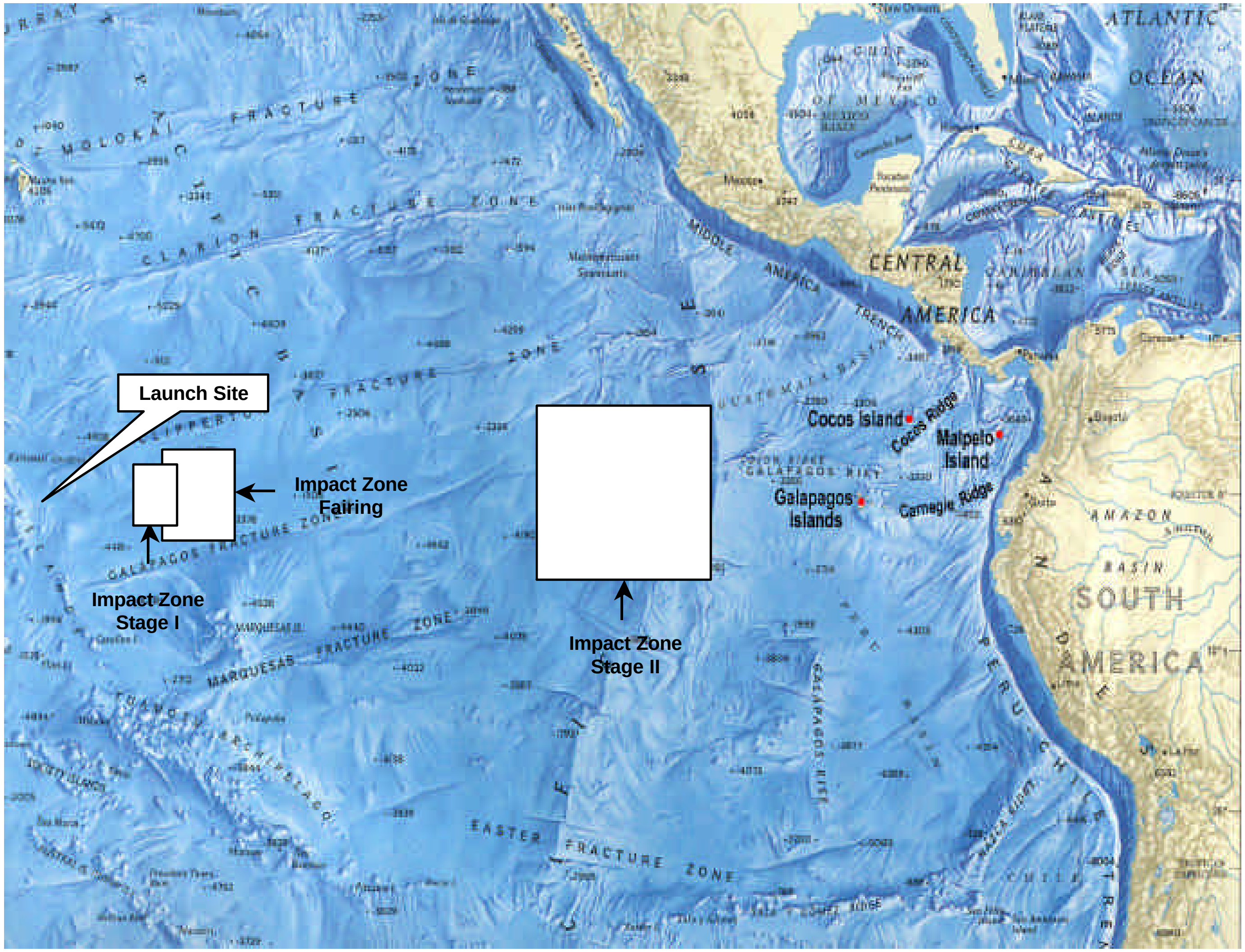
[a] The fairing and Stage I and Stage II impact zones are outside the area of the Convention for the Protection of the Natural Resources and Environment of the South Pacific Region (1986) ("Convention"). Article 2 of the Convention defines the "Convention Area" as:

(i) the 200 nautical mile zones established in accordance with international law off:
American Samoa; Australia (East coast and Islands to eastward including Macquarie Island); Cook Islands; Federated States of Micronesia; French Polynesia; Guam
Kiribati; Marshall Islands; Nauru; New Caledonia and Dependencies; New Zealand; Niue
Northern Mariana Islands; Palau; Papua New Guinea; Pitcairn Islands; Solomon Islands; Tokelau; Tonga; Tuvalu; Vanuatu; Wallis and Futuna; Western Samoa
(ii) those areas of high seas which are enclosed from all sides by the 200 nautical miles zones referred to in sub-paragraph (i).
(iii) areas of the Pacific Ocean which have been included in the Convention Area pursuant to Article 3.

Article 3 allows any Party to add to the Convention Area those areas under its jurisdiction which fall within certain specified coordinates in the Pacific region as long as no other Party objects. These specified coordinates include the area in the "Pacific Ocean between the Tropic of Cancer and 60 degrees South Latitude and between 130 degrees East longitude and 120 degrees West longitude . . . ." (Convention, Article 3). No areas have been added to the Convention Area under this Article 3.

NOTE: No areas were identified within the fairing and Stage I and Stage II impact zones over which any Party to Convention could have jurisdiction – a prerequisite for adding an area to the Convention Area under Article 3.

Figure 4-1
Impact Zones for Stage I, Stage II, and Fairing



Source: National Geographic Society
Mercator Projection,

Note: Depths are in meters.

TABLE 4-2. SHORTEST EXPECTED DISTANCES BETWEEN LAND MASSES AND ILV STAGE IMPACT ZONES

Land Mass (Country)	Distance Between Land Mass and Stage I Impact Zone (km (miles))	Distance Between Land Mass and Fairing Impact Zone (km (miles))	Distance Between Land Mass and Stage II Impact Zone (km (miles))
Kiritimati Island (Kiribati)	1,073 (667)	1,196 (743)	4,526 (2,813)
Malden Island (Kiribati)	841 (523)	954 (593)	4,255 (2,644)
Hatutu Island (France)	1,027 (638)	660 (410)	2,651 (1,648)
Clipperton Island (France)	4,108 (2,553)	3,748 (2,329)	476 (296)
Cocos Island (Costa Rica)	6,487 (4,032)	6,120 (3,804)	1,994 (1,239)
Galapagos Islands (Ecuador)	5,971 (3,711)	5,605 (3,483)	1,483 (922)
Malpelo (Colombia)	7,091 (4,407)	6,724 (4,179)	2,649 (1,646)

The maximum impact areas[b] of spent Stage I, fairing (assuming the larger 5-m fairing), and Stage II components (including the sleeve adapter) would be 404 m^2 (4,400 ft^2), 177 m^2 (1,930 ft^2) and 127 m^2 (1,380 ft^2), respectively, for any launch. In the context of the expanse of ocean area in each impact zone, the environmental effect of this deposition would be minimal. The 3-sigma impact zones for Stage I, for the fairing, and for Stage II are 1.18×10^9 m^2 (1.28×10^{10} ft^2), 4.71×10^9 m^2 (5.13×10^{10} ft^2), and 1.26×10^{10} m^2 (1.37×10^{11} ft^2), respectively. These areas are where, with 99.67 percent certainty, the components are predicted to fall.[c] Therefore, for any individual launch, only 0.00003 percent, 0.000003 percent, and 0.000001 percent of the ocean area within the impact zone area would be affected by Stage I, fairing, and Stage II debris, respectively. The deposited fairing material from successful launches would initially float and gradually sink as it becomes waterlogged, while stage material would sink and slowly dissolve and be buried in the ocean bottom. These materials are primarily composed of aluminum, steel, or graphite composite, some with small quantities of plastic, ceramic, and rubber products. On the bottom, the debris would become part of the ocean floor habitat much as materials such as old ships, drilling rigs, and tires submerged in coastal waters become substrate and shelter for marine organisms and attract new communities (Chou, et al., 1991).

Over this area of the equatorial Pacific Ocean, residual propellants would be released as spent ILV components fall into the ocean. Table 4-3 shows the quantity of residual kerosene and LOX associated with stage deposition during a successful flight. Residual LOX would dissipate immediately upon release. Residual kerosene would be dispersed into a mist during descent, and all but the largest droplets of kerosene would evaporate within a few minutes. Kerosene that reached the ocean surface would quickly spread on the surface from the effects of gravity, wind, and waves. A circular area with a radius of approximately 130 m (430 ft) would eventually be covered by a visible sheen from approximately 2,750 kg (or 6,050 lbs) of residual kerosene in Stage I (Doerffer, 1992). This estimate assumes that the entire residual amount of Stage I kerosene reaches the ocean surface, and that it would not evaporate.

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[b] The maximum impact area is defined as the largest amount of the sea floor that would be covered by the flattened surface areas of stage or fairing debris.

[c] This impact area is based on a probability estimate that accounts for each component's momentum as well as wind dispersion. For Stage I, the 3-sigma area is estimated to be an ellipse 50 km long and 30 km wide (31 by 18.8 mi; for the fairing, 120 km long and 50 km wide (75 by 31 mi); and for Stage II/Upper Stage sleeve adapter, 200 km long and 80 km wide (125 by 50 mi). For the purposes of this EA, the 5-m fairing is being evaluated as the worst case.

With these assumptions, the kerosene thickness in the center of the circle, after a few days, would be approximately one millimeter (0.05 in) (Patin, 1999; Ramade, 1978; and Lee, 2001). This theoretical approach, however, greatly overstates the area affected. Over 95 percent of this residual kerosene would evaporate within a few hours, while the remainder would disperse in the water column and degrade, such that the ocean environment would return to its initial condition within a few days (Doerffer, 1992; National Research Council, 1985; Rubin, 1989; ITOPF, 2001; and EPA, 1999). The area affected by Stage II kerosene would be proportionately less given the smaller volume of residual kerosene.

Although product-specific data are not available on alternative kerosene supplies presently being considered by SLLP, i.e., Boktan from Russia or kerosene from suppliers in the U.S., it is believed that either alternative would have physical and chemical characteristics and environmental effects comparable to the kerosene addressed in this EA. Should SLLP decide to use alternative kerosene supplies at some point in the future, proper environmental analysis will be conducted as appropriate. SLLP will continue to try to improve and optimize the use of the amount of propellants loaded on the ILV. This will serve to further reduce residual quantities of propellants remaining in tanks after engine burn.

TABLE 4-3. PRIMARY PROPELLANTS ASSOCIATED WITH STAGE I AND II FLIGHT AND DEPOSITION

Associated Component	Initial Kerosene (kg (lbs))	Initial LOX (kg (lbs))	Residual Kerosene (kg (lbs))	Residual LOX (kg (lbs))
Stage I	89,773 (197,500)	235,331 (517,728)	2,750 (6,050)	7,250 (15,950)
Fairing halves	N/A	N/A	N/A	N/A
Stage II	22,950 (50,490)	58,703 (129,147)	700 (1,540)	1,800 (3,960)

Recovery Time

The environment would recover from the effects of the residual hazardous material from each launch relatively quickly, and return to its natural condition within a few days. In terms of this recovery time, there would be no indication that a launch had taken place when the next launch occurred (approximately 45 days later under the license applicant's proposed action (Doerffer, 1992; National Research Council, 1985; Rubin, 1989; ITOPF, 2001; and EPA, 1999). No other hazardous materials would be released to the environment during this phase of a successful launch; Stages I and II, which consist of metal and small amounts of ceramic, rubber and plastic materials, would sink to the ocean floor and remain in an inert state.

The ILV would consume approximately 414,000 kg (911,000 lbs) of propellant during ascent, and produce carbon monoxide (CO), carbon dioxide (CO_2), hydrogen (H_2), and water vapor (H_2O) emissions, see Table 4-4. In addition to these main emission products, relatively small quantities of soot and sulfate particles (i.e., fine particulate matter produced in combustion) may be released to the atmosphere (Newman et al., 2001; Fahey et al., 1995). Also, as the ILV plume, which is rich in water vapor, transits the lower layer of High Altitude Tropical cirrus clouds, ice crystals form in the water vapor of the plume and mix with existing ice crystals. This higher concentration of ice crystals makes the contrail visible.

TABLE 4-4. TOTAL EMISSIONS PER LAUNCH

Atmospheric Layer	Altitude* Range (km (mi))	Propellant Consumed (kg (lbs))	Emission Products per Launch in kg (lbs)				
			CO	CO_2	H_2	H_2O	N_2
Lower Troposphere	0.0-2.0 (0.0-1.2)	61,714 (135,771)	17,033 (37,473)	26,907 (59,195)	432 (950)	17,342 (38,152)	0
Free Troposphere	2.0-10.0 (1.2-6.2)	69,100 (152,020)	19,072 (41,958)	30,128 (66,282)	484 (1,065)	19,417 (42,717)	0
Stratosphere	10.0-51.0 (6.2-32)	158,831 (349,428)	43,837 (96,441)	69,250 (152,350)	1,112 (2,446)	44,632 (98,190)	0
Mesosphere and Thermosphere	51.0-292 (32-182)	124,697 (274,333)	33,987 (74,771)	55,508 (25,231)	991 (2,180)	34,226 (75,297)	36 (80)
	Total	414,342 (911,552)	113,929 (250,643)	181,793 (303,058)	3,019 (6,641)	115,617 (254,356)	36 (80)

These emission products are thought to contribute to several types of atmospheric environmental impacts, including global warming, acid rain, and ozone layer destruction. Although CO_2 is a probable contributor to global warming, the amount released by SLLP during a year of operation is much less than the amount of CO_2 normally cycled at the ocean surface (see Section 4.1.3.4; Takahasi, et al., 1997). Launch vehicle operations in general have a negligible effect on acid rain, with effects attributable to the combination of sulfur dioxide, nitrogen oxides, and aluminum with water vapor in the atmosphere. Many studies have been done on the cumulative environmental effects of launches worldwide. The American Institute for Aeronautics and Astronautics convened a workshop to identify and quantify the key environmental issues that relate to the effects on the atmosphere of launches. The conclusion of the workshop, based on evaluation of scientific studies performed in the U.S., Europe, and Russia, was that the effects of launch vehicle propulsion exhaust emissions on stratospheric ozone depletion, acid rain, toxicity, air quality, and global warming were extremely small compared to other anthropogenic impacts. SLLP propellants would not generate significant amounts of these substances therefore these launches would have negligible effects on acid rain formation.

Biological Communities and Commercial Activities

The potential effects of successful launches and Stage I and II flight on biological communities and commercial activities are limited to the noise effects associated with the launch; and spent stages and fairing falling on a marine organism, ship, fishing vessel, or aircraft.

Noise Effects on Biological Communities

In terms of noise, steady noise from pre- and post-launch operations (e.g., from ship engines) may reach approximately 70 dB. Research indicates that this level of noise would not have a detrimental affect on any animal that would linger in the area (Shulhof, 1994; Richardson, et al., 1997). In fact, wind speeds of approximately 60 km/hr (37 mi/hr), which occur in the eastern portion of the Pacific Ocean, generate similar levels of noise (i.e., approximately 70 dB) on the open ocean (NIMA, 1998; Cato, 1994).

No significant noise impacts would be expected from the launch because of the relatively short duration of launch noise and the unlikely presence of the higher trophic level organisms near the launch site. Section 4.3.2.1 of the February 11, 1999 EA identified noise from a single launch to be 150 dB at 378 m

(1240 ft), with the equivalent sound intensity in the water at this distance being 75 dB. This reflects the fact that noise generated above the ocean is significantly attenuated by the air-water interface, which protects fish and marine mammals from most above-water noise impacts (Bowles, 1995). Navy research indicates that noise levels of 130 dB in the water are needed before changes in behavior patterns of certain whale species (Sperm and Humpback) are observed (Office of Naval Research, 2000). Other research found that noise of 130 dB might cause humpback whales to move away from the noise source and increase their dive duration. This level of noise did not result in any observed mass strandings or desertion of young (Ocean Studies Board, 1995). This study also found that elephant seal behavior near the sound source was apparently unaffected (Ocean Studies Board, 1995). Some environmental groups assert that noise levels of 140 dB cause whales to change their course and abandon their calves (ENS, 2000a). The Navy is currently preparing an EIS that evaluates the effect of its Surveillance Towed Array Sonar System (STASS) on marine mammals. The STASS generates noise levels of 160 to 180 dB; noise levels that could cause behavioral changes and/or injury to marine mammals, according to the U.S Marine Mammal Commission (ENS, 2000a). The Navy's Draft EIS concluded that the STASS is not likely to adversely affect listed species under the National Marine Fisheries Services (NMFS) jurisdiction, which include marine mammals. On 5 May 2000, NMFS informed the Navy that NMFS was not able to concur with their determination (ENS, 2000b). The Navy's Final EIS has not been released. The noise generated from SLLP's ILV would be diffuse compared to that generated by STASS.

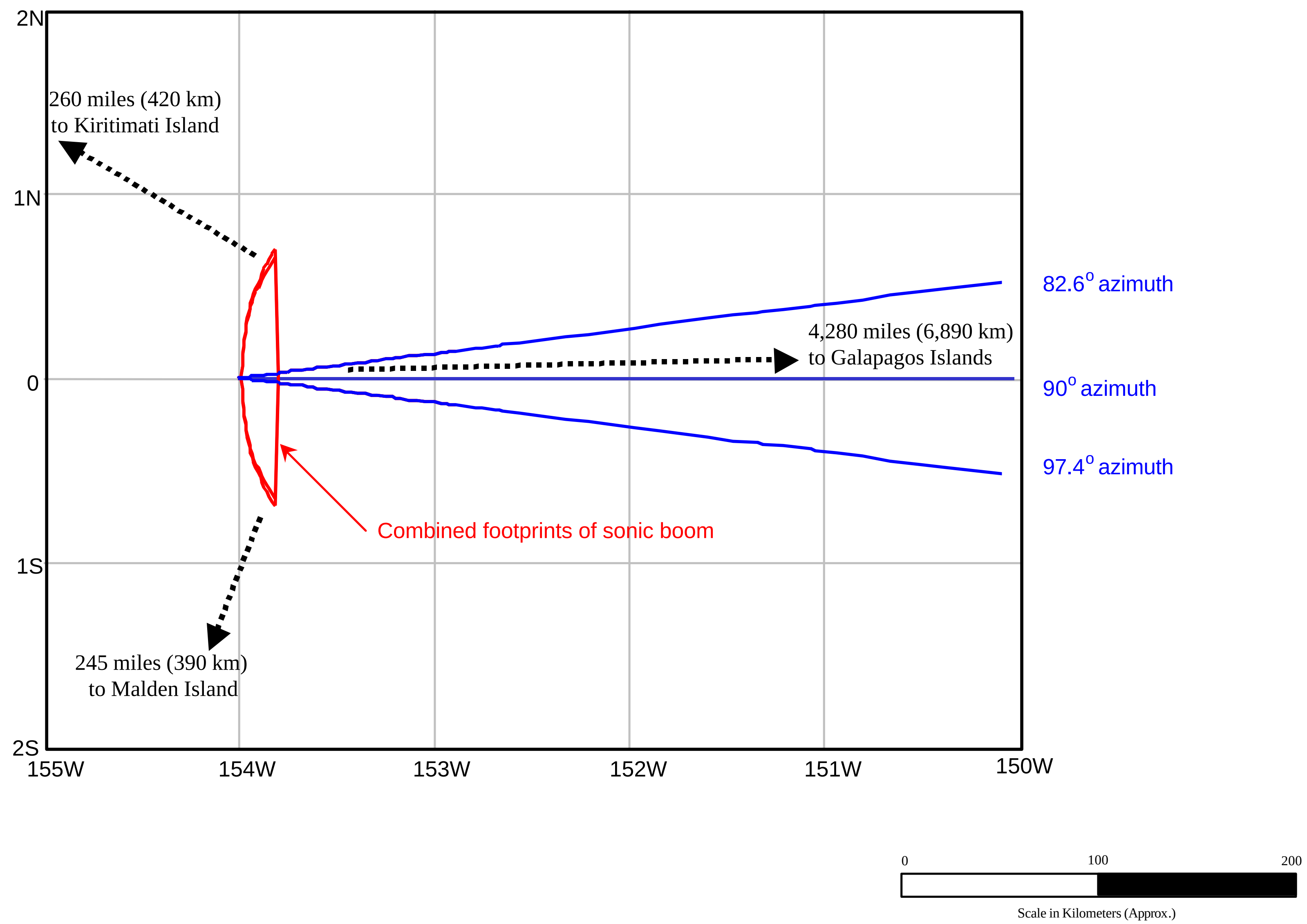
Data suggest that fish and marine mammals will move to avoid chronic high level noise and noise that may increase slowly in magnitude (Office of Naval Research, 2000; ENS, 2000). Fish and marine mammals, however, are not likely to be able to move quickly enough to avoid sudden acute high level noise. The velocity of sound in seawater is approximately 1,500 m/s (4,950 ft/s), or about 4.5 times faster than in air (Taley, 1990).

The decibel scale used to measure acoustic energy or sound is logarithmic (i.e., an increase from 60 dB to 120 dB represents a million times greater level of acoustic energy). The available data indicate that noise levels impacting the ocean environment would need to be much higher than the 75 dB generated by an SLLP Zenit-3SL launch to adversely affect marine life. Further, noise generated by the launch would last less than a minute (i.e., in less than 60 seconds the ILV would be over 10 km (6 mi) in altitude). Finally, as a condition of the launch license, an individual launch would be postponed if a whale or turtle were spotted within 100 m (330 ft) of the LP by visual observers up to 60 minutes prior to launch, at which time automatic launch processes are activated. In the seven launches to date, only one species of concern has been sighted during the entire launch countdown. An endangered species of Hawaiian Petrel was observed as part of the environmental monitoring for Mission 4. A bird was observed on the day before the launch and one-hour after the launch by observers on the ACS. Environmental monitors noted the sighting and submitted the information as part of the launch monitoring report. (See Environmental Monitoring Program Plan (EMPP), found in Appendix G.)

Sonic Booms

A sonic boom would occur when the ILV reaches supersonic velocity during Stage I flight. A sonic boom is caused when an object moving faster than sound (i.e., 1,200 km/hr (750 mi/hr) at sea level) compresses the air in its path. The sound heard at the Earth's surface as a "sonic boom" is the sudden onset and release of pressure after the buildup by the shock wave or "peak overpressure." The change in pressure caused by a sonic boom is only a few kilograms per square meter (pounds per square foot). The footprint of the sonic boom extending from the ILV during supersonic flight is provided in Figure 4-2, which encompasses the sonic boom footprint for all launch azimuths under the license applicant's proposed action. In other words, the effects of a sonic boom for flight on any azimuth within the license applicant's proposed action would be contained within the limits depicted in the footprint in Figure 4-2

Figure 4-2
Sonic Boom Footprint and Distances to Selected Land Masses



The maximum pressures experienced from a sonic boom would be directly under the launch vehicle flight path, and is primarily a function of velocity and altitude. As Figure 4-2 indicates, the sonic boom would occur over the open ocean far from any of the Oceanic Islands. The distance between the sonic boom footprint and the closest landmass (i.e., Kiritimati Island) is 420 km (260 mi). The effects of the sonic boom would be rapidly attenuated by the air-water interface (i.e., the acoustic energy associated with the sonic boom will be partially absorbed as it goes from the air into the water surface, lessening the effect) (Bowles, 1995). Thus, it would not have any significant adverse effects on marine organisms that happen to be in the area other than a startle reaction. A startle reaction may cause an adverse effect in a threatened and endangered species; however, little information on the physiological impacts of the startle effect is available for marine organisms in the open ocean. No physical harm to animals or ships at sea level would occur because of the altitude of the launch vehicle and its vertical acceleration (USAF, 1996).

Limiting Potential Impacts from Falling Stages and Fairing

The likelihood of spent stages and fairing striking a marine organism, ship, fishing vessel, or aircraft and preventative measures taken to avoid such an event are described in Sections 4.3.2.1 and 4.5.5, respectively, of the February 11, 1999 EA. (See Appendix A.) Coordination efforts to reduce this possibility are further detailed in the EMPP (Revision 1, August 21, 1999), which is attached to this document as Appendix G. In summary, for each launch, SLLP gives advance notice to the FAA (Central Altitude Reservation Function), the USCG (14^{th} District), NIMA, and the U.S. Space Command (USSC). To coordinate air, marine, and space traffic, these organizations routinely issue necessary information through well-established communication channels. For vessels without receiving equipment, standard notices are delivered by fax to Kiribati government authorities and regional fishing fleet and tour operators for distribution and posting. Notices are broadcast using U.S. Government protocols via INMARSAT-C, Pacific Ocean Region satellite on Safety Net channel at 10:00-10:30 and 22:00-22:30 GMT each day starting 5 days prior to each launch. The notice is also broadcast on frequencies in the high frequency (HF) band by USCG, Honolulu. The notice is distributed to Christmas Island local authorities and tour boat operators for posting and distribution; the Ministry of Information, Communication, and Transport for posting; and the operators of regional fleets at their headquarters, e.g., national and industry operators. In addition, the launch criteria prescribe that no launches would be conducted unless all vessels are clear of the predetermined safety zones surrounding the LP (visual observations would be taken up to 30 minutes prior to launch). Visual and radar sensors would be used to verify the absence of vessels in this zone. Therefore, the chance of spent stages or fairing striking a marine organism, ship, fishing vessel, or aircraft is very remote.

4.1.1.3 Upper Stage Flight Over the Oceanic Islands and South America

Upper Stage and payload flight would progressively transit over open ocean waters, the Oceanic Islands, and the northern part of South America. Upper Stage flight during a successful mission would have no effect on the ocean or land environments or the lower atmosphere because its operation occurs at very high altitudes.

Atmospheric Processes

The only environmental effect associated with Upper Stage flight of a successful mission is the combustion or venting of relatively small quantities of Upper Stage and payload propellants at high altitudes that are well above the range for potential atmospheric impact. The Upper Stage would achieve a low Earth orbit at an approximate altitude of 180 km (112 mi), at which point motors would be fired as needed to position the payload in the specified orbital parameters.

Future launches may use alternatives to the Russian kerosene (RP-1) presently used on the Upper Stage of the Zenit-3SL. Specifically, a petroleum hydrocarbon product called "Boktan" that is manufactured in Russia may be used to enhance ILV performance by increasing thrust and lift capacity. Kerosene from suppliers in the United States may be used to lower operating costs. The analyses presented in this EA, therefore, anticipate the possible substitution of Russian RP-1 kerosene with either of these alternatives. The U.S. kerosene is chemically equivalent to the RP-1 kerosene presently used by SLLP. The Boktan product, however, is a different chemical that needs to be considered further. See Appendix E for a comparison of chemical and physical characteristics of these propellants. Should SLLP decide to use either U.S. kerosene or Boktan at some point in the future, proper environmental analysis will be conducted as appropriate.

While Boktan requires somewhat greater personnel safety precautions (e.g., gloves and protective clothing) during handling than kerosene (based on their respective toxicity classes), its fate and effect during use or in the event of a spill are expected to be similar to kerosene or other low molecular weight hydrocarbon products. Specifically, Boktan would be used in equivalent quantities as an engine fuel and it would have the same emission products (e.g., CO, CO_2, H_2, and H_2O) as kerosene when burned. Boktan's rates of dispersion and evaporation in the open ocean environment if spilled or released would be somewhat greater given that its boiling, melting, and flash points are all somewhat lower than kerosene (i.e., resulting vapor pressure would be somewhat greater). Therefore, it is likely that the fate (i.e., ultimate break down and chemical form in the environment) and effect of Boktan in the environment would be very similar to those of the currently used Russian kerosene. Should SLLP decide to use Boktan at some point in the future, proper environmental analysis and review will be conducted as appropriate.

The February 11, 1999 EA (Section 4.3.2.1) solely considered the use of MMH as an Upper Stage propellant, which is the propellant used in six SLLP launches to date (the seventh mission used UDMH and N_2O_4). It is conceivable that UDMH (both U.S. and Russian produced) would be used in future launches proposed in this action. The properties of UDMH are summarized in Appendix E. Although it has a different molecular structure in the hydrazine family of chemical compounds, UDMH is equivalent to MMH in terms of its use in the Upper Stage. UDMH quantity, behavior, fate, and effect relative to the environment during a successful launch would also be equivalent as it is expended at very high altitudes beyond the range of potential atmospheric impact.

Once in the target orbit, the Upper Stage would be separated from the satellite payload, its gases and propellants would be vented or depleted into space, and it would be put into a final disposal orbit where it would remain for decades or longer.

4.1.1.4 Post-Launch Operations

Debris remaining on the LP would be collected, identified as to source (for compliance with U.S. Department of State Technology Transfer requirements), and disposed of in accordance with the International Convention for the Prevention of Pollution (in compliance with MARPOL 73/78) or brought back to Home Port for proper disposal. As part of post-launch cleaning, particulate residues (i.e., scorched deck paint) would be swept and washed off the deck with freshwater, and the deck would be repainted while at sea. The quantity of such wash water is expected to be a few kilograms/pounds.

4.1.2 Environmental Impacts of Possible Failed Mission Scenarios

A possible failed mission can occur at the LP, during Stage I or Stage II flight, or during Upper Stage flight. In most cases, a failure would result from a detected deviation between the programmed flight path parameter (e.g., pitch, yaw, roll) and the actual flight parameters as monitored by ILV sensors. If flight deviations exceed established limits, the thrust termination system would terminate the flight. Failure of the onboard computer systems could also result in thrust termination and loss of the mission. SLLP has projected launch reliabilities of 0.982 for Stage I flight, 0.956 for Stage II flight, and 0.974 for Upper Stage flight (SLLP, 2001). For the purposes of conducting debris risk analyses the FAA specifies that for launch vehicles "with fewer than 15 flights, a launch operator shall use an overall launch vehicle failure probability of 0.31." 14 CFR § 417.227(b)(6)(i) For launch vehicles "with at least 15 flights, but fewer than 30 flights, a launch operator shall use an overall launch vehicle failure probability of 0.10 or the empirical failure probability, whichever is greater." 14 CFR § 417.227 (b)(6)(ii) For launch vehicles "with 30 or more flights, a launch operator shall use the empirical failure probability determined from the actual flight history." 14 CFR § 417.227 (b)(6)(iii)

4.1.2.1 Possible Failure at the Launch Platform

Section 4.3.4.1 of the February 11, 1999 EA considered an explosion on the LP as representing a worst-case occurrence of Stage I and II failure. A possible failure at the LP would likely result in a cascading explosion of all ILV propellants. The explosions would scatter pieces of the ILV, and perhaps pieces of the LP, as far as three kilometers (two miles) away (the LP is designed to survive an explosion of the fully fueled launch vehicle). A smoke plume would rise and drift downwind some distance before dissipating. In the course of about one minute, the entire matter and energy of the ILV would be dispersed in the environment in a relatively concentrated area of the ocean. Environmental effects would include intense heat generated at the ocean surface; debris and noise released during the explosion; emissions released to the atmosphere; and the subsequent cleanup needed on the LP. Despite this intense, short-term, and localized disruption, there would be no discernible long-term impact to the environment. The fuels not consumed in the explosion would evaporate or become entrained in the water column and would eventually be degraded by microbial activity and oxidation (Doerffer, 1992; National Research Council, 1985; Rubin, 1989; ITOPF, 2001; and EPA, 1999). The areas of plankton lost due to heat or toxic effect would be re-colonized as currents redistribute the surface waters (Grigg and Hey, 1992). Section 4.3.4.1 of the February 11, 1999 EA concluded that the environmental effects of a failure at the LP would be short-term and localized relative to the scale and character of the ocean environment. For the license applicant's proposed action, the environmental effects of a failure at the LP would be the same as described in the February 11, 1999 EA.

Launch Abort Scenarios

There is also the potential for a launch abort at the LP (i.e., when a countdown is interrupted or no launch occurs, which is technically not a failure). In general, a launch would be aborted if equipment malfunctions or unresolved deviations of ILV parameters occur just before launch. Due to the inherent complexity of the ILV, a deviation in any number of factors could trigger an abort, and the extent to which propellants need to be safeguarded would vary based on the time prior to launch that the abort occurs. In all cases, however, the resulting contingency measures initiated by SLLP would follow established routines to stabilize the ILV on the LP. A worst-case abort, which would occur three seconds prior to launch, involves the largest quantities of propellant and the most detailed contingency measures. An abort scenario would involve draining small quantities of propellant into the flame bucket where it would evaporate due to wind effects. In addition, the pyrophoric fluid that initiates kerosene ignition would be burned according to SLLP's operating procedures. The ILV would be returned to a horizontal position in the LP hanger, and the propellant reservoirs from the Stage I engine would be drained into containers for later disposal at the Home Port as a hazardous waste.

An abort at three seconds prior to launch occurred during the SLLP Mission 6 launch planned for January 8, 2001. Visual observations by safety personnel during that event reported that, when drained, the pyrophoric fluid combusted instantly upon exposure to air in a sporadic stream approximately 4 m (13 ft) long, over several minutes. The draining of kerosene in engine propellant lines occurred as described in Section 4.3.1 the February 11, 1999 EA. Specifically, approximately 70 kg (150 lbs) of kerosene from the Stage I engine splashed onto the exhaust deflector, a large steel structure positioned under the ILV, and evaporated over the course of several hours from the effects of a steady breeze. No hazardous material was observed contacting the ocean surface. The emissions from the propellants that burned or evaporated during this process were dispersed into the atmosphere. These emissions would pose less environmental risk than those from a successful launch because much less of the propellant would be combusted during an abort event.

This is considered the worst-case abort scenario since before this point in the countdown, fewer hazardous materials would be involved, while after this point, the starting fluid would have initiated ILV ignition and flight. After this point, the event would take the form of either failure on the LP (see above) or during flight (Sections 4.1.2.2 and 4.1.2.3 below). As this observed event represents the worst-case abort scenario and did not result in significant environmental impacts, this or similar potential launch aborts would not be expected to significantly affect the environment.

The environmental impacts of failed missions that occur during Stage I or II flight or during Upper Stage flight, however, are evaluated below as such failures would affect a broader geographic area due to the proposed range of azimuths. The effect of successive launch failures is also considered in Section 4.1.3.6.

4.1.2.2 Potential Failure During Stage I and II Flight Over Open Ocean

An ILV failure moments after the ILV leaves the deck of the LP could also be considered a worst-case scenario since the propellant quantities involved would still be near a maximum at the onset of flight, and the failure would occur over the ocean rather than on the LP. A possible failure at this stage of flight would put all unexpended propellants, other hazardous materials, and ILV hardware into the environment in a more concentrated area than would occur during a successful flight. The quantity of hazardous material and debris reaching the ocean surface would depend on when in the flight the failure occurred (i.e., the longer the flight before failure, the less propellant would be onboard the ILV and available to potentially reach the ocean surface).

Possible failure at this point of the launch could occur in two ways: explosive failures and thrust termination failures. The mass and character of hazardous material (including the various propellants) and debris that would reach the ocean would depend on the type and time of failure during a launch.

Explosive versus Thrust Termination Failures

Potential explosive failures (marked by the sudden destruction of propellants and the ILV during flight) would result in the scattering of ILV parts and the immediate consumption by burning of most if not all of the hazardous materials incorporated by or contained in those parts. In contrast, possible thrust termination failures (i.e., one in which a deviation in flight triggers engine cutoff) would result in the ILV losing upward and forward momentum and falling toward Earth. In this case, an ILV early in Stage I flight would likely fall intact and rupture on the ocean surface, while later in Stage I flight and during all of Stage II flight, the ILV would begin to tumble within seconds and break up due to stresses on the structure. Explosions may also occur during thrust termination if, as the ILV breaks up, flammable materials become exposed to hot engine parts and ignite. If an explosion does not occur, the extent to which ILV materials would reach the Earth's surface would depend on the altitude and speed of the ILV at the time of thrust termination.

Possible Failure Near the Launch Platform

The worst-case scenario during initial ILV flight would be a thrust termination failure within 20 seconds of the ILV leaving the LP and the ILV falling intact and rupturing on the ocean surface. Regardless of when within the first 20 seconds the failure occurs, the ILV flight would continue until the twentieth second at which time the thrust termination system would automatically end the flight. This delayed termination has been automated to ensure that this type of failure does not damage the LP and to ensure that the ILV falls safely away from the ACS, which is positioned approximately five km (three mi) from the LP. At this point in flight, most of the propellant is unburned and virtually all of the ILV mass of propellants (see Table 4-3), other hazardous material, and components would be released into the environment in a concentrated area.

A possible failure near the launch platform would be worse than either an explosive failure or a thrust termination failure in which the ILV explodes later in the flight. In the case of a failure involving an explosion, most of the ILV would be consumed, destroyed, and scattered in a series of cascading explosions, and the propellants and other flammable materials would be burned before reaching the ocean surface. A thrust termination or explosive failure later in the launch may have less environmental impact (depending on the impact location). During such a failure later in flight more of the debris and virtually all of the propellants would be incinerated or evaporated and not reach the ocean surface, while those debris or propellants that would reach the ocean surface would be more dispersed. In general, larger and more concentrated amounts of ILV material and debris released during a failure would have a proportionately greater impact and take more time to dissipate and break down in the environment.

Effects of a Possible Failure During Stage I or II Flight

For the license applicant's proposed action, the scenario of possible Stage I or II failure, and especially the worst-case scenario of possible thrust termination failure during the first 20 seconds of flight, would occur over the east-central Pacific Ocean, well away from the Oceanic Islands and South America. Even if a failure caused a deviation from the intended flight plan, the deviation prior to thrust termination would not be so great as to have any environmental effects significantly closer to the Oceanic Islands than the normal debris deposition areas of a successful flight (see Table 4-2). Therefore, the debris from the ILV would fall into the deep waters of the open ocean far from any Oceanic Islands. The debris, which includes metal and composite components that incorporate small amounts of rubber, plastics, and ceramics, is largely inert and would settle to the ocean bottom as described in Section 4.1.2.1 and become an inert part of the seafloor ecology (Chou, 1991).

A possible failure during Stage I or II flight would result in the release of propellants and other hazardous materials (see Section B.3 and Table B.3-1 of the February 11, 1999 EA). In addition to the main propellants, kerosene (or Boktan) and LOX, small quantities of the propellants MMH (or UDMH) and N_2O_4 would be released, as would even smaller amounts of explosive compounds and metals present in release mechanisms and batteries.

The primary effects of a failure during Stage I or II flight are threefold:

- Release of emissions to the atmosphere.
- Release of propellants and other hazardous material to the ocean.
- Likelihood of Stage I or II debris falling on marine organisms, marine vessels, or aircraft.

Each of these effects is evaluated below for the worst-case scenario.

Release of Hazardous Materials, Including Emissions, to the Atmosphere

Vapors and aerosols (from evaporating propellants including LOX, kerosene (or Boktan), MMH (or UDMH), and N_2O_4) and combustion reaction products (primarily O_2, CO, CO_2, H_2, H_2O, nitrogen oxides (NO_x), including potentially small quantities of soot and sulfate particles) would disperse with the prevailing winds. Vapors would react with solar energy, break down to form smog and dissipate into the environment. Aerosols and liquid drops large enough to fall to the ocean surface would disperse with surface currents and break down under the influence of solar energy and microbial action (primarily to CO_2 and H_2O). As combustion during a failure is uncontrolled and inefficient, not all propellant mass would be converted to energy and some particulate residues would travel with the wind, settle on the ocean surface some distance from the point of failure, and break down into the same more basic compounds.

Release of Hazardous Materials to the Ocean

Potential impacts from the release of hazardous materials to the open ocean as a result of a possible failure during Stage I or II flight would be the same as those discussed in Section 4.1.1.2, "Oceanography and Atmospheric Processes."

Kerosene can be toxic to marine organisms, and it would likely affect plankton on the ocean surface. Overall plankton mortality, however, would be minimal because the affected area would be small relative to the scale of the ocean, and plankton population densities are naturally discontinuous and concentrated below the surface (Murray, 1994). Plankton re-colonization of the affected area would occur within a few days to a week in even the most directly affected area as surface waters move and mix under the effect of currents and winds (Grigg and Hey, 1992). Accordingly, the surface and ocean environment would return to pre-launch conditions within a week or so, even considering the most significant aspect of this worst-case failure. As such, there would be no indication of a failure by the time the next launch would occur. As discussed in Section 4.1.4.6 of this EA, this duration would be four to 12 months, considering the mandatory investigation that would follow any failure.

Comparable physical and chemical processes would be expected if the present kerosene product is replaced by Boktan or another kerosene. This determination is based on product data presented in Appendix E. Should SLLP decide to use either U.S. kerosene or Boktan at some point in the future, proper environmental analysis will be conducted as appropriate.

The hazardous materials in the Upper Stage and payload (primarily MMH (or UDMH) and N_2O_4) that would be released to the environment during a failure, would have slightly greater initial toxic effect than released kerosene because they are more volatile and reactive (see Appendix E and discussions in this section above). UDMH and MMH are both hydrazine fuels (a type of launch vehicle and spacecraft fuel used in hypergolic propellant systems) that have different chemical and physical parameters (e.g., boiling point, specific gravity, vapor pressure, flash point). The two fuels, however, are similar in terms of their reactivity, products of combustion (based on using N_2O_4 as an oxidizer), exposure limits and United Nations and United States Department of Transportation hazard classification. The overall impact from these materials would be considerably less than the impacts from kerosene because smaller quantities would be used.

Compared with the worst-case failure scenario (i.e., thrust termination failure within 20 seconds of flight), the return to pre-launch conditions for Stage I or Stage II failure would be somewhat faster (i.e., hours and days rather than days to a week) given the decreasing mass of propellants and other hazardous material onboard the ILV as the flight progresses (Doerffer, 1992; National Research Council, 1985; Rubin, 1989; ITOPF, 2001; and EPA, 1999).

Risk of Debris Falling on Marine Organisms, Vessels, or Aircraft

There is likely to be more debris reaching the Earth surface from a failure than from a successful mission. Also, and as indicated above, a thrust termination failure without an explosion would result in the most debris (i.e., potentially the entire ILV), while a failure late in Stage II flight would introduce less debris as some of the ILV would vaporize or burn before reaching the Earth's surface. In general, therefore, increasing altitude and speed would result in more debris being burned up during descent, and debris that does reach the ocean surface from a high-altitude Stage II failure would be inert after being subjected to the intense heat generated while re-entering the upper atmosphere. The surviving debris, which would cool during the descent through the lower atmosphere, would still initially be hot to warm. The debris would cool to ambient ocean water temperature within minutes of contact, and would have a negligible effect on any marine life.

The risk of ILV debris falling on marine organisms is remote given the launch criterion that a launch would not occur if whales or sea turtles are observed in the area surrounding the LP prior to launch. As with Stage I or II deposition during a successful flight, however, there is a chance that the debris and/or hazardous material from a failure later in flight may fall on a marine organism at the ocean surface. Because of the relatively low population densities of marine organisms (especially marine mammals) in this region, and low probability of an organism being present at the ocean surface (e.g., during breaching) (Kasamatsu, et al., 1995), such an impact would be very unlikely. The probability of debris falling on a marine vessel or aircraft during Stage I or II failure is discussed in Section 4.1.2.3 of this document, and is calculated to be between 0.6 x 10^{-8} to 1.1 x 10^{-13}.[d]

4.1.2.3 Potential Failure During Upper Stage Flight Over the Ocean, Oceanic Islands, or South America

Possible failure during flight of the Upper Stage could conceivably occur at any point as the Upper Stage progressively transits over the open ocean, the Oceanic Islands, and the northern part of South America. Given the speed and altitude of the Upper Stage during this period, a failure during any point in Upper Stage flight would result in most of the material components and all of the propellants being heated in the atmosphere and vaporized or burned from frictional effects before reaching the Earth's surface. Approximately 42 components from the Upper Stage and payload could survive reentry friction and reach the Earth's surface. These objects range from 0.04 m (0.13 ft) to 1.2 m (3.9 ft in size, and 0.3 kg (0.7 lbs)) to 90 kg (205 lbs) in mass (see Table 4-5). The actual amount of debris that survives depends on the time of failure during the flight (i.e., more debris would survive a failure that occurs earlier during the flight).

As is the case for possible Stage I and II failures discussed above, a possible Upper Stage failure could occur as an explosion (where propellants in the Upper Stage suddenly combust) or a thrust termination (where acceleration ceases and the remaining ILV components begin to fall). In both types of failure scenarios, the hazardous materials associated with the Upper Stage, the satellite payload, and their connecting components would be rapidly consumed (in an explosion) or released and dispersed (as the ILV components tumble and break up in the fall to Earth). In this manner, only the ILV components that would survive the fall to Earth (Table 4-5) would affect the environment.

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[d] *Draft: Standard Geosynchronous Transfer Orbit Missions, Launch Operator License Application*, Document D688-10739-1, SLLP, October 2000.

TABLE 4-5. DEBRIS EXPECTED FROM UPPER STAGE AND PAYLOAD REENTRY

DM-SL Debris Surviving Re-entry			
Components	**Size** **m (ft)**	**Mass** **Kg (lb)**	**Area** **m^2 (sq. ft)**
Uncooled nozzle	1.2x1.0 (3.9x3.3)	12 (26)	1.2 (13)
Engine frame	0.4x1x1 (1.3x3.3x3.3)	14 (31)	0.4 (14)
Combustion chamber	0.14x0.25 (0.46x0.82)	13 (29)	0.035 (0.38)
Cooled nozzle	1x0.6 (3.3x2.0)	40 (88)	0.6 (6.6)
Turbo pump	0.75x0.25 (2.46x0.82)	31.5 (70)	0.188 (2.02)
Tank valves (2)	0.12x0.2 (0.39x0.66)	9 (20)	0.024 (2.6)
Submerged bottle	0.48 dia. (1.57)	16 (35)	0.18
Oxidizer supply unit	0.75x0.3 (2.46x1.0)	35.5 (78)	0.22 (2.46)
Gas generator	0.6x0.1 (1.97x0.3)	19 (42)	0.06 (0.59)
Batteries (6)	0.5x0.5 (1.6x1.6)	90 (205)	0.25 (0.59)
Fuel supply unit	0.4x0.2 (1.3x1.7)	25.5 (56)	0.08 (2)
Multiple start unit	0.365 dia. (1.197)	18 (40)	0.10
Bolts – titanium	0.04x0.014 (0.13x0.045)	1.5 (3.3)	0.0006 (0.006)
L-brackets – titanium	0.13x0.25 (0.42x0.82)	0.30 (0.7)	0.033 (0.34)
Payload Debris Surviving Reentry			
Liquid apogee motor	0.56x0.028 (1.84x0.09)	3.8 (8.4)	0.02 (0.2)
5-lbThrusters (12)	0.3x0.08 (1.0x0.26)	2.4 (5.3)	0.02 (0.3)
Battery (4)	0.52x0.5 (1.71x1.6)	73 (161)	0.26 (2.7)
Fuel tanks (4)	0.90 dia. (3.0)	60 (132)	0.63 (6.9)
Propulsion/ACS assembly (equip)	0.90 dia. (3.0)	58 (128)	0.63 (6.9)

Effects of Debris, Including Hazardous Materials, in Open Ocean

An Upper Stage failure has the potential to affect the open ocean, with the impacts being less than those described in Section 4.1.2.2 because most of the material components and all of the propellant would vaporize or burn. Only inert materials, such as durable metals in engine components and batteries, would reach the Earth's surface.

Several types of batteries (i.e., nickel-cadmium, nickel-hydrogen, and silver-zinc), are used in the Upper Stage payload unit, and they would fall to Earth during Stage I, Stage II, and Upper Stage failures. These types of batteries are widely used (e.g., consumer electronics) and are not unique to the space industry. The batteries contain relatively small volumes of potentially toxic chemicals, which would be released into the environment under the various failure scenarios. Specifically, batteries would either fall into the ocean if the batteries do not rupture during Stage I or II failure, or partially disperse in the atmosphere when ILV structures containing batteries rupture during Stage II or Upper Stage flight. In the latter situation, some portion of the battery material would fall to the Earth's surface.

Nickel-cadmium and silver-zinc batteries use potassium hydroxide as an electrolyte between the two metal plates in each battery. Potassium hydroxide is a very corrosive chemical (pH of 13.5). Once in contact with the ocean, an acid-base reaction would quickly occur that would form a potassium based salt, which is not toxic to the environment (Pankow, 1991). Any remaining potassium hydroxide would dissipate in the ocean since it is soluble in water. Nickel, zinc, and cadmium are naturally occurring metals found in trace amounts in ocean water (Eisler, 1998; Eisler, 1985). Silver is most commonly found deposited as a mineral ore, but as a result of various anthropogenic sources (e.g., smelting operations) is now commonly found in trace amounts in the open ocean (Eisler, 1996). The small amount of these metals present in the batteries would gradually disperse.

In the event of a failure during Stage II or Upper Stage flight, the batteries would rupture either from the explosion or from the frictional forces encountered in their descent. Although the battery casings would be expected to survive the reentry, the potassium hydroxide would likely vaporize and react with water vapor present in the atmosphere, again forming a non-toxic salt.

The overall effect on the open ocean from batteries and other surviving debris would be minor, as the hot to warm debris would immediately cool, sink, and come to rest on the ocean floor. An Upper Stage failure, however, also has the potential to impact Oceanic Islands (i.e., the Galapagos Island group, Malpelo Island, or Cocos Island) and the portions of South or Central America that are located within the ILL overlay area (see Figure 3-1). In the unlikely event of an Upper Stage failure, the potential impacts would be small but could include effects from debris falling on:

- Marine organisms,
- Coral reef communities,
- Terrestrial communities on oceanic islands,
- South American habitats, and
- Vessels, aircraft, or humans.

Each of these potential environmental effects is evaluated below.

Debris Impacting Marine Organisms

There is a very slight chance that Upper Stage debris may strike marine organisms. The effects associated with an Upper Stage failure would be less than that for a Stage I or II failure, because most of the components and all of the propellants would burn up or be vaporized before reaching the ocean surface; consequently, there would be less material available to fall on or affect marine organisms. In general, the population density of most marine organisms is low throughout much of the area of concern. The lack of microhabitats and decreased solar energy inputs at necessary water depths limits the diversity and density of marine organisms in the deep ocean (Rex, 1981). Seasonal migrations of Southern minke whales and sharks are relatively dispersed in the eastern Pacific Ocean while right, humpback, and gray whales migrate along the shore, congregate in nearshore breeding areas, and are rarely found in the open ocean (Kasamatsu, et al., 1995). There are, however, particular areas (such as near or on the Oceanic Islands and upwelling boundaries) where population densities would be more variable and potentially higher due to localized increased primary productivity attributable to nutrient and mineral levels (Barber, 1996). On the whole, however, the impact of debris alone falling on individual organisms would be negligible at the population level.

There is a remote possibility that debris may fall on a marine animal (e.g., whale, seal, or turtle) that is listed as a threatened or endangered species by the IUCN or USFWS (see Table 3-2). For the vast majority of the open ocean that constitutes the affected environment of the license applicant's proposed action, however, population densities of these species are very low; the probability of debris falling on one of these species is remote. Although their populations are generally higher near the oceanic islands and where upwelling occurs, they occupy a very small percentage of the surface area of the equatorial Pacific Ocean based on estimates of population sizes and survey data (Hill, et al., 1990). In addition, these species are highly mobile and occupy the ocean at varying depths. An individual would need to be at or near the ocean surface and within the impact zone (e.g., while breaching) to risk injury from falling debris.

Debris Impacting Coral Reef Communities

As described in Section 3.2.1.4, coral growths and reefs are relatively small, poorly developed, and of discontinuous distribution in the eastern equatorial Pacific Ocean. This is generally attributed to low water temperatures, low salinity, high nutrient loads, natural bioerosion, and storm disturbances. Nearshore steep slopes also limit the amount of area suitable for underwater coral platforms (Cortes, 1997). Cocos Island has the only relatively well-developed coral reef in the area affected by the license applicant's proposed action and it is, therefore, considered here in terms of possible impacts to coral.

The Cocos Island reef system would only be susceptible to damage in the Upper Stage failure scenario because Stage I and II failures would occur far to the west of Cocos Island. If an Upper Stage failure occurs during an overflight of Cocos Island, the probability of debris falling on the coral reef at Cocos Island is estimated to be 1.4×10^{-8}, based on a reef area of approximately 15 km^2 (5.8 mi^2) (see Figure 3-8). This calculation overestimates the true probability in that it assumes that the entire reef system area is densely filled with coral growths when it is actually discontinuous (Bakus, 1975). Further, corals near the Oceanic Islands of the eastern Pacific Ocean and off the western shore of Central America have undergone a dramatic decline in recent years, with large areas of coral dying or becoming diseased (Camoin and Davies, 1998).

Corals at Cocos Island are found from just below the water surface to depths of approximately 30 m (99 ft) (Bakus, 1975). Debris from a possible Upper Stage failure could strike an area of healthy coral and damage or dislodge the coral. Because the debris would quickly decelerate during its initial transit through the water, deeper coral areas would sustain less damage. Some inferences may be drawn on the potential effects of Upper Stage debris striking coral from studies in which coral were intentionally damaged by hammer strikes (Syms, 2000) or surficial scrapes (Hall, 1997). These corals showed relatively rapid commencement of recovery within a year or so, as did the associated reef communities. If the foundation platform is undamaged new growth would replace the dislodged coral within decades (Pearson, 1981; and Jaap, 1984). Bioerosion, which is naturally prevalent from time to time, would further jeopardize coral growth and reef recovery in such situations (Reaka-Kudla, 1996). In any event, the probability of debris striking coral reefs is remote.

Recovery from a possible failure that affects coral would require at least several years or more. Because of the discontinuous nature of the coral and the size of the predicted surviving debris is relatively small (see Table 4-5), damage from this failure scenario would be extremely unlikely, would remain very localized and would not threaten the reef system itself.

As discussed in Section 3.2.1.4, Malpelo Island and the Galapagos Islands have even more discontinuous, solitary coral growths with little reef development. Therefore, the risk of falling debris striking living coral reefs at these islands would be commensurately less than at Cocos Island. If coral at Malpelo Island or the Galapagos Islands were affected, the impacts to and recovery of individual coral would be comparable to those described here for Cocos Island.

