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

VOLUME 2: COMMENT RESPONSE DOCUMENT FOR THE 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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EXECUTIVE SUMMARY

In accordance with Executive Order (E.O.) 12114 on the Environmental Effects Abroad of Major Federal Actions, the implementation of which is guided by the National Environmental Policy Act (NEPA), 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) the Federal Aviation Administration (FAA) initiated a 30-day public review and comment period for the Draft Environmental Assessment for a Launch Operator License (LOL) for Sea Launch Limited Partnership (SLLP). The need for the 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 the 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 LOL would allow SLLP to conduct up to eight launches per year for five years, for a maximum of 40 launches. The LOL would allow SLLP to launch on exact equatorial azimuths (e.g., 90^{o}), which are optimal for GSO launches in terms of fuel efficiency, payload weight, and satellite life span.

Two sets of comments were received regarding the Draft Environmental Assessment during the public comment period. These comments were categorized into two groups of submitters: Government Agencies and Industrial Organizations. Specific comments were received from the following government agency: U.S. Air Force (AXFV). Additional comments were received from the Aerospace Corporation.

The comments were further categorized by subject matter and were each coded into one of the following topic areas: Safety, Debris, Noise, Miscellaneous, and Editorial. To facilitate the organization of the comments, an index was developed that grouped the comments by topic area only. The Table of Contents cross-references the Index for quick reference to responses by topic area. Appendix A provides statistics on the characteristics of comments received during this process.

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FOREWORD

This volume of the Environmental Assessment for a Launch Operator License for Sea Launch Limited Partnership is divided into two sections based on the source of the comment. Each comment is addressed individually. The text provided by the commentor was not altered to correct for grammatical or spelling errors.

Due to the composite nature of this document a Table of Contents and an Index are included to enhance readability. Each comment was analyzed to determine the key topic addressed. Section number, comment number, and subject matter reference each comment in the Table of Contents, Responses, and Index.

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TABLE OF CONTENTS

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GOVERNMENT AGENCIES

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1.0 Ted Krawczyk – U.S. Air Force AXFV

1.1 Comment 1 [Miscellaneous]

Draft EA addresses proposed issuance of a launch- specific license for the Launch of a GalxyIIIC payload in addition to LOL's. No comment found relating to the Galaxy IIIC PAYLOAD in the Draft EA.

FAA Response 1: The commentor correctly states that the Draft LOL EA addresses the issuance of a launch specific license for the Galaxy IIIC launch in addition to addressing the impacts of launches licensed under the proposed LOL. For environmental review purposes, the specified classes of payload were generally defined in Chapter 2 of the Draft EA, "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." The FAA also conducts a payload review as a separate part of the licensing determination.

1.2 Comment 2 [Debris]

Precludes that all debris would sink immediately which is not necessarily true. Some debris may hover at some depths depending on weight and surface area.

FAA Response 2: The Draft LOL EA assumes that, with the exception of the fairing pieces, the vast majority of all debris will begin to sink soon after impacting the ocean surface. The Draft LOL EA explains that based upon the launch industry's experience, "[t]he 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." (Draft EA Section 4.1.1.2; see also Section 4.1.3.4, [the 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."]) In addition, the February 11, 1999 EA referenced in the Draft LOL EA states that the payload fairing could "float at or below the surface (of the ocean) for a number of years and drift under the effects of local current and winds." This assessment of the disposal of the fairing is expected to be the same for launches conducted under the LOL.

1.3 Comment 3 [Editorial]

Why wasn't this EA supplemented to the February 1999 EA?

FAA Response 3: A supplemental Environmental Assessment was not prepared because the proposed action for this project (i.e., the issuance of a multi-year, multi-launch operator license) is not simply an extension of an existing Sea Launch launch-specific license but rather a separate Launch Operator License which approves a number of launches over a period of time within a set of specified parameters. This is not the same as a single launch license and therefore FAA determined that it should have separate NEPA evaluation.

1.4 Comment 4 [Miscellaneous]

Mentions that this EA addresses a larger payload fairing…. Where? Is this on the Galaxy IIIC?

