Federal Aviation Administration

Draft

Environmental Assessment for Issuing a Launch Operator License to Virgin Orbit, LLC for LauncherOne Operations from Andersen Air Force Base, Guam

October 2020

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Environmental Assessment (EA) for Issuing a Launch Operator License to Virgin Orbit, LLC (VO) for LauncherOne Operations from Andersen Air Force Base (AFB), Guam

AGENCIES: Federal Aviation Administration (FAA), lead federal agency; 36th Wing, Andersen AFB, cooperating agency.

This EA is submitted for review pursuant to Section 102(2)(C) of the National Environmental Policy Act of 1969 (NEPA), as amended (42 U.S. Code 4321, et seq.); Council on Environmental Quality NEPA-implementing regulations (40 Code of Federal Regulations Parts 1500-1508)[(1)]; and FAA Order 1050.1F, *Environmental Impacts: Policies and Procedures*.

DEPARTMENT OF TRANSPORTATION, FAA: The FAA is evaluating VO's proposal to conduct 747 carrier aircraft operations from Andersen AFB, Guam and conduct LauncherOne rocket operations over the Pacific Ocean east of Guam for purposes of transporting small satellites into a variety of low earth orbits. To operate LauncherOne from Andersen AFB, VO must obtain a launch license from the FAA. Issuing a license is considered a major federal action subject to environmental review under NEPA. Under the Proposed Action, the FAA would issue a launch license to allow VO to operate LauncherOne from Andersen AFB. VO is proposing to conduct 25 launches over the next 5 years (2021-2025), with a maximum of 10 launches per year in any 1 year over the 5-year period.

The EA considers the potential environmental impacts from the Proposed Action and No Action Alternative on air quality; climate; noise and noise-compatible land use; cultural resources; Section 4(f) resources; water resources; biological resources; and hazardous materials, solid waste, and pollution prevention. Potential cumulative impacts are also addressed in the EA.

PUBLIC REVIEW PROCESS: In accordance with the applicable requirements, the FAA is initiating a 30-day public review and comment period for the Draft EA. The public comment period for the NEPA process begins with the publication of the Draft EA. Comments are due on November 16, 2020. The Notice of Availability published in the *Federal Register* and in the Pacific Daily News provides information and how to submit comments.

CONTACT INFORMATION: For questions, please contact Leslie Grey, Environmental Protection Specialist, FAA, 800 Independence Avenue SW, Suite 325, Washington, DC 20591; leslie.grey@faa.gov.

This EA becomes a Federal document when evaluated, signed, and dated by the responsible FAA Official.

Responsible FAA Official:

DANIEL P MURRAY Digitally signed by DANIEL P MURRAY Date: 2020.10.14 17:37:28 -04'00'

________________________________ Date: __________________________

Daniel Murray
Manager, Safety Authorization Division

[(1)] The Council on Environmental Quality (CEQ) amended its regulations implementing NEPA on September 14, 2020. Agencies have discretion to apply the amended regulations to NEPA processes that were begun before September 14, 2020 (40 CFR § 1506.13). FAA initiated its NEPA process for this action on February 7, 2020 and has decided not to apply the amended regulations. Therefore, the prior CEQ regulations continue to apply to this NEPA process.

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Acronyms & Abbreviations

36 CES/CEV	36th Civil Engineer Squadron Environmental Flight
AEM	Area Equivalent Method
AFB	Air Force Base
AFCEE	Air Force Center for Engineering and the Environment
AGL	above ground level
AHA	Aircraft Hazard Area
AICUZ	Air Installations Compatibility Use Zones
ARTCC	Air Route Traffic Control Center
ATCSCC	Air Traffic Control System Command Center
CAA	Clean Air Act
CEQ	Council on Environmental Quality
CERAP	Center Radar Approach Control
CFR	Code of Federal Regulations
CH_4	methane
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent
CSOSA	Commercial Space Operations Service Agreement
CWA	Clean Water Act
dB	decibel(s)
dBA	A-weighted decibel(s)
dB_{rms} re 1 µPa	decibels root mean square reference 1 micropascal
DNL	day-night average sound level
EA	Environmental Assessment
EEZ	Exclusive Economic Zone
EFH	Essential Fish Habitat
EIS	Environmental Impact Statement
EO	Executive Order
ESA	Endangered Species Act
FAA	Federal Aviation Administration
ft	foot/feet
GHG	greenhouse gas
Hz	hertz
JRM	Joint Region Marianas
lb	pound(s)
lbm	pound mass
LEO	low-Earth orbit
LOX	liquid oxygen
LTO	landing and take off
MMPA	Marine Mammal Protection Act
mph	miles per hour
MSA	Munitions Storage Area
MSL	above mean sea level
MT	metric ton(s)
MTMNM	Marianas Trench Marine National Monument
N_2O	nitrous oxide
NAAQS	National Ambient Air Quality Standards
Navy	U.S. Navy
NEPA	National Environmental Policy Act
NHPA	National Historic Preservation Act
nm	nautical mile(s)
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NOTAM	Notice to Airmen
NOTMAR	Notice to Mariners
NO_x	nitrogen oxides
NRHP	National Register of Historic Places
PACAF	Pacific Air Forces
psf	pounds per square foot
RP-1	rocket propellant 1
SO_2	sulfur dioxide
U.S.	United States
USAF	U.S. Air Force
USC	U.S. Code
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
VO	Virgin Orbit, LLC

Chapter 1. Purpose and Need

1.1 Introduction

The Federal Aviation Administration (FAA) is currently evaluating a proposal by Virgin Orbit, LLC (VO) to conduct launches using its 747 carrier aircraft and LauncherOne rocket from Andersen Air Force Base (AFB), Guam over the Pacific Ocean east of Guam for the purposes of transporting small satellites into a variety of low-Earth orbits (LEOs). As authorized by Chapter 509 of Title 51 of the United States (U.S.) Code (USC), the FAA is to "oversee and coordinate the conduct of commercial launch and reentry operations, issue permits and commercial licenses and transfer commercial licenses authorizing those operations, and protect the public health and safety, safety of property, and national security and foreign policy interests of the United States; and to facilitate the strengthening and expansion of the United States space transportation infrastructure, including the enhancement of United States launch sites and launch-site support facilities, and development of reentry sites, with Government, State, and private sector involvement, to support the full range of United States space-related activities" (51 USC § 50901(b)).

To operate LauncherOne from Andersen AFB, VO must obtain a launch license from the FAA Office of Commercial Space Transportation. Issuing launch licenses is considered a major federal action subject to environmental review under the National Environmental Policy Act (NEPA), as amended (42 USC 4321 et seq.). The FAA is the lead federal agency and is preparing this Environmental Assessment (EA) in accordance with NEPA, Council on Environmental Quality (CEQ) Regulations for Implementing the Procedural Provisions of NEPA (40 Code of Federal Regulations [CFR] Parts 1500-1508), and FAA Order 1050.1F, *Environmental Impacts: Policies and Procedures*. This EA evaluates the potential environmental impacts of activities associated with the Proposed Action of issuing a launch license to VO at Andersen AFB (see Section 2.1 for more details). The completion of the environmental review process does not guarantee that the FAA will issue a launch license to VO for LauncherOne operations from Andersen AFB. VO's license application must also meet FAA safety, risk, and financial responsibility requirements (14 CFR Part 400).

1.2 Federal Agency Roles

1.2.1 FAA Office of Commercial Space Transportation

As the lead federal agency, the FAA is responsible for analyzing the potential environmental impacts of the Proposed Action. As authorized by Chapter 509 of Title 51 of the USC, the FAA licenses and regulates U.S. commercial space launch and reentry activity, as well as the operation of non-federal launch and reentry sites. The mission of the Office of Commercial Space Transportation is to ensure protection of the public, property, and the national security and foreign policy interests of the U.S. during commercial launch or reentry activities, and to encourage, facilitate, and promote U.S. commercial space transportation.

1.2.2 Cooperating Agencies

The 36th Wing, Andersen AFB will participate in the EA process as a cooperating agency due to its jurisdiction by law and special expertise.[2] Under the proposed action, VO would perform integration,

[2] A cooperating agency is any federal agency other than the lead agency which has jurisdiction by law or special expertise regarding any environmental impact involved in a proposal or reasonable alternative (40 CFR Part 1508.5).

mate, and propellant loading operations, and takeoff and landing operations on Andersen AFB; no construction or ground-disturbing activities would occur and there would be no change to existing infrastructure on Andersen AFB. In accordance with NEPA, the 36th Wing prepared an Environmental Impact Analysis and determined that the activities qualified for the following Categorical Exclusion (CATEX) under OPNAVINST 5090.1D, CH-10 (CATEX 21): Temporary (for less than 30 days) increases in air operations up to 50% of the typical installation aircraft operation rate or increases of 50 operations a day, whichever is greater (36th Civil Engineer Squadron Environmental Flight [36 CES/CEV] 2019a, b).

1.3 Purpose and Need

The purpose of VO's proposal is to provide a low cost, responsive, and adaptable launch method to place small satellites into orbit. The satellite launch environment is evolving from medium-and heavy-lift orbital launch vehicles to small commercial orbital satellite launch vehicles. The shift to smaller launch vehicles is largely due to the development of an emerging market for smaller commercially used satellites, and a national security environment that demands quick launch capabilities. The need for VO's proposal is to fulfill the requirements of clients in the small satellite commercial orbital and suborbital markets.

1.4 Public Involvement

In accordance with CEQ's NEPA-implementing regulations and FAA Order 1050.1F, the FAA has made this Draft EA available for a 30-day public review. The FAA encourages all interested parties to provide comments concerning the content of the Draft EA on or before November 16, 2020. Comments should be as specific as possible and address the analysis of potential environmental impacts and the adequacy of the proposed action or merits of alternatives and any mitigation being considered. Reviewers should organize their participation so that it is meaningful and makes the agency aware of the commenter's interests and concerns using quotations and other specific references to the text of the Draft EA and related documents. Matters that could have been raised with specificity during the comment period on the Draft EA may not be considered if they are raised for the first time later in the decision process. This commenting procedure is intended to ensure that substantive comments and concerns are made available to the FAA in a timely manner so that the FAA has an opportunity to address them. Prior to including your address, phone number, e-mail address, or other personal identifying information in your comment, be advised that your entire comment—including your personal identifying information—may be made publicly available at any time. While you can ask us in your comment to withhold from public review your personal identifying information, we cannot guarantee that we will be able to do so.

The FAA provided public notice of the availability of the Draft EA for public review and comment in the *Federal Register* on October 16, 2020. An electronic version of the Draft EA is available at https://www.faa.gov/space/environmental/nepa_docs/.

Following the close of the public comment period, the FAA will revise the EA, as appropriate, in response to comments received on the Draft EA, and a Final EA will be prepared. The Final EA will reflect the FAA's consideration of comments and will provide responses to substantive comments. Following review of the Final EA, the FAA will issue either a Finding of No Significant Impact (FONSI) or a Notice of Intent to prepare an Environmental Impact Statement (EIS). The FAA may also make a determination to prepare an EIS at any time during this EA process.

Chapter 2. Description of the Proposed Action and Alternatives

2.1 Proposed Action

The FAA's Proposed Action is to issue a launch license to allow VO to conduct launches using its 747 carrier aircraft and LauncherOne rocket from Andersen AFB, Guam over the Pacific Ocean east of Guam. VO is proposing to conduct a maximum of 25 launches over the next 5 years (2021-2025), with a maximum of 10 launches in any 1 year during the 5-year period. For example, a potential launch scenario could be the following: 1 launch in 2021, 3 in 2022, 5 in 2023, 6 in 2024, and 10 in 2025. The following subsections provide a description of the project's location, launch system (carrier and launch vehicle), and proposed launch operations.

2.1.1 Location

Located in the Western Pacific Ocean, Guam is the southernmost and largest island of the Mariana Islands archipelago (Figure 2.1-1). The Mariana Islands include Guam and the Commonwealth of the Northern Mariana Islands (CNMI), both of which are sovereign (self-governing) territories of the U.S. CNMI is comprised of 14 islands, territorial waters, and submerged lands immediately north of Guam. Guam is situated approximately 3,700 miles west-southwest of Hawaii and 1,560 miles south-southeast of Japan (Joint Region Marianas [JRM] 2019).

Andersen AFB encompasses approximately 15,400 acres and is located in northern Guam (Figure 2.1-2). The main operations area of the base is in the eastern third of the installation and includes the main active airfield and an array of operations, maintenance, and community support facilities. The central third of the installation is a Munitions Storage Area. The western third is Northwest Field, which is used for helicopter training, various field exercises, bivouacs, and is the permanent location of the Pacific Air Forces (PACAF) Regional Training Center and the U.S. Army Terminal High-Altitude Area Defense ballistic missile defense battery. The 36th Wing is the host unit to U.S. Air Force (USAF), U.S. Army, U.S. Navy (Navy), and U.S. Marine Corps active forces along with Air Force Reserve and Air National Guard. The Wing's mission is to provide the highest quality peacetime and wartime support from its strategic Pacific location. Guam serves as a stopping point for numerous aircraft *en route* to Japan, Korea, and other Indo-Asian Pacific locations (Navy 2010; JRM 2019).

The Andersen AFB airfield has two parallel runways: one 11,200 feet (ft) long and one 10,527 ft long; both are 200 ft wide. Based on the most current data summarizing flight operations by aircraft type, Andersen AFB supported approximately 23,691 flights annually, or approximately 65 operations per day in 2013 (PACAF and Air Force Center for Engineering and the Environment [AFCEE] 2013). The airfield supports flight operations including takeoffs, landings, and traffic pattern training of all types of based and transient aircraft including B-1, B-2, B-52, C-5, C-17, E-2, EA-18G, F/A-18, F-15, F-16, KC-10, KC-135, fixed-wing aircraft; CH-53, H-60, and H-1 helicopters; MV-22 tilt rotor aircraft, and B747 aircraft, which is the same aircraft as the carrier aircraft (Wyle 2008; Navy 2010; PACAF and AFCEE 2013).

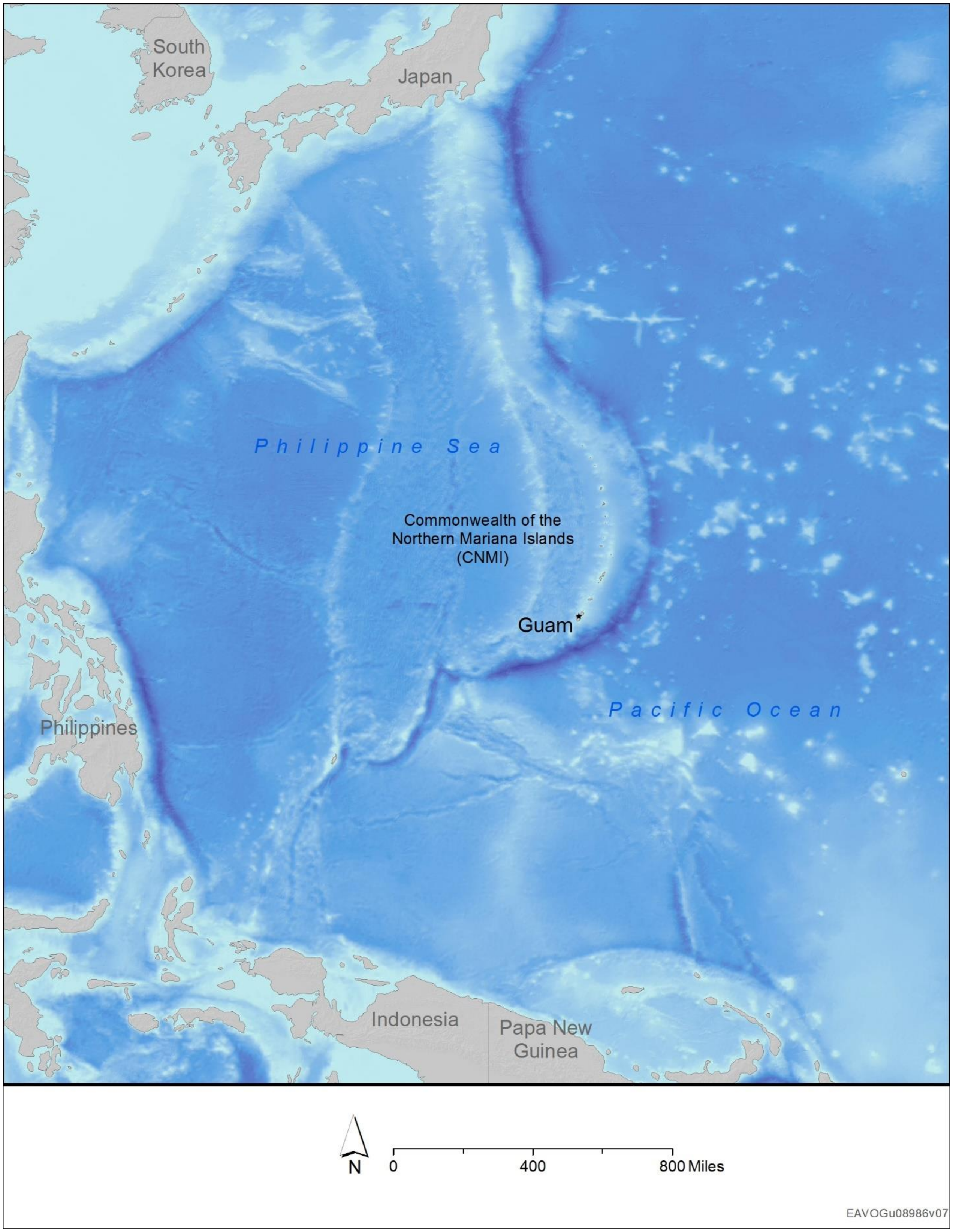


Figure 2.1-1. Regional Location of Guam

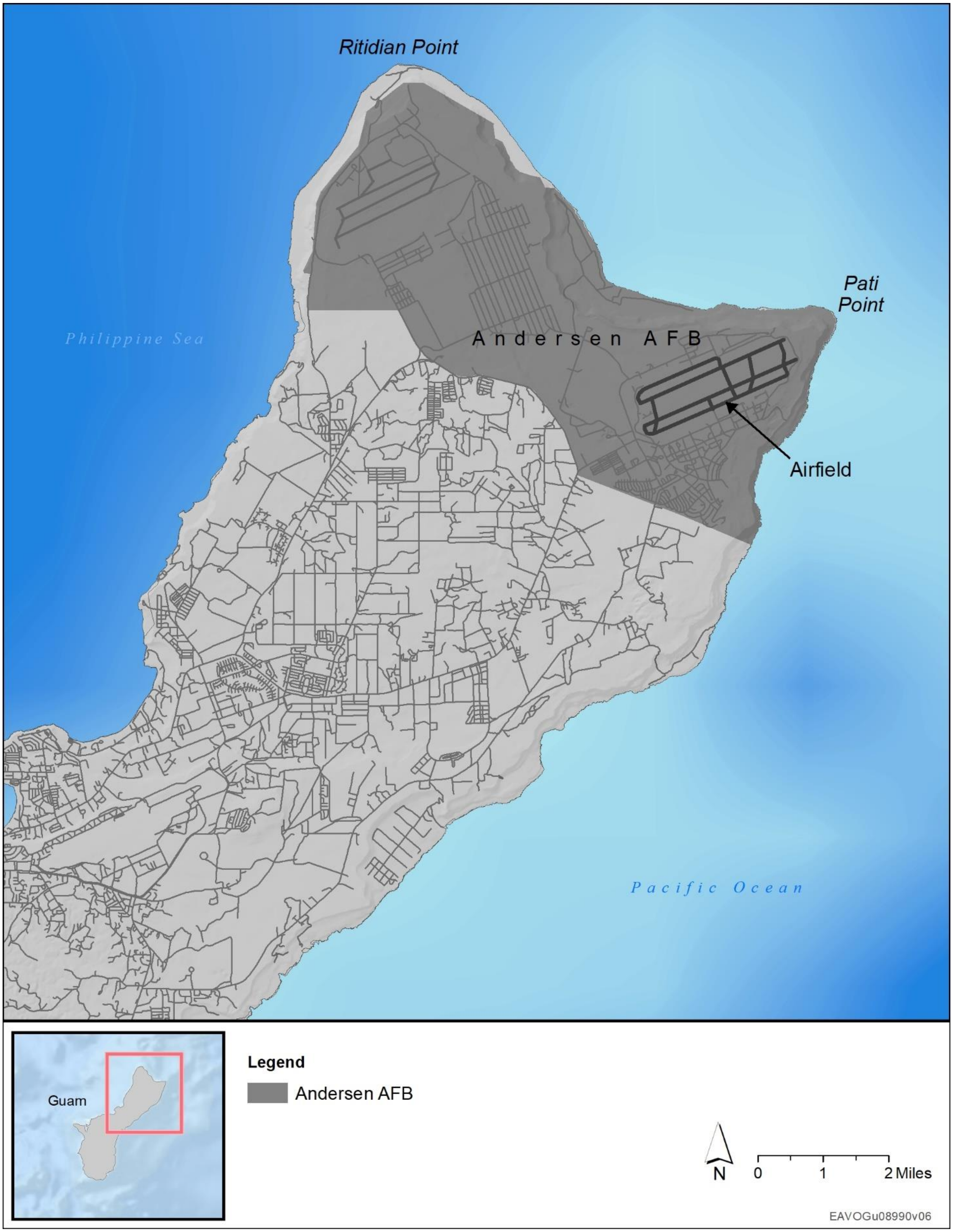


Figure 2.1-2. Andersen AFB and Vicinity, Guam

2.1.2 Launch System

2.1.2.1 Carrier Aircraft

The carrier aircraft, a Boeing 747-400, is a four-engine, wide-body vehicle, similar to other Boeing 747 aircraft that have been extensively used in commercial passenger and cargo transport for the last few decades (Figure 2.1-3). The 747-400 has a non-stop range of over 8,055 miles at almost maximum payload weight. The aircraft itself has the capability to carry over 100 metric tons (MT) of internal payload. To facilitate LauncherOne operations, the port wing of the carrier aircraft has been modified to carry both the rocket and a removable adapter, which houses the structural release mechanism, and quick release electrical and pneumatic connections to the carrier aircraft. The carrier aircraft provides electrical power, purge gasses, and monitoring and control of the rocket by a launch engineer onboard the carrier aircraft. For a round trip flight from the Andersen AFB to the LauncherOne drop point, the carrier aircraft would use approximately 83,775 pounds (lb) of Jet-A fuel.