Debris Impacting Terrestrial Communities on Oceanic Islands

There is also the potential for debris from a possible Upper Stage failure to land on an Oceanic Island (i.e., Malpelo, Cocos, or one of the Galapagos Islands) (see Table 4-6). The debris would be inert after being subject to the intense heat generated while re-entering the upper atmosphere. The surviving debris, which would cool during the descent through the lower atmosphere, is highly unlikely to be hot enough to pose a risk of fire. Of the islands involved, the Galapagos and Cocos Islands in particular have notable diversities in terrestrial plant and wildlife species, while Malpelo Island is steep and rocky with relatively less diversity or abundance in terrestrial plant or wildlife species.

As indicated in Table 4-5, approximately 42 components totaling less than 10 m^2 are predicted to survive reentry. The combined size of these components represent less than 0.0000001 percent of the land area of the Galapagos Islands, 0.0005 percent of Cocos Island, and 0.0006 percent of Malpelo Island. The chance of the debris striking a plant or animal is remote. If debris struck a terrestrial organism, however, it could be injured or killed. There is a remote chance that a threatened or endangered species could be hit by falling debris. In such an unlikely event, replacement in terms of population dynamics would depend on the species' abundance, reproduction characteristics, and recruitment success.[e]

The probability of debris landing on the Oceanic Islands would be very low (see Table 4-6), the risk of damage to an island habitat or harm to any individual member of a resident species would also be very remote, and any possible impact would be limited in extent. Taking Cocos Island as an example from Table 4-6, most azimuths within the range in the license applicant's proposed action would present virtually no risk of debris landing on Cocos Island. In fact, azimuths of 83.00° to 83.28° and 84.50° to 97.00° are far enough away from the island that their ILLs would not overlay it at all. Only with azimuths of 83.29° to 84.49° would the Upper Stage overfly or the ILL overlay Cocos Island, thus presenting a probability that should a failure of the Upper Stage occur, some debris might survive and fall on the island.

[e] In this instance, recruitment success refers to the ability of one member of a species to convince another individual to behave in a desired manner.

TABLE 4-6. PROBABILITY OF UPPER STAGE DEBRIS FALLING ON AN OCEANIC ISLAND DURING A SINGLE LAUNCH

Oceanic Island	**Azimuth Associated With**			**Dwell Time[a] (sec)**	**Probability of Debris Falling on an Island**
	ILLs do not overlay island(s)	ILLs overlay island(s) but less than maximum dwell time	Island(s) directly overflown with maximum dwell time		
Galapagos Islands (as a group) [b]	82.6° to 87.47° and 92.22° to 97.4°			0	0.0[c]
		87.48° to 90.84° and 90.86° to 92.21°		Between 0 and 10.61	Less than 0.00067
			90.85°	10.61	0.00067
Cocos Island	82.6° to 83.28° and 84.50° to 97.4°			0	0.0
		83.29° to 83.89° and 83.91° to 84.49°		Between 0 and 0.15	Less than 0.0000094
			83.90°	0.15	0.0000094
Malpelo Island	82.6° to 85.07° and 86.36° to 97.4°			0	0.0
		85.08° to 86.04° and 86.06° to 86.35°		Between 0 and 0.03	Less than 0.0000019
			86.05°	0.03	0.0000019

[a] Dwell time can be considered the amount of time when the Upper Stage is over the island. More technically, it is the amount of flight time when the Instantaneous Impact Point (IIP) (based on a speed of 33,000m/s and a failure probability of 6.28×10^{-5}/sec) traverses the island.
[b] For Galapagos Islands (as a group), assumes debris would land on an island rather than in inter-island water.
[c] As a statistical concept, the probability cannot be zero.

In applying these data to the Galapagos Islands, which possess the greatest variety of habitat types and species among the islands considered in this EA, some general observations can be made. Extensive parts of the islands are very arid and devoid of vegetation or much soil; this is especially true of the steep flanks and young lava flows that usually extend to the sea from the numerous volcanic peaks and ranges. Also dominant on the islands are extensive areas that, while very arid, are more moderate or level in slope, which allows established soils to support desert vegetation including cactus, brush, and grasses. Also present, but less common, are relatively moist areas marked by lush grasses and trees. Most fauna are concentrated near the sea or in the moist habitats due to their reliance on associated nutrients.

Debris could directly fall on resident reptiles, birds, or mammals, or damage habitat due to the initial force of contact. Such debris impacts could damage vegetation, cause cracks and depressions in harder material (e.g., volcanic rock), or lodge into softer material (e.g., soil) on a semi-permanent basis. No scientific studies were found specific to this scenario relative to the Galapagos Islands; however, recovery following severe events (e.g., hurricanes, logging, and poor farming practices) in tropical regimes were studied in other parts of the world. These reports indicate that vegetation in moist to arid regimes would recover from these more severe conditions over a few years to decades, respectively (Mack, 1998; Kuerpick, 1997; Boucher, 1997; Living Earth, 2001; and Donfack, 1995). In light of habitat recoveries in these extreme situations, and given the significantly smaller impact that could possibly occur during a failure of the Upper Stage, it may be inferred that any damage to the islands' habitats would be minor and short-term.

When a launch vehicle uses the 83.90° azimuth it directly overflies Cocos Island with the greatest dwell time (which is described as the amount of time the Upper Stage flies over the island). For this azimuth the potential for damage from surviving debris reaching Cocos Island is the greatest, however there is a probability of only 0.0000094 that damage would occur from a failed launch.

For Malpelo Island, there is a similar effect from the possibility of debris impacting the island environment. Azimuths of 82.6° to 85.07° and 86.36° to 97.4° are far enough away that ILLs for these flightpaths would not overlay the island. The 86.05° azimuth corresponds to the flight path with the greatest dwell time directly over Malpelo Island (i.e., 0.03 sec), and that corresponds to a probability of 0.0000019 that some debris might survive and fall on the island should there be a failure during Upper Stage flight.

For the Galapagos Islands—taken as a group—azimuths of 82.6° to 97.47° and 92.22° to 97.4° are far enough away so that ILLs for these flight paths would not overlay the islands or the 40-mile marine sanctuary surrounding the islands. The 90.85° azimuth corresponds to the flight path with the greatest dwell time (i.e., 10.61 sec) over several islands as well as inter-island water. This azimuth corresponds to a probability of 0.00067 that some debris might survive and fall on one of the Galapagos Islands or in the surrounding inter-island waters, should there be a failure during Upper Stage flight.

To provide some context to the remoteness of the probabilities being discussed above, the following probabilities have been reported (for U.S. citizens on an annual basis):

- the probability of a coal miner or farmer dying on the job is 0.0004,
- the probability of drowning is 0.00002,
- the probability of dying from a bicycle accident is 0.0000077, and
- the probability of being killed by lightning 0.0000005 (Laudan, 1994).

Debris Impacting South American Habitats

The probability of Upper Stage debris falling on South America (as well as a small portion of Panama) is very low. As indicated above, during a possible Upper Stage failure, approximately 42 components representing a combined surface area of 10 m^2 could survive reentry. Most debris would burn or vaporize in the atmosphere as it falls from an altitude of approximately 180 km (110 mi), and would, therefore, not affect either Central or South America. The surviving debris would be subjected to the intense heat generated while re-entering the upper atmosphere and would cool during the descent through the lower atmosphere. As such, it is highly unlikely that surviving debris could present a fire hazard.

The probability of debris falling on Central or South America is related to the amount of time the Upper Stage is over the area, which varies with the azimuth of the launch, but ranges between 25 and 44 seconds[f] (see Table 4-7).

[f] These dwell times are associated with the heaviest anticipated payload (i.e., 6,100 kg or 13,420 lbs). Lighter payloads would result in shorter dwell times.

TABLE 4-7. UPPER STAGE AZIMUTHS OVER SOUTH AMERICA AND POPULATION CENTERS

Launch Azimuth (degrees)	Dwell Time for Continental overflight (sec)]	High Population[a] Density (per km^2)	Low Population Density (per km^2)	Cities Overflown (Populations Over 50,000)
083	25	207.22	0	Bucaramanga, Georgetown
084	27	207.22	0	Medellin, Puerto Ayacucho, Paramaribo
085	29	422.22	0	Pereira, Bogota, Cayenne
086	30	178.56	0	Buenaventura
087	30	44.30	0	Neiva, Boa Vista
088	32	44.30	0	Tumaco, Florencia
089	34	95.38	0	Esmeraldas, Ipiales, Mitú
090	37	131.16	0	Quito, Macapá
091	39	131.16	0	Manta, Portoveijo
092	40	211.47	0	Guayaquil, São Luís
093	39	874.36	0	Manaus, Fortaleza
094	43	88.14	0	Loja, Iquitos
095	44	117.55	0	Piura, Teresina, Mossoró
096	43	45.82	0	Imperatriz, Natal
097	42	289.72	0	Chiclayo, João Pessoa

[a] The data in Table 4-7 are calculated by using the 1° x 1° grid data from the *Carbon Dioxide Information Analysis Center* (CDIAC) database.

Though remote, the chance of damage to plants, animals or the habitat from falling debris would be due solely to the initial force of contact (e.g., a stricken animal or damaged vegetation). If debris falls on an animal, that animal could be injured or killed; however, the probability of such an event is estimated to be on the order of one in one million, or 1×10^{-6}. The potential for long-term harm occurring to a regional habitat from falling debris would be minimal, and the recovery of damaged areas would occur through re-colonization by neighboring species or replacement by the larger population over a period of months or years.

Over much of the affected portion of South and Central America, the predominant ecosystem is tropical rain forest (see Figure 3-10). Since Upper Stage debris would at most cause a few isolated impacts (e.g., broken limbs) to widely spaced trees or similar foliage, recovery from such damage would occur relatively rapidly (i.e., on the order of months), although it may not completely return to pre-impact conditions for a number of years (Kuerpick, 1997; Boucher, 1997; Living Earth, 2001; Mack 1998; Westy 2000; and Donfack, 1995). The majority of nutrients and natural resources in the tropical rain forest is typically found in the dense vegetation and canopy, and not in the soil. Any damage to the canopy or vegetation would affect these nutrients by temporarily removing them from the vegetative growth cycle, however these impacts are expected to be negligible. In the western lowlands and the more rocky mountainous areas of the continent, less vegetation is present to be damaged; however, recovery times would be much longer (i.e., several years or more) given the less fertile substrate and conditions for new growth. Nevertheless, any impact is expected to be negligible from this scenario on these receptors.

Debris Impacting Vessels, Aircraft, or Humans

An Upper Stage failure could also pose a small risk to vessels, aircraft, and humans. As described in Section 3.2.1.6 of this EA, shipping and aircraft traffic in the affected environment is relatively low, though traffic does increase closer to the coast of South and Central America. Conversely, the probability of Upper Stage debris falling on a vessel or aircraft diminishes as the Upper Stage approaches the coast of South America because as the altitude and speed of the Upper Stage increase, the impact window becomes smaller and more debris is burned up during descent.

The probability of debris from a mission failure falling on a person in an affected portion of Central and South America is also generally low and must satisfy FAA safety standards for SLLP to receive a license.[g] Based on the population densities calculated in Table 4-7, SLLP estimates the risk of debris falling on a person in the affected portions of Central and South America to be between 1.18×10^{-6} (corresponding to an 88° azimuth) and 3.26×10^{-6} (for a 93° azimuth).[h] The FAA has not yet conducted its review of SLLP's estimates for licensing purposes for the LOL. Although the FAA will be conducting a more detailed review of these estimates in its safety analysis through the licensing process, as estimates, they are considered the best information currently available, are not unreasonable and can be relied upon for the purposes of analyzing potential environmental impacts.

Summary of Possible Failure Scenarios and Impacts

Table 4-8 summarizes the possible failure scenarios and their potential environmental consequences.

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[g] The FAA's standard is based on the expected casualty rate (E_c), which is a function of dwell time, population density, and impact size. FAA's standards for an acceptable E_c is 30×10^{-6} or less.

[h] 1.18×10^{-6} corresponds to a chance of one in 847,000 of debris falling on a person, this is similar to the one-year odds of drowning in a bathtub. 3.26×10^{-6} corresponds to a chance of one in 306,000 of debris falling on a person, this is similar to the one-year odds of being struck and killed by a falling object.

TABLE 4-8. SUMMARY OF FAILURE SCENARIOS AND ASSOCIATED ENVIRONMENTAL IMPACTS

Failure Scenarios	Impact Area	Failure Rate	Potential Environmental Impacts
During initial Stage I Flight	Launch region	3×10^{-18}/sec (one in 30 trillion)	• ILV impacts open ocean virtually intact (Thrust Termination Failure), or in pieces (Explosive Failure) • Maximum quantity of propellants (e.g., kerosene) released and dispersed in the topmost ocean layer • Inert ILV fragments settle on ocean floor • Very low probability of debris falling on vessels (fishing, shipping, or air traffic) or marine organisms
During Stage I Flight	Downrange area of 800 km (500 mi)	26.94×10^{-5}/sec (one in 3,700)	• ILV (less most Stage I propellants) impacts open ocean after tumbling and fragmentation or explosion • Propellants (e.g., kerosene) released and dispersed in atmosphere through evaporation, residual reaching the topmost ocean layer (or combustion if Explosive Failure) • Inert ILV fragments settle on ocean floor • Very low probability of debris falling on vessels (fishing, shipping, or air traffic) or marine organisms
During Stage II Flight	Downrange area beyond 4,600 km (2,900 mi)	28.65×10^{-5}/sec (one in 3,450)	• Fragments of the ILV (less Stage I) surviving descent, impact open ocean • Propellants (e.g., kerosene) released and dispersed in atmosphere through evaporation, no propellant expected to reach the topmost ocean layer • Inert ILV fragments settle on ocean floor • Very low probability of debris falling on vessels (fishing, shipping, or air traffic) or marine organisms
During Upper Stage Flight Over Ocean Waters	Downrange area beyond 4,600 km (2,900 mi) affecting shipping	6.28×10^{-5}/sec (one in 15,800)	• Fragments of the Upper Stage (ILV less Stages I and II) surviving descent, impact open ocean • Propellants (e.g., kerosene) released and dispersed in atmosphere through evaporation, no propellant expected to reach the topmost ocean layer • Inert ILV fragments settle on ocean floor • Low probability of debris falling on vessels (fishing, shipping, or air traffic) or marine organisms
During Upper Stage Fight Over an Oceanic Island	Potentially populated areas	6.28×10^{-5}/sec (one in 15,800)	• Fragments of the Upper Stage surviving descent, impact terrestrial ecosystems or shallow, near-island ocean • Propellants (e.g., kerosene) released and dispersed in atmosphere through evaporation, no propellant expected to reach the ocean or land • Low probability of debris falling on vessels (fishing, shipping or air traffic) or on land or marine organisms
During Upper Stage Flight in vicinity of Panama Canal shipping	Western approaches to Panama Canal affecting shipping	6.28×10^{-5}/sec (one in 15,800)	• Fragments of the Upper Stage surviving descent, impact terrestrial ecosystems or coastal area • Propellants (e.g., kerosene) released and dispersed in atmosphere through evaporation, no propellant expected to reach the ocean or land • Low probability of debris falling on vessels (shipping) or land or marine organisms
During Upper Stage Flight Over South America	Potentially populated areas	6.28×10^{-5}/sec (one in 15,800)	• Fragments of the Upper Stage surviving descent, impact terrestrial ecosystems • Propellants (e.g., kerosene) released and dispersed in atmosphere through evaporation, no propellant expected to reach land • Low probability of debris falling on plants animals or people

4.1.3 Cumulative Impacts

Cumulative impacts to the environment result from incremental effects of the license applicant's proposed action or other alternatives when considered in combination with other past, present, and reasonably foreseeable future projects in the area. Cumulative impacts can result from minor, but collectively substantial, actions undertaken by various governments and U.S. agencies (Federal, state, and local) or by individuals. NEPA[i] requires the assessment of cumulative impacts resulting from all projects that are proposed, under construction, recently completed, or expected to be implemented in the near future.

The FAA is not aware of any past, present or reasonable foreseeable future projects in the area. Therefore, this EA focuses on the cumulative impacts associated with the proposed eight SLLP launches per year for five years, or a maximum of 40 launches, over the broader range of azimuths of the license applicant's proposed action. Section 4.6 of the February 11, 1999 EA evaluated the cumulative effects associated with up to six launches per year along a single azimuth. The February 11, 1999 EA concluded that SLLP operations at the proposed launch site, during launch, at the Home Port, and other connected actions including transport to and from the Home Port, would cause only insignificant and temporary impacts to the environment.

In general, all of the potential environmental impacts of the license applicant's proposed action would occur on a regional scale. No larger global impacts are expected to occur, mainly because of the small amounts of debris, hazardous material, and atmospheric emissions produced by the ILV relative to other anthropogenic activities (e.g., power generation and the scale of natural processes in the Pacific Ocean).

The potential cumulative effects for each phase of the launch operation are discussed below.

4.1.3.1 Home Port

The license applicant's proposed action differs from the February 11, 1999 EA in that it would involve eight launches per year. Other than the increase in the number of launches requiring processing, operations at the Home Port would be the same as those evaluated in the February 11, 1999 EA. The higher rate of throughput of both payload processing and marine vessel activity would remain within the capacity and regulatory approvals of all Home Port facilities, which were designed by SLLP to handle eight launches per year. Additional launches would generate more solid and hazardous waste material requiring disposal, although this increase may be offset by more efficient use of inventories (and less material being disposed of because it has expired). Home Port is allowed to store waste up to 90 days in its Central Hazardous Waste Accumulation area.

The Navy Mole facility, where the Home Port is located, is currently underutilized as compared to past levels of operation and development. The Navy Fuel Depot and the U.S. Department of Transportation Maritime Administration currently use the Navy Mole facility as well. It is planned that, in time, the former Navy facility will become part of the Alameda corridor, which is a rail transit system which moves containers from shipyards to railroad distribution points in Los Angeles. The additional launches would not place a significant burden on the Home Port's workforce or equipment; rather, the license applicant's proposed action would be expected to have a slight beneficial cumulative effect on socioeconomic conditions in the Home Port area through increased payrolls and material expenditures. Scrubber filters were installed at the Home Port facility to prevent UDMH vapors from escaping the building. Therefore, the license applicant's proposed action would have no adverse cumulative effects on the Home Port area.

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[i] This document is being developed based on the requirements of E.O. 12114, the implementation of which is guided by NEPA.

4.1.3.2 Pre-Launch

Transit of the LP and ACS from Home Port to the launch site would be like any normal maritime shipping and would be subject to U.S., United Nations (UN), and other international rules and regulations. The vessels carry and must comply with the following certificates:

- Safety Construction Certificate (per International Convention for the Safety of Life at Sea (SOLAS), 1974, as modified by Protocol 1988),
- International Load Line Certificate (per International Convention on Load Lines, 1966 as modified by Protocol of 1988),
- International Oil Pollution Prevention Certificate (per International Convention for the Prevention of Pollution from Ships, 1973, as modified in Protocol 1978 and Resolution MEPC.39(29),
- Mobile Offshore Unit Safety Certificate (per Code for the Construction and Equipment of MODUs),
- Safety Equipment Certificate (per SOLAS 1974, as amended 1988),
- Certificate of Compliance for Prevention of Pollution by Sewage From Ships (per Annex IV of the International Convention for the Prevention of Pollution from Ships, 1973, as modified by Protocol of 1978),
- Certificate of Compliance ILO No. 92 and 133 - Crew Accommodation (per International Labour Organization (ILO)), and
- International Tonnage Certificate (per International Convention of Tonnage Measurements, 1969).

The ships are further required to operate in compliance with the regulations of

1. The Government of The Republic of Liberia and carry the following certificates issued by Flag State:
    - Liberian Certificate of Registry
    - Liberian Ship Radio Station License
    - Liberian Minimum Safe Manning Certificate (per International Convention on Standards of Training, Certification and Watchkeeping, 1978, Resolution A.481(XII))
    - Liberian Special Purpose Ship Safety Certificate (per IMO Resolution A.534(13), Code of safety for Special Purpose Ships)
    - Liberian Self Propelled Mobile Offshore Unit Minimum Manning Scale for Marine Personnel

and

2. USCG Pollution Regulations Foreign Vessels, CFR Title 33 Part 155 and 159, and carry
    - Department of Transportation, USCG Vessel Certificate of Financial Responsibility (COFR), and
    - The State of California, Department. of Fish and Game, Certificate of Financial Responsibility.

The two additional round-trip transits by the ACS and LP per year would not contribute significantly to marine vessel traffic on the Pacific Ocean. Normal ACS ship wastes, including food waste, generated onboard are handled in accordance with the International Convention for the Prevention of Pollution (in compliance with MARPOL 73/78). All other solid waste is stored onboard and properly disposed of at the Home Port. Hazardous waste is accumulated onboard in hazardous waste accumulation areas and lowered to the pier at the Home Port when the vessels return. Waste is then taken to the Central Accumulation Area and disposed of in accordance with local, state, and Federal regulations. Therefore, the proposed vessel operations would cause no significant cumulative effects.

Upon arrival at the launch location, pre-launch operations would only involve final equipment and process checks, coupling of propellant loading lines to the ILV, transfer of kerosene and LOX, and the decoupling of the loading lines. The only aspect of pre-launch operations that poses any potential environmental impact would be propellant loading of the ILV. However, standard propellant operations are expected to result in no loss of kerosene or LOX other than an incidental loss of vapors from the fluid connections, which would dissipate immediately. These propellants are volatile materials and any small amount released to the atmosphere would dissipate shortly thereafter resulting in no cumulative effects. LOX released to the environment during pre-launch loading would instantaneously vaporize upon being exposed to ambient pressure and temperature. Almost 95 percent of any kerosene released during pre-launch loading, which reaches the ocean, would evaporate within a few hours in the tropical conditions observed at the LP. The remaining 5 percent would be dispersed due to turbulence in the top few meters/feet of the ocean and then degraded to CO_2 and H_2O through photochemical oxidation and microbial degradation within days of the initial release (Doerffer, 1992; National Research Council, 1985; Rubin, 1989; ITOPF, 2001; and EPA, 1999). Accordingly, the ocean environment would return to pre-launch conditions within a day or so of these possible effects. Section 4.1.2.2 above discusses the impact of kerosene on marine communities.

In the open ocean, fish and marine mammals are not likely to be harmed by the small amount of kerosene released during pre-launch operations for several reasons:

- As mentioned above, SLLP would not initiate the launch if any whales or sea turtles were detected in the vicinity of the LP (during the visual observation period prior to launch).
- Relatively few fish or marine mammals are located in this region of the Pacific Ocean.
- Kerosene (in the amounts that would possibly be released during normal pre-launch operations) would disperse and degrade within hours of the release, which would minimize potential exposure to marine organisms until the next launch, in roughly 45 days.

Therefore, no cumulative effects are expected from this short term and highly localized impact. Based on the license applicant's proposed action, pre-launch operations would cause no cumulative impact.

4.1.3.3 Launch

Repeated launches over the Pacific Ocean present the potential for cumulative impacts, which may be one of two types:

- Effects of debris blown into the ocean, and
- Effects of heat and noise on marine mammals.

Potential Cumulative Effects of Debris Blown into the Ocean

The launch may blow some scattered debris into the ocean, although experience from SLLP launches to date has resulted in little to no material being lost. Should debris be lost, it would primarily be pieces of insulation or other hardware used to shield the LP during launch. The LP is continually hardened and improved to reduce the probability of such damage in the future. To date, only small, nonmetallic covers on the fairing vents have been lost to the ocean during launch. Because these material inputs would be small in volume and inert, they would sink to the ocean floor or otherwise cause little disruption or impact to the ocean ecosystem. Deck washing and repainting would not cumulatively affect the environment since this maintenance activity would occur on the deck of the LP with any waste put into containers for proper disposal at the Home Port. Although the increase in the number of flights would possibly result in more debris entering the ocean environment, the volume of material would remain very small relative to the scale of the east central Pacific Ocean.

Potential Cumulative Effects of Heat and Noise on Marine Mammals

The energy from heat and sound at launch would have only a momentary impact on the ocean, and would be dissipated within minutes, leaving no lasting or cumulative impact (see Section 4.1.1.2). In terms of heat, a freshwater spray would be used to reduce the energy and heat generated during the launch through evaporation. The ocean surface would deflect and absorb (through evaporation) any additional thermal energy. Increases in ocean temperature would be very localized, minimal, and of short duration with no significant adverse effects on marine organisms, which are primarily concentrated at some depth away from the intense tropical solar energy.

In terms of noise, the steady noise from pre- and post-launch operations (e.g., from ship engines) may reach approximately 70 dB. Research indicates, however, that this level of steady noise would not have a detrimental affect on any animal that would linger in the area (Shulhof, 1994; Richardson, et al., 1997). Each launch, in turn, would be a separate isolated incident lasting less than one minute, with approximately 45 days elapsing between events.

No significant noise impacts would be expected from the launch because of the relatively low level and short duration of launch noise, and the unlikely, continual presence of the higher trophic level organisms near the launch site. After each launch, the ambient noise levels and the local and transient biological communities would return to normal conditions within minutes. Accordingly, no cumulative effects are expected from this short term and highly localized impact.

4.1.3.4 Potential Cumulative Effects of Successful Flights Over the Open Ocean, Oceanic Islands, and South America

The potential cumulative effects of 40 successful flights over a five-year period would include:

- Spent stages and the fairing falling to the ocean,
- Residual propellants from the spent stages released to the ocean and atmosphere, and
- Emissions being released to the atmosphere.

It should be noted that although the license applicant's proposed action includes launches on a range of azimuths from 82.6º to 97.4º, actual flights would likely be along a narrower band of azimuths. Specifically, market forecasts indicate the majority of SLLP payloads would be medium-to-heavy geosynchronous earth orbit (GEO) satellites. Thus, SLLP customers would primarily want an equatorial or near-equatorial azimuth (within an approximate range of 88.5º to 91.5º) for their satellites.

Accordingly, cumulative impacts from successful missions for forecast manifests over the five years of the license applicant's proposed action have been assumed along a concentrated area of the open ocean (i.e., into smaller spent stage deposition areas especially along the equator) as the worst case. Since the EA considers launches within the full range of proposed azimuths the cumulative effects of impacts discussed in this section for successful missions are also applicable for any distribution of launches throughout the proposed range 82.6º to 97.4º. The cumulative impacts of successive failed missions are considered in Section 4.1.3.6.

Potential Cumulative Effects of Spent Stages and Fairing Debris, Including Hazardous Materials

Stage I, fairing, and Stage II debris from each launch would fall into the equatorial Pacific Ocean. Of all the potential cumulative impacts listed above for successful launches, the stage and fairing debris would be the only launch byproduct that would remain in the environment for a long period of time. Stage I would be expected to occasionally break up upon descent, while Stage II is expected to always break up during its descent from a high altitude. These objects would cool almost immediately upon reaching the water surface, and with the exception of the fairing pieces, would sink to the ocean floor immediately. The stage debris would be composed primarily of aluminum, steel, and graphite composite components, some incorporated with various plastic, ceramic, and rubber parts. These components are largely inert and would have no long-term direct effect on the ocean ecosystem. Fairing pieces are relatively large and solid but lightweight sheets of composite material. Based on the launch industry's experience with composite fairings, the two halves of the SLLP fairing would break up into a number of rigid pieces that would initially float, but gradually become waterlogged and eventually sink to the ocean floor.

From a cumulative impact perspective, the increase in the number of launches would introduce more debris into the equatorial Pacific Ocean in the debris deposition areas. The amount of this debris, however, is negligible when compared to the expanse of the equatorial Pacific Ocean. To evaluate cumulative impacts, a worst case scenario would be that all 40 launches over a five-year period would use the same azimuth. This hypothetical scenario further assumes that the deposited stage and fairing debris do not overlap (i.e., the flattened stage debris sinks to the bottom of the ocean without overlapping with previously deposited stage debris). In such a scenario, only 0.00015 percent of the ocean floor in the impact zones (see Table 4-1) would be affected by the 40 launches. Even with this hypothetical worst case scenario, the resulting impact to the regional seafloor would be insignificant.

In addition, the ocean depths in the Stage I, fairing, and Stage II impact zones are over 2,000 m (1.2 mi), where marine population densities are relatively low. This debris may potentially provide a benefit in the form of new habitat, which could harbor ocean-floor life forms in much the same way as sunken ships in nearshore areas provide new protective habitat for colonization (Chou, et al., 1991).

Potential Cumulative Effects of Residual Propellants Released from the Spent Stages to the Ocean and Atmosphere

The Stage I fuel tanks may rupture prior to impact with the ocean surface, while Stage II tanks would likely always rupture prior to impact. Any residual kerosene that leaks or is released from the tanks during descent would evaporate. The residual kerosene (up to 2,750 kg, or 6,050 lbs, or 760 gallons per mission) remaining in the Stage I fuel tanks that remain intact during descent, would be released to the ocean surface upon impact. For a maximum of eight launches per year, an annual total of 22,000 kg (48,400 lbs or 6,080 gallons) of residual kerosene would be released. Under worst-case conditions (i.e., assuming 40 launches over five years with all fuel tanks rupturing upon impact on the ocean surface), approximately 110,000 kg (242,000 lbs or 30,400 gallons) of residual kerosene would potentially be released to the open ocean. During each launch, the kerosene would evaporate and degrade relatively quickly. Specifically, almost 95 percent of any kerosene released from spent stages would evaporate and be dispersed as smog by reacting with solar energy. This smog would dissipate in the environment with little to no impact. The remaining kerosene on the ocean surface would be dispersed by turbulence in the top few meters of the ocean, and be degraded to CO_2 and H_2O through photochemical oxidation and microbial degradation within days of the initial release (Doerffer, 1992; National Research Council, 1985; Rubin, 1989; ITOPF, 2001; and EPA, 1999). Therefore, the release of kerosene will not result in a cumulative effect because it will evaporate and dissipate in the environment.

LOX released to the environment as the spent stages break up during descent or on the ocean surface would instantaneously vaporize upon being exposed to ambient pressure and temperature. Accordingly, the ocean environment would essentially return to pre-launch conditions within a few days and before the next launch would occur (45 days later under the license applicant's proposed action).

Section 4.1.2.2 discussed the impact of kerosene on marine communities. In the open ocean, fish and marine mammals would not likely be harmed by the small amount of kerosene released from the rupture of Stage I fuel tanks for several reasons:

- Relatively few fish or marine mammals are located in this region of the Pacific Ocean.
- Kerosene would disperse and degrade within hours to days of the release, which would minimize potential exposure to marine organisms until the next launch, in roughly 45 days.

Considering the recovery time of the marine environment following the particular impacts of any single successful launch (i.e., several days as discussed above), and the time between launches (on the order of 45 days), impacts from propellant reaching the ocean would be short term and not evident by the time the next launch would occur. Therefore, no significant cumulative impacts are expected from released propellants.

Potential Cumulative Effects of Emissions to the Atmosphere

The proposed launches would affect the atmosphere as the LV engines burn propellants, with the associated generation of gas, vapor, and particulate matter emissions. Further the passage of the ILV through the atmosphere will create a short-term hole in the atmosphere. Table 4-9 shows the propellant profile for an individual launch, the annual total fuel profile assuming eight launches per year, and the cumulative total propellant profile assuming 40 launches over five years.

TABLE 4-9. ILV PROPELLANT PROFILE*

Propellant	Single Launch (kg (lbs))	Annual Total (8 Launches) (kg (lbs))	5-Year Total (40 Launches) (kg (lbs))
LOX	304,577 (670,069)	2,436,616 (5,360,555)	94,464,640 (207,822,208)
Kerosene**	117,048 (257,505)	936,384 (2,060,045)	37,455,360 (82,401,792)
N_2O_4/MMH/UDMH	95 (210)	760 (1,672)	30,400 (66,880)

*Does not include payload propellants.
** Data on the various types of kerosene under consideration can be found in Appendix E.

Total annual and cumulative (i.e., from 40 launches) emissions by altitude are provided in Table 4-10. The transit time for the ILV to go from launch through the troposphere and stratosphere is 120 to 140 seconds. This transit time is the basis for determining emission quantities at various altitudes.

TABLE 4-10. TOTAL ANNUAL EMISSIONS FOR EIGHT LAUNCHES AND CUMULATIVE

Atmospheric Layer	Altitude* Range (km (mi))	Annual Propellant Consumed (kg (lbs))	Annual Emission Products Assuming Eight Launches in kg (lbs)				
			CO	CO_2	H_2	H_2O	N_2
Lower Troposphere	0.0-2.0 (0.0-1.2)	493,712 (1,086,166)	136,264 (299,781)	215,256 (473,563)	3,456 (7,603)	138,736 (305,219)	0
Free Troposphere	2.0-10.0 (1.2-6.2)	552,800 (1,216,160)	152,576 (336,667)	241,024 (530,253)	3,872 (8,518)	155,336 (341,739)	0
Stratosphere	10.0-51.0 (6.2-32)	1,270,648 (2,795,425)	350,696 (771,531)	554,000 (1,218,800)	8,896 (19,571)	357,056 (785,523)	0
Mesosphere and Thermosphere	51.0-292 (32-182)	997,576 (2,150,667)	271,896 (598,171)	444,064 (976,940)	7,928 (17,442)	273,808 (602378)	290 (640)
	Annual (8 Launches) Total	3,314,736 (7,248,418)	911,432 (2,009,156)	1,454,344 (3,199,110)	24,152 (53,134)	924,936 (2,034,859)	290 (640)
	Cumulative 5-Year (40 Launches) Total	16,573,680 (36,242,090)	4,557,160 (10,045,780)	7,271,720 (15,995,550)	120,760 (265,670)	4,624,680 (10,174,295)	1,450 (3,200)

* Altitude ranges are rounded to the nearest km.

Most emissions would be caused by operation of the Stage I and II engines; smaller quantities of Upper Stage and payload propellants would be expended beginning at approximately 112 km (70 mi) and 35,000 km (22,000 mi) into the flight, respectively, the latter occurring beyond the range of potential atmospheric impacts. During normal Stage I operation, the emissions would be distributed throughout the trajectory in the lower layers of the atmosphere. Stage I separation occurs at an altitude of approximately 70 km (44 mi). Releases from Stage II would occur well above the stratosphere (approximately between altitudes 70 to 190 km [43 to 118 mi]). In addition, emissions are likely to dissipate within a matter of days to weeks. Recently, a consolidated aerosol cloud was observed intact, nine to 12 days after a launch vehicle, using a kerosene-LOX propellant system, was launched in Central Asia (Newman, et al., 2001).

The chemical compounds released during any 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 to global warming, the amount released by the ILV is not significant compared with the estimated amount of CO_2 cycled at the ocean surface in this region.[j] Estimates of net annual CO_2 flux (from the ocean to the atmosphere) in the area of the launch site are one billion kg (2.2 billion lbs) per 1° latitude/longitude square (Takahasi, et al., 1997). The 215,256 kg (473,563 lbs) predicted to be released annually by SLLP operations within the first two km of altitude represent an increase of 0.02 percent over natural emissions within the same 1° latitude/longitude square. Solar convection mixes the CO_2 inputs from launch and natural sources such that the effect from launch emissions would be assimilated within hours, long before the next launch would occur.

Global warming and ozone depletion would be cumulative effects of the license applicant's proposed action (see Section 4.1.1.2). However, the contribution of these emissions is negligible when compared to

[j] In this region, the primary source of CO_2 is from the ocean air-water interface.

other global sources, natural or man-made. There do not appear to be any specific thresholds for CO_2 in this region and therefore, specific comparisons cannot be made between the potential cumulative effects of the license applicant's proposed action and local thresholds.

The greatest risk for adverse atmospheric impacts due to ILV emissions would be in the area of ozone layer destruction. The ILV does not release chlorine or chlorine compounds (which contribute to ozone destruction) in or below the stratosphere, and the SLLP impact in this regard would not be significant. While chlorine and chlorine compounds are not the sole contributors to ozone destruction - they are a major source because they are ozone destructors rather than simply acting as precursors to ozone depleting substances.

4.1.3.5 Post-Launch

After a successful launch, the crew would reoccupy and clean the LP in preparation for transit to the Home Port. The cleaning operation includes collecting any debris left on the LP, freshwater washing of residues (i.e., scorched, carbonized paint), and repainting the deck of the LP. This waste is put into containers and sent back to Home Port for proper disposal

Based on prior launch experience, little to no debris is typically left on the LP; this has included some damaged insulation that was used to protect equipment from the intense heat. Any debris would be collected and handled onboard as solid waste for later disposal at Home Port. The debris, at the maximum, would total approximately 50 kg (110 lbs) per year (assuming eight launches), or 250 kg (550 lbs) for the proposed five-year period (assuming a maximum of 40 launches). This amount of solid waste is insignificant and would not present any adverse cumulative effects as part of the overall waste stream managed when the vessels return to the Home Port.

4.1.3.6 Cumulative Effects of Multiple Launch Failures in a Single Year in the Same Area

From a cumulative impact perspective, the most significant adverse environmental effect associated with the license applicant's proposed action would be multiple launch failures in a single year along the same azimuth in close proximity to one another. In considering a scenario that would result in a worst-case cumulative impact, two consecutive failures that affect the same geographic area are evaluated. Considering more than two consecutive mission failures, however, is not a practical consideration since such a circumstance would severely challenge the continued viability of the SLLP launch concept.

Time Period Between Launches Following a Failure for An Investigation

Following a launch failure, for both commercial and safety reasons, launches would not resume until the cause of the failure is determined and corrected to the satisfaction of the FAA and SLLP. Considering multiple, successive failures as a hypothetical worst case, given the mandatory investigation process and for the reasons discussed below, the two successive failures would occur many months apart.

Any future SLLP mission failure would be followed by a mandatory FAA investigation lasting at least four and perhaps as much as 12 months before another mission would occur. The FAA conducted a failure investigation following the SLLP Mission 3 failure, which occurred on March 12, 2000. In this case the cause was established within 40 days and the entire investigation was completed within four months. This is atypical for the launch industry in which investigations can take up to 12 months to complete, with a return-to-flight occurring sometime later.

Cumulative Effects of Two Successive Failures in the Same Area

In the context of two successive failures along the same azimuth or in close proximity to one another, there are several failure scenarios that would affect different portions of the environment (i.e., the ocean, Oceanic Islands, Central or South America). These are discussed below.

Possible Failure Scenarios that could have Cumulative Effects on the Ocean

There are several possible failure scenarios that could cumulatively affect the ocean environment:
- Launch abort just prior to launch,
- Thrust termination failure, and
- Explosive failures.

A launch abort just prior to launch occurred during the SLLP Mission 6 launch planned for January 8, 2001. No hazardous materials or propellants were observed contacting the ocean surface and fewer emissions were released to the atmosphere than would occur under a successful launch because less of the propellant was combusted (see Section 4.1.2.1 for more detailed description). Therefore, this abort scenario would not have any significant direct or cumulative effects.

The thrust termination and explosion scenarios represent true mission failures and could possibly occur at the LP (explosive failure only) or at any point during Stage I, II, or Upper Stage flight over the ocean. Upper Stage failure could also occur over the Oceanic Islands or Central or South America and is described below. As analyzed in Section 4.1.2.2 above, thrust termination failure during the first 20 seconds of flight would likely result in the ILV falling intact and rupturing on the ocean surface thereby releasing nearly all of the ILV's propellants and hazardous materials directly to the ocean. This is considered the worst-case failure scenario. Of the explosive failure scenarios, an explosive failure at the LP would have the most significant effects on the ocean because there would be less time for combustion before the propellants and other hazardous materials would reach the ocean surface. Nevertheless, the environmental effects to the ocean of this scenario would still be less than a thrust termination early in flight because more of the propellants and hazardous materials would be consumed in the explosion and the LP provides some degree of protection for the ocean and would likely retain pieces of the ILV. Thrust termination failures later in flight would result in the ILV tumbling, breaking up due to stresses, and possibly exploding if flammable materials are exposed to hot engine parts during the fall. In either case (i.e., with or without an explosion), most of the propellants and other hazardous materials would either incinerate or evaporate before reaching the ocean surface with minimal effects on the ocean other than relatively inert materials settling on the ocean floor. Explosive failures at the LP or during Stage I, II, or Upper Stage flight would result in most of the ILV being consumed and most of the propellants and other hazardous materials being burned before reaching the ocean surface with minimal effects on the ocean other than relatively inert materials settling on the ocean floor.

Therefore, thrust termination failure early in flight is considered the worst-case scenario in terms of ocean effects and the cumulative effects of two consecutive thrust termination failures early in flight in close proximity to one another is addressed below. A single occurrence of this scenario is addressed in Section 4.1.2.2 of this EA, which provides the technical basis and supporting references for the consideration of possible cumulative impacts.

Potential Cumulative Effects of Propellants and Other Hazardous Materials Released into the Ocean Under the Worst-Case Failure Scenario

Under the thrust termination failure early in flight scenario, the ILV would fall intact and rupture on the ocean surface. Nearly all of the ILV's propellants and other hazardous materials would remain unused and would be released directly to the ocean. This would include approximately 304,577 kg (670,069 lbs) of LOX, 117,048 kg (257,505 lbs) of kerosene, 95 kg (210 lbs) of N_2O_4/MMH/UDMH, and minor amounts of starting fluids (see footnote "d" on page 4-13 above). In the event of two successive thrust termination failures early in flight, the amount of propellants and other hazardous materials released into the ocean would double. However, the cumulative impacts are expected to be insignificant. For a discussion of the types and potential impacts of batteries used in the Zenit-3SL please refer to section 4.1.2.3 "Effects of Debris, Including Hazardous Materials in Open Ocean." The cumulative impacts are expected to be insignificant.

For a discussion of the impacts of releases of kerosene and LOX please refer to section 4.1.2.2 "Release of Hazardous Materials to the Ocean." No cumulative environmental impacts are expected due to releases to the ocean.

Recovery Timeframe

Even under the worst-case failure scenario, where the entire amount of propellants and other hazardous materials on the ILV are released directly to the ocean, the ocean environment would recover to natural conditions within a week. The subsequent launch, accounting for the required investigation, would not occur for four to 12 months. The elapsed period of four to 12 months would provide more than sufficient time for the ocean environment to recover, even if the subsequent launch results in a thrust termination failure early in flight and the ILV impacts the same area of the ocean surface. Therefore, no cumulative impact to the ocean environment would occur as a result of two successive, worst-case failures, even those that happen to affect the same area of the ocean.

Potential Cumulative Effects on the Oceanic Islands or South American Landmasses Under the Worst-case Failure Scenario

The Oceanic Islands and Central or South America could only be affected by a possible failure during Upper Stage flight (any failures earlier in flight would only affect the ocean environment). A possible Upper Stage failure could be the result of either thrust termination or explosion. As discussed below, both of these types of failures would have the same environmental effects and therefore are collectively considered the worst-case scenario in terms of potential cumulative impacts to the Oceanic Islands or Central or South America. The cumulative effects of two consecutive Upper Stage failures that strike the Oceanic Islands or Central or South American landmasses in close proximity to one another are addressed below. A single occurrence of this scenario is addressed in Section 4.1.2.3 of this EA, which provides the technical basis and supporting references for this consideration of cumulative impacts.

Potential Cumulative Effects of Propellants and Other Hazardous Materials Released Onto Landmasses

A failure during Upper Stage flight would result in most of the ILV components and all of the propellants and other hazardous materials being heated in the atmosphere and vaporized or burned from frictional effects before reaching the Earth's surface because of the speed and altitude of the Upper Stage during this period of flight. Approximately 42 components from the Upper Stage and payload would survive reentry friction and reach the Earth's surface (see Table 4-5). These objects range from 0.04 m (0.13 ft) to 1.2 m (3.9 ft) and total approximately 10 m^2 in size. Potential cumulative impacts from releases resulting from an Upper Stage failure would be insignificant.

Recovery Timeframe

As described above, the only effects of an Upper Stage failure on the Oceanic Islands or Central or South American landmasses would be from the components that survive reentry. These components would be inert after being subject to the intense heat generated while re-entering the upper atmosphere. The surviving components, which would cool during the descent through the lower atmosphere, would be unlikely to pose a risk of fire. Therefore, the only potential cumulative effects from the components would be the physical damage associated with striking terrestrial plant or animal species.

If debris struck an animal, it could be injured or killed. There is an extremely remote chance that a threatened or endangered species could be hit by falling debris. Should such harm occur, replacement in terms of population dynamics would depend on the individual species' abundance, reproduction characteristics, and recruitment success.

No scientific studies were found specific to this scenario, however, recovery following severe events (e.g., hurricanes, logging, and poor farming practices) in tropical regimes have been studied. These reports indicate that vegetation in moist regimes would recover from these more severe conditions over a few years to decades, respectively (Mack, 1998; Kuerpick, 1997; Boucher, 1997; Living Earth, 2001; and Donfack, 1995). In light of habitat recovery times in these extreme situations, and given the significantly smaller impact that could possibly occur during a failure of the Upper Stage, it may be inferred that any damage to the islands' habitats would be minor, but could require some period of time to fully recover.

Recovery time would be relatively long in this scenario as compared with the ocean environment, and any damaged or injured plants or animals may not recover by the time of the subsequent launch (assuming four to 12 months for the failure investigation). Assuming that the subsequent launch also fails and that the surviving components strike approximately the same portion of the Oceanic Islands or Central or South American landmasses, there would be additional incremental injury to the plant or animal or the local ecosystem.

These additional cumulative impacts, however, would likely be minor, with the exception of any endangered species that may be hit. The probability of these components falling on the Galapagos Islands, for example, is very low (0.00067, see Table 4-6), and the probability of striking an endangered species would be even more remote.

Although an injured individual or ecosystem population may not have had the time to return to pre-event conditions, the incremental damage caused by the second event would marginally prolong recovery time for that species or for the ecosystem as a whole. For example, a delay of six months between two launches that end in failures that cause physical damage to exactly the same area in a rain forest would, in effect, add approximately six months to the time it would take for that rain forest community to recolonize the damaged area. Accordingly, cumulative effects following two successive, worst-case failures affecting the same area would only marginally delay the recovery process. In this hypothetical case, the second impact would double the affected area, marginally prolonging the recovery of the first or second impact due to the corresponding impairment of neighboring habitat that would otherwise facilitate recovery through recolonization (i.e., reestablishment of floral or faunal colonies). However, the likelihood of such events occurring is extremely small.

4.1.4 Other Environmental Concerns

4.1.4.1 Environmental Justice

Although E.O. 12114 requires consideration of Federal actions abroad with the potential for impacts to the environment, the Executive Order specifically defines environment as "the natural and physical environment and excludes social, economic and other environments…." Therefore, potential impacts to environments other than the natural and physical are not analyzed in this document. Nevertheless, given the limited amount of time that the LP and the ACS will be present at the launch location, social and economic considerations are assumed to be negligible.

4.1.4.2 Exclusive Economic Zones

Under successful flight conditions, any potential environmental impact from the stages and fairing would occur outside the EEZ—defined as 200 nautical miles (370 km or 230 statute miles) of all countries bordering the affected environment. (Table 4-2 lists the closest expected distances between stage and fairing impacts to the nearest land areas.) Only in the event of a mission failure during Upper Stage flight would the deposition of debris potentially occur within an EEZ. Potential environmental impacts of such an occurrence are discussed in Section 4.1.2.3. As with all mission failures, an intensive investigation as to the cause of the failure would be completed. A return to flight for the SLLP project would be re-instated only after corrective actions are undertaken to the satisfaction of the FAA and SLLP.

4.1.4.3 Social and Economic Considerations

Although E.O. 12114 requires consideration of Federal actions abroad with the potential for impacts to the environment, the Executive Order specifically defines environment as "the natural and physical environment and excludes social, economic and other environments…." Therefore, potential impacts to environments other than the natural and physical are not analyzed in this document. Nevertheless, under the license applicant's proposed action SLLP would occupy the launch location for two to seven days during each launch cycle (or up to 56 days per year). For each launch, the LP and ACS sail directly to the launch location and return directly to the Home Port. The relatively brief duration of activity and the relative degree of isolation of the launch location provide an effective barrier between the license applicant's proposed action and the social, economic, and cultural character of Kiribati society. Since there would be no significant interaction with Kiribati society, the presence of the ACS and LP for up to 56 days per year at the launch site would have no significant social or economic effects.

The license applicant's proposed action would have no effect on the social or economic conditions of the Galapagos Islands, Cocos Island, or Malpelo Island, or that portion of South America that lie under the flight path as for successful launches, the ILV would simply fly over these areas and would have no beneficial or adverse effects. Under the mission failure scenarios, only a failure during the Upper Stage would have any effect on the Oceanic Islands or Central or South America, and this would be limited to the few fragments of the Upper Stage and payload that would not burn up or vaporize in the atmosphere. The deposition of this debris on the Oceanic Islands or Central or South America would have no significant effect on social or economic conditions.

4.2 ENVIRONMENTAL EFFECTS OF ALTERNATIVE WITH AVOIDANCE OF THE OCEANIC ISLANDS

This section of the EA evaluates the environmental effects of the alternative to the license applicant's proposed action in which the Oceanic Islands are avoided. Under this alternative, only azimuths between 82.60º to 83.28º, 84.50º to 85.07º, 86.36º to 88.80º and 92.89º to 97.4º would be used. While the environmental impacts described in Section 4.1 would largely apply, a different analysis would apply in regard to the Oceanic Islands and the corresponding portions of South American continent, which would not be overflown in this alternative action.

The evaluation of this alternative uses the same operational phases and actions (i.e., Home Port, pre-launch, launch, successful flight, post-launch and possible failure scenarios) to frame the discussion as those identified in Section 4.1. Where discussions of impacts are identical to those for the license applicant's proposed action the reader is referred to that section to avoid redundancy.

4.2.1 Environmental Effects of Successful Flight

4.2.1.1 Home Port

The impacts to Home Port from this alternative are the same as those discussed in Section 4.1.1.1.

4.2.1.2 Pre-launch, Launch, and Stage I and II Flight Over Open Ocean

The impacts to pre-launch, launch, and Stage I and II flight over open ocean from this alternative are the same as those discussed in Section 4.1.1.2.

4.2.1.3 Upper Stage Flight Over South America

Upper Stage and payload flight would progressively transit over open ocean waters and the northern part of South America. Upper Stage flight during a successful mission would have no effect on the ocean or land environments or the lower atmosphere because its operation occurs at very high altitudes. Launch impacts from this alternative are the same as those discussed in Section 4.1.1.3.

4.2.1.4 Post-Launch Operations

The impacts of post launch operations from this alternative are the same as those discussed in Section 4.1.1.4.

4.2.2 Environmental Impacts of Possible Failed Mission Scenarios

The impacts of possible failed mission scenarios from this alternative are the same as those discussed in Section 4.1.2, except for potential impacts to Oceanic Islands which would be avoided.

4.2.2.1 Failure at the Launch Platform Scenario

The impacts of failure at the launch platform from this alternative are the same as those discussed in Section 4.1.2.1.

4.2.2.2 Failure During Stage I and II Flight Over Open Ocean Scenario

The impacts of failures during Stage I and II flight from this alternative are the same as those discussed in Section 4.1.2.2.

4.2.2.3 Failure During Upper Stage Flight Over the Ocean or South America Scenario

The impacts of failure during Upper Stage flight for this alternative would be the same as those discussed in Section 4.1.2.3 with the exception that no impact would occur on or near the Oceanic Islands.

Summary of Failure Scenarios and Impacts

Table 4-8 summarizes the estimated types of failures and their consequences for several different failed mission scenarios.

4.2.3 Cumulative Impacts

The potential cumulative impacts from this alternative are the same as those discussed in Section 4.1.3.

4.2.3.1 Home Port

The potential cumulative impacts to the Home Port facility from this alternative are the same as those discussed in Section 4.1.3.1.

4.2.3.2 Pre-Launch

The potential cumulative impacts of pre-launch operations from this alternative are the same as those discussed in Section 4.1.3.2.

4.2.3.3 Launch

The potential cumulative impacts of launch operations from this alternative are the same as those discussed in Section 4.1.3.3.

4.2.3.4 Successful Flight Over the Open Ocean and South America

The potential cumulative impacts of successful flights over the open ocean and South America from this alternative are the same as those discussed in Section 4.1.3.4. The exception is that no potential cumulative impact would occur on or near the Oceanic Islands.

4.2.3.5 Post-Launch

The potential cumulative impacts of post-launch operations from this alternative are the same as those discussed in Section 4.1.3.5.

4.2.3.6 Cumulative Effects of Multiple Launch Failures in a Single Year in the Same Area

The potential cumulative impacts of multiple launch failures in a single year in the same area from this alternative are the same as those discussed in Section 4.1.3.6.

Possible Cumulative Effects of Two Successive Failures in the Same Area

In the context of two successive failures along the same azimuth or in close proximity to one another, there are several failure scenarios that would affect different portions of the environment (i.e., the ocean, and Central or South America). These are discussed below.

Possible Failure Scenarios Affecting the South American Landmass

Central or South America could only be affected by a failure during Upper Stage flight (any failures earlier in flight would only affect the ocean environment). An Upper Stage failure could be the result of either thrust termination or explosion. Both of these types of failures would have the same environmental effects and therefore are collectively considered the worst-case scenario in terms of impacts to Central or South America. A single occurrence of this scenario is addressed in Section 4.1.2.3 of this EA, which provides the technical basis and supporting references for this consideration of cumulative impacts. The potential cumulative impacts of launch operations from this scenario are the same as those discussed in Section 4.1.3.6.

4.2.4 Other Environmental Concerns

4.2.4.1 Environmental Justice

The impacts on environmental justice from this alternative are the same as those discussed in Section 4.1.4.1.

4.2.4.2 Exclusive Economic Zones

The impacts on exclusive economic zones from this alternative are the same as those discussed in Section 4.1.4.2.

4.2.4.3 Social and Economic Considerations

See Section 4.1.4.3.