FAA Response 4: Page 2-5 of the Draft LOL EA states: "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)." Following issuance of an LOL or a launch-specific license for the Galaxy IIIC mission, SLLP would be permitted to use the 5.0-meter fairing for subsequent launches approved by FAA under the LOL or Galaxy IIIC launch-specific license.

1.5 Comment 5 [Debris]

Makes no mention of De-Orbiting Debris

FAA Response 5: While it is possible that orbital debris could re-enter the Earth's atmosphere, the likely impact would be insignificant. The FAA does require that license applicants demonstrate certain safety measures in order to receive a launch license. While these launch plan features are not required for environmental purposes, the requirement can have a beneficial mitigating effect. In order to obtain a license SLLP is required to comply with all applicable FAA licensing regulations including 14 CFR Part 415.39 Safety at the end of launch, which states in part that for all launch vehicle stages or components that reach earth orbit –

(a) there will be no unplanned physical contact between the vehicle or its components and the payload after payload separation;

(b) debris generation will not result from the conversion of energy sources into energy that fragments the vehicle or its components. Energy sources include chemical, pressure, and kinetic energy; and

(c) stored energy will be removed by depleting residual fuel and leaving all fuel line valves open, venting any pressurized system, leaving all batteries in a permanent discharge state, an removing any remaining source of stored energy. Other equivalent procedures may be approved in the course of the licensing process.

Efforts to reduce the amount of orbital debris have both safety and environmental benefits.

1.6 Comment 6 [Noise]

EA does not sufficiently comment about sonic booms in the various stages of reentry in the event of malfunction in those various stages as well as the under water sound propagation at lower db levels.

FAA Response 6: The ballistic return to Earth of stages I and II, whether during a nominal launch or as a result of a malfunction, could result in sonic booms; however, because these are isolated occurrences they are not expected to create a significant impact. Regarding sonic boom propagation under water, page 4-10 of the SLLP LOL EA indicates that there are no significant adverse effects expected from sonic booms to marine animals from flight of the Zenit-3SL. This is because of the low population density of marine animals in the sonic boom footprint and the attenuating effect of the air-water interface that partially absorbs the noise.

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INDUSTRIAL ORGANIZATION

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2.0 Aerospace Corporation

2.1 Comment 7 [Safety]

The assessment does a good job in covering the debris associated hazard. However, I found a few areas that were weak or somewhat misleading.

For a nominal vehicle ascent jettisoned body impact points and related hazards were covered adequately. However, for an anomalous flight the vehicle could fly an errant trajectory and impact regions beyond the ILL (Impact Limit Lines). The ILL are determined assuming that thrust is terminated for a flight failure (see "instantaneous impact point," p. D-1). Appendix B, p. 14 defines Flight Safety Angle Limits as limits in roll, pitch and yaw angles that define the launch vehicle attitude. If these limits are exceeded during launch the autonomous flight termination system will terminate main engine thrust. However, failure scenarios are possible in which the Safety Angle limits are not violated and thrust is not terminated by the autonomous flight termination system. It appears that these failure cases could result in the upper stage flying beyond the ILL and impacting land areas. For example, a ± 40-degree yaw excursion would easily violate the ILL. This situation could be remedied by having a manned flight termination system, where the actual ascent trajectory is monitored. It the trajectory significantly deviates from the planned trajectory, the flight can be terminated manually. Such a system would help protect sensitive island regions and populated areas in South America.

FAA Response 7: The FAA accounts for safety considerations during the course of the licensing process. The Zenit-3SL is an existing launch vehicle that has been licensed by the FAA to operate safely (within the standards outlined in FAA regulations) using an autonomous Flight Safety System. The autonomous Flight Safety System has been studied, observed and analyzed for performance and safety. There are no proposed modifications to the flight safety system for the Zenit-3SL at this time, nor are any changes reasonably expected. The LOL EA presents data which indicate that sensitive environmental areas will not be significantly affected in the unlikely event of a vehicle failure.

The autonomous flight safety system onboard the Zenit-3SL provides the functions normally associated with a range safety officer, such as flight status monitoring and termination capability. This type of autonomous flight safety system has been used for many years on non-Sea Launch vehicles by Sea Launch's international partners.