Figure 2.1-3. Carrier Aircraft with LauncherOne Attached

2.1.2.2 Launch Vehicle: LauncherOne Rocket

The LauncherOne is an expendable, air-launched two-stage rocket (Figure 2.1-4) that is designed to carry small satellites (approximately 661–1,102 lb of payload) into a variety of LEOs. The rocket is a liquid oxygen (LOX)/rocket propellant 1 (RP-1) (kerosene) system comprised of a first stage with 29,215 pound mass (lbm) of LOX and 13,279 lbm of RP-1, and second stage with 3,642 lbm of LOX and 1,683 lbm of RP-1. The thrust of the first stage is 69,298 ft lb.

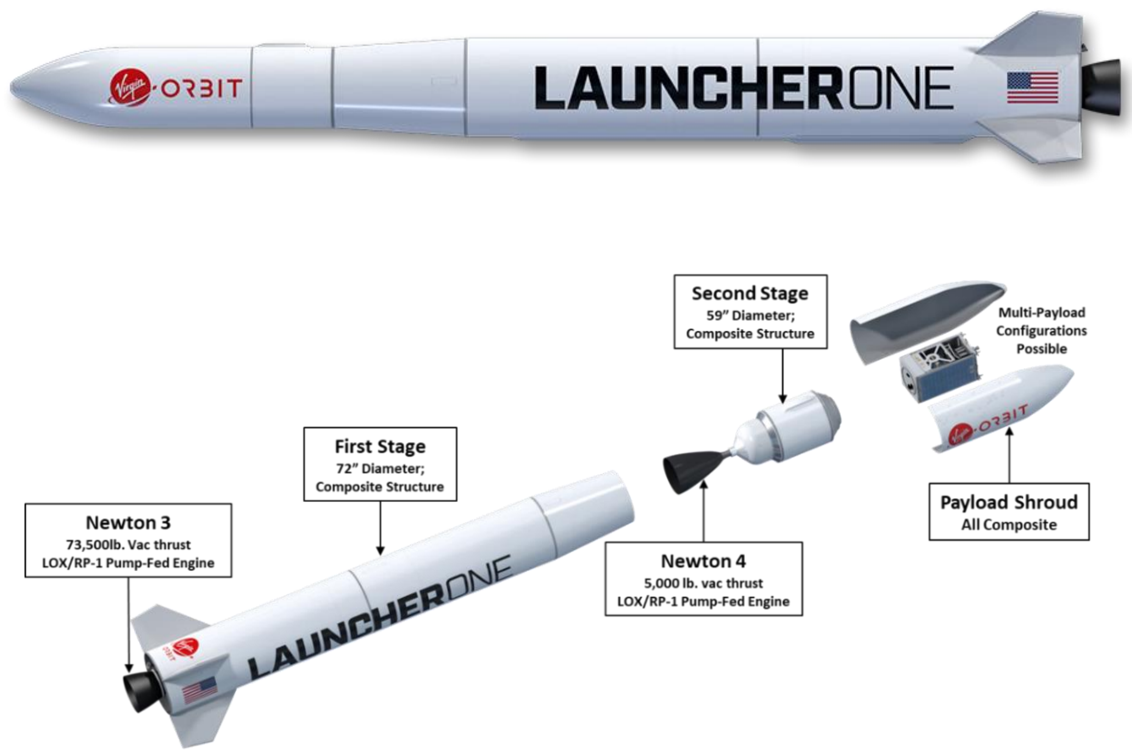


Figure 2.1-4. LauncherOne Rocket

Rather than launching from ground level, the rocket is carried to an altitude of approximately 35,000–40,000 ft above mean sea level (MSL) by the carrier aircraft and released into a flight path angle of approximately 28 degrees. The rocket offers a large fairing with a payload adapter capable of accommodating a variety of standard sizes for one or multiple satellites.

2.1.3 Launch Operations

2.1.3.1 Pre-flight Operations

Pre-flight activities consist of preparing the carrier aircraft and rocket for takeoff and launch, mounting and loading propellants on LauncherOne, and support operations, such as gathering and distributing telemetry. In accordance with Andersen AFB requirements, all hazardous pre-flight ground operations would take place within the eastern third of the base that has established appropriate safety clear zones.

All airspace launch operations would comply with the necessary notification requirements, including issuance of Notices to Airmen (NOTAMs) and Notices to Mariners (NOTMARs), as defined in agreements required for a launch license issued by the FAA Office of Commercial Space Transportation. A NOTAM provides notice of unanticipated or temporary changes to components of, or hazards in, the National Airspace System (FAA Order 7930.2S, *Notices to Airmen [NOTAM]*). The FAA issues a NOTAM at least 72 hours prior to a launch activity in the airspace to notify pilots and other interested parties of temporary conditions. Similarly, the National Geospatial-Intelligence Agency (NGA), in conjunction with the U.S. Coast Guard (USCG), publishes NOTMARs weekly and as needed, informing the maritime community of temporary changes in conditions or hazards in navigable waterways.

As part of the licensing process, VO has entered into a Letter of Agreement (LOA) with Guam Center Radar Approach Control (CERAP), Oakland ARTCC, Air Traffic Control System Command Center (ATCSCC) Space Operations, and Andersen AFB 36th Operations Group to accommodate the flight parameters of LauncherOne (Guam CERAP et al. 2019). The LOA defines responsibilities and procedures applicable to operations, including the technical procedures to follow when issuing a NOTAM defining the affected airspace prior to launch. The Proposed Action would not require the FAA to alter the dimensions (shape and altitude) of the airspace. However, temporary closures of existing airspace may be necessary to ensure public safety during the proposed operations.

For all missions, the FAA and the operators take steps to reduce the airspace closure durations as a successful mission unfolds. First, the launch operator plans to conduct its rocket release for an air launched system at the beginning of its launch window. While it may request a window that spans hours in order to have more opportunity to work around weather or technical issues, the operator makes every effort to launch as soon as it is ready in the launch window. While percentages are not readily available, far more launches occur at or near the launch window opening than the closing. Further, as the launch unfolds successfully, the FAA incrementally releases airspace as it is no longer affected. For example, the airspace nearest the rocket release point for an air launched system can generally be released within 3 to 5 minutes of release as the rocket successfully progresses along its trajectory. In practice, the FAA attempts to divide airspace closures into subsets that can be released incrementally in time, as well as geographically based on airspace boundaries. In doing so, the actual closure times are often significantly smaller than projected maximum values defined in a given NOTAM.

VO has entered into an LOA with the USCG District 14 in order to safely operate the LauncherOne over open ocean. The LOA describes the required responsibilities and procedures for both VO and USCG during a launch operation. USCG will be responsible for issuing NOTMARs for the downrange hazard area south of Guam. USCG will also coordinate issuing NOTMARs with the NGA for stage 1 and fairing splashdown hazard areas in international waters. VO will provide these hazard area locations prior to launch of the rocket.

Advance notice via NOTAMs and NOTMARs would assist general aviation pilots and mariners in scheduling around any temporary disruption of flight or shipping activities in the area of operation. Launches would be infrequent (up to 10 per year in any one year), of short duration, and scheduled in advance to minimize interruption to airspace and waterways.

For the above reasons, environmental impacts of the temporary closures of airspace and the issuance of NOTAMS and NOTMARs under the Proposed Action are not anticipated and thus are not addressed further in the EA.

2.1.3.2 Launch and Mission Profile

VO’s proposed carrier aircraft flight corridors from Andersen AFB to and from the drop point are shown in Figure 2.1-5. The flight corridors would occur within the U.S. Exclusive Economic Zone (EEZ) around Guam. The holding patterns (or ‘Racetrack’) at the drop point are approximately 200 miles around. The exact drop point would be established based on mission-specific needs, communication line of sight (trajectory of the vehicle relative to the location of the ground-based telemetry station), and to avoid sonic boom impacts to land.

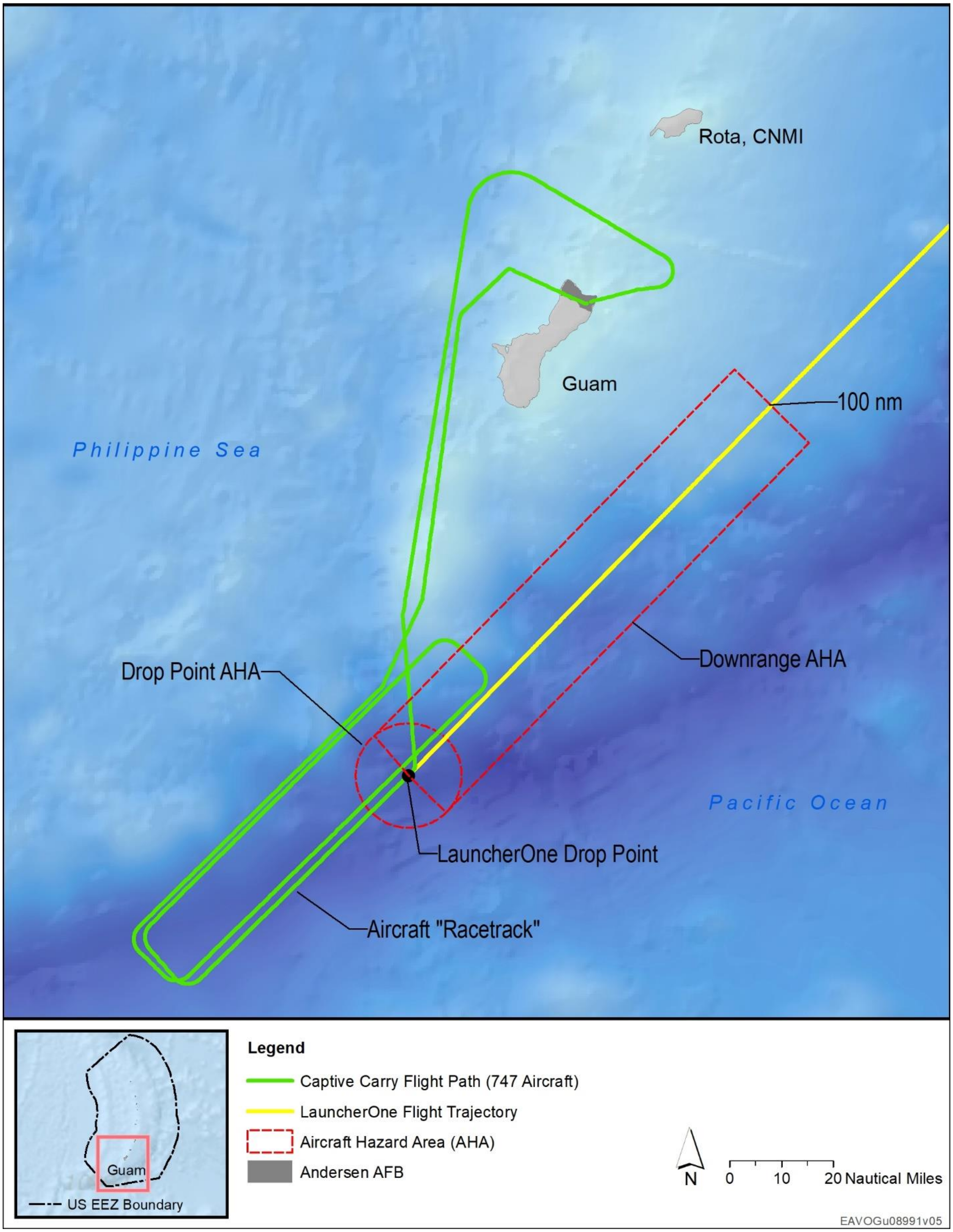


Figure 2.1-5. 747 Carrier Aircraft Flight Corridors, LauncherOne Drop Point, LauncherOne Trajectory, and Associated AHAs

The carrier aircraft with the mated LauncherOne rocket would take off from Runway 24R at Andersen AFB and fly south to the designated drop point approximately 75 nautical miles (nm) south-southwest of Guam. The proposed mission profile is depicted in Figure 2.1-6. Figure 2.1-7 depicts the flight trajectory of the LauncherOne rocket from the drop point to the release of satellites and fairing re-entry.

Release of LauncherOne from the Carrier Aircraft

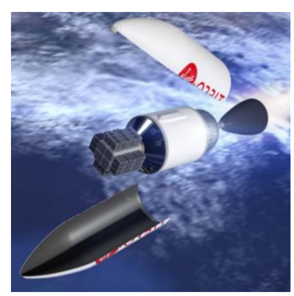
LauncherOne would be carried to an altitude of approximately 35,000–40,000 ft MSL where it would be released. The carrier aircraft would then immediately pull away and return to Runway 6L at Andersen AFB. With a drop flight path angle of approximately 28 degrees and an angle of attack of approximately 5 degrees, the rocket would maintain the flight angle required for vehicle safety through the 5-second drop, prior to ignition of the rocket's first stage (Figure 2.1-6). The 5 seconds of separation is enough for the aircraft to move far enough away that if rocket ignition caused an explosion, debris and/or a pressure wave would not impact or cause damage to the carrier aircraft.

The drop point includes a 10-nm radius Aircraft Hazard Area (AHA) where no other aircraft can be present prior to the drop of the LauncherOne rocket (Figure 2.1-5). In addition, mission-specific AHAs would be defined for the rocket trajectory and associated hardware jettisons (Figure 2.1-7). Details of the mission specific AHAs would be defined in the NOTAMs.

First and Second Stage Separation

Following ignition of the rocket's first stage, the rocket would be at supersonic speed (in excess of 768 miles per hour [mph]), and the engine would burn until all of the propellant is consumed. At approximately 650 nm downrange from the drop point, the rocket's first stage would detach and fall into the Pacific Ocean within a defined AHA (Figures 2.1-6 and 2.1-7).

After release of the first stage, the rocket's second stage would ignite until reaching its desired LEO (Figure 2.1-6). At approximately 700 nm downrange of the drop point, the shroud or fairings covering the satellites would be released and would fall into the Pacific Ocean within a defined AHA (Figures 2.1-6 and 2.1-7). Upon reaching the desired LEO, the second stage rocket would coast while releasing the small satellites at predetermined LEO heights and then re-ignite its engine (or blow-down[3]) until all of the propellants are consumed, per FAA regulations (14 CFR §417.129) (Figure 2.1-6). The second stage would remain in orbit for months or years, eventually burning up upon reentry.



Payload Fairing Separation

[3] To deplete onboard energy sources after completion of mission.

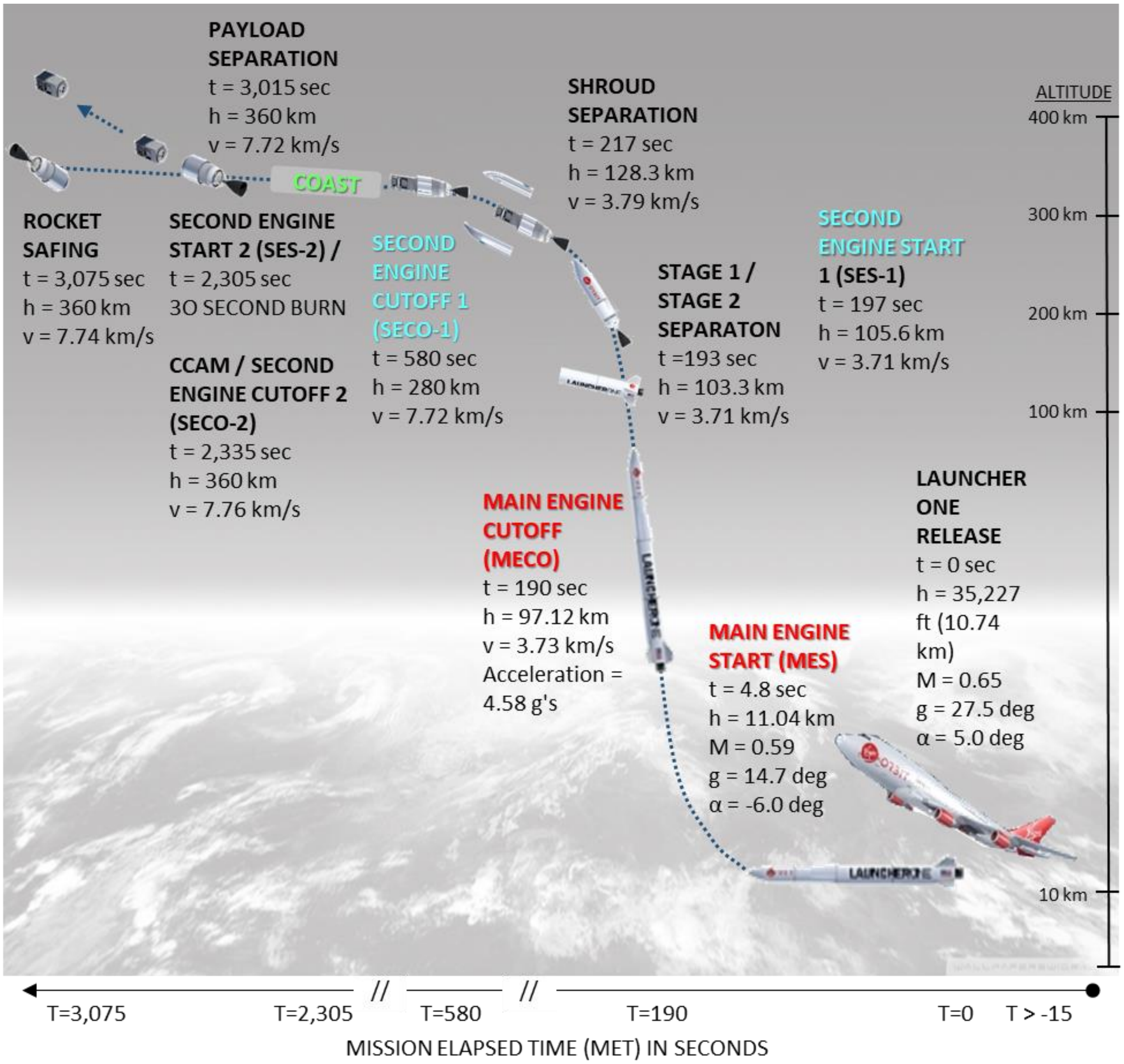


Figure 2.1-6. Proposed LauncherOne Rocket Mission Profile from Release from Carrier Aircraft to Release of Satellite Payload

