Federal Aviation Administration

DRAFT ENVIRONMENTAL ASSESSMENT FOR SIERRA SPACE DREAM CHASER VEHICLE OPERATOR LICENSE AT THE SHUTTLE LANDING FACILITY, BREVARD COUNTY, FLORIDA AND CONTINGENCY REENTRY SITE AT VANDENBERG SPACE FORCE BASE, SANTA BARBARA COUNTY, CALIFORNIA

July 2024

Draft Environmental Assessment for Sierra Space Dream Chaser Vehicle Operator License at the Shuttle Landing Facility, Brevard County, Florida and Contingency Reentry Site at Vandenberg Space Force Base, Santa Barbara County, California

AGENCIES: Federal Aviation Administration (FAA), lead federal agency; U.S. Coast Guard, National Aeronautics and Space Administration, U.S. Fish and Wildlife Service, National Marine Fisheries Service, and National Park Service, cooperating agencies.

The FAA is releasing this Environmental Assessment (EA) for public review pursuant to section 102(2)(C) of the National Environmental Policy Act of 1969 (NEPA), as amended (42 United States Code 4321, et seq.), Council on Environmental Quality NEPA-implementing regulations (40 Code of Federal Regulations Parts 1500 to 1508), and FAA Order 1050.1F, *Environmental Impacts: Policies and Procedures*.

DEPARTMENT OF TRANSPORTATION, FEDERAL AVIATION ADMINISTRATION: The FAA is evaluating Sierra Space's proposal to conduct Dream Chaser reentry operations at the Shuttle Landing Facility (SLF) in Brevard County, Florida. Sierra Space is also proposing to use Vandenberg Space Force Base (VSFB) as a contingency reentry site in the event that Dream Chaser is unable to safely reenter and land at the SLF. Sierra Space must obtain a Vehicle Operator License from the FAA to conduct Dream Chaser reentry operations at the SLF and VSFB. Issuing a Vehicle Operator License is considered a major federal action subject to environmental review under NEPA. The FAA's Federal Action would be to issue a Vehicle Operator License to Sierra Space that would allow Sierra Space to operate the Dream Chaser reentry vehicle at SLF and VSFB. Sierra Space's Proposed Action is to conduct up to four reentries per year starting in 2024.

The EA considers the potential environmental impacts from the Proposed Action and No Action Alternative on air quality; biological resources; climate; coastal resources; Department of Transportation Act, Section 4(f); farmlands; hazardous materials, solid waste, and pollution prevention; historical, architectural, archeological, and cultural resources; land use; natural resources and energy supply; noise and noise-compatible land use; socioeconomics, environmental justice, and children's environmental health and safety risks; visual effects; and water resources.

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 August 9, 2024.

CONTACT INFORMATION: For questions, please contact: Ms. Chelsea Clarkson, Sierra Space at SLF and VSFB, c/o ICF, 1902 Reston Metro Plaza, Reston, VA 20190; email SierraSpaceSLF@icf.com.

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

Responsible FAA Official:

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Acronyms and Abbreviations

AHA	Aircraft Hazard Areas
AST	FAA Office of Commercial Space Transportation
ATCSCC	Air Traffic Control System Command Center
ATO	FAA Air Traffic Organization
CDNL	C-weighted Day-Night Average Sound Level
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
CNEL	Community Noise Equivalent Level
CO2	Carbon Dioxide
CRS2	Commercial Resupply Services 2
CZMA	Coastal Zone Management Act
DNL	Day-Night Average Sound Level
EA	Environmental Assessment
EIS	Environmental Impact Statement
ESA	Endangered Species Act
FAA	Federal Aviation Administration
FONSI	Finding of No Significant Impact
H2O2	Hydrogen Peroxide
IBLHA	Integrated Bag Level Hazard Analysis
ISS	International Space Station
KSC	Kennedy Space Center
LEO	Low Earth Orbit
LOA	Letter of Agreement
NAS	National Airspace System
NASA	National Aeronautics and Space Administration
NEPA	National Environmental Policy Act
NHPA	National Historic Preservation Act
NOAA	National Oceanic and Atmospheric Administration
NOTAM	Notice to Air Missions
NOTMAR	Notices to Mariners
NPS	National Park Service
PEA	Programmatic Environmental Assessment
RCS	Reaction Control Systems
RSOL	Reentry Site Operator License
SHA	Ship Hazard Area
SHPO	State Historic Preservation Officer

SLD	Space Launch Delta
SLF	Shuttle Landing Facility
TFR	Temporary Flight Restrictions
USAF	United States Air Force
USCG	U.S. Coast Guard
USFWS	U.S. Fish and Wildlife Service
USSF	United States Space Force
VSFB	Vandenberg Space Force Base

Chapter 1
Introduction

The Federal Aviation Administration (FAA) is evaluating Sierra Space's proposal for a Vehicle Operator License to conduct Dream Chaser reentry operations at the Shuttle Landing Facility (SLF), which is managed by Space Florida and located at the Cape Canaveral Spaceport, in Brevard County, Florida. Sierra Space is also proposing to use Vandenberg Space Force Base (VSFB) as a contingency reentry site in the event that Dream Chaser is unable to safely reenter and land at the SLF. VSFB is located on the coast in Southern California and is operated by United States Space Force (USSF) Space Launch Delta 30 (SLD 30). Sierra Space must obtain a Vehicle Operator License from the FAA to conduct reentries of the Dream Chaser vehicle at the SLF and VSFB. Issuing a Vehicle Operator License is considered a major federal action, which is subject to environmental review under the National Environmental Policy Act (NEPA) of 1969 as amended (42 United States Code [U.S.C.] § 4321, et seq.), and the Council on Environmental Quality (CEQ) Regulations for Implementing the Procedural Provisions of NEPA (40 Code of Federal Regulations [CFR] Parts 1500-1508), and in consideration of FAA Order 1050.1F, *Environmental Impacts: Policies and Procedures.*

The FAA is the lead federal agency for this Environmental Assessment (EA). This EA evaluates the potential environmental impacts of activities associated with the Federal Action of issuing a Vehicle Operator License to Sierra Space at the SLF and VSFB (see Section 2.1 for a more detailed description). The FAA would also approve related airspace closures. The completion of the environmental review process does not guarantee that the FAA will issue a Vehicle Operator License to Sierra Space for Dream Chaser reentries at the SLF and VSFB and approve related airspace closures. Sierra Space's license application must also meet FAA safety, risk, and fiscal responsibility requirements per 14 CFR Chapter III.

The FAA previously analyzed the potential environmental impacts of issuing a Reentry Site Operator License (RSOL) to Space Florida for the operation of a commercial space reentry site at the SLF in a 2021 Programmatic Environmental Assessment (2021 PEA). The 2021 PEA evaluated the potential environmental impacts of operation of a commercial space reentry site at the SLF. The FAA determined that issuing a RSOL would not significantly affect the quality of the human environment pursuant to Section 102(2)(c) of NEPA and issued a Finding of No Significant Impact (FONSI) in January 2021.[1] The FAA issued a RSOL and a renewed launch site operator license (LSOL) on January 15, 2021 (LRSO 18-018).[2]

This EA analyzes the impacts of the activities associated with Sierra Space's reentry operations and tiers from the 2021 PEA for the SLF RSOL. The representative reentry vehicle operations described in the 2021 PEA were based on Sierra Space's[3] Dream Chaser vehicle and proposed operations at the SLF, which are generally consistent with the proposed vehicle and operations described in this EA. This tiered EA focuses on the vehicle specific operations and associated impacts, and it evaluates changes to the

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[1] The 2021 PEA can be downloaded from the FAA website at: https://www.faa.gov/space/environmental/nepa_docs/slf_ea.

[2] https://www.faa.gov/media/69216.

[3] The space systems group within Sierra Nevada Corporation (SNC) formed a subsidiary called Sierra Space Corporation on June 1, 2021. This document references Sierra Space when discussing the January 2021 PEA.

human environment from the Proposed Action or alternatives that are reasonably foreseeable including direct, indirect, and cumulative effects. To focus this tiered EA on impacts specific to FAA's Proposed Action, valid and current information and analysis from the 2021 PEA is summarized and incorporated by reference for relevant portions of the affected environment and environmental consequences section (see Chapter 3 for more information). This EA also analyzes the impacts associated with contingency reentry operations at VSFB.

The Proposed Action under this EA is only for reentry operations. The Dream Chaser would be launched to orbit as a payload atop the United Launch Alliance's vertically launched Vulcan rocket or equivalent from Cape Canaveral Space Force Station, which was analyzed in the June 2019 Environmental Assessment for Vulcan Centaur Program operations and launch on Cape Canaveral Air Force Station (2019 EA). The FAA was a cooperating agency and adopted the 2019 EA and issued a FONSI on February 27, 2020, to support the potential issuance of a launch license for Vulcan operations from Cape Canaveral Space Force Station. The processing of payloads similar to the Dream Chaser vehicle is assessed in the NASA 2011 Environmental Assessment for Launch of NASA Routine Payloads (2011 EA).[4] Approval of this EA does not constrain Sierra Space to launching with United Launch Alliance or from Cape Canaveral Space Force Station.

The 2021 PEA assessed up to six annual reentry operations from 2021 to 2025.[5] No reentry operations have been conducted at the SLF to date, and no impact has occurred to date as analyzed under the 2021 PEA. As described in Chapter 3, environmental impacts are expected to be similar to those previously analyzed in the 2021 PEA. Therefore, for reentries at the SLF, the description of existing conditions from the 2021 PEA is incorporated by reference in this EA and will not be discussed further in this EA.

Federal Agency Roles

Federal Aviation Administration

As a lead federal agency, the FAA is responsible for analyzing the potential environmental impacts of the Proposed Action. The Commercial Space Launch Act of 1984, as amended and codified at 51 U.S.C. 50901–50923, authorizes the Secretary of Transportation to oversee, license, and regulate commercial launch and reentry activities, and the operation of launch and reentry sites within the United States or as carried out by U.S. citizens. Section 50905 directs the Secretary to exercise this responsibility consistent with public health and safety, safety of property, and the national security and foreign policy interests of the United States. In addition, Section 50903 requires the Secretary to encourage, facilitate, and promote commercial space launches and reentries by the private sector. As codified at 49 CFR § 1.83(b), the Secretary has delegated authority to carry out these functions to the FAA Administrator.

[4] The 2011 EA can be accessed online at: https://www.nasa.gov/emd/routine-payloads-environmental-assessment/

[5] Space Florida's RSOL expires in 2025. Space Florida can apply to the FAA to renew the license at that time.

The FAA is also responsible for creating airspace closure areas in accordance with FAA Order 7400.2P, *Procedures for Handling Airspace Matters*, to ensure public safety.

Cooperating Agencies

The FAA requested the U.S. Coast Guard (USCG), National Aeronautics and Space Administration (NASA), USSF, U.S. Fish and Wildlife Service (USFWS), National Marine Fisheries Service (NMFS), and National Park Service (NPS) to participate in the NEPA process as cooperating agencies[6] due to their jurisdiction by law or their special expertise. If necessary, USCG, NASA, USSF, USFWS, NMFS, and NPS could adopt this EA to support their own federal actions and environmental findings associated with activities covered in this EA.

Purpose and Need

CEQ's NEPA-implementing regulations state that the purpose and need statement shall briefly specify the underlying purpose and need to which the agency is responding in proposing the alternatives including the proposed action (40 CFR § 1502.13). The FAA's authority with respect to Sierra Space's license application is stated above in Section 1.1.1.

The purpose of Sierra Space's proposal is to conduct Dream Chaser reentry missions at the SLF. Sierra Space has chosen to conduct reentry operations at the SLF due to its existing infrastructure and proximity to Cape Canaveral Space Force Station, Kennedy Space Center (KSC), and other commercial space operations. Sierra Space's proposal is needed to support its civil and commercial customers, which includes a NASA contract for resupply of the International Space Station (ISS). Specific to Sierra Space's ISS Commercial Resupply Services 2 (CRS2) contract with NASA, NASA desires the reentry to occur at the SLF due to the proximity of lab facilities for post mission processing of payloads and other cargo being returned from the ISS. Sierra Space is proposing to designate VSFB as a contingency reentry site in the event Dream Chaser is unable to safely reenter and land at the SLF. VSFB was chosen as an alternate landing site due to its existing infrastructure and operational compatibility needed Dream Chaser landing operations.

Public Involvement

The FAA is using multiple methods of stakeholder engagement and public outreach to solicit comments and feedback regarding the proposal.

A prior draft of this EA (*Draft Environmental Assessment for Sierra Space Dream Chaser Vehicle Operator License at the Shuttle Landing Facility, Brevard County, Florida*) was prepared in 2021 and circulated for public review. The Draft EA was published on the FAA website (https://www.faa.gov/space/stakeholder_engagement/shuttle_landing_facility) and advertised in a local newspaper (https://talkoftitusville.com/2021/12/21/sierra-space-proposes-to-land-its-dream-

[6] Cooperating agency means any federal agency (and a state, tribal, or local agency with agreement of the lead agency) other than a lead agency that has jurisdiction by law or special expertise with respect to any environmental impact involved in a proposal (or a reasonable alternative) for legislation or other major federal action that may significantly affect the quality of the human environment (40 CFR §1508.1(e)).

chaser-vehicle-at-the-shuttle-landing-facility/). This prior draft EA addressed proposed reentry operations of the Dream Chaser at the SLF only. The public review period for the prior draft EA closed on January 24, 2022. One comment was received during the review period. Responses to this comment are provided in **Appendix A**.

This revised draft EA adds consideration of using VSFB as a contingency reentry site. In accordance with CEQ's NEPA-implementing regulations and FAA Order 1050.1F, the FAA released this draft EA for a 30-day public review on July 10, 2024. The FAA provided public notice of the availability of the draft EA for public review and comment its project website as well as on the VSFB website.[7] Sierra Space published advertisements in local newspapers including Florida Today, Al Día Today, and Lompoc Record. Additionally, hard copies of the EA were placed in public libraries located in Merritt Island, FL, Titusville, FL, Port St. John, FL, Lompoc, CA, Santa Maria, CA, Santa Barbara, CA, and VSFB.

Following the close of the public comment period, the FAA will revise the draft EA, as appropriate, in response to comments received, 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 either issue a Finding of No Significant Impact (FONSI) or issue a Notice of Intent to prepare an Environmental Impact Statement (EIS).

The FAA developed a project website and email listserv (which can be joined through the project website) to inform the public about the project.[8] The FAA will update the website and provide email updates as the EA and FAA licensing process progresses.

Other Authorizations

No other environmental and regulatory approvals, in addition to the FAA's license, are required for Sierra Space to proceed with the proposed operations identified in Chapter 2 below.

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[7] https://www.faa.gov/space/stakeholder_engagement

[8] https://www.faa.gov/space/stakeholder_engagement

Chapter 2
Description of Proposed Action and Alternatives

This EA considers the No Action Alternative and Sierra Space's Proposed Action.

No Action Alternative

Under the No Action Alternative, the FAA would not issue a Vehicle Operator License to Sierra Space for Dream Chaser reentry operations at the SLF and VSFB. If Sierra Space does not obtain a Vehicle Operator License for reentry operations at the SLF or VSFB, Sierra Space would be unable to meet their NASA contract obligations to resupply the ISS. This alternative provides the basis for comparing the environmental consequences of the Proposed Action.

Proposed Action

The FAA's Federal Action is to issue a Vehicle Operator License along with potential renewals and modifications to the license within the scope of operations analyzed in this EA to Sierra Space that would allow Sierra Space to conduct reentry operations of the Dream Chaser at SLF or VSFB. In addition, the FAA must also approve related airspace closures for reentry operations.

Sierra Space's Proposed Action is to conduct up to four reentries per year starting in 2024. The Proposed Action does not include any construction or site modifications at the SLF or VSFB. The following subsections provide a description of the project's location, the reentry vehicle, and proposed reentry operations.

Location

The nominal reentry location would be the existing SLF Runway 15/33 at the Cape Canaveral Spaceport in Brevard County, Florida (Figure 2-1). If Dream Chaser is unable to safely land at the SLF, but able to safely land at another location, VSFB Runway 12/30 in Santa Barbara County, CA (Figure 2-2) would be utilized for reentry operations. In the event that the Dream Chaser is unable to safely land at either the SLF or VSFB, Dream Chaser would conduct an emergency landing in the broad open ocean and would be expected to sink.

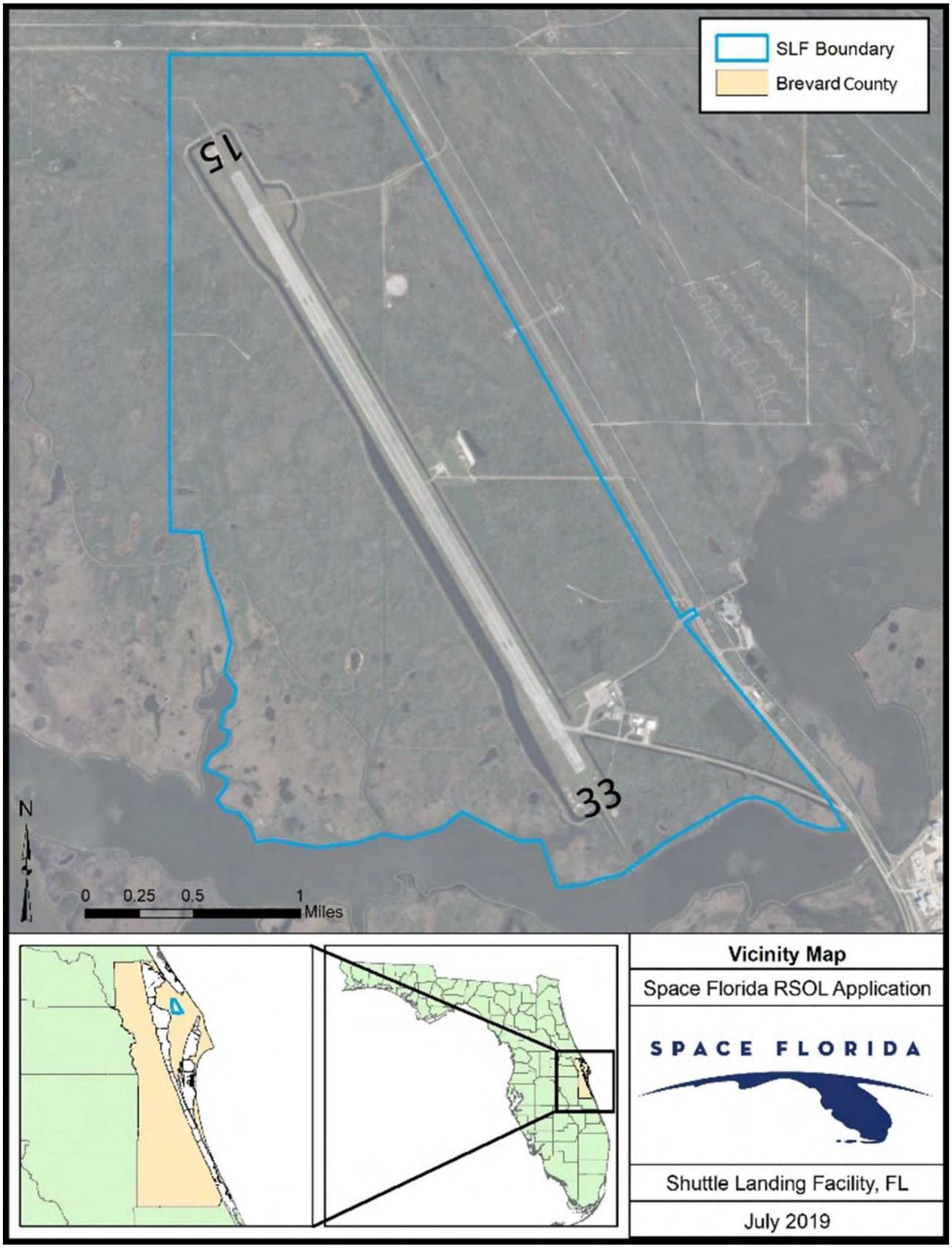

Figure 2-1: Shuttle Landing Facility (SLF) Location

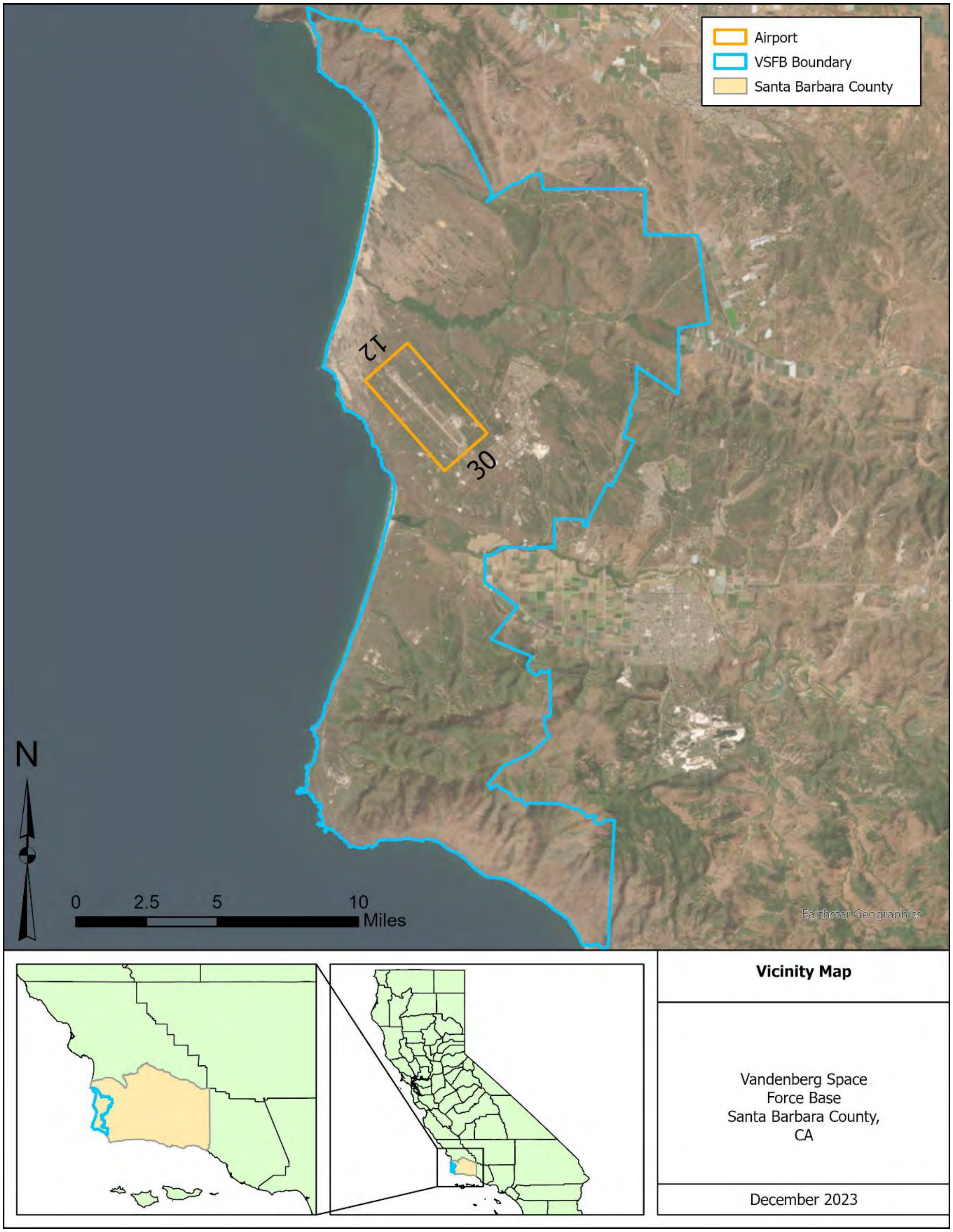

Figure 2-2: Vandenberg Space Force Base (VSFB) Location Map

Reentry Vehicle

Sierra Space's Dream Chaser is a multi-mission space utility vehicle designed to transport cargo to low Earth orbit (LEO) destinations such as the ISS. NASA purchases these missions to provide a commercial resupply service, thus allowing the vehicle to be used to support additional missions for other government and non-government customers.

The Dream Chaser is a lifting-body spacecraft with small wings that provide directional stability in flight (see **Figure 2-3**). The lifting-body design gives Dream Chaser an efficient lift-to-drag ratio and allows for enhanced cross-range landing capability.

Dream Chaser measures approximately 30 feet in length, has a wingspan of 27 feet, and weighs approximately 24,600 pounds. Dream Chaser propellants, Hydrogen Peroxide (H_2O_2) and Kerosene (RP-1), are used by a Reaction Control System (RCS) for orbital maneuvers, deorbit burn, and high-altitude attitude control during reentry. The propulsion system is not used near or on the ground. Near Mach 4, Dream Chaser transitions from RCS attitude control to flight control surfaces. The vehicle lands with residual propellant and any margin not used during reentry. The pressurized/unpressurized cargo capacity is 5,500 kilograms or 30 cubic feet. The return payload capacity is 1,850 kilograms.

Figure 2-3: Dream Chaser Reentry Vehicle

During reentry, Dream Chaser would release the cargo module. Unwanted cargo and the cargo module are expected to burn up upon reentry into Earth's atmosphere. Any surviving debris fragments would be small and land in a remote part of the Pacific Ocean away from major commercial shipping lanes. **Figure 2-4** provides a representation of the cargo module.

Figure 2-4: Dream Chaser with Cargo Module

Typical cargo includes scientific experiments, items no longer needed on the ISS packaged in cargo transfer bags, and trash for disposal in the cargo module. Overall, for the CRS2 missions, NASA provides Sierra Space and thus the FAA an integrated bag level hazard analysis (IBLHA). The IBLHA assesses any hazards present in the proposed cargo manifest. Sierra Space does not expect any hazardous material as defined by the FAA to be manifested on a reentry. Per NASA's payload process for CRS2 missions, the cargo for each mission is provided to Sierra Space, and thus the FAA, at the integrated bag level 60 days prior to reentry. The cargo module is constructed of metallic materials (Aluminum, Steel, and Titanium), as well as Sierra Space proprietary composites.

Figure 2-5 shows a notional mission profile for the Dream Chaser vehicle. The Dream Chaser would be launched to orbit as a payload atop a vertical launch vehicle. Accordingly, launch activities for Dream Chaser would occur at a FAA-licensed launch site or other government facility under a separate license or approval.

Figure 2-5: Dream Chaser Mission Profile

Reentry Operations

Pre-Reentry Operations

Before a planned reentry of the Dream Chaser at the SLF, Sierra Space would notify Space Florida, FAA Office of Commercial Space Transportation (AST), FAA Air Traffic Organization (ATO), Space Launch Delta (SLD) 45, and KSC. For contingency reentries at VSFB, Sierra Space would notify FAA AST, FAA ATO, and SLD 30. Sierra Space would be made aware of other activities at or near the SLF or VSFB and work with the stated stakeholders to resolve potential conflicts for use. Flight and ground crews would be trained for nominal and non-nominal operations before each reentry, and training would be repeated with various failure scenarios and irregular performance to ensure crew readiness per FAA regulations (14 CFR §450.155 Readiness).

While on orbit, Dream Chaser would be prepared for entry, descent, and landing by conducting vehicle checkouts and maneuvering to mission specific deorbit burn targets. Dream Chaser has a cross-range capability of ±700 nautical miles (nmi), meaning the ground track of the current vehicle orbit can be up to 700 nmi away when perpendicular to the landing site for Dream Chaser to have enough energy to successfully land. Only ascending trajectories would be considered.[9] The specific trajectory Dream Chaser would fly would be a function of where the Dream Chaser is relative to the landing site at the time of departure from orbit. This can be calculated in advance of a reentry as it is based on the orbital mechanics (physics) of the orbit relative to the Earth.

[9] The ascending phase of an orbital spacecraft is the portion of the orbital path that travels in a northerly direction relative to the latitudes of earth. In this context, ascending should not be confused with the “ascent” or launch phase of a mission which places the spacecraft into orbit around the Earth.

Figure 2-6: Example Cross Range Capability

All reentry operations would comply with the necessary notification requirements, including issuance of Notice to Air Missions (NOTAMs), as defined in agreements required for a launch license issued by the FAA. A NOTAM provides notice of unanticipated or temporary closures to components of, or hazards in, the National Airspace System (FAA Order 7930.2S, *Notices to Air Missions [NOTAM]).* The FAA issues a NOTAM 24 to 72 hours prior to a launch or reentry activity in the airspace to notify pilots and other interested parties of temporary conditions. Advance notice via NOTAMs and the identification of Aircraft Hazard Areas (AHAs) would assist pilots in scheduling around any temporary disruption of flight activities in the area of operation. Launches and reentries would be infrequent, of short duration, and scheduled in advance to minimize interruption to air traffic.

To comply with the FAA's licensing requirements, Sierra Space has entered into a Letter of Agreement (LOA) with the local Air Traffic Control Centers, Air Traffic Control System Command Center (ATCSCC), Local Terminal Radar Approach Control Facility, ATO Space Operations, SLF, and SLD 45 to accommodate the flight parameters of Dream Chaser vehicle at SLF. Similar LOAs, including stakeholders for VSFB contingency reentries have been put in place, and/or are in development at this time. The LOAs outline procedures and responsibilities applicable to operations including notification of launch activity; communication procedures prior to, during, and after a launch; planning for contingencies/emergencies; NOTAM issuance; and any other measures necessary to protect public health and safety. 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.

The FAA conducts an analysis of the effects on airspace efficiency and capacity for each licensed launch operation. When determining whether the operator may proceed as requested or whether alternative approaches are required, the FAA considers location and timing, the number of flights and passengers affected, holidays or significant events that result in more airspace congestion, launch window duration, nighttime vs. daytime launches (with nighttime being preferred), and mission purpose (prioritizing commercial space operations with a national security purpose or are in the national interest and commercial space operations carrying payloads. This analysis is documented in an Airspace Management Plan, which is completed approximately 3–5 days prior to launch or reentry. This information helps the FAA determine whether the proposed launch or reentry would result in an unacceptable limitation on air traffic. If that were the case, the FAA may need to work with the operator to identify appropriate mitigation strategies, such as shortening the requested launch/reentry window or shifting the launch/reentry time, if possible. The FAA often provides data to launch operators to avoid operations during days with high aviation traffic volume. Prior analyses have concluded that most commercial space launch operations result in minor or minimal impacts on commercial and private users of airspace. This is largely due to the FAA's ability to manage the airspace for all users.

Sierra Space would submit a Flight Safety Data Package to the FAA in advance of the reentry. The package would include the reentry trajectory and associated AHAs. These Aircraft Hazard Areas define the temporarily closed airspace that would be defined and published through a NOTAM prior to the reentry. FAA Air Traffic Organization Space Operations Office uses the Aircraft Hazard Area information to produce an Airspace Management Plan, which describes the reentry information and any associated impacts to the National Airspace System (NAS). Airspace controlled by the FAA may be restricted through the activation of airspace closures. The most common type of airspace closures are Temporary Flight Restrictions (TFRs) and altitude reservations. The FAA generally uses TFRs to protect airspace over land up to 12 nautical miles offshore and altitude reservations to protect oceanic airspace beyond 12 nautical miles offshore. The NOTAM would establish a closure window that is intended to warn aircraft to keep out of a specific region throughout the time that a hazard may exist. The length of the window is primarily intended to account for the time needed for the operator to meet its mission objectives. The location and size of the closure area is defined to protect the public. For a launch or reentry, typically the keep-out must begin at the time of launch and ends when the mission has been completed, terminated, or cancelled. Airspace closures are immediately released once the mission has successfully cleared the area and no longer imposes a risk to the public. The actual duration of airspace closure is normally much less than the original planned closure, especially if the launch or reentry window is relatively long and the launch or reentry occurs at the beginning of the window. The FAA typically begins to clear airspace and reroute aircraft in advance of a launch or reentry and directs aircraft back into the released airspace after the mission to recover to normal flow and volume.

The location and size of airspace closures for commercial space operations also vary with each mission type and are influenced by multiple factors, including vehicle hardware reliability. The size of airspace closures shrink as reliability is established with results and analysis from each launch or reentry. For the initial reentry of a new vehicle (e.g., Dream Chaser), the hazard areas and associated airspace closures are bigger to account for the increased risk of a vehicle failure, relative to a mature vehicle. Subsequent reentries of that vehicle will include smaller hazard areas compared to the initial reentry.

All launch and reentry operations would comply with necessary notification requirements, including issuance of Notices to Mariners (NOTMARs), as defined in agreements required for a launch license issued by the FAA. A NOTMAR provides a notification regarding a temporary hazard within a defined area (a Ship Hazard Area [SHA]) to ensure public safety during proposed operations. A NOTMAR itself does not alter or close shipping lanes; rather, the NOTMAR provides a notification regarding a temporary hazard within a defined area to ensure public safety during the proposed operations.

To comply with FAA's licensing requirements, Sierra Space may enter into a Letter of Intent with appropriate USCG Districts in order to safely operate the Dream Chaser over open ocean. The Letter of Intent would describe the required responsibilities and procedures for both Sierra Space and USCG during a launch, which can include a landing, or reentry operation resulting in the issuance of a NOTMAR.

The USCG publishes NOTMARs weekly and as needed, informing the maritime community of temporary changes in conditions or hazards in navigable waterways. Notices in international areas are published by the National Geospatial Intelligence Agency. Advance notice via NOTMAR and the identification of SHAs would assist mariners in scheduling around any temporary disruption of shipping activities in the area of operation. The Proposed Action would not require shipping lanes to be altered or closed. Launches and reentries would be infrequent, of short duration, and scheduled in advance to minimize interruption to ship traffic.

Reentry

Sierra Space anticipates up to four reentries per year. Each reentry could occur during daytime or nighttime, (depending on the mission) with reentries beginning below that threshold in 2024 and steadily increasing. Sonic booms resulting from Dream Chaser reentry and landings will be infrequent and of low magnitude (up to 1.1 psf peak overpressure), additional information on noise and sonic booms are discussed in Section 3.3 Based on flight safety analysis conducted as a part of the license application, Sierra Space anticipates that there are no areas within the State of Florida, or the State of California, that will exceed individual or cumulative risk criteria limits.[10] Therefore, Sierra Space does not expect Dream Chaser reentry operations would require any closures of non-involved KSC property, VSFB Property, or public use areas (e.g., Merritt Island National Wildlife Refuge, Canaveral National Seashore, Jalama Beach County Park, Ocean Beach County Park), including coastal waters. Dream Chaser's cargo module would be released and burned-up during reentry and any surviving debris would be intentionally placed in a remote part of the Pacific Ocean within the cargo module disposal ranges and outside of known major shipping lanes, (see Figure 2-7). Cargo module disposal ranges are intended to cover the entirety of possible disposal location whereas the specific disposal area is representative of what would be impacted on a given mission. As shown in Figure 2-8, the representative cargo module disposal area is much smaller than the possible disposal range. The placement of the disposal area within the disposal range will be dependent on each mission. The disposal area would also, for a given mission and reentry location, bound the extent of any AHAs what would need to be managed during a reentry operation. Specific AHAs would be calculated and coordinated with the FAA and any foreign authorities on a mission by mission basis.

Contents within the cargo module would be dependent on the mission manifest. However, hazardous materials are not intended to be transported within the cargo module. The cargo module is largely

[10] Under 14 CFR § 450.101 (b)(1) and (2), collective risk is measured as an expected number of casualties (EC). Individual risk is measured as probability of casualty (P_C). Risk to all members of the public must not exceed an EC probability of 1 x10^{-4} per reentry and a P_c of 1 x 10^{-6} per reentry for individual members of the public.

designed from composite materials that will demise upon reentry. Surviving debris pieces are expected to be small, inert, metallic components that have partially demised by the time they reach the ocean surface. The quantity of surviving debris is anticipated to be very minimal and can vary based on the particular payload manifest for a given mission. Debris that does reach the ocean surface are expected to sink soon after.

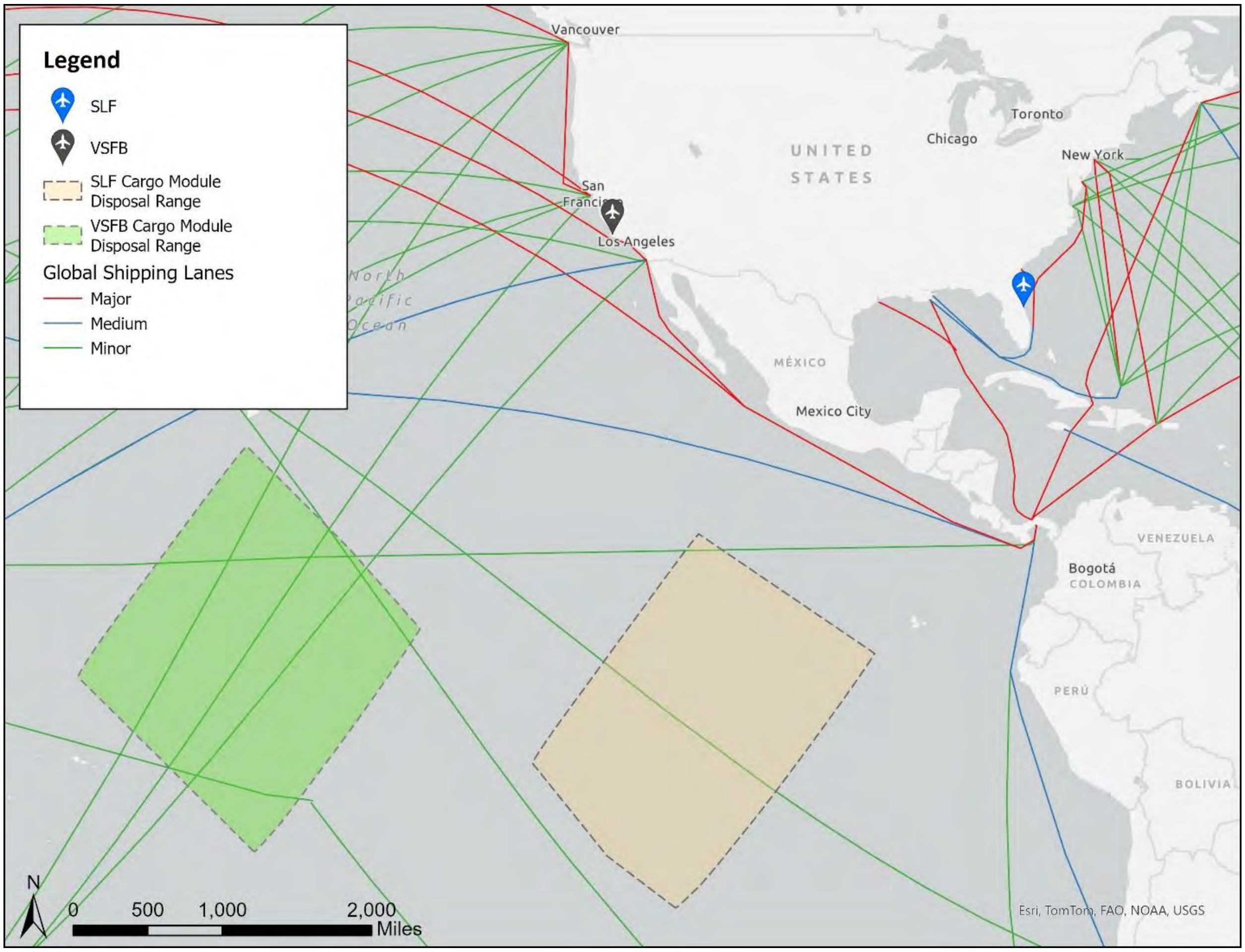

Figure 2-7: Cargo Module Disposal Ranges with Shipping Lanes

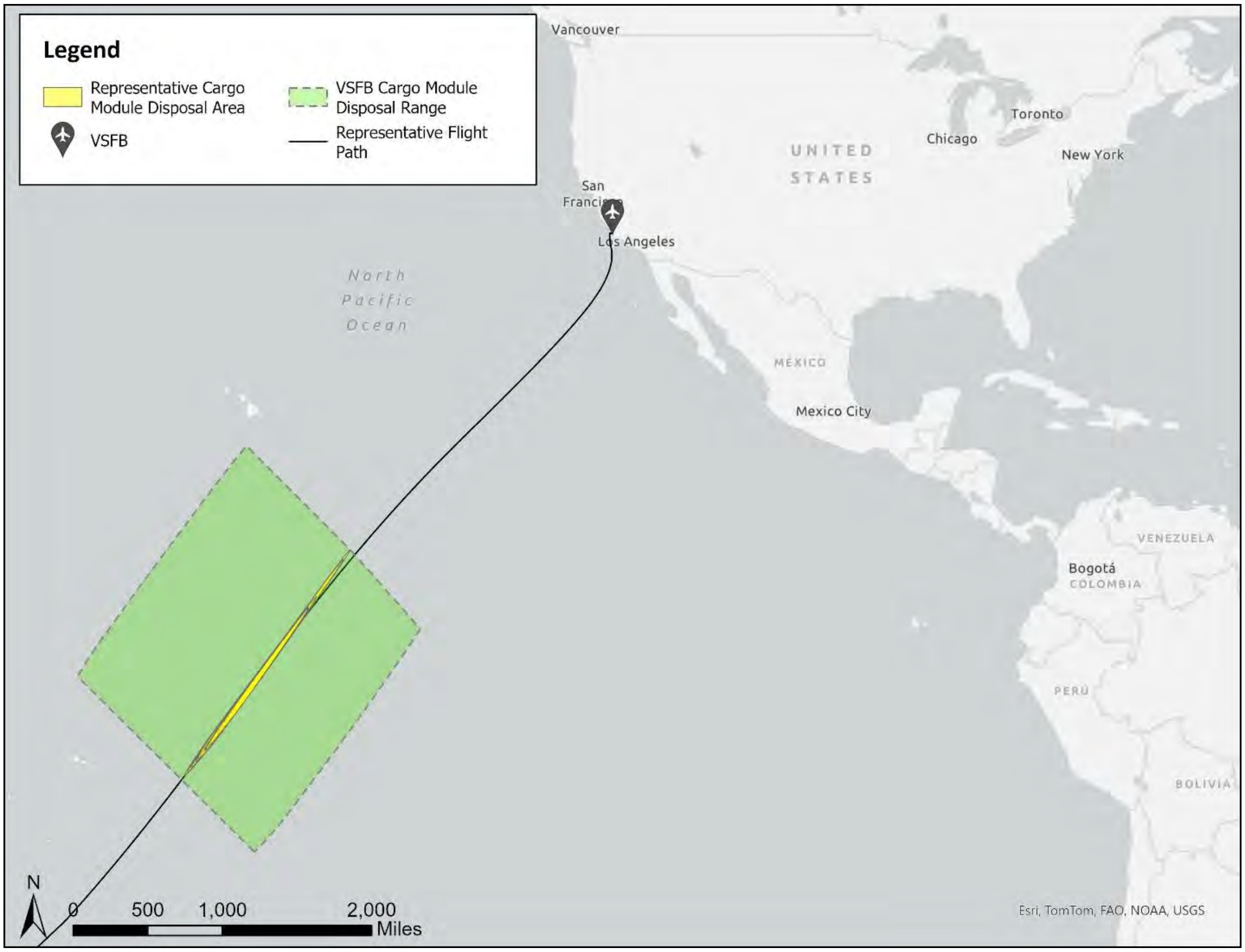

Figure 2-8: VSFB Cargo Module Disposal Area within Disposal Range

Shuttle Landing Facility

Dream Chaser would reenter from the west/southwest on an ascending trajectory in an unpowered landing at the SLF. Ascending trajectories would include high atmospheric overflight of Central American countries as well as overflight of the southern half of Florida, south of 29° North latitude. Dream Chaser's trajectories over Florida for landings on Runway 15/33 are shown in

Figure 2-9, which is identical to the figure shown in the 2021 PEA.

The reentry vehicle would descend below 60,000 feet altitude above mean sea level approximately 30-40 miles from the SLF prior to landing and would be operating below 60,000 mean sea level for less than 30 seconds before entering Cape Canaveral Restricted Airspace. The reentry vehicle would remain in the Cape Canaveral Restricted Airspace for the remainder of its reentry and landing at the SLF (for approximately 2.5 – 3 minutes). The vertical profile of the Dream Chaser reentry operation is shown in **Figure 2-10**.

Upon touch down, the vehicle would brake and come to a complete stop along the runway. Due to the potential for residual propellants on vehicle, a safety area would be established around the vehicle within the SLF property boundary.