By conducting computer simulations of a wide variety of failures at various times in the ascent trajectory, impact limit lines (ILLs) were estimated by Sea Launch for the purposes of determining where debris could 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 are based on "computer simulations of a wide variety of failures at various times in the ascent trajectory (Appendix B, page B-14)." These computer simulations, which account for potential dispersions due to atmospheric wind effects as well as launch vehicle guidance and control, indicate that the probability of an impact outside the ILLs is remote. In the unlikely event of a vehicle failure, there are only 3 out of 1000 chances of launch vehicle debris impacting any area outside the ILLs. The FAA has confirmed the reasonableness of the calculations performed by SLLP.

2.2 Comment 8 [Debris]

The debris expected to survive from upper stage reentry presented in Table 4-5 on page 4-17 appears to be missing attitude control propellant tanks containing MMH/N_2 O_4. The tank(s) are probability [sic.] made of steel or titanium and would likely survive to surface impact. The document states that only 10 square meters of debris would survive reentry. In addition, in comment #2 in appendix E, the FAA states that 99% of the upper stage and satellite payload would burn up from exposure to extreme temperature upon return to earth. Evidence from reentry events indicate that the amount of mass that typically survives reentry heating ranges from 20% to 40% of the vehicle mass. Therefore, the amount of surviving debris is likely to be significantly greater than the 10 square meters mentioned in the report.

> ***FAA Response 8:*** The attitude control tanks are made of an aluminum alloy, not steel or titanium as the commentor hypothesized, and therefore are not expected to survive the reentry temperatures. The information regarding debris surviving reentry is based on analysis and data from experience on Commonwealth of Independent States launch vehicles. As the Draft LOL EA indicates, current estimates of reentry survivability are highly uncertain.
>
> In responding to the Government of Ecuador in Appendix E of the February 11, 1999 EA, Response Two stated that "…nearly 99% of the material would burn up from exposure to extreme temperature and deceleration forces." This figure was cited in the February 11, 1999 EA and therefore predated the ICO mission failure, however the 99% "burn up" figure is consistent with the analysis of what components survived the ICO failure.

2.3 Comment 9 [Debris]

The document states that surviving debris would be cooled by convection during free fall prior to impact. It is stated throughout the document that "in no case could falling debris be hot enough to pose any risk of fire." (see Appendix E comment #2, P. 4-20,P.4-22 and Environmental Impacts 4-14). This conclusion is inconsistent with analysis performed on reentered debris analyzed by The Aerospace Corporation. The Delta II 2nd stage propellant tank that reentered in Texas in 1997 was analyzed and found to have a temperature over 1200 degrees centigrade at the time of impact. In addition, eyewitness accounts of Delta II 2 stage debris that reentered near Cape Town South Africa in April 2000 indicated that the debris was hot enough to char foliage. Thus, more information or analysis is required to support the assertion that reentered debris could not cause fire after ground impact.

> ***FAA Response 9:*** Debris surviving a failure of the Zenit-3SL would be cooled by convection during free fall prior to impact. The second stage of the Zenit-3SL would fall into deep open ocean and, therefore is not expected to pose a risk of fire. Given the trajectories of the launches proposed in the LOL, it is very unlikely that debris from a failure of the Zenit-3SL's first or second stage would strike land. If any debris from an Upper Stage failure survived reentry from the altitude of approximately 180 km (110 mi), it would likely be very small in size (much smaller than the Delta II 2nd stage propellant tank). In the unlikely event a small piece of debris reached land or populated areas it could cause some small localized charring effects.

The best available current estimates of the temperature at ground impact of surviving launch vehicle debris are highly uncertain. The text of the Final EA has been revised to indicate that very little debris from an Upper Stage incident would be expected to survive reentry and fall onto sensitive areas or receptors on the ground, and any debris that would survive would likely not remain hot enough to pose a risk of fire on the ground. Thus, falling debris would not be expected to cause any significant impacts.

2.4 Comment 10 [Safety]

The document lacks a casualty expectation calculation (CE) and presents contradictory information. On page 4-24 the casualty expectation resulting from a launch failure over Central and South America was estimated to be between 1.18e-6 and 3.26e-6. Supporting analysis was not provided. In section B.2.2.2.1 on p. B-13 the document states that a CE of one in one million was adopted by Sea Launch. The FAA allows a CE of 30e-6 or less as correctly state [sic.] in the footnote on p. 4-24. Casualty expectation estimates should be clarified and supported by analysis.