Legend: α = angle of attack
CCAM = Collision and Contamination Avoidance Maneuver
ft = feet
g = flight path angle
h = height above sea level
km = kilometers
km/s = kilometers per second
M = Mach number
sec = seconds
t = time since release of LauncherOne
v = velocity

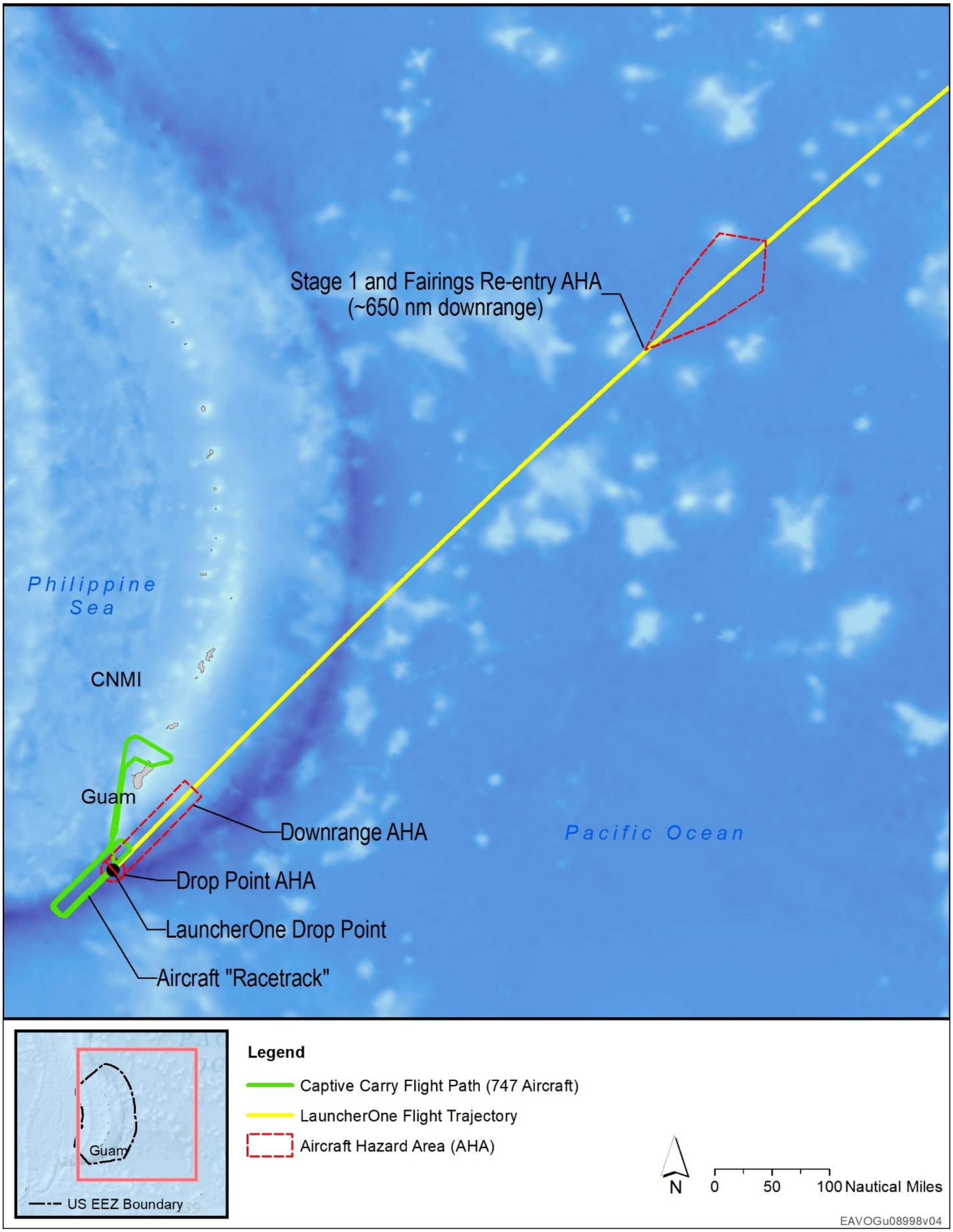


Figure 2.1-7. LauncherOne Flight Trajectory Including Drop Point, Downrange AHA, and Stage 1 and Fairings Re-entry AHA

If after the LauncherOne rocket has been released from the carrier aircraft and there is a malfunction or other issue that results in the abort of the flight, the rocket is expected to maintain structural integrity until impact with the ocean within the Drop Point AHA if there is no secondary explosive failure. There is no destruct component on the vehicle. The vehicle safety system will shut down all thrust as soon as a failure is detected, preventing it from moving to a different area. As the drop of LauncherOne from the carrier aircraft occurs at approximately 35,000 ft MSL, if propellant tanks are ruptured, the RP-1 will vaporize when exposed to the ambient environment. The oxidizer in the rocket is LOX that will boil off into the atmosphere with no adverse effects. Once the rocket impacts the ocean surface, it will break up into small pieces and most will sink.

In the event the mission is aborted and the rocket is not released, or in case of an emergency, the carrier aircraft and LauncherOne rocket would return to Andersen AFB.

VO may identify additional flight corridors, trajectories, and drop points to support future mission needs. However, this EA analyzes the launch and mission parameters as described above. If VO requests to modify the launch license to include additional launch and mission parameters, the FAA will review any new information to determine whether it falls outside the scope of the analysis in this EA and whether it would require additional environmental review.

2.1.3.3 Post-flight Operations

For nominal launches, all of the oxidizer would be consumed during the rocket's powered flight. For a nominal launch, no hazardous post-flight ground operations would be required to return the carrier aircraft to safe conditions, so the carrier aircraft would be returned to Andersen AFB. For aborted flights, LOX and RP-1 would remain on-board the rocket for the return to Andersen AFB. After the carrier aircraft returns to Andersen AFB, for safety purposes, the LOX would be off-loaded (it takes approximately 2 hours to unload), and the aircraft would be moved so it does not interfere with runway operations. The RP-1 may stay on board if there is an intent to re-attempt the launch, and the carrier aircraft would be moved to an area at Andersen AFB that would not interfere with runway or other aircraft operations. In accordance with Andersen AFB requirements, any hazardous post-flight ground operations would take place in a specified location that has established appropriate safety clear zones.

2.2 No Action Alternative

Under the No Action Alternative, the FAA would not issue a launch license to VO for LauncherOne operations from Andersen AFB. This alternative provides the basis for comparing the environmental consequences of the Proposed Action.

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Chapter 3. Affected Environment and Environmental Consequences

3.1 Introduction

This chapter provides a description of the affected environment and potential environmental consequences for the environmental impact categories that have the potential to be affected by the Proposed Action and No Action Alternative. The environmental impact categories assessed in this EA include air quality; climate; cultural resources, including historical, architectural, and archeological; noise and noise-compatible land use; Section 4(f) resources; water resources; biological resources; and hazardous materials, solid waste, and pollution prevention.

This EA examines two general areas that encompass the areas potentially affected by the Proposed Action. The first area, associated with takeoff and landing of the carrier aircraft, is Andersen AFB and the immediate airspace. The second area includes the LauncherOne drop point and associated flight trajectory, potential sonic boom area, and the location of the splashdown of the first stage and fairings. Specific environmental impact category study areas vary and are defined in this chapter. The level of detail provided in this chapter is commensurate with the importance of the potential impact on the environmental impact categories.

The following environmental impact categories are not analyzed in detail for the reasons stated.

- **Visual Effects:** Visual effects are related to the extent to which the Proposed Action would produce light emissions that create annoyance or interfere with activities; or the extent to which the Proposed Action would detract from, or contrast with, visual resources or the visual character of the existing environment. Andersen AFB currently supports existing aircraft operations, including B747 aircraft, which is the same as the carrier aircraft, as well as numerous large military aircraft such as B-52 and B-1 bombers. Based on the most current data summarizing flight operations by aircraft type, Andersen AFB supported approximately 23,691 flights annually, or approximately 65 operations per day in 2013 (PACAF and AFCEE 2013). The addition of a proposed maximum of 10 flight operations per year by the carrier aircraft would be imperceptible with respect to visual effects, as it would represent approximately 0.04% of all flights annually. The pre-flight and post-flight activities involved with the Proposed Action would not differ visually from those activities already occurring at Andersen AFB. Operation of the carrier aircraft with a mated rocket would not affect visual resources in either study area, as the contrails left by the carrier aircraft and rocket would be similar in visual impact to the contrails from existing aircraft operations in the vicinity of Andersen AFB and in airspace east of Guam. The Proposed Action would not degrade the existing visual character or quality of Andersen AFB and its surroundings and would have no adverse effect on a scenic vista or scenic resources. Under the Proposed Action, no new source of substantial light or glare would be created that would adversely affect day or nighttime views in the area. Therefore, implementation of the Proposed Action would not have significant visual effects.
- **Coastal Resources:** Per FAA Order 1050.1F, coastal resources include all natural resources occurring within coastal waters and their adjacent shorelands. The entire island of Guam is classified as a coastal zone under the Coastal Zone Management Act (CZMA), excluding lands solely under federal jurisdiction such as Andersen AFB, where part of the Proposed Action takes

place. The Guam Coastal Management Program was established in 1979 through a Cooperative Agreement between the National Oceanic and Atmospheric Administration (NOAA) and the Bureau of Planning Office of the Governor. The program's authorities are provided for in the CZMA, as well as by the regulatory and enforcement authorities of a network of local agencies, including the Department of Land Management, Public Works, Parks and Recreation, Agriculture, and Guam Environmental Protection Agency (JRM 2019). Under the Proposed Action, carrier aircraft takeoffs and landings would occur on an existing runway at Andersen AFB and LauncherOne operations would occur over the open ocean at an altitude >35,000 ft MSL. These operations would take place well away from coastal resources on Guam. Therefore, implementation of the Proposed Action would not result in any impacts to the coastal zone or coastal resources. Prior to the FAA issuing VO a license, in compliance with the CZMA and its implementing regulations as well as FAA policy, VO must submit a consistency certification to the Guam's Coastal Management Program (CMP) to ensure the project is consistent with Guam's CMP.

- **Land Use:** The Proposed Action would not result in any new types of ground operations and would not change the existing or planned land use of Andersen AFB. Carrier aircraft operations would take off from an existing runway at Andersen AFB and would conform to the designated land uses. As mentioned previously, Andersen AFB currently supports existing aircraft operations, including B-747 aircraft, which is the same as the carrier aircraft.
- **Farmlands:** The Proposed Action does not involve construction activities and therefore will not impact farmlands, as defined by the Farmland Protection Policy Act.
- **Natural Resources and Energy Supply:** The Proposed Action would not result in any measurable effect on local supplies of energy or natural resources. The Proposed Action would not result in the development of new facilities or result in notable changes in local energy demands or consumption of other natural resources. The Proposed Action would not require additional sources of power or other public utilities.
- **Socioeconomics, Environmental Justice, and Children's Environmental Health and Safety Risks:** The Proposed Action would not require construction or development. Further, only existing VO personnel would be used to conduct launch activities and therefore would not induce population growth or affect the number of jobs at Andersen AFB or in the nearby communities. Proposed carrier aircraft takeoffs and landings would constitute approximately 0.04% of the daily operations at Andersen AFB over a 12-month period and would be similar to existing operations. There would be no impacts that disproportionately affect environmental justice populations. Additionally, no component of the Proposed Action would result in a disproportionate health and safety risk to children. Therefore, implementation of the Proposed Action would not result in significant impacts related to socioeconomics, environmental justice, or children's environmental health and safety risks.

3.2 No Action Alternative

Under the No Action Alternative, the FAA would not issue a launch license to VO for carrier aircraft operations from Andersen AFB. Therefore, VO would not conduct 747 carrier aircraft operations from Andersen AFB and LauncherOne rocket operations over the Pacific Ocean east of Guam. Under the No Action Alternative, there would be no new impacts to the environmental impact categories analyzed in this EA.

3.3 Air Quality

3.3.1 Definition of Resource and Regulatory Setting

Air quality is the measure of the condition of the air expressed in terms of ambient pollutant concentrations and their temporal and spatial distribution. Air quality regulations in the United States are based on concerns that high concentrations of air pollutants can harm human health, especially for children, the elderly, and people with compromised health conditions; as well as adversely affect public welfare by damage to crops, vegetation, buildings, and other property.

3.3.1.1 National Ambient Air Quality Standards (NAAQS)

Under the Clean Air Act (CAA), the U.S. Environmental Protection Agency (USEPA) developed the NAAQS for seven common air pollutants: carbon monoxide (CO), nitrogen dioxide (NO_2), ozone (O_3), particulate matter $\leq$10 micrometers in diameter and >2.5 micrometers in diameter (PM_{10}), particulate matter $\leq$2.5 micrometers in diameter ($PM_{2.5}$), sulfur dioxide (SO_2), and lead (Pb) (USEPA 2016a). The USEPA determined that these criteria air pollutants may harm human health and the environment, and cause property damage. The USEPA regulates these pollutants to permissible levels through human health-based (primary standards) and environmental-based (secondary standards) criteria. Toxic air pollutants, also called hazardous air pollutants, are a class of pollutants that do not have ambient air quality standards but are examined on an individual basis when there is a source of these pollutants. Additional information on the CAA and the NAAQS can be found in the FAA Order 1050.1F Desk Reference (FAA 2020).

3.3.1.2 Conformity Analyses in Nonattainment and Maintenance Areas

Areas that exceed a NAAQS standard are designated as "nonattainment" for that pollutant, while areas in compliance with a standard are in "attainment" for that pollutant. An area may be nonattainment for some pollutants and attainment for others simultaneously. The USEPA delegates the regulation of air quality to states and U.S. territories, through their air quality management agencies, and are required to prepare and implement a State Implementation Plan (SIP) for nonattainment areas, which demonstrate how the area will meet the NAAQS. Areas that have achieved attainment may be designated as "maintenance areas," subject to maintenance plans showing how the area will continue to meet the NAAQS.

Federal actions are required to conform with the approved SIP for those areas of the U.S. designated as nonattainment or maintenance air quality areas for any criteria pollutant under the CAA (40 CFR §§ 51 and 93). This is also known as the General Conformity Rule. The purpose of the General Conformity Rule is to demonstrate that the Proposed Action would not cause or contribute to new violations of an air quality standard and that the Proposed Action would not adversely affect the attainment and maintenance of the NAAQS. A federal action would not conform if it increased the severity of any existing violations of an air quality standard or delayed the attainment of a standard, required interim emissions reductions, or delayed any other air quality milestone. To ensure that federal activities do not impede local efforts to control air pollution, Section 176(c) of the CAA (42 USC § 7506(c)) prohibits federal agencies from engaging in or approving actions that do not conform to an approved SIP. The emissions thresholds that trigger the conformity requirements are called *de minimis* thresholds.

Federal agency compliance with the General Conformity Rule can be demonstrated in several ways. The requirement can be satisfied by a determination that the Proposed Action is not subject to the General Conformity Rule, by a Record of Non-Applicability, or by a Conformity Determination. Compliance is presumed if the net increase in emissions from a federal action would be less than the relevant *de minimis* threshold. If net emissions increases exceed the *de minimis* thresholds, then a formal conformity determination must be prepared.

3.3.2 Study Area

The study area for air quality includes Andersen AFB and the surrounding area that would receive air emissions from carrier aircraft take offs and landings, and extends up to 3,000 ft above ground level (AGL). Of primary importance in this evaluation is the mixing height. In general, the mixing height is defined as the vertical region of the atmosphere where pollutant mixing occurs. Above this height, pollutants that are released generally do not mix with ground level emissions and do not have an effect on ground level concentrations in the local area. Per FAA-AEE-00-01, DTS-34 (*Consideration of Air Quality Impacts By Airplane Operations at or Above 3000 feet AGL*; September 2000), emissions above 3,000 ft AGL are not considered for local or regional air quality impacts because 3,000 ft AGL is a reasonable approximation of the nominal mixing height. Therefore, as the activities associated with the drop and operation of the LauncherOne rocket would occur >35,000 ft MSL, impacts associated with activities above the mixing level are not analyzed as they do not have an effect on ground level air pollutant concentrations.

3.3.3 Existing Conditions

Guam meets all national and local ambient air quality standards except for the area of the Cabras Power Plant, 20 miles southwest of Andersen AFB, which is in nonattainment for SO_2 primary NAAQS (USEPA 2020a). The nonattainment area extends in a circle with a radius of 3.8 miles from the power-generating facilities. The study area is not within any nonattainment areas. In addition to anthropogenic sources, volcanic activity within the Study Area naturally contributes to SO_2 concentrations in the region.

3.3.4 Environmental Consequences

Air quality impacts would be significant if the action would cause pollutant concentrations to exceed one or more of the NAAQS, as established by the USEPA under the CAA, for any of the time periods analyzed, or to increase the frequency or severity of any such existing violations.

3.3.4.1 Proposed Action

<u>Pre-Flight and Post-Flight Activities</u>

Emissions can occur from support equipment used during ground fueling operations, including trucks and equipment, and RP-1 tank venting. Trucks would be driven to the carrier aircraft and the rocket would be fueled. Approximate travel time to the loading location is anticipated to be less than 10 minutes roundtrip. For each flight event, it is assumed that up to five trucks would be utilized. Given the small number of trucks used, and the short run-time of each truck, the total emissions from pre-flight and post-flight activities would be too small to lead to violations of the NAAQS. Five trucks operating for 1 hour each during 10 fueling operations would create approximately 0.00134 tons of carbon dioxide (CO_2) per year, and proportionately less emissions of other pollutants. The air quality impacts would be insignificant and would not be distinguishable from the impacts of the other flight and ground operations at Andersen AFB.

In accordance with the Commercial Space Operations Service Agreement (CSOSA) between VO and the USAF (USAF and VO 2019), VO will provide, in advance and in a timely manner, any information that relates to activities that might have an impact upon the installation's air conformity status. VO will provide advance notice of any changes in operations or conditions that might result in increased air emissions in sufficient time to allow any necessary permits to be obtained or permits modified.

Carrier Aircraft Emissions

As described in Section 2.1, the Proposed Action would include a maximum of 10 flights per year in one year of the proposed 5-year operating period; the other 4 years would see ≤9 flights/year. The pollutants emitted by an aircraft during takeoff and landing operations are dependent on the emission rates and the duration of these operations. The emission rates are dependent upon the type of engine and its size or power rating. An aircraft operational cycle includes landing and takeoff operations and is termed the Landing and Take Off (LTO) cycle. An LTO cycle includes all normal operational modes performed by an aircraft between its descent from an altitude of about 3,000 ft on landing and subsequent takeoff to reach the 3,000 ft altitude. The term "operation" in this context is used by the FAA to describe either a landing or a takeoff cycle. Therefore, two operations make one LTO cycle. The aircraft LTO cycle is divided into five segments or operational "modes" and categorized by:

- landing approach (descent from about 3,000 ft to runway touch down),
- taxi/idle-in,
- taxi/idle-out,
- takeoff, and
- climb out (ascent from runway to about 3,000 ft)

The USEPA's basic methodology for calculating aircraft emissions at any given airport in any given year can be summarized in six steps: (1) determine airport activity in terms of the number of LTOs; (2) determine the mixing height to be used to define an LTO cycle; (3) define the fleet make-up at the airport; (4) estimate time-in-mode (TIM); (5) select emission factors; and (6) calculate emissions based on the airport activity, TIM, and aircraft emission factors.