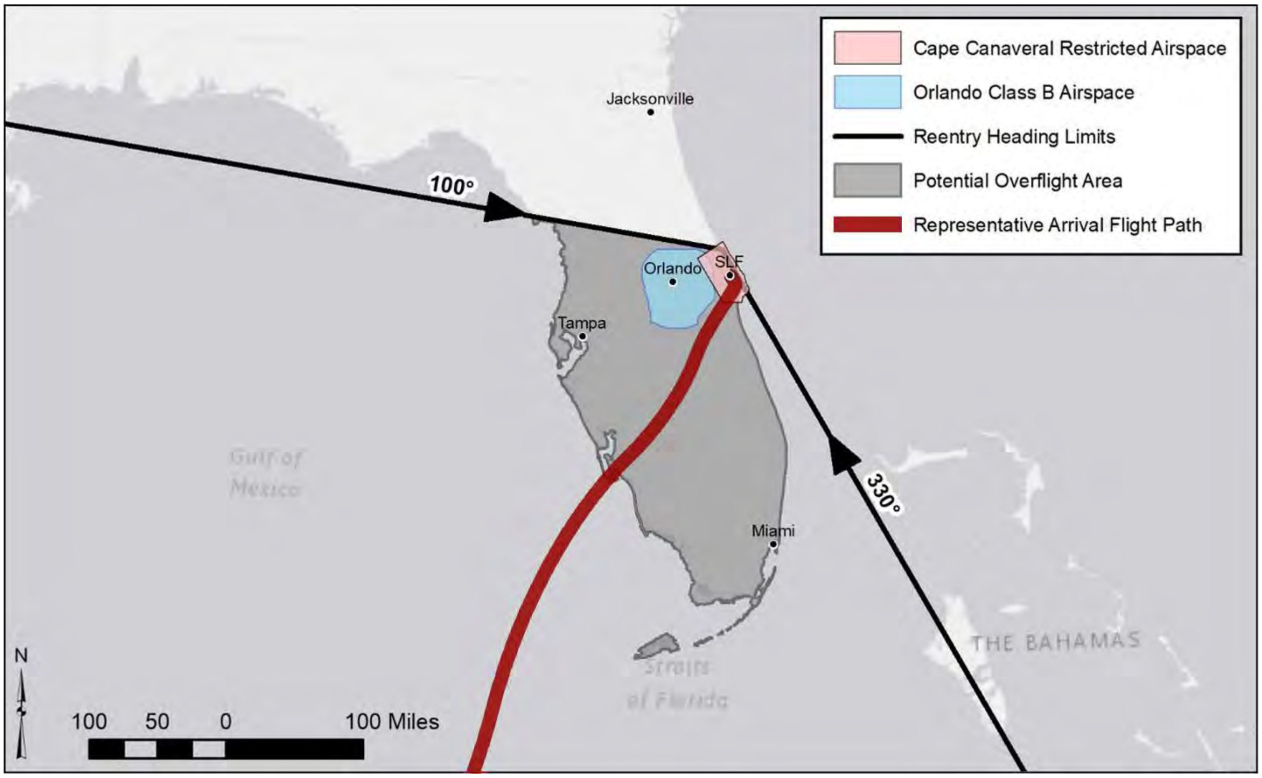

Figure 2-9: Dream Chaser Trajectories for SLF Landings

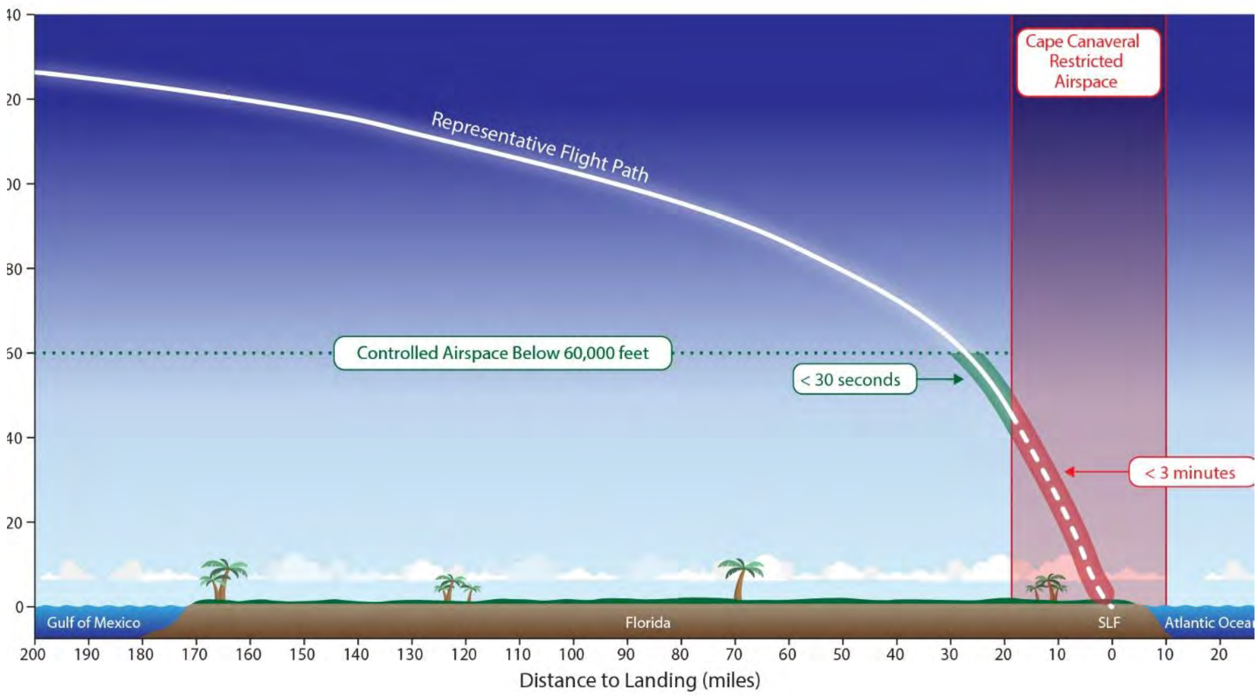

Figure 2-10: Dream Chaser Vertical Flight Profile for SLF Landings

Specific latitude and longitude coordinates for reentry operations at the SLF are not known to Sierra Space or the FAA at this time; each specific reentry trajectory and associated AHAs[11] would be provided to the FAA in advance of the reentry activity. The size, location, and extent of these areas vary mission-to-mission, based on mission-specific parameters. However, for the purposes of this EA, the general dimensions of an AHA, as well as the geographic range that has the potential to be affected by an AHA (and therefore subject to NOTAMs), have been identified. **Figure 2-11** shows a representative AHA generated for a single deorbit opportunity. The location of the AHA could vary based on the specific deorbit opportunity being executed for a particular mission. **Figure 2-12** shows the geographic range that has the potential to be affected by an AHA for a given deorbit opportunity based on the full ±700 nmi cross-range capability. The vertical profile of the Dream Chaser reentry operation with the representative AHA is shown in **Figure 2-13**.

[11] Under 14 CFR § 450.101(b)(3), an aircraft hazard area is defined by the 10^{-6} risk contour that is generated by the risk analysis performed as part of licensing. The aircraft hazard areas for Dream Chaser were developed using a series of cross-range cases. Hazard areas were produced assuming a 747-400 aircraft cruising between 11 and 12 km in altitude.

Figure 2-11: Dream Chaser Trajectories for SLF Landings

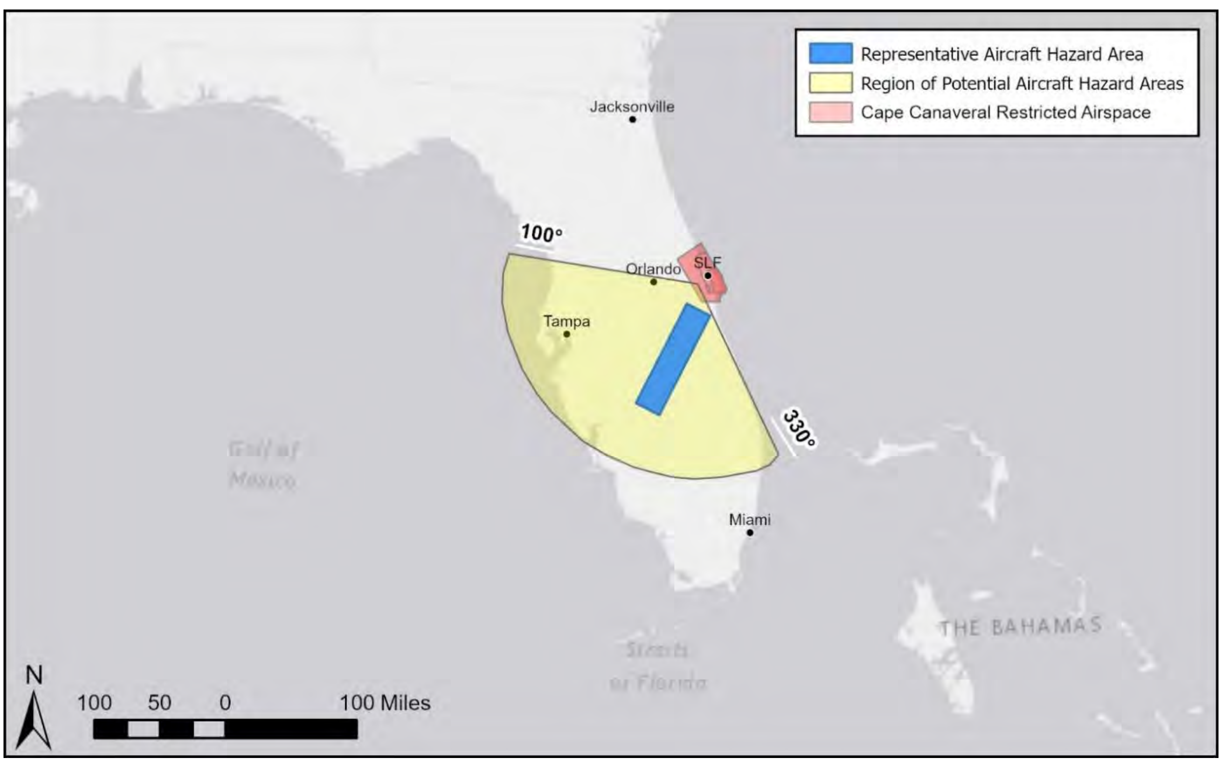

Figure 2-12: Geographic Range for Potential Aircraft Hazard Areas for SLF Landings

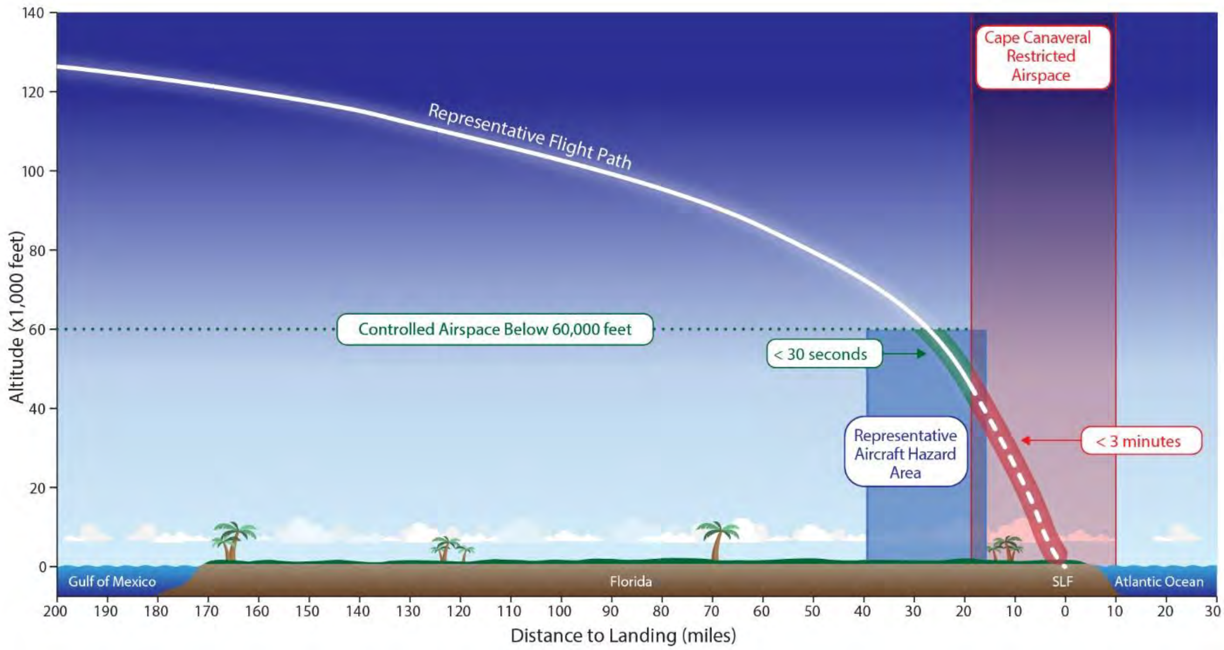

Figure 2-13: Vertical Flight Profile with Aircraft Hazard Area for SLF Landings

Vandenberg Space Force Base

For contingency reentries at VSFB Runway 12/30, Dream Chaser would reenter from the west/southwest on an ascending trajectory in an unpowered landing (**Figure 2-14**). Ascending reentry trajectories would include high atmospheric overflight of the Pacific Ocean. The reentry vehicle would descend below 60,000 feet altitude above mean sea level approximately 30-40 miles from VSFB prior to landing and would be operating below 60,000 mean sea level for less than 30 seconds before entering Vandenberg Restricted Airspace. The reentry vehicle would remain in the Vandenberg Restricted Airspace for the remainder of its reentry and landing at VSFB (for approximately 2.5 – 3 minutes), similar to reentry activities at the SLF. The vertical profile of the Dream Chaser reentry operation is shown in **Figure 2-15**.

Upon touch down, the vehicle would apply brakes and come to a complete stop along the runway. Due to the potential for residual propellants on vehicle, a safety area would be established around the vehicle within VSFB property boundary.

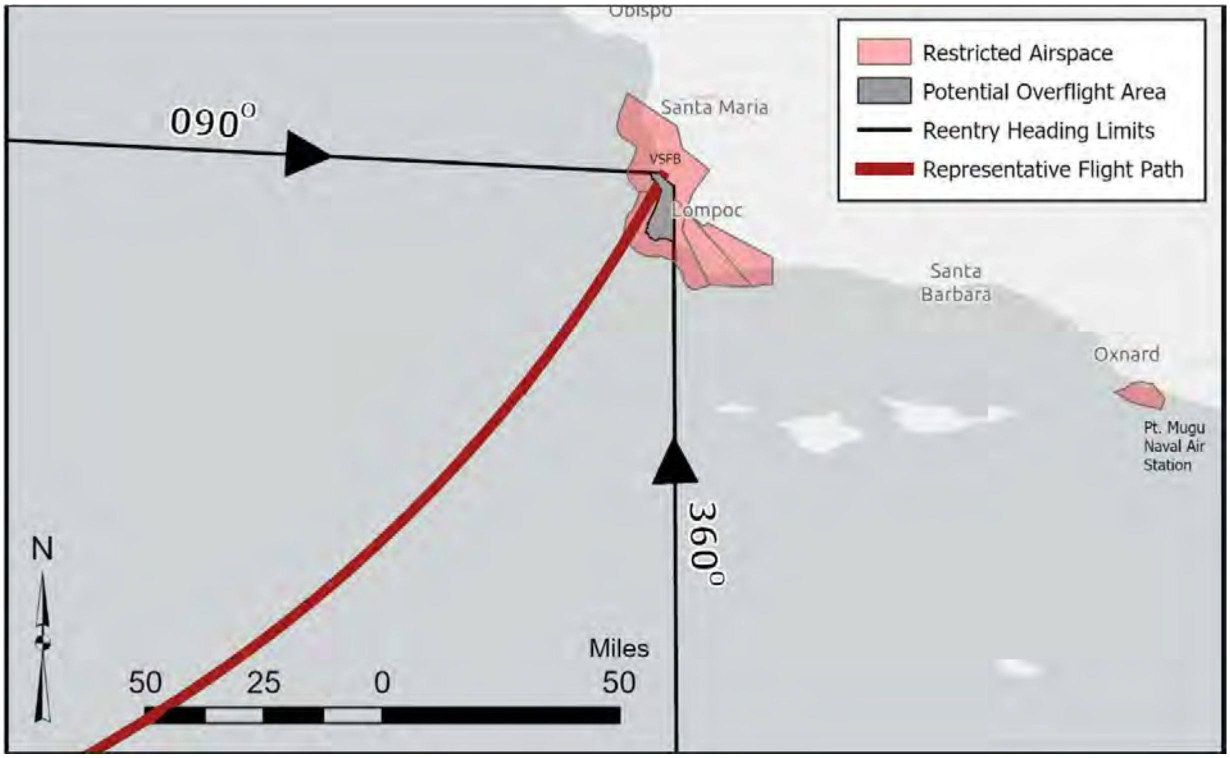

Figure 2-14: Dream Chaser Trajectories for VSFB Landings

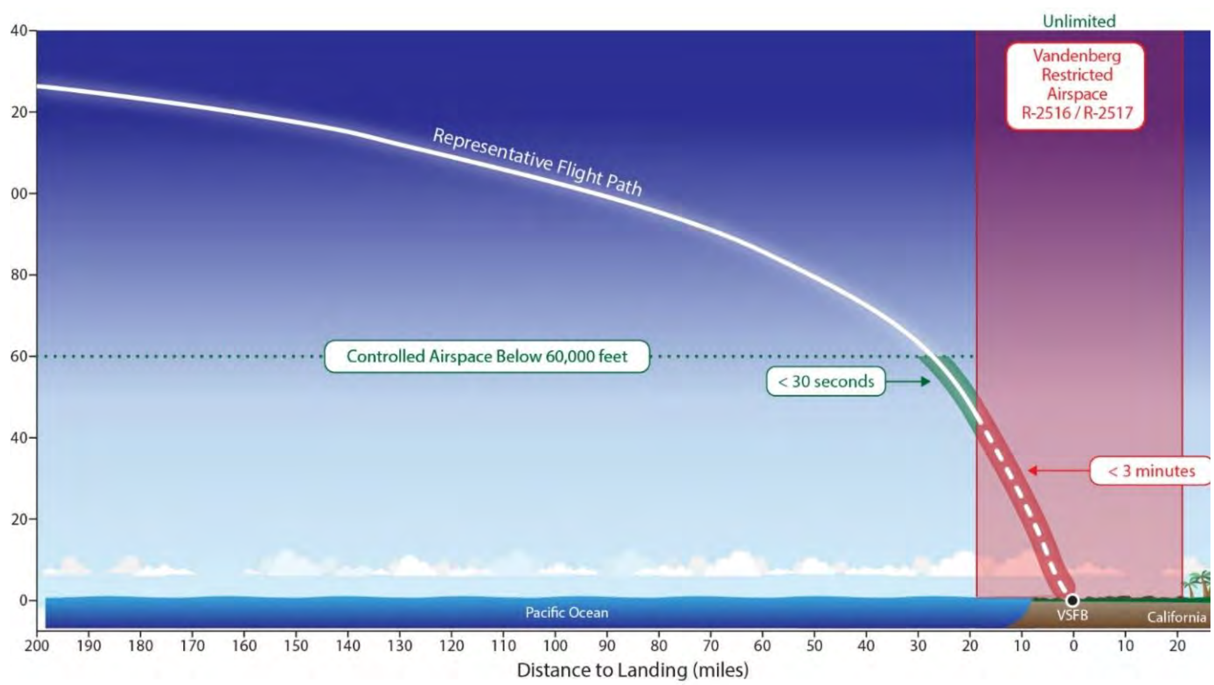

Figure 2-15: Dream Chaser Vertical Flight Profile for VSFB Landings

Figure 2-16 shows a representative AHA generated for a single deorbit opportunity at VSFB. The location of the AHA could vary based on the specific deorbit opportunity being executed for a particular mission. **Figure 2-17** shows the geographic range that has the potential to be affected by an AHA for a given deorbit opportunity based on the full ±700 nautical miles (nmi) cross-range capability. Both the representative AHA and geographic range were generated using conservative assumptions that account for variables such as seasonal winds, time of mission, and operational changes. The vertical profile of the Dream Chaser reentry operation with the representative AHA is shown in **Figure 2-18**.

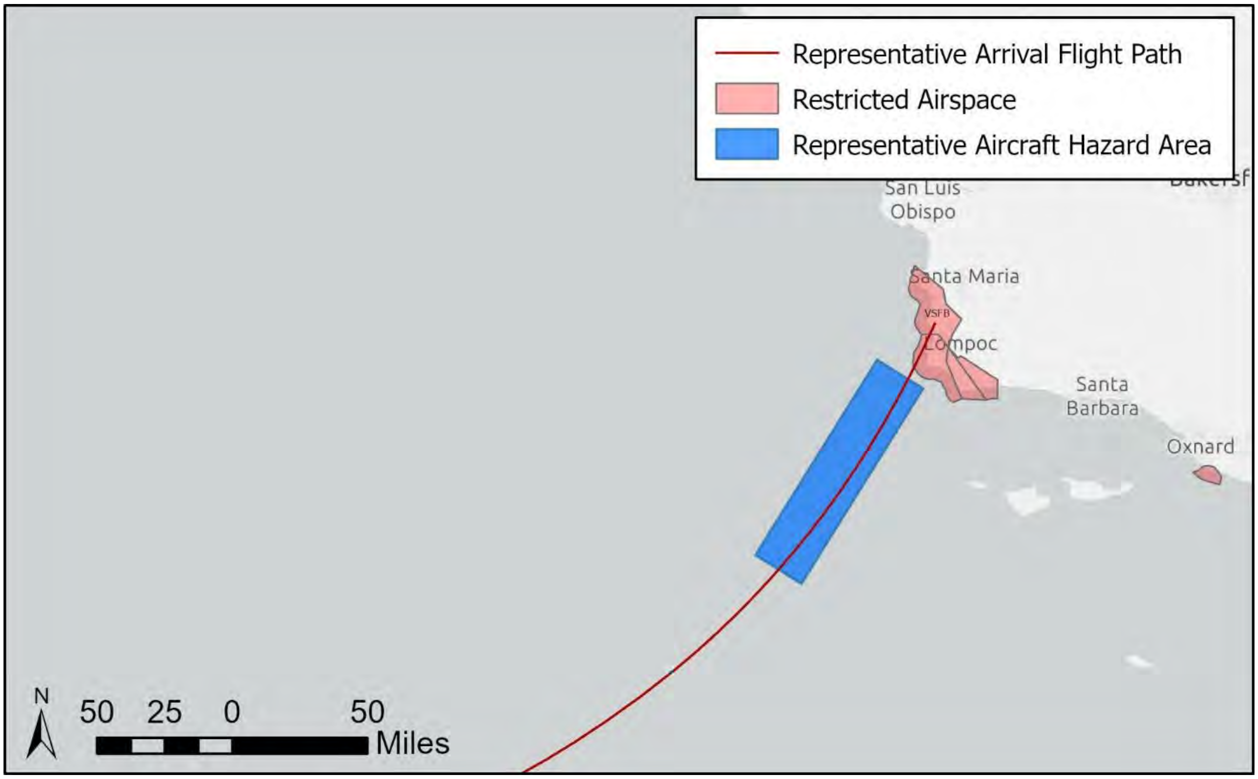

Figure 2-16: Representative Aircraft Hazard Area for VSFB Landings

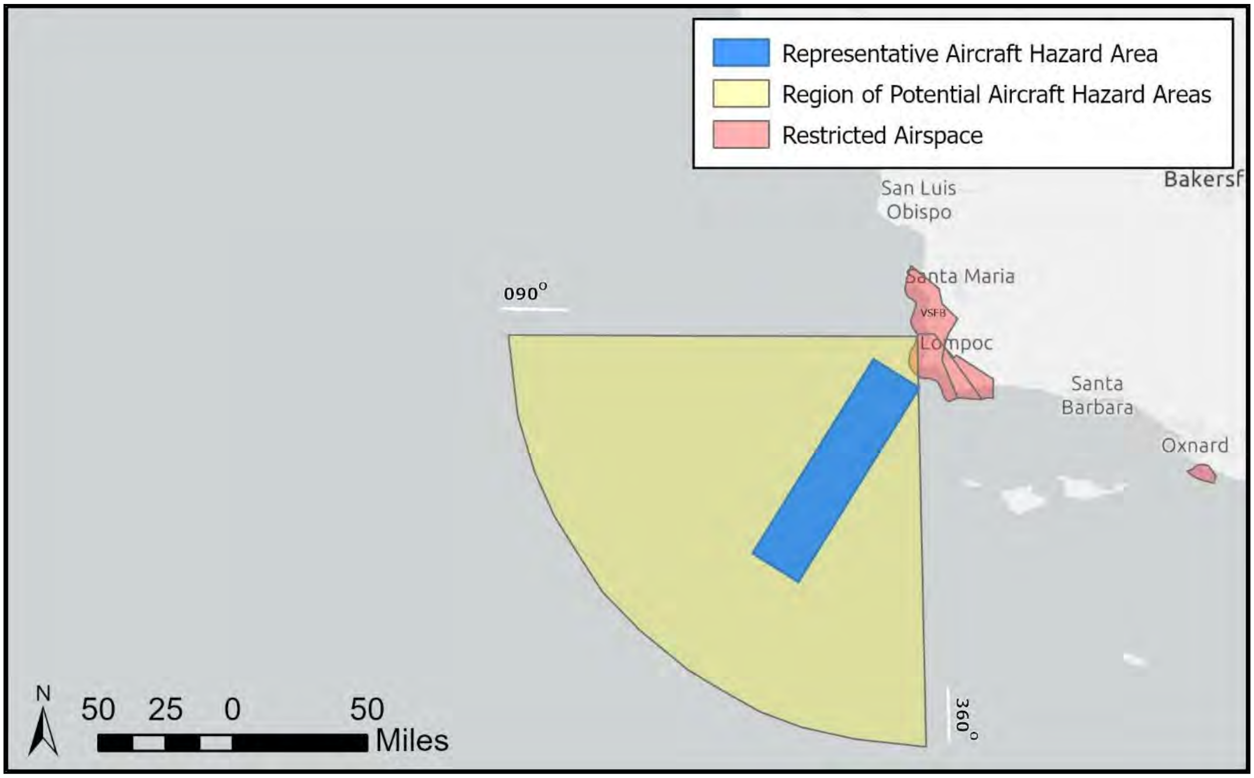

Figure 2-17: Geographic Range for Potential Aircraft Hazard Areas for VSFB Landings

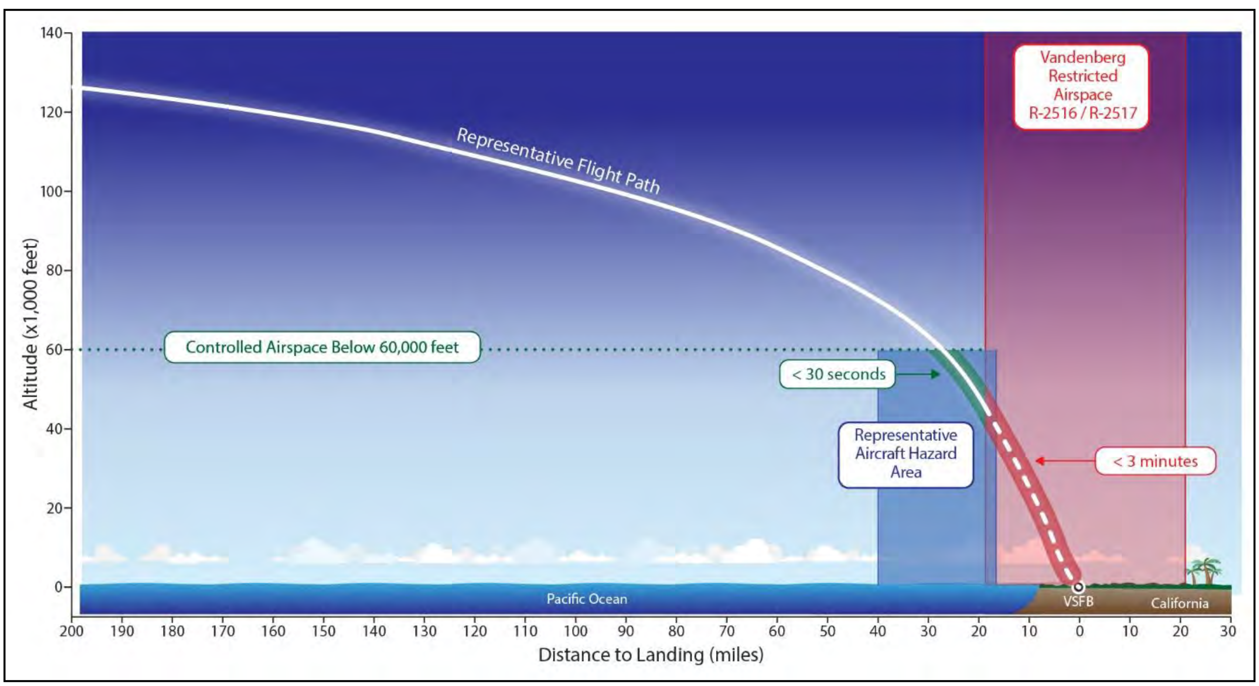

Figure 2-18: Dream Chaser Vertical Flight Profile with Aircraft Hazard Area for VSFB Landings

Post-flight Operations

Propellant handling operations, following landing and wheel-stop, and unloading of cargo would follow procedures that are dependent on the cargo manifest needs.

To process the Dream Chaser post-flight, Sierra Space would begin safing the vehicle on the runway. This would include activities such as disengaging and locking out the propulsion system, aerodynamic system, pressurized system, and other safety checks. If present, time-critical cargo would be unloaded, and Dream Chaser would be towed to a designated location, as defined in the explosive site plan for the respective reentry site. Sierra Space would coordinate with the respective reentry site operator to ensure only essential personnel are permitted on-site for up to a 24-hour period, or longer, if required for vehicle safing procedures.

Residual RP1 shall remain isolated within the propulsion system of the Dream Chaser and not extracted during post-landing operations until the Dream Chaser is at a Sierra Space facility. Residual H_2O_2 will be diluted to a concentration of approximately 35% by pumping water into the tanks via a valve in the aft end of the vehicle and loaded onto a truck for offsite disposal in accordance with the ESP for the respective landing site and applicable local, state, and federal regulations. The dilution procedure will be executed on the runway. No changes to the ESP or any facilities at SLF or VSFB are planned.

SLF Runway 15/33 or VSFB Runway 12/30 would be unavailable to other operations or activities while Dream Chaser is stopped on the runway. Space Florida and VSFB, respectively, would perform a runway inspection prior to reopening the runway for other aircraft/spacecraft. Dream Chaser would be prepped for transportation from SLF or VSFB and moved to Sierra Space facilities.

Approximately 28 Sierra Space employees will arrive at the Vandenberg area 7 days prior to landing and remain there up to 15 days post landing. During post flight processing, this crew will utilize no more than four 35-hp Santa Barbara County limit ground generators for a total of 48 hours. Onsite transportation and equipment towing will be performed using up to four F-450 Super Duty utility trucks. The generators will run on gasoline and the trucks on diesel.

After onsite processing is complete, the Dream Chaser will be loaded onto a flatbed for heavy duty trucking (18-wheeler) to the Sierra Space facility in Florida.

Construction/Site Modifications

No construction or site modifications at the SLF or VSFB is required as part of the Proposed Action. See Section 2.2.3.5 for further details.

Chapter 3
Affected Environment and Environmental Consequences

Introduction

This chapter provides a description of the geographic area and environmental resources therein that the Proposed Action may affect as required by FAA Order 1050.1F, *Environmental Impacts: Policies and Procedures*. The study area for this EA is the geographic area that could be directly or indirectly affected by the Proposed Action. The Proposed Action would not result in ground disturbing activities or directly affect the SLF or VSFB.

For the SLF, the sonic boom study area (consistent with that analyzed in the 2021 PEA) is based on the combined footprint of the Dream Chaser's 1.0 pounds per square foot (or psf) sonic boom noise contour as it descends to land at the SLF on Runway 15 or Runway 33 (**Figure 3-1**). For VSFB, the study area analyzed in this EA is based on the combined footprint of the Dream Chaser's 1.0 psf sonic boom noise contour as it descends to land at VSFB Runway 12 or Runway 30 (**Figure 3-2**).

The study area for both the SLF and VSFB also includes the Cape Canaveral and VSFB Restricted Airspace, the airspace surrounding the reentry trajectory, and the airspace associated with any hazard area that must be protected to ensure public safety (see Section 2.2.3.2 for a depiction of the range of potential AHAs).

Additionally, there is study area for remote areas of the Pacific Ocean where surviving debris from the cargo module may be disposed, for reentries conducted at the SLF and VSFB. The Dream Chaser vehicle is designed to support a wide variety of reentry trajectories that would each fly over different portions of the Pacific Ocean. The disposal range is intended to cover the entirety of possible disposal location whereas the specific disposal area is representative of what would be impacted on a given mission. As shown in **Figure 3-3**, the representative cargo module disposal area is much smaller than the possible disposal range. The discrete location of the cargo module disposal would be calculated by Sierra Space in advance of a specific reentry operation. These areas are mission dependent and would be determined prior to a scheduled reentry. Cargo module debris disposal ranges are depicted in **Figure 3-4**. AHAs associated with cargo module reentry would be consistent with the mission-specific cargo module disposal area and within the cargo module disposal range.

Figure 3-1: Study Area for SLF

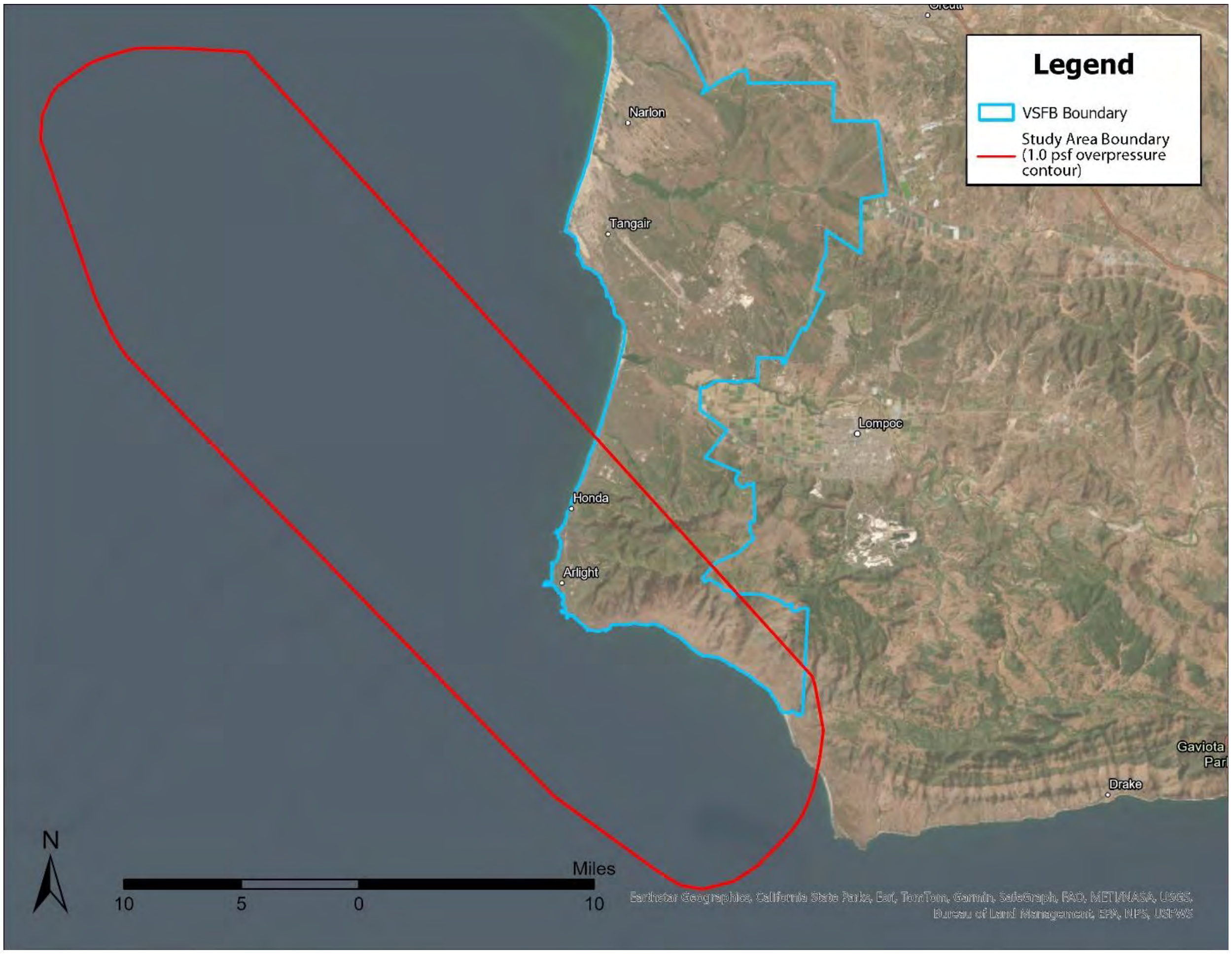

Figure 3-2: Study Area for VSFB

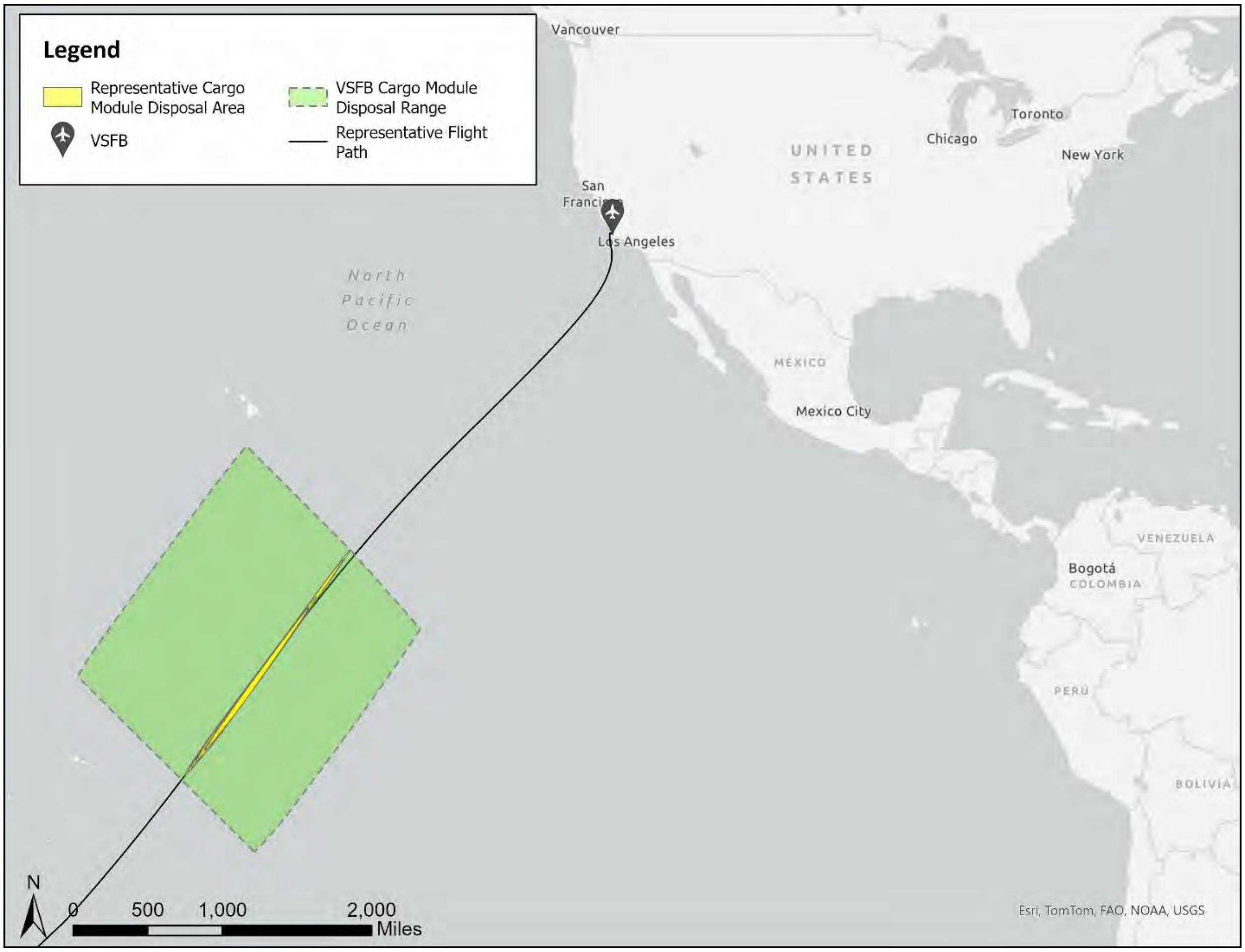

Figure 3-3: Cargo Disposal Area versus Cargo Disposal Range

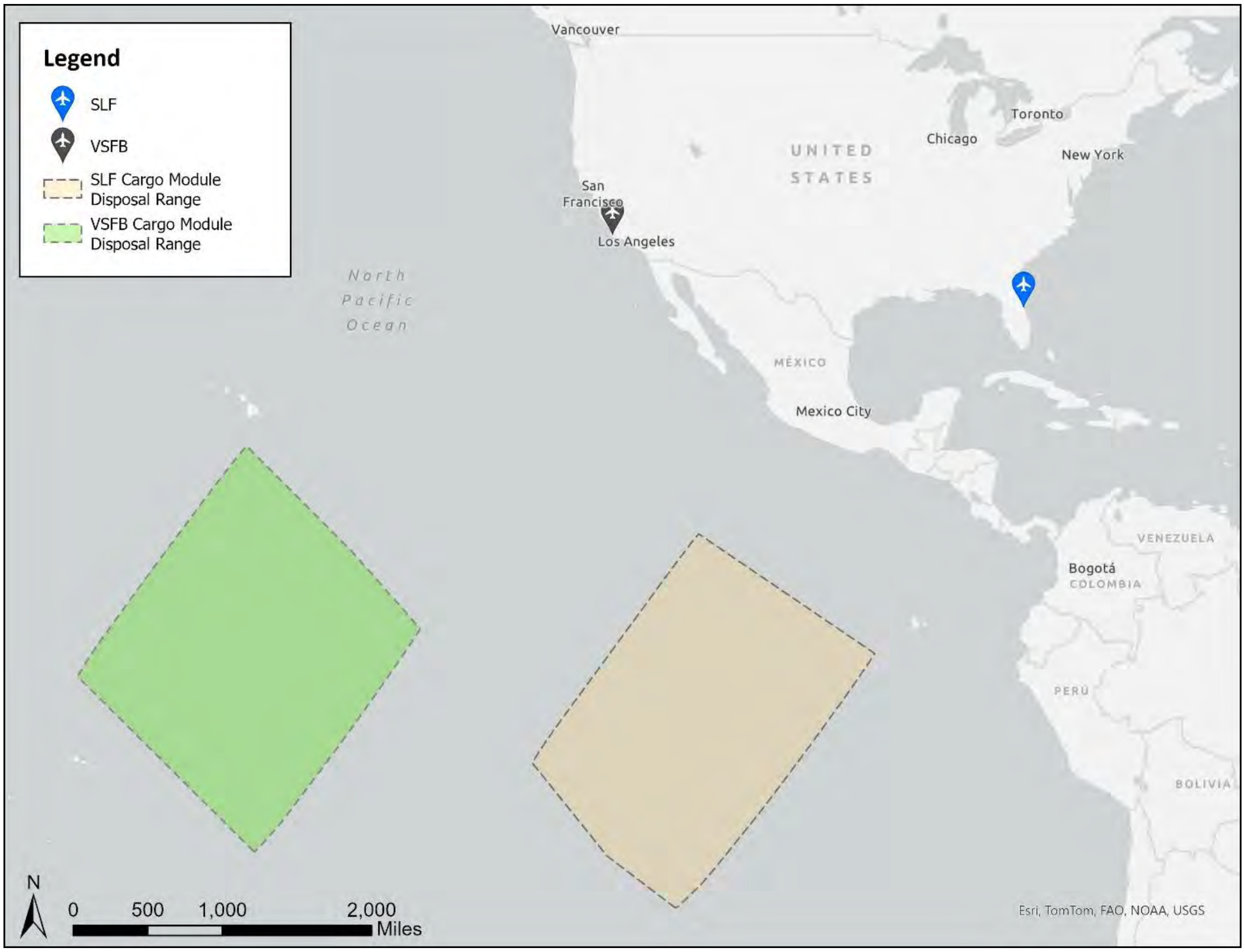

Figure 3-4: VSFB and SLF Cargo Module Disposal Ranges

Resources Related to the Shuttle Landing Facility Sonic Boom Study Area

The Dream Chaser was the representative vehicle evaluated in the 2021 PEA and the total number of reentry operations (up to four annually) would not exceed those analyzed in the 2021 PEA (up to six annually). The FAA Prepared a Written Re-evaluation of the affected environmental and environmental impacts of the 2021 PEA and concluded that the contents of the 2021 PEA remain current and substantially valid and therefore may be incorporated by reference per 40 CFR §1501.12. The affected environment and environmental consequences contained in the 2021 PEA are incorporated by reference for the below impact categories.

