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Environmental Impact Assessment of U.S. Air Force Launches from Kodiak, Alaska

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Prepared by

V. I. LANG,[1] T. HUYNH,[2] A. BOWLES,[3]
B. STEWART,[3] and K. PLOTKIN[4]

[1]Systems Planning & Engineering Group
The Aerospace Corporation
Los Angeles, CA 90009

[2]United States Air Force
Los Angeles AFB, CA 90245

[3]Hubbs-Sea World Research Institute
San Diego, CA 92109

[4]Wyle Laboratories
Arlington, VA 22202

Prepared for

SPACE AND MISSILE SYSTEMS CENTER
AIR FORCE MATERIEL COMMAND
2430 E. El Segundo Boulevard
Los Angeles Air Force Base, CA 90245

Systems Planning and Engineering Group

THE AEROSPACE CORPORATION
El Segundo, California

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John Edwards
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14. ABSTRACT

A comparison between noise predictions made with the RNOISE computation model and actual monitoring data, for two USAF atmospheric interceptor technology (ait) Program launches from the Kodiak Launch Complex (KLC), is presented. Maximum A-weighted sound pressure levels (L_{AMAX}) recorded at locations within 2 km of the launch site ranged from approximately 103 to 105 dB for the two launch vehicles. A-weighted sound exposure levels (ASEL) from the same area ranged from approximately 109 dB to 113 dB. At 5.7 km from the launch site, in the vicinity of a haulout for endangered Steller sea lions, the measured ait-1 L_{AMAX} was reduced to approximately 78 dB while the ASEL was approximately 88 dB. The latter values agreed well with A-weighted sound levels predicted using RNOISE for the same location.

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1. Introduction

In November 1998, the United States Air Force (USAF) launched the first of two atmospheric interceptor technology (ait) suborbital vehicles from the Kodiak Launch Complex (KLC), located on Kodiak Island, Alaska. This was the first launch (either government or commercial) from the Alaska state-operated facility, which opened in 1998. The second atmospheric interceptor technology (ait-2) launch took place in November 1999.

In 1997, the USAF completed an Environmental Assessment (EA) *(USAF, 1997)* and signed a Finding of No Significant Impact (FONSI) for the ait launches, according to National Environmental Policy Act (NEPA) requirements. The USAF was required to monitor the potential impacts of each of the two ait launches on endangered or threatened species. The Federal Aviation Administration (FAA) [in collaboration with the Alaska Aerospace Development Corporation (AADC)] prepared a separate EA for KLC *(AADC, 1996),* and, therefore, has a separate obligation to monitor the first five launches from the site, under the terms of their consultations with the United States Fish and Wildlife Service (FWS) and the National Marine Fisheries Service (NMFS).

USAF monitoring efforts have focused on the potential effects of launch noise on the Steller sea lion. The Steller sea lion is on the federal list of endangered species and is protected under both the Endangered Species Act (ESA) and the Marine Mammal Protection Act (MMPA). The Steller's eider, a threatened sea duck in the vicinity, is also protected under the ESA. Only potential noise impacts to the Steller sea lion were considered in this USAF study because the University of Alaska, Environmental and Natural Resources Institute (ENRI) *(AADC, 1998)* was responsible for monitoring the birds. Other species that inhabit the vicinity of the launch corridor include gray whales and bald eagles.

Prior to each of the ait launches, predictions of on-pad and in-flight noise were made using the RNOISE computer code. During each of the ait-1 and ait-2 launch periods, digital audio tape (DAT) recorders and sound level meters were deployed *(Stewart, 1999; Bowles, 2000).* The monitoring sites included one on Ugak Island where a seasonal Steller sea lion haulout is located.

The presence of Steller sea lions at the Ugak Island haulout during the ait-2 launch period allowed for opportunistic observations of their behavior, which is described in *Bowles, 2000.* The sea lions were not present during the ait-1 launch; however, the noise data provided ground truthing for the model results.