The emissions for the Proposed Action are based on the time of operation in each mode and the emission rates of the carrier aircraft engines. The time in the landing approach and climb-out modes are assumed to be 4.7 minutes and 3.0 minutes, respectively. The anticipated takeoff time is 0.5 minute and represents the time for initial climb from ground level to about 500 ft. The time in taxi/idle mode has been estimated as 15 minutes for both taxi/idle in and taxi/idle-out (FAA 2017).

Aircraft emissions for criteria pollutants were calculated by multiplying the TIM against respective emission factors and number of estimated flights. Table 3.3-1 lists the estimated annual criteria and precursor air pollutant emissions for the Proposed Action and compares them to the General Conformity *de minimis* emission levels for each pollutant as an indicator of potential impacts. The increase in carrier aircraft activities would result in a corresponding increase in criteria and precursor pollutant emissions. Although all would increase under the Proposed Action, air pollutant emissions under the Proposed Action would not result in violations of NAASQ because they would not have a measurable impact on air quality. As shown in Table 3.3-1, estimated emissions from the Proposed Action would account for less than 1% of the allowable emissions. Refer to Appendix A for detailed calculations and assumptions.

Table 3.3-1. Criteria and Precursor Air Pollutant Emissions for LTO Cycle under the Proposed Action

Emission Source	Criteria and Precursor Air Pollutant Emissions (tons/year)				
	CO	NO_x	VOCs	SO_x	PM
Carrier Aircraft LTOs (tons per LTO)	0.009	0.043	0.001	0.001	<0.001
Annual Carrier Aircraft LTOs	**0.089**	**0.43**	**0.01**	**0.01**	**<0.01**
de Minimis Levels	100	100	100	100	100

Notes: NO_x = nitrogen oxides, VOC = volatile organic compounds, SO_x = sulfide oxides.
Sources: USEPA 1999; USAF 2002; International Civil Aviation Organization 2019.

The USEPA has listed 188 hazardous air pollutants regulated under Title III (Hazardous Air Pollutants), Section 112(g) of the CAA. Hazardous air pollutants are emitted by processes associated with the Proposed Action, including fuel combustion. The amounts of hazardous air pollutants emitted are small compared to the emissions of criteria pollutants; emission factors for most hazardous air pollutants from combustion sources are roughly three or more orders of magnitude lower than emission factors for criteria pollutants. Hazardous air pollutant emissions estimates were not calculated because of the small amounts that would be emitted.

Under the Proposed Action, hazardous pollutant emissions would increase, and the increases would be roughly proportional to the increases observed for the criteria air pollutants emitted. Hazardous air pollutants emissions would be intermittent and distributed over the Andersen AFB study area. Their concentrations would be further reduced by atmospheric mixing and other dispersion processes. After initial mixing, it is possible that hazardous pollutants would be measurable, but they would be in very low concentrations and would not affect the air quality in the region. Therefore, no significant impacts to air quality would occur under the Proposed Action.

LauncherOne Rocket Emissions

Rocket activities would occur at altitudes above 35,000 ft AGL, in the atmospheric layer of the stratosphere. Pollutants that are released in the stratosphere do not mix with ground level emissions and do not have an effect on ground level concentrations in any local area. Additionally, per FAA-AEE-00-01 DTS-34, these activities are exempt from analysis for local and regional air quality. Accordingly, rocket activities would have no impact on regional air quality.

3.4 Climate

3.4.1 Definition of Resource and Regulatory Setting

Climate change is a global phenomenon that can have local impacts. Scientific measurements show that Earth's climate is warming, with concurrent impacts including warmer air temperatures, increased sea level rise, increased storm activity, and an increased intensity in precipitation events. Research has shown there is a direct correlation between fuel combustion and greenhouse gas (GHG) emissions. GHGs are defined as including carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF6). CO2 is the most important anthropogenic GHG because it is a long-lived gas that remains in the atmosphere for up to 100 years.

GHGs have varying global warming potential (GWP). The GWP is the potential of a gas or aerosol to trap heat in the atmosphere; it is a measure of the total energy the emissions of 1 ton of gas will absorb over a given period of time (usually 100 years), compared to the emissions of 1 ton of CO_2 (USEPA 2018). The reference gas for GWP is CO_2; therefore, CO_2 has a GWP of 1. The other main GHGs that have been attributed to human activity include CH_4, which has a GWP of 28, and N_2O, which has a GWP of 265

(Myhre et al. 2013). CO_2, followed by CH_4 and N_2O, are the most common GHGs that result from human activity. CO_2, and to a lesser extent, CH_4 and N_2O, are products of combustion and are generated from stationary combustion sources as well as vehicles. The following formula is used to calculate the Carbon Dioxide Equivalent (CO_2e).

$$CO_2e = (CO_2 \times 1) + (CH_4 \times 28) + (N_2O \times 265)$$

The FAA has developed guidance for considering GHGs and climate under NEPA, as published in the Desk Reference to Order 1050.1F (FAA 2020). An FAA NEPA review should follow the basic procedure of considering the potential incremental change in CO_2 emissions that would result from the proposed action and alternative(s) compared to the no action alternative for the same timeframe, and discussing the context for interpreting and understanding the potential changes. For such reviews, this consideration could be qualitative (e.g., explanatory text), but may also include quantitative data (e.g., calculations of estimated project emissions).

3.4.2 Study Area

GHG emissions for this project are considered globally since climate change is a global issue. This means GHG emissions are considered at all altitudes for a carrier aircraft flight and LauncherOne launch.

3.4.3 Existing Conditions

In 2018, U.S. GHG emissions totaled an estimated 6,677 million MT of CO_2e. This 2018 total represents a 10.2% decrease since 2005 (USEPA 2020b). Transportation activities accounted for 36.3% of U.S. CO_2 emissions from fossil fuel combustion in 2018. The largest sources of transportation CO_2 emissions in 2018 were light-duty vehicles (including passenger cars and light-duty trucks) (58.6%), medium- and heavy-duty trucks (23.2%), commercial aircraft (6.9%), other aircraft (2.4%), and other sources (9.5%). Across all categories of aviation, CO_2 emissions decreased by 7.2% between 1990 and 2018 (USEPA 2020b).

Based on the most current GHG data for Guam, GHG emissions for 2012 totaled 1.2 million MT of CO_2e (USEPA 2019). This value is based only on emissions from large facilities (e.g., power plants) and does not include other sources such as transportation.

While aviation in general represents a small percentage of fossil fuel use, it is important to note the unique impacts aviation emissions contribute because of their release at altitude. The majority of aircraft emissions occur high in the atmosphere, and the impact of burning fossil fuels at altitude is greater than burning the same fuels at ground level (particularly with regard to NO_x) (Intergovernmental Panel on Climate Change 1999). In addition, the mixture of exhaust gases discharged from aircraft perturbs radiative forcing directly through the heating effect and indirectly through affecting the microphysical processes of cirrus clouds formations (Lee et al. 2009).

3.4.4 Environmental Consequences

The FAA has not established a significance threshold for climate, nor has the FAA identified specific factors to consider in making a significance determination for GHG emissions. There are currently no accepted methods of determining significance applicable to commercial space launch projects given the small percentage of global GHG emissions they contribute. There is a considerable amount of ongoing scientific research to improve understanding of global climate change, and FAA guidance will evolve as the science matures or if new federal requirements are established.

3.4.4.1 Proposed Action

The projected increase in GHG emissions from the Proposed Action is discussed in the context of national and global emissions from all sources. GHG emissions for ground activities were not calculated for the Proposed Action because their minor usage contributes only incrementally (0.00134 tons of CO_2/year) when compared to the GHG emissions from carrier aircraft and rocket operations.

A maximum of 10 missions are anticipated in any 1 year during the 5-year operating period. Each mission would produce 33.0 MT of CO_2e (Table 3.4-1). Refer to Appendix A for detailed calculations and assumptions. Therefore, the total GHG emissions for the single year with a maximum of 10 missions would be 330 MT. The number of proposed annual missions during all other years during the 5-year operating period would be <u><</u>9.

Table 3.4-1. Projected Annual Greenhouse Gas (CO_2e) Emissions under the Proposed Action

Emission Source	$C0_2e$ Emissions (MT)
GHG Emissions of Carrier Aircraft per LTO Cycle (<3,000 ft)	3.1
GHG Emissions of Carrier Aircraft per Flight to Drop Point (≥3,000 ft)	19.3
GHG Emissions per Rocket Launch	10.6
Total GHG Emissions for One Operation	**33.0**

Sources: U.S. Energy Information Administration 2016; The Climate Registry 2019.

As the 2018 GHG emissions on Guam were estimated at 1.2 million MT, the addition of a maximum of 33 MT/year would only represent an increase of 0.0001% in the annual GHG emissions on Guam. This is an inconsequential amount and would not result in a significant increase in GHG emissions on Guam. In addition, the level of GHG emissions under the Proposed Action would be lower in the other 4 years of the proposed 5-year operating period for proposed carrier aircraft and rocket operations.

3.5 Noise and Noise-Compatible Land Use

3.5.1 Definition of Resource and Regulatory Setting

Sound is a physical phenomenon consisting of pressure fluctuations that travel through a medium, such as air, and are sensed by the human ear. Noise is considered any unwanted sound that interferes with normal activities (e.g., sleep, conversation, student learning) and can cause annoyance. Noise sources can be constant or of short duration and contain a wide range of frequency (pitch) content. Determining the character and level of sound aids in predicting the way it is perceived. Noise associated with aircraft takeoffs and landings, launch noise, and sonic booms are classified as short-duration events.

The compatibility of existing and planned land uses with proposed FAA actions is usually determined in relation to the level of aircraft (or launch vehicle) noise. Federal compatible land use guidelines for a variety of land uses are provided in Table 1 in Appendix A of 14 CFR part 150, *Land Use Compatibility with Yearly Day-Night Average Sound Levels*.

The FAA has determined that the cumulative noise energy exposure of individuals to noise resulting from FAA actions must be established in terms of yearly Day-Night Average Sound Level (DNL), the FAA's primary noise metric. DNL accounts for the noise levels of all individual aircraft/launch vehicle events, the number of times those events occur, and the period of day/night in which they occur. Both noise metrics logarithmically average aircraft sound levels at a location over a complete 24-hour period, with a 10-decibel (dB) adjustment added to those noise events occurring from 10:00 p.m. to 7:00 a.m. The 10-dB adjustment is added because of the increased sensitivity to noise during normal night time hours and because ambient (without aircraft/launch vehicles) sound levels during nighttime are typically about 10-

dB lower than during daytime hours. More information on noise and noise-compatible land use can be found in the FAA Order 1050.1F Desk Reference (FAA 2020).

3.5.2 Study Area

Andersen AFB is located on the north end of the island of Guam. Northwest Field, an unlit auxiliary airfield, is approximately 5 miles northwest of the center of the primary airfield at Andersen AFB. The only other major aviation use on the island is A.B. Won Pat International Airport (or Guam International Airport). The Andersen AFB runways terminate approximately 1 mile inside the border of Andersen AFB. Numerous residences are located on the border of Andersen AFB to the south and west and there is one school (Lupi Elementary) approximately 1 mile south of the Andersen AFB runways. This school is outside the 2013 Air Installations Compatibility Use Zones (AICUZ) 65-dB DNL contour (PACAF and AFCEE 2013). The 65-dB DNL contour is typically used to help determine compatibility of aircraft operations with local land use and the 65-dB DNL contour is the Federal significance threshold for aircraft noise exposure (FAA 2020). Therefore, the study area for Andersen AFB extends to the 65-dB DNL contour based on the 2013 AICUZ report for Andersen AFB (PACAF and AFCEE 2013) (Figure 3.5-1).

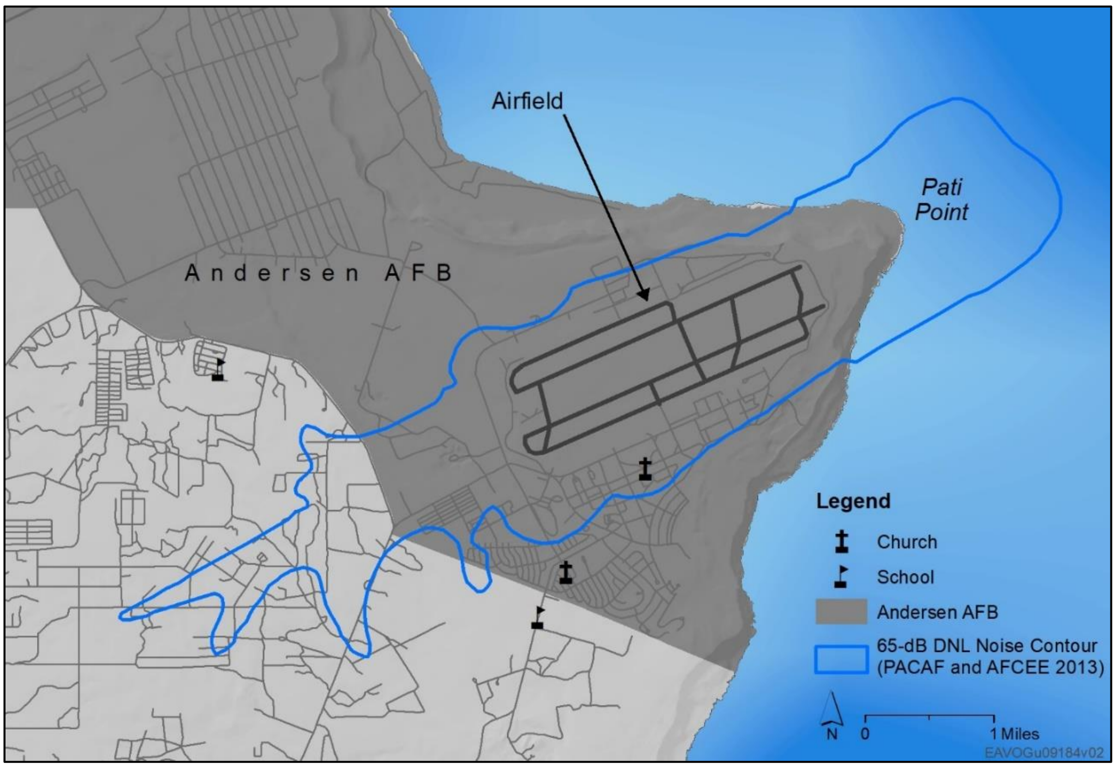

Figure 3.5-1. Current 65-dB DNL Noise Contour at Andersen AFB

The carrier aircraft and LauncherOne rocket would take off from Andersen AFB and fly south to the designated drop point approximately 75 nm south-southwest of Guam. LauncherOne would be carried to an altitude of approximately 35,000–40,000 ft MSL where it would be released. Following ignition of the rocket's first stage, the rocket would be at supersonic speed (in excess of 768 mph), and the engine would burn until all of the propellant is consumed. Therefore, the study area for noise also includes the area under the LauncherOne trajectory when travelling supersonically and can create a sonic boom that would propagate to the ocean surface.

3.5.3 Existing Conditions

Based on the most current data summarizing flight operations by aircraft type, Andersen AFB supported approximately 23,691 flights annually, or approximately 65 operations per day in 2013 (PACAF and AFCEE 2013). Aircraft from both Andersen AFB and the Guam International Airport contribute to aircraft noise on Guam. The International Airport is operated by the Guam International Airport Authority, and handles nearly all of the commercial flights into and out of Guam and is the only civilian air transportation facility on Guam. Andersen AFB is home to the 36th Wing (host unit) as well as to the 624th Regional Support Group, Navy Helicopter Squadron 25, and several other tenant organizations, and also handles Air Mobility Command Flights for military personnel and their dependents.

The area south and west of Andersen AFB is mostly rural. The most commonly occurring noise sources in the area include local vehicle traffic and noise associated with activities at Andersen AFB. Community noise levels in the area are presented in the Andersen AFB AICUZ (PACAF and AFCEE 2013), show noise contours above 65 dBA extending to the northeast and southwest past the boundaries of AAFB. The configuration of the contours generally follows that of aircraft takeoff and landing routes. While these contours represent the 24-hour average sound level a sensitive receptor might encounter, single event noise levels from aircraft activity are readily audible throughout the surrounding community.

3.5.4 Environmental Consequences

Noise impacts would be significant if the action would increase noise by DNL 1.5 dB or more for a noise-sensitive area that is exposed to noise at or above the DNL 65 dB noise exposure level, or that will be exposed at or above the DNL 65 dB level due to a DNL 1.5 dB or greater increase, when compared to the no action alternative for the same timeframe. For example, an increase from DNL 65.5 dB to 67 dB is considered a significant impact, as is an increase from DNL 63.5 dB to 65 dB.

To determine the potential change in DNL, the FAA's Area Equivalent Method (AEM) is used. AEM is a screening procedure used to simplify the assessment step in determining the need for further analysis. AEM is a mathematical procedure that provides an estimated noise contour area of a specific airport given the types of aircraft and the number of operations for each aircraft. The noise contour area is a measure of the size of the landmass enclosed within a level of noise as produced by a given set of aircraft operations. The AEM produces noise contour areas (in square miles) for the DNL 65 dBA noise level and the purpose of AEM is to screen for significant impact within the 65-dBA contour area. Whether AEM results are significant depends both on the threshold of 17% area increase (an increase of approximately DNL 1.5 dBA distributed proportionately with no change in contour shape) and the level of public controversy surrounding the study project.

3.5.4.1 Proposed Action

Carrier Aircraft Operations at Andersen AFB

Based on the most current data summarizing flight operations by aircraft type, Andersen AFB supported approximately 23,691 flights annually, or approximately 65 operations per day in 2013 (PACAF and AFCEE 2013). The adjacent community experiences high noise levels from takeoffs and landings of military jets and helicopters. Portions of the community underlie 24-hour noise contours in excess of 65 dBA DNL.

To determine the potential noise impacts from a maximum of 10 annual carrier aircraft takeoffs and landings per year, the AEM model was used. As shown in Table 3.5-1, adding 10 take off and landings per year has the potential to change the 65 dBA DNL by 0.2%. This is below the 17% increase threshold which would represent a 1.5 dB increase in the DNL. Note that the AEM does not incorporate helicopters in its model. At Andersen AFB, helicopters account for approximately one-third of the daily operations. Inclusion of these helicopter operations would further decrease the contribution of the carrier aircraft noise to the airfield DNL contours and further reduce the percent change in area.

Table 3.5-1. AEM Model Results

DNL (dBA)	Baseline Area (acres)	Alternative Area (acres)	Change in Area
65	25,568	25,632	0.2%

Carrier aircraft takeoffs and landings are not expected to change the average DNL contours as reported in the 2013 AICUZ study (PACAF and AFCEE 2013) or elevate the DNL noise level more than 1.5 dB above the acceptable levels of 65 dBA. The Proposed Action would represent a very small increase over the existing air traffic and it is unlikely that these activities would contribute to the overall sound environment. Therefore, noise associated with proposed take off and landings of the carrier aircraft under the Proposed Action would not significantly impact the acoustic environment of Andersen AFB and vicinity.

LauncherOne Rocket Operations

The carrier aircraft would take off from Andersen AFB and fly south to the drop point. Once at the drop point, the rocket would be released at an altitude of 35,000–40,000 ft MSL. Within 20 seconds releasing the rocket, the rocket would be flying at supersonic speeds.

To determine the potential for a sonic boom, the modeling program PCBOOM was used. Based on the modeling results, no sonic boom would intersect with land or human-sensitive receptors (Figure 3.5-2). The closest boom to the coast with a magnitude of 1.0 psf or greater is located approximately 75 nm south-southwest of Guam. Received sonic boom levels at the water's surface would be <1 psf. As none of the sonic boom events that were modeled overlap or otherwise affect the coastal zone, terrestrial areas, sensitive marine habitats (such as the Marianas Trench Marine National Monument), or sensitive receptors, impacts to the marine environment related to sonic booms would be less than significant.