4.3 ENVIRONMENTAL EFFECTS OF ALTERNATIVE WITH AVOIDANCE OF THE GALAPAGOS ISLANDS

This section of the EA evaluates the potential environmental effects of the alternative to the license applicant's proposed action in which the Galapagos Islands are avoided. Under this alternative, only azimuths between 83.60º to 86.80º, and 92.89º to 97.40º would be used. While the environmental impacts described in Sections 4.1 and 4.2 above would largely apply, a different analysis would apply in regard to Galapagos Islands and the corresponding portions of the South American continent, which would not be overflown under this alternative action.

The evaluation of this alternative uses the same operational phases and actions to frame the discussion as were identified in Section 4.1 for the license applicant's proposed action. The reader will be directed to the relevant section in this EA.

4.3.1 Environmental Effects of Successful Flight

4.3.1.1 Home Port

The impact to Home Port from this alternative will be the same as those discussed in Section 4.1.1.1.

4.3.1.2 Pre-launch, Launch, and Stage I and II Flight Over Open Ocean

The impact to pre-launch, launch, and Stage I and II flight over open ocean from this alternative will be the same as those discussed in Section 4.1.1.2.

4.3.1.3 Upper Stage Flight Over the Oceanic Islands and South America

Upper Stage and payload flight would progressively transit over open ocean waters, the Oceanic Islands (excluding the Galapagos Islands), and the northern part of South America. Upper Stage flight during a successful mission would have no effect on the ocean or land environments or the lower atmosphere because its operation occurs at very high altitudes. Launch impacts from this alternative are the same as those discussed in Section 4.1.1.3.

4.3.1.4 Post-Launch Operations

The impacts of post launch operations from this alternative are the same as those discussed in Section 4.1.1.4.

4.3.2 Environmental Impacts of Possible Failed Mission Scenarios

The impacts of possible failed mission scenarios from this alternative are the same as those discussed in Section 4.1.2, except for potential impacts to the Galapagos Islands which would be avoided.

4.3.2.1 Possible Failure at the Launch Platform

The impacts of possible failure at the launch platform from this alternative are the same as those discussed in Section 4.1.2.1.

4.3.2.2 Possible Failure During Stage I and II Flight Over Open Ocean

The impacts of possible failures during Stage I and II flight from this alternative are the same as those discussed in Section 4.1.2.2.

4.3.2.3 Possible Failure During Upper Stage Flight Over the Ocean, Oceanic Islands (excluding the Galapagos Islands), or South America

The impacts of possible failure during Upper Stage flight for this alternative would be the same as those discussed in Section 4.1.2.3 with the exception that no impact would occur on or near the Galapagos Islands.

Summary of Possible Failure Scenarios and Impacts

Table 4-8 summarizes the estimated types of failures and their consequences for several different possible failed mission scenarios.

4.3.3 Cumulative Impacts

The potential cumulative impacts from this alternative are the same as those discussed in Section 4.1.3.

4.3.3.1 Home Port

The potential cumulative impacts to the Home Port facility from this alternative are the same as those discussed in Section 4.1.3.1.

4.3.3.2 Pre-Launch

The potential cumulative impacts of pre-launch operations from this alternative are the same as those discussed in Section 4.1.3.2.

4.3.3.3 Launch

The potential cumulative impacts of launch operations from this alternative are the same as those discussed in Section 4.1.3.3.

4.3.3.4 Successful Flight Over the Open Ocean, Oceanic Islands (excluding the Galapagos Islands), and South America

The potential cumulative impacts of successful flights over the open ocean Oceanic Islands excluding the Galapagos Islands and Central and South America from this alternative are the same as those discussed in Section 4.1.3.4.

4.3.3.5 Post-Launch

The potential cumulative impacts of post-launch operations from this alternative are the same as those discussed in Section 4.1.3.5.

4.3.3.6 Cumulative Effects of Multiple Launch Failures in a Single Year in the Same Area

The potential cumulative impacts of multiple launch failures in a single year in the same area from this alternative are the same as those discussed in Section 4.1.3.6.

Possible Cumulative Effects of Two Successive Failures in the Same Area

In the context of two successive failures along the same azimuth or in close proximity to one another, there are several possible failure scenarios that would affect different portions of the environment (i.e., the ocean, Cocos or Malpelo Island, South America).

Possible Failure Scenarios Affecting Cocos Island, Malpelo Island, or South American Landmasses

The Cocos and Malpelo Islands and Central and South America could only be affected by a failure during Upper Stage flight (any failures earlier in flight would only affect the ocean environment). A possible Upper Stage failure could be the result of either thrust termination or explosion. As discussed below, both of these types of failures would have the same environmental effects and therefore are collectively considered the worst-case scenario in terms of Cocos and Malpelo Islands or Central or South American effects. The cumulative effects of two consecutive Upper Stage failures that strike the Cocos and Malpelo Islands or Central or South American landmass in close proximity to one another is addressed below. A single occurrence of this scenario is addressed in Section 4.1.2.3 of this EA, which provides the technical basis and supporting references for this consideration of cumulative impacts.

Possible Cumulative Impacts of Propellants and Other Hazardous Materials Released Onto Landmasses

For a discussion of the possible cumulative impacts of propellants released onto landmasses please refer to Section 4.1.3.6 *"Potential Cumulative Effects of Propellants and Other Hazardous Materials Released onto Landmasses"* with the exception that no impact would occur on or near the Galapagos Islands.

4.3.4 Other Environmental Concerns

4.3.4.1 Environmental Justice

See Section 4.1.4.1.

4.3.4.2 Exclusive Economic Zones

The impacts on exclusive economic zones from this alternative are the same as those discussed in Section 4.1.4.2.

4.3.4.3 Social and Economic Considerations

See Section 4.1.4.3.

4.4 NO ACTION ALTERNATIVE

Under the No Action alternative FAA would not issue the LOL to SLLP for eight launches per year for five years, for azimuths ranging from 82.6° to 97.4° or the launch specific license for a 90° launch of the Galaxy IIIC. SLLP would continue to prepare and submit launch-specific applications for individual licenses to launch up to six satellites per year within the launch parameters analyzed in the February 11, 1999 EA. Home Port operations would continue at their present level. If a customer required a different launch azimuth, SLLP would prepare individual environmental analyses and documentation (to support launch-specific applications) for each launch.

The launch-specific application and license process would be repeated approximately every 60 days, as warranted by commercial demand.

4.5 SUMMARY OF ENVIRONMENTAL IMPACTS FOR LICENSE APPLICANT'S PROPOSED ACTION AND ALTERNATIVES

Table 4-11 provides a brief summary of the potential environmental impacts associated with the license applicant's proposed action and reasonable alternatives including no action. Table 4-11 provides a brief summary comparing the license applicant's proposed action and alternatives.

TABLE 4-11. POTENTIAL ENVIRONMENTAL EFFECTS OF THE LICENSE APPLICANT'S PROPOSED ACTION ON THE ATMOSPHERE, OPEN OCEAN, OCEANIC ISLANDS, AND SOUTH AMERICA

		License Applicant's Proposed Action	Alternative with No Oceanic Island Overflight	Alternative with Avoidance of Galapagos Islands	No Action
	Probability of Effect[k]	**Potential Environmental Effects**	**Potential Environmental Effects**	**Potential Environmental Effects**	**Potential Environmental Effects**
Atmosphere					
Release of residual propellants (kerosene, LOX)	Unavoidable[l]	Insignificant	Same as license applicant's proposed action	Same as license applicant's proposed action	Same as impacts in February 11, 1999 EA
Release of combustion emissions (CO, CO_2, H_2, and H_2O)	Unavoidable	Insignificant	Same as license applicant's proposed action	Same as license applicant's proposed action	Same as impacts in February 11, 1999 EA
Open Ocean					
Debris deposition[m]	Unavoidable	Insignificant	Same as license applicant's proposed action	Same as license applicant's proposed action	Same as impacts in February 11, 1999 EA
Release of residual propellants into ocean	Unavoidable	Insignificant	Same as license applicant's proposed action	Same as license applicant's proposed action	Same as impacts in February 11, 1999 EA

[k] In Table 4-11, the column titled "Probability of Effect" refers to the likelihood of the potential effect occurring.

[l] In this instance, unavoidable effects refer to those impacts that will occur because they are part of the normal operations.

[m] In this instance, debris refers to jettisoned spent stages that are part of the normal operations of expendable launch vehicle launches.

		License Applicant's Proposed Action	Alternative with No Oceanic Island Overflight	Alternative with Avoidance of Galapagos Islands	No Action
	Probability of Effect	**Potential Environmental Effects**	**Potential Environmental Effects**	**Potential Environmental Effects**	**Potential Environmental Effects**
Injury or mortality of marine organisms from heat and noise associated with launch	Unlikely	Insignificant	Same as license applicant's proposed action	Same as license applicant's proposed action	Same as impacts in February 11, 1999 EA
Injury or mortality of marine organism from impact with falling debris	Unlikely	Insignificant	Same as license applicant's proposed action	Same as license applicant's proposed action	Same as impacts in February 11, 1999 EA
Oceanic Islands					
Damage to terrestrial habitat/vegetation from impact with falling debris	Unlikely	Insignificant	None	Probability of impact is slightly lower than license applicant's proposed action (reduced by 0.00067)	Same as impacts in February 11, 1999 EA
Injury or mortality of terrestrial organism from impact with falling debris	Unlikely	Insignificant	None	Probability of impact is slightly lower than license applicant's proposed action (reduced by 0.00067)	Same as impacts in February 11, 1999 EA
Damage to coral reef communities from impact with falling debris	Unlikely	Insignificant	None	Approximately the same as license applicant's proposed action since majority of coral reefs surround Cocos Island and not the Galapagos	Same as impacts in February 11, 1999 EA

		License Applicant's Proposed Action	Alternative with No Oceanic Island Overflight	Alternative with Avoidance of Galapagos Islands	No Action
	Probability of Effect	Potential Environmental Effects	Potential Environmental Effects	Potential Environmental Effects	Potential Environmental Effects
South America					
Damage to terrestrial habitat/vegetation (i.e., rain forest) from impact with falling debris	Unlikely	Insignificant	Same as license applicant's proposed action	Same as license applicant's proposed action	Same as impacts in February 11, 1999 EA
Damage to commercial vessel or aircraft or injury or mortality of human from impact with falling debris	Unlikely	Insignificant	Same as license applicant's proposed action	Same as license applicant's proposed action	Same as impacts in February 11, 1999 EA

4.6 ENVIRONMENTAL MONITORING AND PROTECTION PLAN (EMPP)

The EMPP is an evolving document, incorporating improvements approved by the FAA, including those identified by the FAA or SLLP, or those recommended by public reviewers (see Appendix G of this document for the current EMPP). The plan consists of four elements:

- Visual observation for species of concern.
- Remote detection of atmospheric effects during launch.
- Collection of surface water samples to detect possible launch effects.
- Notification to mariners and air traffic.

By reviewing EMPP reports, for example, the FAA determined that more specific visual observation training of personnel was required. Additional training was conducted and improvements in this area continue to be evaluated periodically. Similarly, the water sampling processing has undergone changes to improve the accuracy of results. SLLP has implemented a three pre-launch and nine post-launch water sampling method in which samples are taken on points on a grid located down-current from the LP and positioned to intercept waters flowing past the LP, as estimated by the set and drift of the surface current. Additionally, SLLP and FAA are currently evaluating automated water sampling equipment and photometering equipment to determine if their use would improve the accuracy of results while maintaining the required level of safety for onboard crew. Nighttime water sampling occurred once but it was determined to pose an unacceptable safety risk to the crew. The notification process for mariners and air traffic has also been refined, as feedback to prior notices has been collected.

As part of SLLP's ongoing EMPP program, crew members have made visual observations for species of concern. Sightings have included sharks, tuna, dorado, and gulls, all not included as species of concern. The only species of concern (as listed in the EMPP) to be sighted to date was one Hawaiian Dark-Rumped Petrel, sighted on the fourth launch.

Also as part of SLLP's ongoing EMPP program, crew members have taken samples of the downstream surface water within 30 minutes of launch to analyze for the presence of kerosene on the ocean surface. For six of the seven launches to date water sampling has been conducted (water sampling was not conducted during one night launch for safety reasons). The chemical analysis for each of these samples (three pre-launch and nine post-launch) has returned a result of "no detection" for kerosene. Sampling methods are being reviewed to improve the ability to capture possible contaminant releases during the pre- and post-launch period.

Under the EMPP, SLLP collects video- and radar-scan data on atmospheric effects of each launch. Data are available for three of the four launches to date. Visible plumes were recorded on two of the launches; night conditions and low-cloud cover prevented video scans for the other two launches. The results of the scans for the fourth mission, by way of example, are discussed below.

A visible plume associated with the launch was sighted between 61 and 72 seconds after launch. This equates to the base of the plume beginning at approximately 13.5 km (8.4 mi), and the top of the plume ending at 18.4 km (11.5 mi) above sea level. In the tropics, a layer of High Altitude Tropical (HAT) cirrus clouds (ice crystals) extends about 3 to 5 km (1.9 to 3.1 mi) below the tropopause. The HAT cirrus clouds are occasionally visible; at other times, the concentration of ice crystals is not sufficient to be visible to the naked eye. Based on data SLLP obtained from a weather balloon released 40 minutes before the launch, the base of the tropopause was at approximately 16.2 km (10.1 mi) at the time of launch. The base of the ILV contrail was thus observed approximately 2.7 km (1.7 mi) below the tropopause base.

As the ILV plume, which is rich in water vapor, transits the lower layer of the HAT, ice crystals form in the water vapor of the plume and mix with existing ice crystals. The increased concentrations of ice crystals make the contrail visible. This process involves the same mechanism that generates airplane contrails. As the ILV transitions into the stratosphere, where ambient moisture is practically nonexistent, ice crystal formation is dramatically reduced and the contrail abruptly terminates at about 18.4 km (11.5 mi).

C-Band Doppler weather radar scans have generated data for three of the four launches. The radar scan is used to determine the presence of particles within the nonvisible spectrum. No particles were detected in the second and third launches. In the first launch particles were detected with a density reading of 5 particles per cubic centimeter (cm^3); however, because no visible plume was detected at the same time, it is hypothesized that the particles were less than 1mm in diameter. It is further hypothesized that this concentration of particles was possible only with the aid of external atmospheric features. In fact, a significant wind-shear was detected at the launch site at an 8-km (5 mi) altitude from this analysis.

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6.0 GLOSSARY

accretion	Gradual buildup of land or seafloor formed by magma rising to the surface along some tectonic plate boundaries.
agouti	A neotropical burrowing rodent, similar to a raccoon.
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.
basalt	A dark-colored, fine-grained rock of volcanic origin.
bathymetry	Generally, the study of the bathyal zone of the ocean, extending from the seaward edge of the continental shelf down to approximately 4,000 meters below the surface.
benthic	Pertaining to or found at or on the bottom of a large body of water.
biomass	The dry weight of living matter present in a species or ecosystem pollution for a given habitat area or volume.
boundary layer	The lowest portion of the atmosphere where the fractional effects of the earth's surface are substantial.
breaching	Usually in reference to whales, a formal term for when a fish or mammal breaks the ocean surface.
caldera	Volcanic basin, commonly at the summit of a volcano, formed by explosion during eruption or the collapse of the volcanic summit.
capybara	A large (1.2-1.5 m) neotropical, semi-aquatic rodent; the largest known rodent.
crater lake	Lake, usually with a diameter at least three times depth, lying inside a volcanic caldera.
Coriolis effect	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	Dermersal 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 (EEZ)	An offshore boundary, set at 200 nautical miles (320 km), establishing a nation's economic sovereignty over the resources present within that perimeter.
failure	A condition of a component, subsystem or system in which the intended design or specified operation is not met.
flight azimuth	The angular direction of the launch and flight trajectory of a launch vehicle measured in degrees.
food chain	Scheme for describing feeding relationships by trophic levels among the members of a biological community.
fumarole	Natural vent formed by escaping volcanic steam and gases.
geosynchronous	Designating or of a satellite or spacecraft in an orbit above the equator revolving at a rate of speed synchronous with that of the earth's rotation so as, in effect, to be hovering over a point on the earth's surface.
habitat	The physical environment in which a plant or animal lives.
impact limit line (ILL)	A predetermined line defining a limit beyond which a failed ILV or its jettisoned spent stages will not be allowed to impact on the ground, in order to protect people or property.
inert	Not reactive; lacking a usual or anticipated chemical or biological action.
instantaneous impact point (IIP)	An impact point following thrust termination of a launch vehicle. The IIP may be calculated with or without atmospheric drag effects.
ionosphere	That part of the earth's upper atmosphere ionized by solar ultraviolet radiation so that the concentration of free electrons affects the propagation of radio waves.
lava tube	Natural conduits through which lava travels beneath the surface of a lava flow; partially empty conduits beneath the ground.
lithosphere	The solid, rocky part of the Earth; the Earth’s crust.

long-lining	A non-selective method of commercial fishing which employs strings of baited hooks, usually tens of miles long, to capture large open-ocean species.
mass balance	The accounting of all 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.
microbial degradation	The breakdown of material, usually organic, by the natural processes of microorganisms.
ozone	A form of oxygen, O_3, naturally found in the ozonesphere within the stratosphere.
paca	A medium sized (0.5 m) neotropical nocturnal rodent.
peccary	A small pig-like mammal of Central and South America.
pitch	The movement up or down of the nose or tail or an object in flight.
photometer	An instrument used in measuring the intensity of light.
photochemical oxidation	Oxidation resulting from the chemical action of radiant energy and especially light.
phytoplankton	Passively floating or weakly self-propelled aquatic plant life.
primary productivity	A new organic matter produced by plant life.
pumice	An igneous rock formed from magma that trapped air bubbles while cooling, giving it a characteristic “honey-combed” appearance.
purse seining	A commercial fishing method used to capture schools of fish in the open ocean using a large, bag-shaped net with a drawstring-type closure at the bottom.
seamount	A submerged, flat-topped mountain.
shield volcano	Volcanic dome, much broader than tall, built over geologic time from lava poured out in a succession of quiet eruptions.
sonic boom	Sound, resembling an explosion, produced when a shock wave formed at the nose of an aircraft or launch vehicle traveling at supersonic speed reaches the ground.

stratosphere	That part of the Earth's atmosphere between the troposphere and the mesosphere in which the temperature increases with altitude.
subduction zone	Region along which one lithospheric block descends relative to another lithospheric block.
substrate	The base on which an organism lives (e.g., soil, rock).
tapir	Mammal of South American and southern Asian forests with a stout body, short legs, and flesh proboscis.
trachytic intrusion	Of or pertaining to the internal structure of some igneous rocks, in which hair-like, feldspar crystals are in nearly parallel rows.
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 tip of the mesosphere to outer space, including the exosphere and ionosphere, marked by more or less steadily increasing temperatures with altitude.
transform fault	A type of rupture in the Earth’s surface that is most often associated with oceanic ridges.
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.
tuff	Rock consolidated from volcanic ash.
upwelling	The process by which water rises from a deeper to a shallower depth; may be caused by a variety of physical phenomena.
yaw	To turn by angular motion about the vertical axis.
zooplankton	Passively floating or weakly self-propelled aquatic animal life.

7.0 LIST OF PREPARERS

This list presents the primary contributors to the technical content of this Environmental Assessment (EA).

Name:	**Nikos Himaras**
Affiliation:	FAA Office of the Associate Administrator for Commercial Space Transportation
Education:	MS Aeronautics and Astronautics
Experience:	Nineteen years in systems engineering and management with ten years in commercial space regulatory issues

Name:	**Michon Washington**
Affiliation:	FAA Office of the Associate Administrator for Commercial Space Transportation
Education:	MS Environmental Management and Technology
Experience:	Thirteen years of NEPA related experience

Name:	**Deborah Shaver**
Affiliation:	ICF Consulting
Education:	MS Chemistry
Experience:	Twenty-six years of experience in environmental and safety impacts management

Name:	**Pamela Schanel**
Affiliation:	ICF Consulting
Education:	BA Environmental Public Policy Analysis
Experience:	Four years of experience in environmental assessments

Name:	**Trevor McCroskey**
Affiliation:	ICF Consulting
Education:	BA Environmental Biology
Experience:	One year experience in environmental assessments

Name:	**Ramsis Adam**
Affiliation:	Boeing Commercial Space Company
Education:	BS Electrical Engineering and Computer Science
Experience:	Seventeen years in spacecraft and launch vehicle design, system engineering, integration and test, and management

Name:	**Ed Simek**
Affiliation:	ERM
Education:	PhD Oceanography
Experience:	Twenty years experience in environmental management

Name: **David Blaha**
Affiliation: ERM
Education: MA Environmental Management
Experience: Twenty years experience in NEPA documentation and environmental impact assessment.

Name: **Julia Tims**
Affiliation: ERM
Education: Masters in Natural Resources Management
Experience: Ten years in environmental science and resource management

Name: **Carol Young**
Affiliation: ERM
Education: ME Civil Engineering
Experience: Ten years experience with environmental engineering and NEPA documentation

Name: **Kevin Groppe**
Affiliation: ERM
Education: MS Environmental Engineering and Science
Experience: Two years experience in environmental assessments and air emissions

Name: **William Weil**
Affiliation: ERM
Education: BS environmental policy and management
Experience: Three years experience in environmental management

Name: **Will Ernst**
Affiliation: Consultant
Education: MS Oceanography, MBA
Experience: Nine years in oceanography, ten years in environmental management

8.0 EA DISTRIBUTION

NEWSPAPERS LOCAL TO LONG BEACH

Long Beach Press – Telegram
604 Pine Avenue
Long Beach, CA 90844

Los Angeles Times
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MAILING LIST

UNIVERSITIES/FOUNDATIONS

Dr. Craig MacFarland
Charles Darwin Foundation
836 Mabelle
Moscow, ID 83843

Executive Director Johannah Barry
Charles Darwin Foundation, Inc.
407 North Washington Street, Suite 105
Falls Church, VA 22046

University of Tennessee
Center for Space Transportation
Assistant Director
UTSI Research Park
Tullahoma, TN 37388

ENVIRONMENTAL GROUPS

Director
Environmental Defense Fund
257 Park Avenue South
New York, NY 10010

Galapagos Coalition
The Wilderness Society
900 17th Street, NW
Washington, DC 20006

Greenpeace
Legislative Director
1436 U Street, NW
Washington, DC 20009

Mr. Clifton Curtis
Biodiversity/Oceans Political Adviser
Political Division
Greenpeace International
1436 U Street, NW
Washington, DC 20009

National Wildlife Federation
President
1400 16th Street, NW
Washington, DC 20036-2266

Natural Resources Defense Council
National Headquarters
P.O. Box 96048
Washington, DC 20090

Sierra Club National Headquarters
85 Second Street
Second Floor
San Francisco, CA 94105-3441

STATE AND LOCAL GOVERNMENT AGENCIES

California Department of Toxic Substances Control
Region 4
245 W. Broadway, Suite 350
Long Beach, CA 90802

California Department of Fish & Game
20 Lower Ragsdale Drive, Suite 100
Monterey, CA 93940

California Coastal Commission
45 Fremont, Suite 2000
San Francisco, CA 94105-2219

Ms. Cherilyn Widell
California State Historic Preservation Officer
Office of Historic Preservation
P.O. Box 942896
Sacramento, CA 94296

Mr. David E. Plummer
California State Lands Commission
100 Howe Avenue, Suite 1005
Sacramento, CA 95825-8202

Mr. Larry Watkins
Program Supervisor
South Coast Air Quality Management District
21865 E. Copley Drive
Diamond Bar, CA 91765-4182

The Honorable Beverly O'Neil
Office of the Mayor
City of Long Beach
14th Floor
333 West Ocean Boulevard
Long Beach, CA 90802

Chief Rick DuRee, Deputy Fire Chief
Long Beach Fire Department
925 Harbor Plaza, Suite 100
Long Beach, CA 90802

Ms. Geraldine Knatz
Director of Planning
Port of Long Beach
925 Harbor Plaza
P.O. Box 570
Long Beach, CA 90801

City of Long Beach Public Library
101 Pacific Avenue
Long Beach, CA 90801

FEDERAL AGENCIES

Council on Environmental Quality
722 Jackson Place, NW
Washington, DC 20006

Department of Commerce
National Oceanographic and Atmospheric Administration
National Marine Fisheries Service
1315 East-West Highway
Silver Spring, MD 20910-3266

Department of Interior
U.S. Fish and Wildlife Service
1849 C. Street, NW
Washington, DC 20204

Ms. Melinda L. Kimble
Department of State
Principal Deputy Assistant Secretary
Bureau of Oceans and International Environmental and Scientific Affairs
2201 C. Street, NW, Room 7831
Washington, DC 20520-7818

Mr. Daniel A. Hutchens
Country Officer for Ecuador
Office of Andean Affairs
U.S. Department of State
2201 C Street, NW, Room 5906
Washington, DC 20520-6263

Lt. Colonel Henry D. Baird
Department of State
Assistant Director, Space and Multilateral Cooperation
2201 C Street, NW, Room 7831
Washington, DC 20520-7818

Mr. R. Tucker Skully
Department of State
Director, Office of Ocean Affairs
2201 C Street, NW, Room 5805
Washington, DC 20520-7818

Department of Transportation
Federal Aviation Administration
800 Independence Avenue
Washington, DC 20591

Commander Kevin S. Cook
Chief, Hazardous Materials Standards Division
US Coast Guard
2100 2nd Street, SW
Washington, DC 20593-0001

Captain George Wright
Commanding Officer
Marine Safety Officer, LA/LB
165 Pico Ave.
Long Beach, CA 90802-1096

US Environmental Protection Agency
Office of Federal Activities
401 M Street, SW
Washington, DC 20460

Mr. David Farrel
Chief, Office of Federal Activities
US Environmental Protection Agency
Region IX
75 Hawthorne Street
San Francisco, CA 94105

National Aeronautics and Space Administration
Headquarters
300 E Street, SW
Washington, DC 20024-3210

National Aeronautics and Space Administration
Marshall Space Flight Center
Environmental Management Office
Bldg. 4201, MC AE01, Rideout Road
Huntsville, AL 35812

Mr. Allan Lee, Base Environmental Coordinator
Department of the Navy
Southwest Division
Naval Facilities Engineering Command
1220 Pacific Highway
San Diego, CA 92132-5190

Department of the Air Force
SMC/AXF
2420 Vela Way
Suite 1467
El Segundo, CA 90245

Department of the Air Force
Space Plans and Policy
SAF/SX
The Pentagon, Room 4E999
Washington, DC 20330-1000

Department of the Air Force
30th Space Wing
Environmental Management Office
30 CES/CEVP, 806 13th Street
Suite 116
Vandenberg AFG, CA 93437

Federal Communications Commission
Administrative Law Division
1919 M Street, NW
Room 616
Washington, DC 20554

Federal Communications Commission
Office of Plans and Policy
1919 M Street, NW
Washington, DC 20554

Federal Communications Commission
Common Carrier Bureau
1919 M Street, NW
Washington, DC 20554

Ms. Tara Zimmerman
U.S. Fish and Wildlife Service Region 1
911 NE 11th Avenue (ARW-MBHP)
Portland, OR 97232-4181

Mr. John Naughton
Pacific Islands Environmental Coordinator, NOAA
2570 Dole Street
Room 106
Honolulu, HI 96822-2396

National Oceanographic and Atmospheric Administration
14th and Constitution Avenue, NW
Room 6222
Washington, DC 20230

Ms. Susan Ware
Office of International Affairs, NOAA
14th and Constitution Avenue, NW
Room 5230
Washington, DC 20230

White House
Office of Science and Technology Policy
Old Executive Building Room 423
Washington, DC 20502

United States House of Representatives
Committee on Science
Rayburn Building Room 2320
Washington, DC 20515

National Science Foundation
Office of Planning and Assessment
4201 Wilson Boulevard
Arlington, VA 22230

National Science Foundation
Division of Astronomical Sciences
4201 Wilson Boulevard
Room 1045
Arlington, VA 22230

Mr. Kenneth Kumor
NEPA Coordinator
NASA HQ
300 E Street, SW
Washington, DC 20024-3210

Ms. Sara Najjar-Wilson
Office of General Counsel
NASA HQ
300 E Street, SW
Washington, DC 20024-3210

Ken Mittelholtz
EPA
Office of Federal Activities
401 M Street (2251-A)
Washington, DC 20460

D. Lisa Chang
EPA
Office of Atmospheric Products
401 M Street (6205J)
Washington, DC 20460

U.S. MISSIONS ABORAD

Marshall Islands
American Embassy
P.O. Box 1379
Majuro, Republic of the Marshall Islands 96960-1379

Australia
American Embassy
Moonah Place, Canberra,
A.C.T. 2600
APO AP 96549
Tel: (61-6) 270-5000/5900
Fax: (61-6) 273-3191

Ecuador
American Embassy
Avenida Patria y Avenida 12 de Octubre Avenue
Quito, Ecuador
APO AA 34039
Tel: 011593256890

Japan
American Embassy
Micro Region 11, Big Rind Rd.
PSC 461, Box 300
FPO AP 96521-0002
Tel: (946-1) 329-095/606
Fax: (946-1) 320-776

Micronesia
American Embassy
P.O. Box 1286, Pohnpei
Federated States of Micronesia 96941
Tel: (691) 320-2187
Fax: (691) 320-2186

New Zealand
American Embassy
29 Fitzherbert Terrace
Thorndon, Wellington
PO Box 1190 PSC 467, Box 1
FPO AP 96531-1001
Tel: (64-4) 472-2068
Fax: (64-4) 471-2380

Papua New Guinea
American Embassy
Douglas St., Port Moresby
PO Box 1492
APO AE 96553
Tel: (675) 321-1455
Fax: (675) 321-3423

INDUSTRY AFFILIATED

Mr. David Burney
Untied States Tuna Foundation
One Tuna Lane
San Diego, CA 92101

Dr. Jim Joseph
Director
Inter-American Tropical Tuna Commission
8604 LaJolla Shores Drive
LaJolla, CA 92037

Ms. Kitty M. Simonds
Executive Director
Western Pacific Fisheries Management Council
1164 Bishop Street, Room 1405
Honolulu, HI 96813

Brent Stewart
Senior Research Biologist
Hubbs-Sea World Research Institute
2595 Ingraham Street
San Diego, CA 92109

Mr. Lawrence D. Six
Executive Director
Pacific Fisheries Management Council
2130 SW 5th Avenue, Suite 224
Portland, OR 97201

Mr. Erik Langeland
Sea Launch Company, L.L.C.
One World Trade Center
Suite 950
Long Beach, CA 90831

Mr. Ramsis Adam
Boeing Commercial Space Company
P.O. Box 3999 MC 6E-62
Seattle, WA 98124-2499

Mr. Will Ernst
Boeing Commercial Space Company
MS 6E-62
P.O. Box 3999
Seattle, WA 98124-2499

Mr. Tim Hansen
Boeing Commercial Space Company
M/S 6E-60
P.O. Box 3999
Seattle, WA 98124-2499

American Institute of Aeronautics and Astronautics
1801 Alexander Bell Drive
Suite 500
Reston, VA 20191

Dr. Valerie Lang
Project Leader, Environmental Programs
The Aerospace Corporation
2350 E. El Segundo, CA 90245-4691

Aerospace Daily
1200 G Street, NW
Suite 200
Washington, DC 20005

INTERNATIONAL ORGANIZATIONS

The Honorable Willie Tokataake
Minister of Information, Communications and Transport
Republic of Kiribati
P.O. Box 487
Betio, Tarawa Atoll, Republic of Kiribati

FOREIGN GOVERNMENTS & GOVERNMENT ORGANIZATIONS

Mr. Juan Manuel Escalante
Second Secretary
Embassy of Ecuador
2535 15th Street, NW
Washington, DC 20009

Mr. Alistair MacLean
First Secretary
Embassy of Australia
1601 Massachusetts Avenue, NW
Washington, DC 20036

Ms. Kirsty Graham
Second Secretary
Embassy of New Zealand
37 Observatory Circle, NW
Washington, DC 20008

Mr. Tamari'i Tutangata
Director
South Pacific Regional Environmental Programme
P.O. Box 240
Apia, Western Samoa

South Pacific Forum
Forum Secretariat
Ratu Sukuna Road
Suva, Fiji Islands

South Pacific Forum Fisheries Agency
P.O. Box 629
Honiara, Solomon Islands

Office of the Fisheries Attache
Embassy of Japan
2520 Massachusetts Avenue, NW
Washington, DC 20008

Office of the Fisheries Attache
Embassy of Korea
2450 Massachusetts Avenue, NW
Washington, DC 20008

Office of the Agricultural Counselor (Fisheries)
Tiapei Economic and Cultural Office in the United States
4201 Wisconsin Avenue, NW
Washington, DC 20016

PRIVATE CITIZENS

Peter Allan
306 Potomac Drive
Basking Ridge, NJ 07920-3123

Bob Werth
SAIC
20201 Century Boulevard
Germantown, MD 20874

Harry A. Bryson, CHMM
P.O. Box 5307
Huntsville, AL 35814-5307

Appendix A – February 11, 1999 EA

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FINAL

ENVIRONMENTAL ASSESSMENT FOR THE SEA LAUNCH PROJECT

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

by

ICF Kaiser Consulting Group

February 10, 1999

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

Responsible FAA Official Date

EXECUTIVE SUMMARY FOR THE SEA LAUNCH FINAL ENVIRONMENTAL ASSESSMENT

INTRODUCTION

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

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

PURPOSE AND NEED

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

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

DESCRIPTION OF PROPOSED ACTION

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

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

CONSIDERATION OF ALTERNATIVES

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

NO ACTION ALTERNATIVE

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

ENVIRONMENTAL IMPACTS

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

Pre-Launch Operations

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

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

Launch and Flight

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

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

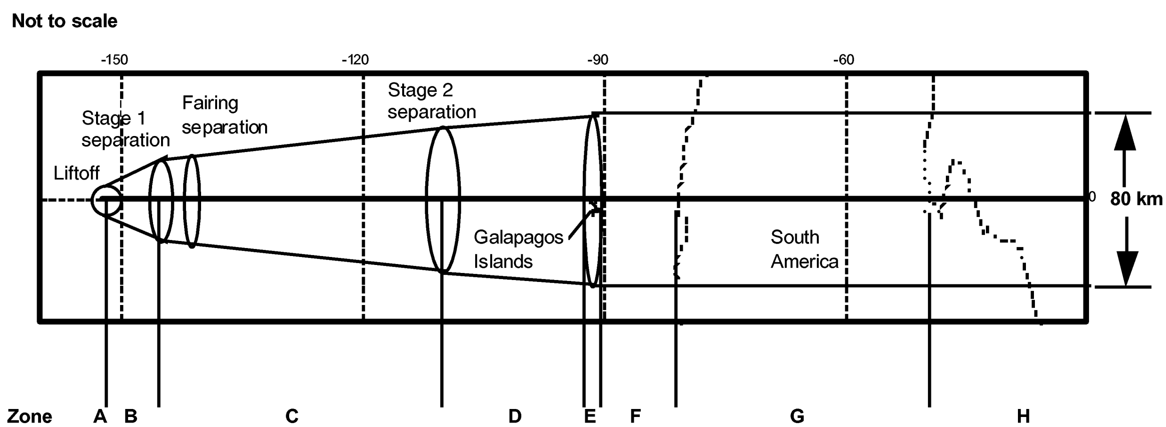

Figure ES-1. Stage 1 and 2 Impact Zones

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

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

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

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

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

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

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

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

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

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

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

Post-Launch Operations

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

Failed Mission Scenarios

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

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

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

Other Environmental Considerations

Home Port

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

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

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

Notices to Mariners

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

Environmental Monitoring Plan

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

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

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

Environmental Justice

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

No Action

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

CUMULATIVE IMPACTS

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

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^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).

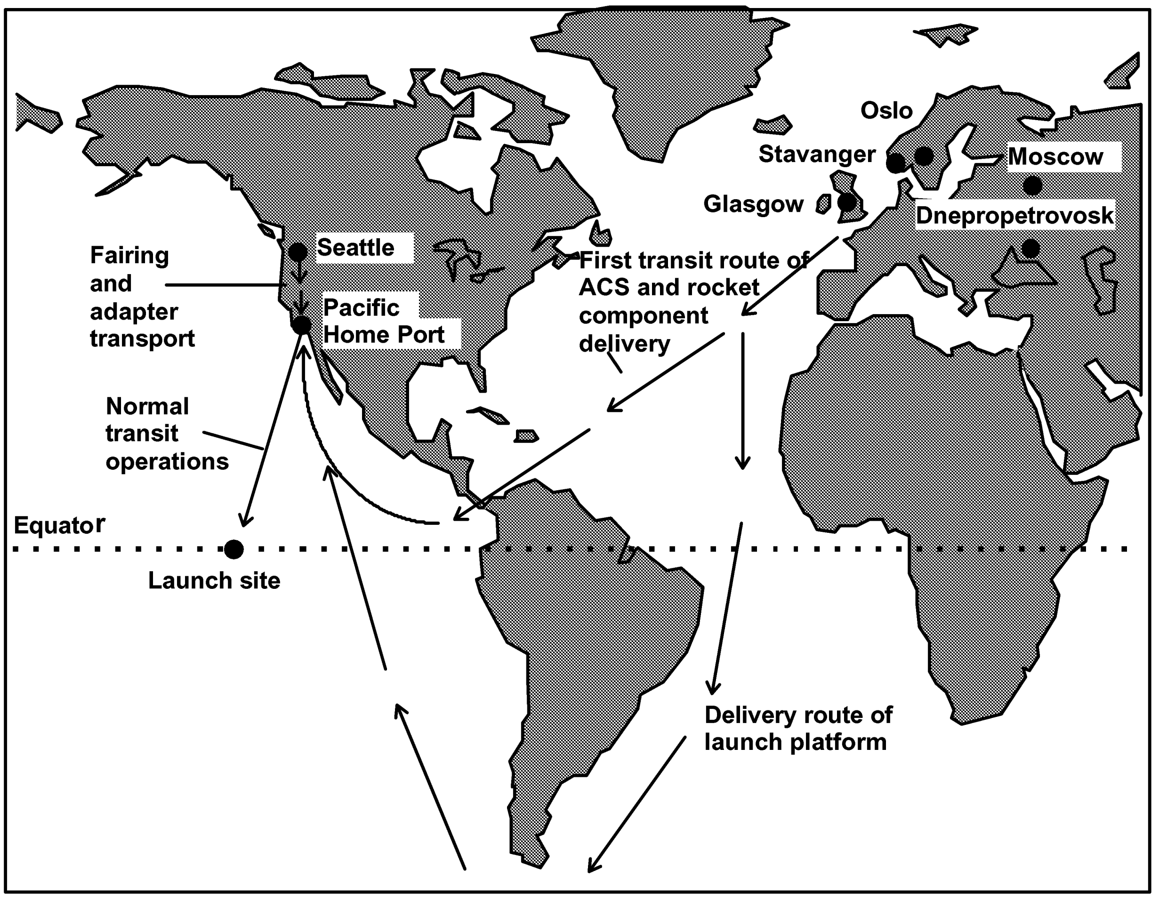

Figure 2.1-1. Sea Launch ACS, LP, and Launch Transit Routes

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.

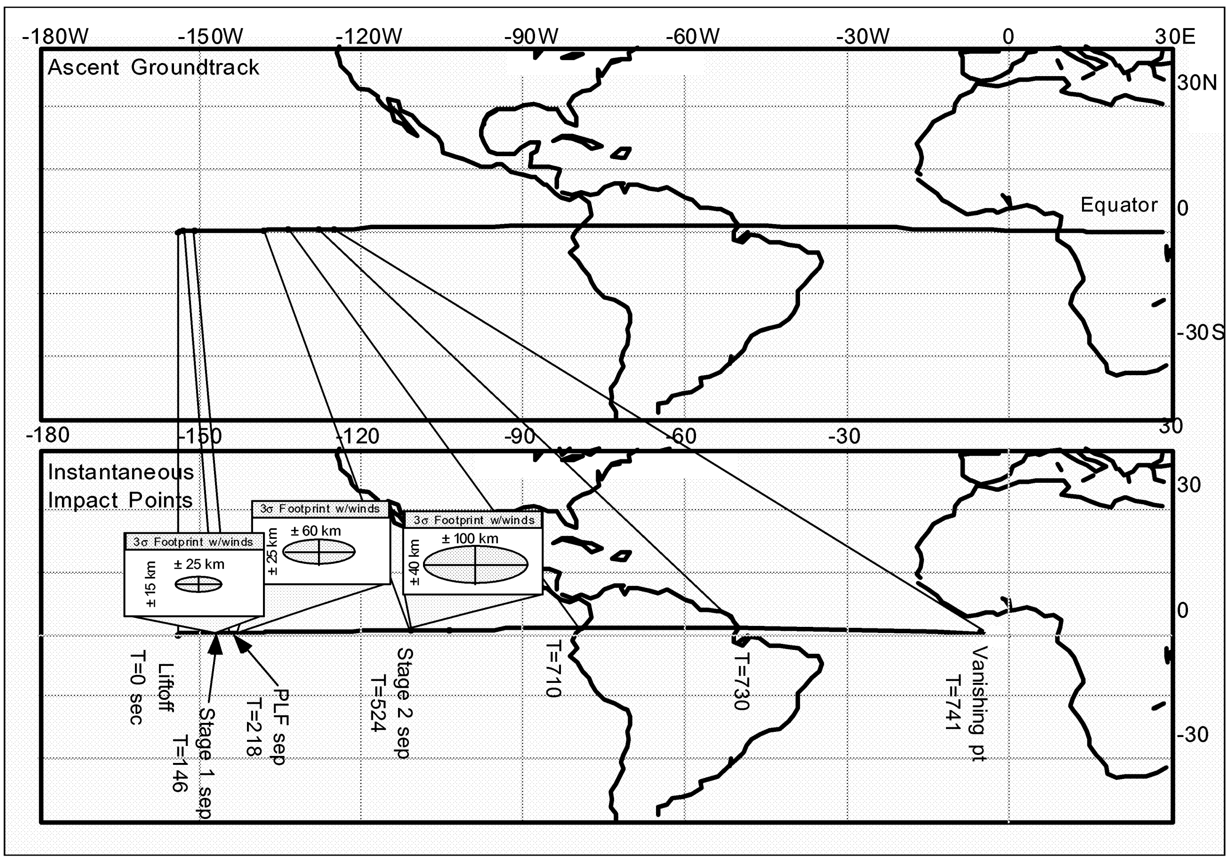

Figure 3.1-1. GTO Mission Ascent Groundtrack, IIP Trace, and Debris Footprint from Launch Location at 0°, 154° W

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).

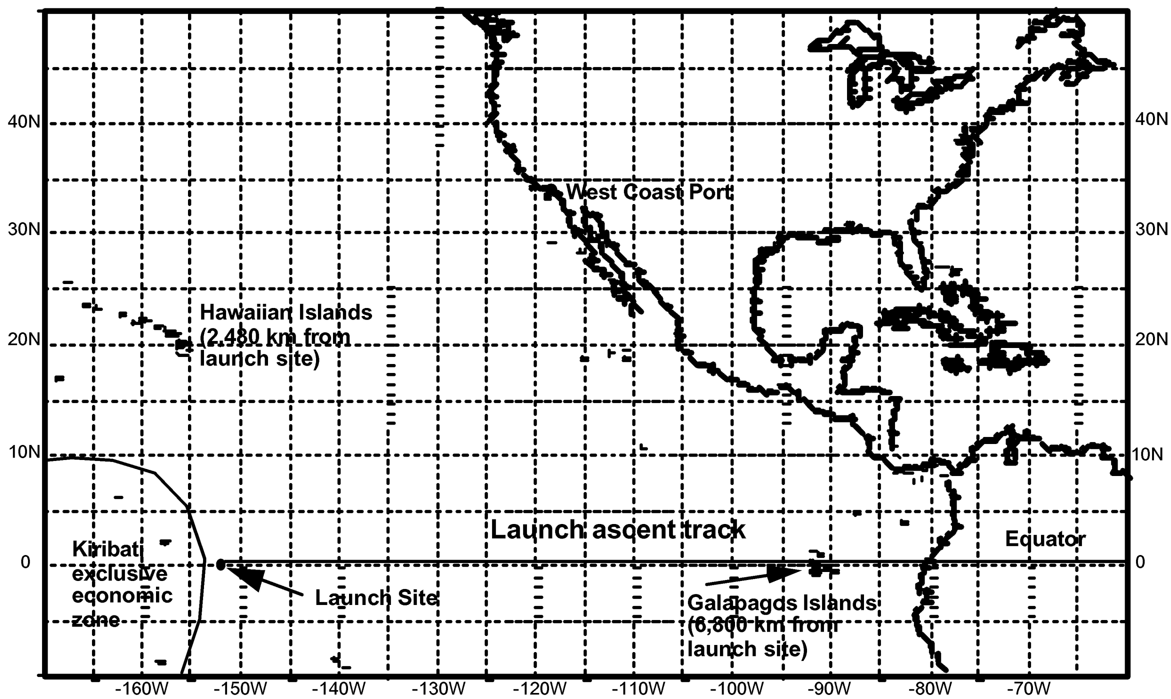

Figure 3.2-1. Launch Location

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)

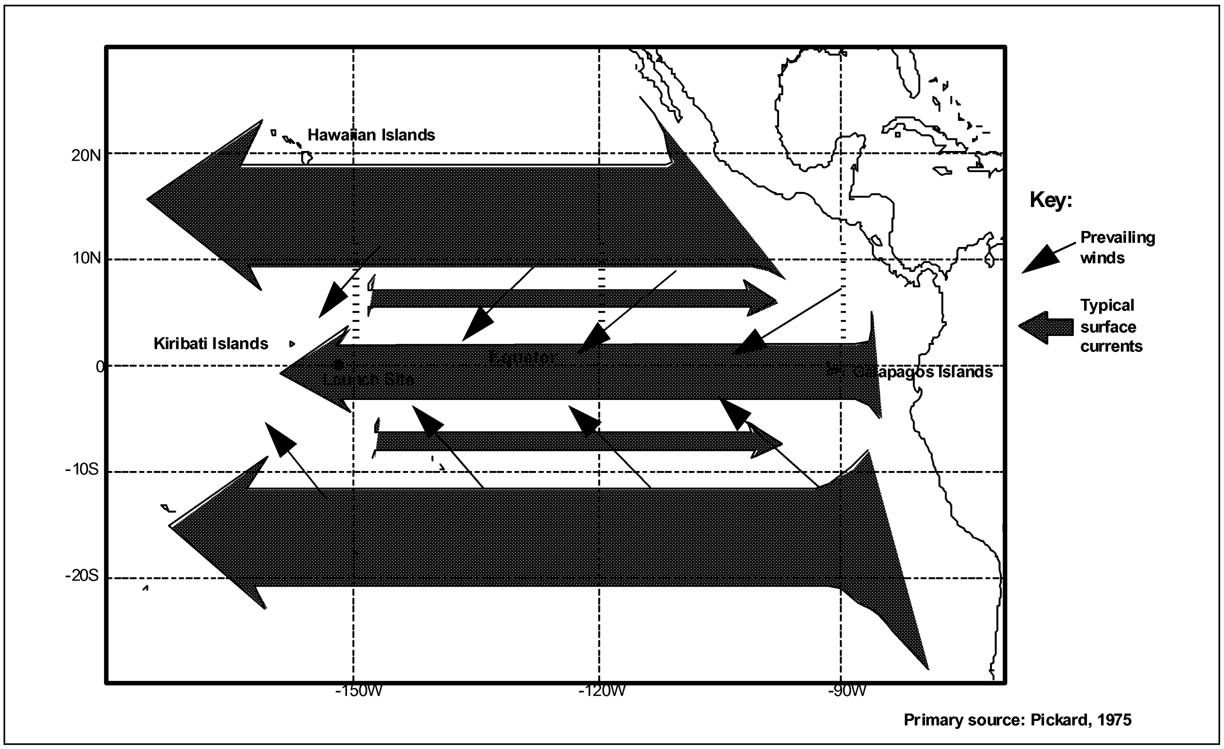

Figure 3.3-1. Launch Area Winds and Surface Currents

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° 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.

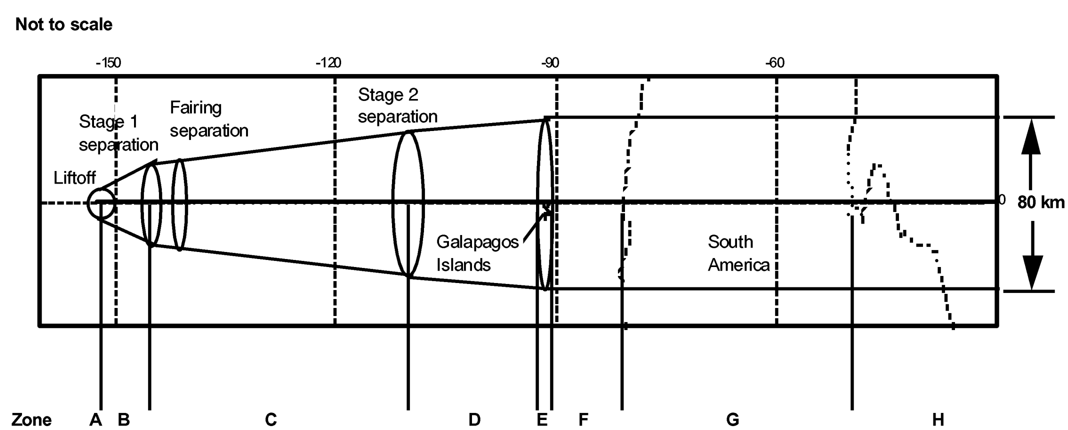

Figure 4.3.2-1. Flight Zones

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.

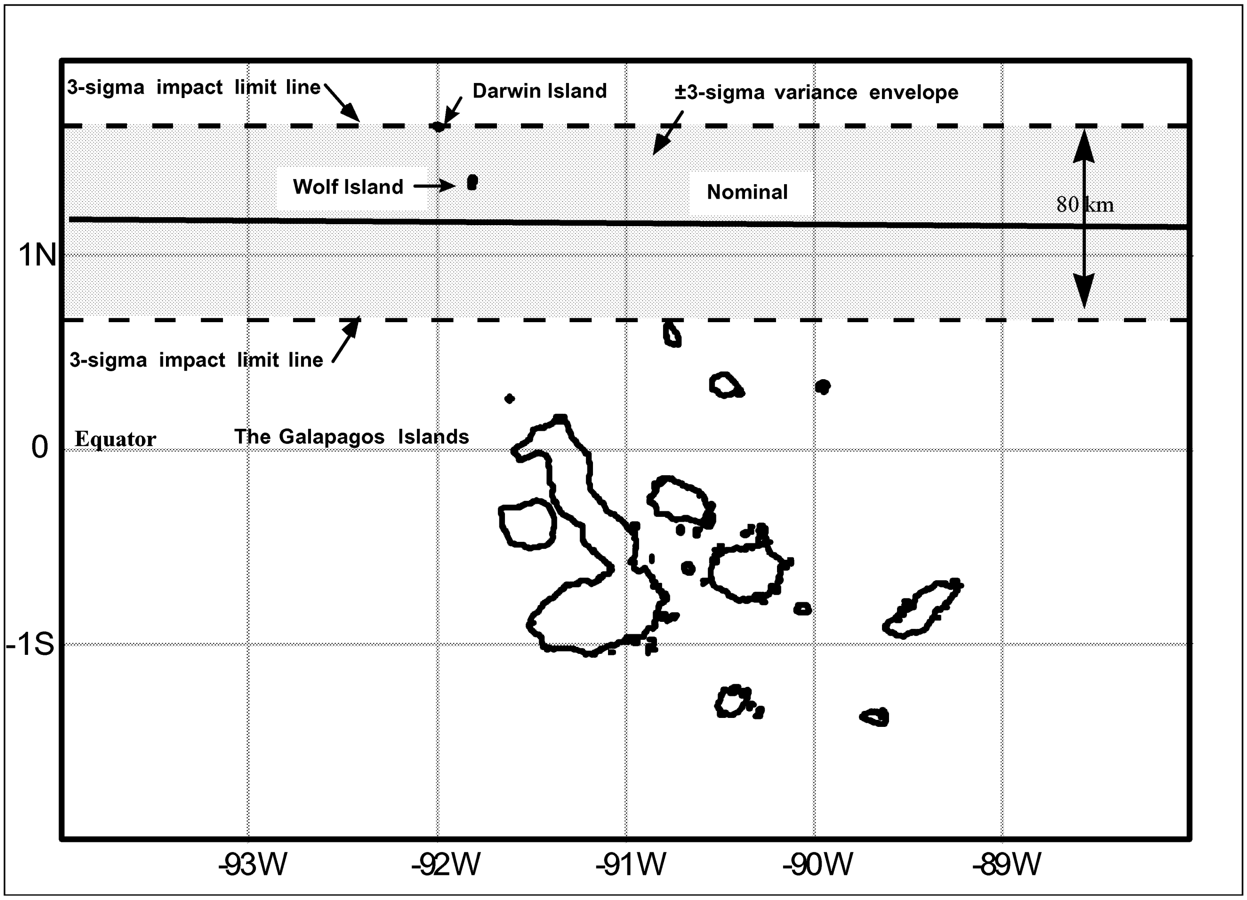

Figure 4.3.4-1. Galapagos Area Overflight

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 (14th District), and the U.S. Space Command (Onizuka Air Station in Los Angeles), who would issue necessary information to coordinate air, marine, and space traffic (SLLP, 1996a). 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

6. List Of Preparers

This list presents the primary contributors to the technical content of this Environmental Assessment (EA). The Boeing Company directed the preparation of the Environmental Analysis Report which, after independent review by the FAA Office of the Associate Administrator for Commercial Space Transportation (AST), formed the basis of this EA.