Representative data from the ait-1 and ait-2 monitoring campaigns are presented in this summary report. A collaborative team consisting of the USAF, Hubbs-Sea World Research Institute (HSWRI), The Aerospace Corporation, and Wyle Laboratories contributed to the work. A list of detailed reports resulting from the monitoring efforts is provided in Section 7.

2. Location

The Kodiak Launch Complex is located on Narrow Cape, Kodiak Island, Alaska. The locations of the launch site, as well as the seasonal Steller sea lion haulout on Ugak Island, are shown in Figure 1. The launch complex is under development by the Alaska Aerospace Development Corporation. The adjacent land includes state recreational facilities as well as ranchland.

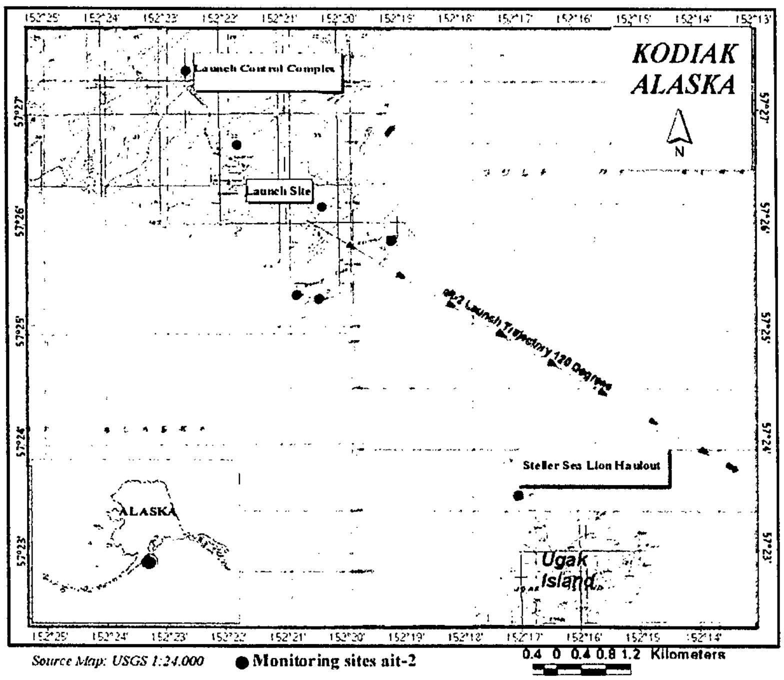

Figure 1. Kodiak Launch Complex and vicinity.

3. ait Launches

The ait-1 and ait-2 sub-orbital vehicles each consisted of two solid-propellant rocket stages. The larger of these, the ait-2 launch vehicle, was approximately 17.3 m long and weighed 11,910 kg at liftoff. The vehicles were launched from a portable stool located near the permanent KLC Launch Pad and Service Structure shown as the launch site in Figure 1. The second stage of each vehicle terminated in the Pacific Ocean after following a southern trajectory along the west coast of the continental United States. The overflight area of both launches was the Gulf of Alaska, northeast of Ugak Island. The ground path of the ait-2 launch trajectory is shown in Figure 1. The closest approach of the vehicle to the sea lion haulout on Ugak Island was 13.5 km slant distance for ait-1 and 14.8 km for ait-2.

4. Monitoring

HSWRI was responsible for deploying and operating the noise monitoring equipment for the USAF ait-1 and ait-2 launches. Monitoring was conducted from three sites in 1998 and from five sites in 1999. Detailed descriptions of the equipment and their mode of operation are given in *Stewart, 1998* and *Bowles, 2000*. Larson-Davis sound-level meters (Models 820 and 824) were used for unattended collection of detailed information about noise events. The sound meters were set to record noise above a software-adjustable threshold. Calibrated real-time launch recordings were made with a digital audio tape recorder (TEAC RD101T DAT) with a flat response microphone (ACO 7013; 12 Hz-20 kHz). In addition to the actual launch events, background ambient noise levels were recorded prior to and after the launches. ENRI carried on a coordinated and parallel monitoring effort, which is described elsewhere *(Bowles, 2000)*.