- **Coastal Resources:** The Proposed Action would be consistent to the maximum extent practicable with the enforceable policies of the Florida Coastal Management Program and would not adversely affect coastal resources, create plans to direct future agency actions, propose rulemaking that alters uses do the coastal zone that are inconsistent with the Programs, or involve Outer Continental Shelf Leases.

- **Department of Transportation Act, Section 4(f):** Using the SLF as a landing facility for the Dream Chaser would not require the physical or constructive use of or have direct impact on any Section 4(f) properties.
- **Farmland:** The operation of the Dream Chaser at the SLF would not disturb surrounding soils or affect the air quality, water quality, or noise levels in a way that would affect nearby farmlands.
- **Historical, Architectural, Archaeological, and Cultural Resources:** The Dream Chaser using the SLF as a landing facility would have no adverse effect to historic properties, as determined by the FAA and concurred with by the Florida State Historic Preservation Office on August 3, 2020.
- **Land Use:** The Dream Chaser using the SLF as a reentry facility is compatible with the existing operations that occur at the SLF and would not significantly impact the land use. The Proposed Action would not result in ground disturbing activities.
- **Natural Resources and Energy Supply:** Local supplies of natural resources, fuel, or energy will not be required to land the Dream Chaser at the SLF. Therefore, the Proposed Action would not significantly impact Natural Resources and Energy Supply.
- **Noise:** For reentry operations at the SLF, the Proposed Action includes up to four annual reentries that may be either during daytime or nighttime. To be conservative, the noise analysis analyzed up to four nighttime reentries at the SLF, while the 2021 PEA analyzed up to four daytime reentries plus up to two nighttime reentries annually. The increase in nighttime reentries, while reducing the overall number of entries, would increase the CDNL from 41 C-weighted decibels to 43 C-weighted decibels, well below the significance threshold of CDNL 60 C-weighted decibels (equivalent to a DNL of 65 dbA). Therefore, there would be no significant impact from Dream Chaser reentry operations at the SLF.
- **Visual Effects (including Light Emissions):** Operating the Dream Chaser at the SLF would have a similar visual effect as the current aircraft operations at the SLF. The Proposed Action would comply with the KSC Exterior Lighting Guidelines, the Lighting Management Plan, and requirements of the USFWS Biological Opinion for KSC impacts to threatened and endangered species.

Potential environmental impacts that are specific to the current Proposed Action and were therefore not fully analyzed in the 2021 PEA are considered independently in this EA. Potential environmental impacts from noise and noise-compatible land use are analyzed in this EA in detail (Section 0). Potential environmental impacts for the following impact categories are not analyzed in this EA in detail for the reasons stated below:

- **Air Quality:** There would be no combustion from reentry vehicles once the deorbit burn completes, so there would be no Dream Chaser emissions below 3,000 feet (the mixing layer). Airspace closures associated with commercial space operations (Dream Chaser vehicle and cargo module) could result in additional aircraft emissions mainly from aircraft being re-routed and expending more fuel. Airspace-related impacts could occur up to a maximum of four times per year due to the Proposed Action. Any delays in aircraft departures from affected airports would be short term, as the NOTAM has a duration of one-hour or less. Thus, any increases in air emissions from grounded aircraft are expected to be minimal and would occur in attainment areas. Therefore, these emissions increases are not expected to result in an exceedance of a National Ambient Air Quality Standard for any criteria pollutant. Emissions from aircraft being re-routed would occur above 3,000 feet and thus would not affect ambient air quality.

- **Climate:** There would be no combustion from reentry vehicles once the vehicle enters the atmosphere, so the Proposed Action would not significantly affect climate. Airspace closures associated with commercial space operations would result in additional aircraft emissions mainly from aircraft being re-routed and expending more fuel. These emissions include carbon dioxide (CO_2), which is a greenhouse gas. Based on Sierra Space's proposal, these temporary increases in aircraft emissions could increase up to a maximum of four times per year. The amount of time that affected aircraft would spend being re-routed would be short. In addition, the number of aircraft that would be impacted per reentry would not be expected to produce additional emissions that would have a notable impact on climate. Therefore, the increases in greenhouse gases caused by short-term airspace closures during the Dream Chaser's reentry at the SLF is not expected to result in significant climate-related impacts.
- **Biological Resources:** Sonic booms generated from using the SLF as a reentry facility for the Dream Chaser "may affect, but would not adversely affect" Endangered Species Act-listed wildlife species, as determined by the FAA and concurred with by USFWS on May 8, 2020 during consultation for the 2021 PEA. A copy of the USFWS concurrence letter is provided in Appendix B. Due to the low probability of potential bird strikes, the introduction of additional reentries would not significantly increase the chance of a bird strike during landing activities. In addition to this, the SLF has a Wildlife Hazard Management Plan in place to reduce the risk of impacts to birds and wildlife, in addition to improving the safety of reentry vehicle landing at the SLF. Surviving debris of the cargo module, if it is not completely demised during reentry, would occur in the remote Pacific Ocean and would not result in significant impacts on federally protected species or habitat due to lower species densities than compared to nearshore.
- **Hazardous Materials, Pollution Prevention, and Solid Waste:** The Proposed Action would not significantly alter the use and storage of hazardous materials onsite as there are similar operations and materials currently handled at the SLF. Hazardous materials needed would not be permanently stored onsite. When operating the Dream Chaser from the SLF, hazardous material use, storage, and disposal would comply with applicable regulations, therefore minimizing the potential effects from those materials. No hazardous materials would be disposed of in the cargo module.
- **Socioeconomics, Environmental Justice and Children's Environmental Health:** The Proposed Action is not expected to affect Brevard or Volusia Counties' population, labor force, and travel patterns as there is no proposed construction and Sierra would only employ 20 to 40 people in a mix of full- and part-time positions, for post-reentry procedures. In addition, it would not have a disproportionately high or adverse human health or environmental impact on minority or low-income populations. Conducting Dream Chaser reentries at the SLF would not significantly affect children's environmental health or safety, as access to the reentry would require security clearance/badging or escort by approved access, and the only impact outside of the reentry site boundary would be a low-magnitude and infrequent sonic boom. Socioeconomic impacts from re-routing aircraft due to landing of the Dream Chaser at the SLF would be similar to re-rerouting aircraft for other reasons (e.g., weather issues, runway closures, wildfires, military exercises, and presidential flights). Potential socioeconomic impacts would include additional airline operating

costs for increased flight distances and times resulting from re-routing aircraft and increased passenger costs as a result of impacted passenger travel, including time lost from delayed flights, flight cancellations, and missed connections. Alternatively, restricting or preventing a reentry event would have socioeconomic impacts on Sierra Space, commercial payload providers, and consumers of payload services. Operations would not result in the closure of any public airport during the operation nor so severely restrict the use of the surrounding airspace as to prevent access to an airport for an extended period of time. Given existing airspace closures for commercial space operations are temporary as discussed above and the FAA's previous analyses related to the NAS have concluded minor or minimal impacts on the NAS from commercial space operations, the FAA does not expect airspace closures from Sierra Space's proposal would result in significant socioeconomic impacts. Furthermore, local air traffic controls would coordinate with airports and aircraft operators to minimize the effect of the reentry operations on airport traffic flows as well as traffic flows in enroute airspace. On April 13, 2023, the FAA issued a *Notice of Updated Factors for Optimizing Use of the National Airspace System*. To mitigate the impacts of increased commercial space operations on other aircraft flight operations without impeding commercial space operations, the FAA updated factors to inform decisions to optimize the NAS. The factors include, among other things, limiting launches during times of high NAS congestion (such as holidays), encouraging commercial launches during nighttime hours when other flight operations tend to be reduced, and minimizing launch windows. The anticipated impact from implementation of these factors was to minimize disruptions to and reroutes of other airspace users.

- **Water Resources:** The Proposed Action would not affect wetlands. The measures required by Space Florida's National Pollution Discharge Elimination System and Environmental Resource permits and the Spill Prevention Control and Countermeasures and SLF emergency spill plan ensure that Dream Chaser operations at the SLF would not impacts to the surface water. Neither development nor construction activities are needed at the SLF for the Proposed Action and therefore no significant impact to water resources should occur. Potential splashdown of the cargo module, if it is not completely reduced during reentry, would break into fragments in the remote Pacific Ocean. The fragments would be composed of inert materials that are not chemically or biologically reactive so would not significantly impact water resources. The cargo module would not carry hazardous materials, has no propulsion tanks, and all hazards would be understood prior to reentry.

A detailed analysis of potential noise and noise-compatible land uses is included below in Section 00.

Resources Related to Vandenberg Space Force Base Sonic Boom Study Area

Resources Considered but not Analyzed in Detail

The following resources related to sonic booms generated by reentry operations at VSFB were considered but not analyzed in detail in this EA:

- **Coastal Resources:** The Coastal Zone Management Act (CZMA) provides for the management of the nation's coastal resources, and any federal action that may affect the coastal zone must be consistent with state coastal zone management programs. The Coastal Zone, defined by the California Legislature, is located within the Study Area. However, proposed landing operations at VSFB would not result in any coastal closures, ground disturbances, require new construction, or propose rulemaking that alters uses to the coastal zone that are inconsistent with the CZMA or California Coastal Act.

- **Farmland:** The operation of the Dream Chaser at VSFB would not require new construction or disturbance to surrounding soils. In addition, the proposed activities would not impact the air quality, water quality, or noise levels in a way that would affect nearby farmlands.
- **Historical, Architectural, Archaeological, and Cultural Resources:** Section 106 of the National Historic Preservation Act (NHPA) requires federal agencies to consider the effects of its undertaking on historic properties in accordance with 36 CFR Part 800. The Dream Chaser, using VSFB as a landing facility, would not require any new construction or ground disturbance; therefore, there would be no disturbance to archaeological resources. Impacts to historic resources as result of sonic booms are not anticipated. Within the study area, sonic booms are anticipated but would be temporary, short in duration, and would be a maximum 1.1 psf. For a sonic boom to cause impacts, overpressure would need to exceed at least 2 psf, at which minor structural damage may occur, but would still be unlikely. Historical structures within the study area may be exposed to a peak overpressure of 1.1 psf, and therefore are not anticipated to be impacted. No consultation with the California State Historic Preservation Officer is required as the Proposed Action does not have the potential to affect historical, architectural, archaeological, or other cultural resources. A letter of no effect to the SHPO is provided in **Appendix C**.
- **Land Use:** The Dream Chaser, using VSFB as a reentry facility, is compatible with the existing operations that occur at VSFB. No new construction or ground disturbances are proposed that would change the current the land use.
- **Natural Resources and Energy Supply:** Local supplies of natural resources, fuel, or energy will not be required to land the Dream Chaser at VSFB. Therefore, the Proposed Action would not significantly impact Natural Resources and Energy Supply.
- **Visual Effects (including Light Emissions):** Operating the Dream Chaser at VSFB would have a similar visual effect as the current aircraft operations at VSFB. The proposed project would not impact existing visual resources or block/obstruct views from other locations.
- **Air Quality:** There would be no combustion from reentry vehicles once the deorbit burn completes. Airspace closures associated with commercial space operations would result in additional aircraft emissions mainly from aircraft being re-routed and expending more fuel. Minimal, if any, additional emissions would be generated from aircraft departure delays because the FAA has rarely, if ever, received reportable departure delays associated with commercial space operations around VSFB. Based on Sierra Space's proposal, airspace-related impacts could occur up to a maximum of four times per year due to the Proposed Action. Any delays in aircraft departures from affected airports would be short term, as the NOTAM has a duration of one-hour or less. Thus, any increases in air emissions from grounded aircraft are expected to be minimal and would occur in attainment areas. Therefore, these emissions increases are not expected to result in an exceedance of a National

Ambient Air Quality Standard for any criteria pollutant. Emissions from aircraft being re-routed would occur above 3,000 feet (the mixing layer) and thus would not affect ambient air quality.

- **Climate:** There would be no combustion from reentry vehicles once the vehicle enters the atmosphere, so the Proposed Action would not significantly affect climate. Airspace closures associated with commercial space operations (Dream Chaser vehicle and cargo module) could result in additional aircraft emissions mainly from aircraft being re-routed and expending more fuel. These emissions include CO_2, which is a greenhouse gas. Based on Sierra Space's proposal, these temporary increases in aircraft emissions could increase up to a maximum of four times per year. The amount of time that affected aircraft would spend being re-routed would be short. In addition, the number of aircraft that would be impacted per reentry would not be expected to produce additional emissions that would have a notable impact on climate. Therefore, the increases in greenhouse gases caused by short-term airspace closures during the Dream Chaser's reentry at VSFB is not expected to result in significant climate-related impacts.
- **Hazardous Materials, Pollution Prevention, and Solid Waste:** The Proposed Action would not significantly alter the use and storage of hazardous materials onsite as there are similar operations and materials currently handled at VSFB (see Section 2.2.3.5). Hazardous materials needed would not be permanently stored onsite. When operating the Dream Chaser from VSFB, hazardous material use, storage, and disposal would comply with applicable regulations, therefore minimizing the potential effects from those materials. No hazardous materials would be disposed of in the cargo module.
- **Socioeconomics, Environmental Justice and Children's Environmental Health:** The Proposed Action is not expected to affect Santa Barbara County's population, labor force, and travel patterns as there is no proposed construction and Sierra would only employ 10 to 40 people in a mix of full- and part-time positions, for post-reentry procedures. In addition, it would not have a disproportionately high or adverse human health or environmental impact on minority or low-income populations. Conducting Dream Chaser reentries at VSFB would not significantly affect children's environmental health or safety, as access to the reentry would require security clearance/badging or escort by approved access, and the only impact outside of the reentry site boundary would be a low-magnitude and infrequent sonic boom. Socioeconomic impacts from re-routing aircraft due to landing of the Dream Chaser at VSFB would be similar to re-rerouting aircraft for other reasons (e.g., weather issues, runway closures, wildfires, military exercises, and presidential flights). Potential socioeconomic impacts would include additional airline operating costs for increased flight distances and times resulting from re-routing aircraft and increased passenger costs as a result of impacted passenger travel, including time lost from delayed flights, flight cancellations, and missed connections. Alternatively, restricting or preventing a reentry event would have socioeconomic impacts on Sierra Space, commercial payload providers, and consumers of payload services. Operations would not result in the closure of any public airport during the operation nor so severely restrict the use of the surrounding airspace as to prevent access to an airport for an extended period of time. Given existing airspace closures for commercial space operations are temporary as discussed above and the FAA's previous analyses related to the NAS have concluded minor or minimal impacts on the NAS from commercial space operations, the FAA does not expect airspace closures from Sierra Space's proposal would result in significant socioeconomic impacts.

Furthermore, local air traffic controls would coordinate with airports and aircraft operators to minimize the effect of the reentry operations on airport traffic flows as well as traffic flows in enroute airspace. On April 13, 2023, the FAA issued a Notice of Updated Factors for Optimizing Use of the NAS. To mitigate the impacts of increased commercial space operations on other aircraft flight operations without impeding commercial space operations, the FAA updated factors to inform decisions to optimize the NAS. The factors include, among other things, limiting launches during times of high NAS congestion (such as holidays), encouraging commercial launches during nighttime hours when other flight operations tend to be reduced, and minimizing launch windows. The anticipated impact from implementation of these factors was to minimize disruptions to and reroutes of other airspace users.

- **Water Resources:** The Proposed Action would not affect any undisturbed wetlands, floodplains, or any water features. Development nor construction activities are not needed at VSFB for the Proposed Action and, therefore, no significant impact to water resources should occur. Surviving debris of the cargo module, if it is not completely reduced during reentry, would occur in the remote Pacific Ocean. The fragments would be composed of inert materials that are not chemically or biologically reactive so would not significantly impact water resources. No hazardous materials would be disposed of in the cargo module.

Resources Analyzed in Detail

Resources analyzed in detail for the sonic boom study area at VSFB include biological resources and Department of Transportation Act, Section 4(f). A detailed analysis of potential impacts to noise and noise-compatible land use is included below in Section 0.

Biological Resources for Reentry Sonic Boom Impacts

The Proposed Action would not result in ground disturbing activities at VSFB that could result in direct impacts to federally or state-listed threatened or endangered species or critical habitat. Operational impacts associated with the Proposed Action could potentially cause noise impacts to federally or state-listed species in the study area in the form of a sonic boom. Dream Chaser reentry operations could produce a maximum sonic boom overpressure of 1.1 psf, which would be similar to a thunderclap. The study area for the Proposed Action is the area that has the potential to be exposed to a sonic boom of 1.0 psf or higher (**Figure 3-2**).

Migratory bird habitats would not be significantly impacted by reentry operations due to the low risk of bird strikes at VSFB. Continuous aircraft and launch activity from VSFB create a less suitable habitat for migratory birds, and with only four reentry operations occurring, it is unlikely that these operations would impact migratory bird habitats. Additionally, VSFB has a wildlife strike management plan to mitigate the potential for strikes in the vicinity of the airfield.

Table 3-1 provides a summary of Endangered Species Act (ESA)-listed species under the jurisdiction of the US Fish and Wildlife Service (USFWS) that may be present in the study area. Designated critical habitat for the California Red-legged Frog and Gaviota Tarplant are present and shown within **Figure 3-5**.

Table 3-1: ESA-Listed Species for the Study Area USFWS

Category	Species Common Name	Species Scientific Name	State Status	Federal Status
Mammals	Southern Sea Otter	*Enhydra lutris nereis*	-	FT
Birds	Bald Eagle	*Haliaeetus leucocephalus*	SE	-
	California Condor	*Gymnogyps californianus*	SE	FE
	Belding's Savannah Sparrow	*Passerculus sandwichensis beldingi*	SE	-
	California Least Tern	*Sternula antillarum browni*	SE	FE
	Least Bell's Vireo	*Vireo bellii pusillus*	SE	FE
	Little Willow Flycatcher	*Empidonax traillii brewsteri*	SE	-
	Marbled Murrelet	*Brachyramphus marmoratus*	SE	FT
	Short-tailed Albatross	*Phoebastria albatrus*	-	FE
	Southwestern Willow Flycatcher	*Empidonax traillii extimus*	SE	FE
	Western Snowy Plover	*Charadrius nivosus*	-	FT
	Yellow-billed Cuckoo	*Coccyzus americanus*	SE	FT
Amphibians	California Red-legged Frog	*Rana draytonii*	-	FT
Fishes	Steelhead- Southern California DPS	*Oncorhynchus mykiss irideus* pop. 10	SCE	FE
	Tidewater Goby	*Eucyclogobius newberryi*	-	FE
	Unarmored Threespine Stickleback	*Gasterosteus aculeatus williamsoni*	SE	FE
Insects	Monarch Butterfly	*Danaus plexippus*	-	FC
Crustaceans	Vernal Pool Fairy Shrimp	*Branchinecta lynchi*	-	FT
Plants	Beach Layia	*Layia carnosa*	SE	FT
	Beach Spectaclepod	Dithyrea maritima	ST	-
	Gambel's Watercress	*Rorippa gambellii*	-	FE
	Gaviota Tarplant	*Deinandra increscens ssp. villosa*	SE	FE
	La Graciosa Thistle	*Cirsium loncholepis*	ST	FE
	Lompoc Yerba Santa	*Eriodictyon capitatum*	-	FE
	Marsh Sandwort	*Arenaria paludicola*	-	FE
	Salt Marsh Bird's-beak	*Cordylanthus maritimus ssp. maritimus*	-	FE
	Seaside Birds-beak	*Cordylanthus rigidus ssp. littoralis*	-	SE
	Surf Thistle	*Cirsium rhothophilum*	ST	

Status Abbreviations = Federal Threatened (FT), Federal Endangered (FE), Federal Candidate (FC), State Threatened (ST), State Endangered (SE), State Candidate Endangered (SCE), Distinct Population Segment (DPS)

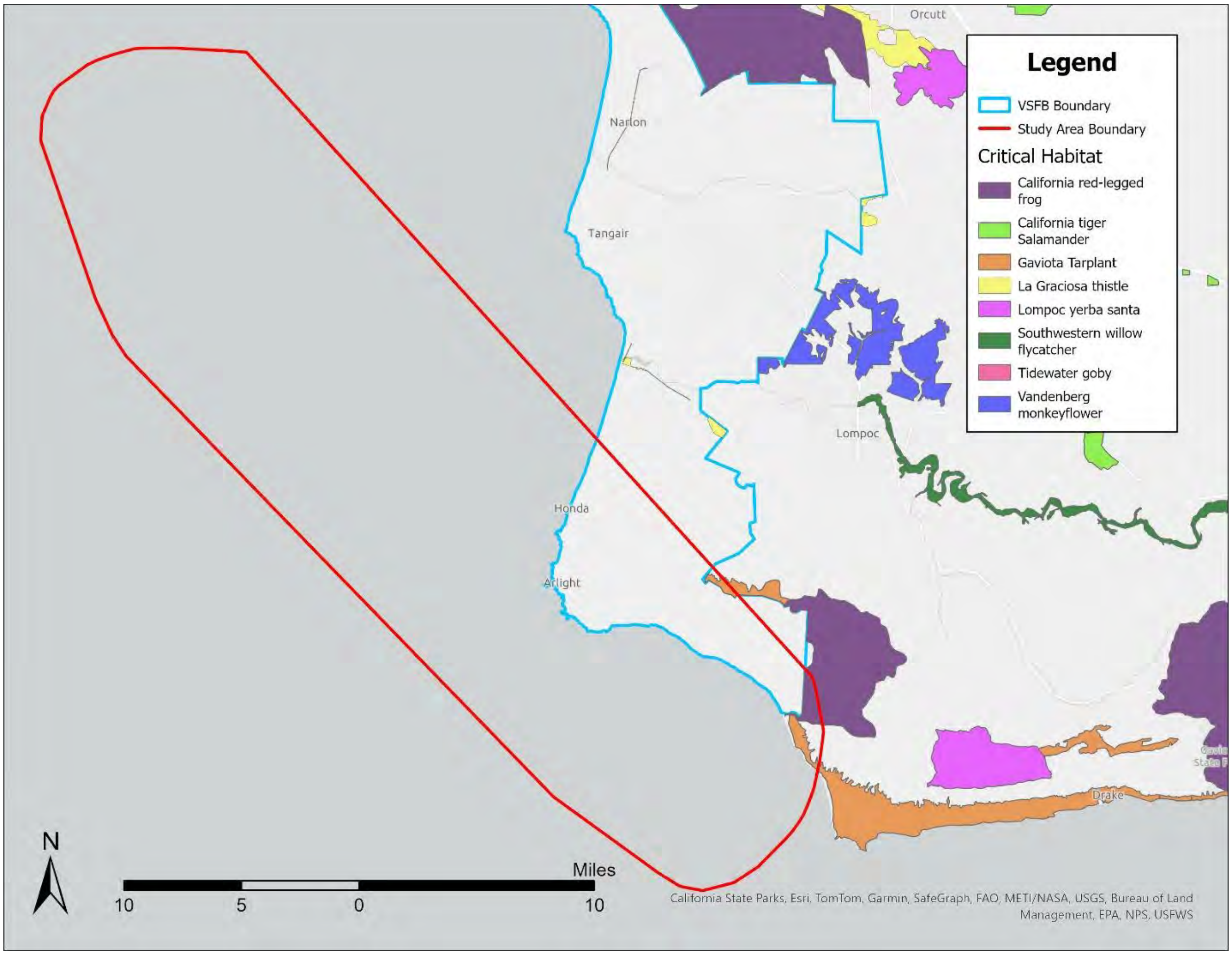

Figure 3-5: Critical Habitats within the Study Area USFWS

Studies suggest that common animal responses to noise include the startle response and, ultimately, habituation. It has been reported that the intensities and durations of the startle response decrease with the numbers and frequencies of exposures, suggesting no long-term adverse effects. The majority of the literature suggests that wildlife species exhibit adaptation, acclimation, and habituation after repeated exposure to jet aircraft noise and sonic booms (Bowles 1995, Manci et al. 1988, and Teer and Truett 1973).

Based on the lack of observed adverse effects to wildlife and the lack of known adverse effects to ESA-listed over decades of operations at VSFB, the FAA expects that sonic booms associated with the Proposed Action "may affect, but would be not likely to adversely affect", ESA-listed wildlife species in the study area. The FAA submitted a consultation letter with these findings (see **Appendix C**) to USFWS on July 8, 2024.

Table 3-2 provides a summary of ESA-listed species under the jurisdiction of the National Marine Fisheries Service (NMFS) for the sonic boom study area. Designated critical habitat for Black Abalone, Humpback Whale, and Leatherback Turtle is present and shown within **Figure 3-6.**

Table 3-2: ESA-Listed Species for the VSFB Study Area NOAA

Common Name	Scientific Name	*ESA Listing Status
Marine Mammals		
Blue whale	*Balaenoptera musculus*	Endangered
Fin whale	*Balaenoptera physalus*	Endangered
Gray whale (Western North Pacific DPS)	*Eschrichtius robustus*	Endangered
Humpback Whale (Central America DPS)	*Megaptera novaeangliae*	Endangered
Humpback Whale (Mexico DPS)	*Megaptera novaeangliae*	Threatened
Killer Whale (Southern Resident DPS)	*Orcinus orca*	Endangered
North Pacific Right Whale	*Eubalaena japonica*	Endangered
Sei Whale	*Balaenoptera borealis*	Endangered
Sperm Whale	*Physeter macrocephalus*	Endangered
Guadalupe Fur Seal	*Arctocephalus townsendi*	Threatened
Steller Sea Lion	*Eumetopias jubatus*	Endangered
Sea Turtles		
Green (East Pacific DPS)	*Chelonia mydas*	Threatened
Leatherback	*Dermochelys coriacea*	Endangered
Loggerhead (North Pacific Ocean DPS)	*Caretta caretta*	Endangered
Olive Ridley (Mexico’s Pacific coast breeding population)	*lepidochelys olivacea*	Endangered
Fish		
Scalloped hammerhead shark (Eastern Pacific DPS)	*Sphyrna lewini*	Endangered
Steelhead (Southern California DPS)	*Oncorhynchus mykiss*	Endangered
Invertebrates		
Black Abalone	*Haliotis cracherodii*	Endangered

* Each of the listed species have an effect determination of NLAA, NLAA = May affect, not likely to adversely affect

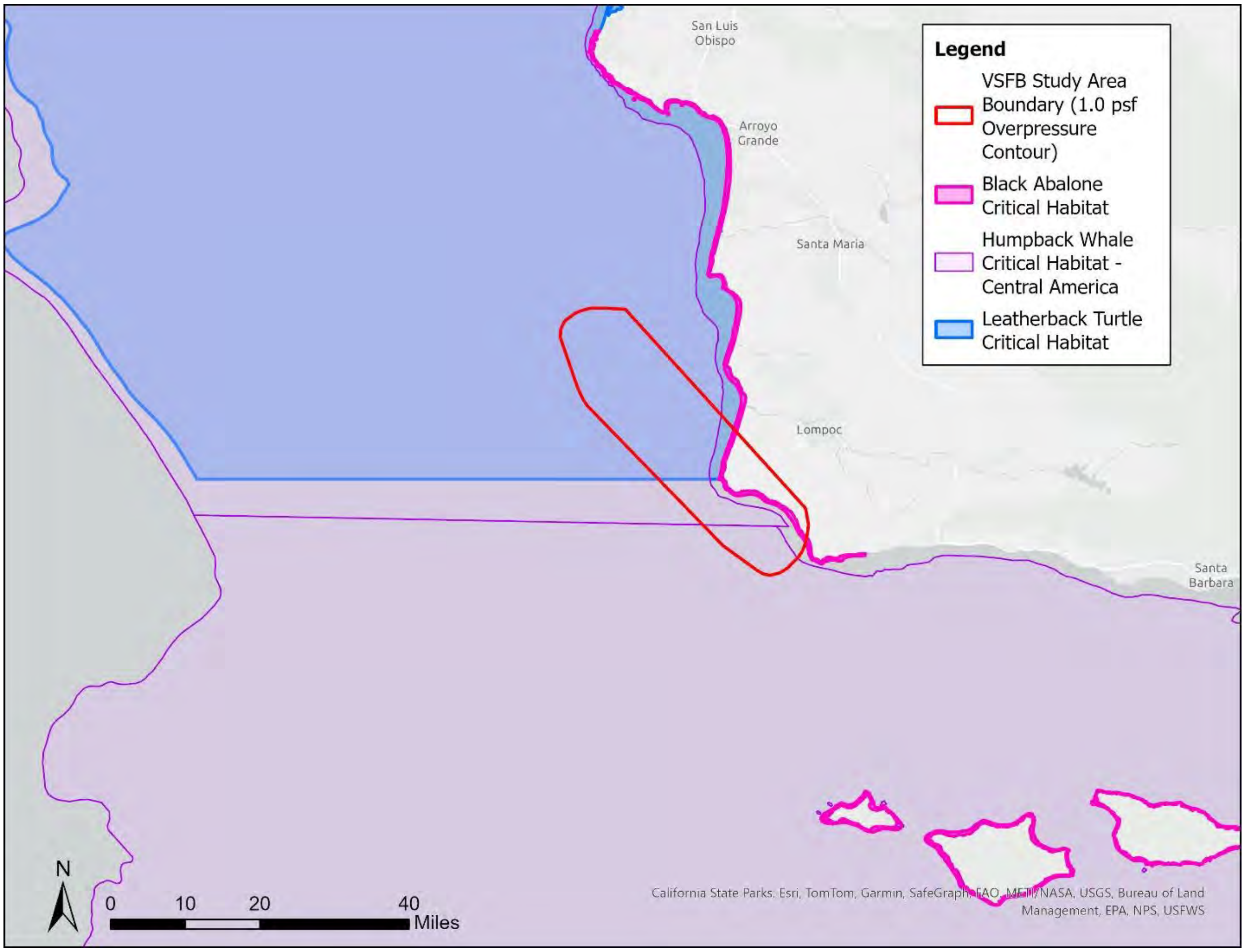

Figure 3-6: Critical Habitat within the Study Area NMFS

The Proposed Action does not involve construction, pile-driving, or any in-water activities. Potential effects of the Dream Chaser vehicle reentry at VSFB from sonic booms would be infrequent, temporary, and short in duration. Research has shown that acoustic energy from in-air noise, such as sonic booms, is not expected to effectively cross the air/water interface and therefore would not impact marine species underwater (Richardson et al. 1995). United States Air Force (USAF) research has confirmed that special-status marine species including marine mammals, turtles, fish, and marine invertebrates underwater are not at risk of harassment from in-air noise (USAF Research Laboratory 2000). Marine mammals that are out of the water within the action area would be minimally impacted due to sonic boom overpressure levels of 1.1 psf or lower and that at most would occur four times annually. A map showing known harbor seal haul-out areas within and near the action area is provided in **Figure 3-7**. Additionally, effects to marine critical habitats within the study area, as shown in **Figure 3-6** above, would not be expected due the lack of energy transfer between air and water, as well as low magnitude of sonic boom overpressure, and cadence of operations.

The FAA conducted programmatic consultations with NMFS that considered ESA-listed marine mammals, sea turtles, and fish and EFH protected under the Magnuson-Stevens Fishery Conservation and Management Act. A project-specific review was prepared and submitted to NMFS on <insert date., to determine if the proposed activity is within the existing programmatic consultation with NMFS. Based

on the analysis above, the FAA determined that sonic boom produced by the proposed reentry operations at VSFB *may affect, but is not likely to adversely affect* additional listed species or critical habitat under NMFS's jurisdiction. On <insert date>, NMFS concurred with these determinations and determined proposed action is covered under the programmatic letter of concurrence (**Appendix C)**.

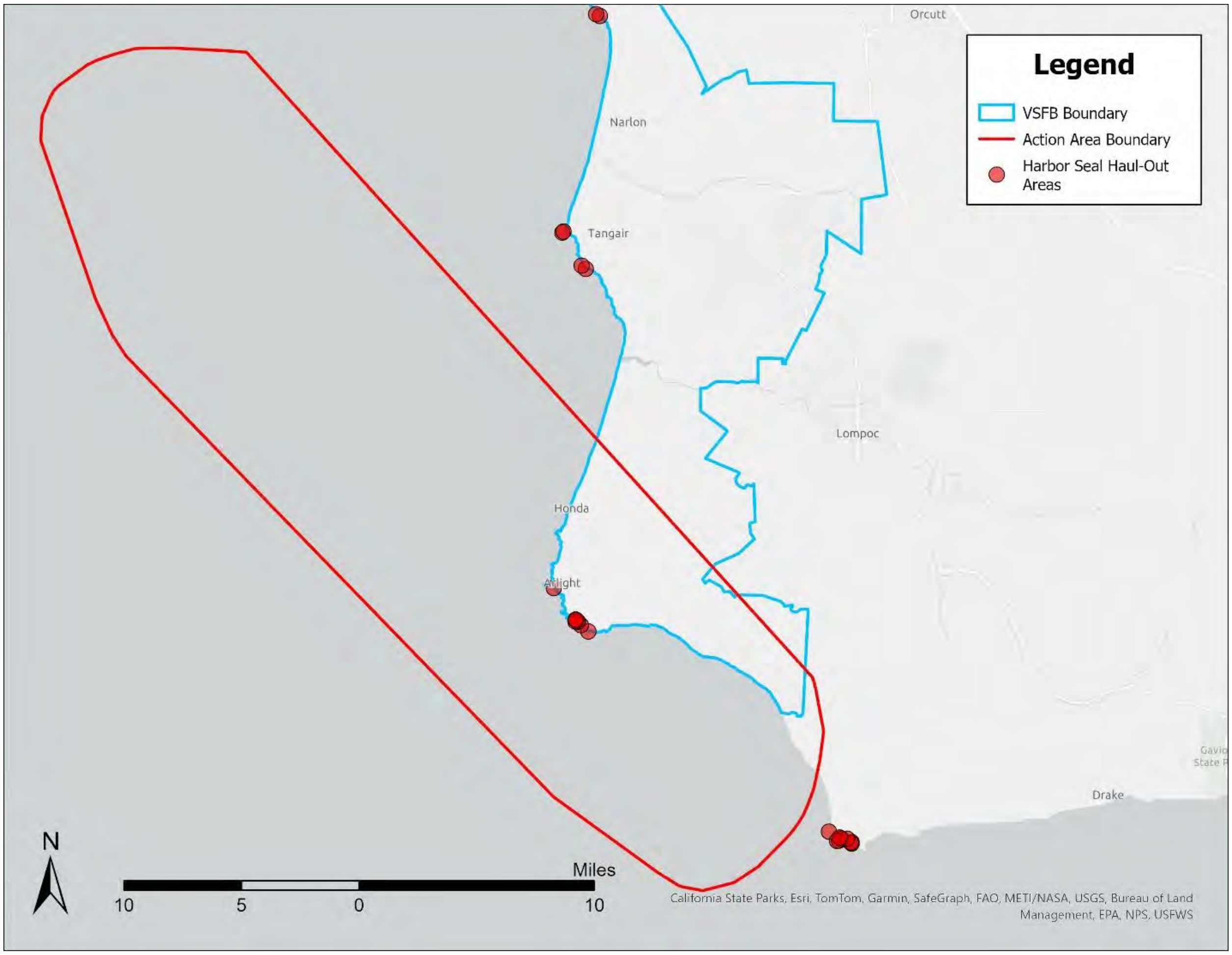

Figure 3-7: Known Harbor Seal Haul-Out Areas

Department of Transportation Act, Section 4(f)

Section 4(f) of the U.S. Department of Transportation (USDOT) Act of 1966, Section 4(f), codified as 49 U.S.C. § 303(c), protects significantly publicly owned parks, recreation areas, wildlife and waterfowl refuges, and public and private historic sites. Section 4(f) resources located within the study area include the following:

- Jalama Beach County Park (managed by Santa Barbara County)
- Jack and Laura Dangermond Preserve (managed by The Nature Conservancy)
- Ocean Beach Park (managed by Santa Barbara County)
- Vandenberg State Marine Preserve (managed by the California Department of Fish and Wildlife)

Use of a Section 4(f) property occurs when there are physical (permanent) or constructive-use type impacts. A physical use is when land from the Section 4(f) property is permanently acquired to support the Proposed Action. A constructive use involves no physical use or taking but occurs when the Proposed Action results in proximity impacts such that the purpose and significance of the property is meaningfully reduced or lost.

The Proposed Action does not involve any new construction, or ground disturbance, or closures of Section 4(f) properties; therefore, no physical use (permanent or temporary) would occur to any of the Section 4(f) resources listed above. In addition, no constructive use impacts would occur. Within the study area, sonic booms are anticipated but would be temporary, short in duration, and limited to 1.1 psf or less, which would be similar to a thunderclap. Using VSFB as a landing facility for the Dream Chaser would not impact the activities, features, or attributes of any of the Section 4(f) resources within the Study Area.

Noise and Noise-Compatible Land Use

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. Both 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*. Compatible land use analysis considers the effects of noise on special management areas, such as national parks, national wildlife refuges, and other sensitive noise receptors. The concept of land use compatibility corresponds to the objective of achieving a balance between the Proposed Action and the surrounding environment.

The FAA's primary noise metric for sonic booms is the C-weighted Day-Night Average Sound Level (CDNL). In California, a variant of CDNL, C-weighted Community Noise Equivalent Level (CNEL), is used in accordance with California Code of Regulations Title 21, Public Works. For measuring cumulative noise exposures, the FAA utilizes the Day-Night Average sound Level (DNL). 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. The DNL metric logarithmically averages sound levels at a location over a complete 24-hour period, with a 10-decibel (dBA) 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 nighttime hours and because ambient (without aircraft/launch vehicles) sound levels during nighttime are typically about 10-dB lower than during daytime hours. More information about noise and noise-compatible land use can be found in Chapter 11 of the FAA 1050.1F Desk Reference (FAA 2020).

For reentry operation at VSFB, the study area for noise is based on the landings on Runway 12/30. The study area encompasses about 320 square miles including portions of Santa Barbara County and extends over a portion of the Pacific Ocean (**Figure 3-2**Error! Reference source not found.).

Within the VSFB Study Area, the current noise environment includes vertically launched rockets that take off from the launch complexes at VSFB, which have resulted in sonic booms. Other existing sources of noise include automobile and truck traffic, aircraft operations, and missile launches.

For reentry operations at VSFB, the Proposed Action includes up to four annual nighttime reentries. The nighttime reentries would result in a C-weighted CNEL of 45 C-weighted decibels, well below the significance threshold of CDNL 60 C-weighted decibels (equivalent to a DNL of 65 dbA). Therefore, there would be no significant impact from reentry operations at VSFB. Additionally, the maximum sonic boom overpressure of 1.1 psf would not pose a concern for structural property damage from Dream Chaser reentry operations, as damage is generally not seen below 2 psf. See noise analysis in **Appendix D**.

Airspace closures associated with commercial space operations could result in temporarily grounded aircraft at affected airports and re-routing of en-route flights on established alternate flight paths. Aircraft could be temporarily grounded if airspace above or around the airport is closed. Ground delays are also used under some circumstances to avoid airborne reroutes. If aircraft were grounded, noise levels at the airport could temporarily increase as the planes sit idle. Also, depending on the altitude at which aircraft approach an airport, there could be temporary increases in noise levels in communities around the airports. However, aircraft would travel on existing en-routes and flight paths that are used on a daily basis to account for weather and other temporary restrictions. In addition, not all reentry missions would affect the same aircraft routes or the same airports, and re-routing associated with reentry-related closures would represent a small fraction of the total amount of re-routing that occurs from all other reasons in any given year. Any incremental increases in noise levels at individual airports would only last the duration of the airspace closure on a periodic basis and are not expected to meaningfully change existing day-night average sound levels at the affected airports and surrounding areas. Therefore, airspace closures due to reentry operations of the Dream Chaser at VSFB are not expected to result in significant noise impacts. Advancements in airspace management as mentioned above are expected to further reduce the number of aircraft that would contribute to noise at the affected airports and surrounding areas.

Resources Related to Cargo Module Disposal (Shuttle Landing Facility and Vandenberg Space Force Base)

This section analyzes impacts to resources generated by cargo module disposal for operations at both the SLF and VSFB.

Biological Resources

Species located in the cargo module disposal areas for both VSFB and SLF are not anticipated to be significantly impacted from reentry operations. Surviving debris from cargo module reentry over the

Pacific Ocean is not likely to adversely affect ESA-listed species and designated critical habitats. Marine mammals and ESA-listed species are sparsely distributed across these ocean expanses, resulting in very low densities of species overall. Direct strikes by surviving debris are extremely unlikely for all species of concern, fish, sea turtles, and marine mammals. This is due to the small size of the components as compared to the vast open ocean. If debris from the vehicle struck an animal near the water's surface, the animal would be injured or killed. Given the low cadence of operations, and the fact that marine wildlife, marine mammals, and special status species spend the majority of their time submerged as opposed to on the surface, it is extremely unlikely they would be impacted. The relative availability of these animals at the ocean surface, spatially and temporally, combined with the low frequency of the Proposed Action, reduce the likelihood of impacts to extremely low. Additionally, cargo module disposal ranges are located outside all National Marine Sanctuaries and are highly unlikely to impact coral reef areas. A map of the cargo module disposal ranges in relationship to National Marine Sanctuaries and coral reef areas is shown in Error! Reference source not found.. **Table 3-3** provides a summary of ESA-listed species under the jurisdiction of the NMFS for the VSFB and SLF cargo module disposal ranges.