Name: **Nikos Himaras**
Affiliation: FAA Office of the Associate Administrator for Commercial Space Transportation
Education: MS Aeronautics and Astronautics
Experience: Sixteen years in systems engineering and management with seven years in commercial space regulatory issues

Name: **R. Dickinson Roop**
Affiliation: Jones Technologies, Inc., FAA contractor
Education: MA Ecology
Experience: Twenty years NEPA experience, eleven years in project management

Name: **Alethea Woodworth**
Affiliation: Jones Technologies, Inc., FAA contractor
Education: BS Environmental Engineering
Experience: One year NEPA experience

Name: **Deborah Shaver**
Affiliation: ICF Kaiser, FAA contractor
Education: MS Chemistry
Experience: Twenty-four years of experience in managing the environmental and safety impacts of the management and transportation of hazardous materials and wastes.

Name: **Jean Hoff**
Affiliation: ICF Kaiser, FAA contractor
Education: MS Chemistry, MBA
Experience: Ten years of experience in chemical, environmental and energy analyses

Name: **Lora Siegmann**
Affiliation: ICF Kaiser, FAA contractor
Education: BS Science and Technology Studies
Experience: Four years of experience in emergency response, chemical accident prevention, and industry uses of toxic substances

Name: **David Goldbloom-Helzner**
Affiliation: ICF Kaiser, FAA contractor
Education: BA Chemistry, BS Engineering and Public Policy
Experience: Ten years of risk and hazards assessment, air contamination, and dispersion and modeling.

Name: **Elizabeth Ebersole**
Affiliation: ICF Kaiser, FAA contractor
Education: M.S. Marine-Estuarine Environmental Science
Experience: Eight years experience in NEPA environmental impact assessment and aquatic ecology environmental research, management, and consulting

Name: **Will Ernst**
Affiliation: The Boeing Company
Education: MS Oceanography, MBA
Experience: Nine years in oceanography, ten years in environmental management

Name: **Darrel Choate**
Affiliation: The Boeing Company
Education: MA Mathematics, MS Computer Science
Experience: Thirty years in defense and space programs

Name: **Marc Nance**
Affiliation: The Boeing Company
Education: MSAA Aeronautics Astronautics Engineering
Experience: Twelve years in defense and space programs

Name: **David Bickett**
Affiliation: The Boeing Company
Education: BS Electrical Engineering Technology
Experience: Three years in plant electrical engineering, six years in system safety engineering

Name: **Larry Weinberg**
Affiliation: The Boeing Company
Education: PhD Mathematics, JD
Experience: Twenty-six years technical and management experience in mathematics; and safety, health and environmental laws, audits, and prevention

Name: **L.B. "Skip" Fox, Jr.**
Affiliation: The Boeing Company
Education: BA Geology
Experience: Twenty-five years oceanography and environmental sciences

Name: **Peter Sloane**
Affiliation: The Boeing Company
Education: JD
Experience: Thirteen years corporate and international law

Name: **Charles Malmborg**
Affiliation: Superior Design
Experience: Thirteen years system safety engineering

Name: **Svein Johnsen**
Affiliation: Kværner Maritime a.s
Experience: Twenty-seven years naval architecture and marine engineering

Name: **Alexander Shorin**
Affiliation: RSC Energia
Education: Mechanical Engineering
Experience: Twenty-five years designing rocket/space systems and launch vehicles

Name: **Igor Kolosanov**
Affiliation: RSC Energia
Education: Mechanical Engineering
Experience: Ten years designing and testing rocket/space systems and launch vehicles

Name: **Yuri Smetanin**
Affiliation: KB Yuzhnoye
Education: Doctorate of Rocket Engineering

7. EA DISTRIBUTION

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UNIVERSITIES/FOUNDATIONS

Julie Ashton
Dept. of Biological Sciences
University of Exeter
Prince of Wales Road,
Exeter
Devon EX4 4PS
UK

Dr. Craig MacFarland
Charles Darwin Foundation
836 Mabelle
Moscow, ID 83843

University of Tennessee
Center for Space Transportation
Assistant Director
UTSI Research Park
Tullahoma, TN 37388

Sal V. Cuccarese
Manager of Program Development
ENRI
University of Alaska Anchorage
707 A Street
Anchorage, AK 99501

ENVIRONMENTAL GROUPS

Director
Environmental Defense Fund
257 Park Avenue South
New York, NY 10010

Galapagos Coalition
The Wilderness Society
900 17th Street, NW
Washington, DC 20006

Greenpeace
Legislative Director
1436 U Street, NW
Washington, DC 20009

Mr. Clifton Curtis
Biodiversity/Oceans Political Adviser
Political Division
Greenpeace International
1436 U Street, NW
Washington, DC 20009

National Wildlife Federation
President
1400 16th Street, NW
Washington, DC 20036-2266

Natural Resources Defense Council
National Headquarters
P.O. Box 96048
Washington, DC 20090

Sierra Club National Headquarters
730 Polk St.
San Francisco, CA 94109

STATE AND LOCAL GOVERNMENT AGENCIES

California Department of Toxic Substances Control
Region 4
245 W. Broadway, Suite 350
Long Beach, CA 90802

California Department of Fish & Game
20 Lower Ragsdale Drive, Suite 100
Monterey, CA 93940

California Coastal Commission

45 Fremont, Suite 2000
San Francisco, CA 94105-2219

Ms. Cherilyn Widell
California State Historic Preservation Officer
Office of Historic Preservation
P.O. Box 942896
Sacramento, CA 94296

Mr. David E. Plummer
California State Lands Commission
100 Howe Avenue, Suite 1005
Sacramento, CA 95825-8202

Mr. Larry Watkins
Program Supervisor
South Coast Air Quality Management District
21865 E. Copley Drive
Diamond Bar, CA 91765-4182

The Honorable Beverly O'Neil
Office of the Mayor
City of Long Beach
14th Floor
333 West Ocean Boulevard
Long Beach, CA 90802

Chief Rick DuRee, Deputy Fire Chief
Long Beach Fire Department
925 Harbor Plaza, Suite 100
Long Beach, CA 90802

Ms. Geraldine Knatz
Director of Planning
Port of Long Beach
925 Harbor Plaza
P.O. Box 570
Long Beach, CA 90801

City of Long Beach Public Library
101 Pacific Avenue
Long Beach, CA 90801

FEDERAL AGENCIES

Council on Environmental Quality
722 Jackson Place, NW
Washington, DC 20006

Department of Commerce

National Oceanographic and Atmospheric Administration
National Marine Fisheries Service
1315 East-West Highway
Silver Spring, MD 20910-3266

Department of Interior
U.S. Fish and Wildlife Service
1849 C Street, NW
Washington, DC 20240

Ms. Melinda L. Kimble
Department of State
Principal Deputy Assistant Secretary
Bureau of Oceans and International Environmental and Scientific Affairs
2201 C Street, NW, Room 7831
Washington, DC 20520-7818

Lt. Colonel Henry D. Baird
Department of State
Assistant Director, Space and Multilateral Cooperation
2201 C Street, NW, Room 7831
Washington, DC 20520-7818

Mr. R. Tucker Skully
Department of State
Director, Office of Oceans Affairs
2201 C Street, NW, Room 5805
Washington, DC 20520 - 7818

Mr. Ralph L. Braibanti
Department of State
Director, Space and Advanced Technology Staff
2201 C Street, NW, Room 5806
Washington, DC 20520 - 7818

Mr. Alfred Anzaldua
Department of State
Foreign Affairs Officer, Office of Oceans Affairs
2201 C Street, NW, Room 5805
Washington, DC 20520 - 7818

Department of Transportation
Federal Aviation Administration
800 Independence Avenue
Washington, DC 20591

Federal Aviation Administration
Regional Administrator
Southwest Office
2400 Blue Mound Road
Ft. Worth, TX 76193-0600

Commander Kevin S. Cook
Chief, Hazardous Materials Standards Division
US Coast Guard
2100 2nd Street, SW
Washington, DC 20593-0001

Captain George Wright
Commanding Officer
Marine Safety Office, LA/LB
165 Pico Ave.
Long Beach, CA 90802-1096

US Environmental Protection Agency
Office of Federal Activities
401 M Street, SW
Washington, DC 20460

Mr. David Farrel
Chief, Office of Federal Activities
US Environmental Protection Agency
Region IX
75 Hawthorne Street
San Francisco, CA 94105

National Aeronautics and Space Administration
Headquarters
300 E Street, SW
Washington, DC 20024-3210

National Aeronautics and Space Administration
Marshall Space Flight Center
Environmental Management Office
Bldg. 4201, MC AE01, Rideout Road
Huntsville, AL 35812

Mr. Allan Lee, Base Environmental Coordinator
Department of the Navy
Southwest Division
Naval Facilities Engineering Command
1220 Pacific Highway
San Diego, CA 92132-5190

Department of the Air Force

Space Systems Division
Environmental Planning Division
P.O. Box 92960
Los Angeles, CA 90009-2960

Department of the Air Force
Space Plans and Policy
SAF/SX
The Pentagon, Room 4E999
Washington, DC 20330-1000

Department of the Air Force
30th Space Wing
Environmental Management Office
30 CES/CEVP, 806 13th Street
Suite 116
Vandenberg AFB, CA 93437

Department of Health and Human Services
Division of Special Programs Coordinator
Cohen Building Room 4711
330 Independence Avenue, SW
Washington, DC 20201

Federal Communications Commission
Administrative Law Division
1919 M Street, NW
Room 616
Washington, DC 20554

Federal Communications Commission
Office of Plans and Policy
1919 M Street, NW
Washington, DC 20554

Federal Communications Commission
Common Carrier Bureau
1919 M Street, NW
Washington, DC 20554

Ms. Tara Zimmerman
U.S. Fish and Wildlife Service Region 1
911 NE 11th Avenue (ARW-MBHP)
Portland, OR 97232-4181

Mr. John Naughton
Pacific Islands Environmental Coordinator, NOAA
2570 Dole Street
Room 106
Honolulu, HI 96822-2396

National Oceanographic and Atmospheric Administration
14th and Constitution Avenue, NW
Room 6222
Washington, DC 20230

Ms. Susan Ware
Office of International Affairs, NOAA
14th & Constitution Avenue, NW
Room 5230
Washington, DC 20230

White House
Office of Science and Technology Policy
Old Executive Building Room 423
Washington, DC 20502

United States House of Representatives
Committee on Science
Rayburn Building Room 2320
Washington, DC 20515

National Science Foundation
Office of Planning and Assessment
4201 Wilson Boulevard
Arlington, VA 22230

National Science Foundation
Office of Astronomical, Atmospheric, Earth, and Ocean Sciences
1800 G Street, NW Room 510
Washington, DC 20550

Mr. Kenneth Kumor
NEPA Coordinator
NASA HQ
300 E Street, SW
Washington, DC 20024-3210

Ms. Sara Najjar-Wilson
Office of General Counsel
NASA HQ
300 E Street, SW
Washington, DC 20024-3210

Mr. Ellis McElroy

FAA/AAL-4
222 W. 7th Avenue Box 14
Anchorage, AK 99513

Ken Mittelholtz
EPA
Office of Federal Activities
401 M Street (2251-A)
Washington, DC 20460

Dr. Lisa Chang
EPA
Office of Atmospheric Products
401 M Street (6205J)
Washington, DC 20460

Sid Gutierrez
Sandia National Laboratories
P.O. Box 5800
Albuquerque, NM 87185-0859

Ann G. Rappoport
U.S. Fish and Wildlife Service
Anchorage Field Office
605 West 4th Avenue Room G-62
Anchorage, AK 99501

Gary P. Wheeler
U.S. Fish and Wildlife Service
Anchorage Field Office
605 West 4th Avenue Room G-62
Anchorage, AK 99501

Gregory R. Balogh
U.S. Fish and Wildlife Service
Anchorage Field Office
605 West 4th Avenue Room G-62
Anchorage, AK 99501

Teresa Anaya
STEWS-MTD-SB
WSMR, NM 88002-5157

William E. Stepp
Branch Manager
Environmental Services
Physical Sciences Laboratory
Box 30002
Las Cruces, NM 88003-0002

U.S. MISSIONS ABROAD

Marshall Islands
American Embassy
P.O. Box 1379
Majuro, Republic of the Marshall Islands 96960-1379

Australia
American Embassy
Moonah Place, Canberra,
A.C.T. 2600
APO AP 96549
Tel: (61-6) 270-5000/5900
Fax: (61-6) 273-3191

Ecuador
American Embassy
Avenida Patria y Avenida 12 de Octubre Avenue
Quito, Ecuador
APO AA 34039
Tel: 011593256890

Japan
American Embassy
Micro Region 11, Big Rind Rd.
PSC 461, Box 300
FPO AP 96521-0002
Tel: (946-1) 329-095/606
Fax: (946-1) 320-776

Micronesia
American Embassy
PO Box 1286, Pohnpei
Federated States of Mirconesia 96941
Tel: (691) 320-2187
Fax: (691) 320-2186

New Zealand
American Embassy
29 Fitzherbert Terrace
Thorndon, Wellington
PO Box 1190 PSC 467, Box 1
FPO AP 96531-1001
Tel: (64-4) 472-2068
Fax: (64-4) 471-2380

Papua New Guinea
American Embassy
Douglas St., Port Moresby
PO Box 1492
APO AE 96553
Tel: (675) 321-1455
Fax: (675) 321-3423

INDUSTRY AFFILIATED

Mr. David Burney
United States Tuna Foundation
One Tuna Lane
San Diego, CA 92101

Dr. Jim Joseph
Director
Inter-American Tropical Tuna Commission
8604 LaJolla Shores Drive
LaJolla, CA 92037

Ms. Kitty M. Simonds
Executive Director
Western Pacific Fisheries Management Council
1164 Bishop Street, Room 1405
Honolulu, HI 96813

Brent Stewart
Senior Research Biologist
Hubbs-Sea World Research Institute
2595 Ingraham Street
San Diego, CA 92109

Mr. Lawrence D. Six
Executive Director
Pacific Fisheries Management Council
2130 SW 5th Avenue, Suite 224
Portland, OR 97201

Ms. Viola Brady
Sea Launch Company
P.O. Box 10168 APO
Grand Cayman
British West Indies

Mr. Richard Williams
Mr. Del Roosevelt
US Sea Launch
P.O. Box 32889
Long Beach, CA 90832-2889

Mr. Tim Hansen
Boeing Commercial Space Company
M/S 6E-60
P.O. Box 3999
Seattle, WA 98124-2499

Dr. V. G. Aliev
RSC Energia
4a, Lenin Street, Korolev
Moscow Region,
141070, Russia

Mr. Per Herbert Kristensen
Kværner Maritime a.s
Lysaker Torg 8
1324 Lysaker, Norway

Mr. S. Seyanin
DBTM
101-2, pr Vernadskogo
117415 Moscow
Russia

Mr. Argakov
KB Yuzhnoye
Krivorozhskaya Street, 3
Dnepropetrovsk City
320008 Ukraine

Mr. Trond Stenstad
Barber Kværner Marine
P.O. Box 374
N 1324 Lysaker
Norway

American Institute of Aeronautics and Astronautics
1801 Alexander Bell Drive
Suite 500
Reston, VA 20191

Dave Sadlowski
Aviation Development Manager
Arctic Slope World Services
3033 Gold Canal Drive
Rancho Cordova, CA 95670

Dr. Valerie Lang
Project Leader, Environmental Programs
The Aerospace Corporation
2350 E. El Segundo, CA 90245-4691

Aerospace Daily
1200 G Street, NW
Suite 200
Washington, DC 20005

INTERNATIONAL ORGANIZATIONS

The Honorable Manraoi Kaiea
Minister of Information, Communications and Transport
Republic of Kiribati
P.O. Box 487
Betio, Tarawa Atoll, Republic of Kiribati

FOREIGN GOVERNMENTS & GOVERNMENT ORGANIZATIONS

Ms. Mireya Munoz Mera
Second Secretary
Embassy of Ecuador
2535 15th Street, NW
Washington, DC 20009

Mr. Alistair MacLean
First Secretary
Embassy of Australia
1601 Massachusetts Avenue, NW
Washington, DC 20036

Ms. Kirsty Graham
Second Secretary
Embassy of New Zealand
37 Observatory Circle, NW
Washington, DC 20008

Mr. Tamari'i Tutangata
Director
South Pacific Regional Environmental Programme
P.O. Box 240
Apia, Western Samoa

South Pacific Forum
Forum Secretariat
Ratu Sukuna Road
Suva, Fiji Islands

South Pacific Forum Fisheries Agency
P.O. Box 629
Honiara, Solomon Islands

Office of the Fisheries Attache
Embassy of Japan
2520 Massachusetts Avenue, NW
Washington, DC 20008

Office of the Fisheries Attache
Embassy of Korea
2450 Massachusetts Avenue, NW
Washington, DC 20008

Office of the Agricultural Counselor (Fisheries)
Taipei Economic and Cultural Office in the United States
4201 Wisconsin Avenue, NW
Washington, DC 20016

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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.

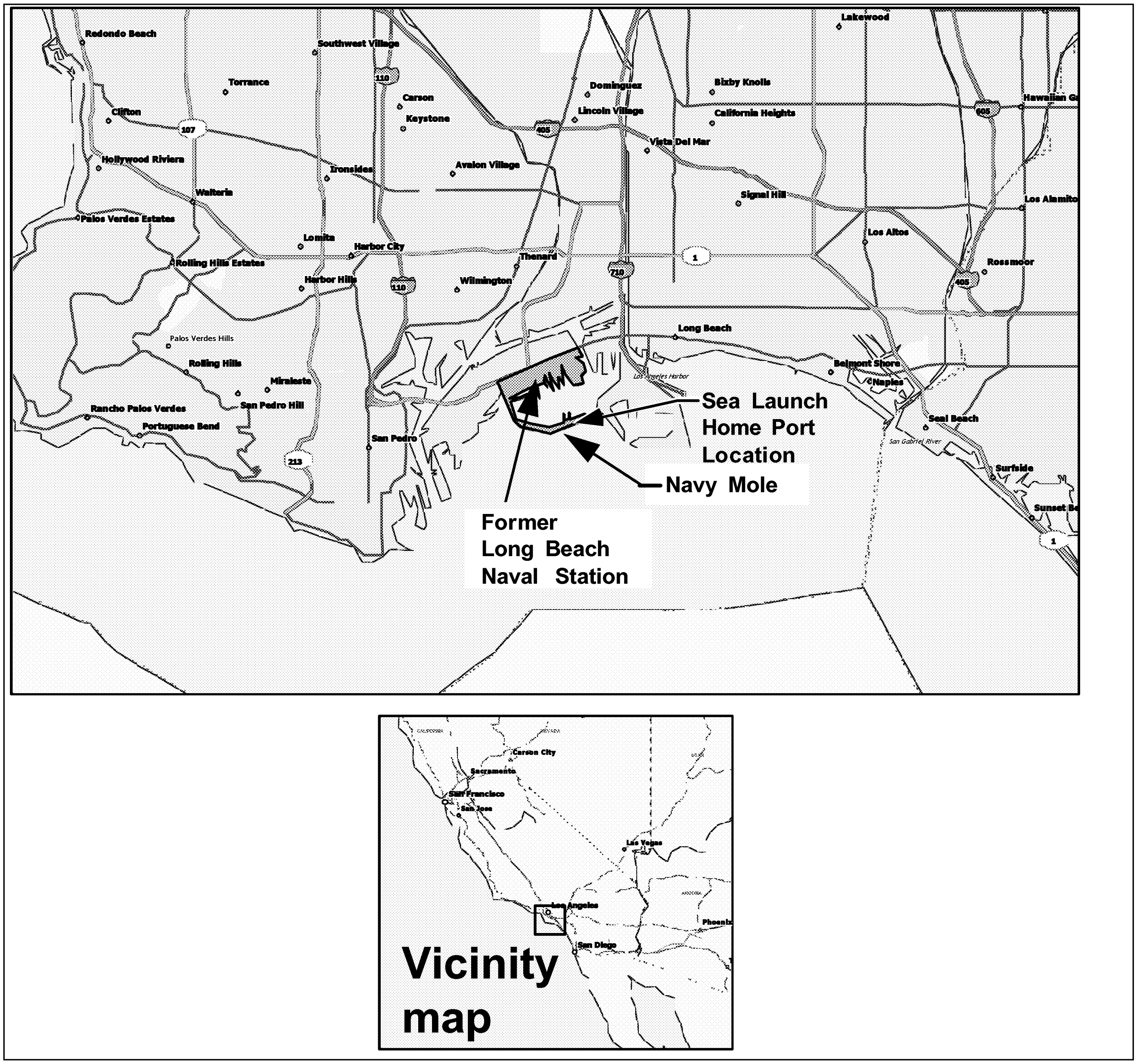


Figure A-1. Home Port Location and Vicinity

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.

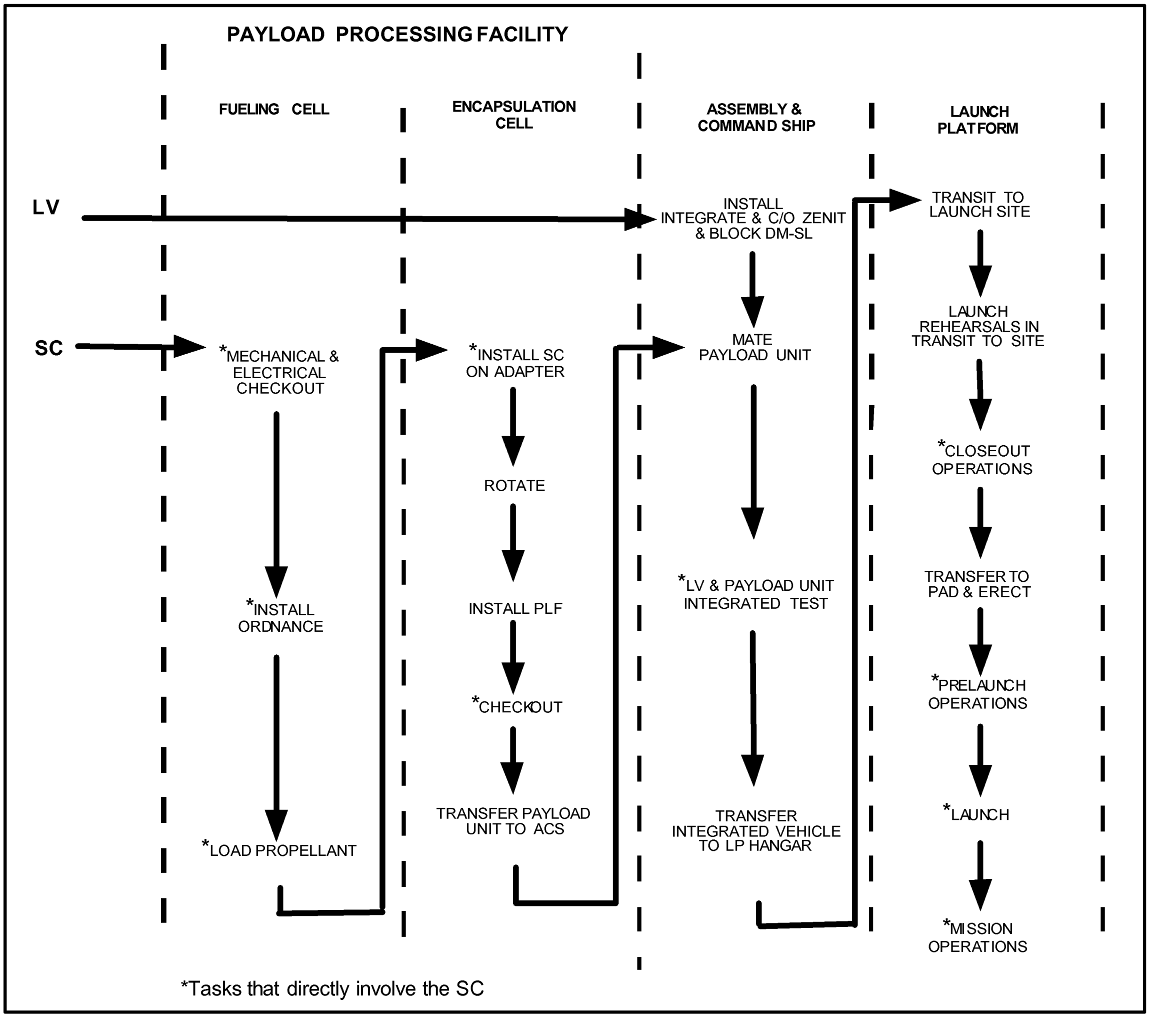


Figure A-2. Spacecraft Processing Flow

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.

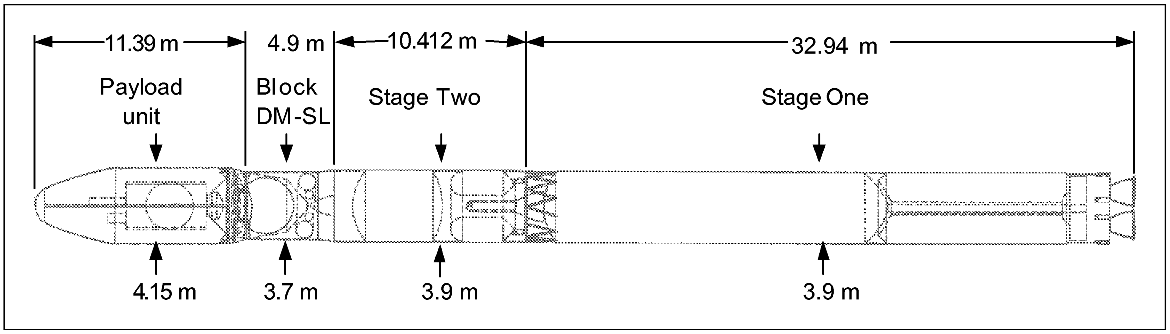


Figure A.1.1-1. Zenit-3SL Launch Vehicle

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.

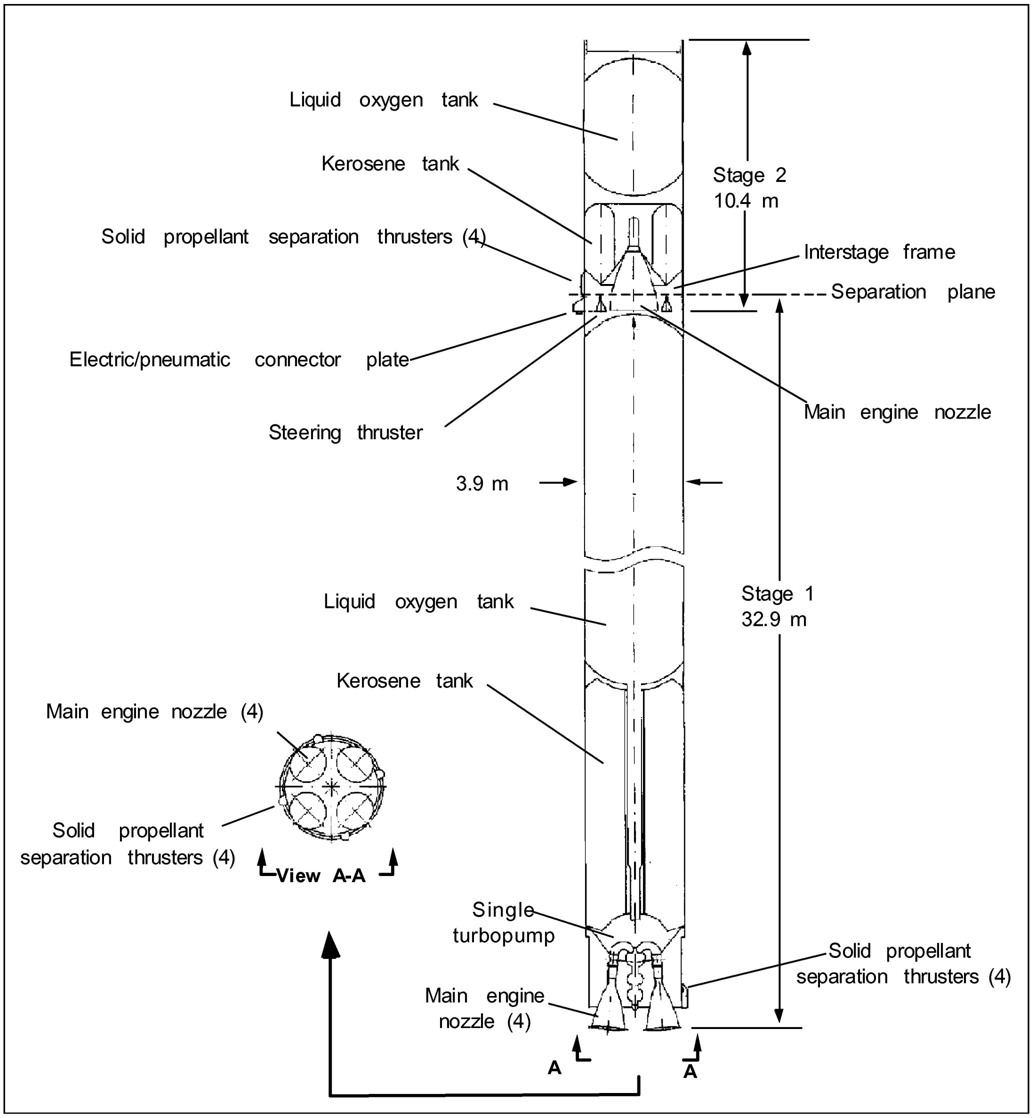


Figure A.1.3-1. Zenit Stage 1 and Stage 2 Configuration

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).

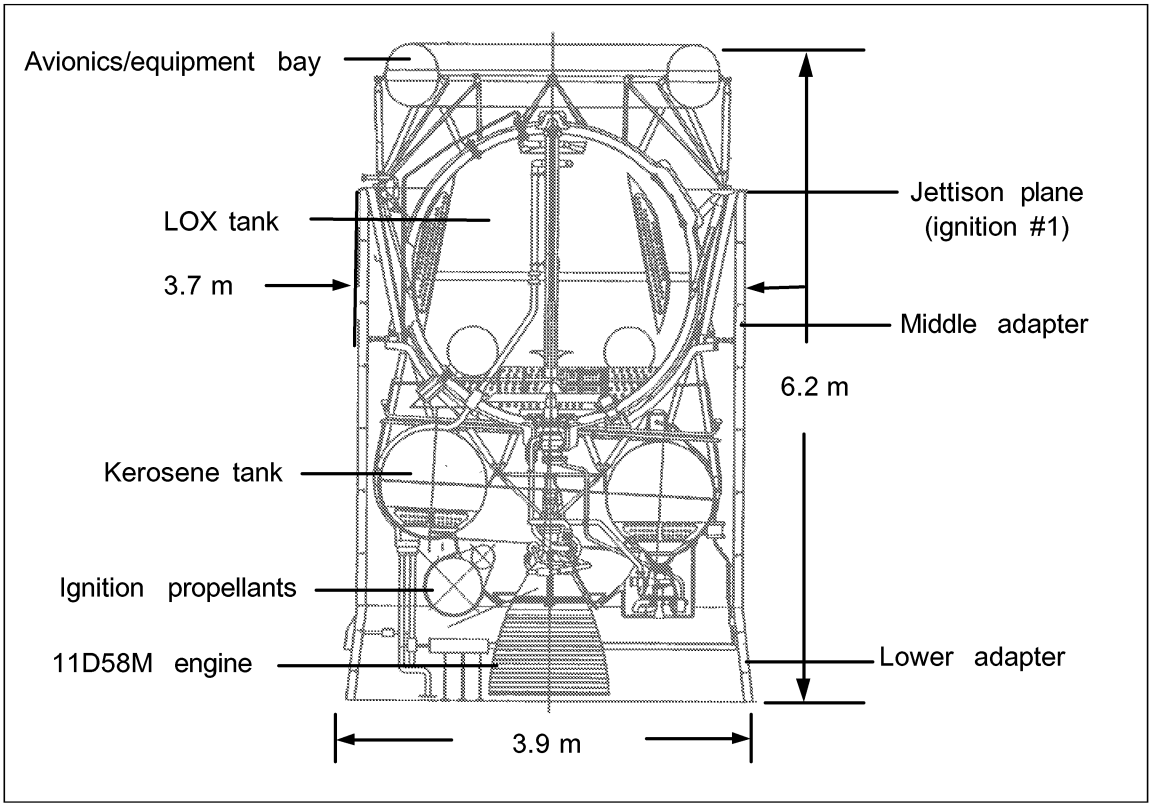


Figure A.1.4-1. Block DM-SL

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.

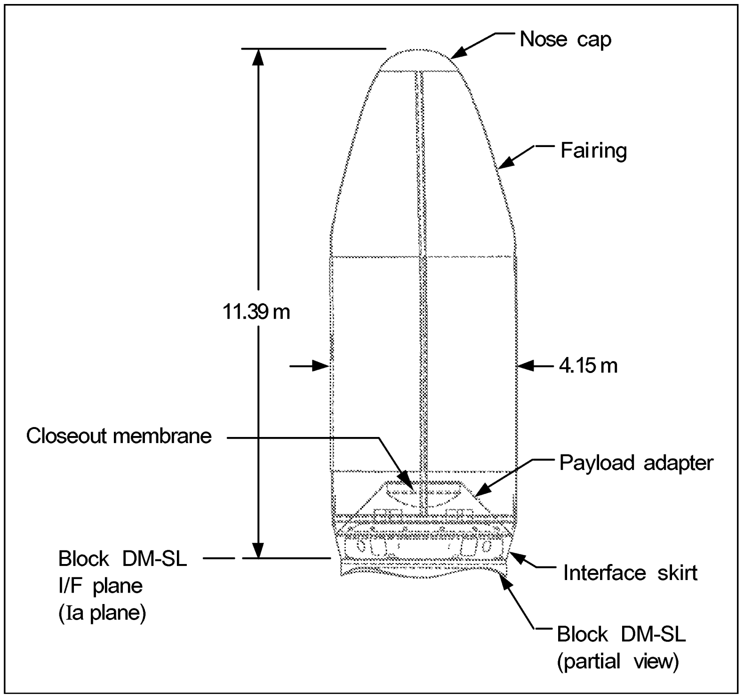


Figure A.1.5-1. Zenit-3SL Payload Unit

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.

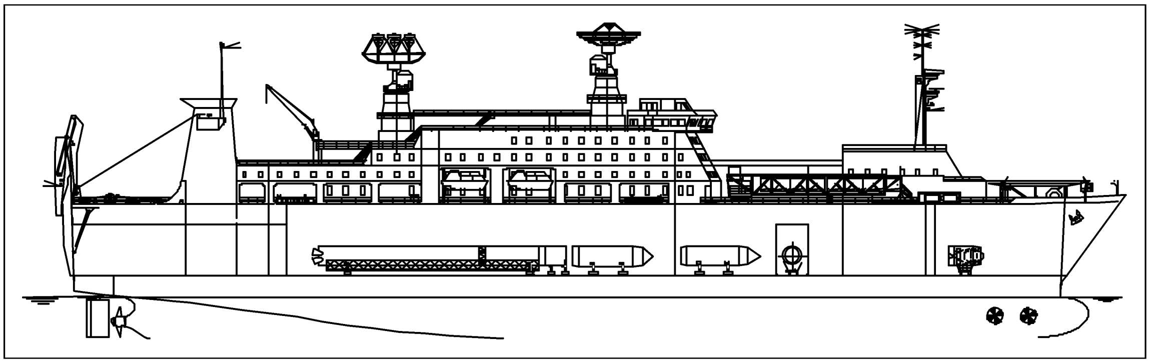


Figure A.2.1-1. Assembly & Command Ship

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.

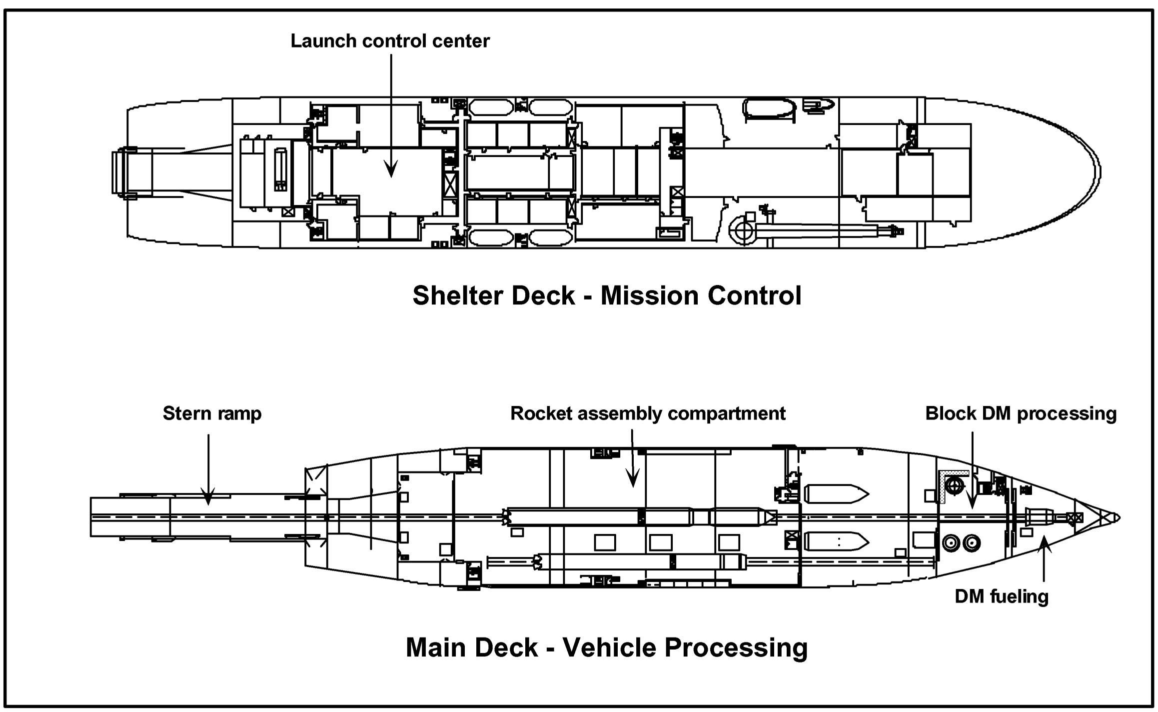


Figure A.2.2-1. Launch Vehicle Processing and Mission Control

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.

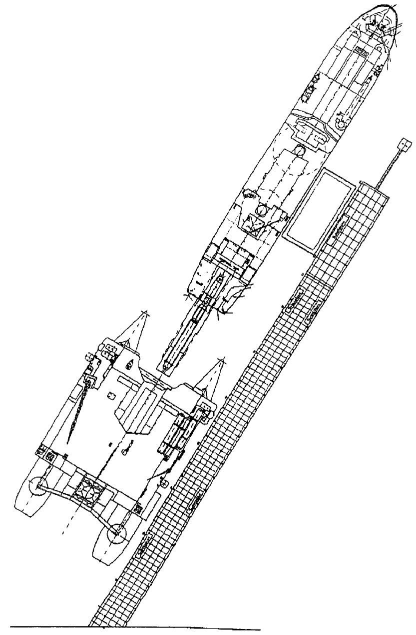
After the payload is integrated with the launch vehicle and all checkouts are complete, the integrated launch vehicle will be transferred to the launch platform. Environmental conditioning and monitoring of the encapsulated spacecraft is continuous from spacecraft encapsulation through launch. The only 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

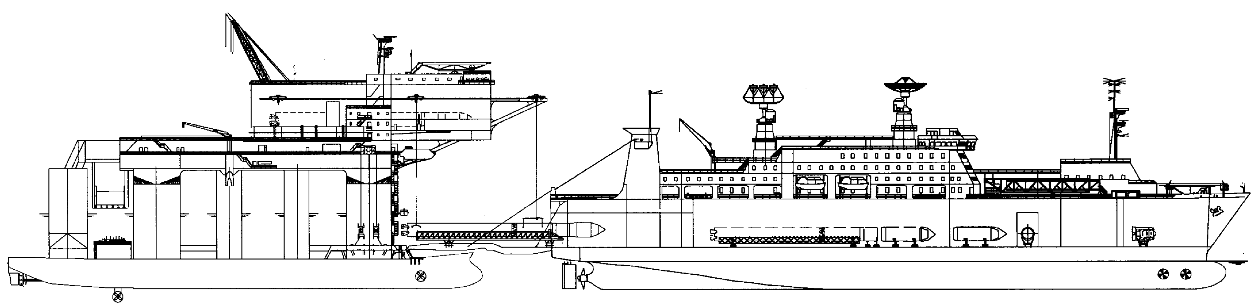
Transfer of the ILV from the ACS assembly area to the LP hangar will be accomplished just prior to the LP departing the Home Port for the launch area. At this time, all other operations related to provisioning the LP and preparation of the ILV will have been completed. The following general sequence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



Plan View



Side View

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

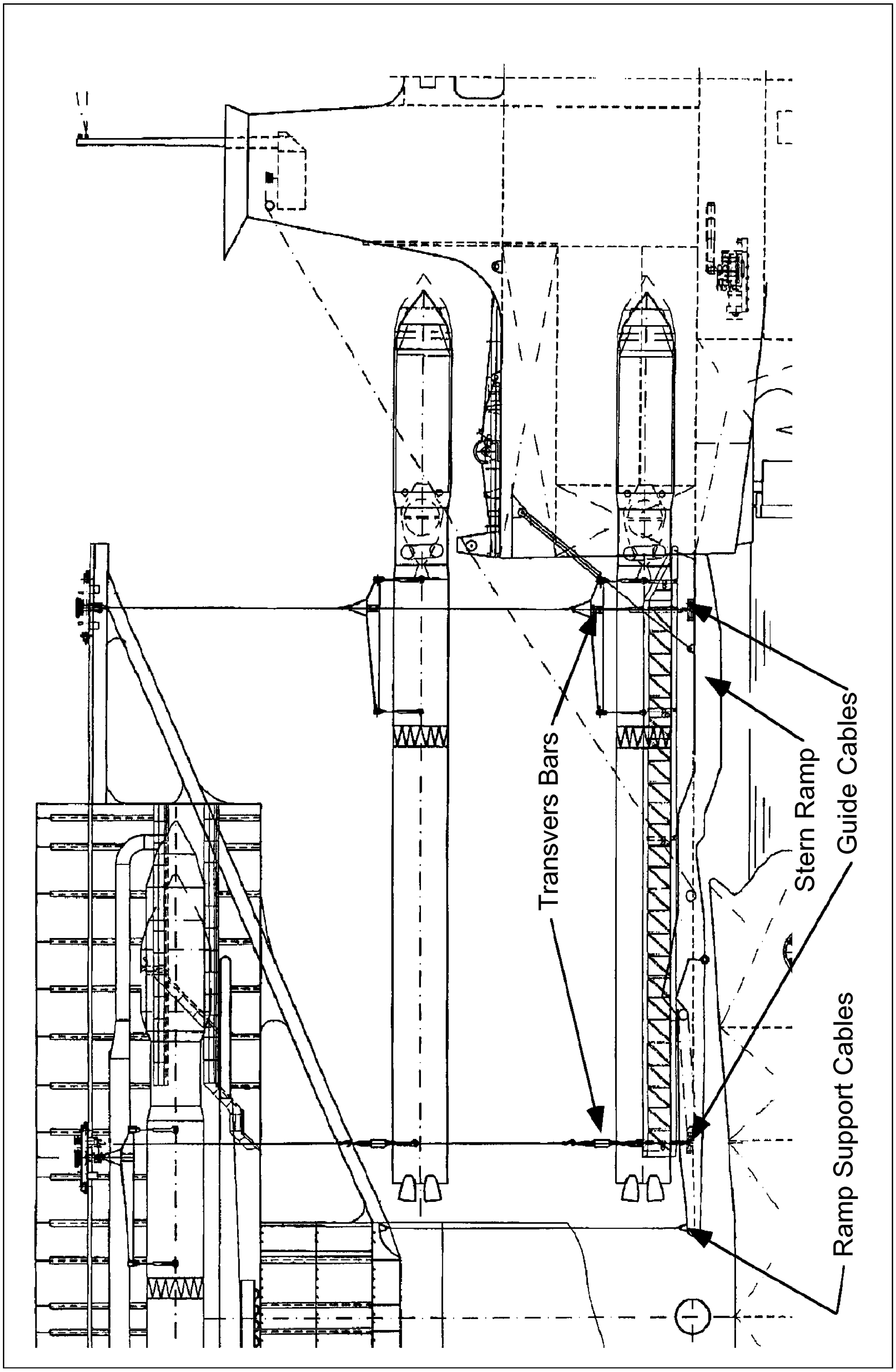


Figure A.2.2-3. Integrated Launch Vehicle Transfer Arrangement (1 of 2)

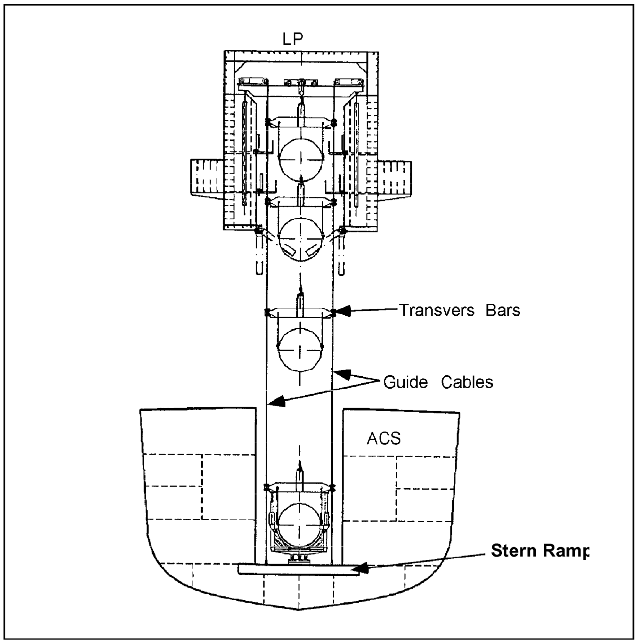


Figure A.2.2-3. Integrated Launch Vehicle Transfer Arrangement (2 of 2)

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.

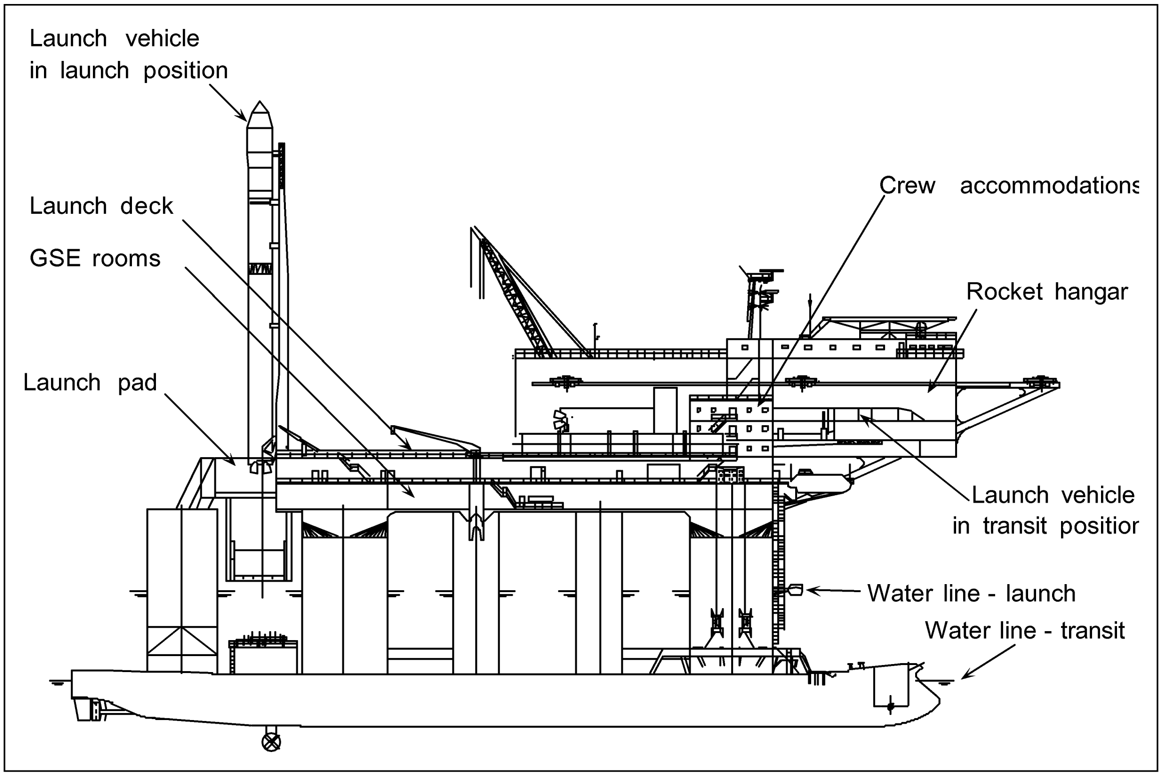


Figure A.2.3-1. Launch Platform

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.

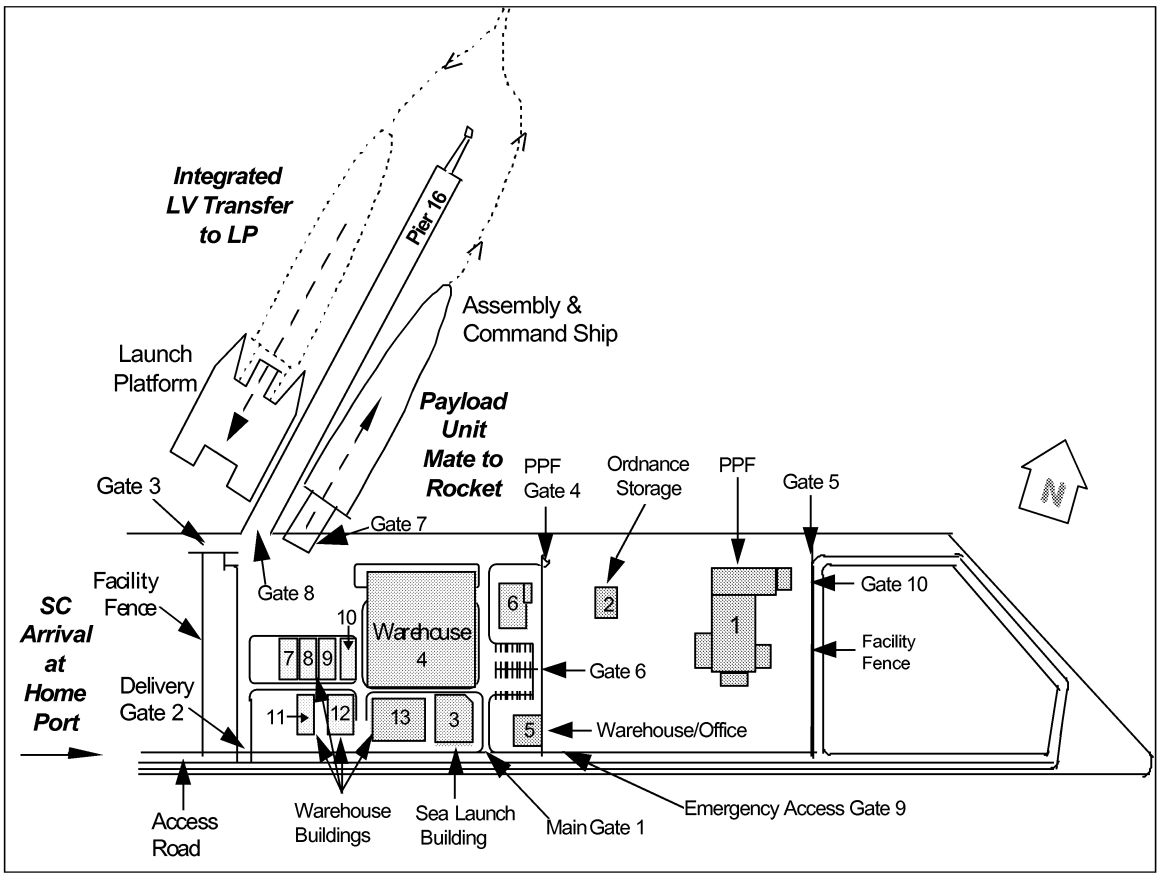


Figure A.4-1. Sea Launch Home Port Complex

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.

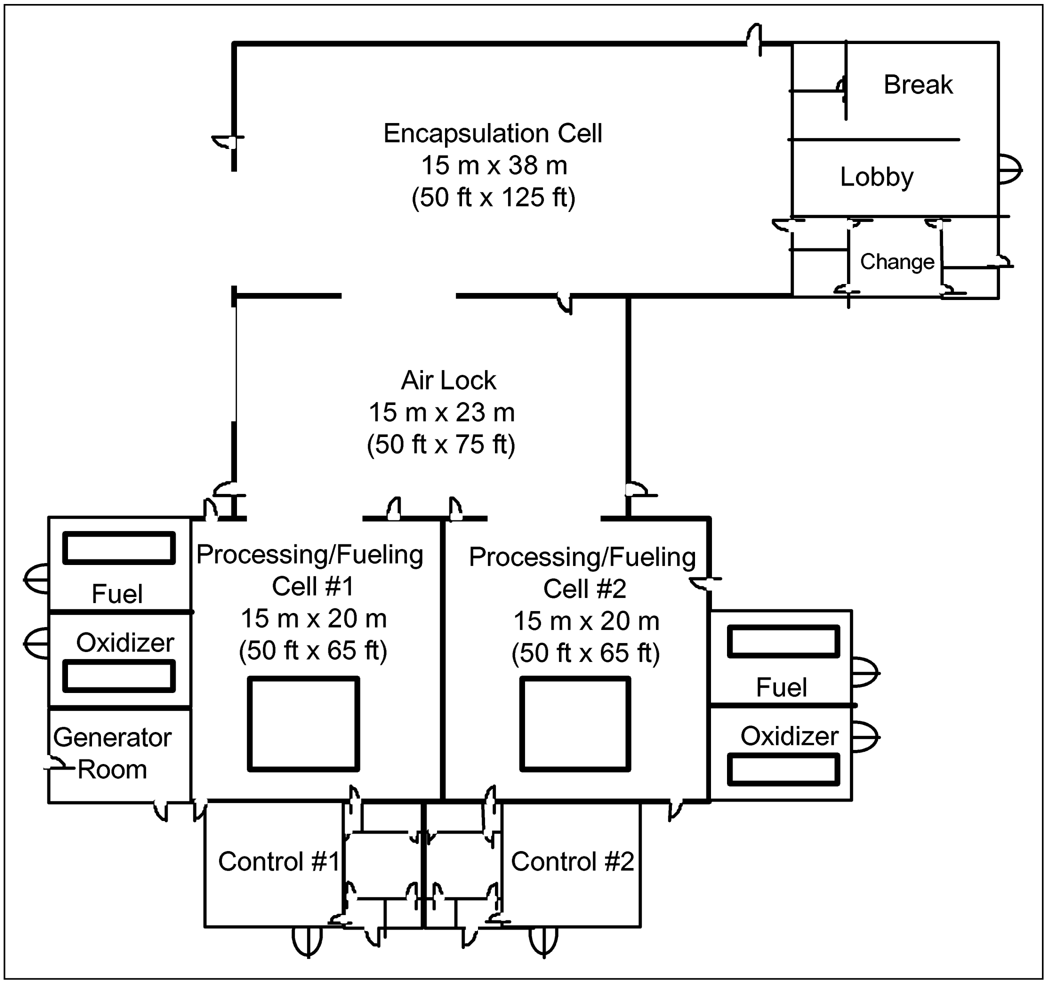


Figure A.4.2-1. Payload Processing Facility

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 ±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.