Before and after the ait-2 launch, a Meade ETX-90EC telescope was used to observe and photograph the Steller sea lions on Ugak Island. The observations were made from sites on Narrow Cape that were 4.5–5.0 km from the haulout *(Lang, 2000)*. The sea lions were also observed from a closer site on Ugak Island the evening before the ait-2 launch. Due to range safety constraints, observers were not allowed within the debris impact zone during the launch.

5. Results

Although unweighted, C-weighted, and A-weighted sound pressure data have been considered in the assessment of potential launch noise impacts on the Steller sea lions, only representative A-weighted data are presented here. A-weighting is based on the human response to sound, which is reduced at <1 kHz and >6kHz. Similar filter functions have yet to be determined and standardized for marine mammals. A more detailed discussion of the appropriate filter weighting for marine mammal applications can be found in *Bowles, 2000.* A discussion of frequency responses of marine mammal auditory systems can be found in *Richardson et al., 1995.*

5.1 ait-1 Launch, November 1998

Since this launch occurred in the month of November, the endangered Steller sea lions were not present. Figures 2 and 3 compare maximum A-weighted sound pressure levels (L_{AMAX}) and A-weighted sound exposure levels (ASEL) measured during the ait-1 launch to noise levels predicted with RNOISE.* The predictions are shown as sound level contour lines. The sound event durations for ait-1 are given in *Stewart, 1999.*

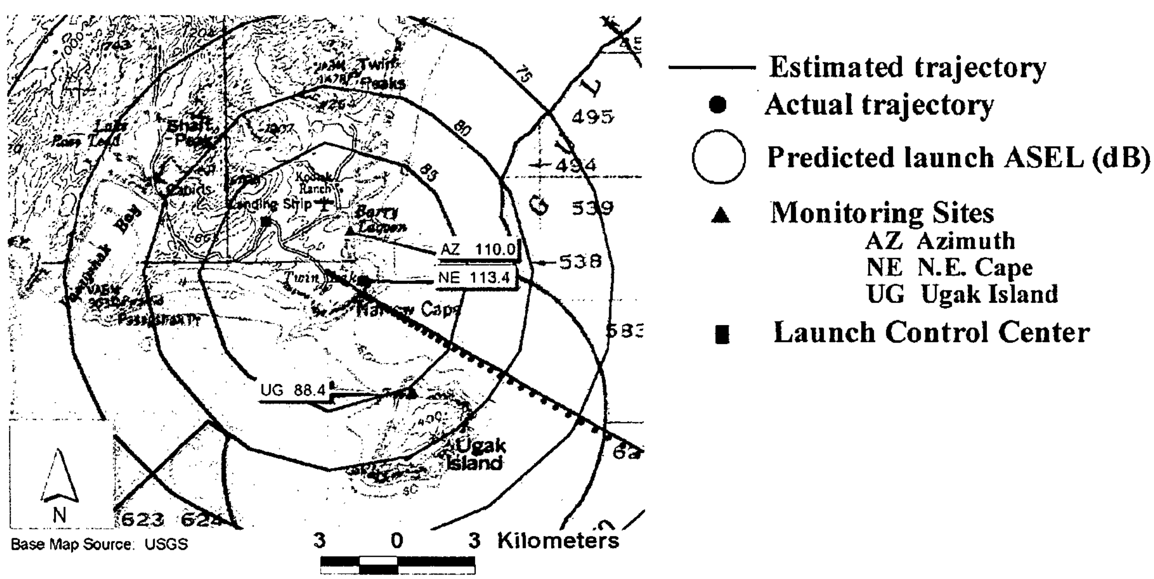

Figure 2. ait-1 predicted vs. measured A-weighted sound exposure level (ASEL). RNOISE predictions made by K. Plotkin of Wyle Labs and the sound pressure levels recorded by B. Stewart of HSWRI.

*A maximum sound pressure level for a noise event is determined from the greatest of average root-mean-square instantaneous sound pressure levels during either 125-ms (fast time averaging) or 1-s (slow time averaging) periods. The representative maximum sound pressure levels reported here were calculated with slow time averaging and were further A-weighted (L_{AMAX}). The sound exposure level (SEL) is a measure of the integrated energy in a noise event. For ait-2, maximum sound pressure levels were measured with instruments set for both fast and slow response; however, only the latter are given here for comparison to the RNOISE calculations. RNOISE predictions were computed at 1-s intervals, but do not account for fluctuations associated with atmospheric conditions.