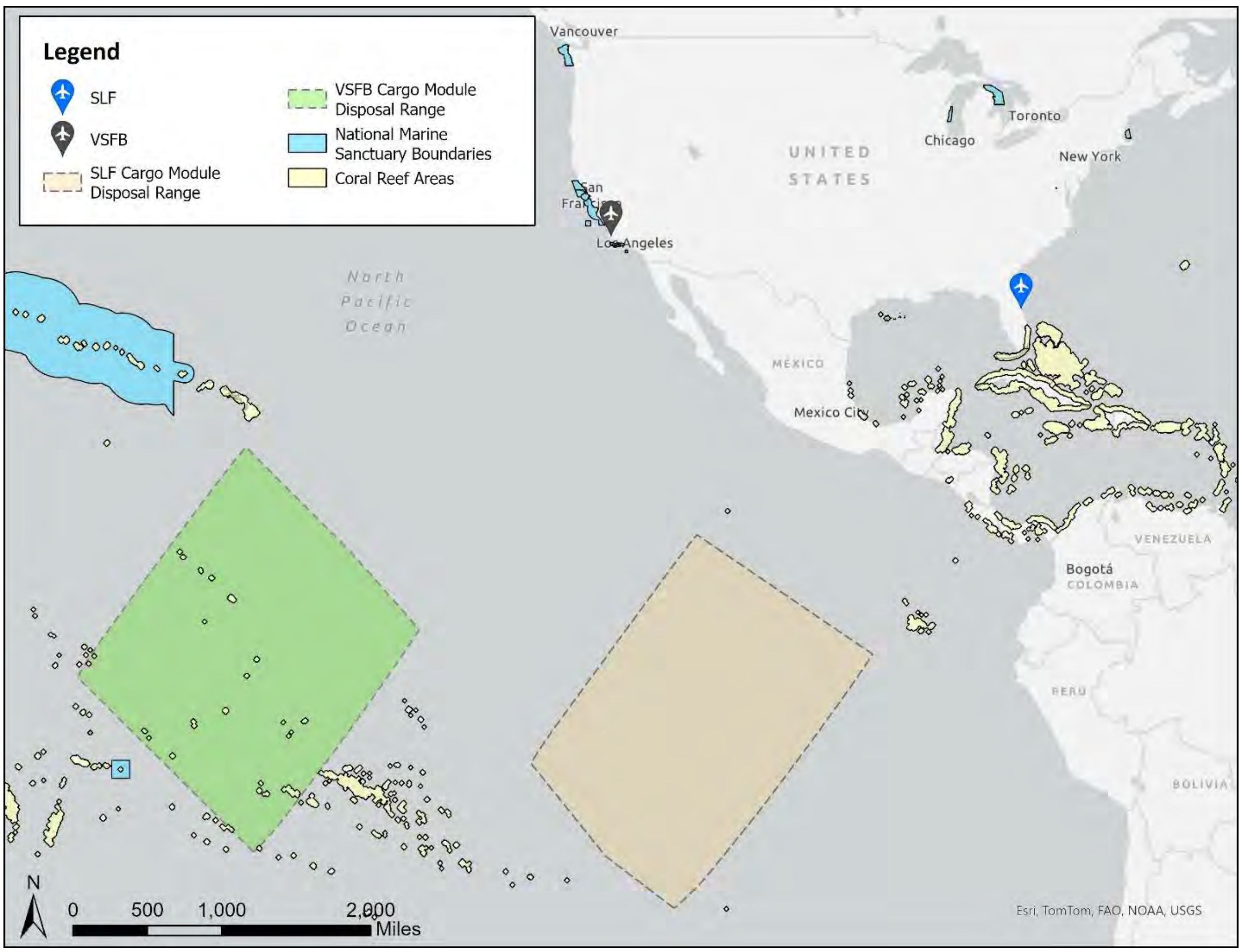

Figure 3-8: National Marine Sanctuaries and Coral Reef Areas

Table 3-3: ESA-Listed Species within the VSFB and SLF Cargo Disposal Ranges NOAA

Common Name	Scientific Name	ESA Listing Status	Potential Occurrence of Marine Species
Marine Mammals			
Humpback Whale – Central America DPS	*Megaptera novaeangliae*	Endangered	VSFB and SLF CM Disposal Range
Humpback Whale – Mexico DPS	*Megaptera novaeangliae*	Threatened	VSFB and SLF CM Disposal Range
Blue Whale	*Balaenoptera musculus*	Endangered	VSFB and SLF CM Disposal Range
False Killer Whale - Hawaiian Insular	*Psuedorca crassidens*	Endangered	VSFB and SLF CM Disposal Range
Fin Whale	*Balaenoptera physalus*	Endangered	VSFB and SLF CM Disposal Range
North Pacific Right Whale	*Eubalaena japonica*	Endangered	VSFB and SLF CM Disposal Range
Sei Whale	*Balaenoptera borealis*	Endangered	VSFB and SLF CM Disposal Range
Sperm Whale	*Physeter macrocephalus*	Endangered	VSFB and SLF CM Disposal Range
Hawaiian Monk Seal	*Neomonachus schauinslandi*	Endangered	VSFB CM Disposal Range
Sea Turtles			
Central North Pacific Green Turtle	*Chelonia mydas*	Threatened	VSFB and SLF CM Disposal Range
Central South Pacific Green Turtle	*Chelonia mydas*	Endangered	VSFB and SLF CM Disposal Range
Hawksbill Turtle	*Eretmochelys imbricata*	Endangered	VSFB and SLF CM Disposal Range
Leatherback Turtle	*Dermochelys coriacea*	Endangered	VSFB and SLF CM Disposal Range
North Pacific Loggerhead Turtle	*Caretta caretta*	Endangered	VSFB and SLF CM Disposal Range
South Pacific Loggerhead Turtle	*Caretta caretta*	Endangered	VSFB and SLF CM Disposal Range
Olive Ridley Turtle (Pacific Ridley)	*lepidochelys olivacea*	Threatened	VSFB CM Disposal Range
Fish			
Giant Manta Ray	*Mobula birostris*	Threatened	VSFB and SLF CM Disposal Range
Oceanic Whitetip Shark	*Carcharhinus longimanus*	Threatened	VSFB and SLF CM Disposal Range
Scalloped Hammerhead Shark (Indo-West Pacific)	*Sphyrna lewini*	Threatened	VSFB and SLF CM Disposal Range
Invertebrates			
Coral	*Acropora globiceps*	Threatened	VSFB CM Disposal Range
Coral	*Acropora retusa*	Threatened	VSFB CM Disposal Range
Coral	*Acropora speciosa*	Threatened	VSFB CM Disposal Range
Coral	*Fimbriaphyllia paradivisa*	Threatened	VSFB CM Disposal Range
Coral	*Isopora crateriformis*	Threatened	VSFB CM Disposal Range
Chambered Nautilus	*Nautilus pompilius*	Threatened	VSFB CM Disposal Range
Giant Clams	*Tridacna derasa*	Candidate	VSFB CM Disposal Range
Giant Clams	*Tridacna squamosa*	Candidate	VSFB CM Disposal Range
Giant Clams	*Tridacna gigas*	Candidate	VSFB CM Disposal Range
Giant Clams	*Hippopus hippopus*	Candidate	VSFB CM Disposal Range

The FAA conducted programmatic consultations with NMFS that considered ESA-listed marine mammals, sea turtles, and fish and EFH protected under the Magnuson-Stevens Fishery Conservation and Management Act. A project-specific review was prepared and submitted to NMFS on June 28, 2024, to determine if the proposed activity is within the existing programmatic consultation with NMFS. Based on the analysis above, the FAA determined that sonic boom produced by the proposed reentry operations at VSFB *may affect, but is not likely to adversely affect* additional listed species or critical habitat under NMFS's jurisdiction.

Cumulative Impacts

Cumulative impacts are defined by CEQ in 40 CFR § 1508.1(i)(3) 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." Additionally, CEQ describes in Considering Cumulative Effects under NEPA that, "each resource, ecosystem and human community must be analyzed in terms of its ability to accommodate additional effects, based on its own time and space parameters." The CEQ regulations require the analysis and disclosure of the Proposed Action's potential cumulative effects (40 CFR §§ 1508.25(a)(2) and (3)). The disclosure of potential cumulative effects informs the public if the Proposed Action, when considered with other projects occurring in the past, present, or reasonably foreseeable future, would contribute to potentially significant cumulative effects.

Cumulative impacts Related to the Shuttle Landing Facility

This EA incorporates by reference the cumulative effects contained in the 2021 PEA. The spatial boundary for this cumulative analysis is the study area defined by the 1.0 psf sonic boom contour (**Figure 3-1**), which encompasses sufficient area to capture the extent of the Proposed Action's ability to contribute to potentially significant cumulative effects. The Proposed Action's reentries would result in a modeled maximum of 1.1 psf, which is equivalent to CDNL 41 dBC if all operations occurred during daytime hours or up to 43 dbC if all operations occurred during nighttime hours (if there were a combination of daytime and nighttime reentries, the value would fall between these two). This noise exposure would be less than the significance threshold of DNL 65 dBA (equivalent to CDNL 60 dBC) and compatible with Section 4(f) Resources and Historic, Architectural, Archaeological, and Cultural Resources. Existing activities at the Cape Canaveral Spaceport, including returning stages of vertical rockets, have resulted in sonic booms that would intersect with the study area. Since the 2021 PEA, Relativity Space and Stoke Space have proposed additional launch operations that would contribute to cumulative noise impacts. However, current data from the Relativity Terran R Final EA[12] and the Stoke Space Draft EA[13] show that anticipated sonic boom overpressure contours from the Dream Chaser would not overlap with sonic boom contours of these two programs, and are therefore cumulative noise

[12] The Relativity Terran R EA can be accessed online at: https://www.patrick.spaceforce.mil/Resources/Environmental/FileId/125061/

[13] The Stoke Draft EA can be found online at: https://www.patrick.spaceforce.mil/Portals/14/Draft%20EA%20and%20FONSI%20for%20Stoke%20Space%20Nova%20Launch%20Program%2C%20CCSFS.pdf

impacts would have no significant impacts. Other existing sources of noise include aircraft operations, orbital test vehicles, construction vehicles and equipment, surface transportation vehicles (e.g., personal cars), urban/residential noise, and natural noise. In the event a marine mammal (e.g., West Indian Manatee) or sea turtle was present during the descent of a reentry vehicle or returning vertical rocket stage, and the area was exposed to a sonic boom, the boom would not affect the mammal. The sonic boom footprint is low intensity (similar to thunder). The sound pressure produced by the sonic boom during reentry would not affect submerged marine mammals or sea turtles because there is little sound transmitted between the air-water interface.

Cumulative Impacts Related to the Vandenberg Space Force Base

The spatial and temporal boundaries for this cumulative analysis is the cargo module disposal area in the remote Pacific Ocean and western Santa Barbara County, California. The Proposed Action includes up to four reentries per year. Upon reentry, surviving debris or fragments from the cargo module would splash down in the remote Pacific Ocean and not within any global shipping lanes. The cargo module will not contain any hazardous materials and will be composed of inert materials that are not chemically or biologically reactive. Surviving debris is not likely to adversely affect ESA-listed species and designated critical habitats. Marine mammals and ESA-listed species are sparsely distributed across these ocean expanses, resulting in very low densities of species overall. In addition, the cargo module dispersion areas are large and will vary depending on the return trajectory; therefore, surviving debris would not accumulate or concentrate in one area from future yearly operations.

In western Santa Barbara County, California, the Proposed Action's reentries would result in a modeled maximum of 1.1 psf on a small area along the coast of Santa Barbara County, which is equivalent to CDNL 45 dBC. This noise exposure would be less than the significance threshold of DNL 65 dBA (equivalent to CDNL 60 dBC) and not significantly impact public park and recreational areas (Section 4(f) Resources) and Historic, Architectural, Archaeological, and Cultural Resources. VSFB has been operating since 1941. Existing activities, including returning stages of vertical rockets, have resulted in sonic booms that would intersect with the study area. Other on-going sources of noise include aircraft operations, orbital test vehicles, construction vehicles and equipment, surface transportation vehicles (e.g., personal cars), urban/residential noise, and natural noise. Therefore, the addition of four reentries per year would constitute a negligible increase over past, present, and future activities at VSFB and the surrounding human environment. The sonic boom footprint is low intensity (similar to thunder). The sound pressure produced by the sonic boom during reentry would not affect submerged marine mammals or sea turtles because there is little sound transmitted between the air-water interface.

Since the Dream Chaser would be operating above 60,000 feet between the cargo module disposal area and the landing approach at VSFB, the overflight area was not included in the cumulative impacts analysis. The Proposed Action, when combined with other past, present, and future activities, would not result in cumulative impacts on the natural and human environment.

Chapter 4
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Jennifer Fownes, NEPA Specialist
ICF, FAA Environmental Support Contractor

Chapter 5

List of Agencies and Persons Consulted

Federal Agencies

Federal Aviation Administration Air Traffic Organization

National Aeronautics and Space Administration

National Marine Fisheries Service

National Park Service

United States Coast Guard

United States Fish and Wildlife Service

United States Space Force

State Agencies

Florida State Division of Historic Resources

Tribes

Catawba Indian Nation

Chitimacha Tribe of Louisiana

Coushatta Tribe of Louisiana

Eastern Band of Cherokee Indians

Jena Band of Choctaw Indians

Miccosukee Tribe of Indians of Florida

Muscogee (Creek) Nation

Poarch Band of Creek Indians

Seminole Tribe of Florida

Chapter 6
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2021 Draft EA Public Comments

From:	Myers, Brendan T
To:	Sierra Space SLF
Cc:	Clarkson, Chelsea (FAA)
Subject:	RE: [EXTERNAL] RE: FAA Reentry Permit BASH and Migratory Bird Questions
Date:	Tuesday, December 21, 2021 11:42:13 AM

Good morning Chelsea,

It appears that the Draft EA is open for public comments. On page 3-2 of the Draft EA, it states that the SLF has a Wildlife Hazard management Plan in place to reduce the risk of impacts to birds and wildlife. Could this document be provided to the Service prior to any public comments being drafted?

Thanks and stay safe!

Brendan Myers
Regulatory Biologist
U.S. Fish and Wildlife Service
Florida Ecological Services Office
7621 Hillsborough Loop Drive
MacDill AFB, FL 33621
Cell: 850-348-6560
Office: 904-731-3328

From: Sierra Space SLF <SierraSpaceSLF@icf.com>
Sent: Monday, November 22, 2021 2:11 PM
To: Sierra Space SLF <SierraSpaceSLF@icf.com>; Myers, Brendan T <brendan_myers@fws.gov>
Cc: Clarkson, Chelsea (FAA) <chelsea.clarkson@faa.gov>
Subject: [EXTERNAL] RE: FAA Reentry Permit BASH and Migratory Bird Questions

Hi Brendan,

I wanted to let you know that AST is continuing to work through comments received on the Sierra at SLF project and plans to get back to you after the holiday.

Thank you!

From: Sierra Space SLF <SierraSpaceSLF@icf.com>
Sent: Thursday, November 4, 2021 1:14 PM

To: Myers, Brendan T <brendan_myers@fws.gov>
Cc: Sierra Space SLF <SierraSpaceSLF@icf.com>
Subject: RE: FAA Reentry Permit BASH and Migratory Bird Questions

Hi Brendan,

Thank you for the follow up on your question from Tuesday's stakeholder meeting. We will pass this on to the FAA for a response.

Best,
Jen

From: Myers, Brendan T <brendan_myers@fws.gov>
Sent: Wednesday, November 3, 2021 8:40 AM
To: Sierra Space SLF <SierraSpaceSLF@icf.com>
Subject: FAA Reentry Permit BASH and Migratory Bird Questions

Good morning,

I attended the stakeholder meeting yesterday afternoon on behalf o the U.S. Fish and Wildlife Service (USFWS). I asked a question about whether bird aircraft strike hazards (BASH) concerns would be addressed and the mitigation and/or dispersal measures utilized during reentry operations at the SLF. Could you please provide all potential BASH mitigation, hazard reduction, and dispersal methods that would be used during reentry operations in regards to this reentry permit? Also, is there a current USFWS migratory bird depredation permit that can be provided for these BASH operations?

Please let me know if you have any questions or would like to discuss the above in greater detail.

Thanks and stay safe!

Brendan Myers
Regulatory Biologist
U.S. Fish and Wildlife Service
Florida Ecological Services Office
7621 Hillsborough Loop Drive
MacDill AFB, FL 33621
Cell: 850-348-6560
Office: 904-731-3328

Section 7 Initiation Letter to the USFWS

U.S. Department of Transportation
Federal Aviation Administration

Office of Commercial Space Transportation

800 Independence Ave., SW.
Washington, DC 20591

October 21, 2021

Ms. Annie Dziergowski
Chief, Project Review and Consultation
U.S. Fish and Wildlife Service, North Florida Ecological Services Office
7915 Baymeadows Way, Suite 200
Jacksonville, FL 32256-7517
Submitted to: jaxregs@fws.gov

RE: Endangered Species Act Consultation for Proposed Sierra Space Corporation Reentry Operations at the Shuttle Landing Facility, Cape Canaveral Spaceport, Brevard County, Florida

Dear Ms. Dziergowski,

The FAA is initiating Endangered Species Act (ESA) Section 7 consultation and soliciting concurrence with our assessment and determination of the potential effects on ESA-listed species for Sierra Space Corporation's (Sierra Space) proposed commercial space reentry operations at the Shuttle Landing Facility (SLF). Sierra Space is applying to the FAA for a Vehicle Operator License that would allow Sierra Space to conduct reentries with its Dream Chaser vehicle at the SLF in Brevard County, Florida.

In 2020, the FAA consulted with USFWS on Space Florida's application to operate the SLF as a commercial space reentry site. The potential impacts to ESA-listed species for issuing Space Florida a Reentry Site Operator License were evaluated using Sierra Space's Dream Chaser as a representative vehicle and it proposed reentry operations. As a result, the potential impacts to ESA-listed species for issuing Sierra Space a Vehicle Operator License are expected to be the same.

For background on previous ESA consultations related to commercial space operations at the SLF, see **Attachment 1**. For a description of Sierra Space's proposed reentry operations, see **Attachment 2**. The action area, ESA-listed species and critical habitat, potential effects to the listed species and critical habitat, and the FAA's effect determination for Sierra Space's proposed operation, described in **Attachment 3**, are consistent with those that were the subject of the 2020 Section 7 consultation.

The FAA anticipates that Sierra Space's proposed reentry operations **may affect, but would not be likely to adversely affect**, all ESA-listed wildlife species in the action area. The FAA seeks your concurrence on our effects determination and welcomes any additional comments. Thank you for your assistance in this matter. Please provide your response to Ms. Chelsea Clarkson of my staff at chelsea.clarkson@faa.gov.

Sincerely,

JAMES R REPCHECK
Digitally signed by JAMES R REPCHECK
Date: 2021.10.21 10:29:01 -04'00'

Randy Repcheck
Manager, Safety Authorization Division

Enclosures:

Attachment 1 – Background
Attachment 2 - Project Description
Attachment 3 – Action Area, ESA-Listed Species and Critical Habitat, and Effects Determination

ATTACHMENT 1 – BACKGROUND

In 2018, the FAA prepared the *Final Environmental Assessment for the Shuttle Landing Facility Launch Site Operator License* (2018 EA) to evaluate the potential environmental impacts of Space Florida's proposal to operate the SLF as a launch site for horizontally launched and landed reusable vehicles. The FAA issued a Finding of No Significant Impact (FONSI) based on the 2018 EA on November 2, 2018 and issued a Launch Site Operator License (License Number: LSO 18-018) to Space Florida to operate a launch site at the SLF.

The FAA conducted ESA Section 7 consultation with the USFWS in 2017 for the FAA's action of issuing Space Florida a Launch Site Operator License (FWS Log No. 04EF1000-2018-I-771). The FAA determined that operation of the SLF as a launch site and associated construction would have no effect on ESA-listed species except the eastern indigo snake (*Dymarchon corais couperi*). The FAA determined the action proposed in 2017 may affect, but would not adversely affect, the eastern indigo snake. The USFWS concurred with this determination.

In 2021, the FAA prepared the *Final Programmatic Environmental Assessment (PEA) for the Shuttle Landing Facility Reentry Site Operator License* (2021 PEA) to evaluate the potential environmental impacts of Space Florida's proposal to operate the SLF as a commercial space reentry site. The 2021 PEA used Sierra Space's Dream Chaser vehicle as the representative vehicle for operations (the space systems group within Sierra Nevada Corporation became called Sierra Space Corporation, its own company, on June 1, 2021). The FAA issued a FONSI based on the 2021 PEA on January 12, 2021 and issued a Reentry Site Operator License (License Number: LRSO 18-018) to Space Florida to operate a reentry site at the SLF.

The FAA conducted ESA Section 7 consultation with the USFWS in 2020 for the FAA's action of issuing a Reentry Site Operator License to Space Florida (FWS Log No. 20-I-0690). The FAA determined that reentry operations may affect, but were not likely to adversely affect, ESA-listed wildlife species in the action area. The USFWS concurred with this determination.

The FAA is currently preparing an Environmental Assessment that tiers from the 2021 PEA to analyze Sierra Space's specific proposed reentry operations (Tiered EA). The 2021 PEA assessed up to six annual reentry operations from 2021 to 2025. Space Florida's Reentry Site Operator License expires in 2025, at which time Space Florida can apply to renew the license. Sierra Space is applying for a vehicle operator license for the time period of 2022 – 2026. No reentry operations were conducted at the SLF in 2021 and therefore no impact occurred in 2021 as analyzed under the 2021 PEA. Therefore, environmental conditions are not expected to be significantly different than those previously analyzed in the 2021 PEA. There are no other changes in Sierra Space's proposed reentry operations between the 2021 PEA and the Tiered EA that would affect biological resources.

ATTACHMENT 2 – PROJECT DESCRIPTION

The FAA's Proposed Action is to issue a Vehicle Operator License to Sierra Space Corporation to conduct reentry operations with its Dream Chaser vehicle at the SLF, which is managed by Space Florida and located at the Cape Canaveral Spaceport (see **Figure 1**).

Figure 1. Project Location

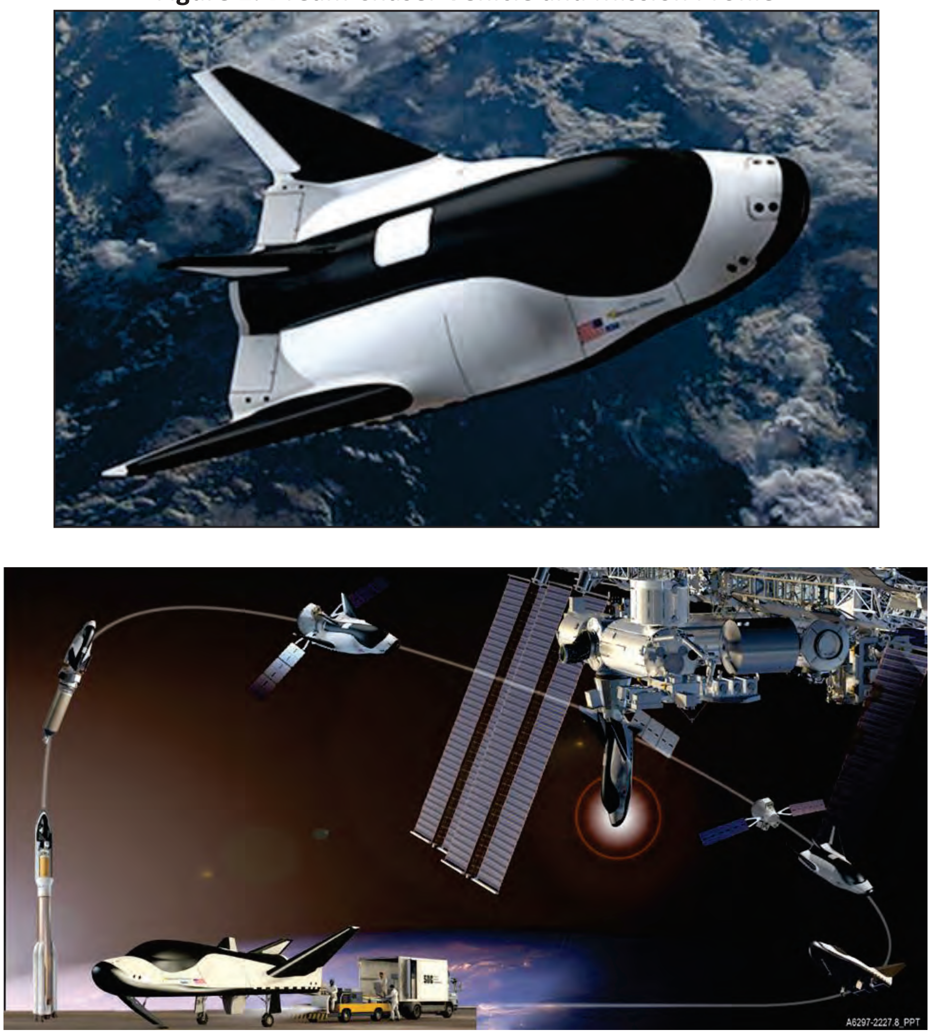
Table 1 summarizes the Dream Chaser parameters that will be evaluated in the Tiered EA. **Figure 2** shows the Dream Chaser vehicle, as well as a notional mission profile in support of a National Aeronautics and Space Administration mission to resupply the International Space Station that ends in a horizontal reentry.

Table 1. Dream Chaser Vehicle Parameters

Characteristic	**Data**
Vehicle Length	30 feet
Wingspan	27 feet
Gross Vehicle Weight	24,600 pounds
Landing Gear Configuration	Nose skid and two rear wheels
Runway Length Required for Landing	10,000 feet
Cross-Range Capability	± 700 nautical miles
Propellants[1]	Hydrogen peroxide (H_2O_2) and kerosene (RP-1)
Return Payload Capacity	1,850 kilograms

[1] Dream Chaser propellants are used by a reaction control system (RCS) for orbital maneuvers, deorbit burn, and high-altitude control during reentry. The system is not used near or on the ground. Source: SNC, 2019.

Figure 2. Dream Chaser Vehicle and Mission Profile



Source: Sierra Space, 2021

Sierra Space is proposing a maximum of 4 reentries annually, for a total of up to 14 reentries over the five-year license period (see **Table 2**).

Table 2. Estimated Annual Number of Reentries

2022	2023	2024	2025	2026
1	2	3	4	4

The Dream Chaser would reenter the atmosphere from the west/southwest and overfly the Gulf of Mexico or Caribbean Sea, based on a mission dependent trajectory before landing at the SLF. Dream Chaser reentry operations at the SLF would not require any closures of non-involved Kennedy Space Center (KSC) property or public use areas (e.g., Merritt Island National Wildlife Refuge, Canaveral National Seashore).

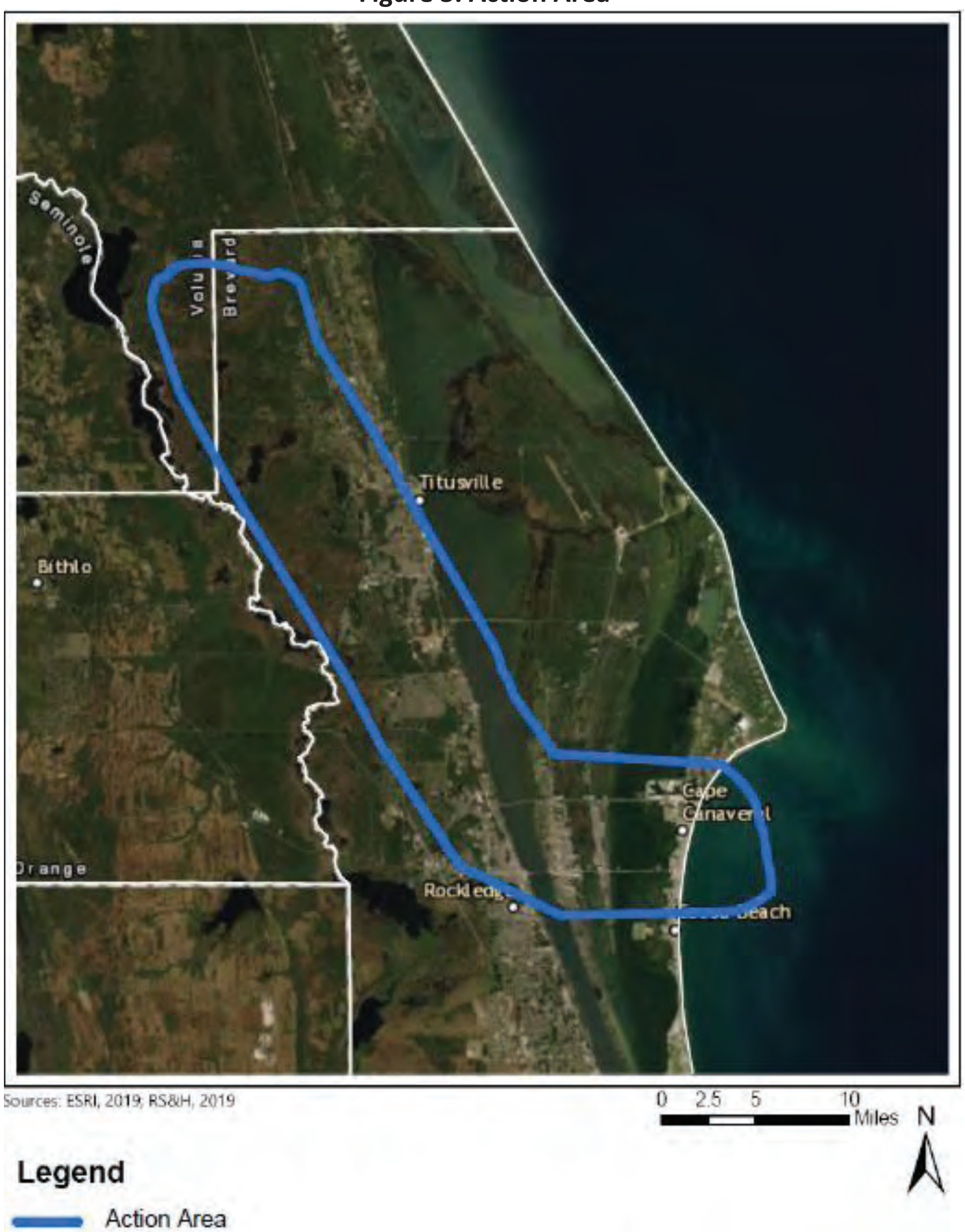
The Dream Chaser would enter controlled airspace (60,000 feet above mean sea level) approximately 30–40 miles prior to landing (for less than 30 seconds) and would enter restricted airspace approximately 25–30 miles (for approximately 2.5 – 3 minutes) prior to landing at the SLF. The vehicle would generate a sonic boom during reentry. No construction activities are proposed as part of the proposed project.

ATTACHMENT 3 – ACTION AREA, ESA-LISTED SPECIES AND CRITICAL HABITAT, AND DETERMINATION OF EFFECTS

Action Area

The action area is defined as all areas directly or indirectly affected by the federal action. The action area for Sierra Space's proposed reentry operations based on the footprint of the Dream Chaser's sonic boom noise contour and includes those areas of the Earth's surface that would experience a sonic boom of 1.0 pound per square foot (psf) or greater. This approximately 280-square mile area encompasses portions of Brevard and Volusia counties (see **Figure 3**).

Figure 3. Action Area



ESA-Listed Species and Critical Habitat
The FAA used the USFWS's Information for Planning and Consultation online system to generate a species list and identify critical habitat for the project. **Table 3** shows ESA-listed species and critical habitat within the action area. Designated critical habitat for the West Indian manatee (*Trichechus manatus latirostris*) is present within the action area.

In 1977, the USFWS designated multiple waterways and parts of coastal Florida, from Jacksonville south to Miami and west around the peninsula to Tampa Bay, as critical habitat for manatees (42 FR 47840). The waters around KSC and Cape Canaveral Air Force Station (CCAFS) are critical habitat for the manatee. The Upper Banana River is an area of particular emphasis for cautious boat operations.

Table 3. ESA-Listed Species for the Action Area

Category	Species Common Name	Species Scientific Name	Status
Mammals	West Indian manatee	*Trichechus manatus latirostris*	E
	Southeastern beach mouse	*Peromyscus polionotus nineiventris*	T
Birds	Audubon's crested caracara	*Polyborus plancus audubinii*	T
	Eastern black rail	*Laterallus jamaicensis* ssp. *jamaicensis*	PT
	Everglade snail kite	*Rostrhamus sociabilis plumbeus*	E
	Florida scrub-jay	*Aphelocoma coeruluscens*	T
	Piping plover	*Charadrius melodus*	T
	Wood stork	*Mycteria americana*	E
	Red knot	*Calidris canutus rufa*	T
	Red-cockaded woodpecker	*Picoides borealis*	E
Reptiles	Atlantic salt marsh snake	*Nerodia clarkii (fasciata)taeniata*	T
	Eastern indigo snake	*Dymarchon corais couperi*	T
	Gopher tortoise	*Gopherus polyphemus*	C
	Green sea turtle	*Chelonia mydas*	T
	Hawksbill sea turtle	*Eremochelys imbricata*	E
	Leatherback sea turtle	*Dermochelys coriacea*	E
	Loggerhead sea turtle	*Caretta*	T
Plants	Carter's mustard	*Warea carteri*	E
	Lewton's polygala	*Polygala lewtonii*	E
	Okeechobee gourd	*Cucurbita okeechobeensis*	E
	Rugel's pawpaw	*Deeringhthamnus rugelii*	E

C = candidate; E = endangered; PT = proposed threatened; T = threatened
Source: USFWS 2019.

Potential Effects to ESA-listed Species and Critical Habitat
The Proposed Action would have no effect on the West Indian manatee's critical habitat because the action does not involve any activities within or near the critical habitat. Similarly, the Proposed Action would have no effect on ESA-listed plants in the action area because the action does involve activities with the potential to affect these plants.

Reentry operations have the potential to affect ESA-listed species in the action area, mainly from noise, including sonic booms. Animal species differ greatly in their responses to noise. Noise effects on domestic animals and wildlife are classified as primary, secondary, and tertiary. Primary effects are direct, physiological changes to the auditory system, and most likely include the masking of auditory signals. Masking is defined as the inability of an individual to hear important environmental signals that may arise from mates, predators, or prey. There is some potential that noise could disrupt a species' ability to communicate or could interfere with behavioral patterns (Manci et al. 1988). Although the effects are likely temporal, sonic booms may cause masking of auditory signals within exposed faunal communities. Animals rely on hearing to avoid predators, obtain food, and communicate with, and attract, other members of their species. Sonic booms may mask or interfere with these functions.

Secondary effects may include non-auditory effects such as stress and hypertension; behavioral modifications; interference with mating or reproduction; and impaired ability to obtain adequate food, cover, or water. Tertiary effects are the direct result of primary and secondary effects, and include population decline and habitat loss. Most of the effects of noise are mild enough that they may never be detectable as variables of change in population size or population growth against the background of normal variation (Bowles 1995). Other environmental variables (e.g., predators, weather, changing prey base, ground-based disturbance) also influence secondary and tertiary effects, and confound the ability to identify the ultimate factor in limiting productivity of a certain nest, area, or region. Overall, the literature suggests that species differ in their response to various types, durations, and sources of noise (Manci et al. 1988; Bowles 1995).

Many scientific studies have investigated the effects of sonic booms on wildlife, and some have focused on wildlife "flight" due to noise. Natural factors which affect reaction include season, group size, age and sex composition, on-going activity, motivational state, reproductive condition, terrain, weather, and temperament (Bowles 1995). Individual animal response to a given noise event or series of events also can vary widely due to a variety of factors, including time of day, physical condition of the animal, physical environment, the experience of the individual animal with noises, and whether or not other physical stressors (e.g., drought) are present (Manci et al. 1988). Consequently, it is difficult to generalize animal responses to noise disturbances across species.

One result of the Manci et al. (1988) literature review was the conclusion that, while behavioral observation studies were relatively limited, a general behavioral reaction in animals from exposure to aircraft noise is the "startle response." The intensity and duration of the startle response appears to be dependent on which species is exposed, whether there is a group or an individual, and whether there have been some previous exposures. Responses range from flight, trampling, stampeding, jumping, or running, to movement of the head in the apparent direction of the noise source. Manci et al. (1988) reported that the literature indicated that avian species may be more sensitive to aircraft noise than mammals.

The following discussion presents a summary of some of the more relevant studies addressing the potential impacts to wildlife from sonic booms.

Teer and Truett (1973) tested quail eggs subjected to sonic booms at 2, 4, and 5.5 pounds per square foot (psf) and found no adverse effects. Heinemann and LeBrocq (1965) exposed chicken eggs to sonic booms at 3–18 psf and found no adverse effects. In a mathematical analysis of the response of avian eggs to sonic boom overpressures, Ting et al. (2002) determined that it would take a sonic boom of 250 psf to crack an egg. Bowles (1995) states that it is physically impossible for a sonic boom to crack an egg because one cannot generate sufficient sound pressure in air to crack eggs.

Teer and Truett (1973) examined reproductive success in mourning doves, mockingbirds, northern cardinals, and lark sparrows when exposed to sonic booms of 1 psf or greater and found no adverse effects. Awbrey and Bowles (1990) in a review of the literature on the effects of aircraft noise and sonic booms on raptors found that the available evidence shows very marginal effects on reproductive success. Ellis et al. (1991) examined the effects of sonic booms (actual and simulated) on nesting peregrine falcons, prairie falcons, and six other raptor species. While some individuals did respond by leaving the nest, the response was temporary and overall there were no adverse effects on nesting. Lynch and Speake (1978) studied the effects of both real and simulated sonic booms on the nesting and brooding of eastern wild turkey in Alabama. Hens at four nest sites were subjected to between 8 and 11 combined real and simulated sonic booms. All tests elicited similar responses, including quick lifting of the head and apparent alertness for between 10 and 20 seconds. No apparent nest failure occurred as a result of the sonic booms.

The literature suggests that common animal responses to noise include the startle response and, ultimately, habituation. It has been reported that the intensities and durations of the startle response decrease with the numbers and frequencies of exposures, suggesting no long-term adverse effects. The majority of the literature suggests that domestic animal species (cows, horses, chickens) and wildlife species exhibit adaptation, acclimation, and habituation after repeated exposure to jet aircraft noise and sonic booms.

The entirety of the sonic boom footprint would be approximately 1 psf or less, which is less than a clap of thunder. Previous ESA consultation between the U.S. Air Force and USFWS in the vicinity of SLF have concluded that sonic booms would not adversely affect ESA-listed species.

Based on the lack of observed adverse effects to wildlife in the studies mentioned above and the lack of known adverse effects to ESA-listed over decades of launch operations at KSC and CCAFS, the FAA expects that sonic booms associated with the Proposed Action ***may affect, but would be not likely to adversely affect***, ESA-listed wildlife species in the action area.

Section 106 and Tribal Government-to-Government Consultation Letter Example

U.S. Department of Transportation
Federal Aviation Administration

Commercial Space Transportation

800 Independence Ave., SW.
Washington, DC 20591

October 21, 2021

Wenonah G. Haire, Tribal Historic Preservation Officer
Catawba Indian Nation
1536 Tom Steven Road, Rock Hill, SC, 29730

RE: Invitation for Government-to-Government Tribal Consultation for Section 106 review of Proposed Sierra Space Corporation Reentry Operations at the Shuttle Landing Facility at Cape Canaveral Spaceport in Brevard County, Florida

The Federal Aviation Administration (FAA) is initiating Section 106 consultation on Sierra Space Corporation's (Sierra Space) proposed commercial space reentry operations at the Shuttle Landing Facility (SLF). Sierra Space is applying to the FAA for a Vehicle Operator License that would allow Sierra Space to conduct reentries with its Dream Chaser vehicle at the SLF in Brevard County, Florida. FAA issuance of a Vehicle Operator License is considered a federal undertaking under the regulations of the Advisory Council for Historic Preservation (36 Code of Federal Regulations [CFR] § 800.16(y)) for Section 106 of the National Historic Preservation Act.

The proposed project and its associated activities are also subject to the National Environmental Policy Act (NEPA) and the FAA will prepare a Tiered Environmental Assessment to meet its regulatory obligations. The agency intends to complete Section 106 in conjunction with the NEPA process.

Sierra Space's proposed operations are described in **Attachment 1** and a map of the proposed Area of Potential Affects is included in **Attachment 2**.

The FAA has identified your tribe as potentially having an interest in the project area. Pursuant to Executive Order 13175 *Consultation and Coordination with Indian Tribal Governments*, FAA Order 1210.20 *American Indian and Alaska Native Tribal Consultation Policy and Procedures*, and 36 CFR § 800.2(c)(2)(B)(ii), the FAA is seeking input on properties of cultural or religious significance that may be affected by the undertaking, and inviting you to participate in government-to-government consultation in the Section 106 consultation process.

Please contact Ms. Chelsea Clarkson of my staff at (202) 286-5447 or chelsea.clarkson@faa.gov within 30 days of the receipt of this letter to confirm your intent to participate in this Section 106 consultation.

Sincerely,

JAMES R REPCHECK
Digitally signed by JAMES R REPCHECK
Date: 2021.10.21 10:38:17 -04'00'

Randy Repcheck
Manager, Safety Authorization Division

Enclosures:
Attachment 1 – Project Description
Attachment 2 – Area of Potential Effects (APE)

ATTACHMENT 1 – PROJECT DESCRIPTION

Background

In 2018, the FAA prepared the *Final Environmental Assessment for the Shuttle Landing Facility Launch Site Operator License* (2018 EA) to evaluate the potential environmental impacts of Space Florida's proposal to operate the SLF as a launch site for horizontally launched and landed reusable vehicles. The FAA issued a Finding of No Significant Impact (FONSI) based on the 2018 EA on November 2, 2018 and issued a Launch Site Operator License (License Number: LSO 18-018) to Space Florida to operate a launch site at the SLF.

In 2021, the FAA prepared the *Final Programmatic Environmental Assessment (PEA) for the Shuttle Landing Facility Reentry Site Operator License* (2021 PEA) to evaluate the potential environmental impacts of Space Florida's proposal to operate the SLF as a commercial space reentry site. The 2021 PEA used Sierra Space's Dream Chaser vehicle as the representative vehicle for operations (the space systems group within Sierra Nevada Corporation became called Sierra Space Corporation, its own company, on June 1, 2021). The FAA issued a FONSI based on the 2021 PEA on January 12, 2021 and issued a Reentry Site Operator License (License Number: LRSO 18-018) to Space Florida to operate a reentry site at the SLF.

The consulted with your tribe in 2020 for Space Florida's proposal to operate the SLF as a commercial space reentry site.

The FAA is currently preparing an Environmental Assessment that tiers from the 2021 PEA to analyze Sierra Space's specific proposed reentry operations (Tiered EA). The 2021 PEA assessed up to six annual reentry operations from 2021 to 2025. Space Florida's Reentry Site Operator License expires in 2025, at which time Space Florida can apply to renew the license. Sierra Space is applying for a vehicle operator license for the time period of 2022 – 2026. No reentry operations were conducted at the SLF in 2021 and therefore no impact occurred in 2021 as analyzed under the 2021 PEA. Therefore, environmental conditions are not expected to be significantly different than those previously analyzed in the 2021 PEA. There are no other changes in Sierra Space's proposed reentry operations between the 2021 PEA and the Tiered EA that would affect historic properties.

Project Activities

The FAA's Proposed Action is to issue a Vehicle Operator License to Sierra Space Corporation to conduct reentry operations with its Dream Chaser vehicle at the SLF, which is managed by Space Florida and located at the Cape Canaveral Spaceport (see **Figure 1**).

Figure 1. Project Location

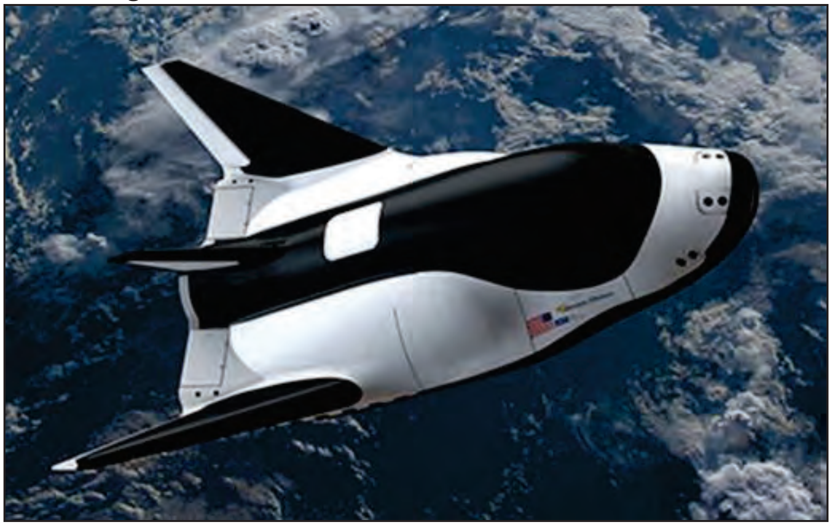
Table 1 summarizes the Dream Chaser vehicle parameters. **Figure 2** shows the Dream Chaser vehicle, as well as a notional mission profile in support of a National Aeronautics and Space Administration mission to resupply the International Space Station that ends in a horizontal reentry.

Table 1. Dream Chaser Vehicle Parameters

Characteristic	Data
Vehicle Length	30 feet
Wingspan	27 feet
Gross Vehicle Weight	24,600 pounds
Landing Gear Configuration	Nose skid and two rear wheels
Runway Length Required for Landing	10,000 feet
Cross-Range Capability	± 700 nautical miles
Propellants[1]	Hydrogen peroxide (H_2O_2) and kerosene (RP-1)
Return Payload Capacity	1,850 kilograms

[1] Dream Chaser propellants are used by a reaction control system (RCS) for orbital maneuvers, deorbit burn, and high-altitude control during reentry. The system is not used near or on the ground. Source: SNC, 2019.

Figure 2. Dream Chaser Vehicle and Mission Profile



Source: Sierra Space, 2021

Sierra Space is proposing a maximum of 4 reentries annually, for a total of up to 14 reentries over the five-year license period (see **Table 2**).