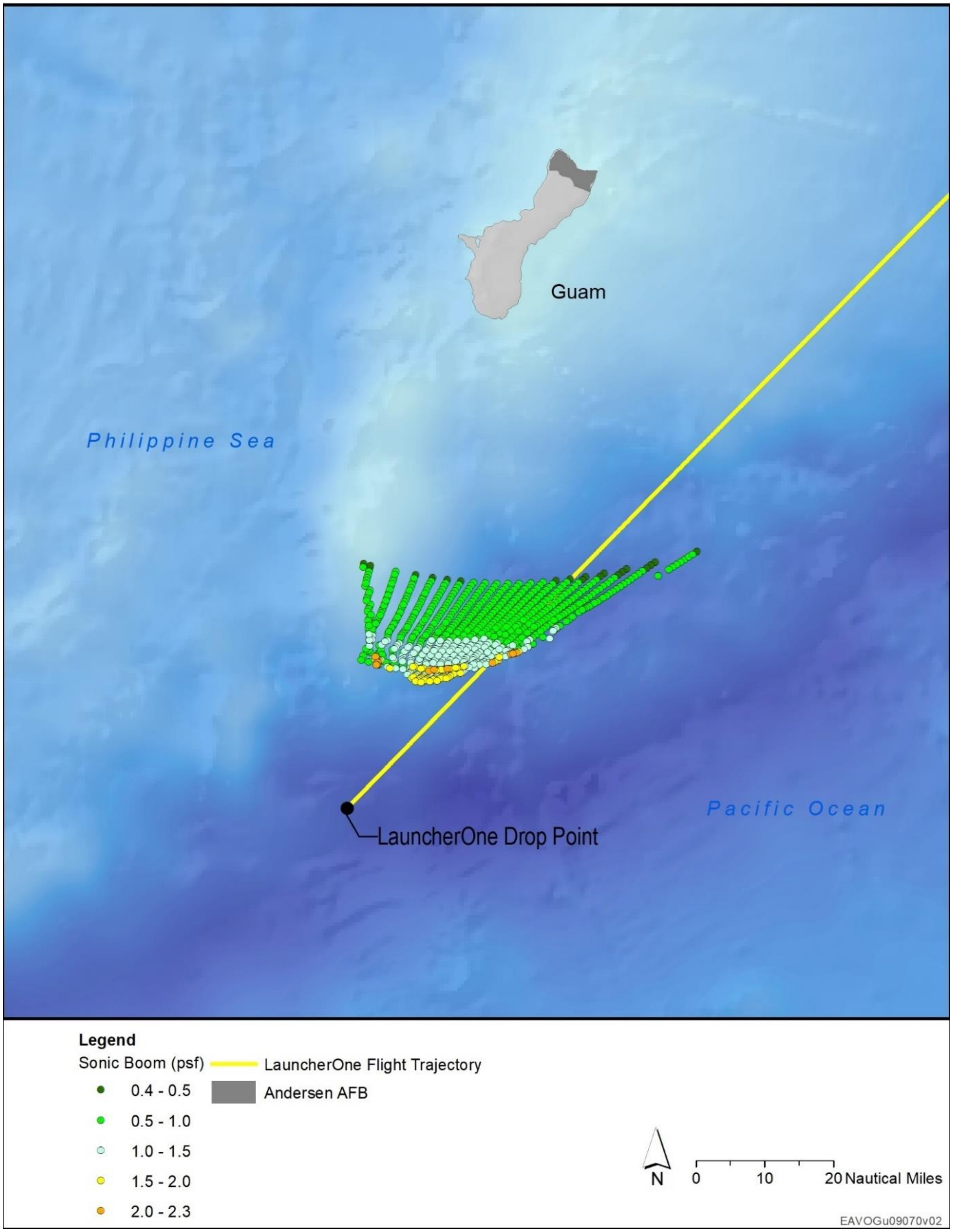

Figure 3.5-2. Modeled Potential Sonic Boom from LauncherOne Vehicle

3.6 Cultural Resources

3.6.1 Definition of Resource and Regulatory Setting

Cultural resources encompass a range of sites, properties, and physical resources relating to human activities, society, and cultural institutions. Such resources include past and present expressions of human culture and history in the physical environment, such as prehistoric and historic archaeological sites, structures, objects, and districts that are considered important to a culture or community. Cultural resources also include aspects of the physical environment, namely natural features and biota that are a part of traditional ways of life and practices and are associated with community values and institutions.

The major law that protects cultural resources is the National Historic Preservation Act (NHPA). Section 106 of the NHPA requires a federal agency to consider the effects of its action (referred to as the *undertaking*) on historic properties. Compliance with Section 106 requires consultation with the State Historic Preservation Officer (SHPO) and other parties, including Indian tribes. The Section 106 process is outlined in 36 CFR Part 800. Major steps in the process include identifying the Area of Potential Effects (APE) in consultation with the SHPO, identifying and evaluating any historic properties within the APE, and assessing the effect of the undertaking on any historic properties. If a historic property would be adversely affected, the consultation process includes resolution of adverse effects. More information on cultural resources can be found in the FAA Order 1050.1F Desk Reference (FAA 2020).

3.6.2 Study Area

In accordance with 36 CFR § 800.4(a)(1), the FAA determined an APE in consideration of the undertaking's potential direct and indirect effects. The APE (or study area) is defined as the airfield runways and immediately adjacent areas on Andersen AFB. In particular, the APE for architectural properties includes the entire potential Munitions Storage Area 2 (MSA-2) Historic District (Figure 3.6-1). Because the rocket is air-launched over the open ocean at >35,000 ft MSL, rocket operations south and east of Guam would not have the potential to affect cultural resources.

3.6.3 Existing Conditions

During World War II (WWII), two B-29 bomber airfields were built on Guam in the area that is now Andersen AFB: Northwest Field and North Field. After WWII, Northwest Field was decommissioned but North Field continued to be used and additional facilities were added in response to military needs arising from the Cold War, Korean War, and Vietnam War. When the USAF became a separate service in 1947, North Field became North Guam AFB. The installation was renamed Andersen AFB in 1949 (Andersen AFB 2007a).

The Andersen AFB study area includes potential historic properties that are part of the built environment, which include the airfield proper (e.g., taxiways, runways, aprons) (eligible for its WWII inception) and MSA-2 (eligible for its Cold War association). There are no other NRHP-listed or -eligible properties within or in the vicinity of proposed carrier aircraft operations at Andersen AFB (Naval Facilities Engineering Command Marianas 2015).

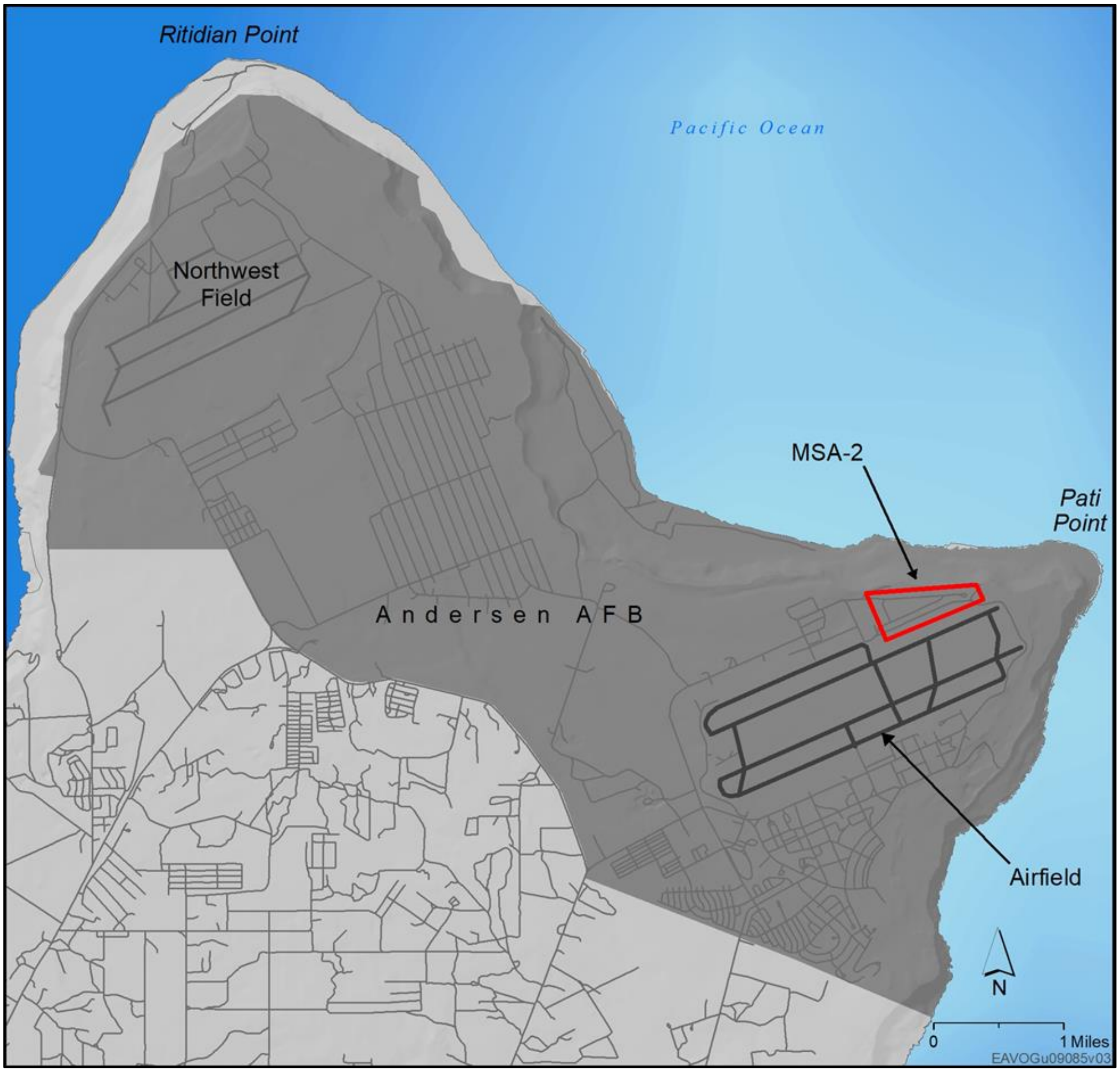

Figure 3.6-1. Location of MSA-2 within Andersen AFB

This potential MSA-2 Historic District was first identified by Mason Architects, Inc. (2004) and recommended eligible for listing in the NRHP under Criteria A and C.[(4)] The 2004 study defined the district as including "the various types of storage igloos" on MSA-2. A 2017 architectural history study of MSA-2 assessed the conditions and significance of architectural resources located within MSA-2 (Dixon et al. 2017). The same study found the Type 4 igloos and Facility 51150 (Munitions Support Equipment Maintenance) in MSA-2 to be eligible for the NRHP under Criterion A for their associations with Strategic Air Command's Cold War era nuclear program. Type 4 igloos and Facility 51150 are also eligible under NRHP Criterion C for their specialized designs that were specific to their direct roles in supporting Strategic Air Command's program. Furthermore, a historic district comprising the individually eligible structures and secondary supporting structures is eligible under NRHP Criterion A. The boundary of the district encompasses the fenced area of MSA-2.

[(4)] NRHP criteria for significance: A = eligible because they are associated with events that have made a significant contribution to the broad pattern of history; C = eligible because they embody the distinctive characteristics of a type, period, or method of construction (36 CFR 60.4).

3.6.4 Environmental Consequences

The FAA has not established a significance threshold for cultural resources. Factors to consider when assessing the significance of potential impacts on cultural resources include whether the action would result in a finding of *Adverse Effect* through the Section 106 process. However, an adverse effect finding does not automatically trigger preparation of an EIS.

3.6.4.1 Proposed Action

Carrier Aircraft Operations at Andersen AFB

Routine aircraft operations at Andersen AFB have not been an issue for any previous Section 106 consultations. Future impacts to historic properties that are part of the built environment, which include the airfield proper (eligible for its WWII inception) and MSA-2 (eligible for its Cold War association), have been addressed with Historic American Engineering Records. While both the airfield and the MSA-2 structures are built to withstand the vibrations inherent in use of the airfield (e.g., B-52s have routinely used the runways and have done their power checks on the parking aprons, exercises are routinely conducted that result in ramped-up flight activities with a variety of aircraft, and the MSA-2 structures are built to contain the effects of explosions), any damage that might result from enhanced vibrations associated with the proposed B-747 carrier aircraft operations on the airfield would not affect eligibility of the airfield-related properties (36 CES/CEV 2020).

The Proposed Action, known as an undertaking per NHPA Section 106, would not result in any ground-disturbing activities and would not require any construction or modification of facilities at Andersen AFB. Proposed carrier aircraft operations would occur on existing apron, taxiway, and runway surfaces and there would be no changes to these areas under the Proposed Action. Carrier aircraft operations would be similar to military activities currently conducted on the same aprons, taxiways, and runways. There are no known cultural resources underlying the proposed LauncherOne trajectory that would be potentially impacted by proposed rocket operations. The FAA has made a finding of No Historic Properties Affected in accordance with 36 CFR part 800. The FAA conducted Section 106 consultation with the SHPO and the SHPO concurred with the FAA's finding. Therefore, the Proposed Action would not result in significant impacts on historical, architectural, archeological, or cultural resources.

3.7 Department of Transportation Act, Section 4(f)

3.7.1 Definition of Resource and Regulatory Setting

Section 4(f) of the U.S. Department of Transportation (DOT) Act of 1966 (now codified at 49 USC § 303) protects significant publicly owned parks, recreational areas, wildlife and waterfowl refuges, and public and private historic sites. Section 4(f) provides that the Secretary of Transportation may approve a transportation program or project requiring the use of publicly owned land of a public park, recreation area, or wildlife or waterfowl refuge of national, state, or local significance, or land of an historic site of national, state, or local significance, only if there is no feasible and prudent alternative to the using that land and the program or project includes all possible planning to minimize harm resulting from the use.

Procedural requirements for complying with Section 4(f) are set forth in DOT Order 5610.1D, *Procedures for Considering Environmental Impacts*. The FAA also uses Federal Highway Administration (FHWA) regulations (23 CFR Part 774) and FHWA guidance (e.g., Section 4(f) Policy Paper) when assessing potential impacts on Section 4(f) properties. These requirements are not binding on the FAA; however, the FAA may use them as guidance to the extent relevant to FAA projects. More information on the DOT Act, Section 4(f) can be found in the FAA Order 1050.1F Desk Reference (FAA 2020).

3.7.2 Study Area

For the purposes of assessing potential impact to Section 4(f) properties, there are two study areas: (1) the existing airfield apron, taxiway, and runway areas of Andersen AFB and associated airspace and noise from carrier aircraft operations; and (2) the Pacific Ocean south and east of Guam under the LauncherOne trajectory, particularly those areas subject to sonic booms and the area beneath the Drop Point, Stage 1, and Fairings Re-entry AHAs (Figure 2.1-7).

3.7.3 Existing Conditions

3.7.3.1 Andersen AFB

The Andersen AFB study area includes potential historic properties that are part of the built environment, which include the airfield proper (e.g., taxiways, runways, aprons) (eligible for its WWII inception) and MSA-2 (eligible for its Cold War association). There are no other NRHP-listed or -eligible properties within or in the vicinity of proposed carrier aircraft operations at Andersen AFB (Naval Facilities Engineering Command Marianas 2015). Refer to Section 3.6, *Cultural Resources*, for further details.

3.7.3.2 Pacific Ocean underlying the LauncherOne Trajectory

The only Section 4(f) property that lies within the Pacific Ocean study area is the Marianas Trench Marine National Monument (MTMNM). Designated in 2009, the MTMNM includes three units:

- Islands Unit: the waters and submerged lands of the three northernmost Mariana Islands (Farallon de Pajaros [also known as Uracus], Maug, and Asuncion).
- Volcanic Unit: the submerged lands within 1 nm of 21 designated volcanic sites located west of the Mariana Islands.
- Trench Unit: the submerged lands extending from the northern limit of the US EEZ in the CNMI to the southern limit of the EEZ in the Territory of Guam.

No waters are included in the Volcanic and Trench Units (USFWS 2012). Only the Trench Unit occurs within the study area and the southern portion underlies the proposed LauncherOne Drop Point and trajectory (Figure 3.7-1).

Presidential Proclamation 8335 established the monument under the authority of the Antiquities Act of 1906, which protects places of historic or scientific significance. Management responsibility was assigned to the Secretary of the Interior, in consultation with the Secretary of Commerce. The Interior Secretary placed the Trench Unit within the National Wildlife Refuge System, and delegated his management responsibility to the USFWS (President of the United States 2009; USFWS 2012).

3.7.4 Environmental Consequences

Impacts on Section 4(f) properties would be significant if the Proposed Action involves more than a minimal physical use of a Section 4(f) resource or constitutes a “constructive use” based on an FAA determination that the project would substantially impair the Section 4(f) resource. The concept of constructive use is that a project that does not physically use land in a park, for example, may still, by means of noise, air pollution, water pollution, or other impacts, dissipate its aesthetic value, harm its wildlife, restrict its access, and take it in every practical sense. Constructive use occurs when the impacts of a project on a Section 4(f) property are so severe that the activities, features, or attributes that qualify the property for protection under Section 4(f) are substantially impaired. Substantial impairment occurs only when the protected activities, features, or attributes of the Section 4(f) property that contribute to its significance or enjoyment are substantially diminished. This means that the value of the Section 4(f) property, in terms of its prior significance and enjoyment, is substantially reduced or lost. For example, noise would need to be at levels high enough to have negative consequences of a substantial nature that amount to a taking of a park or portion of a park for transportation purposes.

3.7.4.1 Proposed Action

Carrier Aircraft Operations at Andersen AFB

The Proposed Action does not involve any construction activities and therefore would not require a physical use of a Section 4(f) property. The Proposed Action would not require a temporary occupancy of a 4(f) resource, such as a temporary easement or right of entry. While the airfield at Andersen AFB is eligible for an NRHP listing and is the site of the Proposed Action, no impacts to the airfield, including visual or noise, would be so severe that the activities, features, or attributes of the airfield would be substantially impaired. Therefore, the Proposed Action would not result in a constructive use of a Section 4(f) property. Thus, the Proposed Action would not result in significant impacts to Section 4(f) properties.

LauncherOne Rocket Operations

The LauncherOne drop point would be located 75 nm south-southwest of Guam and would occur over the Trench Unit of the MTMNM at an altitude >35,000 ft MSL. During the expected LauncherOne firing and flight trajectory, the AHA for the re-entry of Stage 1 and the payload fairings is 325 nm northeast of the MTMNM. Therefore, there would be no impacts to the MTMNM.

However, if after the LauncherOne rocket has been released from the carrier aircraft and there is a malfunction or other issue that results in the abort of the flight, the rocket is expected to maintain structural integrity until impact the ocean within the Drop Point AHA if there is no secondary explosive failure. There is no destruct component on the vehicle. The vehicle safety system will shut down all thrust as soon as a failure is detected, preventing it from moving to a different area. Based on the altitude and speed of the LauncherOne rocket upon release from the carrier aircraft, if ignition does not occur, it is expected to impact the ocean between 1 and 7 nm from the Drop Point. As the drop of LauncherOne from the carrier aircraft occurs at approximately 35,000 ft MSL, if propellant tanks are ruptured, the RP-1 will vaporize when exposed to the ambient environment. The oxidizer in the rocket is LOX that will boil off into the atmosphere with no adverse effects. Once the rocket impacts the ocean surface, it will break up into small pieces and most will sink. These small pieces impacting the ocean floor within the MTMNM would not result in a physical or constructive use of the MTMNM, and thus would not result in significant impacts.