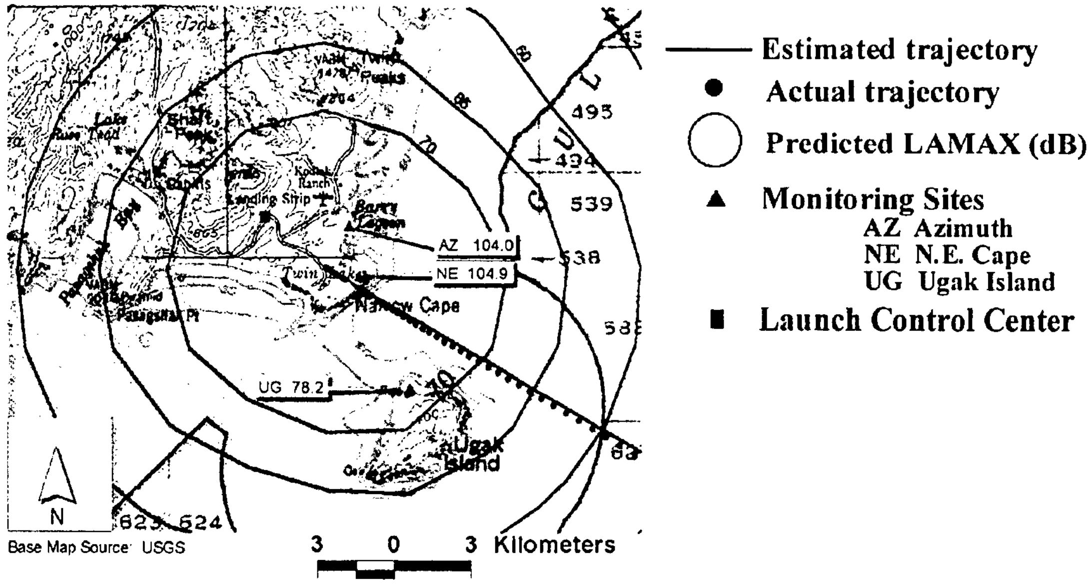

Figure 3. ait-1 predicted vs. measured A-weighted maximum sound pressure levels (L_{AMAX}). RNOISE predictions made by K. Plotkin of Wyle Labs and the sound pressure levels recorded by B. Stewart of HSWRI.

The measured ASEL values for the ait-1 launch were 113.4 dB at approximately 1.5 km from the launch event; 110.0 dB at approximately 2 km; and 88.4 dB at 5.7 km. The latter corresponds to the sea lion haulout area on Ugak Island. These values indicate a decrease in noise levels with increasing distance from the launch event. The L_{AMAX} levels for the same locations were 104.9 dB, 104.0 dB, and 78.2 dB, respectively. While a considerable decrease in the sound level is evident between locations on Narrow Cape and the one on Ugak Island, other trends in the noise levels are difficult to ascertain from this limited data.

The RNOISE predicted ASEL for the Ugak Island site was 85 dB, while the predicted L_{AMAX} is extrapolated to between 70 and 75 dB. The predicted ASEL value is somewhat closer to the measured ASEL value of 88.4 dB than the L_{AMAX} prediction is to the L_{AMAX} measurement.

5.2 ait-2 Launch, September 1999

Steller sea lions were present at the Ugak Island haulout (shown in Figure 1) during the ait-2 launch period in September 1999. Approximate counts of the sea lions were made on three occasions prior to the launch. The logistics of these observations are described in *Lang, 2000.* The highest count of sea lions was 37–45 individuals, 3 days prior to launch. The sea lion haulout is approximately 5.7 km from the launch site.