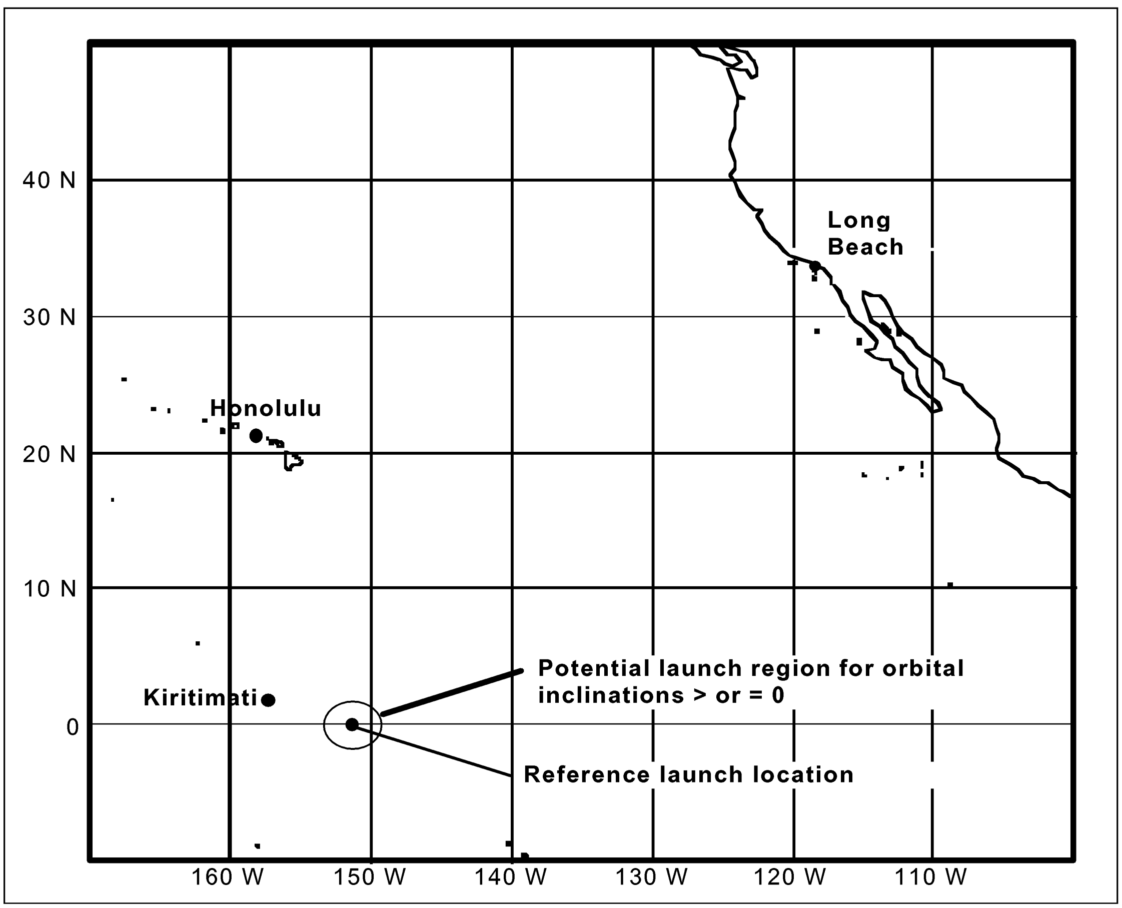


Figure A.5.7-1. Potential Launch Region

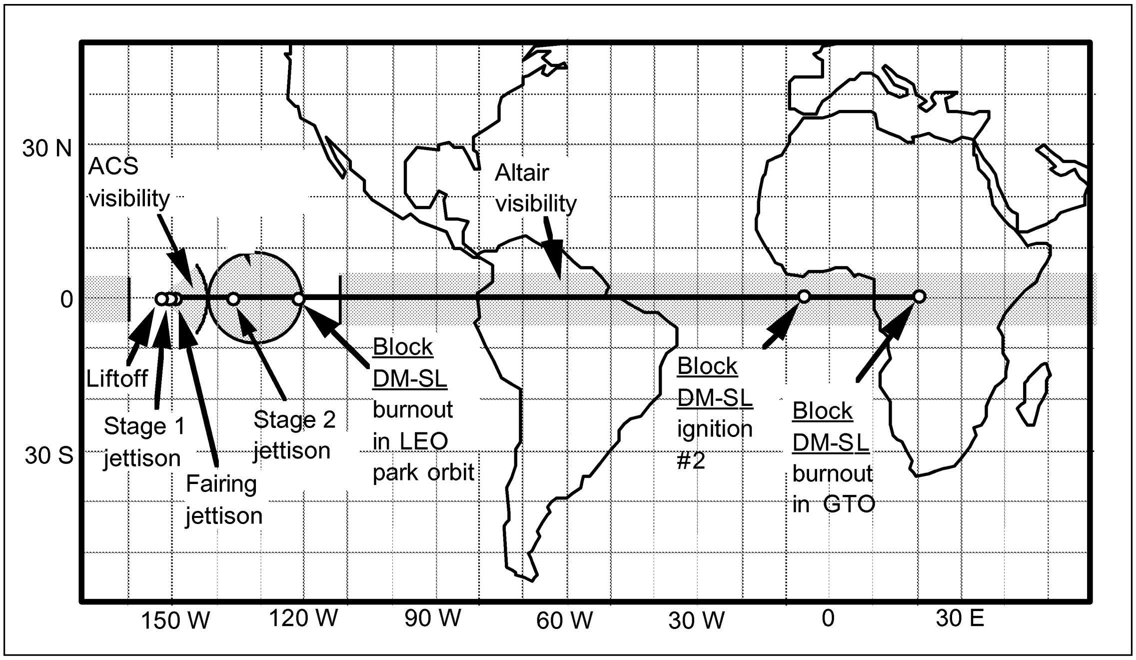


Figure A.5.8-1. Typical Flight Profile - GTO Mission

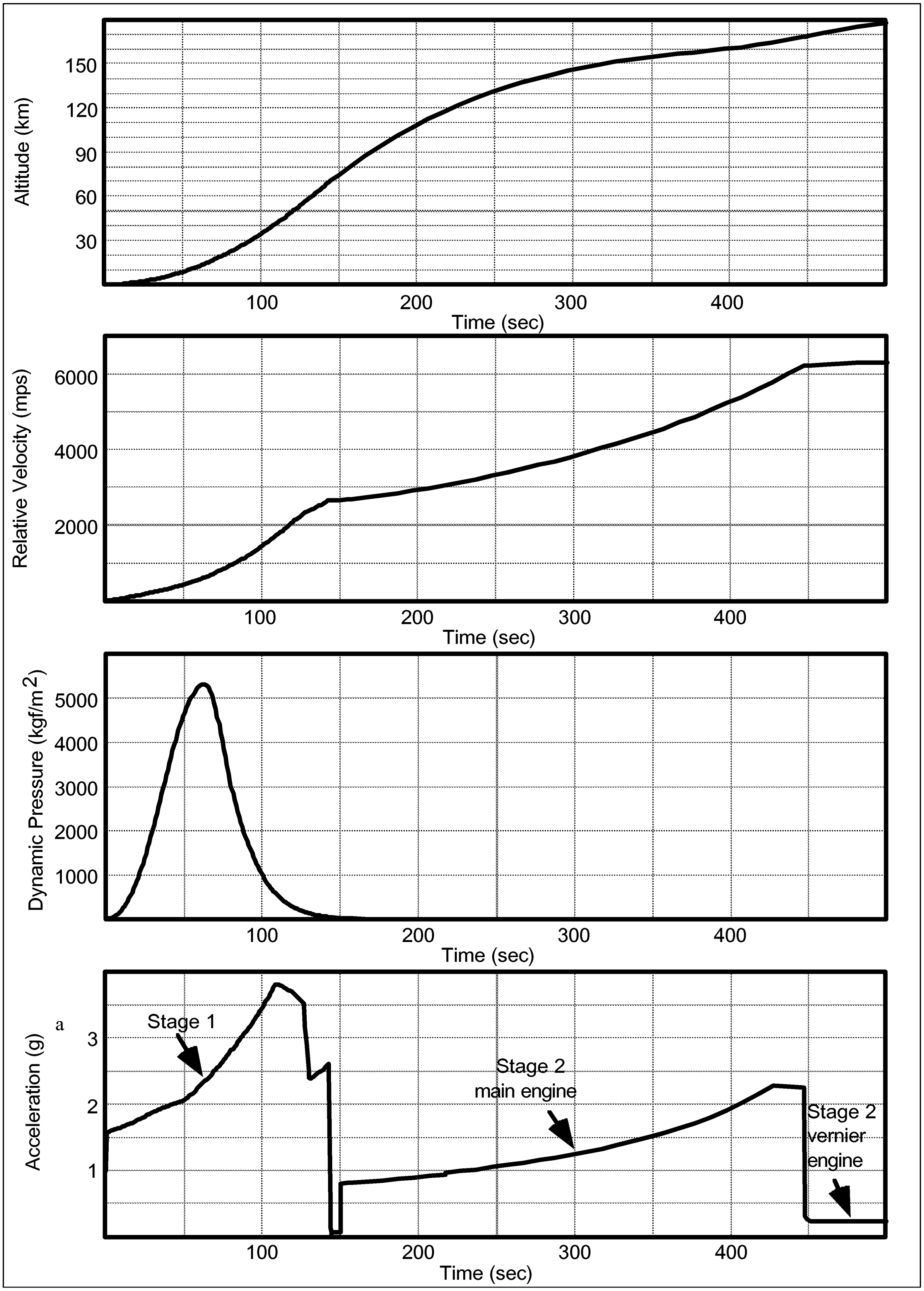


Figure A.5.8-2. Typical GTO Trajectory Parameters - Stage 1 and Stage 2

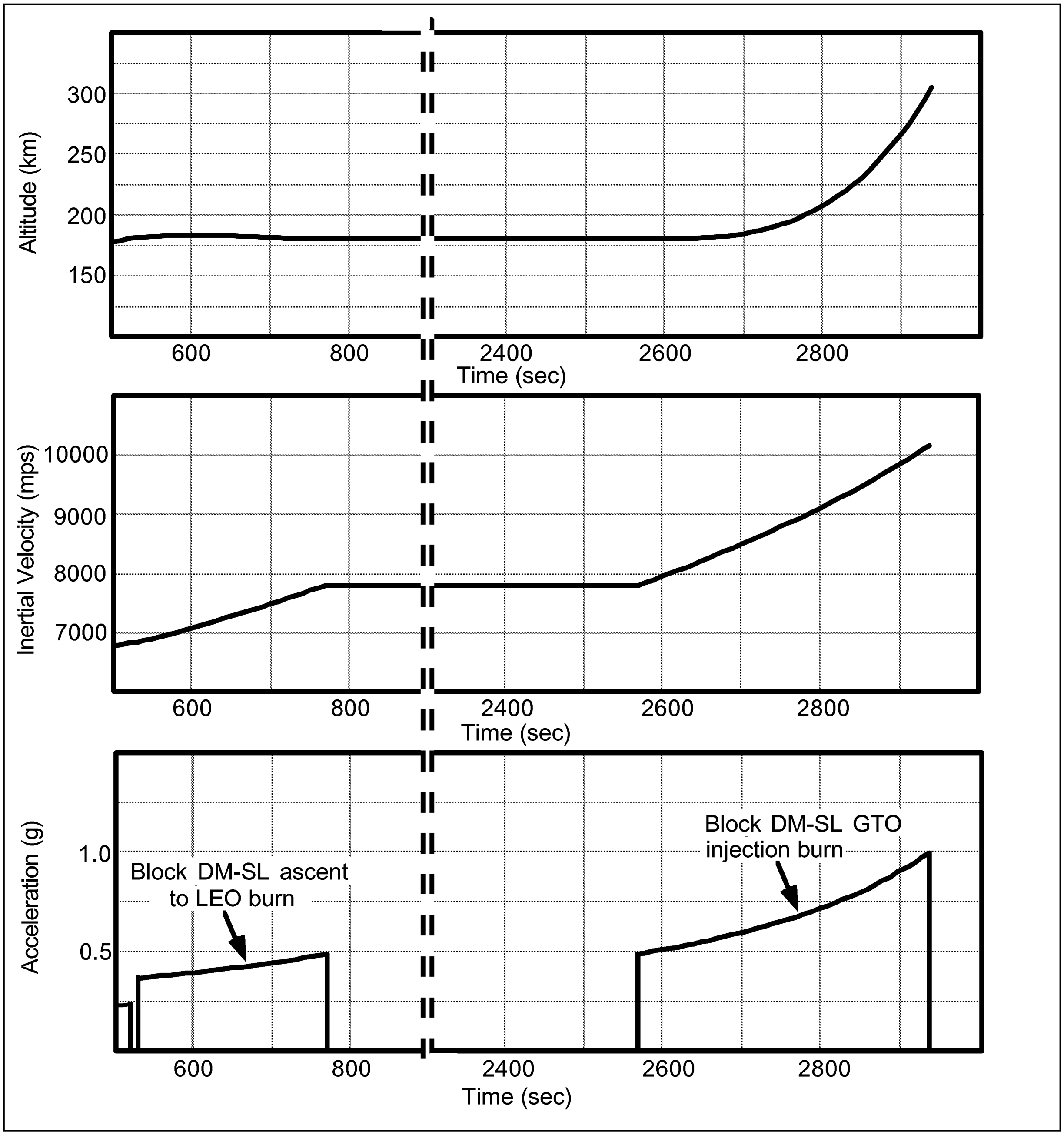


Figure A.5.8-3. Typical GTO Trajectory Parameters - Block DM-SL

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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.

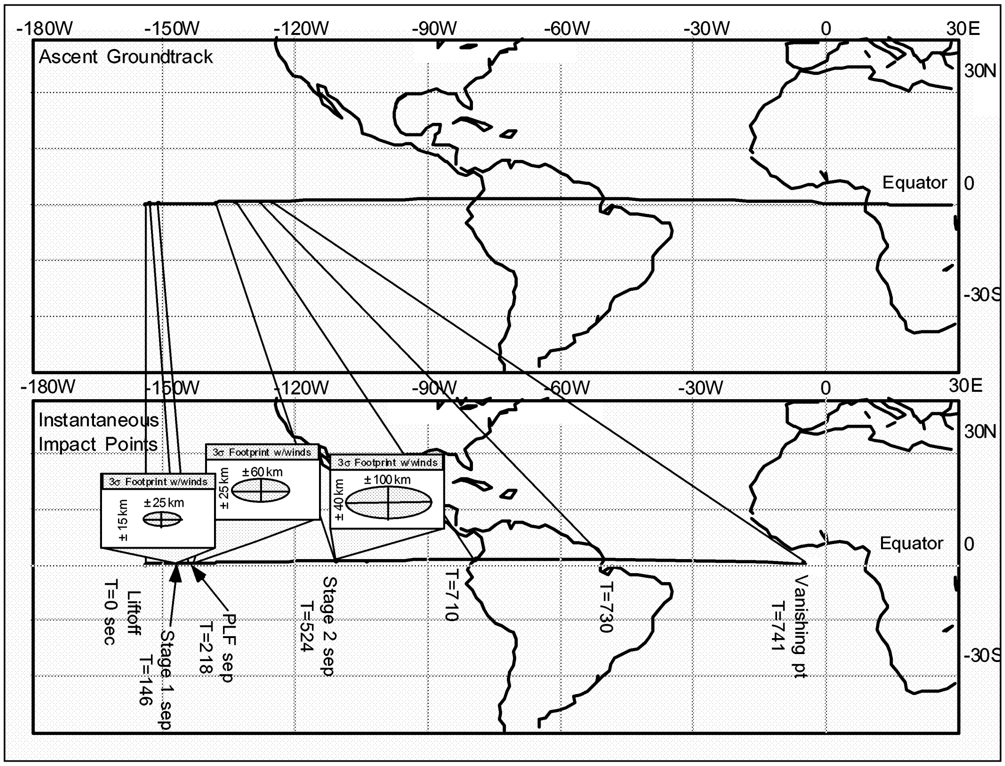

Figure B.2.2-1. Typical Ascent and Instantaneous Impact Point Groundtrack

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.

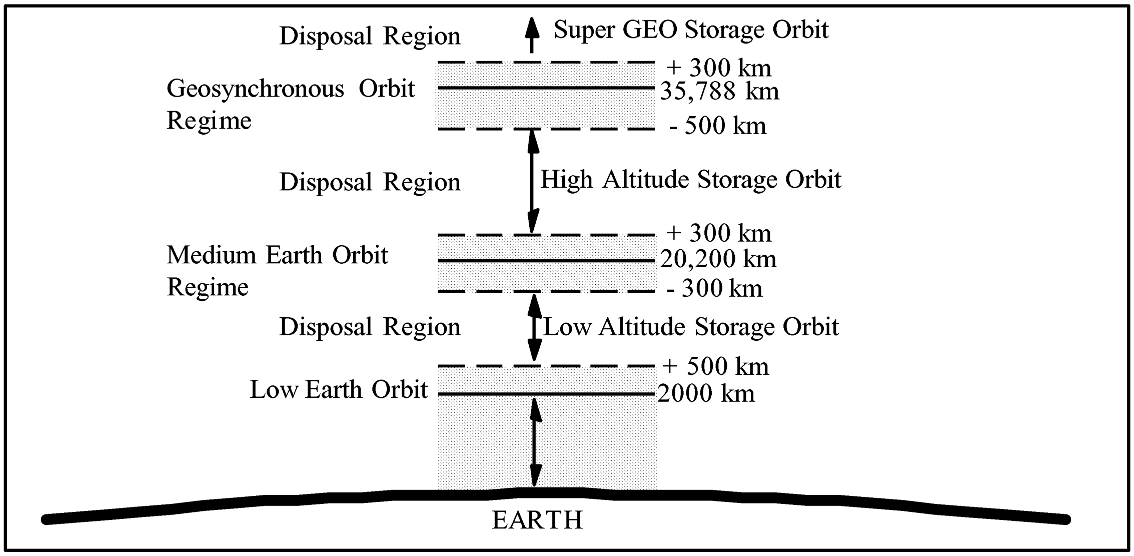

Figure B.2.2-2. Circular Disposal Orbit Regimes for Spent Stages

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.

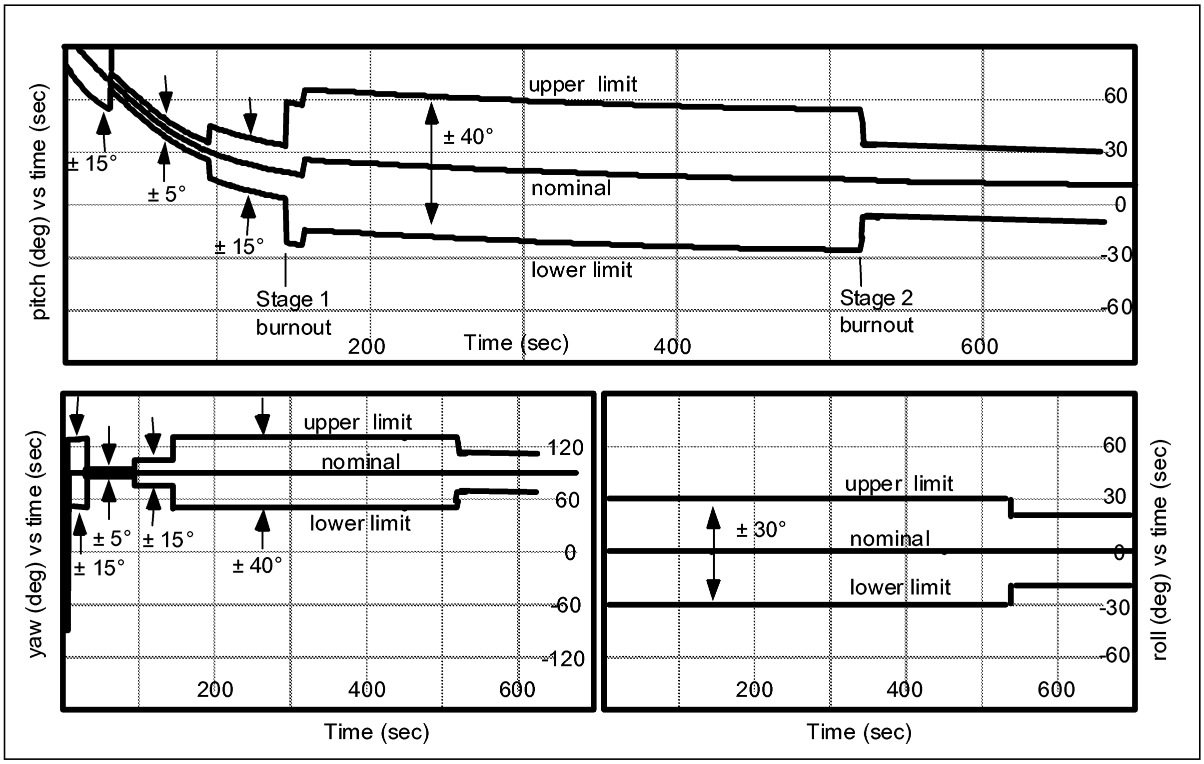

Figure B.2.2-3. Flight Safety Angle Limits

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: a. Resin "ED-20" b. Resin "PO-300" c. Product "AMG-3" d. Product "ADZ-3" e. Titanium dioxide	(Zenit) 0.3 kg 0.2 kg 0.0029 kg 0.001 kg 0.025 kg	GOST 92-0949-74. GOST 10587-84, Moderately dangerous substance Rate 9 TY 6-10-1108-76 Highly flammable fluid. Rate 3 Highly flammable fluid. Rate 3 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: a. Resin "SEDM-6" b. Polyamide resin "L-020" c. Titanium dioxide	(Zenit) 0.6 kg 0.24 kg 0.18 kg	GOST 92-0949-74 GOST 6-05-5125-82, Fire & explosive safe material. TY 6-05-1123-73, Fire & explosive safe material. 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)
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.

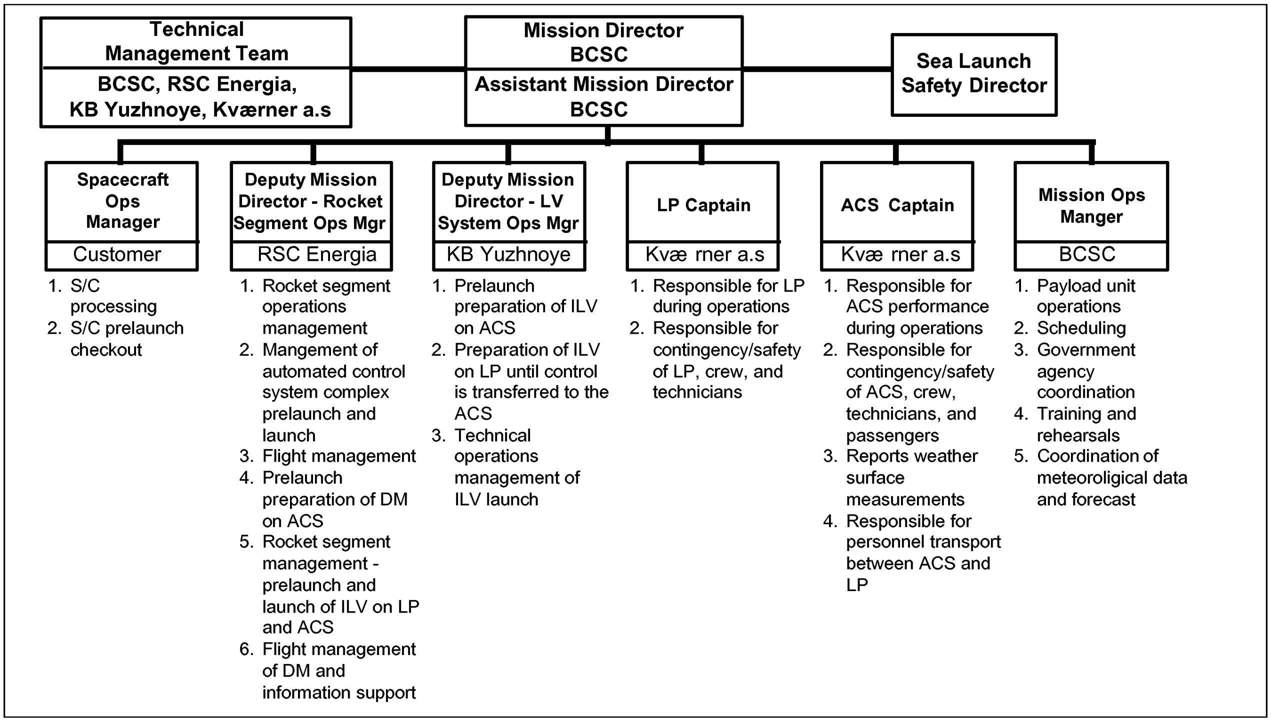

Figure C-1. Mission Operations Team

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).

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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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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

[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

[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.

Appendix B – Updates to Information in February 11, 1999 EA Appendices

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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 a Night Heron Rookery, which is part of the mitigation for the Naval Shipyard closure. The Port of Long Beach has no plans to allow public access to this area. The Port of Long Beach intends to lease the adjoining property for use as a container storage area, which would 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 Upper Stage, 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. Homeport is amending the Business Emergency Plan in accordance with the Long Beach Fire Department and BATF guidelines.

B.1.2.5 Risk Management Plan

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. This plan is administered by the State by the Long Beach Certified, Unified Program Agency.

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 Upper Stage 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 Upper Stage 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.

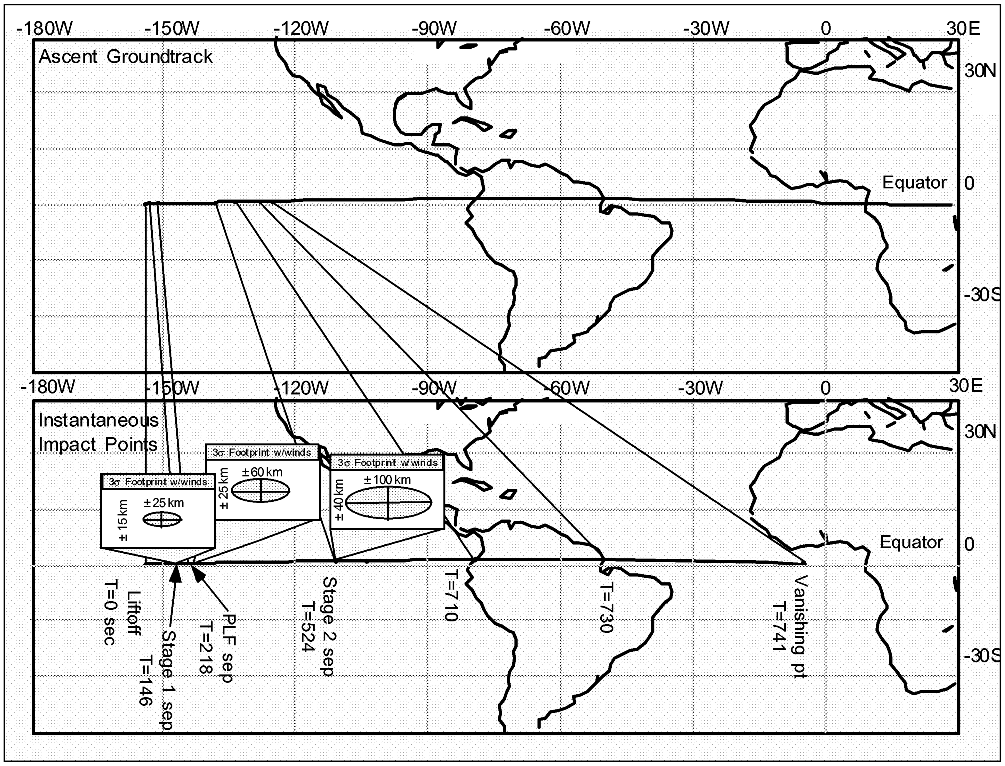

Figure B.2.2-1. Typical Ascent and Instantaneous Impact Point Groundtrack

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 Upper Stage 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 Upper Stage vents all propellants and gases. This procedure mitigates potential problems associated with previous Upper Stage ullage motor tanks exploding while in the post-mission storage orbit and provides for a safe storage configuration.

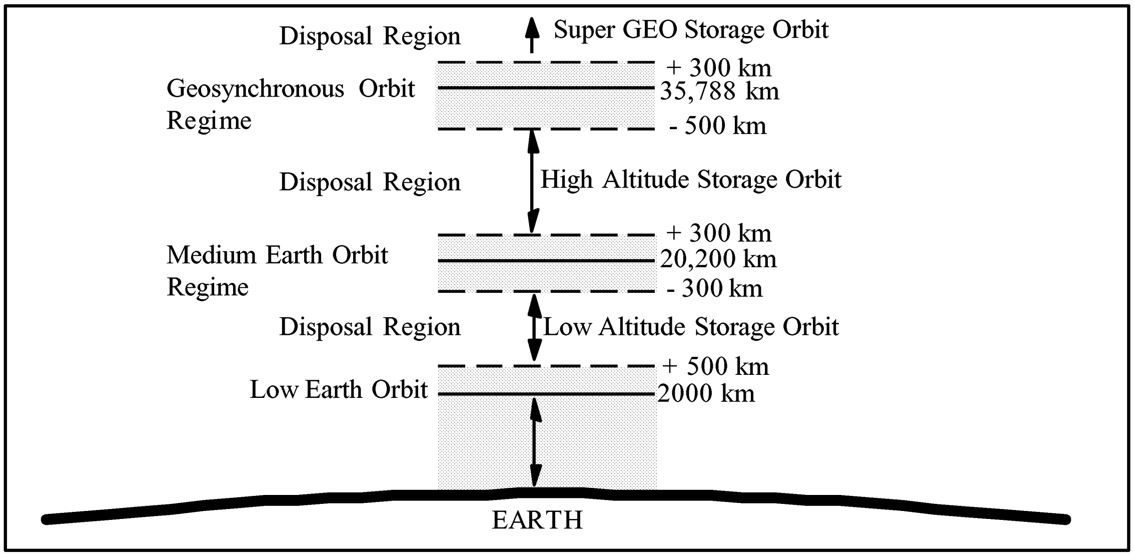

Figure B.2.2-2. Circular Disposal Orbit Regimes for Spent Stages

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.

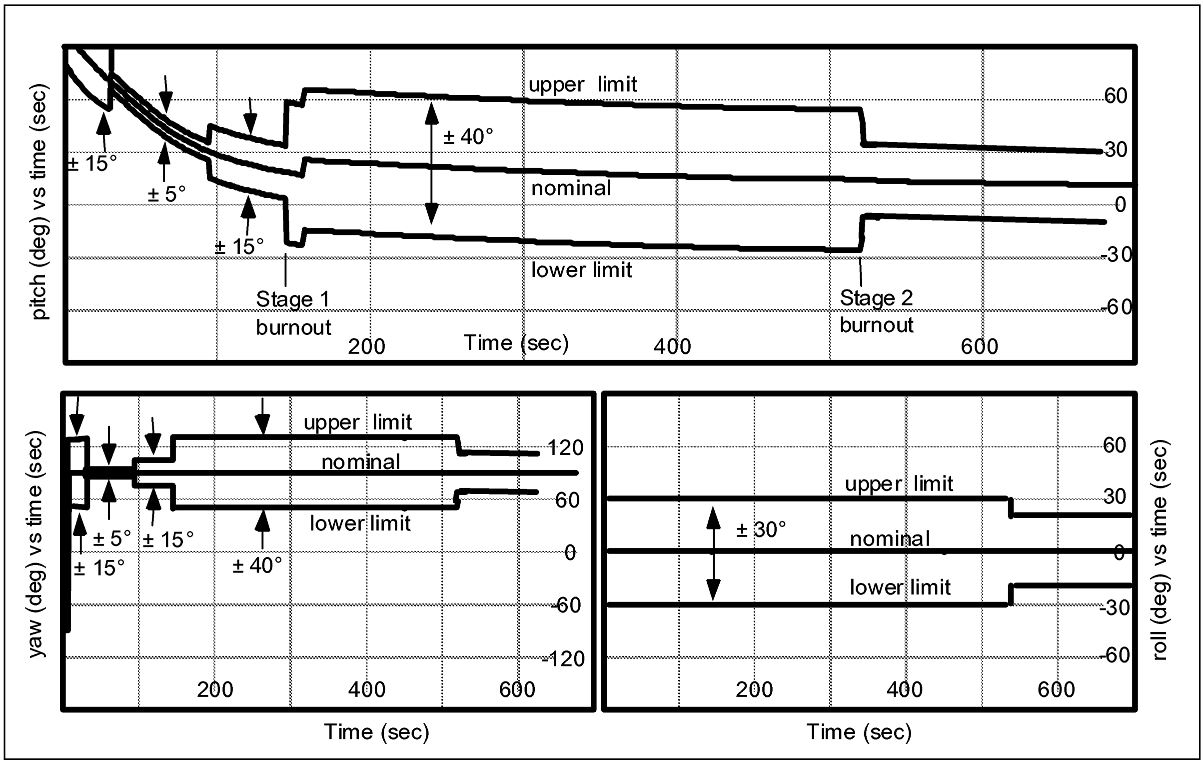

Figure B.2.2-3. Flight Safety Angle Limits

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 Upper Stage 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 Upper Stage 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:	
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:	
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 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. 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 Upper Stage 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 (Upper Stage) 0.5 kg (Zenit)	GOST 260-79
Adhesives (various)	1.22 kg (Upper Stage)	
Diethyleneglycolurethane	0.02 kg (Upper Stage)	
Ethyl alcohol	6.0 L (Upper Stage) 20 kg (Zenit)	GOST 5962-67 Highly flammable fluid. Rate 3
Gasoline	2.0 L (Upper Stage)	Highly flammable fluid. Rate 3
Isopropyl alcohol	TBD	Highly flammable fluid. Rate 3

Material	Approximate Quantity Used Per Launch	References, Remarks
Lacquer	0.5 kg (Upper Stage)	Highly flammable fluid. Rate 3
Lubricants	0.6 kg (Upper Stage)	Highly flammable fluid. Rate 3
Methyl ethyl ketone	TBD	Highly flammable fluid. Rate 3
Paints	2 kg (Upper Stage)	Highly flammable fluid. Rate 3
White spirit	1 kg (Zenit)	GOST 313-18. Highly flammable fluid. Rate 3
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: a. Resin "ED-20" b. Resin "PO-300" c. Product "AMG-3" d. Product "ADZ-3" e. Titanium dioxide	(Zenit) 0.3 kg 0.2 kg 0.0029 kg 0.001 kg 0.025 kg	GOST 92-0949-74. GOST 10587-84, Moderately dangerous substance Rate 9 TY 6-10-1108-76 Highly flammable fluid. Rate 3 Highly flammable fluid. Rate 3 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: a. Resin "SEDM-6" b. Polyamide resin "L-020" c. Titanium dioxide	(Zenit) 0.6 kg 0.24 kg 0.18 kg	GOST 92-0949-74 GOST 6-05-5125-82, Fire & explosive safe material. TY 6-05-1123-73, Fire & explosive safe material. 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)
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.

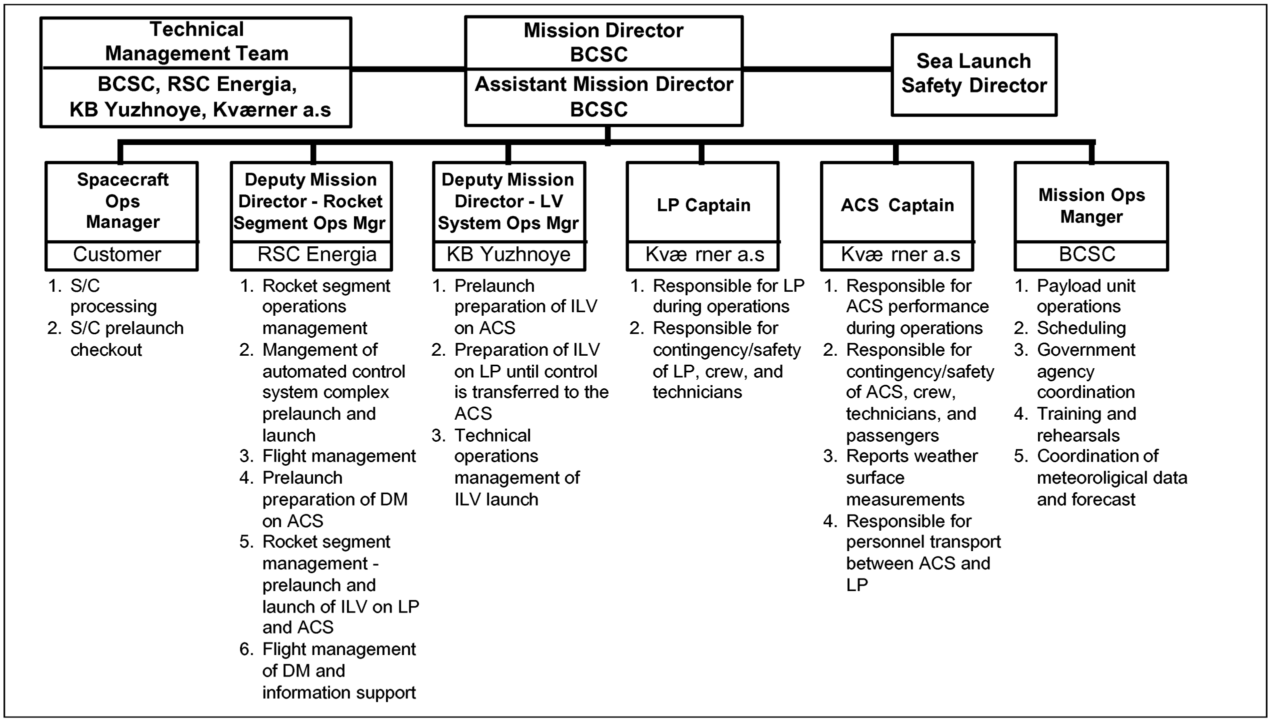

Figure C-1. Mission Operations Team

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 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 Upper Stage 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 Upper Stage.
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

Appendix C – February 11, 1999 EA Environmental Finding

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DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

ENVIRONMENTAL FINDING DOCUMENT

AGENCY: Federal Aviation Administration (FAA), DOT

ACTION: Environmental Finding Document: Finding No Significant Impact; Notice

SUMMARY: The Federal Aviation Administration (FAA) prepared an Environmental Assessment (EA), evaluating a Sea Launch Limited Partnership (SLLP) proposal to construct and operate a mobile, floating launch platform in international waters in the east-central equatorial Pacific Ocean. After reviewing and analyzing currently available data and information on existing conditions, project impacts, and measures to mitigate those impacts, the FAA Associate Administrator for Commercial Space Transportation (AST) finds that licensing the operation of the proposed launch activities is not a major Federal action that would significantly affect the quality of the human environment within the meaning of Executive Order (E.O.) 12114, Environmental Effects Abroad of Major Federal Actions, the application of which is guided by the National Environmental Policy Act (NEPA) of 1969. Therefore, the preparation of an Environmental Impact Statement (EIS) is not required pursuant to E.O. 12114, and AST is issuing an Environmental Finding Document Finding No Significant Impact.

The Environmental Assessment for the Sea Launch Project, dated January 1999, is incorporated by reference and attached to this document. This EA describes the purpose and need for the proposed project and describes the alternatives considered during the preparation of the document. The EA describes the environmental setting and analyzes the impact on the applicable human environment as a consequence of the proposed project.

FOR A COPY OF THE ENVIRONMENTAL ASSESSMENT FOR THE SEA LAUNCH PROJECT/CONTACT: Mr. Nikos Himaras, Office of the Associate Administrator for Commercial Space Transportation, Space System Development Division, Suite 331/AST-100, 800 Independence Ave., S.W., Washington, D.C. 20591; phone (202) 267-7926, or refer to the following Internet address: http://ast.faa.gov

ACTION: If a foreign entity controlled by a U.S. citizen conducts a launch outside the United States and outside the territory of a foreign country, its launch must be licensed. 49 U.S.C. § 70104(a)(3). The FAA determined that SLLP is a foreign entity controlled by a U.S. citizen, Boeing Commercial Space Company. 49 U.S.C. § 70102(1)(C); 14 CFR § 401.5. Because SLLP proposes to launch in international waters, outside the territory of the United States or a foreign country, SLLP must obtain an FAA license to launch. Licensing a launch in the environment outside the United States, its territories, and possessions is a Federal action requiring environmental analysis by the FAA in accordance with E.O. 12114 the application of which is guided by the National Environmental Policy Act of 1969. Upon receipt of a completed license application, the Associate Administrator for Commercial Space Transportation must determine whether or not to issue a license to SLLP to launch. Environmental findings are required for a license evaluation. In this instance, the proposed action is the licensing by the FAA of two launches by the SLLP at the specified launch location. The environmental finding and analysis covers up to six launches per year. SLLP proposes to conduct three (3) launches in the first year of operation. Pursuant to its requirements, the FAA will reevaluate the adequacy of existing environmental documentation if new circumstances develop.

SLLP proposes to conduct commercial space launch operations from a mobile, floating platform in international waters in the east-central equatorial Pacific Ocean. 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 would use a launch platform (LP) and an assembly and command ship (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.

A Zenit-3SL expendable launch vehicle fueled by kerosene and liquid oxygen would be the only launch vehicle used at the Sea Launch facilities. In the first year of operation, SLLP intends to conduct three (3) launches. Six launches are proposed for each subsequent year. The launches are proposed to occur at the equator in the vicinity of 154 degrees west to maximize inertial and other launch efficiencies. The distances from South America (over 7,000 km) and from the nearest inhabited island, Kiritimati (Christmas Island), (340 km) are intended to ensure that Stage 1 and Stage 2 would drop well away from land, coastal populated areas, and exclusive economic zones.

The FAA evaluated open sea areas, the Kiribati Islands, the Galapagos Islands and used a U.S. Navy environmental analysis of the Home Port in Long Beach, California in assessing potential environmental impacts from the proposed launch activities. This FAA environmental study incorporates by reference an environmental assessment conducted by the Navy on the Home Port Facility, which EA resulted in 1996 in a Finding of No Significant Impact. The Navy environmental assessment, also known as the Navy Mole EA, covers SLLP Home Port activities. This FAA environmental study focused on Sea Launch activities conducted at the launch location, activities that may impact the launch range during normal launches, and failed missions. Sea Launch payloads (i.e., commercial satellites) are not included in this evaluation because they will be fueled and sealed at the Home Port and will only become operational at an altitude of over 35,000 km. Potential environmental impacts of payloads are not discussed here except with regard to failed mission scenarios.

ENVIRONMENTAL IMPACTS

Air Quality

Pre-launch activities that may impact air quality include LP and ACS positioning, final equipment and process checks, coupling of fuel lines to the integrated launch vehicle (ILV) prior to fueling, the transfer of kerosene and liquid oxygen (LOX) fuels, and decoupling of the fueling apparatus. Normal launch operations would result only in an incidental loss of kerosene and LOX in vapor form. This loss of vapors would dissipate immediately and form smog. Although unlikely, an unsuccessful ignition attempt would result in automatic defueling of the ILV. Defueling would release LOX vapor and approximately 70 kg of kerosene when the fuel line is flushed. The LOX would dissipate and the vapor and kerosene would evaporate rapidly, dissipate and degrade, thereby having little effect on the surrounding environment. The probability of an unsuccessful ignition attempt resulting in defueling is 4×10^{-4}.

Potential environmental impacts from launch and flight activities would include spent stages, residual fuels, combustion emissions, and thermal energy and noise released into the atmosphere and ocean. During normal launches, any impacts would be distributed across the east-central equatorial pacific region in a predictable manner. Kerosene released during descent of a failed launch attempt would evaporate within minutes. Any residual LOX released during a failed launch attempt would instantly evaporate without consequence.

The proposed launch site is relatively free of combustion source emissions. That fact coupled with the size of the Pacific Ocean and air space allows most launch emissions to dissipate rapidly. Launch effects on the boundary layer up to 2,000 meters would be short term and cause minimal impacts. Emissions occurring in the atmospheric boundary layer would be dispersed away from the islands by winds and local turbulence caused by solar heating. Because dispersion occurs within hours, the planned six missions per year would preclude cumulative effects.

All emissions to the troposphere would come from first stage combustion of LOX and kerosene. Photochemical reactions involving Sea Launch Zenit rocket emissions would form carbon dioxide (CO_2) and oxygenated organic compounds. Nitrogen oxide in the exhaust trail would form nitric and nitrous acids. Cloud droplets and atmospheric aerosols efficiently absorb water-soluble compounds such as acids, oxygenated chemical compounds, and oxidants, thereby reducing impacts to insignificant levels.

Approximately 36,100 kg of carbon monoxide (CO) would be released into the troposphere during the first 55 seconds of flight resulting in an estimated CO concentration at Christmas Island of 9.94 mg/m^3. This release is well below the Occupational Safety and Health Administration Permissible Exposure Limit (PEL) of 55 mg/m^3, the Environmental Protection Agency (EPA) level of concern of 175 mg/m^3 and the industry Emergency Response Planning Guideline-2 of 400 mg/m^3. Nitrogen compounds in the exhaust trail of liquid propellant rockets would cause a temporary reduction of atmospheric ozone, with return to near background levels within a few hours. Models and measurement of other space systems comparable to Sea Launch indicate that these impacts would be 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. The exact chemistry and relative significance of these processes are not known but are believed to be minimal.

Impacts to air quality would be minimal. Those impacts that do occur would be of short duration and would naturally reverse themselves over a short period of time.

Waste

Post-launch operations at the launch site involve cleaning the LP for subsequent launches. Cleaning would result in particulate residues being washed from the LP with fresh water. Only a few kilograms of debris and residues would be generated. These materials would be collected and handled onboard as solid waste for later disposal at the Home Port. Impact locations for the spent rocket stages would be the open ocean. The current descriptions of the ocean environment, including physical, chemical and biological processes, apply equally to the launch location and the approximate locations of spent stage impacts. 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 fall; one has to be much closer to the Galapagos Islands to find meaningfully higher levels of productivity and biological activity.

Noise

Noise from a launch is calculated at approximately 150 decibels at 378 meters with the equivalent sound intensity in the water estimated at less than 75 decibels. Due to the small number of launches per year and scarcity of higher trophic level organisms, noise impacts are expected to be negligible.

Biological and Ecological Impacts

Pre-launch preparations includes spraying fresh water from a tank on the LP into the LP's flame bucket, which would dissipate heat and absorb sound during the initial fuel burn. There would be minor impacts to the ecosystem because of the input of heated freshwater. However, the natural variation in plankton densities would ensure rapid and timely recolonization of plankton in the water surrounding the LP.

Launch and flight activities may impact the ocean environment by depositing spent stages and residual fuels. During normal launches, these impacts would occur and be distributed across the east-central equatorial pacific region. It is unlikely that any falling debris would impact animals, although a small number of marine organisms would be impacted. Plankton immediately beneath any kerosene sheen would likely be killed. However, overall plankton mortality would be minimal as the population densities are greatest around 30 meters below the surface. Fuel dispersed from Stages 1 and 2 would evaporate in minutes and within a few thousand feet, as in the case when a pilot lightens a plane by dumping jet fuel. The small amount of kerosene that might reach the ocean surface would evaporate and decompose within hours.

Two severe accident scenarios were evaluated and determined to cause only minimal damage to the environment. The first case evaluated ILV failure and explosion on the LP with the ILV being fully fueled and ready for launch. This failure would result in an explosion of the ILV fuels scattering pieces of the ILV and LP up to 3 km away. Particulate matter from the smoke plume would drift downwind and be distributed a few kilometers before dissipating. Plankton and fish in the immediate area would be killed over the course of several days. Thermal energy would be deflected and absorbed by the ocean and 100% of the fuels would be consumed or released into the atmosphere through combustion or evaporation. Disruption to the atmosphere and the ocean would be assimilated and the environment would return to pre-accident conditions within several days.

The second scenario evaluated involved failure of the rocket's upper stage. Loss and re-entry of the upper stage and payload would result in materials and fuels being heated by friction and vaporizing. Remaining objects would fall into the ocean causing a temporary disruption as the warm objects cooled and sank. The risk of debris striking any populated areas or ecological habitats is very remote. Sea Launch selected a more northerly route to further reduce the risk to the Galapagos Islands. The risk of an impact to either Wolf or Darwin Islands would only occur in the unlikely event of a scenario in which Stage 3 (the upper stage) suffers a specific type of failure during two specific time intervals of around .25 second each. In the event of mid-flight Stage 3 failure, approximately 99% of the satellite and its components would burn up upon re-entry to the atmosphere. Thus, the total mass of any objects reaching Wolf or Darwin Islands would be small. The probability of this occurring is approximately 8 in 100,000 launches.

Socioeconomics

The SLLP would occupy the launch location for two to seven days during each launch cycle. Due to the brief period of time that the LP and the ACS will be present at the launch location, social and economic impacts to the Kiribati are considered negligible. The brief duration of launch activities, and the relative degree of isolation of the launch location provides a barrier between Sea Launch and cultural and economic character of the Kiribati society. The baseline plan for operations does not include any use of facilities based on any of the Kiribati Islands. Impacts to the Islands, associated with employees transiting Christmas Island on an emergency basis, would be positive given that the expenditures would be an addition to the local economy.

Health and Safety

FAA's licensing process will examine safety aspects of the proposed launch operations.

The SLLP adopted as a population protection risk criteria, an upper limit of one in a million casualty expectation. Public safety assurance and analysis issues are discussed in the SLLP document "Sea Launch System Safety Plan." The launch location was shifted away from South America to ensure 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 rocket traverses land. The launch area, in the vicinity of 154 degrees west was selected because it is located outside of the Kiribati 320 km exclusive economic zone and is roughly 340 km from the nearest inhabited island.

Threatened and Endangered Species

There are no known threatened and endangered species that will be impacted by the proposed launches.

Archeological and Cultural Resources

The launches, proposed to occur in the open ocean, will not impact archeological or cultural resources.

Cumulative Impacts

There are no other foreseeable planned developments in the area of the proposed launch location at this time, therefore, no expected cumulative impacts are expected. The Navy Mole facility is currently underutilized as compared to its historical level of operation and development. Sea Launch activities will generate additional work and revenue and the Home Port facility may be the impetus for other development in the area.

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 of the Port of Long Beach, California. The Navy, as part of the California Environmental Quality Act Process, submitted its Mole EA to the California Coastal Commission for review, which determined the proposed Home Port activities were not inconsistent with the California Coastal Zone Management Program. 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 environment. The LP, ACS, and satellite tracking ships used to transport the launch vehicle, payload and other materials to the launch site 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 site.

Notice to Mariners

Standard notices to mariners will be broadcast using U.S. 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 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 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.

Public Participation

During the planning phase of the Sea Launch environmental review process, the FAA concluded that public participation was required. It was further decided that the Environmental Assessment and proposed finding document would be made available for public review for a 30-day period. Consequently a list of pertinent entities was compiled to ensure that wide distribution of the documents would be possible. The list included cognizant Federal and State agencies, scientific institutes, trade and environmental organizations and foreign embassies of countries in the area of the proposed action. The documents would also be made available to any organization or member of the public and could also be found in the FAA/AST web site. The public review period commenced on April 23, 1998 via publication of a Notice in the Federal Register. During the week preceding this announcement, FAA mailed copies of the documents to all entities on the list. Additional copies were mailed via regular or next-day mail, as requested. The public review and comment period was scheduled from April 23, 1998 until May 26, 1998.

Interest in the project was expressed by a number of South Pacific Nations, Ecuador and the South Pacific Regional Environmental Programme (SPREP). These entities also indicated the need for additional time for internal coordination and consultation. In response to this need, the FAA accepted and addressed all review comments, which arrived after the end of the scheduled public review and comment period.

As part of the public participation program, FAA/AST personnel held face-to-face information exchanges with representatives of Ecuador in Washington DC. In addition, FAA personnel traveled to the Western Pacific and held similar meetings with representatives of the Republic of Kiribati at Tarawa and with SPREP representatives at Apia, Samoa. Diplomatic representatives from Australia and New

Zealand participated at the Apia meeting and Australian representatives met with the FAA in Washington, DC.

Numerous meetings, and information exchanges also took place among FAA/AST personnel and specialists from the National Oceanic and Atmospheric Administration (NOAA), National Marine Fisheries Service (NMFS), Environmental Protection Agency (EPA), National Air and Space Administration (NASA), United States Coast Guard (USCG) and the Department of State (DOS).

The FAA is also making available to the public the Final Sea Launch Environmental Assessment and Environmental Finding Document.