FAA Response 10: Specific data on expected casualty calculations are not included in environmental documentation. These calculations are most appropriately addressed in the safety review which is part of the FAA licensing process. The figures cited on page 4-24 correspond to the risk of debris falling on a person in portions of Central and South America not the expected casualty calculation for the entire flight. The one in a million figure cited by SLLP corresponds to the risk of impact over the entire mission. The FAA expected casualty of 30×10^{-6} applies to the entire flight of the vehicle and needs to be met in order to obtain FAA licensure.

2.5 Comment 11 [Miscellaneous]

Table D.2 in Appendix E states that vapor pressure data on Boktan is not available. On p. 4-11 it states that the vapor pressure of Boktan is lower than that of kerosene. However, since the boiling point of Boktan is lower than that of kerosene its vapor pressure should be high [sic.] than that of kerosene.

FAA Response 11: The comment correctly points out an error in the parenthetical comment on page 4-11. It is assumed that the vapor pressure of Boktan would be greater than for kerosene, and the FAA has corrected the EA text accordingly.

2.6 Comment 12 [Noise]

The document did not address focused sonic booms created during ascent and their impact on the marine environment.

FAA Response 12: Page 4-10 of the Draft SLLP LOL EA discusses the impact of sonic booms. The maximum overpressure, which would be experienced during a focused sonic boom was determined to have no significant impact. This is because of the low population density of marine animals in the sonic boom footprint and the attenuating effect of the air-water interface that partially absorbs the noise.

2.7 Comment 13 [Editorial]

The circular disposal orbit regime for the medium earth orbit regime in Fig. B.2.2-2 on page B-13 is inconsistent with US Government Orbital Debris Mitigation Guidelines. The keep-out region should be 20,200-km ± 500 km not 20,200 ± 300 km.

FAA Response 13: The graphic on page B-13 of the February 11, 1999 SLLP EA was based on Figure 6-1 from NASA Safety Standard 1740.14, *Guidelines and Assessment Procedures for Limiting Orbital Debris*, August 1995. The data presented in the graphic on page B-13 corresponds with the data presented in NASA Safety Standard 1740.14.

INDEX

Comment Topic	Comment Number
Debris	2, 5, 8, 9
Editorial	3, 13
Miscellaneous	1, 4, 11
Noise	6, 12
Safety	7, 10

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APPENDIX A

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Appendix A
Comment Characterization

Table A-1: Percent of Comments Received by Comment Type

Comment Topic	% of Total Comments Received
Debris	31
Miscellaneous	23
Editorial	15
Noise	15
Safety	15

Percent of Total Comments by Topic

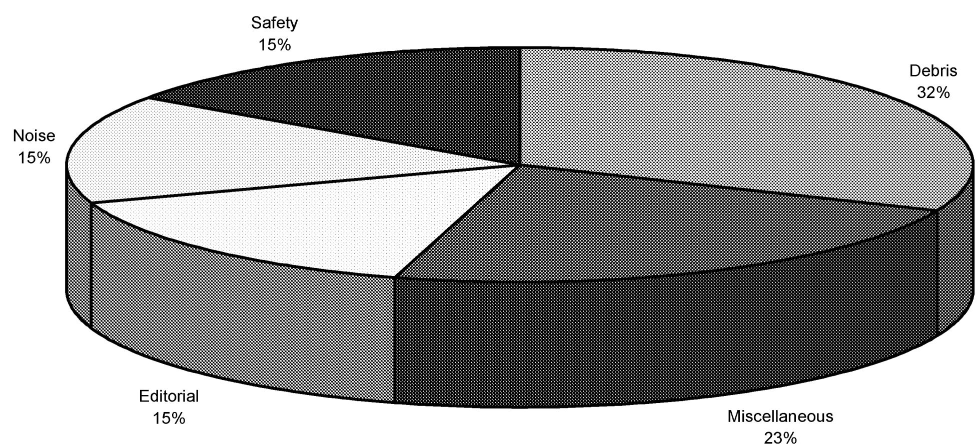

Table A-2: Number of Comments Received from Types of Organizations by Comment Type