Figures 4 and 5 show representative data from the ait-2 noise monitoring effort compared to sound pressure levels predicted with RNOISE. The complete set of HSWRI data and its analysis is given in *Bowles, 2000.* As mentioned earlier, C-weighted and unweighted sound pressure levels are included in *Bowles, 2000,* but only representative A-weighted data are shown here. The average background level (Leq) noise level on Narrow Cape (average of two measured sites) was 49.3 dB(A). Ambient levels on Ugak Island should have been comparable. The measured ASEL values on Narrow Cape were 109.8 at 1.26 km from the launch site; 109.4 at approximately 1.47 km; and 109.7 dB at approximately at 1.72 km from the launch site. Similarly, the measured L_{AMAX} levels were 103.5 dB, 105.3 dB, and 109.7 dB at the same locations. This does not indicate a clear decrease in sound levels with increased distance from the launch event. The HSWRI recorder on Ugak Island malfunctioned; however, a recorder deployed by ENRI recorded an ASEL of 92.2 dB and an L_{AMAX} of 81.5 dB *(Bowles 2000).* It should be noted that the ENRI instrument was not calibrated to the HSWRI instruments. The Ugak Island monitoring site is 5.7 km from the launch site. Sound event durations for ait-2 are given in *Bowles, 2000.*

The RNOISE predictions generated contour lines (Figures 4 and 5) that show a decrease in amplitude with increasing distance from the launch site. This same trend was not evident in the measured ait-2 sound levels. A sound level contour line predicted with RNOISE intersects the Ugak Island sea lion haulout and monitoring site. The RNOISE-predicted ASEL of 85.1 dB for that site is slightly lower than the ENRI measurement of 92.2 dB. The RNOISE predicted L_{AMAX} for that site is 73.4 dB. The actual measured ENRI L_{AMAX} of 81.5 dB is also somewhat higher than the prediction.

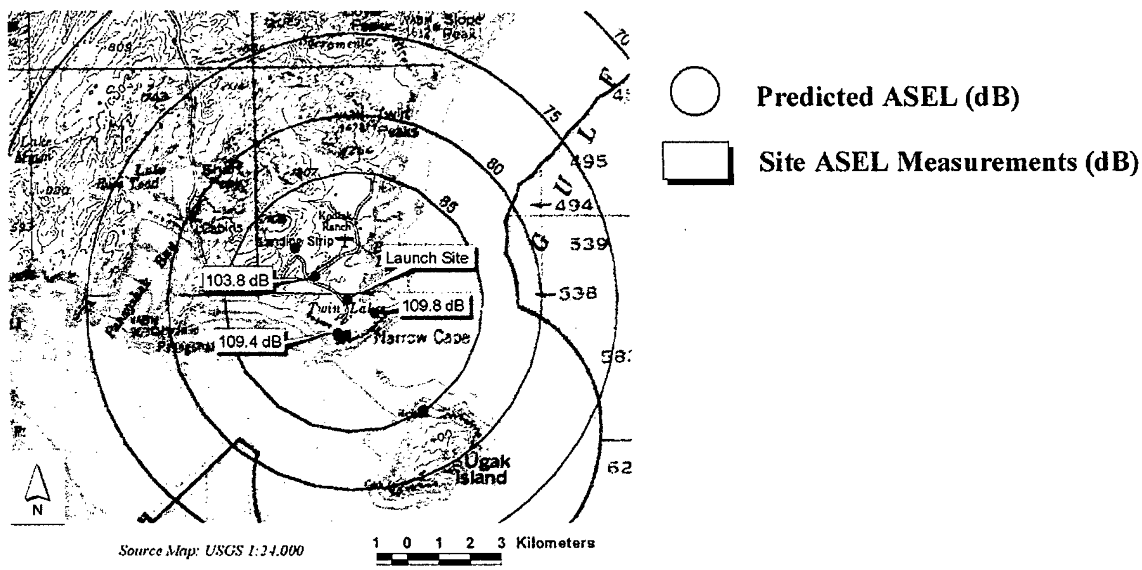

Figure 4. ait-2 predicted vs. measured A-weighted sound exposure levels (ASEL). RNOISE predictions made by K. Plotkin of Wyle Labs and the sound pressure levels recorded by A. Bowles of HSWRI.