No Action Alternative

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 49 U.S.C. Subtitle IX, ch. 701 Commercial Space Launch Activities, would not be realized. Predicted environmental impacts of the proposed launch activities would not occur and the project area would remain in its current state.

Prepared by ____________________________Date__________________
Nikos Himaras

Recommended by________________________Date__________________
Herb Bachner

FINDING

An analysis of the action has concluded that there are no significant short-term or long-term effects to the environment or surrounding populations. After careful and thorough consideration of the facts contained herein, the undersigned finds that the proposed Federal action is consistent with the purpose of national environmental policies and objectives as set forth in E.O. 12114 the application of which is guided by the National Environmental Policy Act of 1969 (NEPA) and that it will not significantly affect the quality of the human environment or otherwise include any condition requiring consultation. Therefore, an Environmental Impact Statement for the action is not required.

Issued in Washington, DC on:______________________________

Patricia G. Smith ____
Associate Administrator for Commercial Space Transportation.

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Appendix D – Written Reevaluations and Environmental Findings

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SUBJECT: Written Reevaluation of the Sea Launch Environmental Assessment with Respect to a Proposed Non-Equatorial Launch Azimuth Scenario for the Sea Launch Company

DATE: January 11, 2000

Introduction and Background

Sea Launch Limited Partnership (SLLP) is an international commercial venture formed to conduct commercial space launch operations from a mobile, floating launch platform in international waters in the east-central equatorial Pacific Ocean. The Federal Aviation Administration (FAA) commercial space launch licensing authority in 49 USC Subtitle IX--ch. 701, Commercial Space Launch Activities, §§ 70101-70121 (the Act), authorizes the U.S. Secretary of Transportation to oversee and coordinate U.S. commercial launch operations and to issue licenses authorizing commercial launches and the operation of commercial launch sites. The Secretary is implementing this authority through the FAA's Associate Administrator for Commercial Space Transportation (AST). FAA exercises its licensing authority in accordance with the 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 is a foreign entity controlled by a U.S. citizen. If a foreign entity controlled by a U.S. citizen conducts a launch outside the United States and outside the territory of a foreign country, its launch must be licensed. 49 USC § 70104 (a)(3). The FAA determined that SLLP is a foreign entity controlled by a U.S. citizen, Boeing Commercial Space Company. 49 USC § 70102 (1)(C); 14 CFR § 401.5. Because SLLP proposes to launch in international waters, outside the territory of the United States or a foreign coontry, SLLP must obtain an FAA license to launch. Licensing a launch in the environment outside the United States, its territories and possessions is a Federal action requiring environmental analysis by the FAA in accordance with Executive Order 12114, the FAA's application of which is guided by the National Environmental Policy Act (NEPA) of 1969.

The FAA prepared a Final Environmental Assessment (EA) for Sea Launch Limited Partnership Project (prepared for the Department of Transportation, FAA Office of the Associate Administrator for Commercial Space Transportation, FAA Office of the Associate Administrator for Commercial Space Transportation by ICF Consulting Group and SLLP) which was signed and issued by the FAA on February 11, 1999. The Final EA assessed the proposed actions of constructing, operating and licensing launches of the Zenit-3SL from a mobile, floating launch platform in international waters in the east-central equatorial Pacific Ocean. An Environmental Finding Document, which is the equivalent of a Finding of No Significant Impact (FONSI) pursuant to the National Environmental Policy Act of 1969, was issued on February 11, 1999, after the FAA reviewed and analyzed the available data and information on existing conditions, potential project impacts on the human environment, and measures to mitigate potential impacts. The FAA concluded that licensing the operation of the proposed launch activities was not a major Federal action that would significantly affect the quality of the human environment within the meaning of Executive Order 12114 and the National Environmental Policy Act (NEPA) of 1969. Therefore the preparation of an Environmental Impact Statement (EIS) was not required. The proposed action as set forth in the Final EA included three launches for the first year of operation and six launches for each subsequent year. As of this date, Sea Launch has successfully launched two Zenit-3SL rockets.

Sea Launch is currently proposing the third launch from the same location in the east-central pacific using a different flight plan.

Sea Launch's application for a FAA launch license for its third mission proposes a non-equatorial launch azimuth to transport a payload into medium earth orbit (MEO). The data and analyses contained in the February 11, 1999, Environmental Finding Document are still substantially valid and Sea Launch states that it will meet all pertinent conditions and requirements of the prior approval, in the current action. The environmental aspects of the third mission are essentially equivalent to the equatorial launch azimuth, geosynchronous transfer orbit (GTO) launches licensed by FAA for Missions 1 and 2. The third mission will utilize the same type of payload, launch vehicle, launch site, and deep and open ocean environments for the stage 1, stage 2 and payload fairing impact zones. As in the first two missions, the flight plan for the third mission is not over any populated land mass until a brief (seven second) very high altitude (over 150 kilometers) traverse of a sparsely populated portion of South America. The third mission is also similar the first two missions in that the flight plan approaches, but does not go directly over, an uninhabited island. For Missions 1 and 2 the flight plan approached the ecologically sensitive Wolf and Darwin Islands of the Galapágos Island group; in the third mission the flight plan approaches but does not go directly over Ducie Island of the Pitcairn Island group, an uninhabited island with only one listed plant species that is neither endemic nor threatened. The very low probability of environmental degradation posed by the third mission are similar to those pose by the first two missions..

Missions 1 and 2	Third Mission
Payload, vehicle and launch site	**Payload, vehicle and launch site**
HS 601 payload	HS 601 payload
Zenit-3SL launch vehicle	Zenit-3SL launch vehicle
154°W, 0N° launch site	154°W, 0N° launch site
Stages 1 & 2 & Payload fairing impact zone	**Stages 1 & 2 & Payload fairing impact zone**
Deep and open ocean	Deep and open ocean
Limited vessel traffic	Limited vessel traffic
Low biological productivity	Low biological productivity
Overflight zone	**Overflight zone**
No overflight of populated islands in Pacific	No overflight of populated islands in Pacific
Near, but not over, Wolf & Darwin Islands	Near, but not over, Ducie Island
Short overflight of South America	Short overflight of South America
Risk to humans below FAA standard	Risk to humans below FAA standard

Proposed Action

A FAA conclusion approving this environmental analysis will support approval of a proposed change to Sea Launch operations for the third mission. The proposed change is the addition of a non-equatorial launch azimuth to transport payloads into MEO.

Reevaluation of Environmental Considerations and Mitigation

The proposed third mission will require a launch toward the southeast to support the placement of a satellite in an inclined MEO (see Figure 1). With the exception of this inclined launch azimuth, Sea Launch's third mission operations will be substantially identical to those addressed in the EA for the Sea Launch Project. The predicted environmental effects of the third mission (i.e. stage and fairing impact) will occur in a different location but in the same type of marine environment as with Missions 1 and 2; therefore, the data and analyses contained in the February 23, 1999, Environmental Finding Document are still substantially valid and all pertinent conditions and requirements of the prior approval have or will be met in the current action. (The failed mission scenario is described in detail on page 13.)

The third mission flight travels over water that ranges from 1,500 to 4,500 meters deep, except in the area of Ducie Island where the water remains deep to within a few kilometers of the island itself, and the brief transit of South America. Although the ocean areas traversed can be considered predominantly open ocean, the relative closeness of a number of islands and reefs in French Polynesia and the Pitcairn Island group has contributed to the formation of a slightly more biologically productive ecosystem when compared to a launch due east along the equator.

The risks to human safety and probability of environmental impact discussed in the EA for Missions 1 and 2 are analogous to those posed by the third mission. In addition, the risks and probability of impact are within FAA standards and guidelines.

The Zenit-3SL launch vehicle described in the EA is the same one proposed for use for the third mission, and the elements of the third mission payload are addressed in the EA. Appendix A of the EA describes the processing of the payload and fueling prior to mating to the launch vehicle. The third mission payload uses a monopropellant propulsion system of Anhydrous Hydrazine fuel (two tanks with 173 kg/tank or 345 kg/spacecraft) pressurized with Helium (initial pressure of 23.8 bars). Several small-scale explosive devices incorporated in the payload are used to activate valves, separation devices, and other similar hardware components. The following materials used in the third mission payload construction are typical of those used in spacecraft construction.

- Aluminum
- Aluminum Honeycomb
- Graphite/Epoxy
- Steel

- Titanium

As with the earlier missions, there are no radioactive materials or emission sources on the third mission. There is non-ionizing radiation associated with the third mission payload from two sources, the Ku-band payload and the Telemetry Tracking Command and Ranging (TTC&R) subsystem. These sources present no radiation concerns that would require additional safeguards other than those already discussed in the EA for health and safety issues. There are no unique exhaust products associated with the Zenit-3SL third mission launch vehicle that are not addressed in the EA.

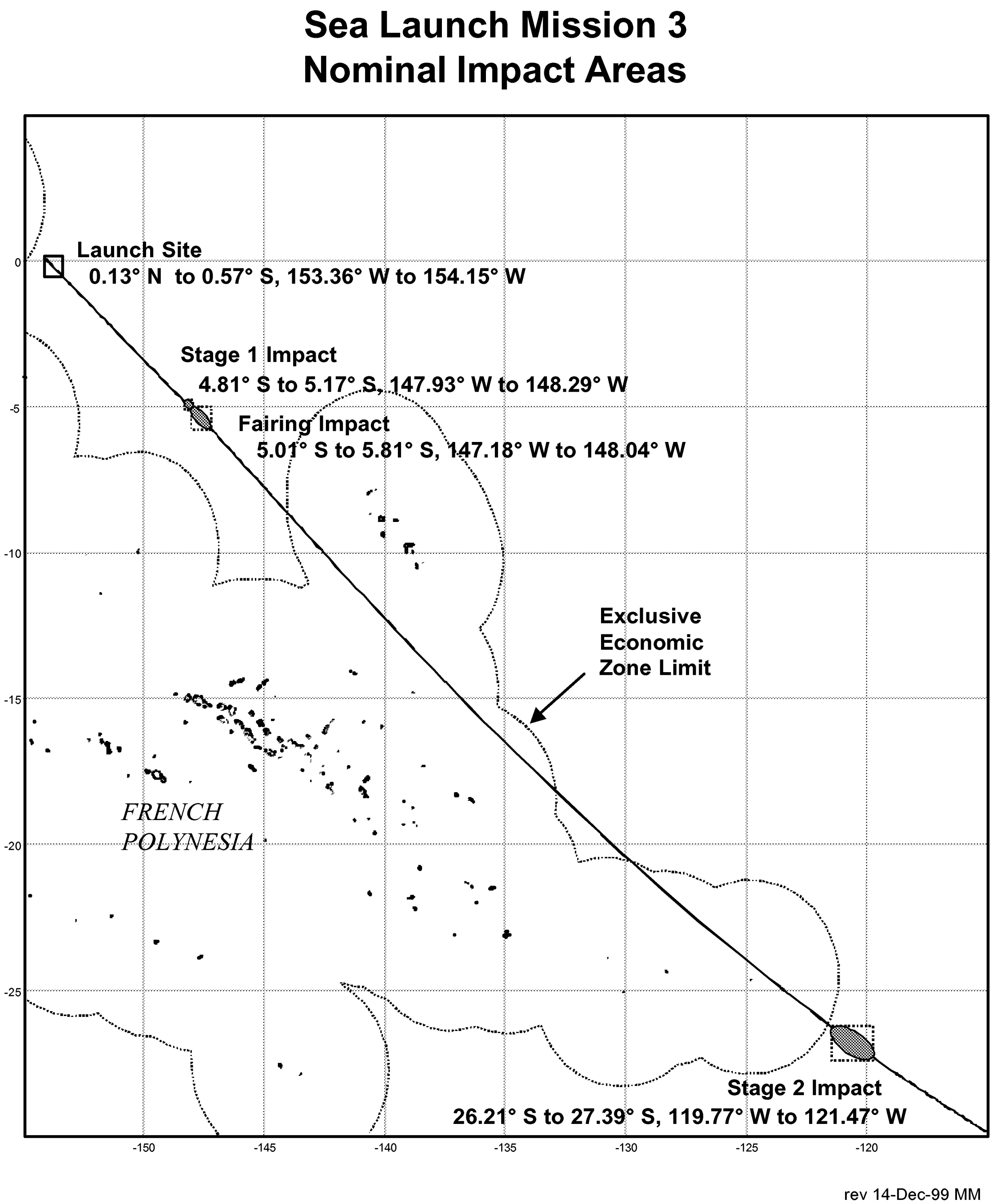

Figure 1: Third mission Non-Equatorial Groundtrack

AFFECTED ENVIRONMENT

First stage flight of the third mission azimuth will begin in international waters at 154° W on the equator, transit over international waters, and terminate following stage 1 separation over international waters at approximately 148.11° W and 4.99° S. The second stage powered flight will include a series of small yaw maneuvers. These will adjust the groundtrack so that the instantaneous impact point (IIP) traverses open waters in the vicinity of French Polynesia and the Pitcairn Island group and beyond, until the second stage separates and impacts in international waters at approximately 121.07° W and 26.38° S. The impacts in international waters corresponding to the separation of the first and second stage occur outside the area covered by the Convention for the Protection of the Natural Resources and Environment of the South Pacific Region. Under normal operational conditions, any impacts from the stages are expected to occur outside the 200-nautical mile exclusive economic zones. The third stage will begin powered flight over international waters, and propel the third stage and satellite payload toward the southern tip of South America. The third stage and payload fly over a very mountainous and sparsely populated area of South America for seven seconds.

In its traverse of deep and open ocean the groundtrack of the rocket in the first 250 seconds after liftoff in third mission is basically equivalent to that described in the EA for an equatorial launch-i.e., Missions 1 and 2 (except that it is following a path that is a 45° angle to the SE of the equator rather than along the equator). Likewise, the groundtrack after 450 seconds following liftoff in the third mission may be considered equivalent to the traverse of equatorial waters described in the EA because the downrange ocean environment overflown by the third mission is comparable to that overflown by Missions 1 and 2. It is an open, deep-water region (1,500 to 4,500 meters) far removed from land, with few differences from the equatorial open-ocean environment described in the EA except that the prevailing currents in this area of the South Pacific are east to west driven by the trade winds (Pickard and Emery, 1990), and there is noticeable but not extreme seasonal variability in solar radiation, which is a function of latitude. Nutrient and productivity levels in this area, along with the expected occurrences of species of concern, would be similar to that described in the EA (see EA Section 3.3). Similarly, the period of the third mission flight over South America corresponds roughly to the equatorial transiting of the continent as discussed in the EA, although the third mission has a shorter transit time (seven seconds as opposed to twenty seconds with an equatorial launch), and the area of South America overflown has a lower population density.

The third mission presents considerations unique when compared to missions 1 and 2 only during the portion of flight from approximately 250 to 450 seconds after liftoff, a duration of about 3 minutes, when the launch vehicle is over the exclusive economic zones of French Polynesia and the Pitcairn Island group (see Figure 2). In the third mission the vehicle will travel closer to islands and reefs than the equatorial missions described in the EA.

A review of a sea lane chart suggests that this inter-island area would have an equivalent frequency of freight, passenger, and commercial vessel traffic as compared with the equatorial region between Kiritimati (i.e., Christmas Island) and the Galapágos Islands off South America (see Figure 3; see also Box 1 for a listing of commercial shipping service in the South Pacific region). Subsistence fishing vessel traffic, however, is assumed to be greater in this inter-island area than in the equatorial region between Kiritimati and the Galapágos Islands, due to the closer proximity of island population centers within French Polynesia and the Pitcairn Island group.

There is also likely to be small-scale inter-island shipping, especially between the islands of French Polynesia. The frequency of this vessel traffic is impossible to quantify because data are not available.

As regards fishing in the vicinity of the area, the flight plan crosses the exclusive economic zones, but not French Polynesia or the Pitcairn Islands themselves. Within these zones there is some degree of subsistence fishing, pursued in the vicinity of the inhabited islands by small vessels on short-duration excursions. In addition to subsistence fishing, there is a commercial fishery operating within the waters of French Polynesia (FAO, 1999). This is primarily a tuna fishery (Flint, 1999), requiring larger vessels to locate and capture this open-ocean, migratory species. Unlike subsistence fishing where vessel distributions would follow island population distributions, tuna fishing fleets would be more randomly distributed, dependent on the seasonal availability and distribution of the species. The flight plan of the third mission and the deep water impact areas for the stages and fairing decent suggest that impacts on fishing activities in the vicinity would be comparable to the impacts described in the February 11, 1999, Environmental Finding Document.

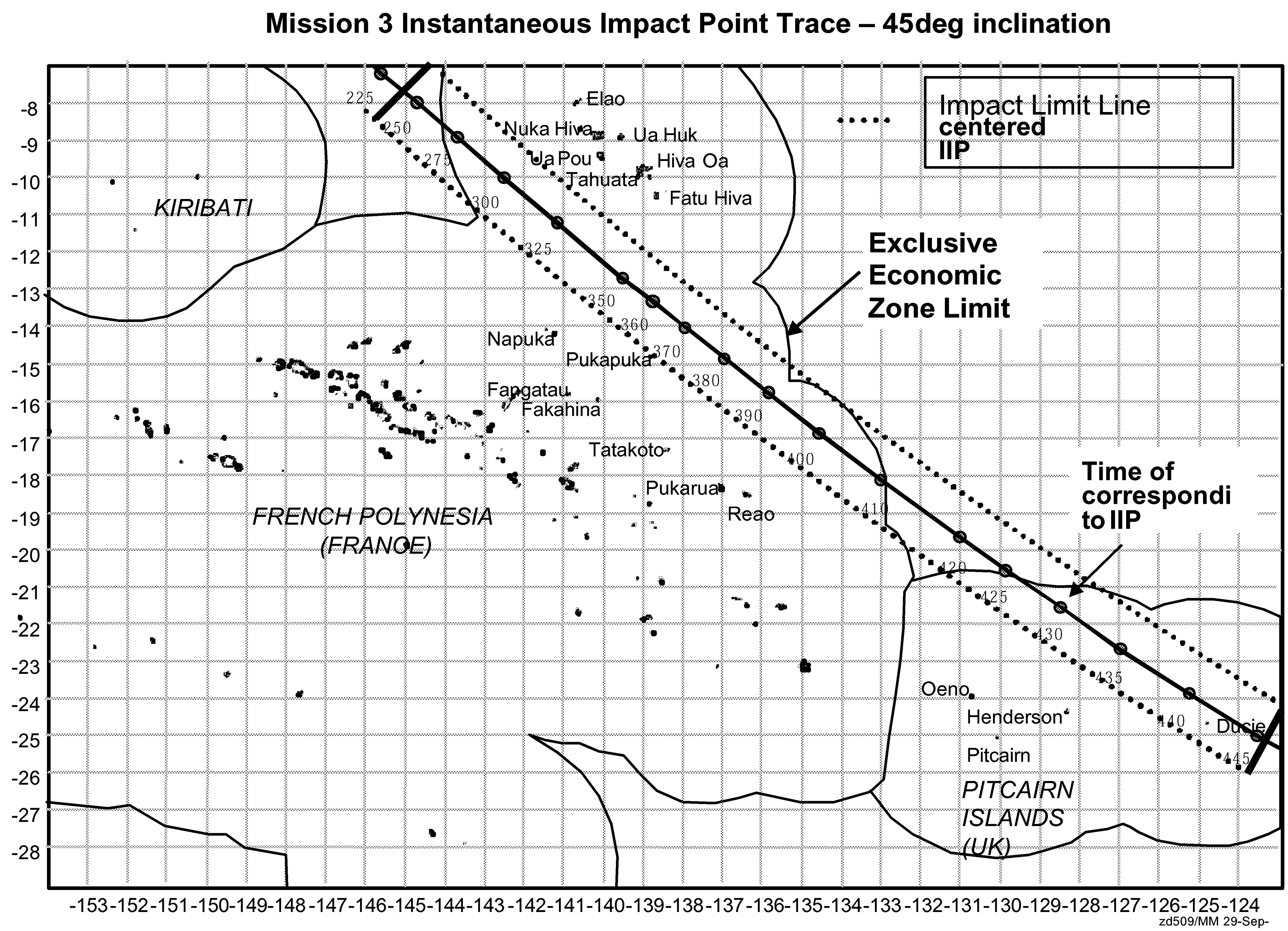

Figure 2: Groundtrack Between 250 and 445 Seconds After Launch

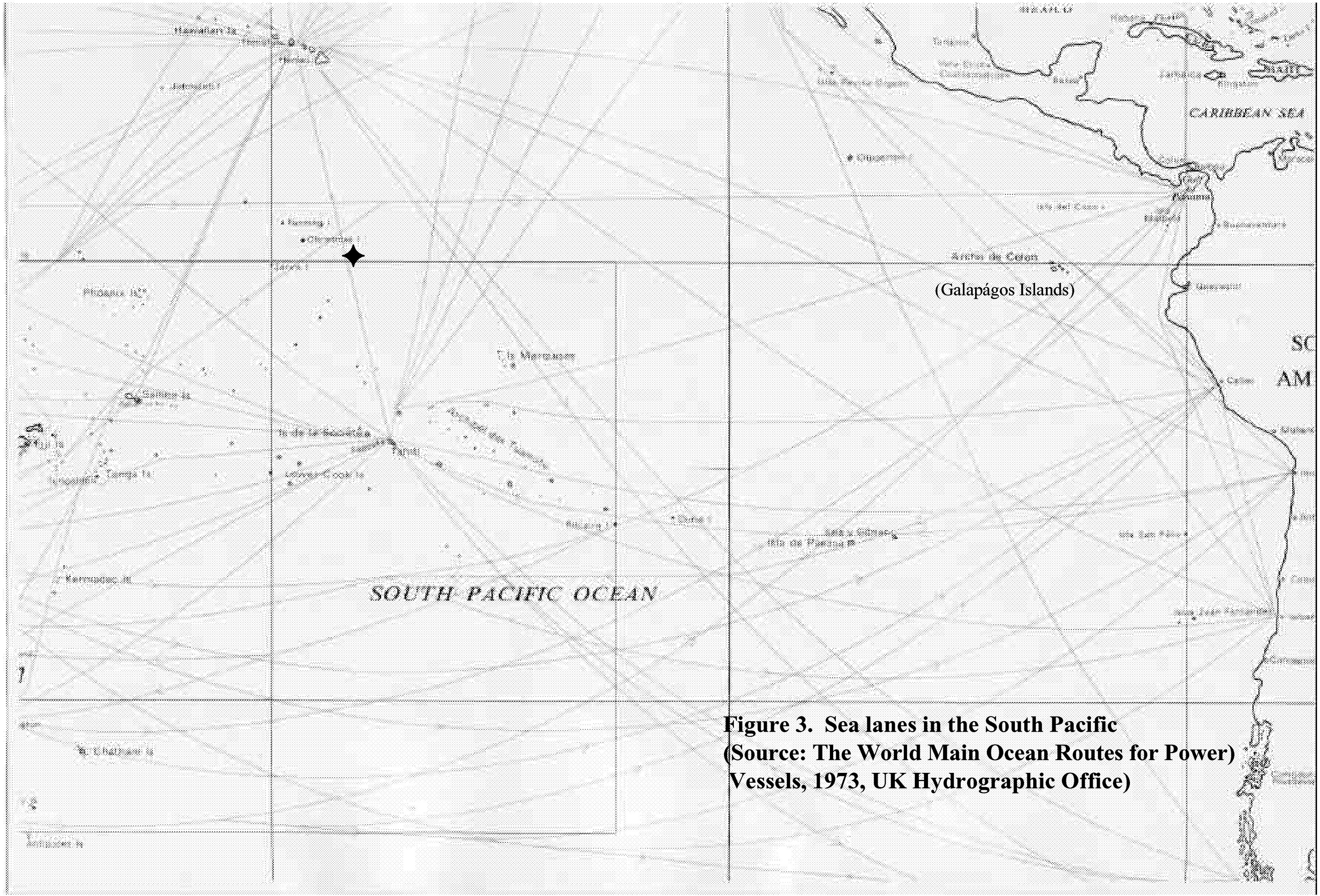

Figure 3. Sea lanes in the South Pacific (Source: The World Main Ocean Routes for Power) Vessels, 1973, UK Hydrographic Office)

Box 1: Shipping Service in the South Pacific Region

•Australia - New Zealand Direct Line (ANZDL): service every 2-3 weeks from Melbourne, Sydney & Tauranga to Tahiti & Fiji.

•Bali Hai (Swire / NYK / Kyowa): 3 ship service from Hong Kong, Korea & Japan to Micronesia; South through Fiji to Samoa, Tahiti, Tonga, New Caledonia, Vanuatu and return to Hong Kong.

•Bank Line (Andrew Weir Shipping): 4 ship service ex UK and Europe to Tahiti, New Zealand, Fiji, Solomon Is. and P.N.G then via Singapore & Suez to Europe.

•Columbus Line: Fortnightly service in conjunction with P&O Nedlloyd from Australia and New Zealand to Fiji, Tahiti and Hawaii and Fiji south bound from US West Coast. Three-weekly service from US to Tahiti, American Samoa, Samoa & Tonga.

•CGM / Marfret: Round the world service ex Europe to Tahiti, New Zealand, New Caledonia, Australia, then Westward to Europe via S.E.Asia, in conjunction with Contship Containerlines.

•Contship Containerlines (CP Ships): Round the world service ex Europe to Tahiti, New Zealand, New Caledonia, Australia, then Westward to Europe via S.E.Asia, in conjunction with CGM/Marfret.

•FANAL (Fesco): Fortnightly service ex Australia & New Zealand to Fiji and Tahiti & from USWC to Tahiti.

•P&O Nedlloyd : Fortnightly service in conjunction with Columbus Line from Australia and New Zealand to Fiji and Tahiti and Fiji south bound from US West Coast.

•PDL(Pacific Direct Line): 1 ship service with NZPCL from New Zealand to Norfolk Island, New Caledonia, Wallis and Futuna, Tuvalu; 1 ship service with NZPCL to Samoas, Tonga & Niue; NVOCC service with NZPCL from NZ to Fiji and from Australia to Noumea, Fiji, Samoas & Tonga; NVOCC service to Tahiti.

•Polynesia Line: 1 ship service from US West Coast to Tahiti, and American Samoa. Contract carrier to one of the Tuna canneries in American Samoa.

•SPCL (South Pacific Container Line): 1 ship service US West Coast to Tahiti, American Samoa. Contract carrier to 2nd Tuna cannery.

Source: "Shipping in the South Pacific," Web Site, at www.oceanz.co.nz/spac.htm, on 11/11/99.

The precise area of interest under a failed mission scenario—the impact limit line (ILL)—is a near-rectangular wedge in which the centerline is the stage 2 IIP from approximately 144° W and 8° S to 124° W and 27° S. The long sides of the wedge are found at an expanding distance on either side of the groundtrack from 50 kilometers in the northwest to 100 kilometers in the southeast (see Figure 4). ILLs were established by SLLP to determine where debris would fall. A statistical confidence level based on three standard deviations was 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 incude dispersions in launch vehicle guidance, navigation and control systems, as well as atmospheric wind effects. That is, if a catastrophic failure occurs—in this case, debris falling associated with a failed mission—the degree of certainty that the effect would take place within the area defined by the ILL is 99.74%; alternatively, the chance that the effect would take place outside the area would be 0.26%, or roughly 1 in 400. It is important to remember that the risk of the effect happening outside the ILL must incorporate both the 3-sigma boundary as well as the estimated chance of the failed mission scenario; consequently, the risk of debris falling outside the ILL would be less than 1×10^{-11}. For normal operations, the area defined within the ILL will be unaffected by the launch vehicle passing overhead, since the planned return-to-earth of stages 1 and 2 occur well before and after overflight of this area, respectively, in international waters.

One island in the Pitcairn Island group, Ducie Island, is within the boundaries of the ILL for the failed mission scenario (e.g., the 3-sigma lateral dispersion envelope). Ducie Island is the smallest of four subtropical islands in the Pitcairn Island group. Ducie Island (Lat. 24.67° S, Long. 124.80° W) is an elevated coral atoll ecosystem (maximum elevation is 4 meters) which encompasses 0.7 square km. The Island is composed of one terrestrial ecosystem (a tree heliotrope forest, covering 70% of the island) and three marine ecosystems. The marine ecosystems include windward and leeward atoll reefs with extensive algae in shallows and coral on deeper reefs, and a poorly circulating lagoon with fair coral cover on the pinnacles. The coral accounts for 99% of the island's shoreline. Reported wildlife use consists of a seabird rookery as well as the presence of invasive Polynesian rats, lizards, the masked booby, Murphy's petrel, the common fairy tern, and the frigate bird (Lonely Planet – Destination Pitcairn Islands Web Site). No endemic or threatened floral or faunal species are reported to be on the island. The island is uninhabited, seldom visited, and largely undisturbed. (UN System-Wide Earthwatch Web Site). Impacts to Ducie Island associated with the failed mission scenario, if they occur, would be minor and have short-term environmental effects only (see Environmental Impacts, page 13, "Failed Mission Scenario"), and would be comparable to the impacts described for the Galapagos Islands in the February 11, 1999, Environmental Finding Document.

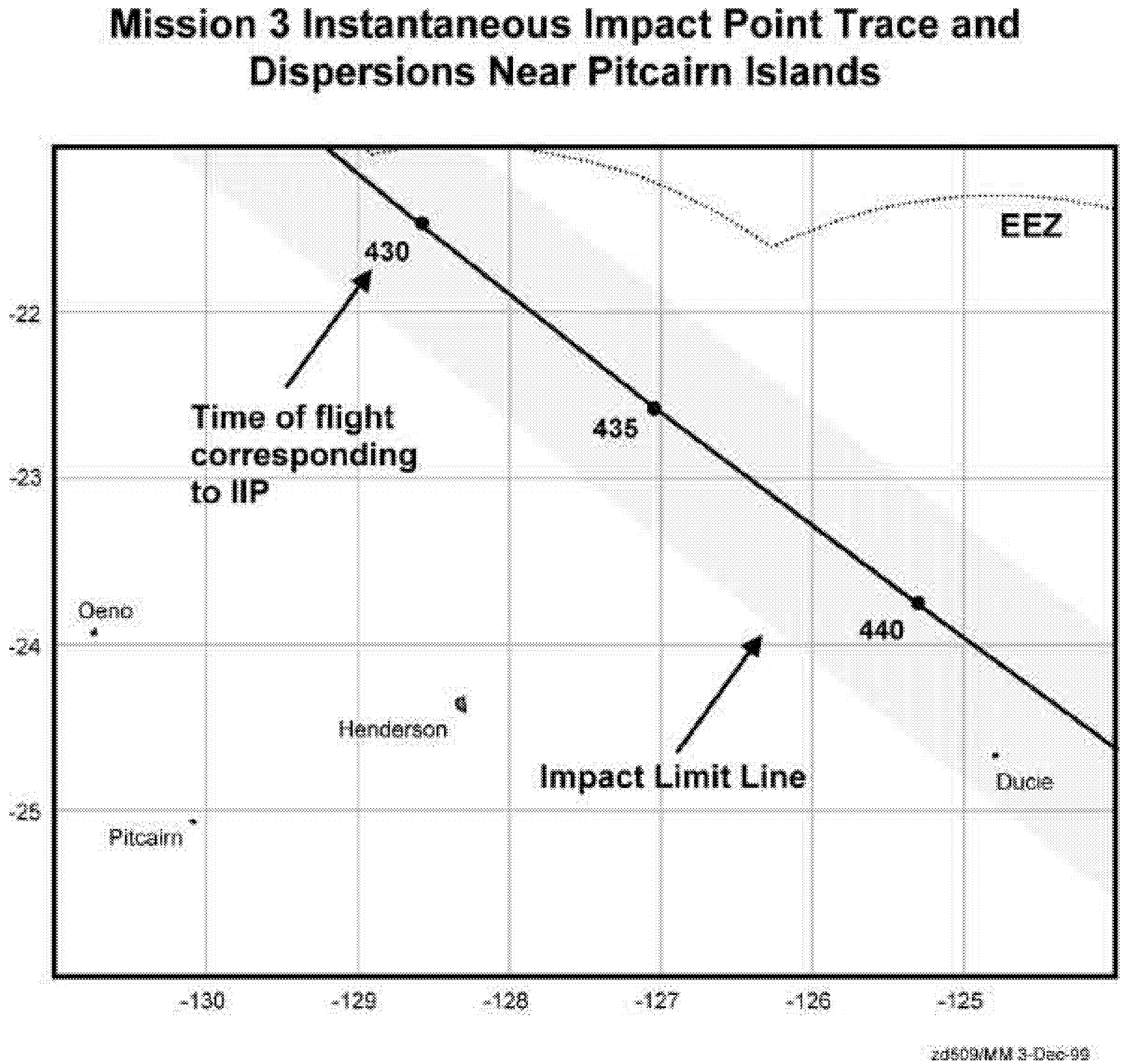

Figure 4: Flight azimuth of 45º in the Vicinity of Ducie Island

ENVIRONMENTAL IMPACTS

Air Quality and Atmospheric Emissions

The proposed change will not create a new impact on air quality or atmospheric emissions. Impacts in this category and the corresponding mitigation program will be similar to those noted in the Final EA and the Environmental Finding Document.

Water Quality

The proposed change will not create a new impact on water quality. Impacts in this category and the corresponding mitigation program will be similar to those noted in the Final EA and the Environmental Finding Document.

Noise

The proposed change will not create a new impact on noise. Impacts in this category and the corresponding mitigation program will be similar to those noted in the Final EA and the Environmental Finding Document.

Waste

The proposed change will not create a new impact on waste generation and management. Impacts in this category and the corresponding mitigation program will be similar to those noted in the Final EA and the Environmental Finding Document.

Biological and Ecological Impacts

The proposed change will not create a new impact related to biological or ecological activity. Impacts in this category and the corresponding mitigation program will be similar to those noted in the Final EA and the Environmental Finding Document.

Social and Economic Considerations

The proposed change will not create a new impact related to social or economic considerations. Impacts in this category and the corresponding mitigation program will be similar to those noted in the Final EA and the Environmental Finding Document. In addition, because of the change in flight plan, the list of recipients of "notification of mariners and other interested parties," as specified in Sea Launch's Environmental Monitoring and Protection Plan, will be evaluated and adjusted accordingly.

Health and Safety

FAA's licensing process will examine safety aspects of the proposed launch operations. The SLLP adopted as a population protection risk criteria, an upper limit of one in a million casualty expectation. Public safety assurances and analysis issues are discussed in the SLLP document "Sea Launch Systems Safety Plan". The Launch location was shifted away from land and America to ensure that stage 1, the fairing and stage 2 would drop well away from land and coastal commercial activity/

The proposed change will not create a new impact in the area of health and safety. Impacts in this category and the corresponding mitigation program will be similar to those noted in the final EA and the Environmental Finding Document.

Threatened and Endangered Species

The proposed change will not create a new impact regarding threatened or endangered species. Impacts in this category and the corresponding mitigation program will be similar to those noted in the Final EA and the Environmental Finding Document.

Archeological and Cultural Resources

The proposed change will not create a new impact in relation to archeological and cultural resources. Impacts in this category and the corresponding mitigation program will be similar to those noted in the Final EA and the Environmental Finding Document.

Home Port Activities

The proposed change will not affect home port activities.

Energy Outputs

The proposed change will not affect energy outputs. Impacts in this category and the corresponding mitigation program will be similar to those noted in the Final EA and the Environmental Finding Document.

Environmental Justice

The proposed change will not create a new impact concerning environmental justice. Impacts in this category and the corresponding mitigation program will be similar to those noted in the Final EA and the Environmental Finding Document.

Cumulative Impacts

The proposed change will not affect cumulative impacts. Cumulative impacts will be similar to those noted in the Final EA and the Environmental Finding Document.

Failed Mission Scenario

Under the failed mission scenario, the third mission's proximity to Ducie Island poses a risk to the environment event equivalent to the proximity of Wolf and Darwin Islands of the Galapágos Island Group during an equatorial launch mission. This latter case is described in Section 4.3 of the EA. A similar failure analysis relative to Ducie Island is provided below. The various hazard scenarios for this phase of the ascent trajectory and the theoretical casualty expectation confirm the very low risks expected from possible failures during this phase of flight.

The third mission flight plan presently accommodates a flight azimuth of 45°, as represented in Figures 2 and 4 above. The altitude of the vehicle will be over 150 kilometers when approaching Ducie Island. The third mission flight plan allows the ILL, but not the groundtrack (or IIP), to traverse Ducie Island.[1] The alternative, i.e., having the ILL also bypass the island, would have required an increase in the number of in-flight maneuvers, each of which negatively affects vehicle safety and reliability, because the risk of failure is usually higher during dynamic state changes (e.g., attitude changes) when compared with steady-state flight behavior.

During the traverse through the vicinity of French Polynesia and the Pitcairn Island group, stage 2 will be undergoing a steady engine burn and acceleration. Historical performance reliability of this stage during this time of flight, as demonstrated by performance in both Zenit-2 and Zenit-3SL vehicles, is better than 97%. The corresponding risk and potential scale of impact to the aquatic ecosystem and vessels in the area from such a failure are, therefore, also extremely small.

In the case of Ducie Island, the launch vehicle groundtrack will pass by the island for a duration of less than 0.5 seconds, approximately 443 seconds after launch, at an speed of over 10,000 meters per second (36,000 kilometers per hour). Additionally, the IIP for the 45° inclination will be approximately 40 kilometers from the island, and the corresponding ILL will parallel both sides of the IIP at a distance of approximately 100 kilometers. As a statistical concept, therefore, the ILL boundary will encompass Ducie Island, and its surrounding reefs as the IIP traverses the ocean surface. Given the launch vehicle's speed and altitude, however, the probability is extremely small that failure would occur at the moment the IIP passes abeam or nearly abeam the island. This is during a time when the propulsion and control systems have been stable for several minutes and, therefore, are less susceptible to failure as mentioned

[1] Henderson Island, a World Heritage Site as of 1988, also one of the Pitcairn Islands, would be approximately 270 kilometers from the flight plan of the launch vehicle, and approxamately 180 kilometers from the end of the impact limit line (ILL), corresponding to the 3-sigma lateral dispersion. Therefore, even under the failed mission scenario, there is no impact predicted for Henderson Island. Other islands in the vicinity of the flight plan are also outside the ILL (e.g., Pukapuka is an uninhabited island with no endangered or threatened species, and Ua Pou is an uninhabited island with 6 plant species and 2 bird species considered threatened) and therefore are predicted to experience no impact even under the failed mission scenario.

above. Further, in the event of a failure during this moment in time, debris from the failed launch vehicle is likely to burn, fragment, and scatter as it returns to earth. Specifically, the stage 2 and payload structures would immediately tumble and rupture; the fuel and propellants would disperse and immediately vaporize and burn; and virtually all of the hardware components would fragment into small pieces, most burning during re-entry. Given the groundtrack IIP separation from the island, the probability that a surviving piece of the dispersed set of debris would strike Ducie Island or the reef extending out from the island is calculated to be one in one billion or 1.1×10^{-9} and therefore produces a negligible chance of environmental effects. This analysis for Ducie Island follows the same method and yields comparable results as the analysis documented for Wolf and Darwin Islands in EA Section 4.3.4.2 and EA Appendix E on Galapágos overflight risk.

CONCLUSIONS

Based on the above review and in conformity with FAA Order 1050.4D, paragraph 92, the FAA has concluded that the proposed change to a non-equatorial launch azimuth for the third mission Sea Launch operations conforms to the prior approved Environmental Finding Document and Final EA, that the data contained in the approved EA and Environmental Finding Document are still substantially valid, that there are no significant environmental changes, and that all pertinent conditions and requirements of the prior approval have been met or will be met in the current action.

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Environmental Finding Document Finding of No Significant Impact

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US DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

Environmental Finding
Written Reevaluation of the Sea Launch Environmental Assessment with Respect to a Proposed Non-Equatorial Launch Azimuth Scenario for the Sea Launch Limited Partnership

On February 11, 1999, the FAA accepted a final Environmental Assessment evaluating proposed launch activities from a mobile, floating launch platform in international waters in the east-central equatorial Pacific Ocean by the Sea Launch Limited Partnership (Sea Launch). The covered actions as evaluated in that Environmental Assessment included six launches per year on an approximate equatorial launch azimuth. Based on that Environmental Assessment, on February 11, 1999 the FAA issued an Environmental Finding Document that found licensing the proposed launch activities was not a major Federal action that would significantly affect the quality of the human environment within the meaning of Executive Order (E.O.) 12114, the FAA's application of which was guided by the National Environmental Policy Act (NEPA). Accordingly, Sea Launch proceeded with two successful launches.

Sea Launch is currently proposing a third launch from the same launch location in the east-central Pacific using a different flight plan involving a southeasterly, non-equatorial launch azimuth to transport a payload into medium earth orbit (MEO). The proposed third launch will use the same type of payload, launch vehicle, launch site and primarily traverse international waters with the stage 1, stage 2 and payload fairing impact zones all located in international waters. Similar to the first two launches which approached Wolf and Darwin Islands of the Galapagos Island Group, the third launch flight plan approaches but does not traverse uninhabited Ducie Island of the Pitcairn Island group. The chance of any environmental impact from failed mission scenarios associated with the change in launch azimuth is extremely small, similar to the scenarios evaluated in the earlier Environmental Assessment (EA), dated February 11, 1999.

In a normal launch scenario, the risk of any stage or fairing impacts remains very low, even though the proposed southeasterly launch azimuth will take the launch vehicle in the vicinity of French Polynesia and the Pitcairn Island group for approximately three minutes. These impact risks are similar to the February 11, 1999 EA scenarios.

Based on a review of the previous Environmental Assessment and the subsequent Written Reevaluation of the Sea Launch Environmental Assessment with Respect to a Proposed Non-Equatorial Launch Azimuth Scenario for the Sea Launch Limited Partnership, it is concluded that licensing the new southeasterly launch azimuth would not create any new environmental impacts. The environmental impacts of the proposed southeasterly launch azimuth are equivalent to those associated with the equatorial launch azimuth used for the geosynchronous transfer orbit launches previously licensed by the FAA. The environmental impacts of the southeasterly launch azimuth are likewise expected to be insignificant. This review concludes that the change in launch azimuth does not controvert the conclusions of the previous study and there are no substantive changes to environmental impacts or mitigation measures as described in the Environmental Assessment.

Based on this review and consistent with FAA Order 1050.4D, paragraph 92, the FAA has concluded that the proposed change to a non-equatorial launch azimuth for the third launch conforms to the previously approved Environmental Finding Document and final Environmental Assessment, that the data in that Environmental Assessment and Environmental Finding Document are still valid and that all pertinent conditions and requirements of the prior approval have been met or will be met in the current action.

After careful and thorough consideration of the facts, the undersigned finds that the proposed change in launch azimuth is consistent with the purpose of the national environmental policies and objectives as set forth in E.O. 12119 the FAA's application of which is guided by NEPA, and that the proposed change will not significantly affect the quality of the human environment or otherwise include any condition requiring additional consultation. These findings are made pursuant to FAA commercial space launch licensing authority in 49 USC Subtitle IXch. 701, Commercial Space Launch Activities, §§ 70101-70121 and implementing regulations and guidance.

Ron Gress

______________________________ ______________________________

Manager, Licensing and Safety Division Date
Associate Administrator for
Commercial Space Transportation

SUBJECT: Written Reevaluation of the Sea Launch Environmental Assessment with Respect to a Proposed Equatorial Launch 83.43°Azimuth Scenario for the Sea Launch Company

DATE: **DRAFT:** April 27, 2000

INTRODUCTION AND BACKGROUND

Sea Launch Limited Partnership (SLLP) is an international commercial venture formed to conduct commercial space launch operations from a mobile, floating launch platform in international waters in the east-central equatorial Pacific Ocean. The Commercial Space Launch Act (CSLA) of 1984 (Public Law 98-575), as amended 49 U.S.C. §§ 70101-70119, authorizes the U.S. Secretary of Transportation to oversee and coordinate U.S. commercial launch operations and to issue licenses authorizing commercial launches and the operation of commercial launch sites. The Secretary is implementing this authority through the Federal Aviation Administration (FAA) Associate Administrator for Commercial Space Transportation (AST). FAA exercises its licensing authority in accordance with the CSLA 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 is a foreign entity controlled by a U.S. citizen. Licensing a launch is a Federal action requiring environmental analysis by the FAA in accordance with Executive Order 12114, the application of which is guided by the National Environmental Policy Act (NEPA) of 1969.

The FAA prepared a Final Environmental Assessment (EA) for the Sea Launch Limited Partnership Project (prepared for the Department of Transportation, FAA Office of the Associate Administrator for Commercial Space Transportation, by ICF Consulting Group and SLLP) which was signed and issued by the FAA on February 11, 1999. The Final EA assessed the proposed actions of constructing, operating and licensing launches of the Zenit-3SL from a mobile, floating launch platform in international waters in the east-central equatorial Pacific Ocean. An Environmental Finding Document, which is the equivalent of a Finding of No Significant Impact (FONSI) pursuant to the National Environmental Policy Act of 1969, was issued on February 11, 1999, after the FAA reviewed and analyzed the available data and information on existing conditions, potential project impacts on the human environment, and measures to mitigate potential impacts. The FAA concluded that licensing the operation of the proposed launch activities was not a major Federal action that would significantly affect the quality of the human environment within the meaning of Executive Order 12114 and the National Environmental Policy Act (NEPA) of 1969. Therefore the preparation of an Environmental Impact Statement (EIS) was not required. The proposed action as set forth in the Final EA included three launches for the first year of operation and six launches for each subsequent year.

As of this date, Sea Launch has launched three Zenit-3SL rockets. The first two launches used an azimuth of 88.67° while the third employed an azimuth of approximately 135°. An Environmental Finding Document related to a Written Reevaluation of the Sea Launch Environmental Assessment addressing this third launch was signed on February 25, 2000. Sea

Launch is currently proposing to launch from the same location in the east-central Pacific using a slightly different flight plan.

Sea Launch Company's application for a FAA launch license for Mission 5 calls for a equatorial launch with an azimuth of 83.43° to transport a payload into geosynchronous transfer orbit (GTO). The data and analyses contained in the February 11, 1999, Environmental Finding Document are still substantially valid and all pertinent conditions and requirements of the prior approval have or will be met in the current action. The environmental aspects of Mission 5 are essentially equivalent to the original equatorial launch azimuth (i.e., 88.67°) launches licensed by FAA for Missions 1 and 2—and Mission 4 which is pending. (Mission 3 employed an azimuth of approximately 135°). Mission 5 would utilize the same type of payload, launch vehicle, launch site, and deep and open ocean environments for the Stage 1, Stage 2, and payload fairing impact zones. As is the case with Missions 1 and 2, the flight plan for Mission 5 presents no risk to any populated land mass until a brief (27 second) very high altitude (over 180 kilometers) Instanteous Impact Point (IIP) traverse of a portion of South America. Mission 5 is also similar to Missions 1 and 2 in that the flight plan approaches, but does not go directly over, an uninhabited island. For Missions 1 and 2 the flight plan approached the ecologically sensitive Wolf and Darwin Islands of the Galapágos Island group; in Mission 5 the flight plan approaches but does not go directly over Cocos Island (Costa Rica), an uninhabited island with a rich and nationally protected environmental system. Sea Launch has carefully selected the flight plan for Mission 5 to meet customer and safety requirements. The risks to human safety and very low probability of environmental degradation posed by Mission 5 are similar to Missions 1 and 2 and are within FAA standards and guidelines.

Missions 1 and 2	Mission 5
Payload, vehicle and launch site	**Payload, vehicle and launch site**
Payload: communications satellite	Payload: communications satellite
Zenit-3SL launch vehicle	Zenit-3SL launch vehicle
154°W, 0N° launch site	154°W, 0N° launch site
Launch azimuth 88.67°	Launch azimuth 83.43°
Stages 1 & 2 & Payload fairing impact zone	**Stages 1 & 2 & Payload fairing impact zone**
Deep and open ocean	Deep and open ocean
Limited vessel traffic	Limited vessel traffic
Low biological productivity	Low biological productivity
Overflight zone	**Overflight zone**
No overflight of populated islands in Pacific	No overflight of populated islands in Pacific
Near, but not over, Wolf & Darwin Islands	Near, but not over, Cocos Island
Short overflight of South America	Short overflight of South America
Risk to humans below FAA standard	Risk to humans below FAA standard

Proposed Action

A FAA conclusion approving this environmental analysis will support approval of a proposed change to Sea Launch operations for Mission 5. The proposed change is the addition of a different azimuth equatorial launch to transport payloads into GTO.

Reevaluation of Environmental Considerations and Mitigation

The proposed Mission 5 will require a launch slightly north of east (i.e., 83.43°) to support the placement of a satellite in a slightly inclined GTO (see Figure 1). With the exception of this slightly inclined orbit, Sea Launch's Mission 5 operations will be substantially identical to those addressed in the EA for the Sea Launch Project. The predicted environmental effects of Mission 5 (i.e. stage and fairing impact) will occur in a similar but not identical location as with Missions 1 and 2; therefore, the data and analyses contained in the February 23, 1999, Environmental Finding Document are still substantially valid and all pertinent conditions and requirements of the prior approval have or will be met in the current action. (The failed mission scenario is described in detail on page 11.)

The Mission 5 flight travels over water that ranges from 1,500 to 4,500 meters deep, except in the area of Cocos Island where the water remains deep to within a few kilometers of the island itself, and the transit of South America. The ocean areas traversed can be considered predominantly open ocean.

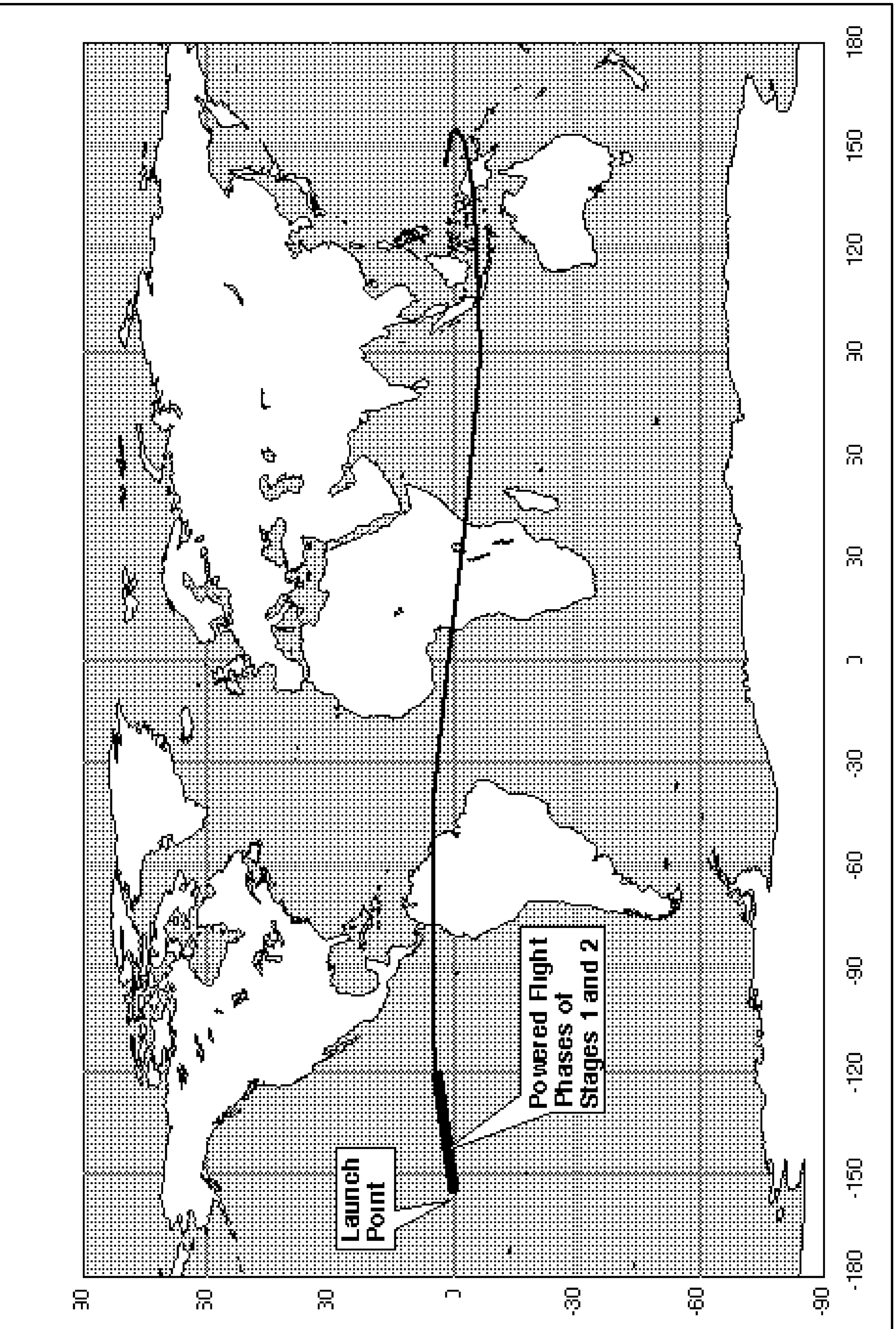
The risks to human safety and probability of environmental impact discussed in the EA for Missions 1 and 2 are comparable to those posed by Mission 5. In addition, the risks and probability of impact are within FAA standards and guidelines.

The Zenit-3SL launch vehicle described in the EA is the same one proposed for use for Mission 5, and the elements of the Mission 5 payload are addressed in the EA. Appendix A of the EA describes the processing of the payload and fueling prior to mating to the launch vehicle. The Mission 5 payload uses a propulsion system of Anhydrous Hydrazine fuel (max. of 826 kg.) and N_2O_4 (max. of 1,348 kg.). Several small-scale explosive devices incorporated in the payload are used to activate valves, separation devices, and other similar hardware components. The following materials used in the Mission 5 payload construction are typical of those used in spacecraft construction.

- Aluminum
- Aluminum Honeycomb
- Graphite/Epoxy
- Steel
- Titanium

As with the earlier missions, there are no radioactive materials or emission sources on Mission 5. There is non-ionizing radiation associated with the Mission 5 payload from the Ku- and C-band payload and the Telemetry Tracking Command and Ranging (TTC&R) subsystem.