Comment Type	Government Agencies	Industry	Total
Debris	2	2	4
Miscellaneous	2	1	3
Editorial	1	1	2
Noise	1	1	2
Safety	0	2	2

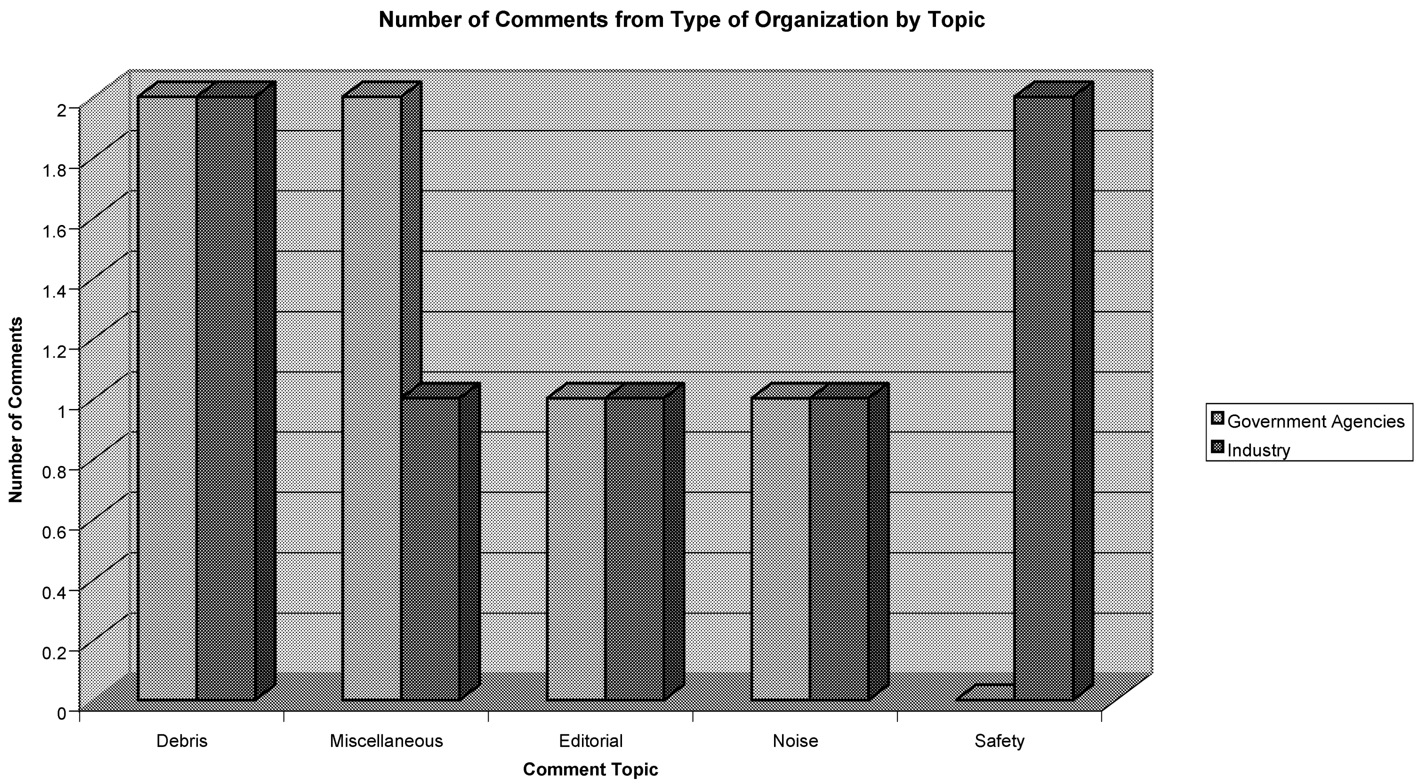

Table A-3: Percent of Total Comments by Type of Commentor

Type of Commentor	% of Total Comments
Government Agencies	46
Industry	54

Percent of Total Comments by Type of Commentor