3.8 Water Resources

3.8.1 Definition of Resource and Regulatory Setting

Water resources are surface waters and groundwater that are vital to society; they are important in providing drinking water and in supporting recreation, transportation and commerce, industry, agriculture, and aquatic ecosystems. This impact category includes surface waters, groundwater, floodplains, and wetlands. These resources do not function as separate and isolated components of the watershed but rather as a single, integrated natural system. Disruption of any one part of this system can have consequences to the functioning of the entire system. The analysis includes not only disruption of the resources but also potential impacts on the quality of the water resources. Because of the close and integrated relationship of these resources, their analysis is conducted under the all-encompassing impact category of water resources. Wild and Scenic Rivers are included because impacts on these rivers can result from obstructing or altering the free-flowing characteristics of a designated river, an impact more closely resembling an impact on a water resource. However, there are no designated wild and scenic rivers on Guam.

The major laws and EOs pertaining to water resources include the Clean Water Act (CWA); EO 11990, *Protection of Wetlands*; EO 11988, *Floodplain Management*; and Safe Drinking Water Act. The CWA establishes the basic structure for regulating the discharge of pollutants into waters of the United States, including wetlands. Of note, the National Pollutant Discharge Elimination System (NPDES) is a federal permit created by the CWA that regulates specific stormwater and other point source pollution discharges.

EO 11990 requires federal agencies to avoid to the extent possible the long- and short-term adverse impacts associated with the destruction or modification of wetlands and to avoid direct or indirect support of new construction in wetlands wherever there is a practicable alternative. Similarly, EO 11988 requires federal agencies to avoid to the extent possible the long- and short-term adverse impacts associated with the occupancy and modification of 100-year floodplains and to avoid direct or indirect support of floodplain development wherever there is a practicable alternative.

More information on water resources, including the laws that protect them, can be found in the FAA Order 1050.1F Desk Reference (FAA 2020).

3.8.2 Study Area

The water resources study areas include the existing airfield apron, taxiway, and runway areas of Andersen AFB and the ocean area under the Drop Point AHA and Stage 1 AHA where Stage 1 would fall into the ocean.

3.8.3 Existing Conditions

Proposed carrier aircraft operations on Andersen AFB would be limited to existing airfield apron, taxiway, and runway areas consisting of concrete. These areas do not contain any surface water features and are not near a floodplain or wetlands. Andersen AFB overlies the Northern Guam Lens Aquifer (NGLA), which is a U.S. Environmental Protection Agency (USEPA)-designated sole source aquifer. The NGLA is the limestone bedrock that underlies the entire northern half of Guam and contains a large and permanent body of fresh groundwater (Water and Environmental Research Institute of the Western Pacific and Island Research & Education Initiative 2020).

The Guam Environmental Protection Agency assists in the administration of NPDES permits and reviews and certifies the permit for compliance with all local regulations and policies and in accordance with the Guam Water Quality Standards. Andersen AFB routes its wastewater discharge to Guam's Northern District Wastewater Treatment plant, which currently has an NPDES permit issued by the USEPA pursuant to the CWA.

Guam is in a tropical environment that receives an estimated 100 inches of rainfall annually. As a result, the island has unique stormwater discharge requirements. Andersen AFB is relatively flat, and heavy precipitation generally flows by sheets into swales, then into sink holes or other depressions, where it percolates into the ground or is channeled into stormwater wells. Dry injection wells that use the porous limestone bedrock to assist in stormwater migration into the NGLA below are located throughout the base. These injection wells are permitted and regulated by Guam Environmental Protection Agency through Underground Injection Control permits. A number of the wells are sampled twice a year to ensure that water entering the wells meets drinking water standards (Navy 2010; Joint Guam Program Office 2015).

The Stage 1 AHA overlies an area of the Pacific Ocean approximately 550 nm northeast of Guam where ocean depths are approximately -20,000 ft.

3.8.4 Environmental Consequences

Impacts on surface waters would be significant if the action would 1) exceed water quality standards established by federal, state, local, and tribal regulatory agencies; or 2) contaminate public drinking water supply such that public health may be adversely affected.

Impacts on wetlands would be significant if the action would:

- Adversely affect a wetland's function to protect the quality or quantity of municipal water supplies, including surface waters and sole source and other aquifers;
- Substantially alter the hydrology needed to sustain the affected wetland system's values and functions or those of a wetland to which it is connected;
- Substantially reduce the affected wetland's ability to retain floodwaters or storm runoff, thereby threatening public health, safety or welfare (the term welfare includes cultural, recreational, and scientific resources or property important to the public);
- Adversely affect the maintenance of natural systems supporting wildlife and fish habitat or economically important timber, food, or fiber resources of the affected or surrounding wetlands;
- Promote development of secondary activities or services that would cause the circumstances listed above to occur; or
- Be inconsistent with applicable State wetland strategies.

Impacts on groundwater would be significant if the action would 1) exceed groundwater quality standards established by federal, state, local, and tribal regulatory agencies; or 2) contaminate an aquifer used for public water supply such that public health may be adversely affected.

Impacts on floodplains would be significant if the action would cause notable adverse impacts on natural and beneficial floodplain values. Natural and beneficial floodplain values are defined in Paragraph 4.k of Department of Transportation Order 5650.2, *Floodplain Management and Protection*.

3.8.4.1 Proposed Action

Carrier Aircraft Operations at Andersen AFB

The Proposed Action does not involve construction activities that would potentially introduce non-point source pollution at Andersen AFB. The potential impact of operations is negligible as the LauncherOne propellants and pressurants are similar to those already in use at Andersen AFB with appropriate safety and pollution control measures in place. Any accidental spills associated with pre- and post-flight activities would be addressed by Andersen AFB emergency response procedures (refer to Section 3.9). Therefore, implementation of the Proposed Action would not have significant impacts on water resources on Andersen AFB.

LaucherOne Rocket Operations

The carrier aircraft and LauncherOne rocket would take off from Andersen AFB and fly south to the designated drop point approximately 75 nm over open ocean south-southwest of Guam. LauncherOne would be carried to an altitude of approximately 35,000–40,000 ft MSL where it would be released. Following ignition of the rocket's first stage, the engine would burn until all of the propellant is consumed and Stage 1 would fall into the ocean within the Stage 1 and Fairings Re-entry AHA approximately 550 nm northeast of Guam (Figure 2.1-7).[5]

Both stages of the rocket are expendable. Stage 1 debris would fall into the Pacific Ocean within the AHA, and second stage debris would expend into Earth's orbit. First stage and fairings debris, which is comprised of inert materials which are neither chemically or biologically reactive, is anticipated to sink relatively quickly. Accordingly, it would not affect water quality in the short term (while the debris is floating or descending through the water column) or in the long term (when the debris has settled into benthic habitats).

The propellant type used by LauncherOne Stage 1 is a mixture of a kerosene-based fuel (known as RP-1) and LOX. In the event of a launch failure and the LauncherOne rocket impacts the Pacific Ocean, surface water quality in the ocean may be temporarily affected by the release of unconsumed RP-1 and the creation of a thin film of petroleum on the water surface near the impact area. RP-1 is a Type 1 "very light oil," which is characterized as being highly volatile and having low viscosity and low specific gravity. Due to its high volatility, RP-1 evaporates quickly when exposed to the air, and would completely dissipate into ocean waters within hours due to a combination of wave movement, oxygen exposure, and sunlight (NOAA 2019). The amount of water in comparison to the amount of propellant would allow the propellant to quickly dilute so that impacts would be temporary and extremely localized. Dissipation Cleanup following a spill of very light oil is usually not necessary or possible, particularly with such a small quantity of oil that would enter the ocean in the event of an unsuccessful launch. Therefore, no attempt would be made to boom nor recover RP-1 fuel from the ocean. Although it would require hours or perhaps days for the RP-1 to completely dissipate, most of its mass would evaporate within the first few minutes. Swells and wave action would enable the remaining RP-1 to be volatized rapidly because of increased agitation and dissipation. LOX is a non-toxic cryogenic liquid which will evaporate into the air when released. Therefore, implementation of the Proposed Action would not have significant impacts on water resources underlying the Stage 1 and Fairings Re-entry AHA.

3.9 Biological Resources

3.9.1 Definition of Resource and Regulatory Setting

Biological resources are valued for their intrinsic, aesthetic, economic, and recreational qualities, and include fish, wildlife, plants, and their respective habitats. Typical categories of biological resources include terrestrial and aquatic plant and animal species, game and non-game species, special-status species (state or federally listed threatened or endangered species, marine mammals, or species of concern, such as species proposed for listing or migratory birds), and environmentally sensitive or critical habitats.

Section 7(a)(2) of the Endangered Species Act (ESA) (16 USC §1531 et seq.) requires that each federal agency, in consultation with the U.S. Fish and Wildlife Service (USFWS) or National Marine Fisheries

(5) If there is a malfunction or other issue that results in the abort of the flight, the LauncherOne may land within the Drop Point AHA. See Section 3.7.4 for further discussion.

Service (NMFS), ensures that any action they authorize, fund, or carry out is not likely to jeopardize the continued existence of a listed species or result in the destruction or adverse modification of designated critical habitat. The FAA is required to consult with the USFWS or NMFS if an action may affect a federally listed species or critical habitat.

The Marine Mammal Protection Act (MMPA) prohibits, with certain exceptions, the "take" of marine mammals in U.S. waters and by U.S. citizens on the high seas. If an action has the potential to impact marine mammals, the FAA is required to consult the USFWS (for sea and marine otters, walruses, polar bears, three species of manatee, and the dugongs) and/or NMFS (for all marine mammals). Often the marine mammals present in a project area are also listed under the ESA.

Under the Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act), the FAA must consult with NMFS if the action may adversely affect essential fish habitat (EFH). As defined by the Act, EFH refers to those waters and substrate necessary to fish for spawning, breeding, feeding or growth to maturity.

More information on biological resources, including the laws that protect them, can be found in the FAA Order 1050.1F Desk Reference (FAA 2020).

3.9.2 Study Area

There are two biological resources study areas: (1) the existing airfield apron, taxiway, and runway areas of Andersen AFB and associated airspace and noise from carrier aircraft operations; and (2) the Pacific Ocean south and east of Guam under the LauncherOne trajectory, particularly those areas subject to sonic booms and the area beneath the Drop Point, Stage 1, and Fairings Re-entry AHAs (Figure 2.1-7).

3.9.3 Existing Conditions

3.9.3.1 Andersen AFB

There would be no ground-disturbing activities associated with the Proposed Action, and therefore, no impact on vegetation communities, ESA-listed plant species, or vegetated terrestrial wildlife habitat; these resources are dismissed from further discussion. In addition, the USFWS has not designated critical habitat for federally listed threatened or endangered species on Andersen AFB. The Guam National Wildlife Refuge at Ritidian Point, approximately 7 miles northwest of the Andersen AFB airfield (Figure 2.1-2), does contain critical habitat for the threatened Mariana fruit bat, endangered Mariana crow, and endangered Guam Micronesian kingfisher (JRM 2019). Proposed carrier aircraft operations would not occur over or in the vicinity of Ritidian Point and the Guam NWR (Figures 2.1-2 and 2.1-5); therefore, critical habitat is dismissed from further discussion.

The following wildlife information is based on Andersen AFB's recent Integrated Natural Resources Management Plan (JRM 2019).

Wildlife species on Andersen AFB include nine species of non-native mammals (Norway rat [*Rattus norvegicus*], black rat [*Rattus rattus*], Polynesian rat [*Rattus exulans*], house mouse [*Mus musculus*], musk shrew [*Suncus murinus*], feral dog [*Canis lupus familiaris*], feral cat [*Felis catus*], feral pig [*Sus scrofa*], and Philippine deer [*Rusa marianna*]), and only one native mammal species, the ESA-listed endangered Mariana fruit bat (*Pteropus mariannus mariannus*). The installation also supports three other ESA-listed animal species: green turtle (*Chelonia mydas*), including nesting on the beaches north of the airfield and occurring in the marine waters north of Andersen AFB; Guam tree snail (*Partula radiolata*); and Mariana eight-spot butterfly (*Hypolimnas octocula marianensis*).

Most avian species on the installation are native to the region; however, many are seasonal visitors that use coastal, grassy, or other open habitats to forage during their annual migration. Migratory birds either spend the winter on Guam or migrate through during the spring and fall to breeding areas to the north and south. Seabirds that have the potential to occur on Andersen AFB either during migration or as year-round residents include black noddy (*Anous minutus*), brown noddy (*Anous stolidus*), brown booby (*Sula leucogaster*), red-footed booby (*Sula sula*), white tern (*Gygis alba*), great frigatebird (*Fregata minor*), sooty tern (*Onychoprion fuscatus*), and white-tailed tropicbird (*Phaethon lepturus*). Several shorebird species also occur on base including Pacific golden plover (*Pluvialis fulva*), ruddy turnstone (*Arenaria interpres*), wood sandpiper (*Tringa glareola*), wandering tattler (*Tringa incana*), grey-tailed tattler (*Tringa brevipes*), sharp-tailed sandpiper (*Calidris acuminata*), whimbrel (*Numenius phaeopus*) and several species of sandpipers and plovers. Wading birds that have the potential to migrate through or reside on Andersen AFB include Eastern cattle egret (*Bubulcus coromandus*), intermediate egret (*Ardea intermedia*), Pacific reef heron (*Egretta sacra*), and yellow bittern (*Ixobrychus sinesis*). Four non-native bird species also occur on base and include black drongo (*Dicrurus macrocercus*), Eurasian tree sparrow (*Passer montanus*), black francolin (*Francolinus francolinus*), and island collared dove (*Streptopelia bitorquata*).

In addition, a number of native and non-native reptile and amphibian species are found in appropriate habitats on Andersen AFB. Native species include Pacific blue-tailed skink (*Emoia caeruleocauda*), moth skink (*Lipinia noctua*), monitor lizard (*Varanus indicus*), and mutilating gecko (*Gehyra mutilata*); and non-native species are curious skink (*Carlia ailanpalai*), house gecko (*Hemidactylus frenatus*), brown treesnake (*Boiga irregularis*), Brahminy blind snake (*Ramphotyphlops braminus*), marine toad (*Rhinella marina*), and greenhouse frog (*Eleutherodactylus planirostris*).

3.9.3.2 Pacific Ocean underlying the LauncherOne Trajectory

<u>Birds</u>

Pelagic seabird species potentially occurring in the open ocean environment south and northeast of Guam beneath the proposed LauncherOne trajectory include Bulmer's petrel (*Bulweria bulwerii*); streaked (*Calonectris leucomelas*), wedge-tailed (*Ardenna pacifica*), and Audubon's shearwaters (*Puffinus lherminieri*); masked (*Sula dactylatra*), brown (*Sula leucogaster*), and red-footed boobies (*Sula sula*); great frigatebird (*Fregata minor*), common tern (*Sterna hirundo*), and sooty tern (*Onychoprion fuscatus*) (Baker 1951; Harrison 1983; Pratt et al. 1989). Three seabirds that may occur in the study area are listed under the ESA as threatened or endangered species: short-tailed albatross (*Phoebastria albatrus*), Hawaiian petrel (*Pterodroma sandwichensis*), and Newell's shearwater (*Puffinus auricularis newelli*) (Table 3.8-1). These three species nest outside the study area and are thought to occur only very rarely within the study area (Navy 2015; USFWS 2010, 2015). Therefore, the proposed action would have no effect on these ESA-listed bird species and are not discussed further.

<u>Marine Mammals</u>

A total of 26 marine mammal species may occur within the marine waters underlying the LauncherOne trajectory, including 5 ESA-listed endangered species (Table 3.8-1). The species presented in 3.8-1 are based on observed marine mammals during surveys in the Mariana Islands Training and Testing (MITT) Study Area and associated transit corridor in support of the MITT Draft Supplemental EIS/Overseas EIS (Navy 2019b). The MITT Study Area extends 450 nm north of Guam, 250 nm east of Guam, and 300 nm south of Guam and includes the LauncherOne drop point. The transit corridor is located on the eastern edge of the MITT Study Area and is 300 nm south of the Stage 1 and Fairings Re-entry AHA. Information from the MITT Supplemental EIS/Overseas EIS provide the best available data regarding the occurrence of marine mammals in the vicinity of the proposed LauncherOne operations. Density estimates for each species are provided in Appendix B.

Sea Turtles

Four ESA-listed endangered sea turtle species may also occur within the marine waters underlying the proposed LauncherOne activities: green sea turtle (*Chelonia mydas*), hawksbill sea turtle (*Eretmochelys imbricata*), leatherback sea turtle (*Dermochelys coriacea*), and loggerhead sea turtle (*Caretta caretta*) (Table 3.8-1). As there are no terrestrial areas underlying proposed LauncherOne activities, there are no sea turtle nesting areas in the study area.

Fish

In addition to hundreds of species of marine fish, three ESA-listed threatened fish species potentially occur within the marine waters underlying the proposed LauncherOne activities: giant manta ray (*Manta birostris*), oceanic whitetip shark (*Carcharhinus longimanus*), and scalloped hammerhead shark (*Sphyrna lewini*).

Although all of the water column and benthic nearshore resources and submerged lands under the management responsibility of Andersen AFB are designated as EFH under the Magnuson-Stevens Act (JRM 2019) occurs in the coastal zone of Guam, there would be no impacts to EFH from takeoff and landings of the carrier aircraft at Andersen AFB. No EFH occurs under the proposed LauncherOne drop point or trajectory, including the AHAs. Therefore, EFH is not discussed further.

Table 3.9-1. Special-status Marine Species Potentially underlying the Proposed LauncherOne Trajectory

Common Name	Scientific Name	ESA Status
SEABIRDS		
Hawaiian petrel	*Pterodroma sandwichensis*	E
Newell's shearwater	*Puffinus auricularis newelli)*	T
Short-tailed albatross	*Phoebastria albatrus*	E
MARINE MAMMALS*		
Blainville's beaked whale	*Mesoplodon densirostris*	nl
Blue whale	*Balaenoptera musculus*	E
Bryde's whale	*Balaenoptera edeni*	nl
Common bottlenose dolphin	*Tursiops truncatus*	nl
Cuvier's beaked whale	*Ziphius cavirostris*	nl
Dwarf sperm whale	*Kogia sima*	nl
False killer whale	*Pseudorca crassidens*	nl
Fin whale	*Balaenoptera physalus*	E
Fraser's dolphin	*Lagenodelphis hosei*	nl
Ginkgo-toothed beaked whale	*Mesoplodon ginkgodens*	nl
Humpback whale (Western North Pacific DPS)	*Megaptera novaeangliae*	E
Killer whale	*Orcinus orca*	nl
Longman's beaked whale	*Indopacetus pacificus*	nl
Melon-headed whale	*Peponocephala electra*	nl
Minke whale	*Balaenoptera acutorostrata*	nl
Omura's whale	*Balaenoptera omurai*	nl
Pantropical spotted dolphin	*Stenella attenuata*	nl
Pygmy killer whale	*Feresa attenuata*	nl

Common Name	Scientific Name	ESA Status
Pygmy sperm whale	*Kogia breviceps*	nl
Risso's dolphin	*Grampus griseus*	nl
Rough-toothed dolphin	*Steno bredanensis*	nl
Sei whale	*Balaenoptera borealis*	E
Short-finned pilot whale	*Globicephala macrorhynchus*	nl
Sperm whale	*Physeter macrocephalus*	E
Spinner dolphin	*Stenella longirostris*	nl
Striped dolphin	*Stenella coeruleoalba*	nl
Sea Turtles		
Green sea turtle (Central West Pacific DPS)	*Chelonia mydas*	E
Hawksbill sea turtle	*Eretmochelys imbricata*	E
Leatherback sea turtle	*Dermochelys coriacea*	E
Loggerhead sea turtle (North Pacific DPS)	*Caretta caretta*	E
Fish		
Giant manta ray	*Manta birostris*	T
Oceanic whitetip shark	*Carcharhinus longimanus*	T
Scalloped hammerhead shark (Indo-West Pacific DPS)	*Sphyrna lewini*	T

Notes: *All marine mammals are also listed under the MMPA. E = endangered; nl = not listed; T = threatened.
Sources: Navy 2015, 2018; National Oceanic and Atmospheric Administration (NOAA) Fisheries 2020; USFWS 2020.