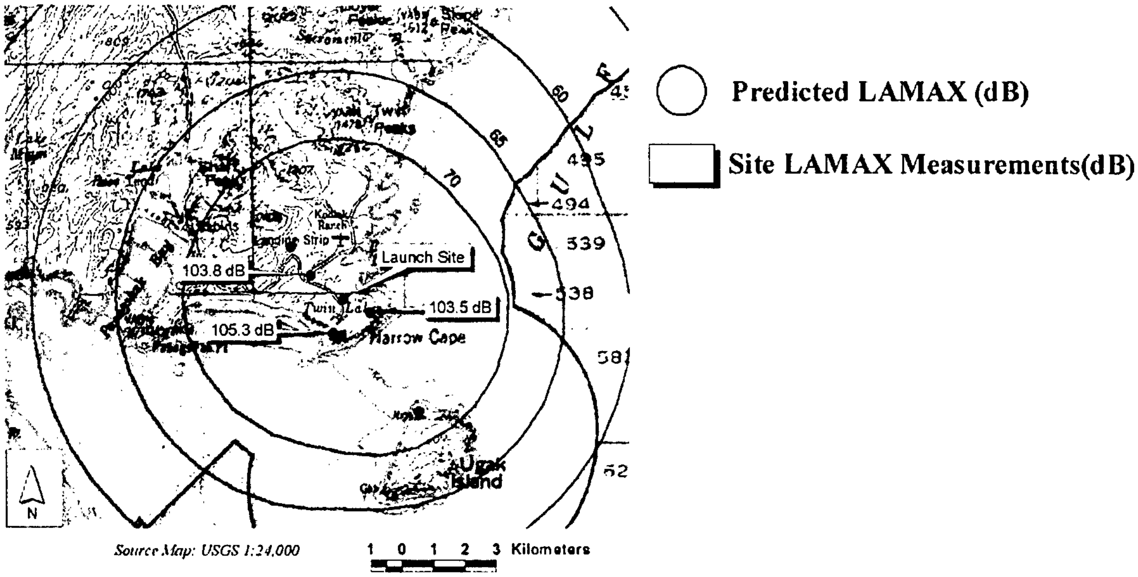

Figure 5. ait-2 predicted vs. measured A-weighted maximum sound pressure levels (L_{AMAX}). RNOISE predictions made by K. Plotkin of Wyle Labs and the sound pressure levels recorded by A. Bowles of HSWRI.

6. Discussion

Comparisons of the monitoring results with RNOISE predictions indicate that for the limited ait-1 and ait-2 cases, the ASEL predictions more closely correspond to the measurements than do the L_{AMAX} predictions. This is an indication that the A-weighted sound exposure levels, which are integrated over time, are not as sensitive to variables that may differ between the predictions and the actual launch. For example, a uniform atmosphere meteorological profile was used in making the RNOISE predictions. However, ground-level wind speed and direction, temperature, and other factors may affect the actual measured sound levels. Terrain may also contribute to interference or enhancement of sound transmission. The terrain surrounding the Narrow Cape launch site contains several gullies, hills, and various levels of coverage by trees. Between the launch site and Ugak Island, the terrain varies from land to ocean with varying degrees of humidity and winds. The RNOISE predictions did not account for these factors. Any differences between the modeled trajectories and the actual flight trajectories should not noticeably affect the differences between RNOISE predictions and measured sound levels since the noise event of interest occurs when the vehicle is on the pad or vertically over it. Down-range variations in the trajectory occur when the sound levels have dropped significantly.

Both ASEL and L_{AMAX} were apparently underestimated by RNOISE for the ait cases. However, RNOISE predictions were, in all cases, within 8 dB of the measured sound levels. This is within the expected uncertainties of the model since the RNOISE computations are largely based on predicted vehicle performance parameters, a uniform atmosphere, and flat terrain. Many NEPA analyses must be completed prior to the availability of actual flight data. For new launch systems or for geographic locations that are difficult to access, RNOISE can provide valuable predictions of noise levels. Understanding the limitations of predictive models and any systematic trends in the calculations allows for improved application of the models.

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