Table 2. Estimated Annual Number of Reentries

2022	2023	2024	2025	2026
1	2	3	4	4

The Dream Chaser would reenter the atmosphere from the west/southwest and overfly the Gulf of Mexico or Caribbean Sea, based on a mission dependent trajectory before landing at the SLF. Dream Chaser reentry operations at the SLF would not require any closures of non-involved Kennedy Space Center property or public use areas (e.g., Merritt Island National Wildlife Refuge, Canaveral National Seashore).

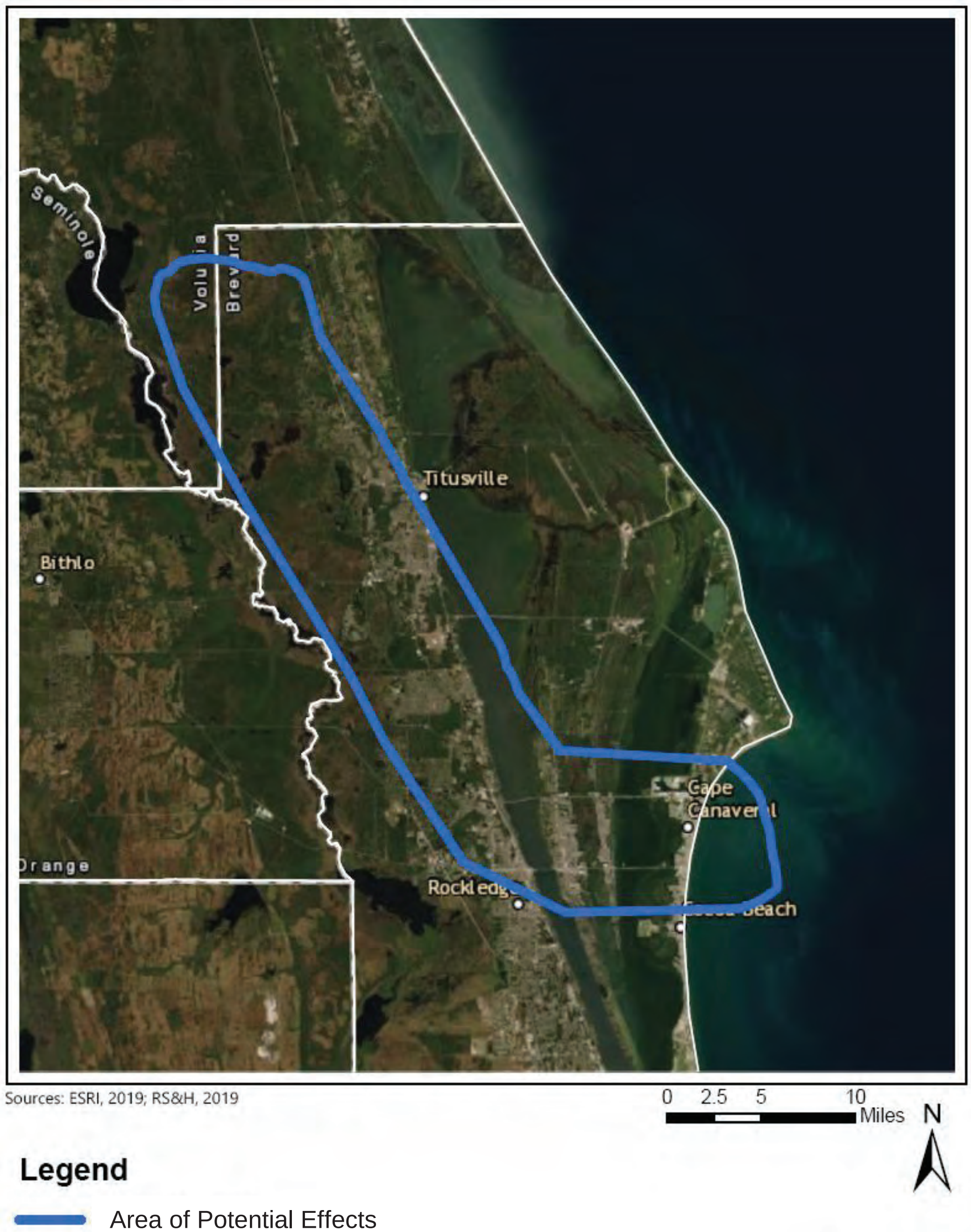
The Dream Chaser would enter controlled airspace (60,000 feet above mean sea level) approximately 30–40 miles prior to landing (for less than 30 seconds) and would enter restricted airspace approximately 25–30 miles (for approximately 2.5 – 3 minutes) prior to landing at the SLF. The vehicle would generate a sonic boom during reentry. No construction activities are proposed as part of the proposed project.

ATTACHMENT 2 – AREA OF POTENTIAL EFFECTS (APE)

The FAA has defined an APE in consideration of both potential direct and indirect effects associated with proposed reentry operations.

The proposed APE encompasses about 280 square miles and includes portions of Brevard and Volusia counties. The APE also extends over a portion of the Atlantic Ocean. This APE is based on the footprint of the Dream Chaser's sonic boom noise contour and includes those areas of the Earth's surface that would experience a sonic boom of 1.0 pound per square foot or greater (**Figure 3**).

Figure 3. Area of Potential Effects



SLF Section 106 Initiation Letter to the State Historic Preservation Officer

U.S. Department of Transportation
Federal Aviation Administration

Office of Commercial Space Transportation

800 Independence Ave., SW
Washington, DC 20591

October 21, 2021

Dr. Timothy Parsons
State Historic Preservation Officer
Florida Division of Historical Resources
R.A. Gray Building
500 South Bronough Street
Tallahassee, Florida 32399-0250

RE: National Historic Preservation Act Section 106 Consultation for Proposed Sierra Space Corporation Reentry Operations at the Shuttle Landing Facility, Cape Canaveral Spaceport, Brevard County, Florida

Dear Dr. Parsons,

The FAA is initiating Section 106 consultation and soliciting concurrence on the proposed Area of Potential Effects (APE) and the FAA's Finding of No Adverse Effect for Sierra Space Corporation's (Sierra Space) proposed commercial space reentry operations at the Shuttle Landing Facility (SLF). Sierra Space is applying to the FAA for a Vehicle Operator License that would allow Sierra Space to conduct reentries with its Dream Chaser vehicle at the SLF in Brevard County, Florida. FAA issuance of a Vehicle Operator License is considered a federal undertaking under the regulations of the Advisory Council for Historic Preservation (36 Code of Federal Regulations [CFR] § 800.16(y)) for Section 106 of the National Historic Preservation Act. The proposed project and its associated activities are also subject to the National Environmental Policy Act (NEPA) and the FAA has initiated preparation of a Supplemental Environmental Assessment to meet its regulatory obligations. The agency intends to complete Section 106 in conjunction with the NEPA process.

In 2020, the FAA consulted with the Florida Division of Historical Resources on Space Florida's application to operate the SLF as a commercial space reentry site. The potential impacts to historic properties for issuing Space Florida a Reentry Site Operator License were evaluated using Sierra Space's Dream Chaser as a representative vehicle and it proposed reentry operations. As a result, the potential impacts to historic properties for issuing Sierra Space a Vehicle Operator License are expected to be the same.

For background on previous Section 106 consultations related to commercial space operations at the SLF, see **Attachment 1**. For a description of Sierra Space's proposed reentry operations, see **Attachment 2**. The proposed APE, described in **Attachment 3**, is consistent with that which was the subject of the 2020 Section 7 consultation. The list of historic resources in the APE is described below and in **Attachment 4**. The FAA's proposed Finding of Effect is included below.

The FAA is inviting the following tribes to participate in this consultation: Catawba Indian Nation, Chitimacha Tribe of Louisiana, Coushatta Tribe of Louisiana, Eastern Band of Cherokee Indians, Jena Band of Choctaw Indians, Miccosukee Tribe of Indians of Florida, Muscogee (Creek) Nation, Poarch Band of Creek Indians, and Seminole Tribe of Florida.

Historic Resources in the APE

Historic, architectural, and cultural resources are sites recorded by the Florida Division of Historical Resources as Florida historical markers or resources that are in or eligible for listing in the National Register of Historic Places (NRHP). **Attachment 4** lists the NHRP-eligible sites in the APE.

The proposed undertaking does not include ground-disturbing activities; therefore, archaeological resources are not considered.

Preliminary Finding of Effects

12 historic properties were identified in the project APE (**Attachment 4**).

No ground disturbing activities would occur in the APE. Operation of the concept reentry vehicles would increase flight activity at the SLF. The Proposed Action would not result air quality or visual (light or viewshed) impacts, but the descent of reentry vehicles would generate a sonic boom. The Proposed Action would result in up to one sonic boom in 2022, up to two sonic booms in 2023, up to three sonic booms in 2024, and up to four sonic booms in 2025 and 2026.

Potential impacts to historic resources were assessed by determining any potential direct and indirect impacts from noise and vibration that could potentially:

- Destroy or damage a historic property;
- Alter the character of the property's use, or physical features within the setting if the setting contributes to the property's qualification for the NRHP;
- Introduce visual, audible, or atmospheric features that would diminish the integrity of the property's historic features, if the setting contributes to the property's NRHP-eligibility; and/or Cause neglect of the property resulting in the property's deterioration or destruction.

Overpressure caused by extreme sonic booms has been associated with the potential for structural damage, specifically for brittle materials such as glass and plaster. The probability of a window breaking when exposed to a sonic boom with a 1.0 psf overpressure ranges from one in a billion to one in a million, depending on the condition of the glass, while the threshold for damage from overpressure on well-maintained structures is greater than 2 psf (BRRC, 2019[1]). The results of the sonic boom analysis indicated that the maximum overpressure associated with operation of the Proposed Action would be 1.1 psf, below the 2 psf threshold.

The potential for sonic boom impacts is also evaluated in relation to human annoyance and hearing conservation. The modeled maximum of 1.1 psf translates to an equivalent CDNL[2] of 41.2 dBC. Noise caused by the proposed reentry vehicle operations would be less than the significance threshold of CDNL 60 dBC for impulsive noise sources (equivalent to DNL 65 dBA).[3] The intensity of sonic booms associated with operation of the Proposed Action would be similar to thunder in intensity. It is estimated that, on average, each resident in the APE experiences the overpressure from a thunderstorm greater than 2.09 psf more than 20 times a year. Users of the historic properties located within the APE therefore likely experience similar levels of thunderstorm activity and noise impacts.

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[1] BRRC. (2019). *Shuttle Landing Facility Reentry Site Licensing Sonic Boom Analysis.*

[2] CDNL is the C-weighted Day-Night Level (DNL). C-weighting is preferred over A-weighting for impulsive noise sources with large low-frequency content such as sonic booms.

[3] Areas exposed to DNL 65 dBA or lower are compatible with all land uses.

Based on the results of the studies and an assessment of effects to historic properties, the FAA has determined that this undertaking will have No Adverse Effect on historic properties. Please review this finding and the enclosed documentation, in accordance with 36 CFR § 800.5 and provide either your concurrence or non-concurrence.

Conclusion

The FAA requests your concurrence on the determination of the APE and the FAA's Finding of No Adverse Effect within 30 days. If you have any questions or need additional information on the project, please contact Ms. Chelsea Clarkson of my staff at (202) 286-5447 or chelsea.clarkson@faa.gov. Thank you in advance for your input on this project.

Sincerely,

JAMES R REPCHECK
Digitally signed by JAMES R REPCHECK
Date: 2021.10.21 10:56:52 -04'00'

Randy Repcheck
Manager, Safety Authorization Division

Enclosures:

Attachment 1 – Background
Attachment 2 - Project Description
Attachment 3 – Area of Potential Effects
Attachment 4 – Historic Resources in the Area of Potential Effects

ATTACHMENT 1 – BACKGROUND

In 2018, the FAA prepared the *Final Environmental Assessment for the Shuttle Landing Facility Launch Site Operator License* (2018 EA) to evaluate the potential environmental impacts of Space Florida's proposal to operate the SLF as a launch site for horizontally launched and landed reusable vehicles. The FAA issued a Finding of No Significant Impact (FONSI) based on the 2018 EA on November 2, 2018 and issued a Launch Site Operator License (License Number: LSO 18-018) to Space Florida to operate a launch site at the SLF.

In 2021, the FAA prepared the *Final Programmatic Environmental Assessment (PEA) for the Shuttle Landing Facility Reentry Site Operator License* (2021 PEA) to evaluate the potential environmental impacts of Space Florida's proposal to operate the SLF as a commercial space reentry site. The 2021 PEA used Sierra Space's Dream Chaser vehicle as the representative vehicle for operations (the space systems group within Sierra Nevada Corporation became called Sierra Space Corporation, its own company, on June 1, 2021). The FAA issued a FONSI based on the 2021 PEA on January 12, 2021 and issued a Reentry Site Operator License (License Number: LRSO 18-018) to Space Florida to operate a reentry site at the SLF.

The FAA consulted with your office in 2020 for the FAA's action of issuing a Reentry Site Operator License to Space Florida. The FAA determined that the proposed project would have no effect on historic properties. Your office concurred with this determination.

The FAA is currently preparing an Environmental Assessment that tiers from the 2021 PEA to analyze Sierra Space's specific proposed reentry operations (Tiered EA). The 2021 PEA assessed up to six annual reentry operations from 2021 to 2025. Space Florida's Reentry Site Operator License expires in 2025, at which time Space Florida can apply to renew the license. Sierra Space is applying for a vehicle operator license for the time period of 2022 – 2026. No reentry operations were conducted at the SLF in 2021 and therefore no impact occurred in 2021 as analyzed under the 2021 PEA. Therefore, environmental conditions are not expected to be significantly different than those previously analyzed in the 2021 PEA. There are no other changes in Sierra Space's proposed reentry operations between the 2021 PEA and the Tiered EA that would affect historic properties.

ATTACHMENT 2 – PROJECT DESCRIPTION

The FAA's Proposed Action is to issue a Vehicle Operator License to Sierra Space Corporation to conduct reentry operations with its Dream Chaser vehicle at the SLF, which is managed by Space Florida and located at the Cape Canaveral Spaceport (see **Figure 1**).

Figure 1. Project Location

Table 1 summarizes the Dream Chaser vehicle parameters. **Figure 2** shows the Dream Chaser vehicle, as well as a notional mission profile in support of a National Aeronautics and Space Administration mission to resupply the International Space Station that ends in a horizontal reentry.

Table 1. Dream Chaser Vehicle Parameters

Characteristic	Data
Vehicle Length	30 feet
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Propellants[1]	Hydrogen peroxide (H_2O_2) and kerosene (RP-1)
Return Payload Capacity	1,850 kilograms

[1] Dream Chaser propellants are used by a reaction control system (RCS) for orbital maneuvers, deorbit burn, and high-altitude control during reentry. The system is not used near or on the ground. Source: SNC, 2019.

Figure 2. Dream Chaser Vehicle and Mission Profile

Source: Sierra Space, 2021

Sierra Space is proposing a maximum of 4 reentries annually, for a total of up to 14 reentries over the five-year license period (see **Table 2**).

Table 2. Estimated Annual Number of Reentries

2022	2023	2024	2025	2026
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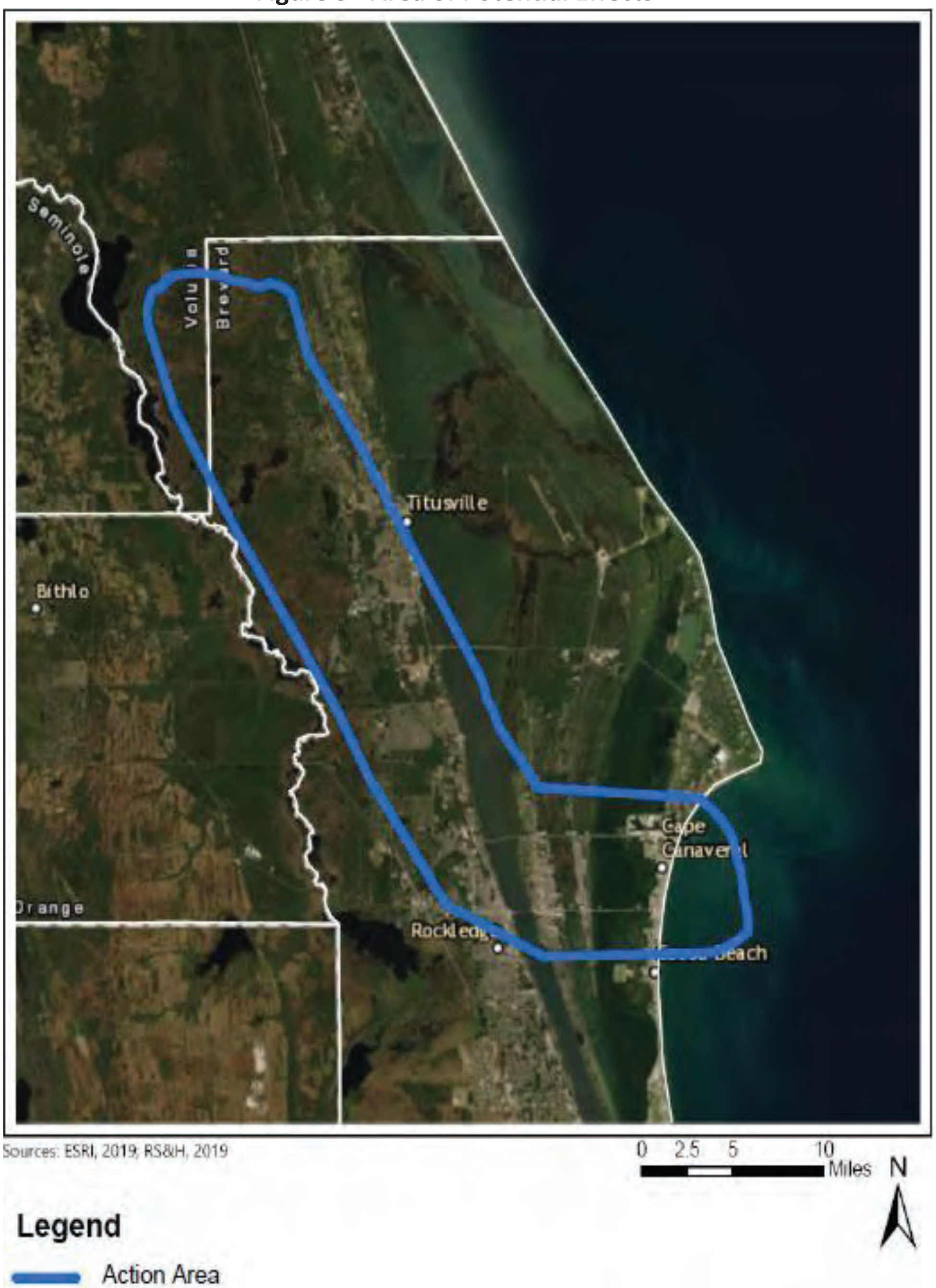
The Dream Chaser would enter controlled airspace (60,000 feet above mean sea level) approximately 30–40 miles prior to landing (for less than 30 seconds) and would enter restricted airspace approximately 25–30 miles (for approximately 2.5 – 3 minutes) prior to landing at the SLF. The vehicle would generate a sonic boom during reentry. No construction activities are proposed as part of the proposed project.

ATTACHMENT 3 – AREA OF POTENTIAL EFFECTS

In accordance with 36 CFR § 800.4(a)(1), an APE needs to be established for the proposed undertaking in consultation with your office. The FAA has defined an APE in consideration of both potential direct and indirect effects associated with proposed reentry operations. The proposed APE encompasses about 280 square miles and includes portions of Brevard and Volusia counties. The APE also extends over a portion of the Atlantic Ocean. This APE is based on the footprint of the reentry vehicle's sonic boom noise contour and includes those areas of the Earth's surface that would experience a sonic boom of 1.0 pound per square foot or greater (**Figure 3**).

Figure 3 - Area of Potential Effects



ATTACHMENT 4 – HISTORIC RESOURCES IN THE AREA OF POTENTIAL EFFECTS

Resource Name	Resource Type
Aladdin Theater	Listed in NRHP
Barton Ave Residential District	Listed in NRHP
Cape Canaveral Air Force Station	Listed in NRHP
City Point Community Church	Listed in NRHP
Cocoa Junior High	Eligible for NRHP
Cocoa Post Office	Eligible for NRHP
Dr. George E Hill House	Listed in NRHP
J.R. Field, Homestead	Listed in NRHP
La Grange Church and Cemetery	Listed in NRHP
Porcher House	Listed in NRHP
Rockledge Drive Residential District	Listed in NRHP
Valencia Subdivision Residential Historic	Listed in NRHP

2024 Revised Draft EA Agency Coordination

U.S. Department
of Transportation
**Federal Aviation
Administration**

Commercial Space Transportation
800 Independence Ave., SW.
Washington, DC 20591

June 27, 2024

Consulting Biologist
Endangered Species Act Interagency Cooperation Division
Office of Protected Resources
National Marine Fisheries Service
Silver Spring, MD 20910

Project Specific Review Request, OPR-2021-02908,
Programmatic Concurrence for Reentry Operation of Sierra Space Dream Chaser Vehicle

Dear Consulting Biologist,

The Federal Aviation Administration (FAA) is preparing an environmental assessment (EA) to analyze the environmental impacts for reentry operations of Sierra Space's Dream Chaser vehicle into the Shuttle Landing Facility (SLF) in Cape Canaveral, Florida. The FAA previously analyzed the potential environmental impacts of issuing a reentry site operator license (RSOL) to Space Florida for the operation of a commercial space reentry site at the SLF in a 2021 Programmatic Environmental Assessment (2021 PEA). The 2021 PEA evaluated the potential environmental impacts of operation of a commercial space reentry site at the SLF using Sierra Space's Dream Chaser as a representative reentry vehicle. The FAA determined that issuing a RSOL would not significantly affect the quality of the human environment pursuant to Section 102(2)(c) of NEPA and issued a Finding of No Significant Impact (FONSI) in January 2021.[1] The FAA issued a RSOL and a renewed launch site operator license (LSOL) on January 15, 2021 (LRSO 18-018). This EA continues to analyze the impacts of the activities associated with Sierra Space's reentry operations and tiers from the 2021 PEA for the SLF RSOL.

Vandenberg Space Force Base (VSFB) in Santa Barbara County, California is also analyzed as part of this EA as a contingency landing site for Dream Chaser in the event landing at the SLF cannot be completed under nominal mission parameters. Environmental impacts of Dream Chaser reentry operations into VSFB have not been previously consulted on with National Marine Fisheries Service (NMFS). As a result, a project-specific review under OPR-2021-02908 is being requested since contingency operations into VSFB will be conducted within the marine environment.

The proposed action for the Sierra Space Dream Chaser Reentry EA is to conduct up to four reentry operations per year starting in 2024. A small sonic boom is expected near the landing sites during reentry operations; impacts are expected to be small and not likely to affect ESA listed species. Additionally, as part of the reentry operation, the Dream Chaser will need to release and dispose of a cargo module over the Pacific Ocean. This cargo module is expected to burn up upon reentry and have minimal surviving debris. In the event there is surviving debris, it would be disposed of within the Pacific Ocean.

[1] The 2021 PEA can be downloaded from the FAA website at: https://www.faa.gov/space/environmental/nepa_docs/slf_ea.

As stated in the April 14, 2023, NMFS Letter of Concurrence (2023 LOC), NMFS issued a programmatic letter of concurrence to the FAA for launch and reentry vehicle operations in the marine environment, which included the Sierra Space Dream Chaser vehicle. Prior consultations related to the Dream Chaser vehicle were not superseded by the 2023 LOC and are therefore referenced within this consultation. The FAA would like NMFS to consider whether Sierra Space's Dream Chaser vehicle program operations is similar enough in nature to the operations to be regulated under OPR-2021-02908. As noted in OPR-2021-02908, "upon receipt of a new proposal that involves operations in the marine environment, the lead action agency (FAA) will review the proposal and coordinate with NMFS to determine if the proposed launch operations fall within the scope of this consultation."

The FAA is requesting a project-specific review by NMFS under OPR-2021-02908 for the Sierra Space Reentry Program because it involves reentry vehicle operations in the marine environment. It should be noted that the proposed Sierra Space Reentry Program Action Area extends beyond the define Pacific Ocean Action Area in OPR-2021-02908. However, impacts to regions outside of the Pacific Ocean Action Area are substantially similar to those within it. These areas are further defined in following sections of this letter. In execution of the Sierra Space Reentry program, Sierra Space will comply with all requirements of OPR-2021-02908.

Appendix A provides a summary of requirements set forth in OPR-2021-02908 and their applicability to the Sierra Space's Reentry Program. The following sections present similarities between the Sierra Space Program Action Area and the information in OPR-2021-02908.

This information was prepared based on the best available scientific and commercial data available. Please contact Chelsea Clarkson, FAA Environmental Protection Specialist, at Chelsea.Clarkson@faa.gov to discuss any questions or concerns on the proposed project.

Sincerely,

Stacy M. Zee
Manager, Operations Support Branch

Attachment

Sierra Space Project-Specific Review OPR-2021-02908 Applicability

Sierra Space Dream Chaser Reentry Vehicle and Cargo Module

Sierra Space's Dream Chaser is a multi-mission space utility vehicle designed to transport cargo to low Earth orbit (LEO) destinations such as the International Space Station (ISS). NASA purchases these missions to provide a market for commercial resupply services, thus allowing the vehicle to be used to support additional missions for other government and non-government customers.
The Dream Chaser is a lifting-body spacecraft with small wings that provide directional stability in flight. The lifting-body design gives Dream Chaser a higher lift-to-drag ratio and allows for more efficient cross-range landing capability. The Sierra Space Dream Chaser is shown in **Figure 1**.

Dream Chaser measures approximately 30 feet in length, has a wingspan of 27 feet, and weighs approximately 24,600 pounds. Dream Chaser propellants, Hydrogen Peroxide (H2O2) and Kerosene (RP-1), are used by a reaction control system (RCS) for orbital maneuvers, deorbit burn, and high-altitude attitude control during reentry. The propulsion system is not used near or on the ground. Near Mach 4, Dream Chaser transitions from RCS attitude control to flight control surfaces. The vehicle lands on a runway with residual propellant (less than 1%) and any margin not used during reentry. The pressurized/unpressurized cargo capacity is 5,500 kilograms or 30 cubic feet. The return payload capacity is 1,850 kilograms.

Figure 1: Sierra Space Dream Chaser

While on orbit, Dream Chaser is attached to a cargo module as shown in **Figure 2**. The cargo module provides power generation and thermal rejection (heat transfer) to Dream Chaser as well as supports the transport of pressurize and unpressurized cargo to and from the ISS. Upon reentry, the Dream Chaser will decouple from the cargo module, and the Dream Chaser vehicle will continue reentry and eventually land at the designated landing site. Typical cargo includes scientific experiments, items no longer needed on the ISS packaged in cargo transfer bags, and trash for disposal in the cargo module. Prior to reentry missions, NASA provides Sierra Space and thus the FAA an integrated bag level hazard analysis (IBLHA). The IBLHA assesses any hazards present in the proposed cargo manifest. Hazardous material will not be transported within the cargo module. It is expected that most of the unwanted cargo and cargo module will be destroyed during reentry. However, if there is surviving debris, it would be extremely minimal and land in designated disposal areas in broad open ocean, in accordance with FAA regulation and Title 14 CFR Part 450.101 (d). The cargo module is largely designed from composite materials that will demise upon reentry. Potential surviving debris pieces are expected to be small, inert, metallic components that have partially demised by the time they reach the ocean surface. The quantity of surviving debris is anticipated to be very minimal and would vary based on the particular payload manifest for a given mission. If there is surviving debris, the majority is expected to sink almost immediately, any debris that does float is expected to become water-logged and sink soon after, further minimizing chances of debris impacting marine sanctuaries and species.

Figure 2: Dream Chaser with Cargo Module in Orbit

Sierra Space anticipates up to four reentries per year (each reentry could occur during daytime or nighttime, depending on the mission) with reentries beginning below that threshold in 2024 and steadily increasing. Sierra Space plans for Dream Chaser to land at the Shuttle Landing Facility (SLF) in Cape Canaveral, FL. However, Vandenberg Space Force Base (VSFB) in Santa Barbara County, CA has been chosen as a contingency landing site in the event Dream Chaser is unable to land at the SLF.

Program Action Area

The Program Action Area for ocean waters is defined as the SLF study area, the VSFB study area, and the cargo module disposal ranges for reentry into the SLF or contingent reentry into VSFB. The Dream Chaser would reenter into the SLF on a trajectory range of 100° to 330°, or into VSFB on a trajectory range of 090° to 360°. It is anticipated that the unwanted cargo and cargo module would burn up during reentry. In the event there is surviving debris, it would land in the Pacific Ocean within the defined disposal area ranges. Representation of the disposal areas and disposal area ranges are shown in **Figure 3** and **Figure 4**. It is important to note that Dream Chaser is designed to support a wide variety of reentry trajectories that would each fly over different portions of the Pacific Ocean. The disposal range is intended to cover the entirety of possible disposal locations across all possible reentry trajectories, whereas the representative disposal area is intended to reflect the possible disposal locations for a given mission. As shown in **Figure 3**, the representative cargo module disposal area is much smaller than the possible disposal range. The specific disposal area within the disposal range will be dependent on each mission and reentry trajectory.

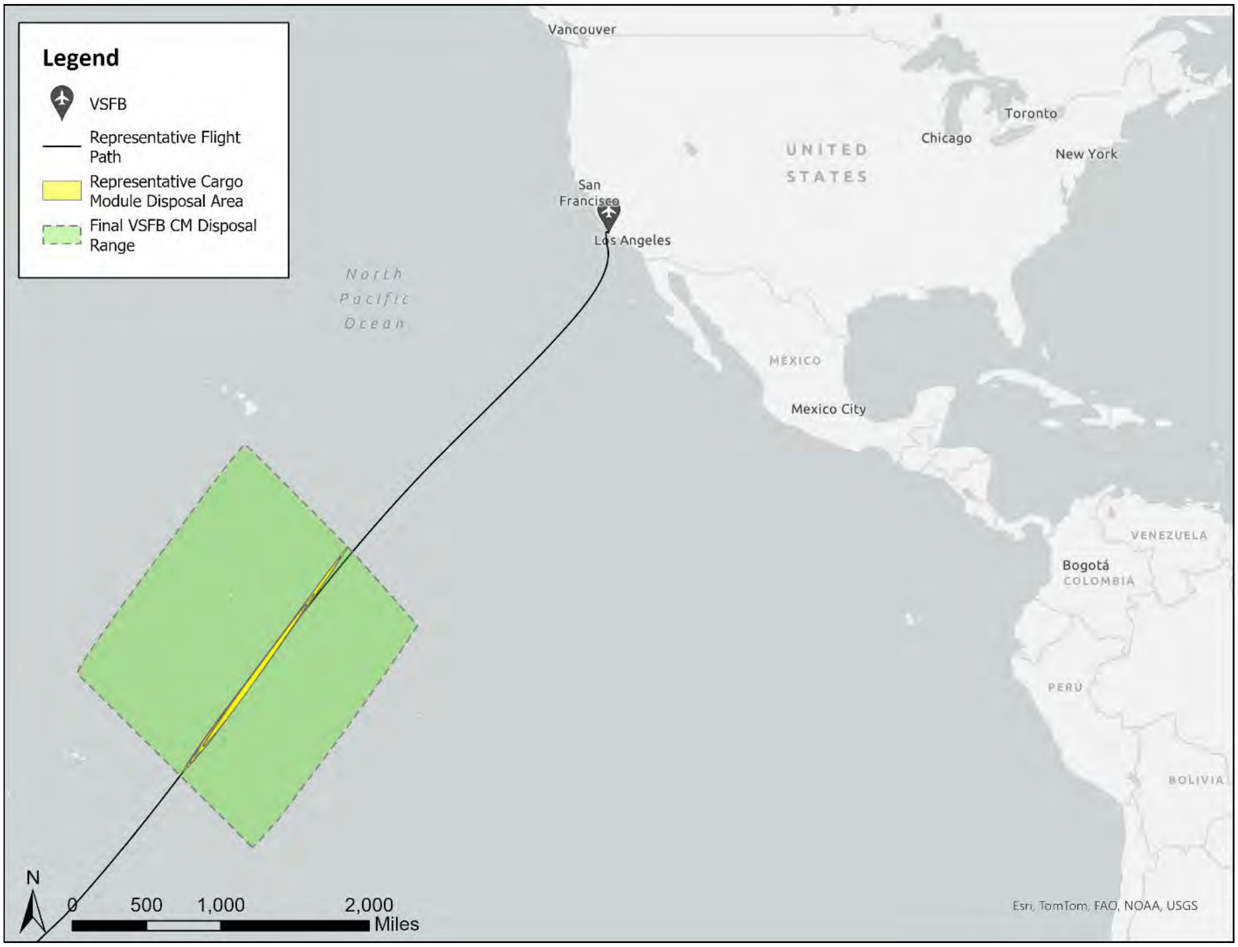


Figure 3: VSFB Cargo Module Disposal Area within Disposal Range

The representative cargo module disposal area for a specific deorbit opportunity was conservatively generated and bounds the possible locations small debris could fall with 97% confidence. Conservatism was also included in the demise estimation of debris that could survive to the ocean surface and the amount surviving debris will likely be lower than that analyzed here. It is important to note that the representative area identified bounds the total area for potential debris and does not equate to certainty that debris will exist everywhere (or even anywhere) within the representative area. Given that the representative area is a probabilistic location of possible small debris, the likelihood of debris impacting a specific location of interest is extremely remote. As shown in **Figure 4**, The associated cargo module disposal ranges push the overall Program Action Area south of the equator; therefore, it is outside the Pacific Ocean Action Area defined on page 26 of OPR-2021-02908 **[3]**.

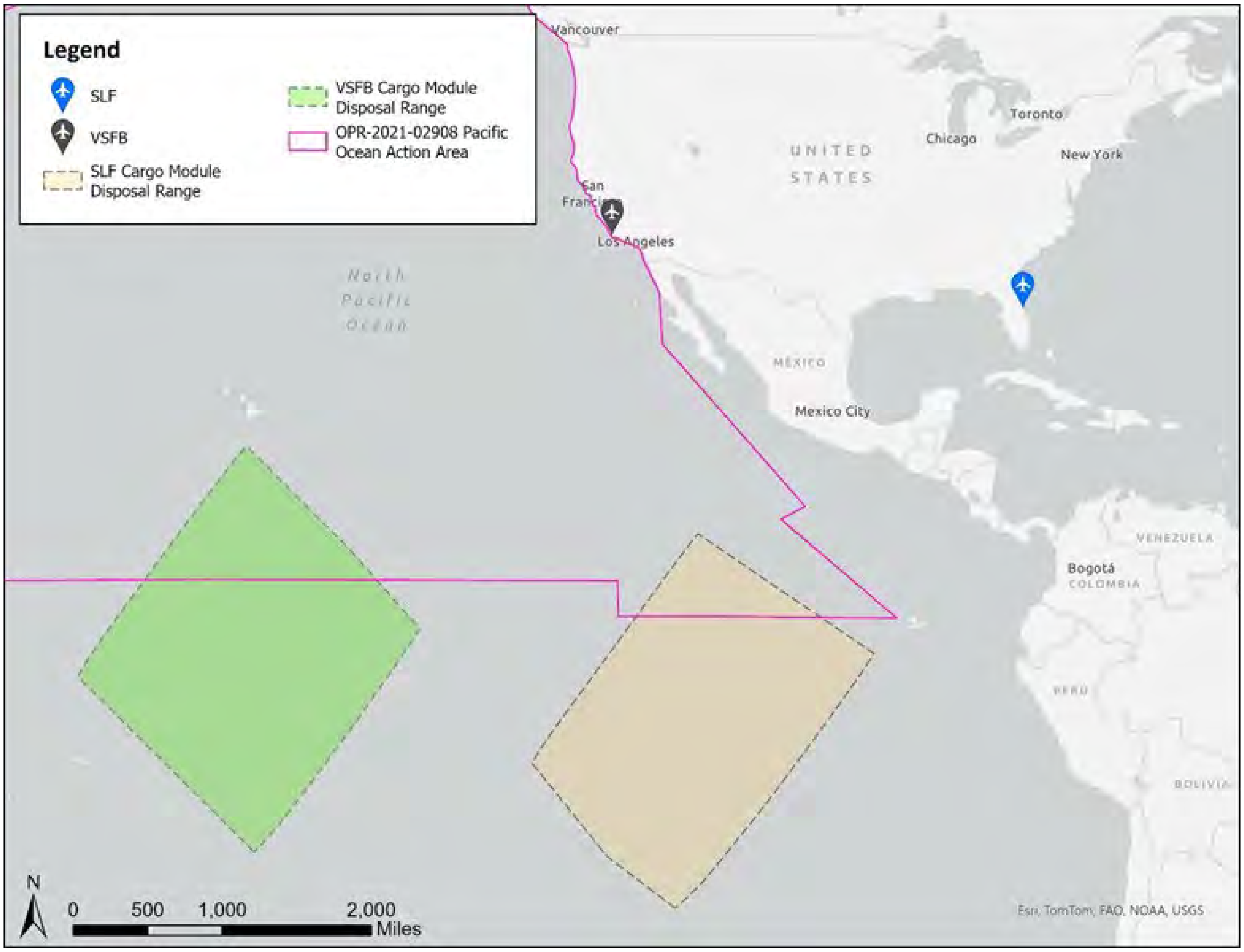


Figure 4: Cargo Module Disposal Ranges SLF and VSFB

Fate of Cargo Module

As noted, the cargo module is expected to burn up during reentry. In the unlikely event the cargo module is not completely demised during reentry operations, remaining debris will splashdown in the remote disposal areas in the Pacific Ocean within the disposal area ranges. The cargo module would not carry hazardous materials and has no propulsion tanks on board – any surviving debris is expected to be small, inert, and sink after reaching the ocean surface.

Landing Sites and Sonic Booms

During reentry, the Dream Chaser will generate a very small sonic boom. The sonic boom peak overpressure will be no more than 1.1 psf over water and is therefore not expected to affect marine species underwater. The proposed action study area is defined by the 1.0 psf overpressure contour. This area is shown in **Figure 5** for VSFB and **Figure 6** for the SLF.

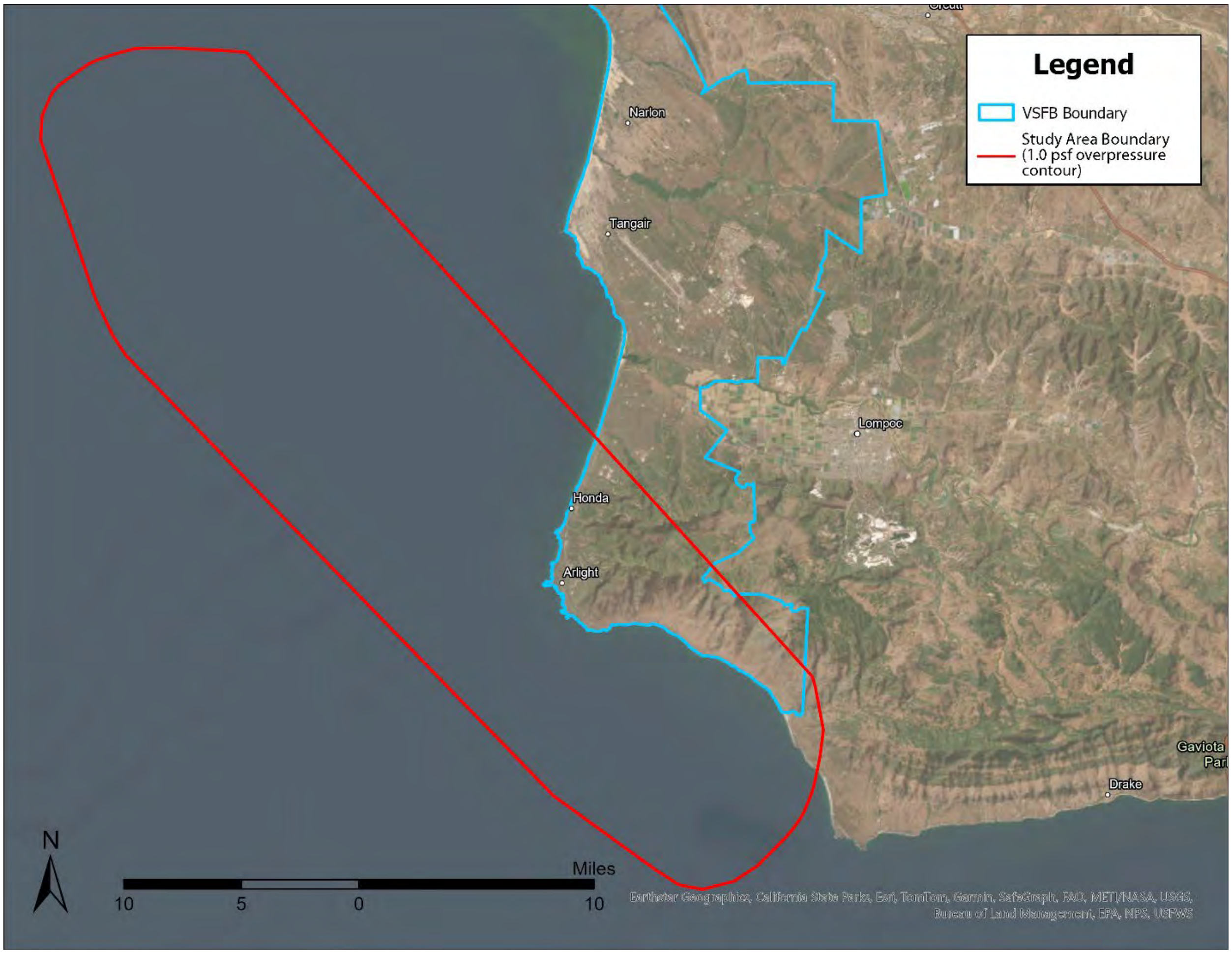


Figure 5: VSFB Study Area

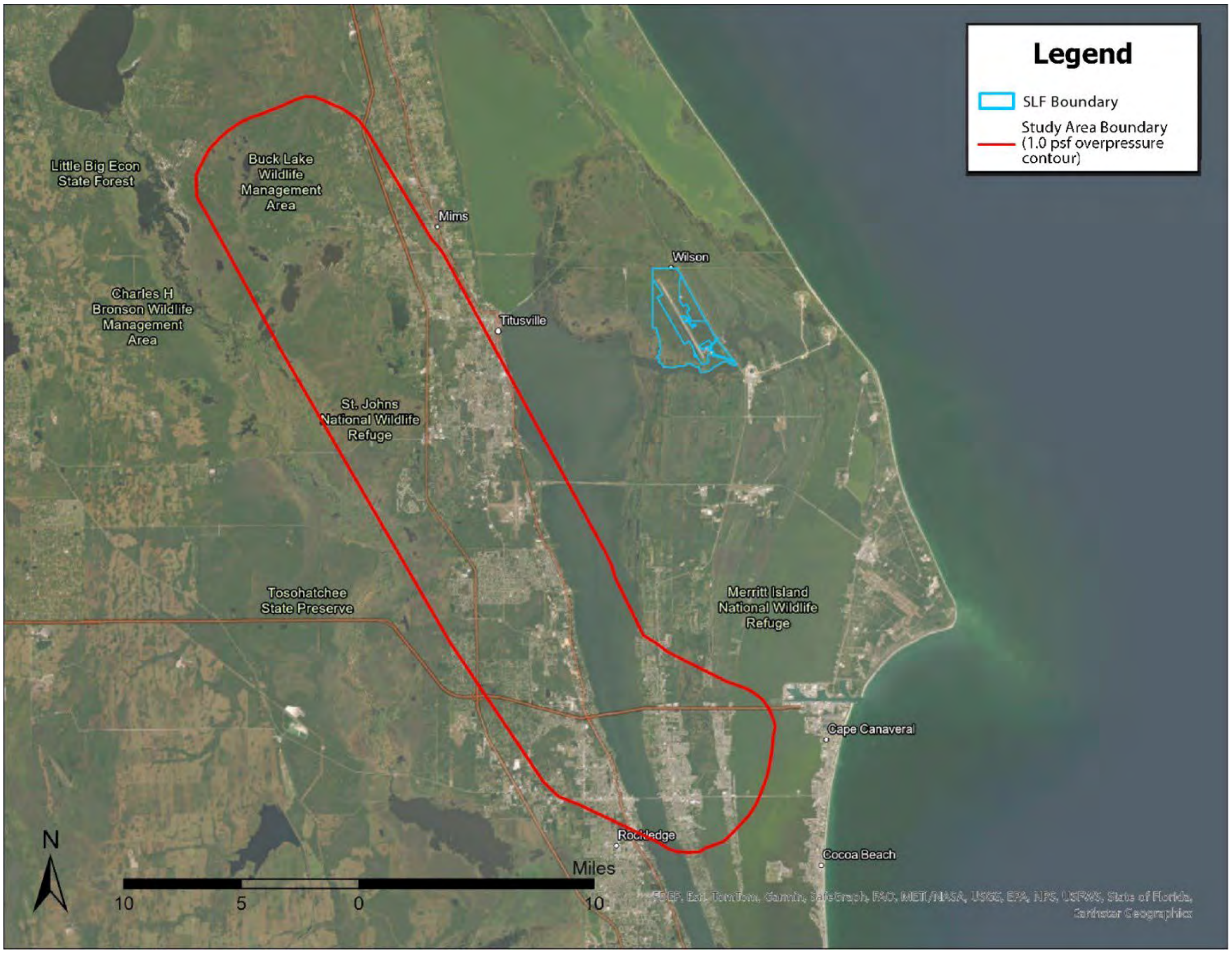


Figure 6: SLF Study Area

ESA-Listed Species Present within the Program Action Area

This section will primarily focus on action areas related to contingency landings at VSFB since the SLF has already received consultation. However, the SLF cargo module disposal range has not received prior consultation and therefore will be included in this section as well.
Table 1 provides a list of ESA -listed species potentially within the program action area, and if these species were analyzed within OPR-2021-02908.