3.9.4 Environmental Consequences

A significant impact on biological resources would occur if the USFWS or NMFS determines that the action would be likely to jeopardize the continued existence of a federally listed threatened or endangered species, or would result in the destruction or adverse modification of federally designated critical habitat. The FAA has not established a significance threshold for unlisted species. Factors to consider when assessing the significance of potential impacts on unlisted species include whether the action would have the potential for:

- A long-term or permanent loss of unlisted plant or wildlife species (i.e., extirpation of the species from a large project area, such as from a new commercial service airport);
- Adverse impacts on special status species or their habitats;
- Substantial loss, reduction, degradation, disturbance, or fragmentation of native species' habitats or their populations; and/or
- Adverse impacts on a species' reproductive success rates, natural mortality rates, non-natural mortality (e.g., road kills and hunting), or ability to sustain the minimum population levels required for population maintenance.

3.9.4.1 Proposed Action

Implementation of the Proposed Action would not result in significant impacts to wildlife and ESA-listed mammals, sea turtles, and fish species in the vicinity of the proposed carrier aircraft and LauncherOne activities. These impacts include noise associated with overflights of the carrier aircraft taking off and landing at Andersen AFB, in-air and underwater acoustic impacts from sonic booms under the LauncherOne trajectory, unspent RP-1 fuel from Stage 1 when it impacts the Pacific Ocean, and potential strike of marine species from Stage 1 and the fairings debris underlying the Stage 1 and Fairings AHA.

Carrier Aircraft Operations at Andersen AFB

Under the Proposed Action, a maximum of 10 takeoffs and landings would occur at Andersen AFB in any one year during the 5-year operating period. The other 4 years would see ≤9 takeoffs and landings at Andersen AFB not exceeding 25 operations across 5 years. The additional 10 flight operations per year would represent a very small increase over the baseline air traffic (23,691 operations) and it is unlikely that these activities would contribute to the overall sound environment or be noticeably different than the current sound environment at Andersen AFB. Therefore, noise associated with proposed take off and landings of the carrier aircraft under the Proposed Action would not result in significant impacts to wildlife species on and in the vicinity of Andersen AFB. In addition, in accordance with ESA section 7, the FAA has determined that the Proposed Action would have no effect on ESA-listed terrestrial species on Andersen AFB (i.e., green turtle, Mariana fruit bat, Guam tree snail, and Mariana eight-spot butterfly).

LauncherOne Rocket Operations

Sonic Booms

Impulse sounds may include a sonic boom from the LauncherOne rocket. NMFS uses conservative thresholds of received sound pressure levels from broad band sounds that may cause behavioral disturbance and injury (NMFS 2018). These conservative thresholds are applied in both MMPA permits and ESA section 7 consultations for marine mammals to evaluate the potential for sound effects. The criterion levels discussed here are specific to the levels of harassment as defined under the MMPA. Level A criteria for in-water permanent threshold shift (PTS) (injury) to marine mammals, excluding tactical sonar and explosives, range from 173 dB cumulative sound exposure level (SEL_{cum}) to 219 dB SELcum, depending on the marine mammal hearing group. Level B criterion for in-water for behavioral disruption for impulsive noise is 16o dB root mean square reference 1 micropascal (160 dB_{rms} re 1 µPa) (NMFS 2018). The proposed project activities were evaluated using the above acoustic thresholds. In the ESA context, these thresholds are informative as the thresholds at which we might expect either behavioral changes or physical injury to an animal to occur, but the actual anticipated effects would be the result of the specific circumstances of the action (as further explained below).

It is likely that any noise associated with the sonic boom would transmit from the air to water and propagate some distance in the water column. All of the boom pressure signals measured in Sohn et al. (2000) experiment decayed to ambient levels in all frequency bands by 131-164 ft. A sonic boom at the surface of 2 psf (2-4 times greater than the anticipated sonic boom from the proposed LauncherOne activities; Figure 3.5-2) decayed to approximately 152 dB_{rms} re 1 µPa at a depth of 23 ft. By 72 ft, the received level was approximately 140 dB_{rms} re 1 µPa and at 121 ft, it was equal to ambient noise levels. All of these sound pressure levels are below the current NMFS threshold for potential permanent injury for cetaceans (180 dB_{rms} re 1 µPa sound pressure level) and potential behavioral change or temporary injury (160 dB_{rms} re 1 µPa sound pressure level). Although it was not possible to estimate the point at which underwater sound pressure levels would equal or exceed 160 dB_{rms} re 1 µPa, but it is estimated this would likely occur at less than 23 ft which could be at or near the surface level of the water based on the decay rate provided above at a depth of 23 ft.

The onset of physical injury to fish would be expected if the peak levels exceed 206 dB re 1 µPa (Stadler and Woodbury 2009). The sonic boom associated with the LauncherOne operations would be significantly less than 206 dB re 1 µPa in the water column.

Based on the estimated sound levels, the frequency with which the sonic booms may occur over the course of a year, and the relative infrequency with which marine mammals (including ESA-listed marine mammals), sea turtles, and ESA-listed fish may be in the immediate vicinity during those times, sonic booms associated with LauncherOne operations would not result in significant impacts to any marine mammal, sea turtle, or ESA-listed fish species. In addition, the FAA has determined that sonic booms associated with the Proposed Action *may affect, but are not likely to adversely affect* ESA-listed marine mammal, sea turtle, and fish species beneath the LauncherOne flight trajectory. In accordance with ESA section 7 consultation requirements, FAA has requested concurrence from NMFS on this effects determination. The conclusion of the consultation will be provided in the Final EA.

Potential for Debris Strike from Stage 1 or Fairings Re-entry

The impact of debris striking a marine mammal or sea turtle may result in injury or mortality to individuals. Using a statistical probability analysis for estimating direct strike impact developed by the U.S. Navy (Navy 2019), the probability of impact of debris with a single marine mammal (P) is then multiplied by the number of animals to obtain the number of exposures (T). Refer to Appendix B for details on the methodology and assumptions. Using this procedure, P and T were calculated for the five species of ESA-listed marine mammals. P and T were also calculated for the non-ESA listed marine mammal species and the sea turtle species with the highest average month density in the Drop Point and Stage 1 AHAs (pantropical spotted dolphin and green sea turtle, respectively).

VO proposes to conduct up to a maximum of 10 LauncherOne operations per any one year during the 5-year operating period; the other 4 years would see <9 LauncherOne operations, not exceeding 25 operations across 5 years. The potential number of individuals impacted/year are reported in Table 3.8-2.

Table 3.9-2. Estimated Representative Marine Mammal and Sea Turtle Exposures from a Potential Direct Strike of the LauncherOne Stage 1 in a Single Year

Species (ESA Status)	Est. Density (km^2)*	Probability of Impact (T)	Est. No. Impacts/Year†
Humpback whale (Endangered)	0.00089	0.0000001	0.000001
Sei whale (Endangered)	0.00013	0.00000002	0.0000002
Fin whale (Endangered)	0.00006	0.00000001	0.0000001
Blue whale (Endangered)	0.00005	0.00000001	0.0000001
Sperm whale (Endangered)	0.00222	0.0000003	0.000003
Pantropical spotted dolphin	0.01132	0.0000002	0.000002
Green sea turtle (Endangered)	0.00039	0.000000005	0.00000005

Notes: *number of animals per square kilometer (km^2). See Appendix B for further details on the calculation of estimated impacts.
†Based on the maximum of 10 proposed launches in any one year of the 5-year operating period; all other years would be <9 launches/year.
Source: *Navy 2018.

For ESA-listed marine mammals, modeling based on the estimated density of individuals for each species results in estimates of the probability of a direct strike of debris with an individual during each event of 0.0000002 or less (Table 3.8-2). The estimated number of takes for each species annually, assuming the maximum of 10 LauncherOne operations and the re-entry of Stage 1, was approximately 0.000002 or less (Table 3.8-2). With the intentionally conservative overestimation of parameters and assumptions in the model, the results indicate that it is extremely unlikely the re-entry of Stage 1 would result in debris impacting the ESA-listed species. These probabilities are sufficiently low to reasonably conclude that it would be unlikely that any of the five ESA-listed marine mammals would be struck by debris as a result of conducting up to 10 LauncherOne operations/year and the impact of Stage 1 and the fairings in the ocean. For marine mammals protected under the MMPA, the probability of debris strike for individuals of all species was also negligible given the species with the highest density in the study area (pantropical spotted dolphin) was modeled and found to have a negligible potential for impact from Stage 1 impact. Therefore, those marine mammal and sea turtle species with lower densities in the study area would have an even lower probability of being struck by the Stage 1.

Sufficient density data are not available to conduct a debris strike analysis for ESA-listed fish species in the manner conducted above for marine mammals and sea turtles. However, it is assumed that ESA-listed fish species likely to be in the area would be rare because of their known distribution in the area and likely swimming below the surface at all times. Should debris hit the water, it is expected that the initial impact at the water's surface or even slightly below the surface, would absorb much of the energy from that impact. If they were present, ESA-listed fish would be expected to be below this initial area of impact, and therefore unaffected by the debris.

Therefore, implementation of the Proposed Action and the impact of Stage 1 and fairings in the Pacific Ocean would not significantly impact marine biological resources, particularly marine mammals and ESA-listed sea turtles and fish species. In addition, the FAA has determined that the Proposed Action *may affect, but is not likely to adversely affect* ESA-listed marine mammal, sea turtle, and fish species beneath the LauncherOne flight trajectory. In accordance with ESA section 7 consultation requirements, FAA has requested concurrence from NMFS on this effects determination. The conclusion of the consultation will be provided in the Final EA.

Unspent RP-1 Fuel and Debris Materials from Stage 1 or Fairings Re-entry[(6)]

As stated above in Section 3.8.4.1 (Water Resources), the propellant type used by LauncherOne is a mixture of a kerosene-based fuel (known as RP-1) and LOX. In the event of a launch failure, and the LauncherOne rocket impacting the Pacific Ocean, surface water quality in the ocean may be temporarily affected by the release of unconsumed RP-1. RP-1 is a Type 1 "Very Light Oil," which is characterized as being highly volatile and having low viscosity and low specific gravity. Due to its high volatility, RP-1 evaporates quickly when exposed to the air, and would completely dissipate within hours or days after a spill in the water (NOAA 2019). Cleanup following a spill of very light oil is usually not necessary or possible, particularly with such a small quantity of oil that would enter the ocean in the event of an unsuccessful launch. Therefore, no attempt would be made to boom nor recover RP-1 fuel from the ocean. Although it would require 1–2 days for the RP-1 to completely dissipate, most of its mass would evaporate within the first few minutes. Swells and wave action would enable the remaining RP-1 to be volatized rapidly because of increased agitation and dissipation. This conclusion is also applicable for any unspent RP-1 fuel that remains in the Stage 1 after a successful launch, separation from Stage 2, and when Stage 1 impacts the ocean. LOX is a non-toxic cryogenic liquid which will evaporate into the air when released. Therefore, the Proposed Action would have insignificant impacts on marine species.

First stage and fairings debris, which is comprised of inert materials which are neither chemically or biologically reactive and contain no hazardous materials, is anticipated to sink relatively quickly. Accordingly, it would not affect the marine environment and associated marine species in the short term (while the debris is floating or descending through the water column) or in the long term (when the debris has settled into benthic habitats).

[(6)] If there is a malfunction or other issue that results in the abort of the flight, the LauncherOne may land within the Drop Point AHA. See Section 3.7.4 for further discussion.

Therefore, implementation of the Proposed Action and the impact of unspent RP-1 fuel and Stage 1 and fairings debris in the Pacific Ocean would not significantly impact marine biological resources, particularly marine mammals and ESA-listed sea turtles and fish species. In addition, the FAA has determined that the Proposed Action *may affect, but is not likely to adversely affect* ESA-listed marine mammal, sea turtle, and fish species beneath the LauncherOne flight trajectory. In accordance with ESA section 7 consultation requirements, FAA has requested concurrence from NMFS on this effects determination. The conclusion of the consultation will be provided in the Final EA.

3.10 Hazardous Materials, Solid Waste, and Pollution Prevention

3.10.1 Definition of Resource and Regulatory Setting

Hazardous materials, solid waste, and pollution prevention as an impact category includes an evaluation of the following:

- Waste streams that would be generated by a project, potential for the wastes to impact environmental resources, and the impacts on waste handling and disposal facilities that would likely receive the wastes;
- Potential hazardous materials that could be used during operation of a project, and applicable pollution prevention procedures;
- Potential to encounter existing hazardous materials at contaminated sites during construction, operation, and decommissioning of a project; and
- Potential to interfere with any ongoing remediation of existing contaminated sites at the proposed project site or in the immediate vicinity of a project site.

The terms hazardous material, hazardous waste, and hazardous substance are often used interchangeably when used informally to refer to contaminants, industrial wastes, dangerous goods, and petroleum products. Each of these terms, however, has a specific technical meaning based on the relevant regulations.

Solid waste is defined by the implementing regulations of the Resource Conservation and Recovery Act (RCRA) generally as any discarded material that meets specific regulatory requirements, and can include such items as refuse and scrap metal, spent materials, chemical by-products, and sludge from industrial and municipal waste water and water treatment plants.

Hazardous waste is a type of solid waste defined under the implementing regulations of RCRA. A hazardous waste is a solid waste that possesses at least one of the following four characteristics: ignitibility, corrosivity, reactivity, or toxicity as defined in 40 CFR part 261 subpart C, or is listed in one of four lists in 40 CFR part 261 subpart D, which contains a list of specific types of solid waste that the USEPA has deemed hazardous. RCRA imposes stringent requirements on the handling, management, and disposal of hazardous waste, especially in comparison to requirements for non-hazardous wastes.

Hazardous substance is a term broadly defined under Section 101(14) of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). Hazardous substances include:

- any element, compound, mixture, solution, or substance designated as hazardous under Section 102 of CERCLA;
- any hazardous substance designated under Section 311(b)(2)(A) or any toxic pollutant listed under Section 307(a) of the CWA;
- any hazardous waste under Section 3001 of RCRA;

- any hazardous air pollutant listed under Section 112 of the CAA; and
- any imminently hazardous chemical substance or mixture for which the USEPA has “taken action under” Section 7 of the Toxic Substances Control Act.

Hazardous material is any substance or material that has been determined to be capable of posing an unreasonable risk to health, safety, and property when transported in commerce. The term hazardous materials includes both hazardous wastes and hazardous substances, as well as petroleum and natural gas substances and materials (see 49 CFR § 172.101).

Pollution prevention describes methods used to avoid, prevent, or reduce pollutant discharges or emissions through strategies such as using fewer toxic inputs, redesigning products, altering manufacturing and maintenance processes, and conserving energy.

EO 13834, *Efficient Federal Operations,* states that agencies “must comply with Federal as well as State, interstate, and local requirements for management and disposal of nonhazardous solid waste and hazardous waste. Agencies should pursue cost-effective waste prevention by first reducing overall waste generated, while also pursuing strategies that reduce disposal fees and minimize environmental impacts by diverting waste from treatment and disposal facilities, including landfill and incineration without energy recovery.”

More information on hazardous materials, solid waste, and pollution prevention can be found in the FAA Order 1050.1F Desk Reference (FAA 2020).

3.10.2 Study Area

The study areas include the existing airfield apron, taxiway, and runway areas of Andersen AFB and associated airspace, and the ocean area under the Drop Point AHA and Stage 1 AHA where Stage 1 and the fairings would fall into the ocean.

3.10.3 Existing Conditions

Routine operations at Department of Defense (DoD) installations require the storage, use, and handling of a variety of hazardous materials. When discussed in this document, hazardous materials include petroleum, oils, and lubricants (POL), cleaning agents, adhesives, and other products necessary to perform essential functions. Bulk quantities of fuels and other POLs are stored and distributed in aboveground storage tanks and underground storage tanks, pumps, and pipelines. Fueling operations to support aircraft, vehicle operations, and emergency power generation require the storage of these bulk quantities of this POL. These POL storage areas represent potential sources of leaks, releases, or spills. The reference to POLs is intended to include various fuels such as gasoline, jet fuels, and diesel fuels; kerosene; and a variety of oils and other lubricant products.

The 36 CES/CEV is responsible for overseeing the management of hazardous materials (and hazardous waste) at Andersen AFB. Air Force Instruction (AFI) 32-7086, *Hazardous Materials Management*, establishes procedures for the management of hazardous materials at all USAF installations. AFI 32-7086 incorporates the requirements of federal regulations, other AFIs, and DoD directives for reducing the use of hazardous materials. Andersen AFB has a Hazardous Materials Management Plan pursuant to the AFI designed to guide and instruct all USAF personnel involved in authorizing, procuring, using, managing, or disposing of hazardous materials. This plan specifically addresses hazardous materials management, transportation, spill/release control and containment, and clean up (Andersen AFB 2007b).

Hazardous materials are managed by the base's hazardous materials pharmacy. This facility was established with the mission of overseeing, procuring, and minimizing the use of hazardous materials. The Andersen AFB pharmacy reduces the need to store large quantities of hazardous materials elsewhere on base and allows these materials to be efficiently reordered on an as-needed basis. The resulting outcome is more effective control over the use of these materials.

Numerous fueling operations to support aircraft, vehicle operation, and emergency power generation are performed at Andersen AFB. The majority of fuel handled at Andersen AFB is aviation fuel. Fuel storage facilities on the base have the primary and secondary containment and leak detection features required to contain unintended leaks, spills, and releases. Bulk jet fuel is sent to Andersen AFB from fuel facilities at Apra Harbor via pipelines. Diesel and gasoline are delivered to the base by tanker truck.

Andersen AFB is a Large Quantity Generator (40 CFR 262.34 [d], [e], and [f]) of hazardous wastes with USEPA identification handler number GU6571999519 (Guam Environmental Protection Agency 2015). The Defense Reutilization and Marketing Office arranges for all hazardous waste collection, transportation, and disposal via licensed contractors who ultimately dispose of the hazardous waste at permitted off-island disposal facilities (Andersen AFB 2007b).

3.10.4 Environmental Consequences

The FAA has not established a significance threshold for hazardous materials, solid waste, or pollution prevention. Factors to consider when assessing the significance of potential impacts include whether the action would have the potential to:

- violate applicable federal, state, tribal, or local laws or regulations regarding hazardous materials and/or solid waste management;
- involve contaminated sites;
- produce an appreciably different quantity or type of hazardous waste;
- generate an appreciably different quantity or type of solid waste or using a different method of collection or disposal and/or exceeding local capacity; or
- adversely affect human health and the environment.

3.10.4.1 Proposed Action

<u>Carrier Aircraft Operations at Andersen AFB</u>

All hazardous pre- and post-flight activities, including propellant loading and unloading (if necessary), would take place in a specified location which has established appropriate safety clear zones in accordance with 36 Wing Safety requirements. LauncherOne propellant loading operations and ground safety plans will comply with 14 CFR Parts 415 and 417. LauncherOne propellant loading operations shall be treated as explosive operations and be coordinated with 36 Wing Weapons Safety accordingly. All fuels and other hazardous materials would be stored and used in compliance with the regulations applicable to their storage and use and already in place at Andersen AFB. In accordance with the CSOSA between VO and Andersen AFB, VO will:

- Handle, store, and otherwise manage solid wastes, including hazardous wastes, in a manner consistent with Andersen AFB procedures. Coordinate hazardous waste management activities with the Andersen AFB Hazardous Waste Program Manager.

- Comply with, and participate in, all applicable elements of Andersen AFB's hazardous materials management program. Provide all information necessary to assist in determining storage and disposal requirements of any hazardous/non-hazardous materials under VO's control.
- Dispose of hazardous waste independently while operating on Andersen AFB.
- Immediately report all hazardous waste, hazardous material, or substance releases to the installation emergency response activity, and fully cooperate with any emergency response in accordance with 36th Wing plans and directives.