Figure 1
Mission 5 Groundtrack



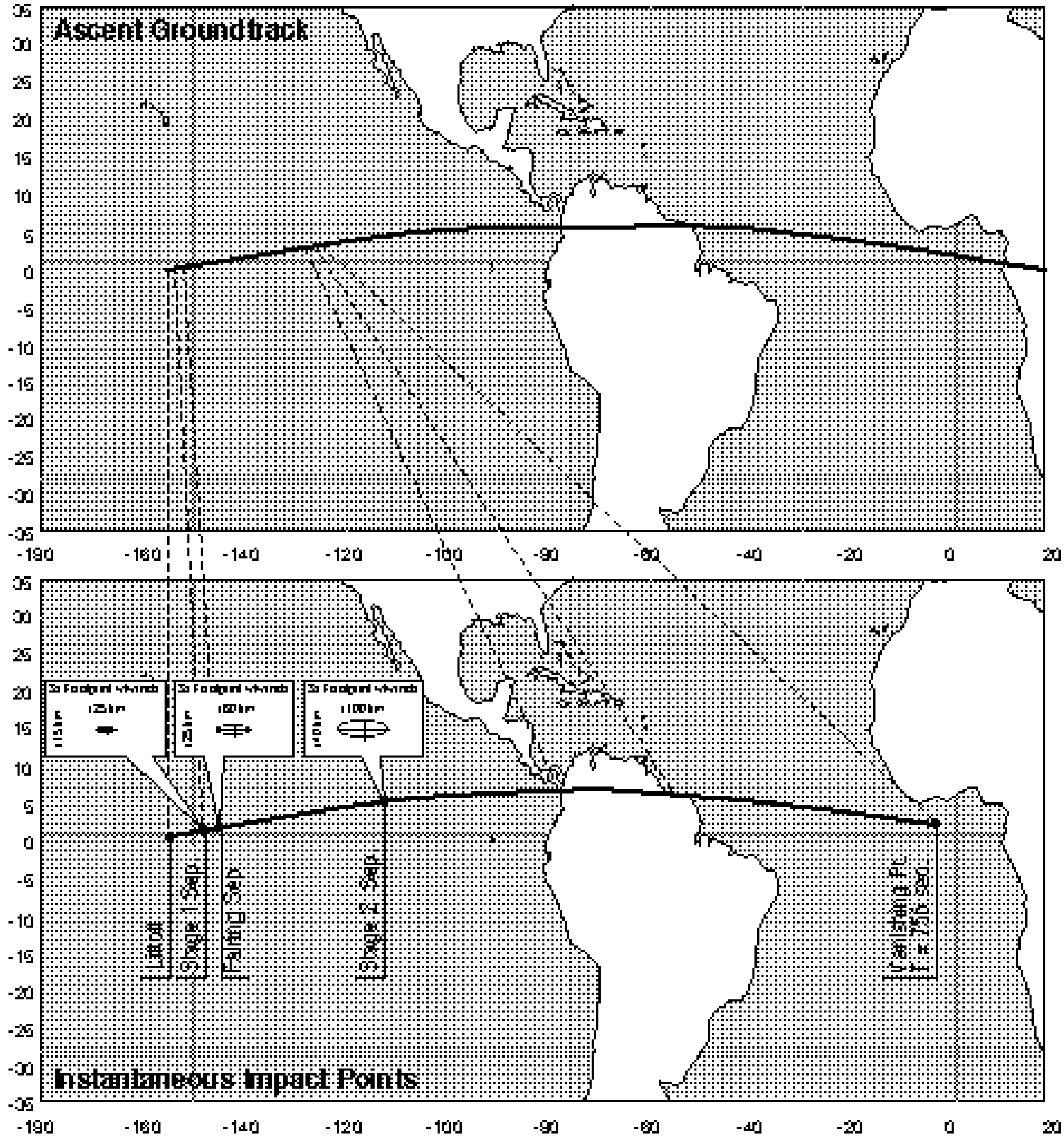
These sources present no radiation concerns that would require additional safeguards other than those already discussed in the EA for health and safety issues. There are no unique exhaust products associated with the Zenit-3SL Mission 5 launch vehicle that are not addressed in the EA.

AFFECTED ENVIRONMENT

First stage flight of Mission 5 will begin in international waters at 154° W on the equator, transit over international waters, and terminate following Stage 1 separation over international waters at approximately 0.83° N and 147.02° W (see figure 2). The payload fairing separates and impacts in international waters at approximately 1.04° N and 145.26° W. The second stage separates and impacts in international waters at approximately 4.29° N and 114.56° W. The impacts in international waters corresponding to the separation of the first and second stages and payload fairing occur outside the area covered by the Convention for the Protection of the Natural Resources and Environment of the South Pacific Region. Under normal operational conditions, any impacts from the stages are expected to occur outside any 200-nautical mile exclusive economic zone. The third stage will begin powered flight over international waters, and propel the third stage and satellite payload toward South America. The Block DM-SL upper stage and payload fly over a slightly north of equatorial region of South America with an IIP transit time of 27 seconds.

A review of a sea lane chart would suggest that the frequency of potentially affected vessel traffic for Mission 5 may be slightly higher than was the case for Missions 1 and 2. The groundtrack for Mission 5 as it approaches the coast of South America is slightly north of east (i.e., approximately 6° N rather than 1° N) and would bring the overflight closer to the Pacific end of the Panama Canal and its traffic separation lanes. Consequently, any canal traffic on the day of the launch exiting the Pacific end of the canal and heading below the equator as well as any traffic leaving South American ports and heading toward the Pacific end of the canal could theoretically cross under the overflight area. It would be impossible to quantify this potential traffic with any precision, however, on a typical day, Panama Canal traffic averages 40 oceangoing transits (this was the monthly average for March 2000, with a daily high of 48 and daily low of 34) It is reasonable to assume that less than half of this traffic would be potentially affected by crossing under the overflight area.

Figure 2
Mission 5 Stage Separation



The precise area of interest under the failed mission scenario—the Impact Limit Lines (ILL)—is a near-rectangular band in which the centerline is the Stage 3 groundtrack (IIP) from approximately 87.5° W and 87° W. The long sides of the ILL are approximately 125 km apart, and are centered on the IPP at approximately 5.9° N during this section (see Figure 3).

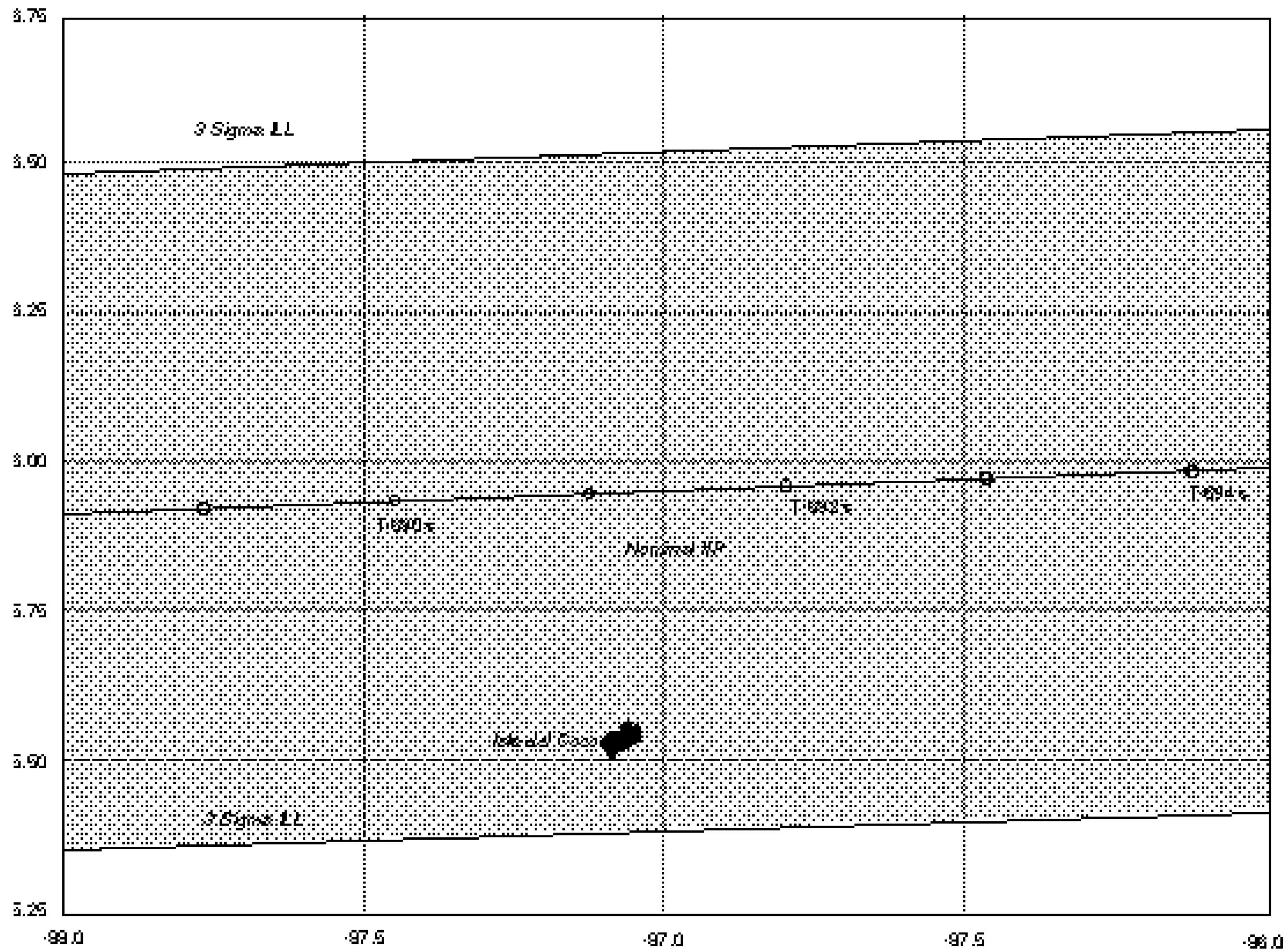
The ILL is a statistical concept. It defines the area where the probability of an effect is within the 3-sigma (or three standard deviation) boundary. That is, if an effect is to occur—in this case, debris falling associated with a failed mission—the degree of certainty that the effect would take place within the area defined by the ILL is 99.74%; alternatively, the chance that the effect would take place outside the area would be 0.26%, or roughly 1 in 400. It is important to remember that the risk of the effect happening outside the ILL must incorporate both the 3-sigma boundary as well as the estimated chance of the failed mission scenario; consequently, the risk of debris falling outside the ILL would be 0.01%. For normal operations, the area defined within the ILL will be unaffected by the vehicle passing overhead, since the planned return-to-earth of Stages 1 and 2 and the Payload Fairing occur well before the overflight of this area, respectively, in international waters.

One island, Isla del Coco or Cocos Island, while not directly under the overflight area is within the boundaries of the ILL for the failed mission scenario (e.g., the 3-sigma lateral dispersion envelope). Cocos Island, located at 5.55° N and 87.00° W, is situated in the Pacific Ocean 532 km from Cabo Blanco in Costa Rica. The Island is a National Park, created by Executive Decree No. 8748-A of Costa Rica, on June 22, 1978, and added to the UNESCO World Heritage List on December 4, 1997. The island comprises 2,400 hectares and is uninhabited except for 5-15 park rangers who reside there for short periods of time, ensuring coverage so that there is always a presence on the island. Visitor to the island (mainly divers who have specifically traveled to the area) are allowed on the island for day hikes but not for overnight stays.

The description of the island's natural history varies considerably depending on the source. According to the UN System-Wide Earthwatch Web Site Island Directory, Cocos Island has only two reptilian/amphibian species that are endemic to the island, but are not threatened.

According to information from a Geocities web site, Cocos Island is the only island in the eastern Pacific with a humid tropical forest. The underwater portion of the national park attracts large pelagic species such as sharks, rays, tuna and dolphins, and has developed into a remote but frequented site for SCUBA divers. The island is volcanic in origin and is bounded by steep cliffs. Only two bays suitable for anchorage are to be found, on the northern end of the island. The cliffs are nesting areas for marine birds such as Boobies, Seagulls, and Noddies. The origin of the island's fauna is mainly eastern Pacific, Galapágos, and Central American mainland, but several groups, including some corals, are of Indo-Pacific origin. At least 60 species of animals are endemic to the island, several of which (although none are specified) are on the endangered species list. Fifty-nine species of fish, 97 mollusks, 57 crustaceans, 2 lizards and 7 land birds have been reported. The island has seventy-four species of birds, including three that are endemic (the Cocos Island Flycatcher, the Cocos Island Finch, and the Cocos

Figure 3
Impact Limit Lines in the Vicinity of Cocos Island (Mission 5)



Island Cuckoo. The flora of the island consists of 155 vascular and 48 nonvascular plants, of which about 15 percent are endemic.

According to the Costa Rican National Park web site, there are 235 species of plants (70 of which are endemic); 362 of insects (64 endemic); 2 reptilian species (i.e., lizard and salamander) both of which are endemic; 3 species of spiders; and 85 species of birds, including 4 endemic species; 57 crustacean; 118 aquatic mollusks; and more than 200 fish.

Despite the differing information, it can be concluded that Cocos Island is rich in plant and animal life, and the legal status and preserved nature of the national park has maintained a relatively undisturbed environmental setting on the island.

ENVIRONMENTAL IMPACTS

Air Quality and Atmospheric Emissions

The proposed change will not create a new impact on air quality or atmospheric emissions. Impacts in this category and the corresponding mitigation program will be similar to those noted in the Final EA and the Environmental Finding Document.

Water Quality

The proposed change will not create a new impact on water quality. Impacts in this category and the corresponding mitigation program will be similar to those noted in the Final EA and the Environmental Finding Document.

Noise

The proposed change will not create a new impact on noise. Impacts in this category and the corresponding mitigation program will be similar to those noted in the Final EA and the Environmental Finding Document.

Waste

The proposed change will not create a new impact on waste generation and management. Impacts in this category and the corresponding mitigation program will be similar to those noted in the Final EA and the Environmental Finding Document.

Biological and Ecological Impacts

The proposed change will not create a new impact related to biological or ecological activity. Impacts in this category and the corresponding mitigation program will be similar to those noted in the Final EA and the Environmental Finding Document.

Social and Economic Considerations

The proposed change will not create a new impact related to social or economic considerations. Impacts in this category and the corresponding mitigation program will be similar to those noted in the Final EA and the Environmental Finding Document. In addition, because of the change in flight plan, the list of recipients of "notification of mariners and other interested parties," as specified in Sea Launch's Environmental Monitoring and Protection Plan, will be evaluated and adjusted accordingly.

Health and Safety

The proposed change will not create a new impact in the area of health and safety. Impacts in this category and the corresponding mitigation program will be similar to those noted in the Final EA and the Environmental Finding Document.

Threatened and Endangered Species

The proposed change will not create a new impact regarding threatened or endangered species. Impacts in this category and the corresponding mitigation program will be similar to those noted in the Final EA and the Environmental Finding Document.

Archeological and Cultural Resources

The proposed change will not create a new impact in relation to archeological and cultural resources. Impacts in this category and the corresponding mitigation program will be similar to those noted in the Final EA and the Environmental Finding Document.

Home Port Activities

The proposed change will not affect Home Port activities.

Energy Outputs

The proposed change will not affect energy outputs. Impacts in this category and the corresponding mitigation program will be similar to those noted in the Final EA and the Environmental Finding Document.

Environmental Justice

The proposed change will not create a new impact concerning environmental justice. Impacts in this category and the corresponding mitigation program will be similar to those noted in the Final EA and the Environmental Finding Document.

Cumulative Impacts

The proposed change will not affect cumulative impacts. Cumulative impacts will be similar to those noted in the Final EA and the Environmental Finding Document.

Failed Mission Scenario

Under the failed mission scenario, the fifth mission's proximity to Cocos Island poses a risk event comparable to the proximity of Wolf and Darwin Islands of the Galapágos Island Group during equatorial launch missions such as in Missions 1 and 2. This latter case is described in Section 4.3 of the EA. A similar failure analysis relative to Cocos Island is provided below. The various hazard scenarios for this phase of the ascent trajectory and the theoretical casualty expectation confirm the very low risks expected from possible failures during this phase of flight.

The altitude of the vehicle will be over 180 kilometers when approaching Cocos Island. The fifth mission flight plan allows the ILL, but not the nominal groundtrack (or IIP), to traverse the island. During the transverse through the vicinity of Cocos Island, the Block DM-SL will be undergoing a steady engine burn and acceleration. Historical performance reliability of this stage during this time of flight, as demonstrated by performance in both Zenit-3SL and Proton vehicles, is better than 98 percent. On-board systems will have been active for over two minutes, and will have stabilized from their start-up phases. The potential for an equipment failure during the timeframe of concern (i.e., approximately 690 seconds after lift-off) therefore, is extremely small. The corresponding risk and potential scale of impact to the ecosystem and vessels in the area from such a failure are, therefore, also extremely small.

In the case of Cocos Island, the nominal IIP will laterally pass by—but not directly over—the island for a duration of less than 0.5 seconds, approximately 691 seconds after launch, at an speed of over 6,900 meters per second (28,000 kilometers per hour). As a statistical concept, the ILL boundary will encompass Cocos Island as the IIP traverses the ocean surface. Given the launch vehicle's speed and altitude, however, the probability is extremely small that failure would occur at the moment the IIP passes abeam or nearly abeam the island. This is during a time when the propulsion and control systems have been stable for several minutes and, therefore, are less susceptible to failure as mentioned above. Further, in the event of a failure during this moment in time, debris from the third stage of the launch vehicle will principally burn, fragment, and scatter as it returns to earth. Specifically, payload structures would immediately tumble and rupture; the fuel and propellants would disperse and immediately vaporize and burn; and virtually all of the hardware components would fragment into small pieces, most burning during re-entry. Debris which could potentially survive include batteries and bolts of extremely durable material (e.g., titanium). Although surviving debris will be hot following re-entry, the risk of fire resulting from debris should be minimal, especially considering the humid climate of the island (which experiences over 7,000 mm of rain annually) as well as the natural convective cooling as the relatively small pieces return to Earth.

Given the groundtrack IIP separation from the island, the probability that a surviving piece of the dispersed set of debris would strike Cocos Island or the shallow waters extending out from the island proper is calculated to be less than $2.06x10^{-7}$. This analysis for Cocos Island follows the same method and yields comparable results as the analysis documented for Wolf and Darwin Islands in EA Section 4.3.4.2 and EA Appendix E on Galapágos overflight risk.

CONCLUSIONS

Based on the above review and in conformity with FAA Order 1050.4D, paragraph 92, the FAA has concluded that the proposed change to a equatorial launch with an azimuth of 83.43° for Mission 5 Sea Launch operations conforms to the prior approved Environmental Finding Document and Final EA, that the data contained in the approved EA and Environmental Finding Document are still substantially valid, that there are no significant environmental changes, and that all pertinent conditions and requirements of the prior approval have been met or will be met in the current action.

REFERENCES

Associated Steamship Agents, S.A., Panama Canal Traffic Status; www.shipsagent.com/traffic.html as of 4/13/00.

Cocos Island National Part at www.geocities.com/The Tropics/3425/unesco.html as of 4/13/00.

Department of Transportation, Federal Aviation Administration, Docket #29280, Environmental Finding Document; Agency: Federal Aviation Administration (FAA), DOT Action: Environmental Finding Document: Finding of No Significant Impacts; February 11, 1999.

Parque Nacional Isla del Coco at www.nacion.co.cr./netinc/costarica/parques/isla.del.coco.html as of 4/13/00.

Personal communication with William Weil, ERM Inc., 4/10/00 (formerly volunteer park ranger on Cocos Island, 1997).

"Sea Launch Environmental Monitoring and Protection Plan," Revision No. 1, August 30, 1999.

U.K. Hydrographic Office, "The World Main Ocean Routes for Power Vessels," nautical chart, December 1973.

U.N. System-Wide Earthwatch Web Site, at www.unep.ch/islands/IWC.htm last updated on February 3, 1998.

Environmental Finding Document Finding of No Significant Impact

US DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

Environmental Finding
Written Reevaluation of the Sea Launch Environmental Assessment with Respect to a Equatorial Launch 83.28° Azimuth Scenario for the Sea Launch Company

On February 11, 1999, the Federal Aviation Administration (FAA) accepted a Final Environmental Assessment evaluating proposed launch activities from a mobile, floating launch platform in international waters in the east-central equatorial Pacific Ocean by the Sea Launch Limited Partnership (Sea Launch). The covered actions as evaluated in that Environmental Assessment included six launches per year using an approximately equatorial launch azimuth. Based on the February 11, 1999 Environmental Assessment, the FAA issued an Environmental Finding Document. This Document found that licensing the proposed launch activities was not a major Federal action that would significantly affect the quality of the human environment within the meaning of Executive Order (E.O.) 12114, the FAA's application of which was guided by the National Environmental Policy Act (NEPA). On February 25, 2000 the FAA issued an Environmental Finding Document based on a Written Reevaluation that found that licensing a single launch at a 135° azimuth was not a major Federal action that would significantly affect the quality of the human environment within the meaning of E.O. 12114. Accordingly, Sea Launch proceeded with two successful equatorial launches and one mission failure (135° azimuth launch).[1]

Sea Launch is currently proposing a fifth mission launch from the same launch location in the east-central Pacific (i.e., 154° W on the equator) using a launch azimuth of 83.28° to transport a payload into geosynchronous transfer orbit (GTO). The fifth mission would use the same type of payload, launch vehicle, launch site and would primarily traverse international waters with the stage 1, stage 2 and payload fairing impact zones all located in international waters. Similar to the first and second missions, the flight plan for the fifth mission presents no risk to any populated land mass until a 27-second high altitude (over 180 kilometer) Instantaneous Impact Point (IIP) traverse of a portion of South America. For the first and second missions, as addressed in the Final Environmental Assessment, the IIP traverse of South America was 29 seconds and the population density in those areas was less than $5/km^2$. For the fifth mission, the population density used in the calculation is $9.5/km^2$ ($10,000/km^2$ for the city of Medellin, Colombia, and less than $6/km^2$ for the rest of South America).

The fifth mission is also similar to the first and second missions in that the flight path approaches, but does not go directly over, an uninhabited island. In the fifth mission, the flight path approaches Cocos Island (Costa Rica), an uninhabited Island with a rich and nationally protected ecosystem.

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[1] The fourth mission used an 88.67° azimuth which is essentially equivalent to the original approximately equatorial launch azimuth launches licensed by FAA for the first and second missions.

In addition, shipping lanes associated with the Panama Canal could be potentially impacted by the fifth mission. A review of the sea lane charts should suggest that the frequency of the affected vessel traffic is the same as it was in the first and second missions. Cocos Island is well outside the expected area for all stage and fairing impact points. The chance of any environmental impact from failed mission scenarios associated with the change in launch azimuth is extremely small and is similar to the scenarios evaluated in the Final Environmental Assessment, dated February 11, 1999.

In a normal launch scenario, the risk of any stage or fairing impact remains very low, even though the proposed launch azimuth will take the launch vehicle in the vicinity of Cocos Island. These impact risks are similar to those assessed in the February 11, 1999 Environmental Assessment failed mission scenarios.

Based on a review of the previous Environmental Assessment and the subsequent Written Reevaluation, it is concluded that licensing the 83.28^{o} launch azimuth would not create any significant environmental impacts. The environmental impacts of the proposed 83.28^{o} launch azimuth are similar to those associated with the equatorial launch azimuth used for the GTO launches previously licensed by the FAA. This review concludes that the change in launch azimuth does not controvert the conclusions of the February 11, 1999 Environmental Assessment and there are no substantive changes to environmental impacts or mitigation measures as described in the document.

Based on this review and consistent with FAA Order 1050.1D, paragraph 92, the FAA has concluded that the proposed change to an 83.28^{o} launch azimuth for the fifth mission conforms to the previously approved Environmental Finding Document and Final Environmental Assessment, that the data in that Environmental Assessment and Environmental Finding Document are still valid and that all pertinent conditions and requirements of the prior approval have been met or will be met in the current action.

After careful and thorough consideration of the facts, the undersigned finds that the proposed change in launch azimuth is consistent with the purpose of the national environmental policies and objectives as set forth in E.O. 12114 the FAA's application of which is guided by NEPA, and that the proposed change will not significantly affect the quality of the human environment or otherwise include any condition requiring additional consultation. These findings are made pursuant to FAA commercial space launch licensing authority in 49 USC Subtitle IX ch. 701, Commercial Space Launch Activities, §§ 70101-70121 and implementing regulations and guidance.

Ron Gress

______________________________	______________________________
Manager, Licensing and Safety Division	Date
Associate Administrator for	______________________________
Commercial Space Transportation	Location Signed

SUBJECT: Written Reevaluation of the Final Environmental Assessment for the Sea Launch Project dated February 11, 1999 with Respect to Substituting Russian UDMH/ N_2O_4 for MMH/ N_2O_4 as Block DM-SL Fuel/Oxidizer Combination for Mission 7.

DATE: April 12, 2001

INTRODUCTION AND BACKGROUND

Sea Launch Limited Partnership (SLLP) is an international commercial venture formed to conduct commercial space launches from a mobile, floating launch platform in international waters in the east-central equatorial Pacific Ocean. 49 U.S.C. §§ 70101-70119 (the Act) authorizes the U.S. Secretary of Transportation to oversee and coordinate U.S. commercial launches, and to issue licenses authorizing commercial launches and the operation of commercial launch sites. The Secretary executes this authority through the Federal Aviation Administration's (FAA) Associate Administrator for Commercial Space Transportation (AST). The FAA exercises its licensing authority in accordance with the Act and Commercial Space Transportation Licensing Regulations 14 CFR Parts 413 and 415. These regulations authorize the FAA to license the launch of a launch vehicle when conducted by U.S. citizens abroad. SLLP is a foreign entity that works through its General Partner, Sea Launch Company, L.L.C. Licensing a launch is a major federal action requiring environmental analysis by the FAA in accordance with the National Environmental Policy Act (NEPA) of 1969. Because the launch to be licensed by the FAA will take place outside the territorial boundaries of the United States, the FAA's review is guided by Executive Order 12114, "Environmental Effects Abroad of Major Federal Actions."

The FAA issued a Final Environmental Assessment (EA) for the SLLP Project on February 11, 1999. The February 11, 1999 EA assessed the proposed actions of operating and licensing launches of the Zenit-3SL from a mobile, floating launch platform in international waters in the east-central equatorial Pacific Ocean. The February 11, 1999 EA analyzed potential impacts of up to six launches per year. The FAA reviewed and analyzed the available data and information on existing conditions, potential project impacts on the environment, as well as measures to mitigate potential impacts, and issued an Environmental Finding Document on February 11, 1999. This Finding Document is the equivalent of a Finding of No Significant Impact (FONSI) pursuant to NEPA. The FAA concluded that issuing licenses for launches within the parameters specified (e.g., launch vehicle, launch location, and payload type) was not a major federal action that would significantly affect the quality of the natural and human environment within the meaning of Executive Order 12114 and NEPA.

As of this date SLLP has launched six Zenit-3SL launch vehicles. The first two, the fourth, and the sixth launches used an azimuth of 88.67°, the third employed an azimuth of 135°, and the fifth employed an azimuth of 83.28º. An Environmental Finding Document addressing the third launch was signed on February 25, 2000, and an Environmental Finding document addressing the fifth launch was signed on October 16, 2000.

PROPOSED ACTION

Mission 7 will utilize the same launch vehicle, launch location, launch azimuth and payload type as analyzed in the February 1999 EA. However, SLLP proposes to use 7 to 13 gallons (26 to 48 liters) of unsymmetrical dimethylhydrazine (1,1-dimethylhydrazine or UDMH) fuel along with nitrogen tetroxide (N_2O_4) oxidizer, imported from Russia as the propellants for the Upper Stage during Mission 7. These Upper Stage propellants would be a substitute for the 7 to 13 gallons (26 to 48 liters) of monomethylhydrazine (MMH) and the U.S. Grade N_2O_4 used for all previous missions. Thus, the proposed Federal action is to issue a launch specific license for the launch of an SLLP Zenit-3SL launch vehicle where the only modification to the mission description is a change in the Upper Stage propellants (Mission 7). Using Russian UDMH would provide a higher specific impulse than using MMH and thus offer an advantage for the commercial customer. This advantage consists of more efficient Upper Stage engine performance with higher engine reliability leading to improved mission safety and mission success. In conjunction with the change in fuel, SLLP intends to substitute, consistent grades of propellants in the Upper Stage, that is Russian Grade N_2O_4 with the Russian-produced UDMH to ensure proper, effective and safe functioning of the Upper Stage propellant.

REEVALUATION OF ENVIRONMENTAL CONSIDERATIONS AND MITIGATION

The only proposed change to the Mission 7 launch parameters when compared to the launch parameters (i.e., launch vehicle, launch location, flight track and payload type) analyzed in the February 11, 1999 Environmental Assessment is the proposed change in Upper Stage propellants. As indicated above, SLLP proposes to use 7 to 13 gallons (26 to 48 liters) of unsymmetrical dimethylhydrazine (1,1-dimethylhydrazine or UDMH) along with nitrogen tetroxide (N_2O_4) oxidizer, imported from Russia as the fuel for the Upper Stage during Mission 7. UDMH and MMH are both hydrazine fuels (a type of launch vehicle and spacecraft fuel used in hypergolic propellant systems[1]) that have different chemical and physical parameters (e.g., boiling point, specific gravity, vapor pressure, flash point). The two fuels, however, are similar in terms of their reactivity, products of combustion (based on N_2O_4 as an oxidizer), exposure limits, and United Nations (UN) and United States Department of Transportation (USDOT) hazard classification Consequently, the procedures employed for handling UDMH and MMH at Home Port and on board the Launch Platform would be the same as those described in detail in the February 11, 1999 EA. With the exception of the labeling of containers and the installation of UDMH-specific scrubber filters, all other handling procedures and processes will be identical to those handling procedures and processes for MMH, used in the previous missions. The combustion emissions of the two fuels will be similar and will occur at the same altitudes
(180 kilometers), well above the Earth's atmosphere, as described in the February 11, 1999 EA. There will be a variation in the stoichiometric ratios—i.e., the quantitative relationship of fuel and oxidizer in a hyperbolic reaction. In this instance the stoichiometric ratio refers to the quantity of MMH versus that of UDMH, required to react completely with a given quantity of N_2O_4 oxidizer.

The two different grades of N_2O_4 are similar in physical and chemical properties; there are however, some differences in the types and level of impurities.

[1] Hypergolic propellant systems use fuel and oxidizer combinations that self-ignite when mixed together without the aid of a spark or other external energy input to initiate the combustion reaction

The handling, storage, and transportation of the two materials will be identical. As oxidizers for the combustion of UDMH or MMH, the two grades will be identical and their effects will occur at the same altitudes (180 kilometers) well above the Earth's atmosphere as described in the February 11, 1999 EA.

The use of UDMH during activities at SLLP Home Port will require SLLP to modify Federal, state and local regulatory documentation prior to UDMH arrival on-site. The following documents will be amended prior to UDMH arrival on-site:

a) Hazardous Material Inventory, Emergency Planning and Community Right to Know Act (EPCRA) Long Beach Department of Health (CUPA)

b) Business Emergency Plan, Long Beach Fire Department

c) Operations Manual for the Transfer of Hazardous Material in Bulk, United States Coast Guard (USCG) Integrated Contingency Plan, Environmental Protection Agency (EPA), Occupational Safety and Health Administration (OSHA), California OSHA, California Offshore Emergency Service (COES), United States Coast Guard

The following document which will be published in 2002, will reflect emission changes occurring in 2001.

d) Annual Emissions Inventory (Year 2001), South Coast Air Quality Management District (SCAQMD)

The following document will not require changes because regulated thresholds are not exceeded:

e) Risk Management Plan, Long Beach Department of Health, Certified Unified Program Agency (CUPA)

Scrubbers[2] are the components of scrubber filters specifically designed and constructed to capture and neutralize UDMH vapors. These filters have been delivered to SLLP and will be installed in the designated spaces. SLLP will not use UDMH at the Home Port until all Federal , state and local permit requirements have been met and all required safety equipment, including the scrubber filter elements, have been installed. Substituting Russian Grade N_2O_4 for U.S. Grade N_2O_4 will not affect Home Port activities or permitting.

The use of MMH in conjunction with N_2O_4 was evaluated in the February 11, 1999 EA and is used as a reference for comparison. A summary of the chemical, physical, and safety parameters of both U.S. and Russian Grade UDMH are compared with those of MMH in Table 1. Table 2 compares both U.S. and Russian Grade N_2O_4.

[2] A scrubber is an air pollution control device for removing impurities from a gas steam. Toxic constituents of the vapor are absorbed into and react with the "scrubber liquor" on the material in the scrubber tower.

Table 1: Summary of Chemical/Physical and Safety Parameters for UDMH and MMH

	MMH	UDMH (U.S. Grade)	UDMH (Russian Grade)
General Information			
Name	Monomethylhydrazine	1,1-Dimethylhydrazine	1,1-Dimethylhydrazine
Chemical formula	CH_3NHNH_2	$(CH_3)_2NNH_2$	$(CH_3)_2NNH_2$
Molecular weight	46.07	60.10	60.10
CAS:	60-34-4	57-14-7	no information
Composition	Methylhydrazine: 95 to 99% Water: 1 to 5%	1,1-dimethylhydrazine: 95 to 99% Dimethyl amine: 1 to 5% Water: 0.1 to 1%	1,1-dimethylhydrazine: 98.6% Dimethyl amine: 0.5% Methyl alcohol: 0.4% Water: 0.5%
Chemical/Physical Characteristics			
Boiling point	87.5°C	63°C	63°C
Melting Point	-52.4°C	-58°C	-57°C
Vapor Pressure	49.6 mm Hg (at 25°C)	157 mm Hg (at 25°C)	no information
Vapor Density (air = 1)	1.59	2.07	no information
Specific Gravity	0.874 (at 25°C)	0.80 (at 20°C)	0.790 (at 20°C)
Flash point	21°C (COC method)	-15°C (COC)	-18°C (Abel)
Solubility in Water	miscible	miscible	soluble
Appearance	clear, colorless liquid with amine odor	clear, colorless liquid with ammonia odor	colorless or light yellow fuming in the air high-toxic liquid with ammonia odor
Handling & Safety Information			
Reactivity	stable, avoid: temperatures greater than 88°C, static discharge, direct sunlight, heat, sparks strong oxidizers	stable, avoid: heat, sparks, open flame, strong oxidizers	explosive, highly inflammable liquid; easily oxidizes
Decomposition/ Combustion products	carbon oxides, nitrogen oxides	carbon oxides, nitrogen oxides	soot, carbon oxides, nitrogen oxides
Hazard classification	classified as IB flammable liquid	classified as IB flammable liquid, corrosive	classified as extremely dangerous substances, Class 1 of danger by effect on organism [a/] (GOST 12.1.007-76)
Health Hazard Data			
Exposure limits and effects	OSHA Permissible Exposure Limit (PEL): 0.35mg/m^3 (skin) Oral LD_{50} (rat) 32 mg/kg; considered mutagenic but not carcinogenic	OSHA PEL: 1mg/m^3 (skin) Oral LD_{50} (rat) 122 mg/kg; not considered carcinogenic	Toxicity level (max. permissible) 0.1mg/m^3 in production rooms air; 0.001mg/m^3 in atmospheric air—maximum single and daily average

NOTE: a/ Class 1 GOST is the most dangerous.

Sources:

S. P. Korolev Rocket and Space Corporation Energia, *Certificate of Material Safety: Unsymmetrical dimethyl hydrazine*, Nov. 10, 2000.
NIOSH, *Pocket Guide to Chemical Hazards: Methyl hydrazine*, www.cdc.gov/niosh/npg/npgd0419.html as of Dec. 18, 2000.
NIOSH, *Pocket Guide to Chemical Hazards: 1-1 Dimethylhydrazine*, www.cdc.gov/niosh/npg/npgd0227.html as of Dec. 18, 2000.
NIOSH, *Manual of Analytical Methods (NMAM): 1-1Dimethylhydrazine, Method 3515*, Fourth Edition, Aug. 15, 1994.
NIOSH, *Manual of Analytical Methods (NMAM): Monomethylhydrazine, Method 3510*, Fourth Edition, Aug. 15, 1994.
Olin Corporation, *Material Safety Data Sheet: Unsymmetrical dimethylhydrazine*, http://msds.pdc.cornell.edu/msds/siri/msds/h/q197/q293.html, Dec. 18, 2000.Olin Corporation, *Material Safety Data Sheet: Monomethylhydrazine*, http://msds.pdc.cornell.edu/msds/siri/msds/h/q384/q195.html, Dec. 18, 2000.

Table 2: Summary of Chemical/Physical and Safety Parameters for N_2O_4

	N_2O_4 (U.S. Grade)	N_2O_4 (Russian Grade)
General Information		
Name	Nitrogen tetroxide	Nitrogen tetroxide
Chemical formula	N_2O_4	N_2O_4
Molecular weight	92.02	92.02
CAS:	10544-72-6	no information
Composition—	Nitrogen tetroxide: 97-97.5% Nitrogen monoxide: 2.5 to 3% Water: 0.17 % Chlorine: 0.04% Iron: 0.5 ppm Particulates: 10 mg/l	Nitrogen tetroxide: 98.2% Nitrogen monoxide: 0.8% Nitric acid: 1.0%
Chemical/Physical Characteristics		
Boiling point	21°C	20.3 to 21.1°C
Melting Point	-11.2°C	-11.3 to -11.9°C
Vapor Pressure	17.7 mm Hg (at 21°C)	no information
Vapor Density (air = 1)	1.56	no information
Specific Gravity	1.49	no information
Solubility in Water	Complete	soluble
Appearance--	greenish brown liquid with acidic odor	brown to green liquid
Handling & Safety Information		
Reactivity	stable, avoid moisture, bases, most metals and organics	stable for 5 years, provided storage conditions are adequate; is a strong oxidizer
Hazard classification	non-flammable liquid, code G7	classified as moderately hazardous material, Class 3 of danger by effect on organism [a/] (GOST 12.1.007-76)
Health Hazard Data		
Exposure limits and effects	OSHA PEL: 9 mg/m^3 (skin)	Toxicity level (max. permissible) 2.0 mg/m^3

NOTE: a/ Class 1 GOST is the most dangerous.

Sources:

S. P. Korolev Rocket and Space Corporation Energia, *Certificate of Material Safety: Nitrogen tetroxide*, Nov. 10, 2000.

NIOSH, *Pocket Guide to Chemical Hazards: Nitrogen dioxide, dinitrogen tetroxide, nitrogen peroxide*, www.cdc.gov/niosh/npg/npgd0454.html as of Mar. 21, 2001.

Vicksburg Chemical, *Material Safety Data Sheet: Nitrogen tetroxide,* http://msds.pdc.cornell.edu/msds/siri/msds/h/q302/q346.html, Mar. 20, 2001.

Affected Environment

The proposed action does not result in a change to the affected environment as described in Section 3.0 of the February 11, 1999 EA.

Environmental Impacts

Air Quality and Atmospheric Emissions

The proposed Federal action, to license the launch of an SLLP Zenit-3SL launch vehicle for Mission 7 where the only change to the mission description is a change in the Upper Stage propellants, will not create a new impact on air quality or atmospheric emissions. The Russian UDMH (fuel) in conjunction with the Russian Grade N_2O_4 (oxidizer) are expected to produce similar emissions during Upper Stage flight as those from the MMH/U.S Grade N_2O_4 propellants previously used. In addition, the proposed propellants will be used in the Upper Stage only and thus would produce emissions well above the Earth's atmosphere (180 km). Impacts in this category and the corresponding mitigation program will be the same as those noted in the February 11, 1999 Final EA and the Environmental Finding Document.

Water Quality

The proposed action will not create a new impact on water quality. Impacts in this category and the corresponding mitigation program will be the same as those noted in the Final EA and the Environmental Finding Document.

Noise

The proposed action will not create a new impact on noise. Impacts in this category and the corresponding mitigation program will be the same as those noted in the Final EA and the Environmental Finding Document.

Waste

The proposed action will not create a new impact on waste generation and management. Impacts in this category and the corresponding mitigation program will the same as those noted in the Final EA and the Environmental Finding Document.

Biological and Ecological Impacts

The proposed action will not create a new impact related to biological or ecological activity. Impacts in this category and the corresponding mitigation program will be the same as those noted in the Final EA and the Environmental Finding Document.

Social and Economic Considerations

The proposed action will not create a new impact related to social or economic considerations. Impacts in this category and the corresponding mitigation program will be the same as those noted in the Final EA and the Environmental Finding Document.

Health and Safety

The proposed action will not create a new impact in the area of health and safety. Impacts in this category and the corresponding mitigation program will be the same as those noted in the Final EA and the Environmental Finding Document.

Threatened and Endangered Species

The proposed action will not create a new impact regarding threatened or endangered species. Impacts in this category and the corresponding mitigation program will be the same as those noted in the Final EA and the Environmental Finding Document.

Archeological and Cultural Resources

The proposed action will not create a new impact in relation to archeological and cultural resources. Impacts in this category and the corresponding mitigation program will be the same as those noted in the Final EA and the Environmental Finding Document.

Energy Outputs

The proposed action will not affect energy outputs. Impacts in this category and the corresponding mitigation program will be to the same as those noted in the Final EA and the Environmental Finding Document.

Environmental Justice

The proposed action will not create a new impact concerning environmental justice. Impacts in this category and the corresponding mitigation program will be the same as those noted in the Final EA and the Environmental Finding Document.

Home Port Activities

The proposed action will not create a new impact resulting from Home Port activities as SLLP will modify and comply with all Federal, state and local permit requirements prior to UDMH arrival on-site. The following documents will be amended prior to UDMH arrival on-site:

a) Hazardous Material Inventory, Emergency Planning and Community Right to Know Act (EPCRA) Long Beach Department of Health, Certified Unified Program Agency (CUPA)

b) Business Emergency Plan, Long Beach Fire Department

c) Operations Manual for the Transfer of Hazardous Material in Bulk, United States Coast Guard (USCG)

d) Integrated Contingency Plan, Environmental Protection Agency (EPA), Occupational Safety and Health Administration (OSHA), California OSHA, California Offshore Emergency Service (COES), United States Coast Guard

The following document which will be published in 2002, will reflect emission changes occurring in 2001

e) Annual Emissions Inventory (Year 2001), South Coast Air Quality Management District (SCAQMD)

The following document will <u>not</u> require changes because regulated thresholds are not exceeded:

f) Risk Management Plan, Long Beach Department of Health, , Certified Unified Program Agency (CUPA)**]**

Scrubbers are the components of scrubber filters specifically designed, and constructed to capture and neutralize vapors UDMH vapors. These filters have been delivered to SLLP and will be installed in the designated spaces. SLLP will not use UDMH at the Home Port until all Federal, state and local permit requirements have been met and all required safety equipment, including the scrubber filter elements, have been installed.

Substituting Russian Grade N_2O_4 for U.S. Grade N_2O_4 will not affect Home Port activities or permitting.

<u>Cumulative Impacts</u>

The proposed action will not affect or cause cumulative impacts. Cumulative impacts will be the same as those noted in the Final EA and the Environmental Finding Document.

<u>Failed Mission Scenario</u>

Failed mission scenarios for this Written Reevaluation include all failure scenarios considered in the February 11, 1999 EA (e.g., explosion on the Launch Platform, uncontrolled Upper Stage loss etc.). Slight differences in combustion emissions may occur due to the small differences in the types and levels of impurities in the U.S. versus the Russian Grade nitrogen tetroxide and the use of UDMH rather than MMH. However, due to the remote likelihood of a failure during Upper Stage flight and the very high altitude of the vehicle at this stage in the flight, no impacts to the environment are expected. In addition, for failures during earlier portions of the flight, any unreacted fuel or oxidizer is likely to be completely destroyed before reaching the ocean or land surface, due to the volatility of hypergolic propellants (i.e., upon release they react with the atmosphere and dissipate),

Conclusions

Based on the above review and in conformity with FAA Order 1050.1D, paragraph 92, the FAA has concluded that the proposed change to substitute Russian UDMH/ N_2O_4 for MMH/ N_2O_4 as a propellant in the Upper Stage for Mission 7 conforms to the prior approved Environmental Finding Document and Final EA dated February 11, 1999, that the data contained in the approved Final EA and Environmental Finding Document are still valid, that there are no significant environmental changes, and that all pertinent conditions and requirements of the prior approval have been met or will be met in the current action. For Home Port activities, SLLP will not use UDMH at the Home Port until SLLP has complied with all Federal , state and local permit requirements and has installed all required safety equipment, including the scrubber filter elements.

REFERENCES

NIOSH, *Manual of Analytical Methods (NMAM): 1-1Dimethylhydrazine, Method 3515,* Fourth Edition, Aug. 15, 1994.

NIOSH, *Manual of Analytical Methods (NMAM): Monomethylhydrazine, Method 3510,* Fourth Edition, Aug. 15, 1994.

NIOSH, *Pocket Guide to Chemical Hazards: 1-1 Dimethylhydrazine*, www.cdc.gov/niosh/npg/npgd0227.html as of Dec. 18, 2000.

NIOSH, *Pocket Guide to Chemical Hazards: Methyl hydrazine*, www.cdc.gov/niosh/npg/npgd0419.html as of Dec. 18, 2000.

NIOSH, *Pocket Guide to Chemical Hazards: Nitrogen dioxide, dinitrogen tetroxide, nitrogen peroxide*, www.cdc.gov/niosh/npg/npgd0454.html as of Mar. 21, 2001.

Olin Corporation, *Material Safety Data Sheet: Unsymmetrical dimethylhydrazine,* http://msds.pdc.cornell.edu/msds/siri/msds/h/q197/q293.html, Dec. 18, 2000.

Olin Corporation, *Material Safety Data Sheet: Monomethylhydrazine,* http://msds.pdc.cornell.edu/msds/siri/msds/h/q384/q195.html, Dec. 18, 2000.

S. P. Korolev Rocket and Space Corporation Energia, *Certificate of Material Safety: Nitrogen tetroxide*, Nov. 10, 2000.

S. P. Korolev Rocket and Space Corporation Energia, *Certificate of Material Safety: Unsymmetrical dimethyl hydrazine*, Nov. 10, 2000.

Vicksburg Chemical, *Material Safety Data Sheet: Nitrogen tetroxide,* http://msds.pdc.cornell.edu/msds/siri/msds/h/q302/q346.html, Mar. 20, 2001.

US DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

Environmental Finding
Written Reevaluation of the Final Environmental Assessment for the Sea Launch Project dated February 11, 1999 with Respect to Substituting Russian UDMH/N_2O_4 for MMH/N_2O_4 as Upper Stage Fuel/Oxidizer Combination for Mission 7

On February 11, 1999, the Federal Aviation Administration (FAA) accepted a Final Environmental Assessment evaluating the proposed launches from a mobile, floating launch platform in international waters in the east-central equatorial Pacific Ocean by the Sea Launch Limited Partnership (SLLP). The covered actions as evaluated in that Environmental Assessment included six launches per year using an approximately equatorial launch azimuth. Based on the February 11, 1999 Final Environmental Assessment, the FAA issued an Environmental Finding Document. This Document found that licensing the proposed launches within the parameters analyzed was not a major federal action that would significantly affect the quality of the human environment within the meaning of Executive Order (E.O.) 12114, the FAA's application of which was guided by the National Environmental Policy Act (NEPA).

As of this date SLLP has launched six Zenit-3SL launch vehicles. The first two, the fourth, and the sixth launches used an azimuth of 88.67°, the third employed an azimuth of 135°, and the fifth employed an azimuth of 83.28º. An Environmental Finding Document addressing the third launch was signed on February 25, 2000, and an Environmental Finding document addressing the fifth launch was signed on October 16, 2000.

Mission 7 will entail the same launch vehicle, launch location, launch azimuth and payload type as analyzed in the February 1999 Final EA. However, for Mission 7, SLLP is proposing to use 7 to 13 gallons (26 to 48 liters) of unsymmetrical dimethylhydrazine (1,1-dimethylhydrazine or UDMH) fuel, along with nitrogen tetroxide (N_2O_4) (oxidizer) imported from Russia as propellants for the Upper Stage or Block DM-SL. These Upper Stage propellants would be a substitute for the 7 to 13 gallons (26 to 48 liters) of monomethylhydrazine (MMH) and the U.S. Grade N_2O_4 used in all previous missions. Thus, the proposed Federal action is to issue a launch specific license for the launch of an SLLP Zenit-3SL launch vehicle where the only modification to the mission description is a change in the Upper Stage propellant (Mission 7).

UDMH and MMH are both hydrazine fuels (a type of launch vehicle and spacecraft fuel used in hypergolic[1] propellant systems) that have different chemical and physical parameters (e.g., boiling point, specific gravity, vapor pressure, and flash point).

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[1] Hypergolic propellant systems use fuel and oxidizer combinations that self-ignite when mixed together without the aid of a spark or other external energy input to initiate the combustion reaction.

The two fuels, however, are similar in terms of their reactivity, products of combustion (based on N_2O_4 as an oxidizer), exposure limits, and United Nations (UN) and United States Department of Transportation (USDOT) hazard classification. The N_2O_4 oxidizer imported from Russia is equivalent to the U.S. Grade used for previous missions with only slight differences in trace impurities. The procedures employed for handling UDMH and MMH at Home Port and onboard the Launch Platform would be the same as handling procedures employed for previous missions and described in detail in the February 1999 Final EA. The labeling of containers will vary based on relevant regulatory requirements. In addition, scrubber filters for UDMH will be installed at the appropriate facilities at Home Port

With regard to SLLP Home Port Activities, the substitution of Russian UDMH/ N_2O_4 for MMH/ N_2O_4 as Upper Stage Fuel /Oxidizer Combination for Mission 7 will necessitate that SLLP comply with all Federal, state and local permit requirements prior to UDMH arrival on-site. Substituting Russian Grade N_2O_4 for U.S. Grade N_2O_4 will not alter Home Port activities or permitting.

Based on a review of the February 1999 Final Environmental Assessment and the "Written Reevaluation of the Final Environmental Assessment for the Sea Launch Project dated February 11, 1999 with Respect to Substituting Russian UDMH/N_2O_4 for MMH/ N_2O_4 as Upper Stage Fuel/Oxidizer Combination for Mission 7", the FAA has determined that issuing a launch specific license for the launch of an SLLP Zenit-3SL launch vehicle where the only modification to the mission description is a change in the Upper Stage propellant (Mission 7), would not create any significant environmental impacts.

During the Mission 7 launch, the potential environmental impacts of the proposed substitution of Russian UDMH/ N_2O_4 for MMH/ N_2O_4 as Upper Stage Propellant/Oxidizer Combination are the same as those assessed for the GTO launches previously licensed by the FAA. For Home Port activities, UDMH will not be used until SLLP has complied with all Federal, state and local permit requirements and has installed all required safety equipment, including the scrubber filters.

Based on this review and consistent with FAA Order 1050.1D, paragraph 92, the FAA has concluded that the proposed substitution of propellants for Mission 7 conforms to the previously approved Environmental Finding Document and Final Environmental Assessment, that the data in that Environmental Assessment and Environmental Finding Document are still valid and that all pertinent conditions and requirements of the prior approval have been met or will be met in the current action.

After careful and thorough consideration of the facts, the undersigned finds that the proposed change in Upper Stage propellants for Mission 7 is consistent with the purpose of the national environmental policies and objectives as set forth in E.O. 12114, the FAA's application of which is guided by NEPA, and that the proposed change will not significantly affect the quality of the human environment or otherwise include any condition requiring additional consultation.

These findings are made pursuant to FAA commercial space launch licensing authority in 49 USC Subtitle IX ch. 701, Commercial Space Launch Activities, §§ 70101-70121 and implementing regulations and guidance.

Ron Gress

______________________________ ______________________________

Manager, Licensing and Safety Division	Date
Associate Administrator for	______________________________
Commercial Space Transportation	Location Signed

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Appendix E – Evaluation of Potential Propellants

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APPENDIX E

EVALUATION OF POTENTIAL PROPELLANTS THAT MAY BE USED BY THE SLLP PROJECT DURING THE PERIOD OF THE LAUNCH OPERATOR LICENSE

As discussed in Section 2.2, during the span of operations considered under the launch operator license (i.e., five years), alternative propellants may be employed on the Upper Stage. Two identified alternatives are Unsymmetrical Dimethylhydrazine (UDMH, or formally 1,1-Dimethylhydrazine) and Boktan (a Russian produced kerosene substitute). Operational evaluations of these products specific to the SLLP project have not been conducted to date. General information, however, is available and has been collected to conduct a preliminary analysis of the environmental consequences of the use of these propellants.

E.1 UDMH

The use of Monomethylhydrazine (MMH) in conjunction with N_2O_4 was evaluated in the February 11, 1999, EA and is used as a reference for comparison here. A potential alternative propellant is Unsymmetrical Dimethylhydrazine (UDMH, or formally 1,1-Dimethylhydrazine) both U.S. Grade and Russian Grade. The quantities of UDMH potentially used in the Upper Stage would be the same as the quantity of MMH currently used in the Upper Stage (approximately 25 to 50 liters, or 7 to 13 gallons).

E.1.1 Comparison of Chemical/Physical and Safety Parameters and Preliminary Analysis

Table E-1 presents several important chemical and physical and safety parameters for UDMH and MMH. A preliminary analysis of the environmental impacts of the use of UDMH, compared with MMH, follows.