Table 1: ESA-Listed Marine Species within Program Action Area [3][13][14]

Marine Mammals				
Common Name	**Scientific Name**	**ESA Listing Status**	**Covered under OPR-2021-02908**	**Location within the Action area**
Humpback Whale – Central America DPS	*Megaptera novaeangliae*	Endangered	Yes	VSFB Study Area, VSFB and SLF CM Disposal Range
Blue Whale	*Balaenoptera musculus*	Endangered	Yes	VSFB Study Area, VSFB and SLF CM Disposal Range
False Killer Whale - Hawaiian Insular	*Psuedorca crassidens*	Endangered	Yes	VSFB and SLF CM Disposal Range
Fin Whale	*Balaenoptera physalus*	Endangered	Yes	VSFB Study Area, VSFB and SLF CM Disposal Range
North Pacific Right Whale	*Eubalaena japonica*	Endangered	Yes	VSFB Study Area, VSFB and SLF CM Disposal Range
Sei Whale	*Balaenoptera borealis*	Endangered	Yes	VSFB Study Area, VSFB and SLF CM Disposal Range
Sperm Whale	*Physeter macrocephalus*	Endangered	Yes	VSFB Study Area, VSFB and SLF CM Disposal Range
Hawaiian Monk Seal	*Neomonachus schauinslandi*	Endangered	Yes	VSFB CM Disposal Range
Sea Turtles				
Common Name	**Scientific Name**	**ESA Listing Status**	**Covered under OPR-2021-02908**	Location within the Program Action Area
Central North Pacific Green Turtle	*Chelonia mydas*	Threatened	Yes	VSFB Study Area, VSFB and SLF CM Disposal Range
Central South Pacific Green Turtle	*Chelonia mydas*	Endangered	Yes	VSFB and SLF CM Disposal Range
Hawksbill Turtle	*Eretmochelys imbricata*	Endangered	Yes	VSFB Study Area, VSFB and SLF CM Disposal Range
Leatherback Turtle	*Dermochelys coriacea*	Endangered	Yes	VSFB Study Area, VSFB and SLF CM Disposal Range
North Pacific Loggerhead Turtle	*Caretta caretta*	Endangered	Yes	VSFB Study Area, VSFB and SLF CM Disposal Range
South Pacific Loggerhead Turtle	*Caretta caretta*	Endangered	Yes	VSFB and SLF CM Disposal Range

Olive Ridley Turtle (Pacific Ridley)	*lepidochelys olivacea*	Threatened	Yes	VSFB CM Disposal Range
Fish				
Common Name	**Scientific Name**	**ESA Listing Status**	**Covered under OPR-2021-02908**	**Location within the Program Action Area**
Giant Manta Ray	*Mobula birostris*	Threatened	Yes	VSFB and SLF CM Disposal Range
Oceanic Whitetip Shark	*Carcharhinus longimanus*	Threatened	Yes	VSFB and SLF CM Disposal Range
Scalloped Hammerhead Shark (Indo-West Pacific)	*Sphyrna lewini*	Threatened	Yes	VSFB and SLF CM Disposal Range
Invertebrates				
Common Name	**Scientific Name**	**ESA Listing Status**	**Covered under OPR-2021-02908**	**Location within the Program Action Area**
Coral	*Acropora globiceps*	Threatened	No	VSFB CM Disposal Range
Coral	*Acropora retusa*	Threatened	No	VSFB CM Disposal Range
Coral	*Acropora speciosa*	Threatened	No	VSFB CM Disposal Range
Coral	*Fimbriaphyllia paradivisa*	Threatened	No	VSFB CM Disposal Range
Coral	*Isopora crateriformis*	Threatened	No	VSFB CM Disposal Range
Black Abalone	*Haliotis cracherodii*	Endangered	No	VSFB Study Area
Chambered Nautilus	*Nautilus pompilius*	Threatened	No	VSFB CM Disposal Range
Giant Clams	*Tridacna derasa*	Candidate	No	VSFB CM Disposal Range
Giant Clams	*Tridacna squamosa*	Candidate	No	VSFB CM Disposal Range
Giant Clams	*Tridacna gigas*	Candidate	No	VSFB CM Disposal Range
Giant Clams	*Hippopus hippopus*	Candidate	No	VSFB CM Disposal Range

As depicted in **Table 1,** the only ESA-listed marine species that are not accounted for in OPR-2021-02908 are invertebrates consisting of coral, Chambered Nautilus, Black Abalone, and Giant Clams. The following subsections detail pertinent life history characteristics, distribution within the action area, and prevailing threats to the species.

Corals

Coral species including *Acropora globiceps, Acropora retusa, Acropora speciosa, Fimbriaphyllia paradivisa,* and *Isopora crateriformis* may be located within the VSFB cargo module disposal range. Within the United States, *Acropora globiceps* occur in Guam, the Commonwealth of the Northern

Mariana Islands, American Samoa, the Pacific Remote Island Areas, and at Lalo (French Frigate Shoals) in the Papahānaumokuākea Marine National Monument **[10]**. *Acropora retusa* occurs in American Samoa and the Pacific Remote Island Areas **[9]**. *Acropora speciosa, Fimbriaphyllia paradivisa,* and *Isopora crateriformis* occurs in the American Samoa. Threats to these coral species include climate change (including ocean warming and ocean acidification), diseases, habitat degradation, land-based sources of pollution, small population size, unsustainable fishing **[8][11][12]**.

Black Abalone

Black abalone live in rocky intertidal and subtidal reefs along the California and Baja California coast. They are “broadcast spawners,” releasing eggs and sperm into the water by the millions when environmental conditions are right. Their strong, muscular “foot” allows them to attach to rocks and other hard surfaces while their oval-shaped shells protect them from predators. Although fishing for black abalone has been illegal in California since 1993, the high price of abalone meat makes them a target of poachers. This species has experienced major declines in abundance throughout the Southern California coast because of historical overfishing and—more recently—mass mortalities associated with a disease known as withering syndrome **[4]**. Black abalone may be present on the coastal areas within the VSFB study area.

Chambered Nautilus

Chambered nautilus are mainly found in the western Pacific Ocean and coastal areas of the Indian Ocean. Nautiluses are relatively long-lived, reaching ages of 15 to 20 years, or more. They grow slowly, maturing around 10 to 15 years of age, and produce a small number of eggs that require at least a year-long incubation period. The main threat to Chambered Nautilus is harvest for international trade of the shell **[6]**. Chambered Nautilus habitats may be located within the VSFB cargo module disposal range.

Giant Clams

Giant clams are classified as two genera, *Tridacna* and *Hippopus* in the order Veneroida and family Cardiidae of bivalve molluscs. They exist only in the Indo-Pacific region and typically occur near coral reefs ranging from Madagascar to Hawaii. Giant Clam habitats may be located within the VSFB cargo module disposal range. Giant clams typically live in shallow and clear waters due to their obligate symbiosis with photosynthetic dinoflaggelate algae, which live in their enlarged siphonal mantle **[18].** They are amongst the most productive primary producers in coral reefs and provide surface structure epibionts and anchor coral reef matricies **[16]**. Threats to Giant Clams include climate change, disease, habitat degradation, illegal trade and poaching, overfishing, sedimentation, and pollution **[5]**.

Critical Habitats within the Program Action Area

A description of ESA-listed critical habitats for Humpback whale and leatherback sea turtles for the study area above are covered under OPR-2021-02908 (Pages 47 – 51) **[3].**
ESA listed species within the VSFB study area are shown in **Figure 7**. Critical habitats within the study area include the Black Abalone, Humpback Whale, and Leatherback Sea Turtle Habitats.

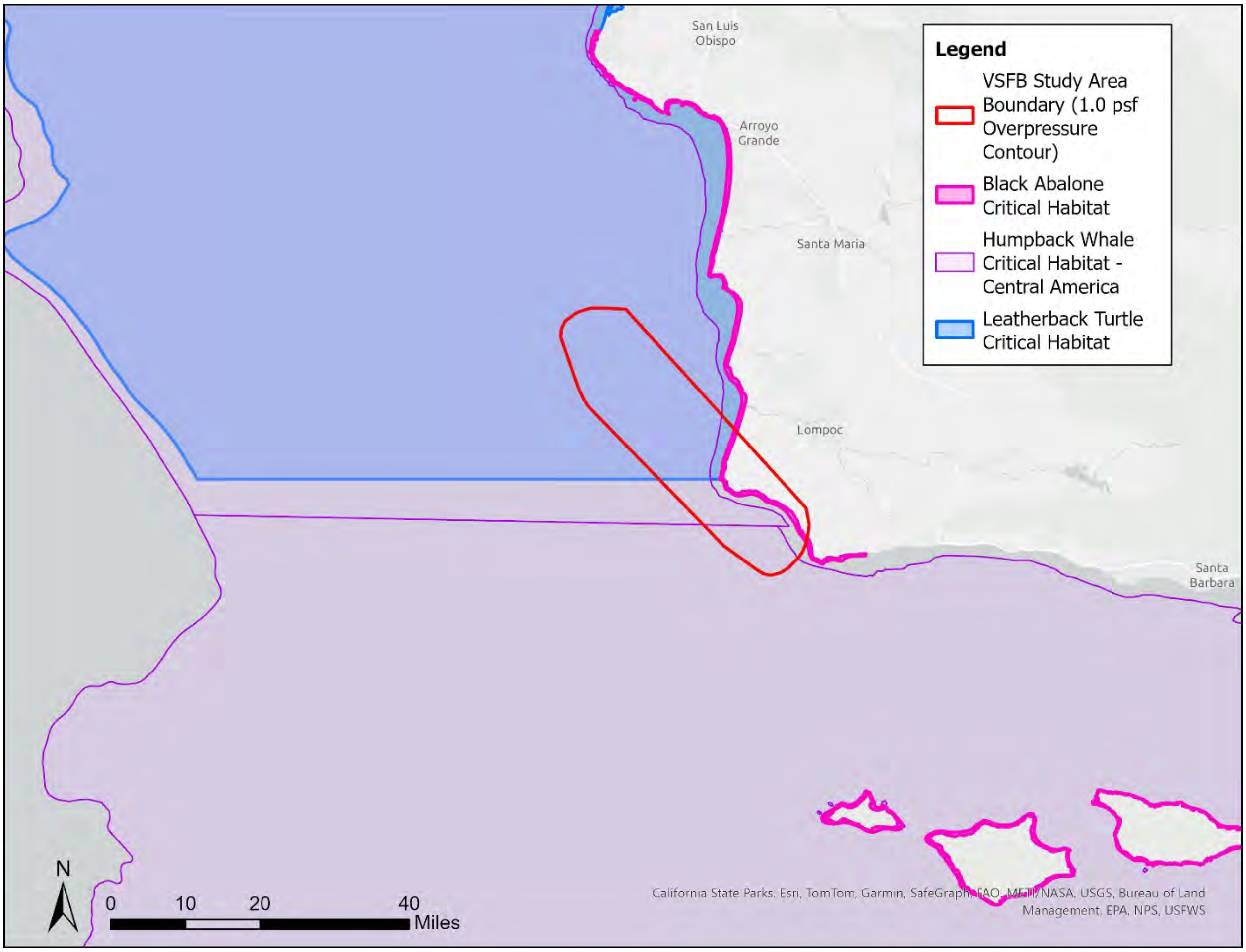


Figure 7: Critical Habitats within VSFB Study Area [3][4]

Potential critical habitats of ESA-listed species in the Pacific Remote Islands are listed in **Table 3**. The only critical habitats within the cargo module disposal ranges are the Green Sea Turtle proposed critical habitat and the Acropora Globicep coral proposed critical habitat in the Palmyra Atoll. This is shown in **Figure 8** and **Figure 9**.

Table 2: Designated Critical Habitat within Program Action Area [3] [8] [9]

Critical Habitat			
Common Name	**Scientific Name**	**Critical Habitat**	**Covered under OPR-2021-02908**
False Killer Whale – Hawaiian Insular	*Pseudorca crassidens*	Designated	Yes
Leatherback Turtle	*Dermochelys coriacea*	Designated	Yes
Green Turtle	*Chelonia mydas*	Proposed	Yes
Hawaiian Monk Seal	*Neomonachus schauinslandi*	Designated	Yes
Pacific Coral	-	Proposed	No

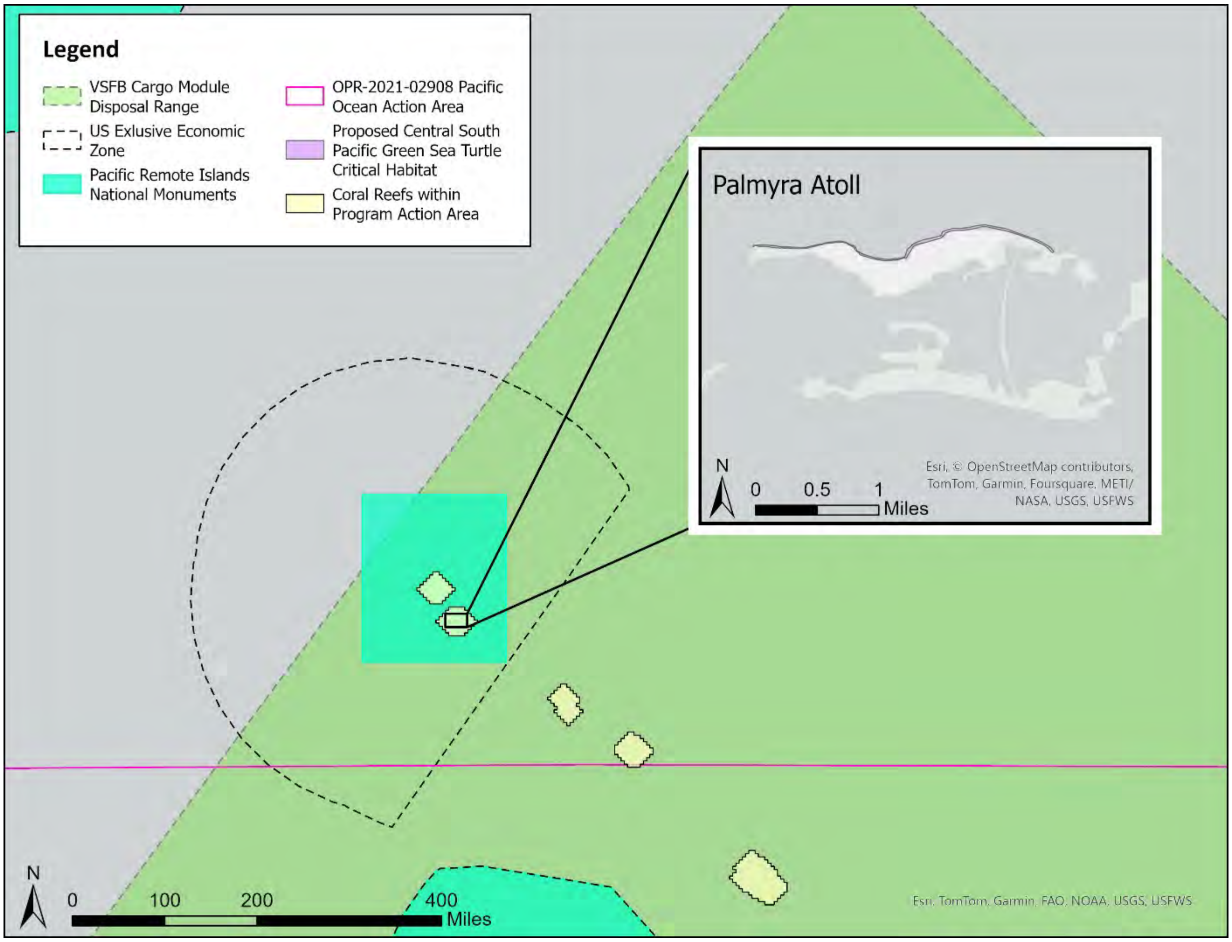


Figure 8: Green Sea Turtle Proposed Critical Habitat [17]

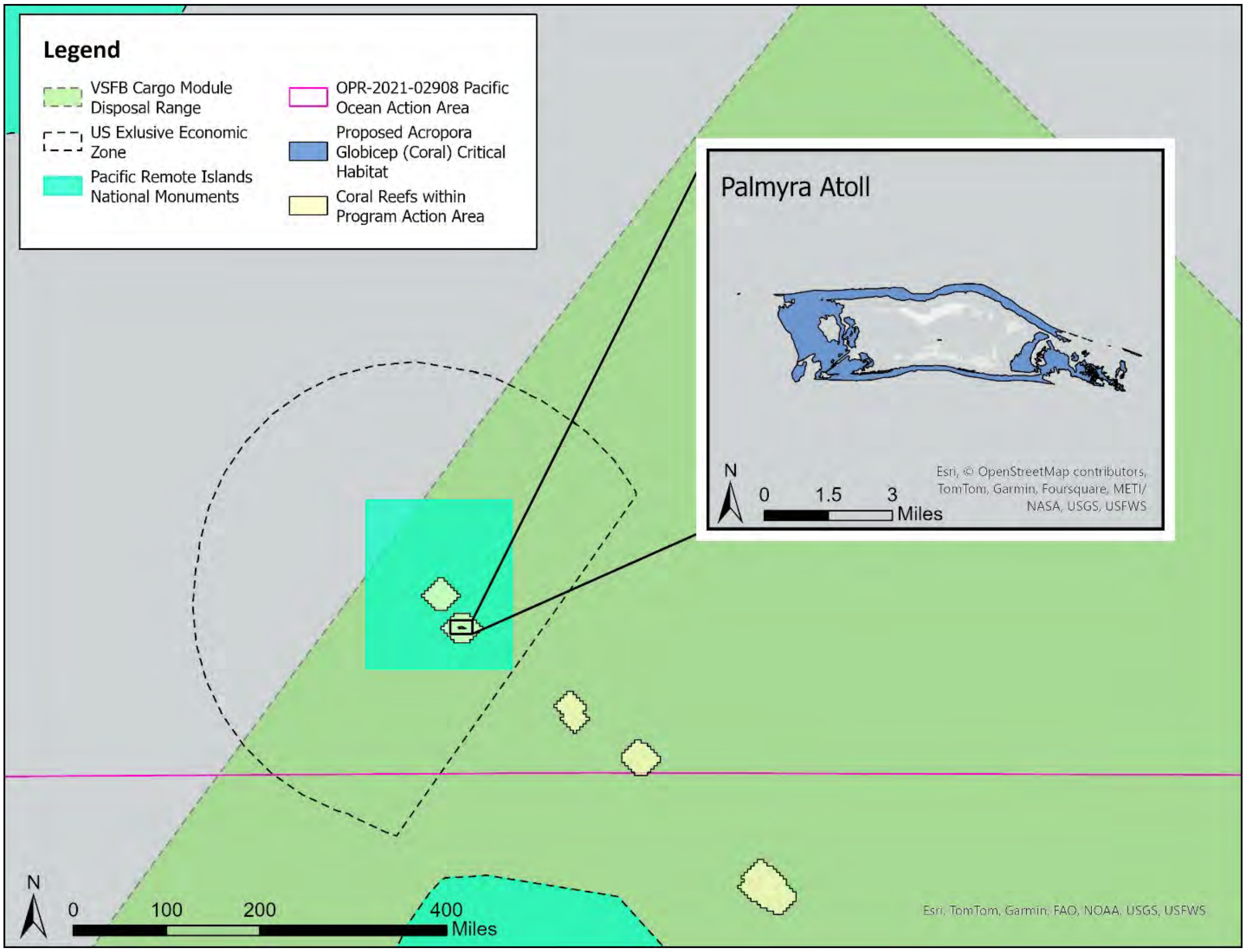


Figure 9: Acropora Globicep (Coral) Proposed Critical Habitat [2]

Marine Sanctuaries

Reentry landing sites and cargo module disposal ranges are located outside all marine sanctuaries. Kingman Reef, Palmyra Atoll, and Jarvis Island Marine National Monuments are within the contingency VSFB cargo module disposal range. **Figure 10** shows the cargo module disposal ranges in relation to marine national monuments and national marine sanctuaries.

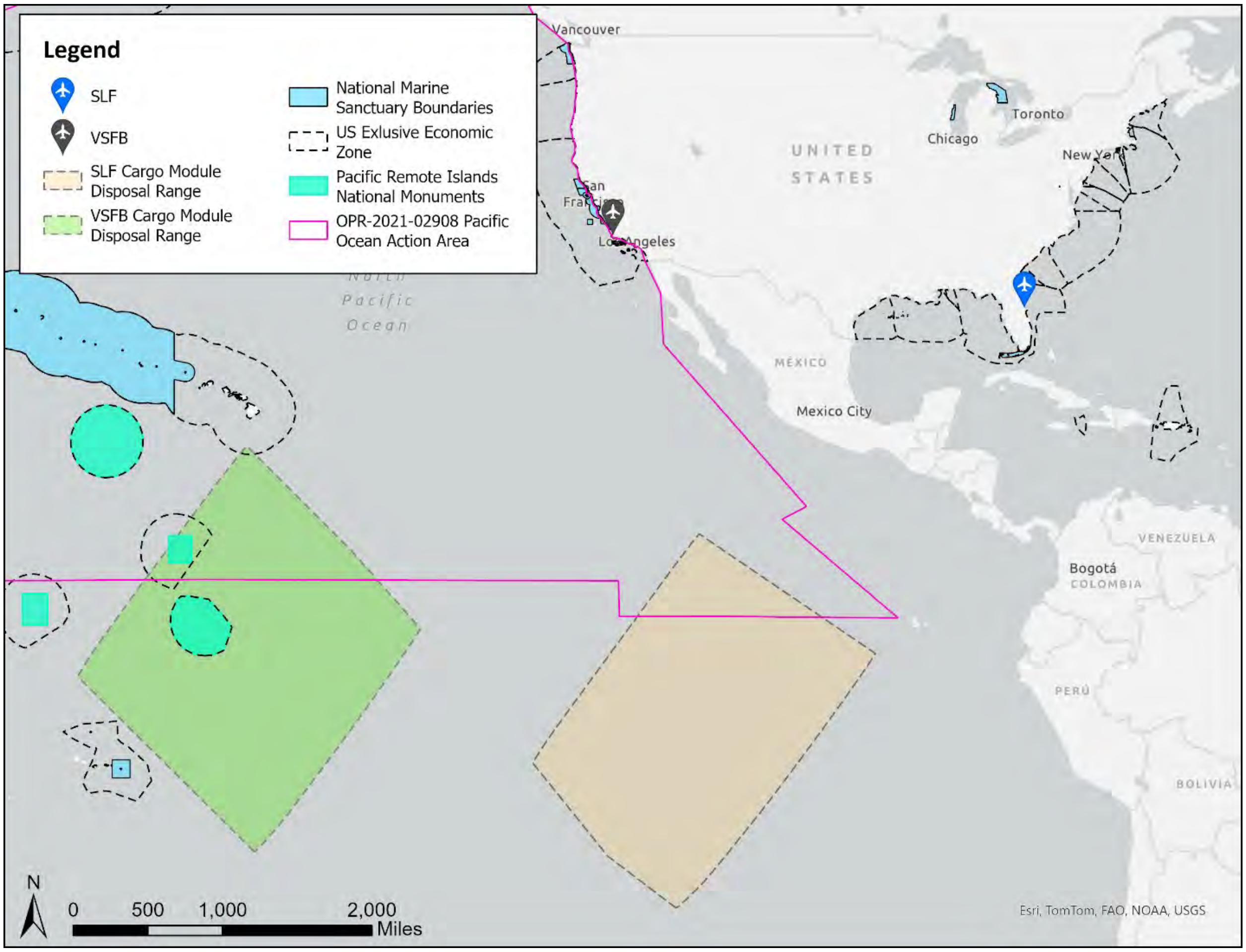


Figure 10: Marine National Monuments and Sanctuaries [18]

Effects on ESA-Listed Species within the Program Action Area

Sonic Booms

As previously stated, sonic boom overpressure is very low at 1.1 psf, similar to a clap of thunder. This is consistent with sonic boom impacts as analyzed in OPR-2021-02908. Research has shown that acoustic energy from in-air noise, such as sonic booms, is not expected to effectively cross the air/water interface and therefore would not impact marine species underwater **[16].** United States Air Force (USAF) research has confirmed that special-status marine species underwater are not at risk of harassment from in-air noise **[1]**. However, marine mammals and sea turtles near the surface of the within the action area could be exposed to up to four sonic booms annually. Given the low expected overpressure intensity and low frequency of occurrence, adverse effects are not expected from any disturbance which may result from sonic booms. Critical habitat is not influenced by noise and would not be affected by sonic booms. As such, sonic booms are expected to have **no effect** on ESA-listed species and designated critical habitat within the program action area.

Cargo Module Debris Effects

The cargo module disposal areas are within broad open ocean, in deep waters that avoid marine sanctuaries. ESA-listed species are sparsely distributed across these ocean expanses, resulting in very low densities of species overall. Direct strikes by surviving debris are extremely unlikely for all ESA-listed invertebrates, fish, sea turtles, and marine mammals. This is due to the small size of the components as compared to the vast open ocean. If debris from the vehicle struck an animal near the water's surface, the animal would be injured or killed. Given the low cadence of operations, and the fact that marine wildlife, marine mammals, and special status species spend the majority of their time submerged as opposed to on the surface, it is extremely unlikely they would be impacted. The relative availability of these animals at the ocean surface, spatially and temporally, combined with the low frequency of the Proposed Action, reduce the likelihood of impacts to extremely low and *discountable*. As such, direct strikes from debris associated with the proposed action **may affect, but is not likely to adversely affect** all ESA-listed marine mammals, fish, and sea turtles potentially present within the action area This is consistent with the effects analyzed in OPR-2021-02908.

As shown in **Figure 12** there are coral reef areas within the VSFB cargo module disposal range which could potentially contain ESA-listed corals and candidate giant clams. As with other marine species, direct strikes with cargo module debris pose the greatest risk to listed and candidate invertebrates. A direct strike from debris may inflict damage or mortality to these species. However, as previously stated, the cargo module debris area identified does not represent a certainty that debris will exist everywhere within the representative area. Given that these areas are probabilistic locations of possible small debris, the likelihood of debris impacting coral reefs is extremely remote. Further, reentry operations are expected to occur at the SLF nominally and any reentries to VSFB are expected to be unlikely. The relatively low spatial density of reef areas and large range of potential debris disposal areas combined with the low frequency of the Proposed Action, reduce the likelihood of impacts to extremely low and *discountable*. As such, direct strikes from debris associated with the proposed action **may affect, but is not likely to adversely affect** all ESA-listed and candidate invertebrates potentially present within the action area.

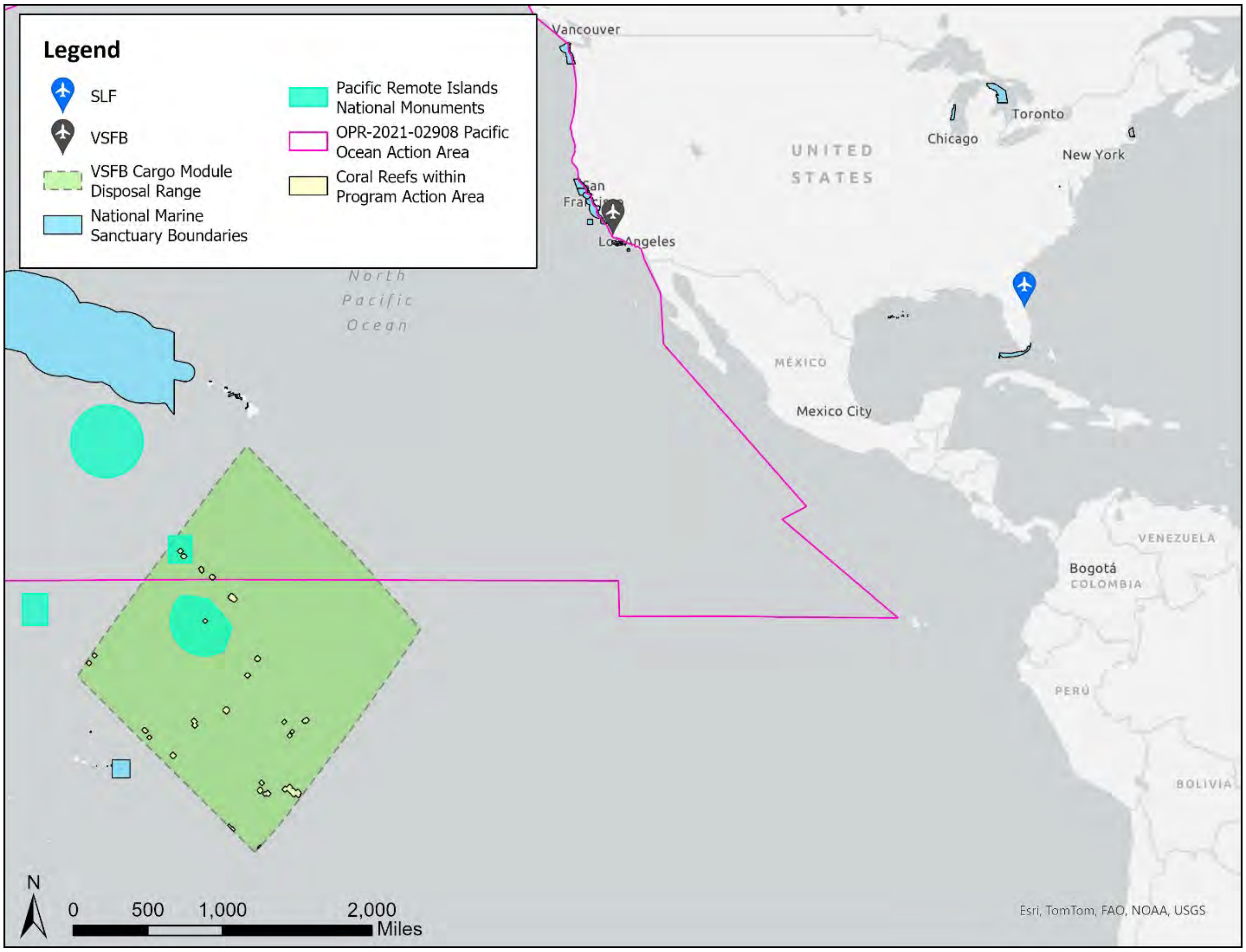


Figure 11: National Marine Sanctuaries [15] and Coral Reef Area [7]

Impacts to surface waters within the disposal area would be minimal as any surviving debris is expected to be small and sink and reentry cadence is limited to four annually. The cargo module would not contain any hazardous materials and would not change the temperature or acidity of surrounding waters. These limited debris disposal events would not measurably influence water quality, prey availability, or overall habitat suitability anywhere within the program action area. Additionally, cargo module disposal ranges are located outside all National Marine Sanctuaries. As such, debris would have **no effect** directly or indirectly on designated critical habitat within the program action area. This is consistent with debris impacts as analyzed in OPR-2021-02908.

Conclusion

The Proposed Action **may affect, but is not likely to adversely affect**, all ESA-listed species within the Program Action Area. Reporting and monitoring requirements will comply with the U.S. Fish and Wildlife Service and NMFS following the conclusion of consultations. Sierra will adhere to all education and observation requirements set forth in OPR-2021-02908. Reporting of stranded, dead, or injured animals will be conducted in accordance with OPR-2021-02908.

References:

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[3] National Marine Fisheries Service (NMFS). 2023. Letter of Concurrence to the Federal Aviation Administration. NMFS No. OPR-2021-02908. April 14.

[4] National Oceanic and Atmospheric Administration. (2022). Critical habitat designation for black abalone. NOAA Fisheries. Retrieved April 16, 2024, from https://www.fisheries.noaa.gov/action/critical-habitat-designation-black-abalone

[5] National Oceanic and Atmospheric Administration. (2022). Giant clam (Tridacna spp.). NOAA Fisheries. Retrieved April 16, 2024, from https://www.fisheries.noaa.gov/species/giant-clam-tridacna-spp

[6] National Oceanic and Atmospheric Administration. (2023). Chambered nautilus. NOAA Fisheries. Retrieved April 16, 2024, from https://www.fisheries.noaa.gov/species/chambered-nautilus

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[9] National Oceanic and Atmospheric Administration. (2024). Acropora retusa Coral. NOAA Fisheries. Retrieved May 7, 2024, from https://www.fisheries.noaa.gov/species/acropora-retusa-coral

[10] National Oceanic and Atmospheric Administration. (2024). Acropora globiceps Coral. NOAA Fisheries. Retrieved May 7, 2024, from https://www.fisheries.noaa.gov/species/acropora-globiceps-coral

[11] National Oceanic and Atmospheric Administration. (2024). Fimbriaphyllia paradivisa Coral. NOAA Fisheries. Retrieved May 7, 2024, from https://www.fisheries.noaa.gov/species/fimbriaphyllia-paradivisa-coral

[12] National Oceanic and Atmospheric Administration. (2024). Isopora crateriformis Coral. NOAA Fisheries. Retrieved May 7, 2024, from https://www.fisheries.noaa.gov/species/isopora-crateriformis-coral

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[15] National Oceanic and Atmospheric Administration. (2024). Sanctuaries. Retrieved from https://sanctuaries.noaa.gov/

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[17] Richardson, John W., Greene, Jr., Charles R., Malme, Charles I., Thomson, Denis H. (1995). Marine Mammals and Noise

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Appendix A
Summary of OPR-2021-02908 Requirements

Project Design Criteria	Description	Dream Chaser Program Adherence
General	Launch and reentry operations will be conducted by the U.S. Space Force, National Aeronautics and Space Administration, or an FAA-licensed (or permitted) commercial operator from a launch site identified in Table 1 of the NMFS's programmatic letter of concurrence to the FAA, also referred to as OPR-2021-02908 (NMFS 2023). Launch preparations will occur in compliance with standard operating procedures and best management practices currently implemented at these existing launch vehicle facilities.	Yes
General	Launch operations will use launch vehicles identified in Table 3 of OPR-2021-02908 (NMFS 2023).	Not applicable, Vehicle operator license application related to reentry operations only.
General	Launch activities, including suborbital landings and splashdowns, and orbital reentry activities will occur in the Proposed Action area at least 5 NM offshore the coast of the U.S. or islands.	Yes
General	No launch operator will site a landing area in coral reef areas.	VSFB CM disposal range is in vicinity of coral reef areas. No significant impacts from small fragmentation of surviving reentry debris would be expected.
General	No activities will occur in or affect a National Marine Sanctuary unless the appropriate authorization has been obtained from the Sanctuary.	Yes
General	Landing operations will not occur in the aquatic zone extending 20 NM (37 kilometers) seaward from the baseline or basepoint of each major rookery and major haul-out of the Western Distinct Population Segment Steller sea lion located west of 144 degrees west.	Yes
General	Launch abort testing will occur only in the Atlantic Ocean from Cape Canaveral Space Force Station or Kennedy Space Center as previously analyzed (SER-2016-17894, FPR-2017-9231).	Not applicable, launch abort testing is not part of the Dream Chaser program.
General	Launch abort testing will not occur in designated critical habitat for the North Atlantic right whale	Not applicable, launch abort testing is not part of the Dream Chaser program.
General	Use all feasible alternatives and avoid landing in Rice's whale core habitat distribution area as much as possible. No more than one splashdown, reentry, and recovery of the capsule will	Not applicable, proposed reentry operations do not occur

	occur in Rice's whale core habitat distribution area per year. No other operations; spacecraft, launch, or reentry vehicle landings; or expended components will occur in Rice's whale core habitat distribution area.	within the Rice's whale core habitat.
Education and Observation	Each launch operator will instruct all personnel associated with launch operations about marine species and any critical habitat protected under the ESA and species protected under the MMPA that could be present in the operations area. The launch operator will advise personnel of the civil and criminal penalties for harming, harassing, or killing ESA-listed and MMPA-protected species.	Yes
Education and Observation	As necessary each launch operator will provide dedicated observer(s) (for example, biologist or person other than the watercraft operator that can recognize ESA-listed and MMPA-protected species) responsible for monitoring ESA-listed and MMPA-protected species with the aid of binoculars during all in-water activities, including transiting marine waters for surveillance or to retrieve boosters, spacecraft, other launch-related equipment or debris.	Not applicable, cargo module is expected to burn up during reentry. Any surviving debris would be small and not expected to impact species.
Education and Observation	When an ESA-listed or MMPA-protected species is sighted, the observer will alert vessel operators to apply the Vessel Operations protective measures.	Not applicable, vessel operations are not part of the Dream Chaser program.
Education and Observation	Dedicated observers will record the date, time, location, species, number of animals, distance and bearing from the vessel, direction of travel, and other relevant information for all sightings of ESA-listed or MMPA-protected species.	Not applicable, vessel operations are not part of the Dream Chaser program.
Reporting Stranded, Injured, or Dead Animals	Dedicated observers will survey the launch recovery area for any injured or killed ESA-listed or MMPA-protected species and any discoveries will be reported.	Not applicable, no launch recovery area for the Dream Chaser program.
Reporting Stranded, Injured, or Dead Animals	Each launch operator will immediately report any collision(s), injuries or mortalities and any strandings of ESA-listed or MMPA-protected species to the appropriate NMFS contact listed in this section and to Cathy Tortorici, Chief, ESA Interagency Cooperation Division by email at cathy.tortorici@noaa.gov.	Yes
Reporting Stranded, Injured, or Dead Animals	In the Gulf of Mexico and Atlantic Ocean waters near Florida, each launch operator will report any smalltooth sawfish sightings to 941-255-7403 or via email Sawfish@MyFWC.com.	Yes
Reporting Stranded, Injured, or Dead	Each launch operator will report any giant manta ray sightings via email to manta.ray@noaa.gov.	Yes

Animals		
Reporting Stranded, Injured, or Dead Animals	Each launch operator will report any injured, dead, or entangled North Atlantic right whales to the U.S. Coast Guard via VHF Channel 16.	Yes
Vessel Operations	Maintain a minimum of 150 feet from sea turtles.	Not applicable, vessel operations are not part of the Dream Chaser program.
Vessel Operations	In the Atlantic Ocean, slow to 10 knots or less and maintain a minimum distance of 1,500 feet (500 yards) from North Atlantic right whales.	Not applicable, vessel operations are not part of the Dream Chaser program.
Vessel Operations	In the Gulf of Mexico, slow to 10 knots or less and maintain a minimum distance of 1,500 feet (500 yards) from Rice's whale (formerly Gulf of Mexico Bryde's whale). If a whale is observed but cannot be confirmed as a species other than a Rice's whale, the vessel operator must assume that it is a Rice's whale.	Not applicable, vessel operations are not part of the Dream Chaser program.
Vessel Operations	Maintain a minimum distance of 300 feet (100 yards) from all other ESA-listed and MMPA-protected species. If the distance ever becomes less than 300 feet, reduce speed and shift engine to neutral. Do not engage the engines until the animals are clear of the area.	Not applicable, vessel operations are not part of the Dream Chaser program.
Vessel Operations	Watercraft operators will reduce speed to 10 knots or less when mother/calf pairs or groups of marine mammals are observed.	Not applicable, vessel operations are not part of the Dream Chaser program.
Vessel Operations	Watercraft 65 feet long or longer will comply with the Right Whale Ship Strike Reduction Rule (Code of Federal Regulations Title 50, Subpart 224.105), including reducing speeds to 10 knots or less in Seasonal Management Areas or in Right Whale Slow Zones, which are dynamic management areas established where right whales have been recently seen or heard.	Not applicable, vessel operations are not part of the Dream Chaser program.
Vessel Operations	Check various communications media for general information regarding ship strikes and specific information regarding North Atlantic right whale sightings in the area. These include National Oceanic and Atmospheric Administration weather radio, U.S. Coast Guard NAVTEX broadcasts, and Notice to Mariners.	Not applicable, vessel operations are not part of the Dream Chaser program.
Vessel Operations	Attempt to remain parallel to an ESA-listed or MMPA-protected species course when sighted while the watercraft is underway (for example, bow-riding) and avoid excessive speed or abrupt changes in direction until the animal(s) has left the area.	Not applicable, vessel operations are not part of the Dream Chaser program.
Vessel Operations	Avoid vessel transit in the Rice's whale core distribution area. If vessel transit in the area is unavoidable, stay out of the depth range of 100 meters to 425 meters (where the Rice's whale has	Not applicable, vessel operations are not part of the Dream Chaser

	been observed; Rosel et al. 2021) as much as possible and go as slow as practical, limiting vessel speed to 10 knots or less.	program.
Vessel Operations	No operations or transit will occur at night in Rice's whale core distribution area.	Not applicable, vessel operations are not part of the Dream Chaser program.
Aircraft Procedures	Spotter aircraft will maintain a minimum of 1,000 feet over ESA-listed or MMPA-protected species and 1,500 feet over North Atlantic right whales. Additionally, aircraft will avoid flying in circles if marine mammals or sea turtles are spotted to avoid any type of harassing behavior.	Not applicable, spotter aircraft are not part of the Dream Chaser program.
Hazardous Materials Emergency Response	If a launch operation fails, launch operators will follow the emergency response and cleanup procedures outlined in their Hazardous Material Emergency Response Plan (or similar plan). Procedures may include containing the spill using disposable containment materials and cleaning the area with absorbents or other materials to reduce the magnitude and duration of any impacts. In most launch failure scenarios, at least a portion (if not most) of the propellant will be consumed by the launch/failure, and any remaining propellant will evaporate or be diluted by seawater and biodegrade over time (timeframes are variable based on the type of propellant and environmental conditions, but generally hours to a few days).	Yes

U.S. Department
of Transportation
**Federal Aviation
Administration**

Commercial Space Transportation
800 Independence Ave., SW.
Washington, DC 20591

June 27, 2024

Julianne Polanco
State Historic Preservation Officer
California Office of Historic Preservation
1725 23rd Street, Suite 100
Sacramento, CA 95816

RE: Finding of No Adverse Effect for Sierra Space Dream Chaser, Vehicle Operator License for the Vandenberg Space Force Base (VSFB), Santa Barbara, California

Dear Ms. Polanco,

Sierra Space is applying to the FAA for a Vehicle Operator License that would allow Sierra Space to conduct reentries with its Dream Chaser vehicle at the Vandenberg Space Force Base (VSFB) in Santa Barbara County, California. The Federal Aviation Administration (FAA) issuance of a vehicle operator license is considered a federal undertaking under the regulations of the Advisory Council for Historic Preservation (36 Code of Federal Regulations [CFR] § 800.16(y)) for Section 106 of the National Historic Preservation Act. As part of the FAA's Section 106 review, the FAA has undertaken identification efforts for proposed project activities. Based on the results of these efforts, the FAA has determined a finding of No Adverse Effect is appropriate for this undertaking.

Project Activities

Sierra Space's Dream Chaser is a multi-mission space utility vehicle designed to transport cargo to low Earth orbit (LEO) destinations such as the International Space Station (ISS). NASA purchases these missions to provide a commercial resupply service, thus allowing the vehicle to be used to support additional missions for other government and non-government customers.