In the event of a launch vehicle accident or spill, Andersen AFB would respond in accordance with its Hazardous Materials Management Plan. Andersen AFB has a highly experienced rescue and firefighting staff onsite, and has established response procedures for safety purposes.

Hazardous materials that would be used to support pre-flight and post-flight activities associated with the Proposed Action are similar to materials already handled at Andersen AFB. Procedures are currently in place to accommodate additional fuel and other launch-related and maintenance-related hazardous materials, including POLs, and solvents, and the Proposed Action would be conducted according to those procedures. The environmental impact of proposed VO operations is negligible as the LauncherOne propellants and pressurants are similar to those already in use at the airfield. The rocket propellant, RP-1 is a highly refined form of kerosene outwardly similar to jet fuel. The oxidizer, LOX, is already in use at Andersen AFB. LOX and liquid nitrogen, used for liquid oxygen conditioning, are non-toxic cryogenic liquids which, if spilled, will evaporate into the air. Pressurants are inert helium and nitrogen gases. LauncherOne also uses a small amount of TEA-TEB, a pyrophoric liquid, to start the first and second stage engines in flight. To mitigate environmental concerns regarding hydrocarbon fuel spills and leaks, Andersen AFB hazmat procedures will be in place and the 36 Wing Hazmat team will be ready on standby.

Because activities associated with the Proposed Action would comply with all relevant Federal and Andersen AFB regulations related to hazardous materials and hazardous waste, no significant impacts are anticipated.

<u>LauncherOne Rocket Operations</u>

The carrier aircraft and LauncherOne rocket would take off from Andersen AFB and fly south to the designated drop point approximately 75 nm over open ocean south-southwest of Guam. LauncherOne would be carried to an altitude of approximately 35,000–40,000 ft MSL where it would be released. Following ignition of the rocket's first stage, the engine would burn until all of the propellant is consumed and Stage 1 would fall into the ocean within the Stage 1 and Fairings Re-entry AHA approximately 650-700 nm northeast of Guam (Figure 2.1-7).[(7)]

Both stages of the rocket are expendable. Stage 1 debris would fall into the Pacific Ocean within the AHA, and second stage debris would expend into Earth's orbit. First stage and fairings debris, which is comprised of inert materials which are neither chemically or biologically reactive and contain no hazardous materials, is anticipated to sink relatively quickly. Accordingly, it would not affect the marine environment in the short term (while the debris is floating or descending through the water column) or in the long term (when the debris has settled into benthic habitats).

[(7)] If there is a malfunction or other issue that results in the abort of the flight, the LauncherOne may land within the Drop Point AHA. See Section 3.7.4 for further discussion.

The propellant type used by LauncherOne Stage 1 is a mixture of a kerosene-based fuel (known as RP-1) and LOX. In the event of a launch failure, surface water quality in the ocean may be temporarily affected by the release of unconsumed RP-1. RP-1 is a Type 1 "very light oil," which is characterized as being highly volatile and having low viscosity and low specific gravity. Due to its high volatility, RP-1 evaporates quickly when exposed to the air, and would completely dissipate within 1–2 days after a spill in the water (NOAA 2019). Cleanup following a spill of very light oil is usually not necessary or possible, particularly with such a small quantity of oil that would enter the ocean in the event of an unsuccessful launch. Therefore, no attempt would be made to boom nor recover RP-1 fuel from the ocean. Although it would require hours or days for the RP-1 to completely dissipate, most of its mass would evaporate within the first few minutes. Swells and wave action would enable the remaining RP-1 to be volatized rapidly because of increased agitation and dissipation.

Therefore, implementation of the Proposed Action would not have significant impacts on the marine environment due to hazardous materials associated with the Stage 1 and fairings.

Chapter 4. Cumulative Impacts

Cumulative impacts are defined by CEQ as "the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (federal or non-federal) or person undertakes such other actions" (40 CFR §1508.7). The FAA analyzed the potential cumulative impacts in accordance with CEQ regulations and FAA Order 1050.1F.

For this EA, spatial and temporal boundaries were delineated to determine the area and projects the cumulative analysis would address. For this cumulative analysis, the spatial boundary is the airfield environment of Andersen AFB. The temporal boundary includes past actions that have occurred within the last 3 years, and reasonably foreseeable future actions include those that are planned to occur within the next 5 years. Because the flight operations of the carrier aircraft with LauncherOne rocket would be above 35,000 ft MSL over open ocean south and east of Guam, past, present, or reasonably foreseeable future projects underlying the areas of the drop point and LauncherOne flight trajectory were not included in the cumulative impacts analysis. Past, present, and reasonably foreseeable actions at Andersen AFB and the surrounding area include current and future aircraft operations at Andersen AFB.

The projects identified in the following sections include those that had or have the potential to affect the environmental impact categories that are analyzed in this EA.

4.1 Past Actions

Past projects and actions at Andersen AFB are primarily tied to aircraft operations and other activities on the airfield, taxiways, aprons and associated infrastructure such as hangars. No projects within the last 3 years have been identified that would result in potential cumulative effects when combined with the Proposed Action.

4.2 Present Actions

Present projects and actions at Andersen AFB are primarily tied to aircraft operations and other activities on the airfield, taxiways, aprons and associated infrastructure such as hangars. Present actions at Andersen AFB that may result in potential cumulative effects when combined with the Proposed Action include on-going military activities, particularly aircraft operations.

4.3 Reasonably Foreseeable Future Actions

Reasonably foreseeable future projects and actions at Andersen AFB are primarily tied to aircraft operations and other activities on the airfield, taxiways, aprons and associated infrastructure such as hangars. No future actions or projects were identified that would result in potential cumulative effects when combined with the Proposed Action.

4.4 Environmental Consequences

This EA uses information presented in Sections 4.1, 4.2, and 4.3 to determine potential cumulative impacts. The Proposed Action's impacts were analyzed for their potential to result in cumulative impacts when added to past, present, and reasonably foreseeable future actions.

As discussed in Section 3.1, implementation of the Proposed Action would result in no impact to the following impact categories: visual effects; coastal resources; land use; farmlands; natural resources and energy supply; and socioeconomics, environmental justice, and children's environmental health and safety risks. Therefore, when combined with past, present, and reasonably foreseeable projects, the Proposed Action would not result in cumulative impacts to these impact categories.

Implementation of the Proposed Action would result in no impacts to cultural resources; water resources; and hazardous materials, solid waste, and pollution prevention; and less than significant impacts related to air quality; climate; noise and noise-compatible land use; and biological resources. The Proposed Action would result in the addition of up to 10 takeoffs and landings of a 747 aircraft at Andersen AFB resulting in a negligible increase in aircraft operations over current levels (~23,700 aircraft operations/year). This negligible increase in aircraft operations would result in associated negligible cumulative impacts to air quality, including climate and GHGs, noise in the airfield environment, and biological resources when combined with current military operations at Andersen AFB. As no past or reasonably foreseeable projects and actions have been identified within the Andersen AFB spatial boundary, implementation of the Proposed Action would not result in significant cumulative impacts to any resource area assessed in this EA.

Chapter 5. List of Preparers and Agencies and Persons Consulted

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APPENDIX A:
Air Quality and Greenhouse Gas Emissions Calculations

This appendix provides the calculations and assumptions for calculating the air quality pollutant and greenhouse gas (GHG) emissions from the proposed carrier aircraft and rocket operations.

B.1 Carrier Aircraft Emissions

Table B-1 provides the estimated emissions associated with the proposed carrier aircraft operations.

Table B-1. Carrier Aircraft Pollutant and GHG Emissions during LTOs and Cruise to/from Drop Point

Mode	Power Setting (%)	Time (mins)	Fuel Flow (lbs/hr)	Emissions Indices (lb/1,000 lbs fuel)					
				VOCs	**CO**	**NO_x**	**SO_2**	**PM**	**CO_2e**
LANDING AND TAKE OFFS (LTOS)									
Take Off	100	0.5	19,222	0.06	0.04	24.94	1.06	0.07	3,233.9
Climb Out	85	3	15,738	0.06	0.05	19.72	1.06	0.06	3,233.9
Approach	30	4.7	5,159	0.13	2.61	12.47	1.06	0.04	3,233.9
Idle	7	30	1,579	1.77	22.41	4.73	1.06	0.05	3,233.9
Emissions per LTO (lbs)				1.41	17.74	85.43	1.36	0.05	6,914.4
				VOCs (tons)	**CO (tons)**	**NO_x (tons)**	**SO_2 (tons)**	**PM (tons)**	**CO_2e (MT)**
Emissions per LTO (tons and MT)				0.001	0.009	0.043	0.001	<0.001	3.1
CRUISE*									
Mode	**Power Setting (%)**	**Speed (mph)**	**Distance (miles)**	**Time (mins)**	**Fuel Flow (lbs/hr)**	**Emissions Indices (lbs/1,000 lbs fuel)**			**CO_2e (MT)**
Cruise	94	678	372.6	32.9	24,000	3,233.9			19.3

Notes: CO = carbon monoxide; CO_2e – carbon dioxide equivalent; lbs/hr = pounds per hour; mins = minutes; mph = miles per hour; MT = metric tons; NO_x = nitrous oxides; PM = particulate matter; SO_x = sulphur oxides; VOC = volatile organic compounds.

*Assumptions:

Aircraft: Boeing 747-400; Engine: GE CF6-80C2B1F. Number of engines: 4 (but database emissions indexes are for 1 engine, so total amounts are multiplied by 4.

Cruise Distance Estimation:

75 nm (86.3 miles from Anderson AFB to Racetrack)

200-mile Racetrack (assume single circuit)

75 nm (86.3 miles from Racetrack to Anderson AFB)

Source: U.S. Air Force 2013. Air Emissions Guide for Air Force Mobile Sources: Methods for Estimating Emissions of Air Pollutants for Mobile Sources at U.S. Air Force Installations. Air Force Civil Engineer Center, Compliance Technical Support Branch, Lackland AFB, TX. January.

B.2 LauncherOne Rocket Emissions

As described in section D.1.1.5 (Federal Aviation Administration [FAA] 2009), rocket emissions were calculated by multiplying the propellant-specific emissions weight fractions for each pollutant by the amount of propellant used. The rocket is a liquid oxygen (LOX)/rocket propellant 1 (RP-1) (kerosene) system comprised of a first stage with 29,215 pound mass (lbm) of LOX and 13,279 lbm of RP-1, and second stage with 3,642 lbm of LOX and 1,683 lbm of RP 1. As described in Section 2.1.3.3 (Post-Flight Operations) of this EA, it is expected that all propellant would be consumed during each launch. Therefore, the total weight of propellant was used in the multiplication against the emissions weight fractions. Only CO_2 is expected to be generated from the use of RP-1/LOX, with no other CO_2e contributors (methane [CH_4] or nitrous oxide [N_2O]) expected to be generated by the use of RP-1/LOX propellant (Table B-2).

Table B-2. LauncherOne Rocket GHG Emissions

Pollutant	Lbs Emitted/ Lb of Propellant	Lbs of Propellant Used	Lbs/ Launch	Tons/ Launch	MT/ Launch
CO	0.2	47,819	9,563.8	4.8	4.3
CO_2	**0.49**	**47,819**	**23,431.3**	**11.7**	**10.6**
H_2	0.004	47,819	200.8	0.1	0.09
H_2O	0.3	47,819	14345.7	7.2	6.5

Assumptions: Exhibit D-7 from FAA (2009) was used for pounds emitted per pound of propellant (RP-1[Kerosene]/LOX). While Exhibit D-6 (FAA 2009) lists propellant consumption by atmospheric layer, total propellant amounts were taken from the project description (see Chapter 2 of this EA).

B.3 Total GHG Emissions from the Proposed Action

Table B-3 provides the total GHGs from proposed carrier aircraft and LauncherOne rocket operations under the Proposed Action.

Table B-3. Total GHG Emissions under the Proposed Action

Event Stage	GHG Emissions/Event
Carrier Aircraft LTO	3.1
Carrier Aircraft Cruise	19.3
LauncherOne Rocket	10.6
Total per Launch Event	**33.0**

References

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APPENDIX B:
Statistical Probability Analysis for Estimating Direct Strike Impacts to Marine Mammals and Sea Turtles from Stage 1 of the LauncherOne Rocket[(1)]

This appendix discusses the methods and results for calculating the probability of the direct strike of an ESA-listed marine mammal or sea turtle by the LauncherOne rocket, Stage 1, or fairings within the Drop Point, Stage 1, and Fairings Re-entry AHAs. Only marine mammals and sea turtles are analyzed using these methods because animal densities are necessary to complete the calculations, and density estimates are currently only available for marine mammals and sea turtles within the Study Area (Table A-1).

Table A-1. Summary of Density Values for Marine Mammals and Sea Turtles within the Stage 1 and Fairings Re-entry AHA

Species	Season*			
	Spring	Summer	Fall	Winter
MARINE MAMMALS				
Blainville's beaked whale	0.00070	0.0007	0.00070	0.00070
Blue whale	0.00005	0	0.00005	0.00005
Bryde's whale	0.00030	0.00030	0.00030	0.00030
Common bottlenose dolphin	0.00077	0.00077	0.00077	0.00077
Cuvier's beaked whale	0.00374	0.00374	0.00374	0.00374
Dwarf sperm whale	0.00430	0.00430	0.00430	0.00430
False killer whale	0.00057	0.00057	0.00057	0.00057
Fin whale	0.00006	0	0.00006	0.00006
Fraser's dolphin	0.00252	0.00252	0.00252	0.00252
Ginkgo-toothed beaked whale	0.00189	0.00189	0.00189	0.00189
Humpback whale	0.00089	0	0.00089	0.00089
Killer whale	0.00009	0.00009	0.00009	0.00009
Longman's beaked whale	0.00025	0.00025	0.00025	0.00025
Melon-headed whale	0.00267	0.00267	0.00267	0.00267
Minke whale	0.00015	0	0.00015	0.00015
Omura's whale	0.00004	0.00004	0.00004	0.00004
Pantropical spotted dolphin	0.01132	0.01132	0.01132	0.01132
Pygmy killer whale	0.00006	0.00006	0.00006	0.00006
Pygmy sperm whale	0.00176	0.00176	0.00176	0.00176
Risso's dolphin	0.00046	0.00046	0.00046	0.00046
Rough-toothed dolphin	0.00185	0.00185	0.00185	0.00185
Sei whale	0.00013	0	0.00013	0.00013
Short-finned pilot whale	0.00211	0.00211	0.00211	0.00211
Sperm whale	0.00222	0.00222	0.00222	0.00222
Spinner dolphin	0.00187	0.00187	0.00187	0.00187
Striped dolphin	0.00584	0.00584	0.00584	0.00584
SEA TURTLES				
Green sea turtle	0.000390	0.000390	0.000390	0.000390
Hawksbill sea turtle	0.000024	0.000024	0.000024	0.000024
Leatherback sea turtle	0.000022	0.000022	0.000022	0.000022
Loggerhead sea turtle	0.000022	0.000022	0.000022	0.000022

Notes: *Numerical values are animals/km^2. 0 = species is not expected to be present.
Source: Navy 2018.

(1) Adapted from Navy (2019a).

The values presented in Table A-1 are based on estimated marine mammal and sea turtle densities for the Mariana Islands Training and Testing (MITT) Study Area and associated transit corridor (Navy 2018) in support of the Public Draft Supplemental EIS/Overseas EIS (Navy 2019b). The MITT Study Area extends 450 nm north of Guam, 250 nm east of Guam, and 300 nm south of Guam. The transit corridor is located on the eastern edge of the MITT Study Area and is 300 nm south of the Stage 1 and Fairings Re-entry AHA. These density estimates are the best available data regarding the occurrence of marine mammals and sea turtles in the vicinity of the LauncherOne operations.

These calculations estimate the impact probability (P) and number of exposures (T) associated with direct impact of the LauncherOne Stage 1 on marine animals on the sea surface within the Stage 1 and Fairings Re-entry AHA. The statistical probability analysis is based on probability theory and modified Venn diagrams with rectangular "footprint" areas for the individual animal (A) and total impact (I) inscribed inside the AHA (R). The analysis is over-predictive and conservative, in that it assumes: (1) that all animals would be at or near the surface 100% of the time, when in fact, marine mammals spend the majority of their time underwater, and (2) that the animals are stationary.

A = length*width, where the individual animal's width (breadth) is assumed to be 20% of its length for marine mammals and 112% of its length for sea turtles. A is multiplied by the estimated number of animals N_a in the AHA (i.e., product of the highest average seasonal animal density [D] and area of AHA [R]: $N_a = D*R$) to obtain the total animal footprint area ($A*N_a = A*D*R$) in the AHA. As a conservative scenario, the total animal footprint area is calculated for the species with the highest average seasonal density (pantropical spotted dolphins).

I = length*diameter of Stage 1 = impact footprint area.

The analysis is expected to provide an overestimation of the probability of a strike for the following reasons: (1) it calculates the probability of the Stage 1 hitting a single animal at its species' highest seasonal density, and (2) it does not take into account the possibility that an animal may not be at the water surface.

The likelihood of an impact is calculated as the probability (P) that the animal footprint (A) and the impact footprint (I) will intersect within the AHA (R). This is calculated as the area ratio A/R or I/R, respectively. Note that A (referring to an **individual** animal footprint) and I (referring to the impact footprint resulting from the Stage 1) are the relevant quantities used in the following calculations of single-animal impact probability [P], which is then multiplied by the number of animals to obtain the number of exposures (T). The probability that the animal in the AHA is within both types of footprints (i.e., A and I) depends on the degree of overlap of A and I. The probability that I overlaps A is calculated by adding a buffer distance around A based on one-half of the impact area (i.e., 0.5*I), such that an impact (center) occurring anywhere within the combined (overlapping) area would impact the animal. Thus, if L_i and W_i are the length and width of the impact footprint such that $L_i*W_i = 0.5*I$ and $W_i/L_i = L_a/W_a$ (i.e., similar geometry between the animal footprint and impact footprint), and if L_a and W_a are the length and width (breadth) of the individual animal such that $L_a*W_a = A$ (= individual animal footprint area), then, assuming a purely static, rectangular scenario, the total area $A_{tot} = (L_a + 2*L_i)*(W_a + 2*W_i)$, and the buffer area $A_{buffer} = A_{tot} – L_a*W_a$. The static, rectangular impact assumes no additional aerial coverage effects of the Stage 1 beyond the initial impact.

Impact probability P is the probability of impacting one animal by the Stage 1 occurring in the area per year, and is given by the ratio of total area (A_{tot}) to AHA (R): $P = A_{tot}/R$. Number of exposures is $T = N*P = N*A_{tot}/R$, where N = number of animals in the AHA per year (given as the product of the animal density [D] and AHA size [R]). Thus, $N = D*R$ and hence $T = N*P = N*A_{tot}/R = D*A_{tot}$.

Using this procedure, P and T were calculated for the five species of ESA-listed marine mammals and the non-ESA listed marine mammal species with the highest average month density (pantropical spotted dolphin), and the sea turtle species with the highest average month density in the AHA (green sea turtles). The potential number of individuals impacted/year are reported in Table A-2.

Table A-2. Estimated Representative Marine Mammal and Sea Turtle Exposures from a Potential Direct Strike of LauncherOne Stage 1 in a Single Year

Species (ESA Status)	Est. Density (km^2)*	Probability of Impact (T)	Est. No. Impacts/Year†
Humpback whale (Endangered)	0.00089	0.0000001	0.000001
Sei whale (Endangered)	0.00013	0.00000002	0.0000002
Fin whale (Endangered)	0.00006	0.00000001	0.0000001
Blue whale (Endangered)	0.00005	0.00000001	0.0000001
Sperm whale (Endangered)	0.00222	0.0000003	0.000003
Pantropical spotted dolphin	0.01132	0.0000002	0.000002
Green sea turtle (Endangered)	0.00039	0.000000005	0.00000005

Note: †Based on the maximum of 10 proposed launches in any one year of the 5-year operating period; all other years would be <9 launches/year.

**Source*: Navy 2018.

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