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.

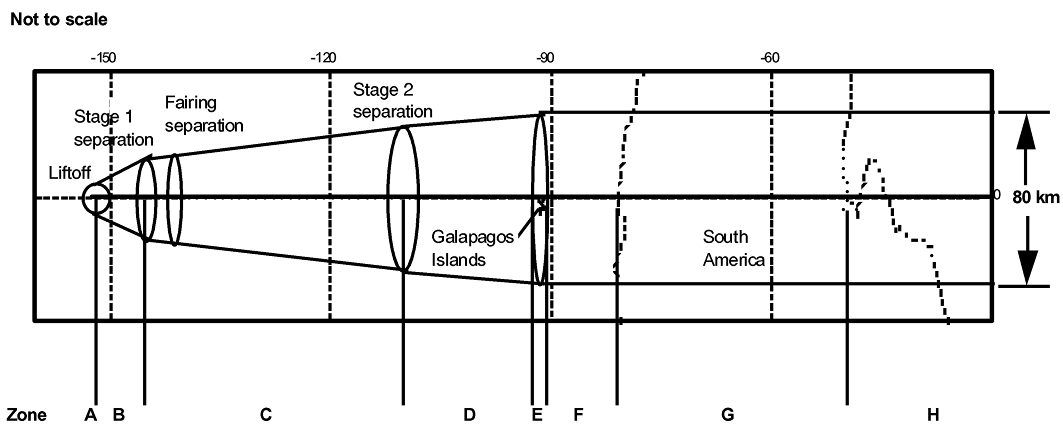

Figure 4.3.2-1. Flight Zones

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.

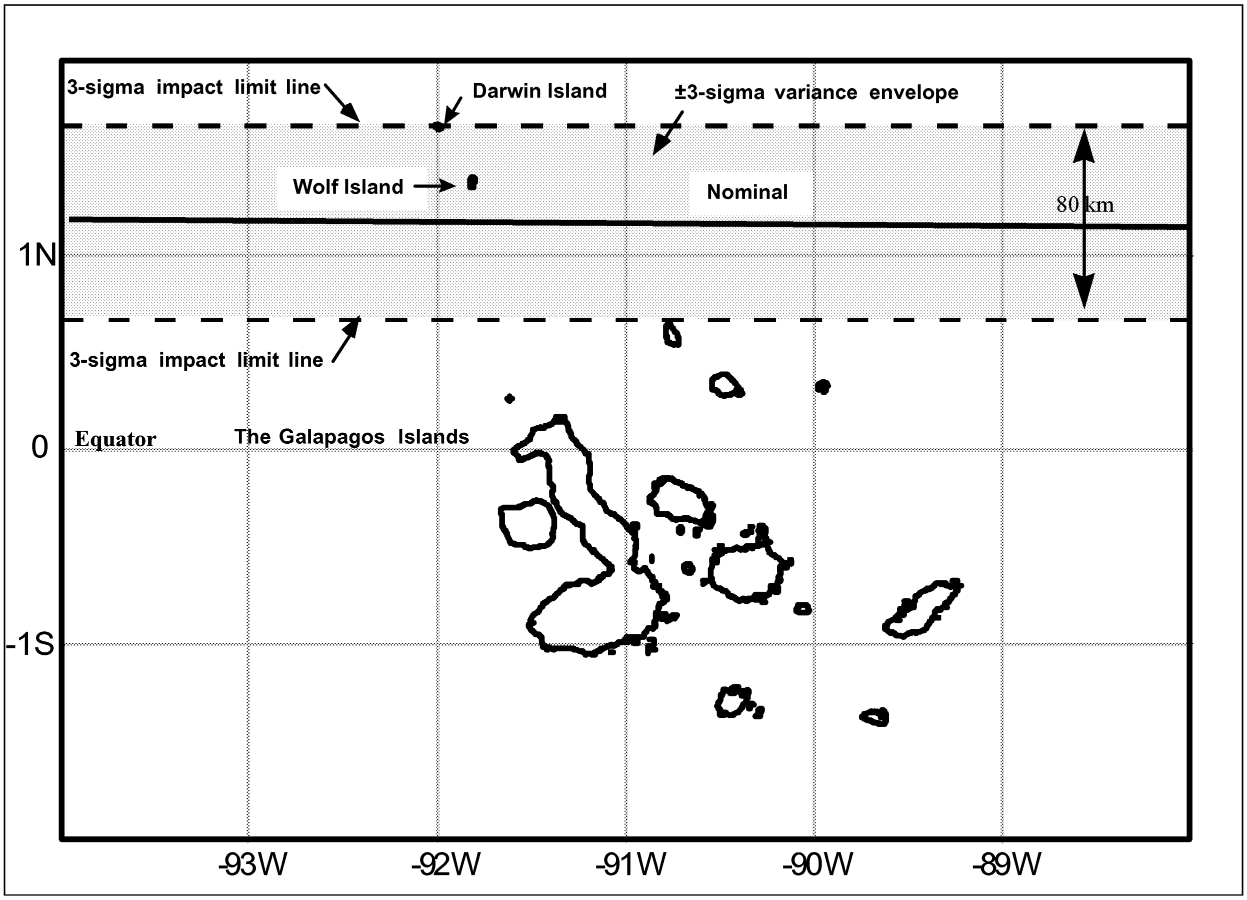

Figure 4.3.4-1. Galapagos Area Overflight

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

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