The Dream Chaser is a lifting-body spacecraft with small wings that provide directional stability in flight (see **Figure 1**). Dream Chaser measures approximately 30 feet in length, has a wingspan of 27 feet, and weighs approximately 24,600 pounds. Dream Chaser propellants, Hydrogen Peroxide (H2O2) and Kerosene (RP-1), are used by a reaction control system for orbital maneuvers, deorbit burn, and high-altitude attitude control during reentry. The propulsion system is not used near or on the ground. The vehicle would land with residual propellant and any margin not used during reentry.

Figure 1: Dream Chaser Reentry Vehicle

The pressurized/unpressurized cargo capacity is 5,500 kilograms or 30 cubic feet. The return payload capacity is 1,850 kilograms. Typical cargo for reentry would includes scientific experiments, items no longer needed on the International Space Station packaged in cargo transfer bags, and trash for disposal in the cargo module. Sierra Space does not expect any hazardous material as defined by the FAA to be manifested on a reentry. Before a mission, NASA would provide Sierra Space and the FAA with an assessment of any hazardous materials.

Sierra Space's Proposed Action is to conduct up to four (4) reentries per year starting in 2024. The reentry location at VSFB is Runway 12/30 in Santa Barbara County, CA (**Figure 2**). In the event that the Dream Chaser is unable to safely land, an emergency landing in the broad open ocean would occur.

The Proposed Action does not include any construction, ground disturbances, or site modifications at or near VSFB.

For reentries at VSFB Runway 12/30, Dream Chaser would reenter from the west/southwest on an ascending trajectory in an unpowered landing (**Figure 3**). Ascending reentry trajectories would include high atmospheric overflight of the Pacific Ocean. The reentry vehicle would descend below 60,000 feet altitude above mean sea level approximately 30-40 miles from the VSFB prior to landing and would be operating below 60,000 mean sea level for less than 30 seconds before entering Vandenberg Restricted Airspace. The reentry vehicle would remain in the Vandenberg Restricted Airspace for the remainder of its reentry and landing at the VSFB (for approximately 2.5 – 3 minutes). The vertical profile of the Dream Chaser reentry operation is shown in **Figure 4**.

During reentry, Dream Chaser's cargo module would be released and burned-up during reentry and any surviving debris would be intentionally placed in a remote part of the Pacific Ocean and expected to sink. Contents within the cargo module are dependent on the mission manifest. However, hazardous materials are not intended to be transported within the cargo module.

Upon touch down, the vehicle would brake and come to a complete stop along the runway. Due to the potential for residual propellants on vehicle, a safety area would be established around the vehicle within the VSFB property boundary.

Figure 2: Project Location

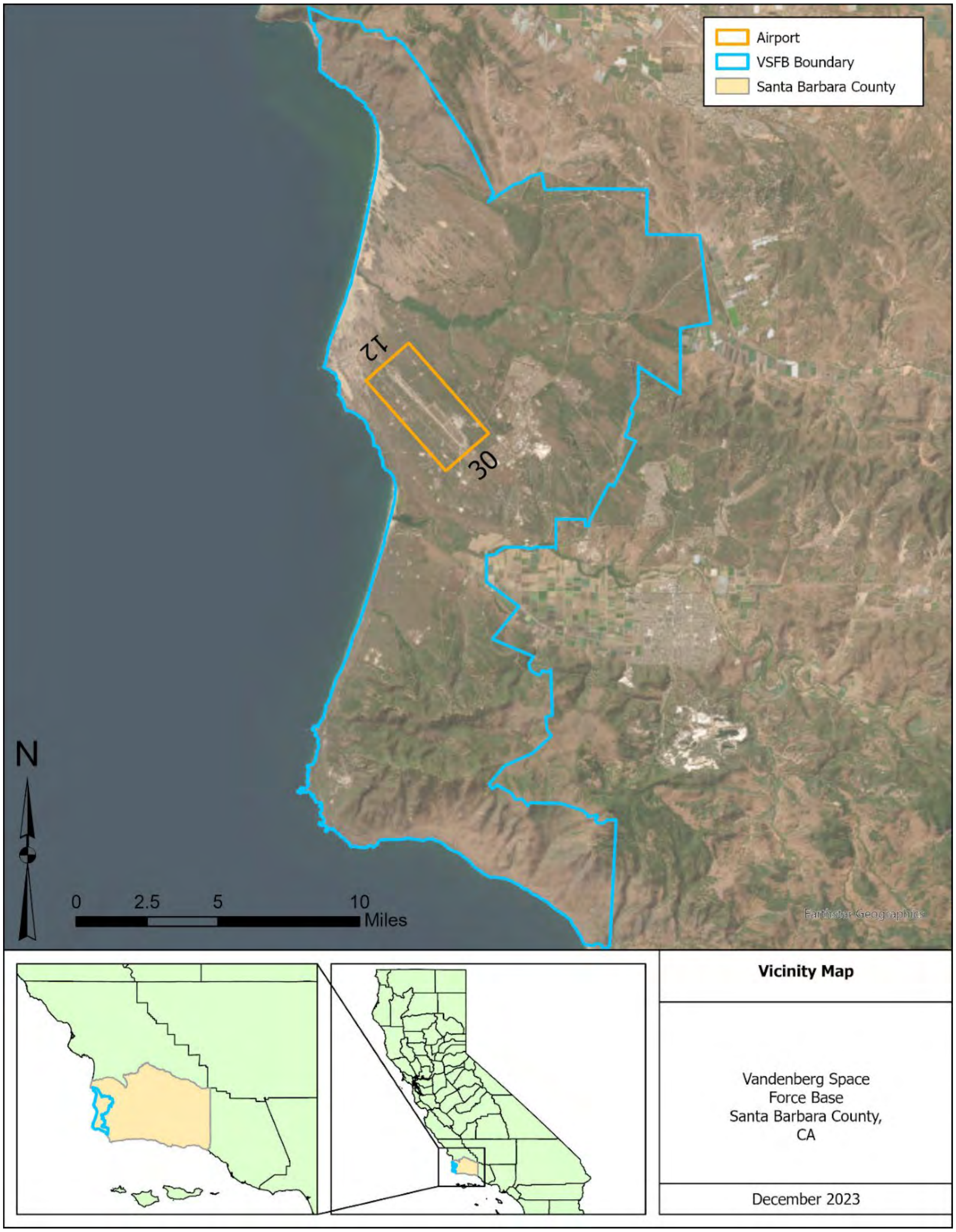


Figure 3: Dream Chaser Trajectories for VSFB Landings

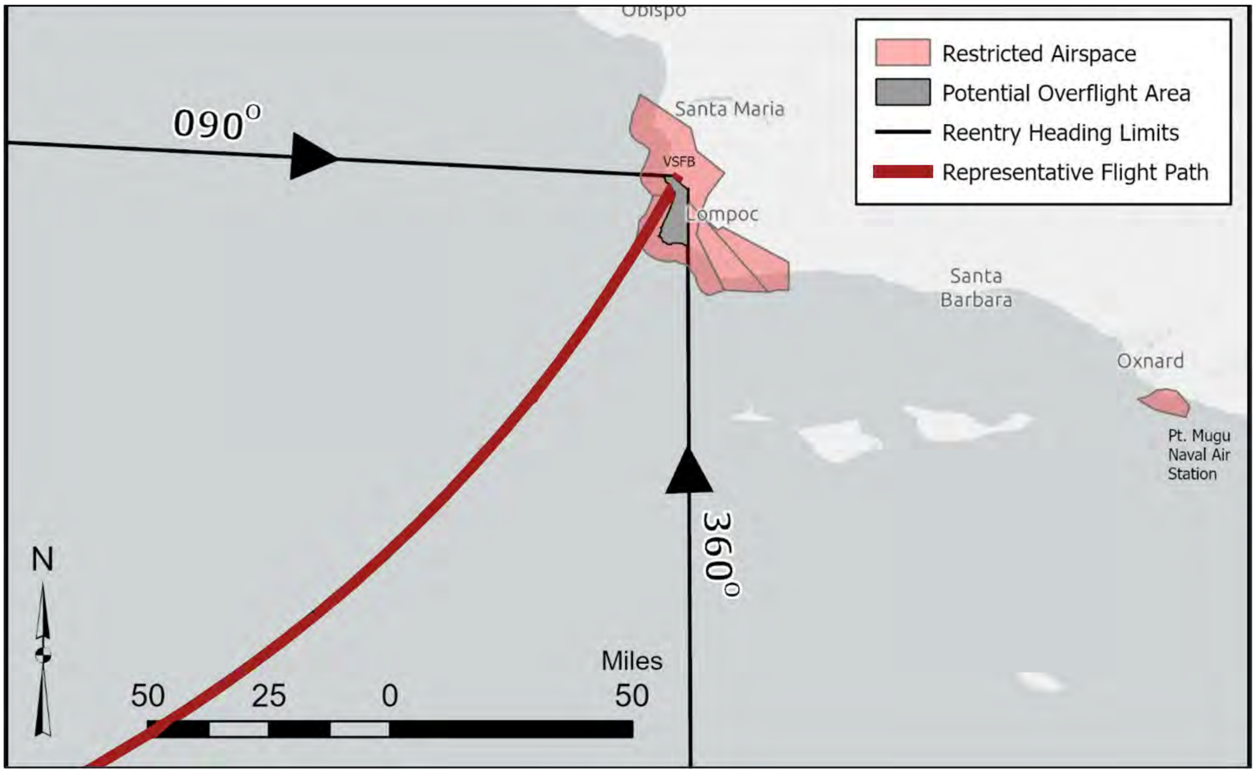
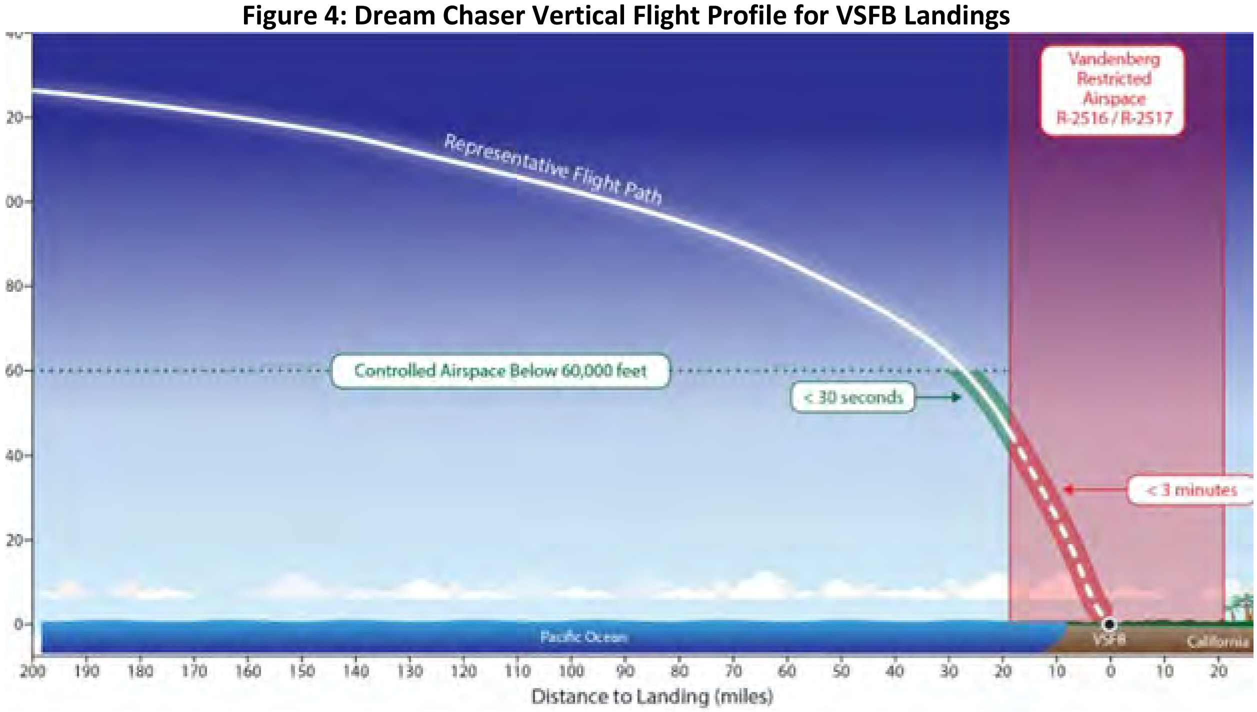


Figure 4: Dream Chaser Vertical Flight Profile for VSFB Landings



Area of Potential Effects (APE)

In accordance with 36 CFR § 800.4(a)(l), an APE needs to be established for the proposed undertaking in consultation with your office. The FAA has defined an APE in consideration of both potential direct and indirect effects associated with proposed reentry operations. The proposed APE (**Figure 5**) for this undertaking is defined as an area encompassing 320 square miles with the majority located over the Pacific Ocean and a portion in Santa Barbara County. This APE is based on the footprint of the reentry vehicle's sonic boom noise contour and includes those areas of the Earth's surface that would experience a sonic boom of 1.0 pound per square foot (psf) or greater.

Figure 5: Area of Potential Effects

Identification Efforts
Research information on historic properties within the APE was obtained from the National Park Service (NPS) National Register of Historic Places (NRHP). The Proposed Action does not include any construction, development, or ground-disturbing activities and, therefore, no additional survey work was performed.

Historic Properties in the APE
There are no historic properties listed on the NRHP within the APE.

Finding of Effect
Although no historic properties listed on the NRHP were identified in the project APE, consideration was given to potential sites that may be eligible or become eligible in the future. The Proposed Action would result in up to four sonic booms each year. Overpressure caused by extreme sonic booms has been associated with the potential for structural damage, specifically for brittle materials such as glass and plaster. The probability of a window breaking when exposed to a sonic boom with a 1.0 psf overpressure ranges from one in a million to one in a billion, depending on the condition of the glass, while the threshold for damage from overpressure on well-maintained structures is greater than 2 psf). The results of the sonic boom analysis indicated that the maximum overpressure associated with operation of the Proposed Action would be 1.1 psf, which is below the 2 psf threshold for damage on well-maintained structures.

The potential for sonic boom impacts was also evaluated in relation to human annoyance and hearing conservation. The modeled maximum of 1.1 psf translates to an equivalent CDNL (C-weighted Day Night Average Sound Level) of 41.2 dBC. Noise caused by the proposed reentry vehicle operations would be less than the FAA's significance threshold of CDNL 60 dBC for impulsive noise sources (equivalent to DNL 65 dBA). The intensity of sonic booms associated with operation of the Proposed Action would be similar to thunder in intensity.

Based on no proposed ground disturbance, no historic properties listed on the NRHP within the APE, and the expected low intensity of potential sonic booms, the FAA has determined that this undertaking will have No Adverse Effect on historic properties. Please review this finding and the enclosed documentation, in accordance with 36 CFR § 800.5 and provide either your concurrence or non-concurrence within the 30-day regulatory time frame.

The documentation provided herein meets the regulatory standard for documenting this effect determination in accordance with 36 CFR § 800.5. If you have questions or concerns regarding this finding or the sufficiency of documentation, please contact Ms. Chelsea Clarkson of my staff at chelsea.clarkson@faa.gov.

Sincerely,

Stacey M. Zee
Manager, Operations Support Branch

Attachment

U.S. Department
of Transportation
Federal Aviation Administration

Commercial Space Transportation
800 Independence Ave., SW.
Washington, DC 20591

July 8, 2024

Mr. Steven Henry
Field Supervisor
USFWS Ventura FWO
2493 Portola Rd Suite B
Ventura, CA 93003

Submitted to: christopher_diel@fws.gov

RE: Endangered Species Act Consultation for Proposed Sierra Space Reentry Operations at the Vandenberg Space Force Base, Santa Barbara County, California

Dear Mr. Henry,

The FAA is initiating Endangered Species Act (ESA) Section 7 consultation and soliciting concurrence with our assessment and determination of the potential effects on ESA-listed species for Sierra Space Corporation's (Sierra Space) proposed commercial space reentry operations at the Vandenberg Space Force Base (VSFB). Sierra Space is applying to the FAA for a Vehicle Operator License that would allow Sierra Space to conduct reentries with its Dream Chaser vehicle at the VSFB in Santa Barbara County, California. There are no physical changes or construction to support reentry of the Dream Chaser vehicle at the VSFB.

In 2021, the FAA consulted with USFWS (North Florida Ecological Services Office) on Sierra Space's application for proposed reentry operations of the Dream Chaser at the Shuttle Landing Facility (SLF) in Brevard County, Florida. Sierra Space is expanding their application to include reentry operations at VSFB as a contingency site in case Dream Chaser is unable to safely reenter and land at the SLF. The consultation requested under this letter is for VSFB only.

For a description of Sierra Space's proposed reentry operations at VSFB, see **Attachment 1**. The action area, ESA-listed species and critical habitat, potential effects to the listed species and critical habitat, and the FAA's effect determination for Sierra Space's proposed operation, are described in **Attachment 2**.

The FAA anticipates that Sierra Space's proposed reentry operations **may affect, but would be likely to not adversely affect**, all ESA-listed wildlife species in the action area. The FAA seeks your concurrence on our effects determination and welcomes any additional comments. Thank you for your assistance in this matter. Please provide your response to Ms. Chelsea Clarkson of my staff at chelsea.clarkson@faa.gov.

Sincerely,

Stacey M. Zee
Manager, Operations Support Branch

Attachments

ATTACHMENT 1 – PROJECT DESCRIPTION

The FAA's Federal Action is to issue a license along with potential renewals and modifications to the license within the scope of operations analyzed in this EA to Sierra Space that would allow Sierra Space to conduct reentry operations of the Dream Chaser at the SLF or VSFB. Section 7 consultation related to proposed operations at SLF in Brevard County, Florida was conducted separately with the determination that the proposed operations "may affect, but would not adversely affect" Endangered Species Act-listed wildlife species, as determined by the FAA and concurred with by USFWS on May 8, 2020.

Sierra Space's Dream Chaser is a multi-mission space utility vehicle designed to transport cargo to low Earth orbit (LEO) destinations such as the International Space Station (ISS). NASA purchases these missions to provide a commercial resupply service, thus allowing the vehicle to be used to support additional missions for other government and non-government customers.

The Dream Chaser is a lifting-body spacecraft with small wings that provide directional stability in flight (see Figure 1-1). Dream Chaser measures approximately 30 feet in length, has a wingspan of 27 feet, and weighs approximately 24,600 pounds. Dream Chaser propellants, Hydrogen Peroxide (H2O2) and Kerosene (RP-1), are used by a reaction control system (RCS) for orbital maneuvers, deorbit burn, and high-altitude attitude control during reentry. The propulsion system is not used near or on the ground.

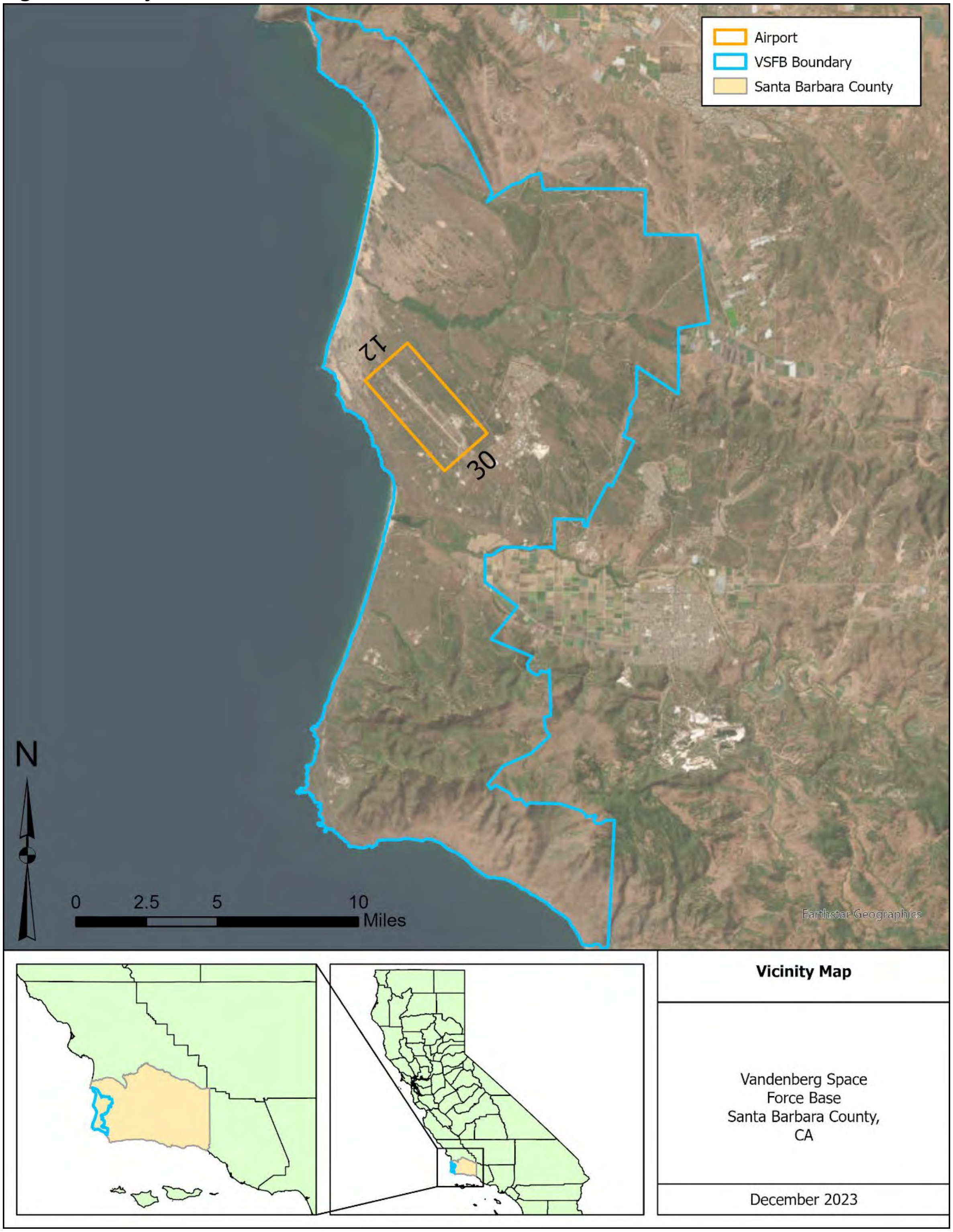
Figure 1-1: Dream Chaser Reentry Vehicle

The vehicle lands with residual propellant and any margin not used during reentry. The pressurized/unpressurized cargo capacity is 5,500 kilograms or 30 cubic feet. The return payload capacity is 1,850 kilograms. Typical cargo includes scientific experiments, items no longer needed on the ISS packaged in cargo transfer bags, and trash for disposal in the cargo module. Overall, for the CRS2 missions, NASA provides Sierra Space and thus the FAA an integrated bag level hazard analysis (IBLHA). The IBLHA assesses any hazards present in the proposed cargo manifest. Sierra Space does not expect any hazardous material as defined by the FAA to be manifested on a reentry.

Sierra Space's Proposed Action is to conduct up to four (4) reentries per year starting in 2024. The reentry location at VSFB is Runway 12/30 in Santa Barbara County, CA (Figure 1-2). In the event that the Dream Chaser is unable to safely land at either the SLF or VSFB, an emergency landing in the broad open ocean would occur.

The Proposed Action does not include any construction or site modifications at VSFB.

Figure 1-2: Project Location



For reentries at VSFB Runway 12/30, Dream Chaser would reenter from the west/southwest on an ascending trajectory in an unpowered landing (Figure 1-3). Ascending reentry trajectories would include high atmospheric overflight of the Pacific Ocean. The reentry vehicle would descend below 60,000 feet altitude above mean sea level approximately 30-40 miles from the VSFB prior to landing and would be operating below 60,000 mean sea level for less than 30 seconds before entering Vandenberg Restricted Airspace. The reentry vehicle would remain in the Vandenberg Restricted Airspace for the remainder of its reentry and landing at the VSFB (for approximately 2.5 – 3 minutes). The vertical profile of the Dream Chaser reentry operation is shown in Figure 1-4.

During reentry, Dream Chaser's cargo module would be intentionally released over a remote part of the Pacific Ocean and is expected to burn-up during reentry. Any surviving debris would be expected to sink. Contents within the cargo module are dependent on the mission manifest. However, no hazardous materials would be transported within the cargo module.

Upon touch down, the vehicle would brake and come to a complete stop along the runway. Due to the potential for residual propellants on vehicle, a safety area would be established around the vehicle within the VSFB property boundary.

Figure 1-3: Dream Chaser Trajectories for VSFB Landings

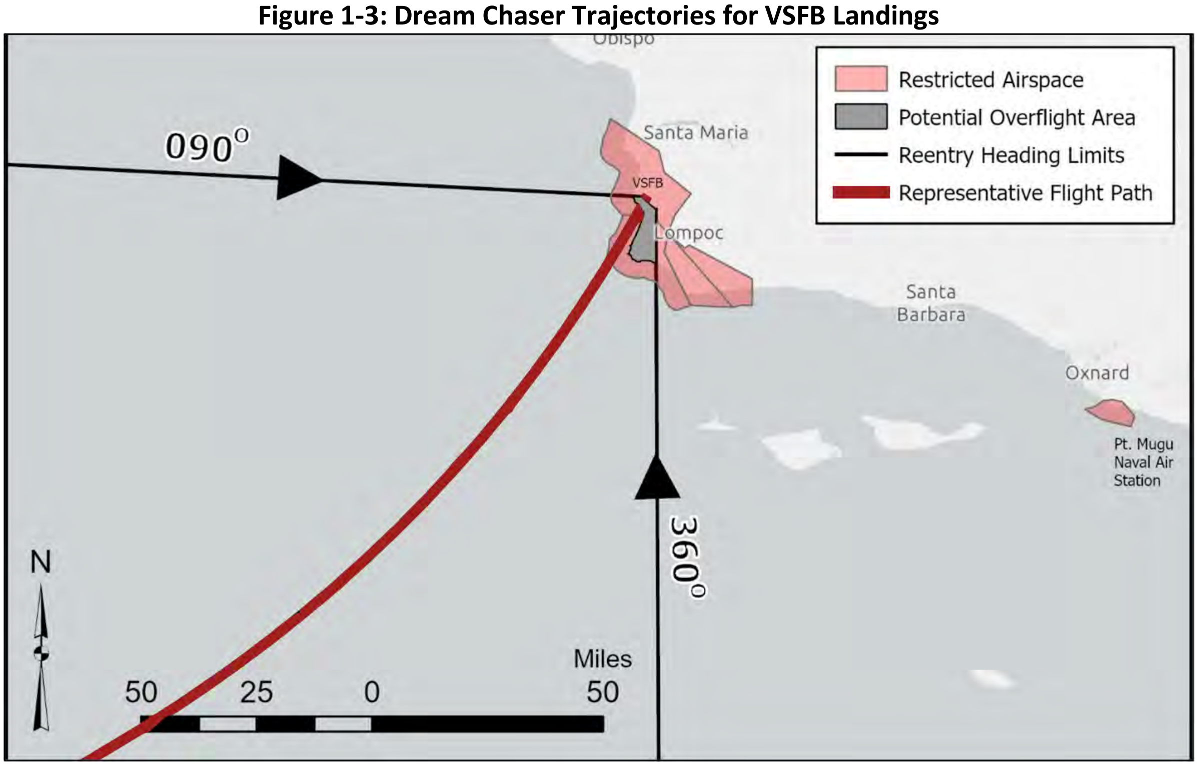
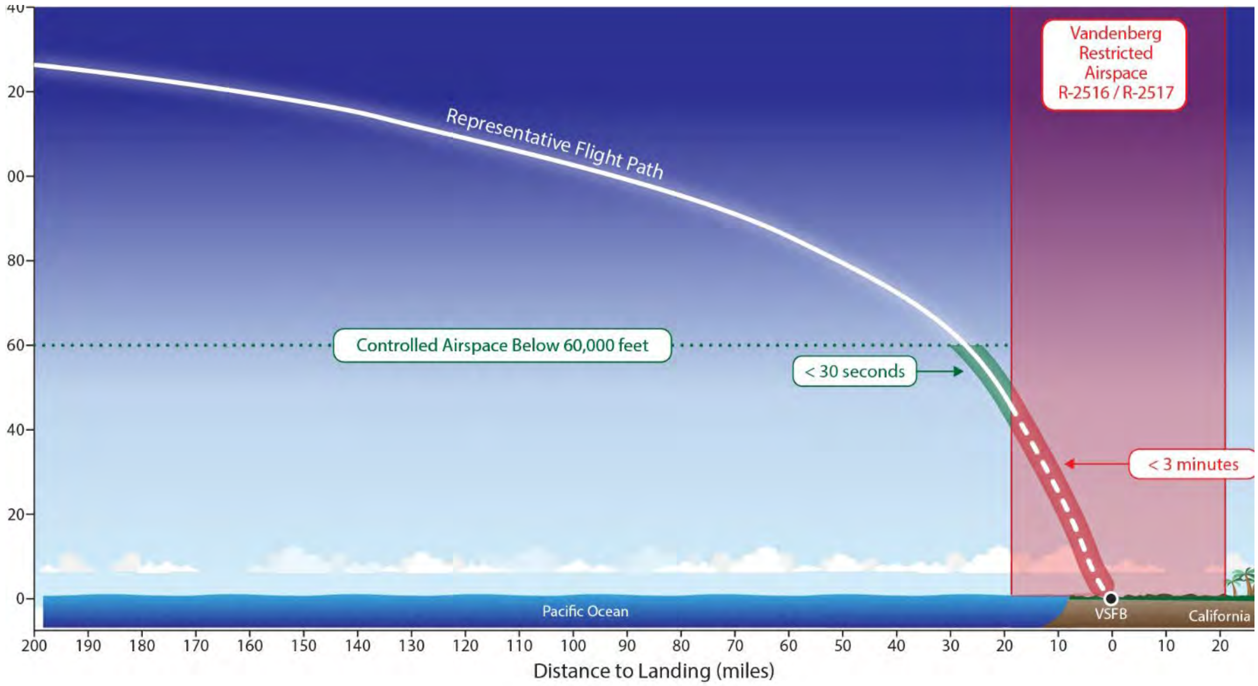


Figure 1-4: Dream Chaser Vertical Flight Profile for VSFB Landings



ATTACHMENT 2 – ACTION AREA, ESA-LISTED SPECIES AND CRITICAL HABITAT, AND DETERMINATION OF EFFECTS

Action Area

The action area is defined as all areas directly or indirectly affected by the federal action. The action area for Sierra Space's proposed reentry operations based on the footprint of the Dream Chaser's sonic boom noise contour and includes those areas of the Earth's surface that would experience a sonic boom of 1.0 pound per square foot (psf) or greater. This approximately 320-square mile area encompasses portions of Santa Barbara County and extends over a portion of the Pacific Ocean (see **Figure 2-1**).

Figure 2-1: Action Area

ESA-Listed Species and Critical Habitat

The FAA used the USFWS's Information for Planning and Consultation online system to generate a species list and identify critical habitat for the project. **Table 2-1** and **Figure 2-2** show ESA-listed species, critical habitat and observation locations within the action area. Designated critical habitat for the California Red-legged Frog and Gaviota Tarplant is present within the action area. Critical habitats are not expected to be adversely affected by sonic boom of 1.0 psf due to the low magnitude similar to that of a clap of thunder.

Figure 2-2: Critical Habitats within Action Area USFWS and Southern Sea Otter observation locations

FIGURE REDACTED DUE TO SENSITIVE INFORMATION

Table 2-1: ESA-Listed Species for the Action Area

Category	Species Common Name	Species Scientific Name	Status
Mammals	Southern Sea Otter	*Enhydra lutris nereis*	Threatened
Birds	California Condor	*Gymnogyps californianus*	Endangered
	California Least Tern	*Sternula antillarum browni*	Endangered
	Hawaiian Petrel	*Pterodroma sandwichensis*	Endangered
	Least Bell's Vireo	*Vireo bellii pusillus*	Endangered
	Marbled Murrelet	*Brachyramphus marmoratus*	Threatened
	Short-tailed Albatross	*Phoebastria (=Diomedea) albatrus*	Endangered
	Southwestern Willow Flycatcher	*Empidonax traillii extimus*	Endangered
	Western Snowy Plover	*Charadrius nivosus nivosus*	Threatened
	Yellow-billed Cuckoo	*Coccyzus americanus*	Threatened
Amphibians	California Red-legged Frog	*Rana draytonii*	Threatened
Fishes	Tidewater Goby	*Eucyclogobius newberryi*	Endangered
	Unarmored Threespine Stickleback	*Gasterosteus aculeatus williamsoni*	Endangered
Insects	Monarch Butterfly	*Danaus plexippus*	Candidate
Crustaceans	Vernal Pool Fairy Shrimp	*Branchinecta lynchi*	Threatened
Plants	Beach Layia	*Layia carnosa*	Threatened
	Gambel's Watercress	*Rorippa gambellii*	Endangered
	Gaviota Tarplant	*Deinandra increscens ssp. villosa*	Endangered
	La Graciosa Thistle	*Cirsium loncholepis*	Endangered
	Lompoc Yerba Santa	*Eriodictyon capitatum*	Endangered
	Marsh Sandwort	*Arenaria paludicola*	Endangered
	Salt Marsh Bird's-beak	*Cordylanthus maritimus ssp. maritimus*	Endangered

Habitat preferences related to the species listed above include the following:

- Southern Sea Otter - Southern sea otters live and feed in marine coastal areas along the central California coastline, including rocky and sandy areas along the exposed outer coast and protected areas such as bays and estuaries. They commonly “raft” near the shoreline of south VSFB, within the potential impact area.
- California Condor - Condors roost on large trees or snags, or on rocky outcrops and cliffs. Nests are located in caves and ledges of steep rocky terrain or in cavities and broken tops of old growth conifers created by fire or wind. Foraging habitat includes open grasslands, oak savanna foothills, and beaches adjacent to coastal mountains. No recent records of this species on VSFB, no recorded nesting or breeding at any time.
- California Least Tern - California least terns nest on natural and man-made sites that include beaches close to river mouths, estuaries and coastal embayments. They do nest within the potential impact area.
- Hawaiian Petrel – Habitat preferences include remote or high elevation areas on the islands of Hawaii, Maui, Molokai, Lanai and Kauai but are also known to occur in California.
- Least Bell’s Vireo - Least Bell’s vireos winter in southern Baja California, Mexico, where they occupy a variety of habitats, including mesquite scrub within arroyos, palm groves, and

hedgerows bordering agricultural and residential areas. One unpaired male, considered to be "transient" was observed (not confirmed) in 2023. No breeding or nesting behavior has been observed.

- Marbled Murrelet - Marbled murrelets generally nest in old-growth forests characterized by large trees, multiple canopy layers and moderate to high canopy closure. Nest stands vary in size from several acres to thousands of acres; larger unfragmented stands appear to be the highest quality habitat for marbled murrelet nesting. There is no suitable nesting habitat at VSFB, however this species is found.
- Short-tailed Albatross - Short-tailed albatross nest on isolated, windswept, offshore islands, with restricted human access. The majority of short-tailed albatross nest on islands near Japan but their range includes the southwest coast of North America.
- Southwestern Willow Flycatcher - The Southwestern Willow flycatcher inhabits riparian areas in the southwestern. This species is associated with dense shrubby and wet habitats and typically nests in flooded areas with willow dominated habitat. No observations of this species on VSFB since approximately 2003, no breeding on VSFB since approximately 1999.
- Western Snowy Plover – Habitat includes barren to sparsely vegetated sand beaches, dry salt flats in lagoons, dredge spoils deposited on beach or dune habitat, levees and flats at salt-evaporation ponds, river bars, along alkaline or saline lakes, reservoirs, and ponds. VSFB closely monitors 14 miles of beach and records hundreds of nests or nest attempts annually.
- Yellow-billed Cuckoo - Yellow-billed cuckoos use wooded habitat with dense cover and water nearby, including woodlands with low, scrubby, vegetation, overgrown orchards, abandoned farmland and dense thickets along streams and marshes. No records of this species on VSFB and very few records in all of Santa Barbara County.
- California Red-legged Frog - The California red-legged frog spends the bulk of its life in or near water sources like streams or stock ponds, which the species uses for breeding. The frog moves into neighboring upland areas to feed and shelter when stream flow levels are high. CRLF are found in almost every drainage or standing body of water on VSFB, including several within the proposed impact area.

Reentry operations have the potential to affect ESA-listed species in the action area, mainly from noise, including sonic booms of up to 1 psf a maximum of four times per year. The Proposed Action does not involve construction, pile-driving, or any in-water activities. Potential effects from sonic booms would be infrequent, temporary, and short in duration. Research has shown that acoustic energy from in-air noise, such as sonic booms, is not expected to effectively cross the air/water interface and therefore would not impact marine species underwater (Richardson et al. 1995).

Plant species will not be affected by sonic booms and are therefore not considered further in this consultation. Noise for the proposed action only includes sonic booms from vehicle reentry and does not include any engine or construction noise. The entirety of the sonic boom footprint would be approximately 1 psf or less, which is less than a clap of thunder. Additionally, reentries would be infrequent, with only up to four per year. Animal species differ greatly in their responses to noise. Noise effects on domestic animals and wildlife are classified as primary, secondary, and tertiary. Primary effects are direct, physiological changes to the auditory system, and most likely include the masking of auditory signals. Masking is defined as the inability of an individual to hear important environmental signals that may arise from mates, predators, or prey. There is some potential that noise could disrupt a species' ability to communicate or could interfere with behavioral patterns (Manci et al. 1988). Although the effects are likely temporal, sonic booms may cause masking of auditory signals within exposed faunal communities. Animals rely on hearing to avoid predators, obtain food, and communicate with, and attract, other members of their species. Sonic booms may mask or interfere with these functions.

Secondary effects may include non-auditory effects such as stress and hypertension; behavioral modifications; interference with mating or reproduction; and impaired ability to obtain adequate food, cover, or water. Tertiary effects are the direct result of primary and secondary effects, and include population decline and habitat loss. Most of the effects of noise are mild enough that they may never be detectable as variables of change in population size or population growth against the background of normal variation (Bowles 1995). Other environmental variables (e.g., predators, weather, changing prey base, ground-based disturbance) also influence secondary and tertiary effects, and confound the ability to identify the ultimate factor in limiting productivity of a certain nest, area, or region. Overall, the literature suggests that species differ in their response to various types, durations, and sources of noise (Manci et al. 1988; Bowles 1995).

Many scientific studies have investigated the effects of sonic booms on wildlife, and some have focused on wildlife "flight" due to noise. Natural factors which affect flight reaction include season, group size, age and sex composition, on-going activity, motivational state, reproductive condition, terrain, weather, and temperament (Bowles 1995). Individual animal response to a given noise event or series of events also can vary widely due to a variety of factors, including time of day, physical condition of the animal, physical environment, the experience of the individual animal with noises, and whether or not other physical stressors (e.g., drought) are present (Manci et al. 1988). Consequently, it is difficult to generalize animal responses to noise disturbances across species.

One result of the Manci et al. (1988) literature review was the conclusion that, while behavioral observation studies were relatively limited, a general behavioral reaction in animals from exposure to aircraft noise is the "startle response." The intensity and duration of the startle response appears to be dependent on which species is exposed, whether there is a group or an individual, and whether there have been some previous exposures. Responses range from flight, trampling, stampeding, jumping, or running, to movement of the head in the apparent direction of the noise source. Manci et al. (1988) reported that the literature indicated that avian species may be more sensitive to aircraft noise than mammals.

The following discussion presents a summary of some of the more relevant studies addressing the potential impacts to wildlife from sonic booms. Teer and Truett (1973) tested quail eggs subjected to sonic booms at 2, 4, and 5.5 pounds per square foot (psf) and found no adverse effects. Heinemann and LeBrocq (1965) exposed chicken eggs to sonic booms at 3–18 psf and found no adverse effects. In a mathematical analysis of the response of avian eggs to sonic boom overpressures, Ting et al. (2002) determined that it would take a sonic boom of 250 psf to crack an egg. Bowles (1995) states that it is physically impossible for a sonic boom to crack an egg because one cannot generate sufficient sound pressure in air to crack eggs.

Teer and Truett (1973) examined reproductive success in mourning doves, mockingbirds, northern cardinals, and lark sparrows when exposed to sonic booms of 1 psf or greater and found no adverse effects. Awbrey and Bowles (1990) in a review of the literature on the effects of aircraft noise and sonic booms on raptors found that the available evidence shows very marginal effects on reproductive success. Ellis et al. (1991) examined the effects of sonic booms (actual and simulated) on nesting peregrine falcons, prairie falcons, and six other raptor species. While some individuals did respond by leaving the nest, the response was temporary and overall there were no adverse effects on nesting. Lynch and Speake (1978) studied the effects of both real and simulated sonic booms on the nesting and brooding of eastern wild turkey in Alabama. Hens at four nest sites were subjected to between 8 and 11 combined real and simulated sonic booms. All tests elicited similar responses, including quick lifting of the head and apparent alertness for between 10 and 20 seconds. No apparent nest failure occurred as a result of the sonic booms. This would be the expected result from sonic booms within the action area for western snowy plovers and other bird species.

The literature suggests that common animal responses to noise include the startle response and, ultimately, habituation. It has been reported that the intensities and durations of the startle response decrease with the numbers and frequencies of exposures, suggesting no long-term adverse effects. The majority of the literature suggests that domestic animal species (cows, horses, chickens) and wildlife species exhibit adaptation, acclimation, and habituation after repeated exposure to jet aircraft noise and sonic booms (Bowles 1995, Manci et al. 1988, and Teer and Truett 1973).

The entirety of the sonic boom footprint would be approximately 1 psf or less, which is less than a clap of thunder. Additionally, reentries would be infrequent, with only up to four per year. Previous ESA consultation for similar proposed actions at VSFB have concluded that sonic booms of this proposed magnitude (1.0 psf) would not adversely affect ESA-listed species.

Based on the lack of observed adverse effects to wildlife in the studies mentioned above and the lack of known adverse effects to ESA-listed over decades of operations at VSFB, the FAA expects that sonic booms associated with the Proposed Action ***may affect, but would not adversely affect***, ESA-listed wildlife species in the action area.

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VSFB Noise Analysis and Report

Blue Ridge Research and Consulting, LLC

BRRC Report 24-01 (Final)

Sonic Boom Study for Sierra Space Landing Operations to VSFB

8 February 2024

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1 INTRODUCTION

This report documents the sonic boom study performed to support Sierra Space's environmental review of Dream Chaser landing operations to Vandenberg Space Force Base (VSFB). The Dream Chaser spaceplane is a winged commercial runway-capable spaceplane manufactured by Sierra Space that is designed to transport crew and cargo to low-Earth orbit (LEO). Sierra Space plans to conduct up to four total operations per year, with the Shuttle Landing Facility (SLF) as the primary location and VSFB Runway 12/30 as an emergency and contingency location. This report analyzes the scenario where all (up to four) reentry operations could occur at VSFB.

The Dream Chaser will create sonic booms during its supersonic landing to VSFB. The sonic boom is shaped by the physical characteristics of the vehicle and the atmospheric conditions through which it propagates. These factors affect the perception of a sonic boom. The noise is perceived as a deep double boom, with most of its energy concentrated in the low frequency range. Although sonic booms generally last less than one second, their potential for impact may be considerable.

This study describes the sonic booms associated with the proposed Dream Chaser landing operations to VSFB. The potential impacts from Dream Chaser sonic booms are evaluated in relation to human annoyance, physiological effects, hearing conservation, and structural damage. The following sections of this report are outlined below.

- Section 2 describes the proposed Sierra Space Dream Chaser landing operations.
- Section 3 reviews the sonic boom metrics and effects discussed throughout this report.
- Section 4 presents the sonic boom modeling results.
- Section 5 summarizes the notable findings of this sonic boom study.
- Appendix A gives an overview of the basics of sound.
- Appendix B provides definitions of the noise metrics discussed throughout this report.
- Appendix C describes the sonic boom modeling methods.

Figure 1. Sierra Space Dream Chaser (Credit: Sierra Space).