Table E-1: Summary of Chemical/Physical and Safety Parameters for UDMH (U.S. and Russian Grade) and MMH

	UDMH	UDMH (Russian Grade)	MMH
General Information:			
Name	1,1-Dimethylhydrazine	1,1-Dimethylhydrazine	Monomethylhydrazine
Chemical formula	$(CH_3)_2NNH_2$	$(CH_3)_2NNH_2$	CH_3NHNH_2
Molecular weight	60.10	60.10	46.07
CAS:	57-14-7	not listed	60-34-4
Composition—	1,1-dimethylhydrazine: 95-99% dimethyl amine: 1-5% water: 0.1 to 1%	1,1-dimethylhydrazine: 98.6% dimethyl amine: 0.5% methyl alcohol: 0.4% water: 0.5%	methylhydrazine: 95-99% water: 1 to 5%
Chemical/Physical Characteristics:			
Boiling point	63°C	63°C	87.5°C
Melting Point	-58°C	-57°C	-52.4°C
Vapor Pressure	157 mm Hg (at 25°C)	not available	49.6 mm Hg (at 25°C)
Vapor Density (air = 1)	2.07	not available	1.59
Specific Gravity	0.80 (at 20°C)	0.790 (at 20°C)	0.874 (at 25°C)
Flash point	-15°C (COC)	-18°C (Abel)	21°C (COC method)
Solubility in Water	miscible	soluble	miscible
Appearance--	clear, colorless liquid with ammonia odor	colorless or light yellow fuming in the air high-toxic liquid with ammonia odor	clear, colorless liquid with amine odor
Handling & Safety Information:			
Reactivity	stable, avoid: heat, sparks, open flame, strong oxidizers	explosive, highly inflammable liquid; easily oxidizes	stable, avoid: temperatures greater than 88°C, static discharge, direct sunlight, heat, sparks strong oxidizers
Decomposition/ Combustion products	carbon monoxide, nitrogen oxides	soot, carbon monoxide, nitrogen oxides	carbon monoxide, nitrogen oxides
Hazard classification	classified as IB flammable liquid, corrosive	classified as extremely dangerous substances, Class 1 of danger by effect on organism [a/] (GOST 12.1.007-76)	classified as IB flammable liquid
Health Hazard Data:			
Exposure limits and effects	OSHA PEL: 1mg/m^3 (skin) Oral LD_{50} (rat) 122 mg/kg; not considered carcinogenic	Toxicity level (max. permissible) 0.1mg/m^3 in production rooms air; 0.001mg/m^3 in atmospheric air—maximum single and daily average	OSHA PEL: 0.35mg/m^3 (skin) Oral LD_{50} (rat) 32 mg/kg; considered mutagenic but not carcinogenic

NOTE: a/ Class 1 GOST is the most dangerous.

Sources:

S. P. Korolev Rocket and Space Corporation Energia, *Certificate of Material Safety Unsymmetrical Dimethyl Hydrazine*, Nov. 10, 2000.
NIOSH, *Pocket Guide to Chemical Hazards: Methyl hydrazine*, www.cdc.gov/niosh/npg/npgd0419.html as of Dec. 18, 2000.
NIOSH, *Pocket Guide to Chemical Hazards: 1-1 Dimethylhydrazine*, www.cdc.gov/niosh/npg/npgd0227.html as of Dec. 18, 2000.
NIOSH, *Manual of Analytical Methods (NMAM): 1-1Dimethylhydrazine, Method 3515,* Fourth Edition, Aug. 15, 1994.
NIOSH, *Manual of Analytical Methods (NMAM): Monomethylhydrazine, Method 3510,* Fourth Edition, Aug. 15, 1994.
Olin Corporation, *Material Safety Data Sheet: Unsymmetrical dimethylhydrazine,* http://msds.pdc.cornell.edu/msds/siri/msds/h/q197/q293.html, Dec. 18, 2000.
Olin Corporation, *Material Safety Data Sheet: Monomethylhydrazine,* http://msds.pdc.cornell.edu/msds/siri/msds/h/q384/q195.html, Dec. 18, 2000.

UDMH and MMH are both hydrazines with several differences in chemical and physical parameters (e.g., boiling point, specific gravity, vapor pressure, flash point). The two fuels, however, are similar in terms of reactivity, products of combustion (based on N_2O_4 as an oxidizer), exposure limits, and hazard classification. Consequently, the handling of these fuels at Home Port and on board the Launch Platform would be equivalent to procedures undertaken for previous missions, although containers and labeling requirements may vary based on relevant regulatory requirements. Equally important, the combustion emissions of the two fuels will be similar (there will be a variation in the stoichiometric ratios—i.e., the quantitative relationship between substances in processes involving chemical change) and will occur at the same altitudes as described in the February 11, 1999 EA.

E.1.2 Effect on Home Port & Marine Operations

The change from MMH to UDMH does not have a large impact on Home Port permitting. The following documents need to be amended prior to UDMH arrival on-site:

a) Hazardous Material Inventory (EPCRA), Long Beach Department of Health (CUPA)
b) Business Emergency Plan, Long Beach Fire Department
c) Operations Manual for the Transfer of Hazardous Material in Bulk, USCG
d) Integrated Contingency Plan

The following document will need to reflect the change in 2002:

e) Annual Emissions Inventory (Year 2001), SCAQMD

The following document will <u>not</u> require changes because thresholds are not exceeded:

f) Risk Management Plan, Long Beach Department of Health (CUPA)

Regarding the physical changes to Home Port or ship-board operations, Kvaerner Govan's HVAC contractor, Novenco, had specific scrubber filter elements designed, constructed, and delivered that would capture and properly neutralize vapors from UDMH. Following approval of the use of UDMH, these scrubbers will be installed at the SLLP facilities.

E.2 BOKTAN

The use of kerosene (Russian grade) in conjunction with LOX was evaluated in the February 11, 1999, EA and is used as a reference for comparison here. A potential alternative propellant is Boktan, a Russian produced kerosene substitute classified as a hydrocarbon product composed mainly of cycloalkanes. The quantities of Boktan potentially used in the Upper Stage would be approximately the same as the quantity of kerosene currently used in the Upper Stage (4,325 kg. or 9,515 lbs.).

E.2.1 Comparison of Chemical/Physical and Safety Parameters and Preliminary Analysis

Table E-2 presents several important chemical and physical and safety parameters for Boktan and kerosene. A preliminary analysis of the environmental impacts of the use of Boktan, compared with kerosene, follows.

Table E-2: Summary of Chemical/Physical and Safety Parameters for Kerosene (U.S. and Russian Grade) and Boktan

	Boktan	Kerosene	Kerosene (Russian Grade)
General Information:			
Chemical class	cycloalkanes	hydrocarbon fraction	hydrocarbon fraction
Common name	boktan (or naphthenes)	kerosene	naphthyl
Elemental composition	CH_2	$CH_{1.96}$ (average)	no information
Composition—	"boktan" or cycloalkanes – 98% dicyclobutylidene – 0.5% light impurities – 1.3% heavy impurities – 0.2% water – 0.05%	complex mixture of hydrocarbons blended to meet product specifications; composition varies and includes C9 to C16 hydrocarbons; common components include hydrodesulfurized kerosene, hydrotreated distillate light, straight run kerosene; functional and performance additives may also be present	mixture of petroleum fractions with boiling point ranges; 98% is distilled at a temperature not higher than 270°C aromatic hydrocarbons 5.0% sulfur 0.01% 4-methyl 2,6 ditertiary butylphenol 0.005 to 0.006% resins 2,0 % dissolved water 0.0006%
Chemical/Physical Characteristics:			
Boiling point	134°C	151°C to 301°C	no information
Melting Point	-62.7°C to -54.5°C	-18°C	no information
Vapor Pressure	no information	0.5 m Hg at 20°C	0.3 mm Hg at 17°C
Vapor Density (air = 1)	no information	4.5	no information
Specific Gravity	0.829	0.80 to 0.81	0.833
Flash point	19°C	38°C PM minimum	61°C
Solubility in Water	no information	insoluble	insoluble
Appearance	colorless clear liquid	colorless to pale straw, or red oily liquid with characteristic odor	colorless transparent liquid with a specific odor of gasoline
Handling & Safety Information:			
Reactivity	highly stable; incompatible with oxidizers, explosives and inflammable substances	stable under normal conditions; incompatible with sources of ignition	inert liquid, explosion hazard
Decomposition/ Combustion products	carbon oxides	carbon oxides	carbon oxides
Hazard classification	Class 3 of danger,[a/] moderately hazardous substances (per GOST 12.1.007-76)	DOT Hazard Class 3 or Combustible Liquid	Low toxic substance, Class 4 (per GOST 12.1.007-76)
Health Hazard Data:			
Exposure limits and effects	toxicity level: max. permissible concentration in production rooms = 5 mg/m^3	NIOSH proposed limit of 100 mg/m^3 for 8 hr.; ACGIH proposed exposure limit of 100 mg/m^3	maximum allowable concentrations of vapors in production rooms = 300 mg/m^3, in populated areas =5 mg/m^3 ; and in water 0.1mg/dm^3.

NOTE: a/ Class 1 GOST is the most dangerous.
Sources:
S. P. Korolev Rocket and Space Corporation Energia, *Certificate of Material Safety Boktan*, Sept. 9, 1999.
S. P. Korolev Rocket and Space Corporation Energia, *Certificate of Material Safety Naphthyl*, Sept. 25, 1997
T.W. Brown Oil Co., Inc., *Material Safety Data Sheet for Kerosene*, www.brownoil.com/msdskerosene.htm, as of February 6, 2001.

The most significant difference between Boktan and kerosene is in chemical classification. Although both hydrocarbons, kerosene is a blend of mainly normal, straight-chain alkanes whereas Boktan is mainly a mixture of cycolalkanes. The ratio of carbon to hydrogen is roughly the same, however. Regarding material stability, both Boktan and kerosene are stable liquids incompatible with sources of ignition or explosion. Hazard classifications for Boktan and kerosene are comparable, although Boktan has a lower exposure limit in occupational settings. The combustion products of the two propellants will be similar (carbon dioxide and possibly carbon monoxide; and the stoichiometric ratios should be relatively similar). Furthermore, emissions would occur at the same altitudes as described in the February 11, 1999, EA.

E.2.2 Effect on Home Port & Marine Operations

It is assumed that Boktan would be handled in the same manner as kerosene is currently handled—i.e., it would not be stored on Home Port property. The Integrated Contingency Plan would have to be updated with a name change (Boktan for kerosene), and any associated Emergency Procedures that may differ than for kerosene would have to be reviewed and documented. Regarding the Operations Manual for the Transfer of Hazardous Materials in Bulk, a name change and any associated emergency procedures that may be different would need to be recorded. Also, Boktan would need to be added to the Annual Emissions Inventory. Finally, Boktan may need to be included in the Risk Management Plan. This may be considered only an update, however, as kerosene has been classified as fuel and Boktan may remain within the same classification.

Appendix F – IUCN and WCMC Listing Status Categories

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APPENDIX F
IUCN AND WCMC LISTING STATUS CATEGORIES

EXTINCT (EX) - A taxon is Extinct when there is no reasonable doubt that the last individual has died.

EXTINCT IN THE WILD (EW) - A taxon is Extinct in the wild when it is known only to survive in cultivation, in captivity or as a naturalized population (or populations) well outside the past range. A taxon is presumed extinct in the wild when exhaustive surveys in known and/or expected habitat, at appropriate times (diurnal, seasonal, annual), throughout its historic range have failed to record an individual. Surveys should be over a time frame appropriate to the taxon's life cycle and life form.

CRITICALLY ENDANGERED (CR) - A taxon is Critically Endangered when it is facing an extremely high risk of extinction in the wild in the immediate future, as defined by any of the criteria (A to E) as described below.

ENDANGERED (EN) - A taxon is Endangered when it is not Critically Endangered but is facing a very high risk of extinction in the wild in the near future, as defined by any of the criteria (A to E) as described below.

VULNERABLE (VU) - A taxon is Vulnerable when it is not Critically Endangered or Endangered but is facing a high risk of extinction in the wild in the medium-term future, as defined by any of the criteria (A to E) as described below.

LOWER RISK (LR) - A taxon is Lower Risk when it has been evaluated, does not satisfy the criteria for any of the categories Critically Endangered, Endangered or Vulnerable. Taxa included in the Lower Risk category can be separated into three subcategories:

1. **Conservation Dependent (cd).** Taxa which are the focus of a continuing taxon-specific or habitat-specific conservation program targeted towards the taxon in question, the cessation of which would result in the taxon qualifying for one of the threatened categories above within a period of five years.
2. **Near Threatened (nt).** Taxa which do not qualify for Conservation Dependent, but which are close to qualifying for Vulnerable.
3. **Least Concern (lc).** Taxa which do not qualify for Conservation Dependent or Near Threatened.

DATA DEFICIENT (DD) A taxon is Data Deficient when there is inadequate information to make a direct, or indirect, assessment of its risk of extinction based on its distribution and/or population status. A taxon in this category may be well studied, and its biology well known, but appropriate data on abundance and/or distribution is lacking. Data Deficient is therefore not a category of threat or Lower Risk. Listing of taxa in this category indicates that more information is required and acknowledges the possibility that future research will show that threatened classification is appropriate. It is important to make positive use of whatever data are available. In many cases great care should be exercised in choosing between DD and threatened status. If the range of a taxon is suspected to be relatively circumscribed, if a considerable period of time has elapsed since the last record of the taxon, threatened status may well be justified.

NOT EVALUATED (NE) A taxon is Not Evaluated when it is has not yet been assessed against the criteria.

USFWS LISTING STATUS CATEGORIES

E -- Endangered
T -- Threatened
EmE -- Emergency Listing, Endangered
EmT -- Emergency Listing Threatened
EXPE, XE -- Experimental Population, Essential
EXPN, XN -- Experimental Population, Non-Essential
SAE, E(S/A) -- Similarity of Appearance to an Endangered Taxon
SAT, T(S/A) -- Similarity of Appearance to a Threatened Taxon
PE -- Proposed Endangered
PT -- Proposed Threatened
PEXPE, PXE -- Proposed Experimental Population, Essential
PEXPN, PXN -- Proposed Experimental Population, Non-Essential
PSAE, PE(S/A) -- Proposed Similarity of Appearance to an Endangered Taxon
PSAT, PT(S/A) -- Proposed Similarity of Appearance to a Threatened Taxon
C -- Candidate Taxon, Ready for Proposal
D3A -- Delisted Taxon, Evidently Extinct
D3B -- Delisted Taxon, Invalid Name in Current Scientific Opinion
D3C -- Delisted Taxon, Recovered
DA -- Delisted Taxon, Amendment of the Act
DM -- Delisted Taxon, Recovered, Being Monitored First Five Years
DO -- Delisted Taxon, Original Commercial Data Erroneous
DP -- Delisted Taxon, Discovered Previously Unknown Additional Populations and/or Habitat
DR -- Delisted Taxon, Taxonomic Revision (Improved Understanding)
AD -- Proposed Delisting
AE -- Proposed Reclassification to Endangered
AT -- Proposed Reclassification to Threatened

Appendix G – Environmental Monitoring and Protection Plan

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Sea Launch Environmental Monitoring and Protection Plan

30 August 1999
Revision No. 1

Prepared for:

Office of Commercial Space Transportation
Federal Aviation Administration
US Department of Transportation

Table of Contents

Appendices

1. Purpose

The Sea Launch Environmental Monitoring and Protection Plan (EMPP) will direct steps to be taken by Sea Launch Company to monitor for significant impacts that could be caused by its operations, assess these monitoring data, and report the results to the government. Over time, the EMPP provides the mechanism for Sea Launch to identify and understand the risks posed by its operations, and to strive to continuously minimize resulting impacts to the environment.

2. U.S. Government Oversight

The EMPP is an integral part of the Launch License granted to Sea Launch by the US Department of Transportation Federal Aviation Administration (FAA). The FAA Launch License authorizes Sea Launch to launch commercial satellites under the jurisdiction of the United States Government. As part of the licensing process, an environmental assessment (EA) was done to determine the possible effects of the launch operation.

In the course of the EA, many actions were identified and taken where feasible to eliminate risks and mitigate impacts due to Sea Launch operations. Those actions are not addressed here. Instead, this EMPP explains how Sea Launch will assess and document the potential impacts that could not be eliminated, and if impacts are observed to occur, initiate actions to minimize or prevent those impacts in the future.

The EMPP covers all launches conducted by Sea Launch under licenses issued by FAA, and it will be reviewed as a part of ongoing FAA license monitoring efforts. It will be updated when changes to Sea Launch operations introduce new risks to the environment, or when prior reasons for concern are eliminated. This version of the EMPP is the first revision to the original, 8 March 1999, EMPP.

FAA may also determine that the EMPP overlooks areas of study needed to adequately understand environmental risks and impacts posed by Sea Launch operations. In this case, changes to the EMPP will be incorporated as a routine part of the FAA licensing process.

The overall objectives of the EMPP are to:

- Cause significant resources that may be jeopardized to be noted, and prompt actions necessary to protect those resources during a launch;
- Document and assess significant impacts to the atmosphere and ocean surface that might occur during a launch; and
- Provide a framework for improving operational procedures and equipment in order to maximize safety.

Under provisions of the launch license process, FAA must approve the EMPP, and Sea Launch is responsible for providing EMPP-generated data to the FAA. The FAA has final responsibility for analyzing the data and initiating any necessary reviews of or changes to Sea Launch operating procedures and equipment based on these data.

3. Monitoring and Protection Approach and Plan

Environmental monitoring is normally done in geographical areas that are at risk of being critically altered or damaged as a result of a human activity. If monitoring is properly planned and carried out, the resulting data will serve to validate, update or challenge assumptions and design decisions made during the activity's planning and government approval process.

In this manner, the nature of Sea Launch operations and the environment was considered in formulating the EMPP to detect and assess possible impacts from Sea Launch operations at sea. The resulting plan prescribes monitoring immediately prior to and after each launch in the general vicinity of the launch location. More specifically, the timeframe of greatest interest is during rocket propellant loading, ignition and initial flight. This encompasses the area and time of greatest risk from potential accidents during operations and from the sound and heat released during a launch. This is shown on figures in the appendix for the first launch location at 154° longitude on the equator, southeast of Kiritimati, Republic of Kiribati.

Given the scale of the environment relative to the Sea Launch operation, the EMPP for the first launch is designed to detect the most likely evidence of potential impacts that might be there, and to do this as effectively as possible. This factor led to the identification of four elements (see box), which collectively focus on the greatest risks of impact from operations. As the EMPP is implemented during the first and subsequent launches, data will allow consideration of revisions to the EMPP to address positive indications of risk and impact, or to refocus monitoring efforts in more productive ways.

Following this approach, therefore, four independent EMPP elements are planned.

Element	Specific objective
Wildlife detection and impact determination	Document and minimize risk to wildlife
Atmosphere disruption and recovery analysis	Record physical effects on atmosphere due to rocket ascent
Surface water sampling and impact detection	Assess extent of kerosene release
Notices to local mariners	Ensure adequate notice is given before launch

The first three elements focus on environmental resources, while the fourth concerns public safety. EMPP monitoring (Elements 1, 2 and 3) begins after the Launch Platform reaches ballasted position, i.e., is semi-submerged for launch, and ends after a successful launch or securing following an abort decision. The baseline plan assumes a successful launch, but allows for possible impacts that might occur during a failed launch. Each element is reviewed in general below and in detail in the appendix.

3.1 Visual observations for species of concern at launch location

Presence or absence of wildlife in the general vicinity of the Launch Platform (LP) will be documented based on visual observations made during daylight hours from the bridges of the Assembly and Command Ship (ACS) and the LP (when manned). Species of general interest are mammals (pinnipeds and cetaceans), sea birds, reptiles (turtles), and fish of commercial interest, while those that are considered to be endangered or threatened are of particular importance (appendix I.3). Training and/or the review of self-instruction materials on the identification of species of concern is held before arrival at the launch site. Sea Launch is presently exploring the possibility of contracting with a Kiribati-based organization to produce additional training materials to help identify species of concern.

Although the area within visual range in all directions will be surveyed and documented, the area within 100 meters or so of the LP stern is of particular concern (appendix I.2). Observations will be logged onto a standard form (appendix I.4) and compiled after the launch mission for analysis and reporting to FAA. Sea Launch is presently exploring the possibility of mounting fixed closed-circuit cameras to monitor the 100 meter area better. Options include mounting the cameras on the LP as well as deploying buoys with mounted cameras. If this approach is found to be feasible and cost-effective, it will be employed at a later date.

3.2 Remote detection of atmospheric effects during ascent

The ACS is outfitted with state-of-the-art weather radar equipment for monitoring atmospheric processes to ensure safe weather conditions prior to a launch. This resource will be use to capture available data on the ascent plume trace to record, to the extent detectable, the disruption and rate of recovery of the atmosphere during ascent (appendix II.2). Basic equipment specifications are provided (appendix II.3) to acquaint potential users of equipment and data parameters. Optical tracking video recordings of the launch will also be archived to augment the study of radar digital data.

This equipment has never been applied to the study of exhaust plumes. As such, it is unclear to what extent the captured radar digital and video data resolutions will support the objectives of characterizing rocket exhaust plume effects. Sea Launch will, however, utilize its capabilities to attempt to detect and measure the ascent plume. Collected data will be archived and made available through FAA for basic research in this area.

3.3 Surface water sampling to detect possible launch effects

Surface water samples will be collected by hand from a small craft in open waters and in a down-current direction from the Launch Platform (appendix III.2). The 'background samples will provide baseline data on the ocean surface water, and the 'down-current' samples will indicate the presence or absence of kerosene pollutants that could conceivably be lost to the ocean during rocket propellant loading and launch.

As soon as safely possible after the launch nine samples will be taken in a rectangular grid downstream of the LP. The down current samples will be collected after calculating the current drift and wind conditions at launch time so as to ensure the water sampled represents the maximum exposure to contaminants. Samples will only be analyzed for Kerosene hydrocarbons, i.e., of all materials and operations onboard the Launch Platform, only a release of Kerosene would be a concern. It should be noted, however, that tests confirm propellant loading equipment performs without leaking, and that these tests are planned for each launch.

Sea Launch is presently exploring the possibility of deploying automatic sampling devices attached to buoys which can be trailed in the water during launch time. If this approach is found to be feasible and cost-effective, it will be employed at a later date as a substitute for the hand sampling method.

Sample collection, handling, labeling, preservation, chain-of-custody, and analysis methods follow accepted scientific standards and are provided in appendix III. Evidence of pollution from launch operations will prompt Sea Launch to study the cause of Kerosene loss, its possible impact, and corrective measures.

3.4 Notices to Local Mariners

Notices to mariners are routinely broadcast prior to launches from the United States to vessels with an INMARSAT-C transceiver or HF band receiver. As this coverage is not guaranteed to reach mariners in the vicinity and east of 154° longitude on the equator, notices will be augmented with an additional, standard message (appendix IV.2) to affected parties. Distribution and posting of this message, in hard copy by fax, will be coordinated with Kiribati government and regional authorities and sport boat and fishing fleet operators (appendix IV.3 and IV.4). Messages will contain an internet address for interested parties to check for up-to-date information about each launch.

4. Plan Implementation Guidelines

At all times in the performance of the EMPP, safety of personnel is the first priority. In this regard, tasks required for Elements 2 and 3 shall be approved as part of routine Operations scheduling with regard to safety. Any condition, e.g., sea state, weather, visibility, or conflicting activities, that potentially creates an unsafe situation for EMPP personnel, is justification for modifying, delaying, or canceling the EMPP activity. If this occurs, the EMPP team will document as part of its record the conditions and decisions that caused EMPP implementation to be interrupted.

5. Report to FAA

Sea Launch will compile, evaluate, summarize and report on the data collected during EMPP implementation. The report to FAA will provide a brief description of the implementation activity - particularly as it deviates from the plan. The report will also include data summaries, the approaches used in evaluating the data and the basis for conclusions where appropriate, and the raw data in appendices. Following FAA review, EMPP results will be made available to the public; accordingly, the report submitted to FAA by Sea Launch will be suitable for the general public in terms of completeness, format and style of writing.

Appendix I.1

<u>Protocol - Visual observation for species of concern at launch location</u>

The following outlines study parameters. See appendix I.5 for operations procedure.

Duration and area of study:	While LP is in semi-submerged position. Visual distance from bridges of ACS and LP (when manned). Area of special concern is within 100 meters or so of LP (appendix I.2).
Observer and location:	Duty Officers on ACS and LP bridges.
Regimen:	Continuous observation during daylight hours, with notations made at least hourly of wildlife sightings or the lack of sightings.
Record keeping:	Notations made by Bridge officers (appendix I.4).

Wildlife taxonomy (species of special concern listed in appendix I.3); more generally:

- Mammals (Cetaceans, Pinnipeds)
- Sea turtles
- Sea birds
- Commercial fish

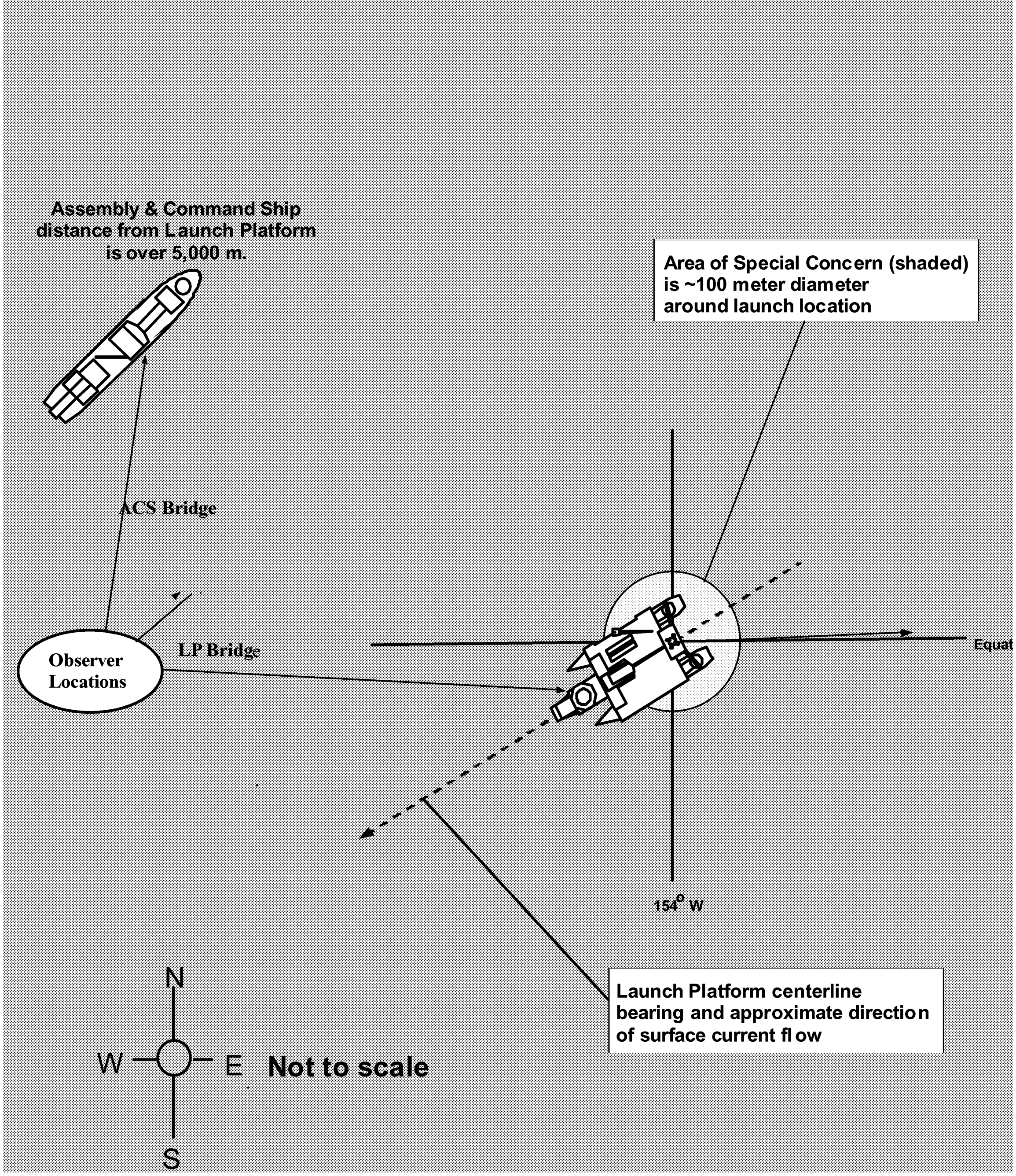
Record as can be determined (field guides and basic training provided to observers):

- Type and number of individuals observed
- Specie, sex and age of individuals
- Proximity to and duration in observation area
- Behavior, bearing, speed
- Behavior possibly caused by operations

Records and reporting:	Observers will retain Record sheets for collection by the Safety/Security Coordinator. The Director, Safety and Mission Assurance, will compile and analyze the record for incorporation in the report submitted to FAA.

Appendix I.2

Figure 1 Plan for Visual Observations for Species of Concern



Appendix I.3

Species of Concern[1]

The following species are listed as Threatened or Endangered by the United States and are known to occur in the equatorial Pacific Ocean region.

Whales:
Endangered - Whale, blue (*Balaenoptera musculus*)
Endangered - Whale, bowhead (*Balaena mysticetus*)
Endangered - Whale, finback (*Balaenoptera physalus*)
Endangered - Whale, humpback (*Megaptera novaeangliae*)
Endangered - Whale, right (*Balaena glacialis* (incl. *Australis*))
Endangered - Whale, Sei (*Balaenoptera borealis*)
Endangered - Whale, sperm (*Physeter macrocephalus* (=*catodon*))

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

Sea Turtles:
Endangered - Turtle, green sea (*Chelonia mydas*) (East coast Florida and West coast Mexico only)
Threatened - Turtle, green sea (*Chelonia mydas*)
Endangered - Turtle, hawksbill sea (*Eretmochelys imbricata*)
Endangered - 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*)

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

Appendix I.4

Sea Launch Environmental Monitoring and Protection Plan
Wildlife Sighting Record

Date (d/m/y): ________________
Observer: ________________
Observer location (circle one): ACS LP
Weather/Sea Conditions: __________

Key for Record Entries

General Type: Mammal, Reptile, Seabird, Fish
Location: Bearing/distance from LP
Ex. of behavior: Direction and speed of travel
Breaching frequency
Grouping and pairing
Interaction between individuals
Response to SL operations

Use new row for each type of wildlife (M, R, S, or F) sighted.

Observer Initials	Time (24hr)	General Type and Number if in group	Location of Wildlife	Genus Specie(s) if identifiable	Behavior and other conditions to note

Retain completed Record for collection after return to Home Port.

Appendix I.5

Operations Procedure for Wildlife Observations

<u>Background</u>

1. Monitoring is to be performed during daylight hours while the Launch Platform is in the semi-submerged launch position.

2. Area to be surveyed is that observable by eye in all directions; binoculars are to be used when necessary to confirm sightings or determine species, etc.

<u>Monitoring by Duty Officers on LP bridge and ACS bridge</u>

Standard practice: Each hour on the hour, observers stationed on the bridge of each vessel are to survey the water surface and sky, and record the <u>presence or absence</u> of wildlife observed in as much detail as possible.

Exception: Any time any wildlife is observed, the observer is to record its presence in as much detail as possible.

Custody of records

The observers on the LP bridge and ACS bridge are to keep their complete records of observations in secure locations on each bridge as part of the ship's log during the monitoring period until turned over to the Safety/Security Coordinator following the monitoring period.

Upon return to Home Port, the Safety/Security Coordinator will provide the records to the Director, Safety and Mission Assurance, for assignment to staff for the purpose of analysis and incorporation into an EMPP report for FAA.

Appendix II.1

Protocol - Remote detection of atmospheric effects during ascent

The following outlines study parameters and operations procedure.

Area of study:	Ascent plume trace as scanned by radar equipment and recorded by video equipment (appendix II.2).
Method:	Activities will be scheduled as a part of operations. 1. Pre-programmed weather radar scan by ship Meteorologist bracketing launch. 2. Optical tracking video of launch ascent
Radar scan duration:	L-30 through L-15 minutes (background) L+0 through L+ 15 minutes (ascent trace)
Record keeping:	1. Digital files generated by radar system 2. Optical tracking video copy
Data analysis:	Radar and video data will be used to determine - to the extent possible - the magnitude and duration of the ascent plume. The data will be examined against the weather radar equation relating received power to range and cloud reflectivity. Analysis will involve graphing the signal level verses altitude in order to characterize particulate presence[2].
Reporting:	The Safety/Security Coordinator will retain stored data and video copies following launch operations. Upon return to Home Port, the Safety/Security Coordinator will provide the records to the Director, Safety and Mission Assurance, for assignment to the Mission Operations meteorologist for the purpose of analysis and incorporation into an EMPP report for FAA.

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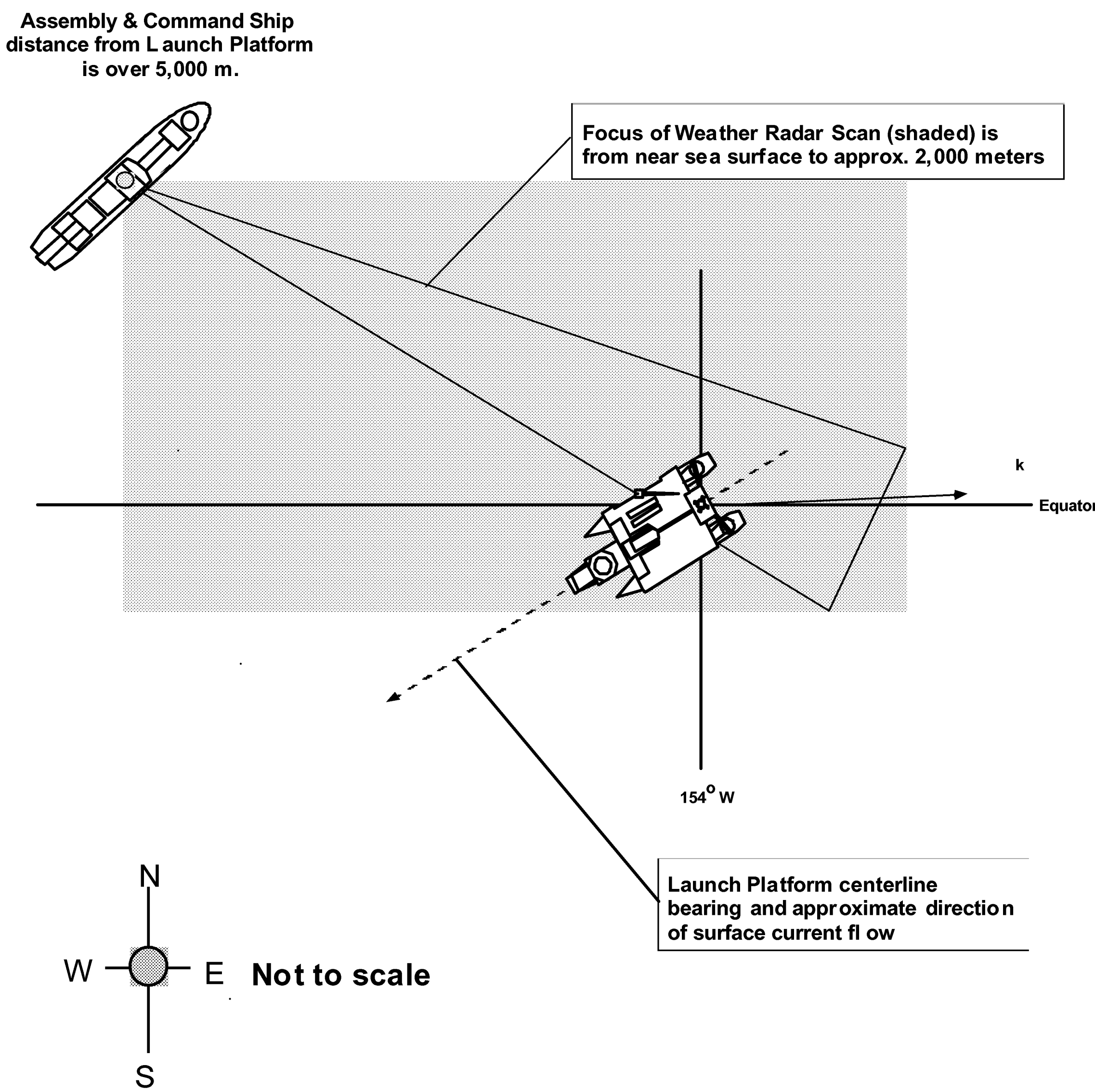
[2] *The Use of Aviation Weather Radars for In Situ Measurements of Contrail Cirrus*, Tank and Thomas, Boeing Co. Seattle Washington, 33rd Aerospace Sciences Conference January 9-12, 1995. Reno, Nevada, AIAA publication 95-0542.

Appendix II.2

Figure 2 Plan for Remote Detection of Plume Effects



Appendix II.3

Sea Launch Command Ship Weather Radar System

Introduction

The Sea Launch command ship represents a unique source of meteorological data that are collected and archived during the periods it is on location for a launch. In general, the ship will be operating a C-Band Doppler Weather Radar using a stabilized antenna, an ocean Wave Radar, and an upper air rawinsonde balloon soundings in support of launch operations.

As part of the EMPP, meteorological data from the Weather Radar will be used to document the physical response in the atmosphere following the ascent of the rocket. It is expected that there are limits in the level of resolution available from the equipment, however, analysis of these data may further the launch industry's basic understanding of atmospheric physical processes during a launch, and help gauge the effect of the Sea launch rocket on the atmosphere.

The archived records, coupled with video recordings, also represent a potentially important data set to researchers interested in the meteorology of an oceanic equatorial location. Accordingly, the raw meteorological data generated by Sea Launch Company will be made available to support these basic research interests. With that in mind, the following general descriptions of the Sea Launch meteorological equipment are provided for consideration by researchers interested in using archived data.

The C-Band Doppler Weather Radar System Specifications

The mission of the weather radar systems is to scan the area around the launch site out to a distance of about 320 km (170 nmi). The weather radar provides continuous, alarmed, threshold assessment of critical launch commit criteria such as lightning potential, rain, storm, and freezing level, and cloud threat extrapolation.

The system utilizes a commercial radar system (i.e., Kavouras 3070-C radar). This consists of a 3 meter offset feed pencil beam antenna, 7.5kW peak power fully coherent Travelling Wave Tube (TWT) transmitter, receiver, and signal processor. This is integrated with a Sigmet RCP-02 antenna controller, a Seapath 200 INU system, and two HP workstations. Key component specifications are listed in Tables II.1 and II.2.

Table II.1 Transmitter/Receiver Subsystem Specifications

Peak Power	7500 watts
Max Average Power	135 watts
Pulse Width	2.5 µs, 5 µs, 10 µs or 20 µs
Dynamic Range	105 dB
PRF	200 to 3000 Hz

Table II.2 Antenna Parameters

Beam Width	1.3 degrees
Gain	42 Db
Side Lobes	-35 dBc (typical)
Azimuth Speed	0 to 6 RPM
Elevation Speed	0 to 6 RPM

Wave Radar

The wave radar system (MIROS brand) is an advanced microwave sensor specially designed for real time measurements of directional ocean wave spectra and surface current. The wave radar sensor outputs processed directional wave-spectra over a digital serial interface or network. The wave radar is operated and maintained as part of the marine segment on the ACS. The wave data is collected and analyzed by the loads measurement system and passed on to the weather measurement and reporting system for further analysis and forecasting. The main functions of the wave radar are to:

- Collect sea surface information from the back-scattered radar signal
- Process the back-scattered signals into wave and current time-series
- Perform power spectrum analysis
- Estimate surface current components
- Calculate wave spectrum parameters
- Calculate integrated wave parameters (significant wave-height, wave period, wave direction, etc.)
- Estimate surface current vector (current speed and direction)
- Perform real-time data quality control
- Generate and transmit data on a serial output format (MIROS DF-005/WR)

The wave radar uses active microwave remote sensing techniques to collect sea state data, i.e., surface wave and current information from the ocean surface. The radar is designed to operate unattended. When the main power is turned on, the system software is automatically transferred from the hard disk into the working memory. The software initializes the sensor hardware and starts data collection. Each of the six horns of the antenna array covers a 30 degrees sector. Raw data are collected as 128 second time-series (256 samples) in each direction. During a complete directional scan, data are collected from all six directions covering 180 degrees included angle. One complete scan takes about 15-16 minutes, dependent on the speed of the CPU. Note that although data are available on the serial data output every minute, the wave and current estimates are updated only after each scan. Table II.3 shows the wave radar performance specifications:

Table II.3 MIROS Wave Radar Performance Specifications

Waves	Height	0.2-20 m +/-5 %
	Period	3-30 s +/-5%
	Direction	0 to 360 deg +/- 7 deg
Current	Speed	0 to 2.5 m/s +/- cm/s
	Direction	0 to 360 +/- 7 deg
Wave Directional Spectra	Frequency Resolution	0.078125 Hz
	Frequency Range	0.3125 Hz
	Directional Resolution	30 deg (nominal)
	Directional Range	0 to 360 deg (unambiguous)

Rawinsonde Balloon System

Upper air conditions are critical to launch vehicle loads and controllability. Commit criteria have been established for wind speed and direction and wind shear. Upper air conditions are measured at least five times during the L-48 hour countdown leading to launch and once after launch for post-launch analysis. These same upper air soundings would be useful in verifying global prediction models as a source of "truth" data for the oceanic equatorial region where presently such data exists. Sea Launch will provide a backup processor for analyzing data collected from the balloon system on the ACS. Key specifications are listed in Table II.4.

Table II.4 Rawinsonde Component Specifications

Parameter	Range	Accuracy
Pressure	1060 to 3 hPa	0.1 hPa
Temperature	+60 to –90 C	0.1 C
Humidity	0 to 100% RH	1% RH
Wind Speed	0 to 180 m/s	0.1m/s
Wind Direction	0 to 360 deg	1 deg

Wind Vector Accuracy	--	0.5-0.2 m/s (GPS)

Appendix III.1

Protocol - Surface water sampling to detect possible launch effects

The following outlines study parameters. See appendix III.3 for procedure.

Area of study: Sampling stations positioned relative to Launch Platform (appendix III.2).

Method: Discrete sampling of surface waters in prepared glass bottles by hand from small craft as LP is re-entered; three background samples and nine down-current samples; exact times to be determined and recorded by Operations team, after considering personnel safety and calculating the current set and drift at the time of launch. The three background samples are to be collected at an up-current location from the LP The nine down-current samples are to be collected in a rectangular grid . Each sample should be collected from a location at least 20 meters from the others.

Sample preservation: One litre glass bottles, with small airspace, capped and held under custody control in a ship refrigerator.

Analysis parameters: EPA Method 8015B, Nonhalogenated Organics using Gas Chromatograph/Flame Ionization Detector

Data analysis: Results of EPA method 8015B to be evaluated and reported by the analytical laboratory, and evaluated and summarized in report to FAA by Director, Safety and Mission Assurance staff.

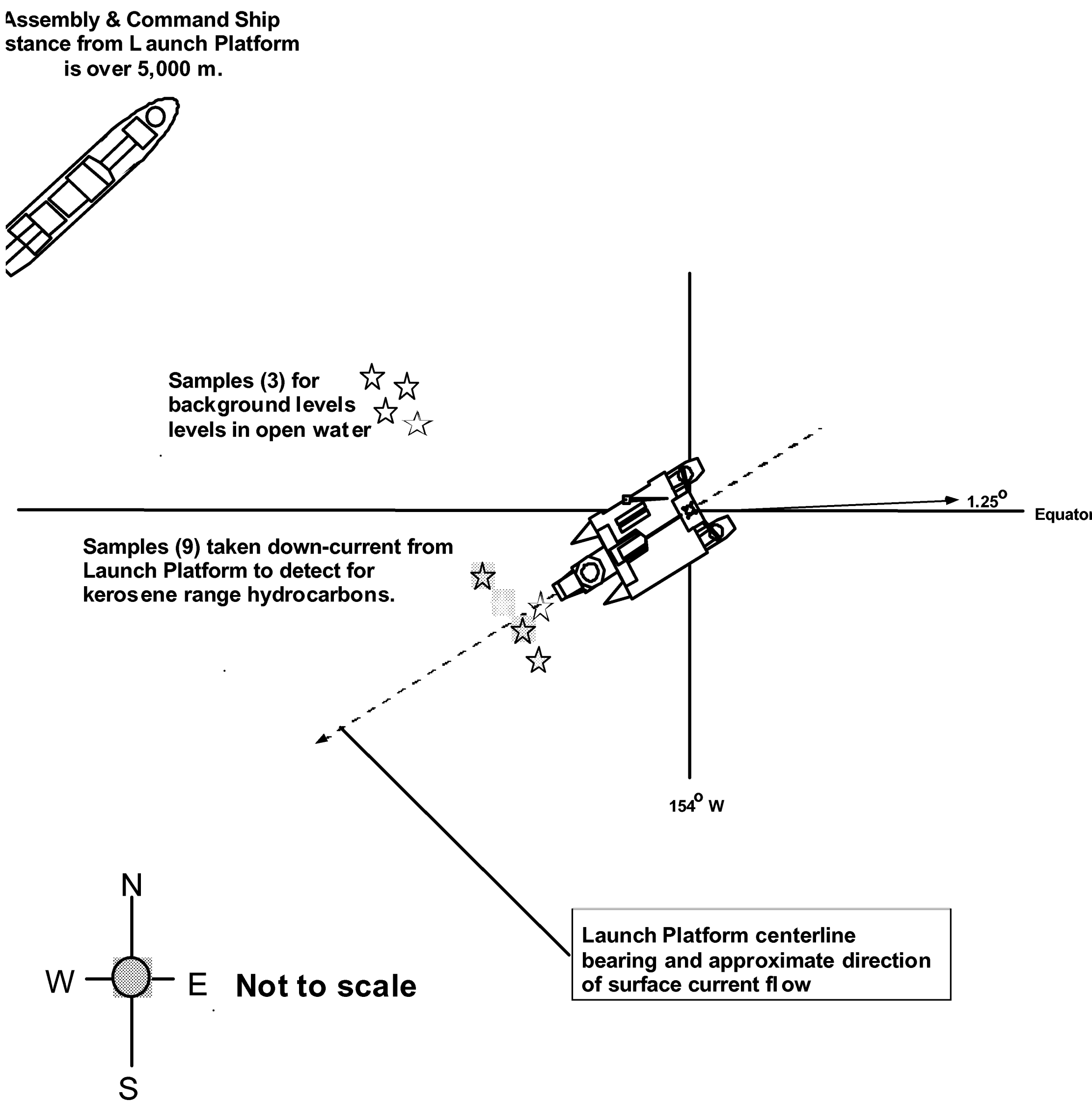
Supplies:
12 - 1 liter bottles, pre-labeled
screw caps with TFE-fluorocarbon liners
labels, tape, and marker pens
cooler container for bottles/supplies
sampling record and custody form

Sample, record, and data custody: The following custody sequence will be maintained

- Sample bottles in cooler maintained by Safety/Security Coordinator
- Sea Launch Safety/Security Coordinator during sampling and when stored at-sea
- Director, Safety and Mission Assurance when at Home Port
- Contract laboratory during analysis
- Director, Safety and Mission Assurance to retain laboratory results and incorporate results in report to FAA

Appendix III.2

Figure 3 Plan for Surface Water Sampling



Appendix

Sea Launch Environmental Monitoring and Protection Plan
Sampling Record

Weather/Sea Conditions:

Directions for taking and maintaining surface water samples:

1. Jars, lids, liners and labels are prepared in advance; coordinate with to take 3 samples away from ACS and LP and 9 samples down-
2. Gradually submerged jar, allowing surface water layer to flow into contamination from small craft boat
3. Leave small airspace in jar; secure lid; return jar
4. After return to ACS, apply tape seal to cooler lid and sign for
5. Place in refrigerator; guard against
6. At Home Port, transfer custody to Director, Safety and Mission

Background Samples

Date taken: Time taken

Location:

Sample Numbers	Samples labeled and signed?
1, 2, and 3.	Yes No

Down-Current Samples

Date taken: Time taken

Location:

Sample Numbers	Samples labeled and signed?
4 through	Yes No

SAMPLE CUSTODY ON

Transferred from sample

____

Transfer date:

Transfer time (UTC):

Stored on ACS in galley fridge

Fridge unit temp.:

Samples Chain of Custody Record

Date	Fro	To	Purpos

Appendix IV.1

Protocol - Notices to Local Mariners

The following outlines the parameters for this activity. See appendix IV.3 for procedure.

Area of applicability:	Vessels in general vicinity of 154° on equator and points east.
Methods:	For vessels with INMARSAT-C transceiver: Messages will be broadcast using US Government protocols via INMARSAT-C, POR (Pacific Ocean Region) satellite on Safety Net channel at 10:00-10:30 and 22:00-22:30 GMT each day starting 5 days prior to each launch. This standard US Government method is not expected to reliably alert vessels in the Christmas Island area. The message is also broadcast on frequencies in the HF band by U.S. Coast Guard, Honolulu, however, this is not expected to reliably extend to the Christmas Island area. For vessels without receiving equipment: Standard message (appendix IV.2) will be delivered in hard copy by fax to points-of-contact (appendix IV.4) who will ensure distribution to: • Christmas Island local authorities and tour boat operators for posting and distribution; • The Ministry of Information, Communication and Transport (MICT) for posting; and • The operators of regional fishing fleets at their headquarters, e.g., national and industry operators
Record keeping:	Record of notices made will be maintained by Sea Launch and provided in the report submitted to FAA.

Appendix IV.2

Sample Notice to Local Mariners

Date March 13,

To: Hon. Tiim Taekiti, PS David
Ministry of Line and Phoenix
Republic of

Subject Notice to Mariners of Planned Rocket

From Sea Launch Range
2700 Nimitz
Long ch, CA
562-951-7000, Ext. 2003 or 562-951-

This communication is to inform you of the planned launch of a rocket by Sea location 240 NM Southeast of Christmas Island, Republic

Location Launch Platform sey"0°, 00`N, °, 00`W.

Date: 26 March

Time: 22:14 – 02:14 (27 March GMT

In the interest of safety, vessels are advised to stay clear of areas bounded

0°, 10`N –°, 10`S ; 15°, 20`W - °, 20`W

0°, 00`N –°, 20`N ; °, 01`W - °, 29`W

0°, 03`S –°, 30`N ; °, 57`W - °, 41`W

0°, 27`N –°, 77`N ; °, 00`W - °, 56`W

Please provide this information to vessel operators within your area of general vicinity of these four

Please contact Sea Launch **562-951-7000** or**562-951-** if you have any

Thank ,

Rick
Range
Sea Launch
Boeing Commercial Space

Appendix IV.2

Sample Notice to Local Mariners (continued)

0°, 10`N** **0°, 10`N
154°, 20`W** **153°, 20`W

Initial launch ascent area

0°, 10`S** **0°, 10`S
154°, 20`W** **153°, 20`W

0°, 20`N** **0°, 20`N
147°, 01`W** **146°, 29`W

Stage 1 impact area

0°, 0`N** **0°, 0`N
147°, 01`W** **146°, 29`W

0°, 30`N** **0°, 30`N
145°, 57`W** **144°, 41`W

Payload fairing impact area

0°, 03`S** **0°, 03`S
145°, 57`W** **144°, 41`W

0°, 77`N** **0°, 77`N
114°, 00`W** **111°, 56`W

Stage 2 impact area

0°, 27`N** **0°, 27`N
114°, 00`W** **111°, 56`W

Appendix IV.3

Operations Procedure for Notices to Local Mariners

Background

Prior notice of a launch is to be distributed by facsimile to the organizations listed in Appendix IV.4. Each organization, in turn, is responsible for communicating the same or similar notice to their community or members by any means they choose. The notice is to be provided to each organization several weeks prior to a planned launch.

Notice Distribution

The list for notice distribution is provided on Appendix IV.4, which is formatted to serve as the Sea Launch record of notices made prior to a launch. The Range Coordinator will ensure broadcast of the notice to organizations on this list. Notice receipt is considered confirmed by a prior phone call made to the office to confirm the accuracy of the facsimile number to be used, and by the record of successful facsimile transmission.

Appendix IV.4

Record of Notice Distribution

Mission Name: Scheduled launch date:

Organization to be notified	**Fax number; date number confirmed**	**Notifications Made (date and initials)**
Hon. Willie Tokataake, PS Taakei Taoaba Ministry of Information, Communications and Transport Republic of Kiribati	Ph. 686-26003 or 26435 Fx 686-26193 5 Mar 99	
Hon. Tiim Taekiti, PS David Yeeting Ministry of Line and Phoenix Development Republic of Kiribati	Ph 686-81212 Fx 686-81278 5 Mar 99	
South Pacific Regional Envir. Programme C/O Mr. Tamari'i Tutangata, Director PO Box 240 Apia, Western Samoa	Ph. 685-21929 Fx 685-20231 2 Mar 99	
South Pacific Forum Fisheries Agency C/O Ms. N. Barbara Hanchard, Director PO Box 629 Honiara, Solomon Islands	Ph 677-22214 Fx 677-23995 2 Mar 99	
United States Tuna Foundation C/O Mr. David Burney One Tuna Lane San Diego, VA 92101	Ph 619-233-6407 Fx 619-233-8336 2 Mar 99	
Inter-American Tropical Tuna Commission C/O Dr. Jim Joseph, Director 8604 LaJolla Shores Drive LaJolla, CA 92037	Ph 619-546-7100 Fx 619-546-7133 2 Mar 99	
Mr. Shingo Ota, First Secretary Office of the Fisheries Attache Ministry of Agriculture, Forestry and Fisheries Embassy of Japan 2520 Massachusetts Avenue, N.W. Washington, D.C. 20008	Ph 202-238-6727 Fx 202-265-9473 2 Mar 99	
Mr. Jung You, First Secretary Ministry of Fisheries Embassy of Korea 2450 Massachusetts Avenue, N.W. Washington, D.C. 20008	Ph 202-939-5676 Fx 202-387-0402 2 Mar 99	
Dr. Jack Chen, Exec. Assistant to the Director Economic Division Taipei Economic and Cultural Office in the US 4201 Wisconsin Avenue, N.W. Washington, D.C. 20016	Ph 202-686-6400 Fx 202-363-6294 2 Mar 99	