2 SIERRA SPACE OPERATIONS

Table 1 presents the vehicle modeling data for the Dream Chaser spaceplane. Sierra Space plans to conduct up to four nighttime landing operations per year to VSFB Runway 12/30 (Figure 2). Dream Chaser landing trajectories to VSFB Runway 12/30 will be unique to the vehicle configuration, mission, and environmental conditions. The proposed landing operations span a range of possible landing trajectory azimuths between 90° and 360°. For purposes of assessing potential sonic boom impacts from Dream Chaser landing operations to VSFB, a total of ten trajectories (five for each runway) were provided by Sierra Space to represent the range of landing trajectories. The ten trajectories are described in Table 2 and shown in Figure 3, where Runway 12 and Runway 30 trajectories are displayed in black and gray, respectively.

Table 1. Dream Chaser modeling parameters.

Length	Wingspan	Gross Vehicle Weight on Landing
30 ft	24.2 ft	24,600 lbm

Figure 2. Runway 12/30 at Vandenberg Space Force Base.

Table 2. Dream Chaser trajectory descriptions

Description
Runway 12 - Northern boundary of landing trajectories
Runway 12 - Northern landing trajectory
Runway 12 - Nominal landing trajectory
Runway 12 - Southern landing trajectory
Runway 12 - Southern boundary of landing trajectories
Runway 30 - Northern boundary of landing trajectories
Runway 30 - Northern landing trajectory
Runway 30 - Nominal landing trajectory
Runway 30 - Southern landing trajectory
Runway 30 - Southern boundary of landing trajectories

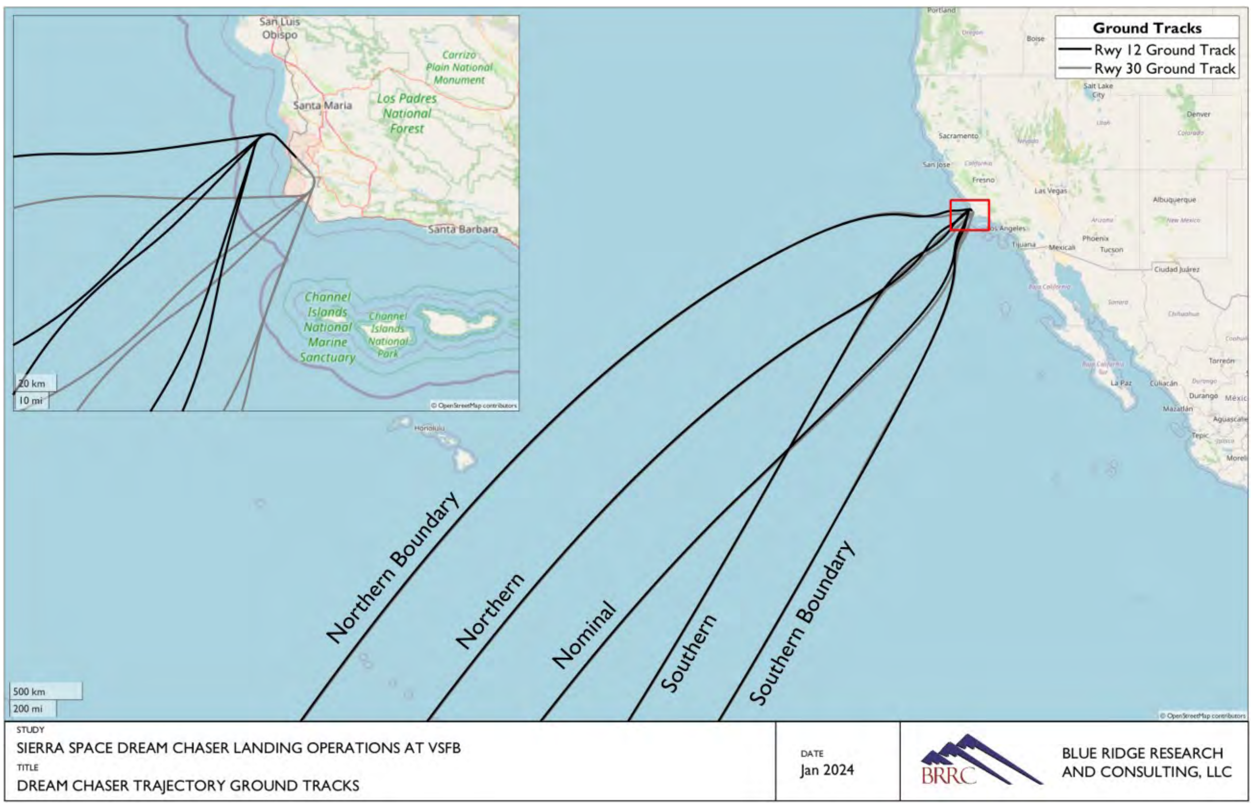

Figure 3. Dream Chaser landing trajectory ground tracks.

3 SONIC BOOM METRICS AND EFFECTS

A variety of acoustic metrics can be used to describe how sonic booms from commercial space operations affect communities and the environment. Metrics can describe the effect of an individual operation (single event) or the cumulative noise of multiple events over a long time. An overview of the basics of sound and definitions of the sonic boom metrics discussed throughout this report are provided in Appendix A and Appendix B, respectively. Additionally, a comprehensive listing of acoustical terminology and definitions is available in the American National Standards Institute's (ANSI) "Acoustical Terminology" standard (ANSI S1.1-1994).

Table 3 presents metrics and associated effects relevant to the analysis of sonic booms from commercial space operations. The associated effects referenced in Table 3 are discussed in more detail in Sections 3.1 through 3.4.

In addition to the Federal Aviation Administration's (FAA's) primary noise metric for sonic booms, C-weighted Day-Night Average Sound Level (CDNL), Table 3 provides supplemental metrics that can be used to evaluate potential impacts to people, and structures. The peak sound pressure level, also known as the peak overpressure level, is useful in aiding the public's understanding of the impulsive sonic boom event(s).

Table 3. Metrics for sonic boom analysis.

Metric	Description	Effect	Level
C-weighted Day-Night Average Sound Level (CDNL)†	A cumulative (C-weighted) metric that accounts for all noise events in a 24-hour period. (Appendix B)	Annoyance (Section 3.1)	60 dBC [1]
Peak Sound Pressure Level (L_{pk})	A single-event metric that describes the highest instantaneous sound pressure level, characterized for sonic booms by the front shock wave. (Appendix B)	Hearing Impairment (Section 3.3)	140 dB (4 psf) [2]
		Vibration on Structures (Section 3.4)	2 psf [3, 4]

† In California, C-weighted CNEL, a variant of CDNL should be used in accordance with California Code of Regulations Title 21, Public Works

3.1 Annoyance

The Day-Night Average Sound Level (DNL) is the FAA's primary noise metric to quantify the cumulative exposure of individuals to noise from aviation activities. For actions within California, the Community Noise Equivalent Level (CNEL) is used in lieu of DNL for FAA actions needing approval in California.

The Day-Night Average Sound Level (DNL) is based on long-term cumulative noise exposure and has been found to correlate with long-term community annoyance for regularly occurring events including aircraft, rail, and road noise [5, 6]. Noise studies used in the development of the DNL metric did not include rockets, which can have significant low-frequency noise energy and are historically irregularly occurring events. Thus, the suitability of DNL for rocket noise events is uncertain [7]. Additionally, the DNL "threshold does not adequately address the effects of noise on visitors to areas within a national park or national wildlife refuge where other noise is very low and a quiet setting is a generally recognized purpose and attribute" [8]. However, DNL is the most widely accepted metric to estimate the potential changes in long-term community annoyance.

Exhibit 4-1 of FAA Order 1050.1F [8] defines the FAA's significance threshold for noise. An action is considered significant if it increases noise in a noise-sensitive area by DNL 1.5 dBA or more and the resulting noise exposure level is at least DNL 65 dBA. For example, an increase from DNL 65.5 to 67 dBA is considered a significant impact, as is an increase from DNL 63.5 to 65 dBA.

However, for impulsive noise sources with significant low frequency content such as sonic booms, C-weighted DNL (CDNL) is preferred over A-weighted DNL [9]. In terms of percentage of people who are highly annoyed, DNL 65 dBA is equivalent to CDNL 60 dBC [1].

3.2 Physiological Effects

The unexpected, loud impulsive noise of sonic booms tends to cause a startle effect in people. However, when people are exposed to impulsive noises with similar characteristics on a regular basis, they tend to become conditioned to the stimulus and no longer display the startle reaction. The physiological effects of single sonic booms on humans [10] can be grouped as presented in Table 4.

Table 4. Physiological effects of a single sonic booms on humans. [10]

Overpressure	Behavioral effects
< 0.3 psf	Orienting, but no startle response; eyeblink response in 10% of subjects; no arm/hand movement.
0.6–2.3 psf	Mixed pattern of orienting/startle responses; eyeblink in about half of subjects; arm/hand movements in about a fourth of subjects, but not gross bodily movements.
2.7–6.5 psf	Predominant pattern of startle responses; eyeblink response in 90 percent of subjects; arm/hand movements in more than 50 percent of subjects with gross body flexion in about a fourth of subjects.

3.3 Noise-Induced Hearing Impairment

Multiple U.S. government agencies provide guidelines on permissible noise exposure limits for impulsive noise such as sonic booms. NIOSH [2] and OSHA [11] state that impulsive or impact noise levels should not exceed 140 dB peak sound pressure level, which equates to a sonic boom peak overpressure level of approximately 4 psf.

3.4 Noise-Induced Vibration Effects on Structures

The potential for damage from sonic booms is generally confined to brittle objects, such as glass, plaster, roofs, and bric-a-brac. Table 5 provides a summary of potential damage to conventional structures at various overpressures. Additionally, Table 5 describes example impulsive events for each level range. A large degree of variability exists in damage types and amounts, and much of the potential for damage depends on the sonic boom overpressure and the pre-existing condition of a structure. Generally, the potential for damage to well-maintained structures from sonic boom overpressures less than 2 psf is unlikely [3, 4]. The probability of the potential for damage to well-maintained structures by overpressures less than 4 psf is low (see Table 5) and increases for levels greater than 4 psf.

Table 5. Possible damage to structures from sonic booms. [3]

Nominal level	Damage Type	Item Affected
0.5 – 2 psf *piledriver at construction site*	Glass	Extension of existing cracks; potential for failure for glass panes in bad repair; failure potential for existing good glass panes is less than 1 out of 10,000 at 2 psf.
	Ceiling Plaster	Fine cracks; extension of existing cracks; mostly from fragile areas.
	Wall Plaster	Fine cracks; extension of existing cracks (less than in ceilings); over doorframes; between some plasterboards; mostly fragile areas.
	Roof	Older roofs may have slippage of existing loose tiles/slates; sometimes new cracking of old slates at nail hole; New and modern roofs are rarely affected.
	Bric-a-brac	Those carefully balanced or on edges can fall; fine glass, such as large goblets, can fall and break.
2 – 4 psf *cap gun/ firecracker near ear*	Glass	Failures show that would have been difficult to forecast in terms of their existing localized condition. Nominally in good condition.
	Ceiling Plaster	Estimated rate of cracking ranges from less than 1 out of 5,000 (2 psf) to 1 out of 625 (4 psf).
	Wall Plaster	Estimated rate of cracking ranges from less than 1 out of 10,000 (2 psf) to 1 out of 1,000 (4 psf).
	Roof	Potential for nail-peg failure if eroded.
	Bric-a-brac	Increased risk of tipping or falling objects.

Table 5. Possible damage to structures from sonic booms. [3] (continued)

Nominal level	Damage Type	Item Affected
4 – 10 psf *handgun at shooter's ear*	Glass	Regular failures within a large population of well-installed glass (1 out 50 (10 psf) to 500 (4 psf)); Failure potential in industrial and greenhouses glass panes.
	Ceiling Plaster	Estimated rate of cracking ranges from 1 out of 625 (4 psf) to 1 out of 10 (10 psf). Potential for partial ceiling collapse of good plaster; complete collapse of very new, incompletely cured, or very old plaster.
	Wall Plaster	Estimated rate of cracking ranges from less than 1 out of 1,000 (4 psf) to 1 out of 50 (10 psf). Measurable movement of inside ("party") walls at 10 psf.
	Roof	Regular failures within a large population of nominally good slate, slurry-wash; some chance of failures in tiles on modern roofs; light roofs (bungalow) or large area can move bodily.
	Bric-a-brac	Increased risk of tipping of falling objects
> 10 psf *fireworks display from viewing stand*	Glass	Some good glass will fail regularly (greater than 1 out of 10) to sonic booms and at an increase rate when the wavefront is normal to the glass panel. Glass with existing faults could shatter and fly. Large window frames move.
	Ceiling Plaster	Plasterboards displaced by nail popping.
	Wall Plaster	Most plaster affected. Internal party walls can move even if carrying fittings such as hand basins or taps; secondary damage due to water leakage.
	Roof	Most slate/slurry roofs affected, some badly; large roofs having good tile can be affected; some roofs bodily displaced causing gale-end and will-plate cracks; rarely domestic chimneys dislodged if not in good condition.
	Bric-a-brac	Some nominally secure items can fall, e.g., large pictures, especially if fixed to party walls.

4 SONIC BOOM RESULTS

Sonic boom modeling of the Dream Chaser landing operations to VSFB was performed using the single-event prediction model, PCBoom. For a more detailed description of the modeling methods, see Appendix C. The modeled peak overpressure levels of sonic booms from Dream Chaser landing operations are described in Section 4.1, and applied in Section 4.2 to evaluate the effects of the modeled sonic booms on people and structures.

4.1 Sonic Boom Peak Overpressure Levels

The sonic boom peak overpressure contours for the modeled Dream Chaser landing operations to VSFB are presented in Figure 4 through Figure 13. Each figure presents the sonic boom contours for levels of 0.25, 0.5, 0.75, and 1.0 psf. Note, the modeled Dream Chaser landing operations to VSFB generate peak overpressure levels up to 1.1psf. The main map in each figure displays the entire extent of the 0.25 psf sonic boom contour over the Pacific Ocean. The inset map within each figure provides a zoomed in view of the contours near the coast. In addition to the contours, the maps display the ground track in black for landings to Runway 12 or gray for landings to Runway 30. Note, the Dream Chaser spacecraft is subsonic before it turns to its final approach. The modeled sonic boom contours for the northern bounding trajectory, northern trajectory, nominal trajectory, southern trajectory, and southern bounding trajectory to Runway 12 are presented in Figure 4 through Figure 8, respectively. Similarly, the sonic boom contours for the five landing trajectories to Runway 30 are presented in Figure 9 through Figure 13. The location/intensity of the sonic boom footprint produced by Dream Chaser landing operations will be highly dependent on the vehicle configuration, trajectory, and atmospheric conditions at the time of flight.

Figure 14 presents the 'envelope' contours which represent the maximum peak overpressure predicted for any trajectory flown within the range of landing trajectories modeled. The area impacted by a single trajectory will be much smaller as shown in Figure 4 through Figure 13. A summary of the modeled 'envelope' sonic boom peak overpressure results presented in Figure 14 is detailed below.

- Land areas within the 'envelope' sonic boom contours include the California coast and the Northern Channel Islands of San Miguel and Santa Rosa. The predicted overpressure levels for a vast majority of this area are between 0.25 and 0.5 psf, comparable to distant thunder.
- Some land areas may experience levels greater than 0.5 psf, including VSFB, the communities near VSFB's eastern border (i.e. Lompoc, Mission Hill, Vandenberg Village), and San Miguel Island. Sonic boom peak overpressures between 1.0 and 1.1 psf may be experienced on VSFB (south of Bear Creek), as well as small land areas outside the southeast boundary of VSFB including part of a wind farm to the east and Jalama Beach to the south.

Figure 4. Sonic boom contours for the northern boundary of landings to Runway 12.

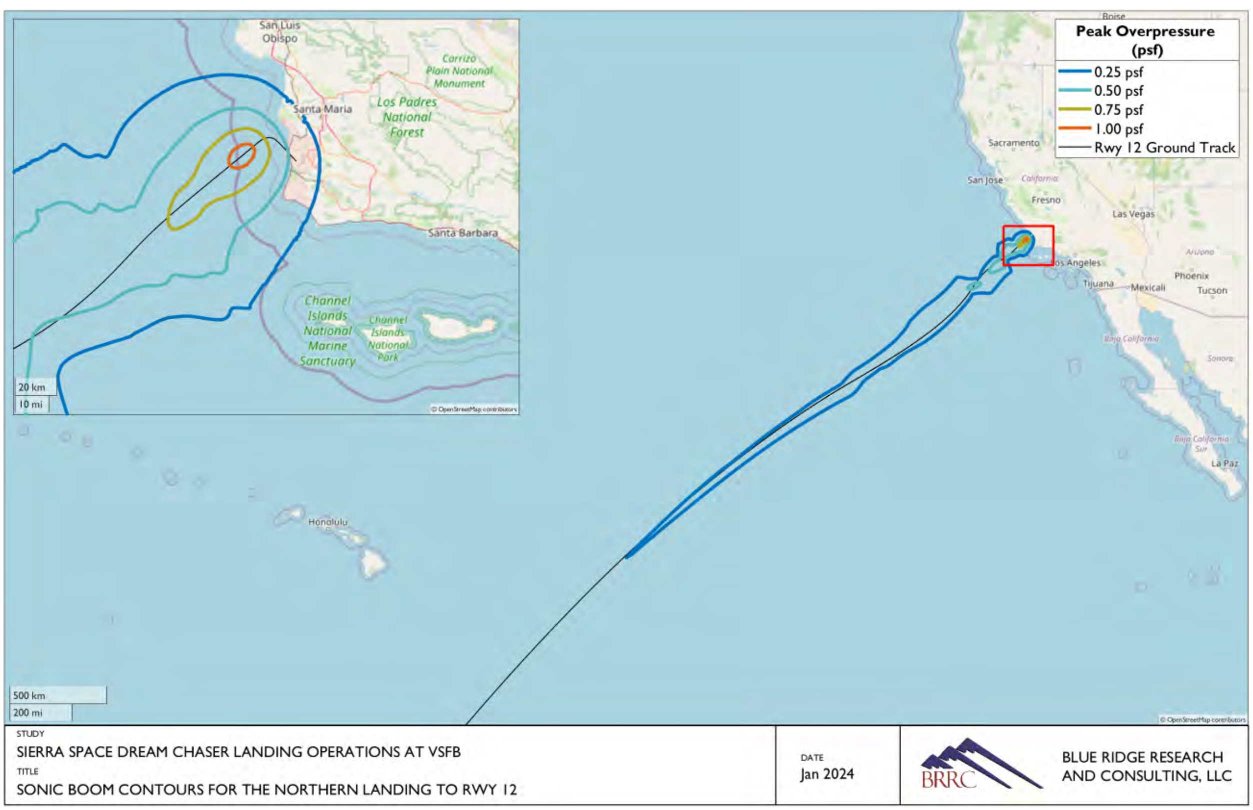

Figure 5. Sonic boom contours for the northern landing to Runway 12.

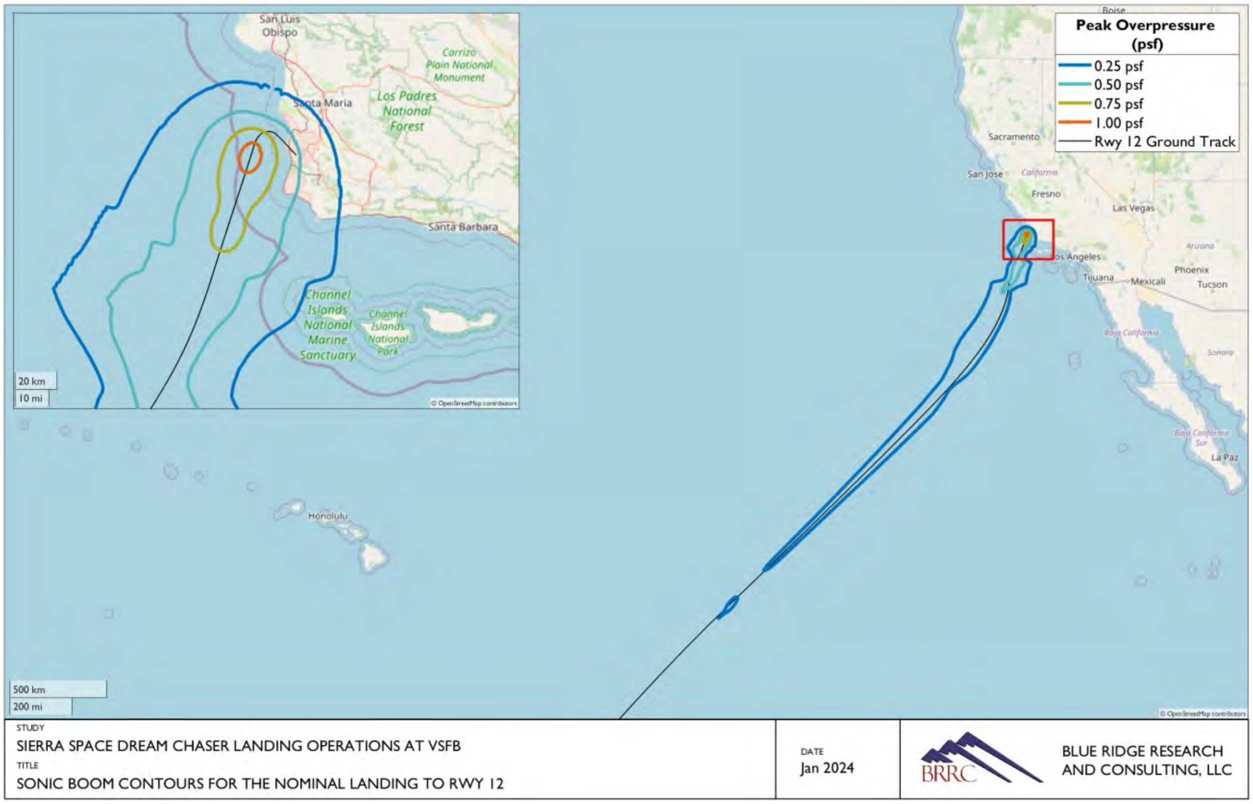

Figure 6. Sonic boom contours for the nominal landing to Runway 12.

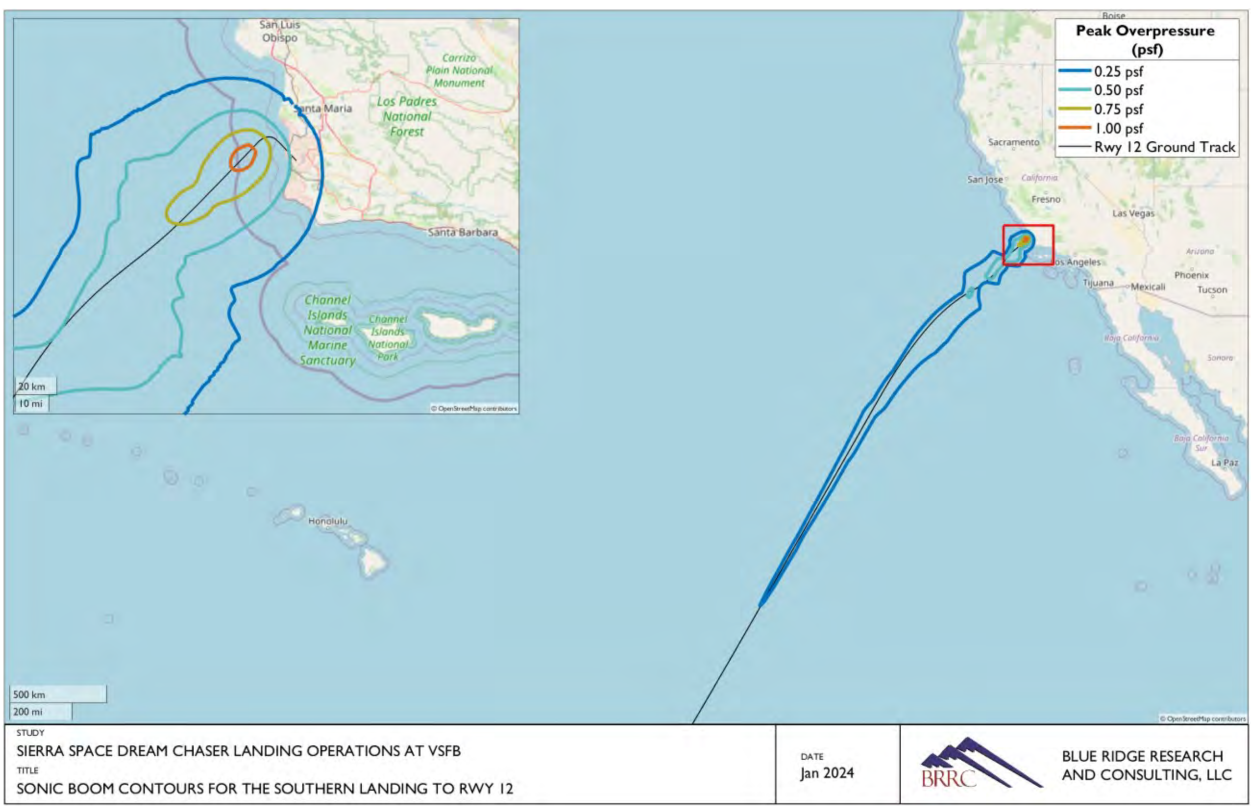

Figure 7. Sonic boom contours for the southern landing to Runway 12.

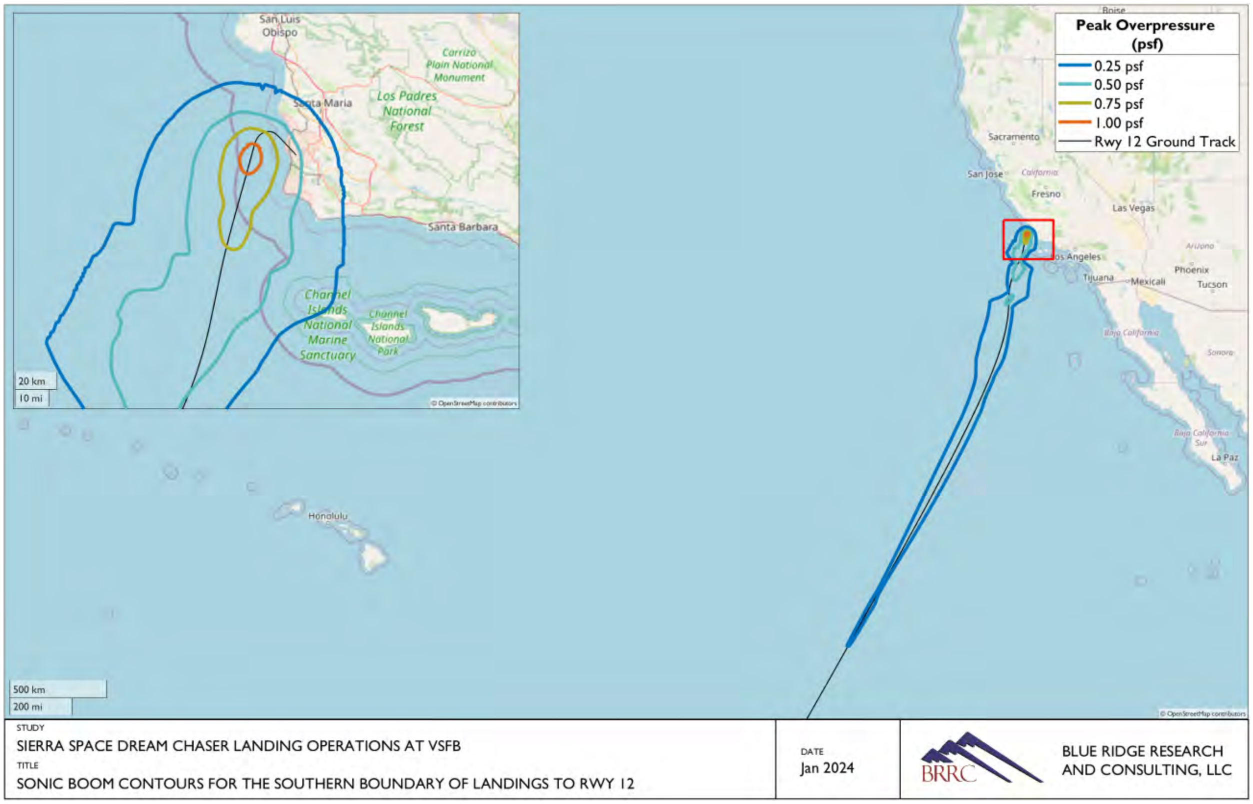

Figure 8. Sonic boom contours for the southern boundary of landings to Runway 12.

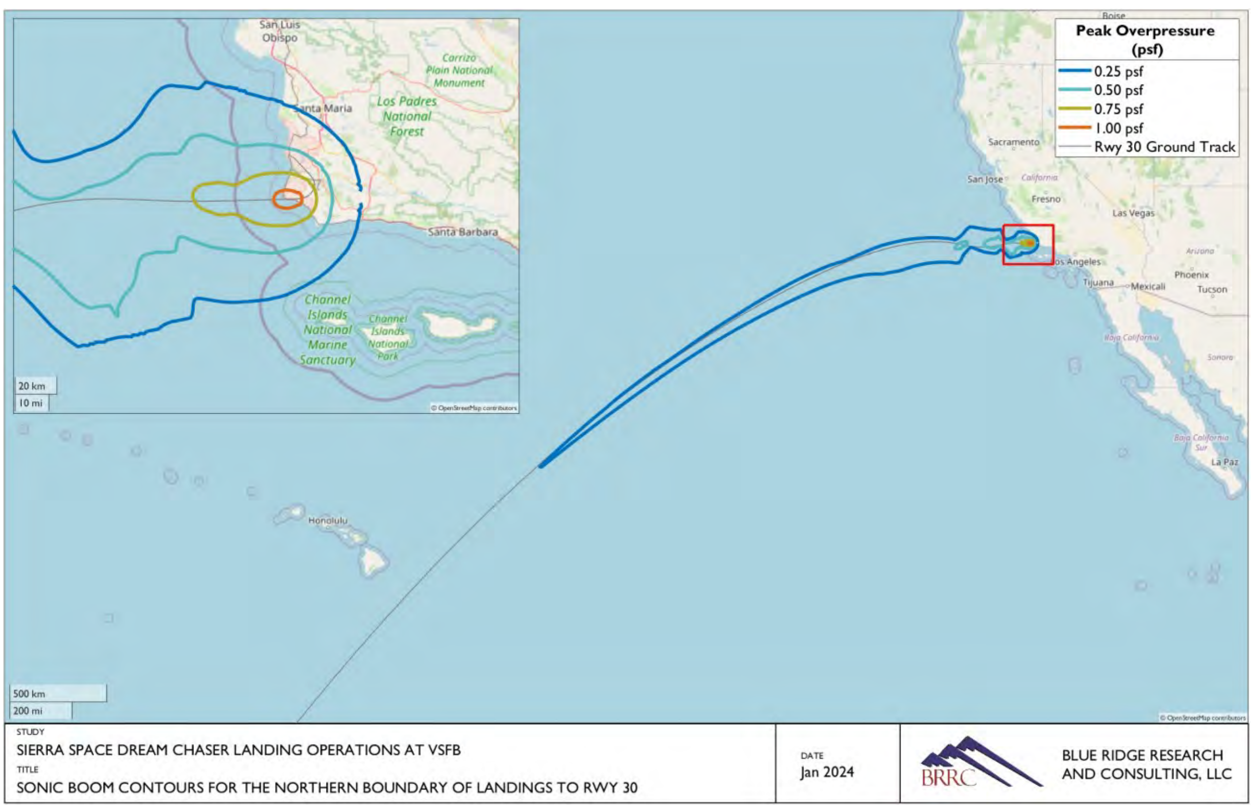

Figure 9. Sonic boom contours for the northern boundary of landings to Runway 30.

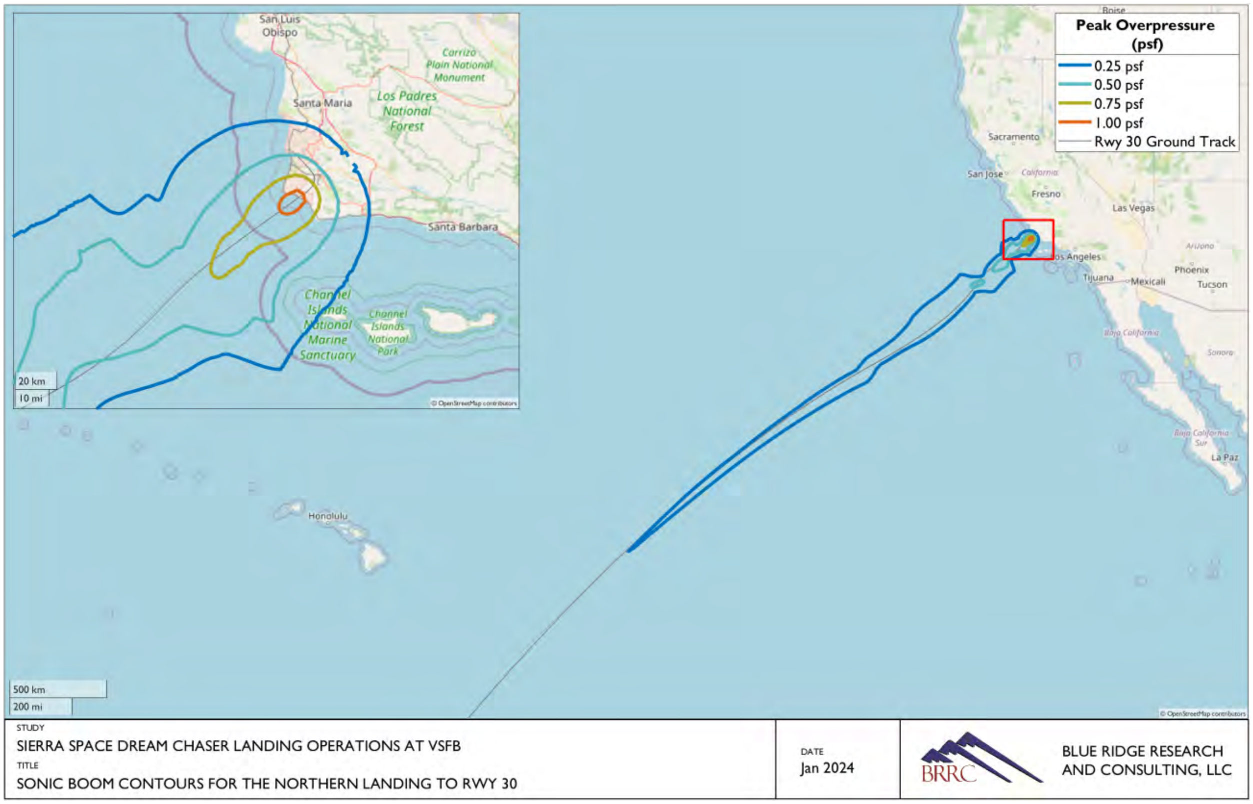

Figure 10. Sonic boom contours for the northern landing to Runway 30.

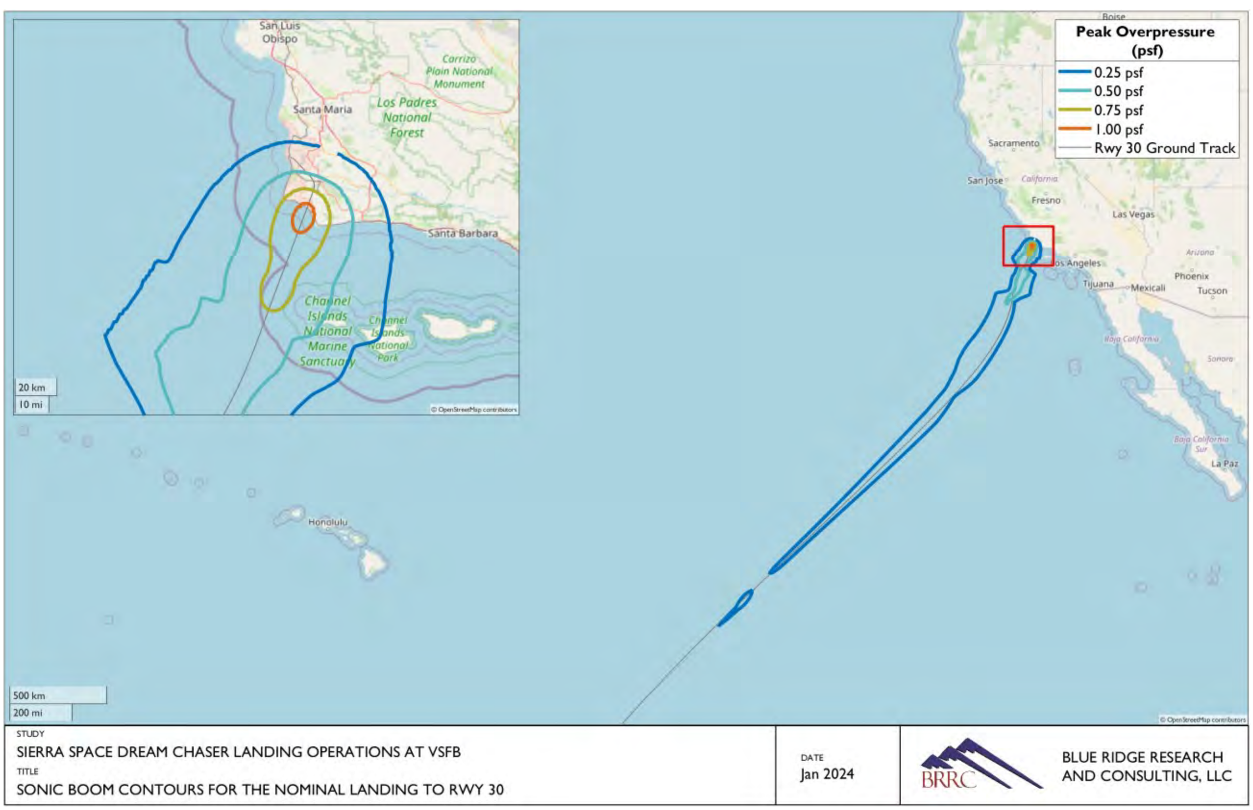

Figure 11. Sonic boom contours for the nominal landing to Runway 30.

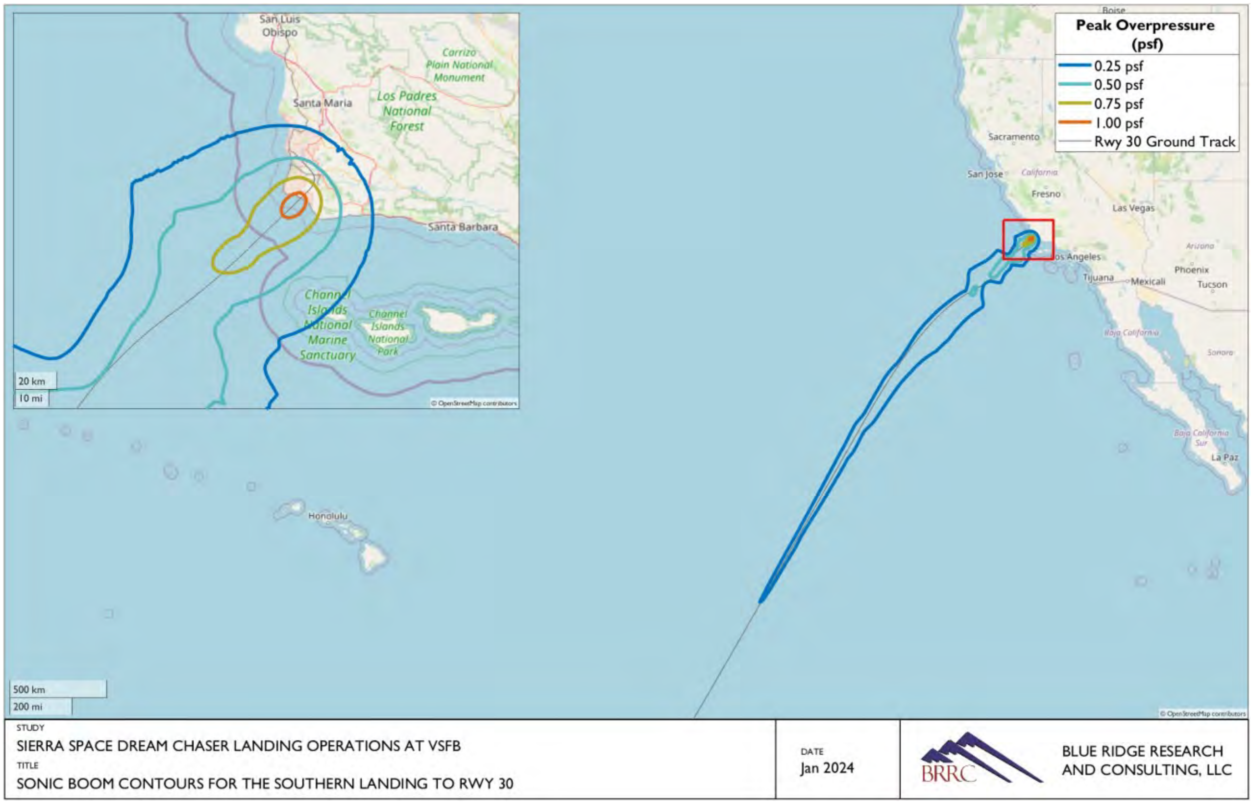

Figure 12. Sonic boom contours for the southern landing to Runway 30.

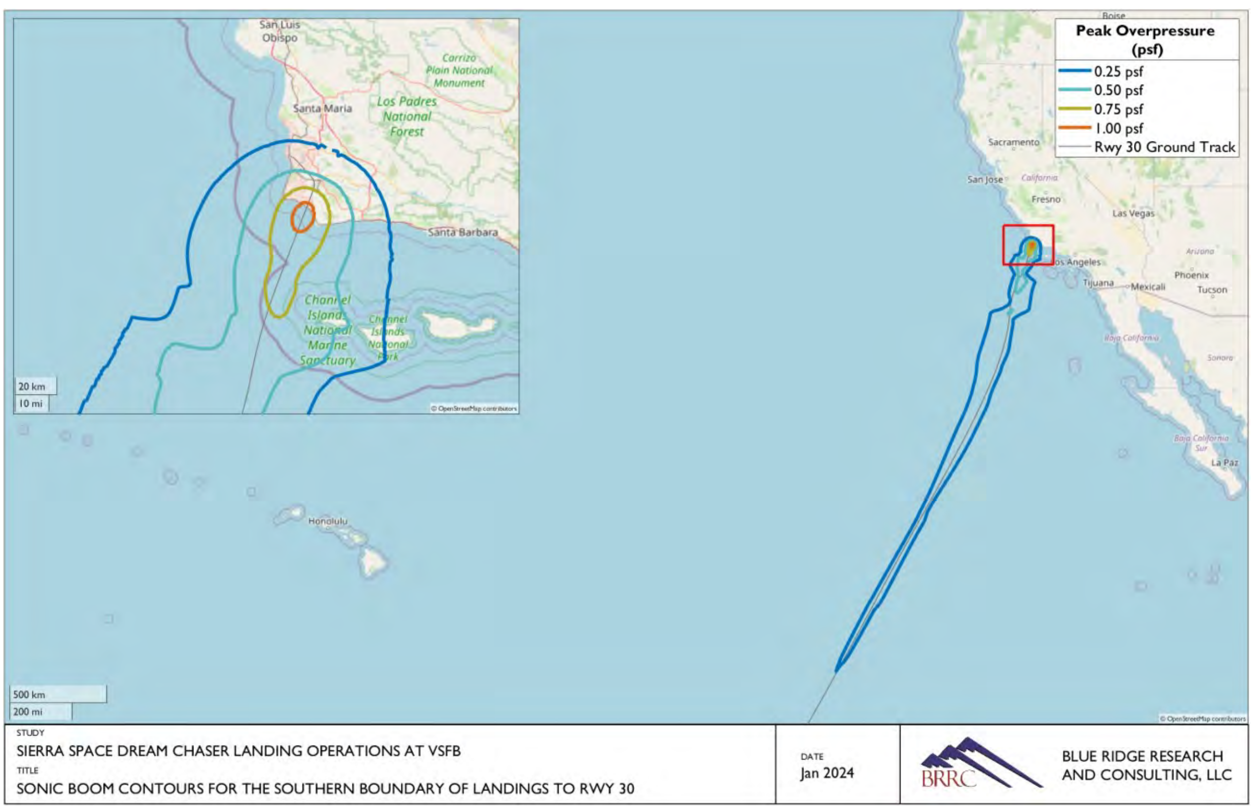

Figure 13. Sonic boom contours for the southern boundary of landings to Runway 30.

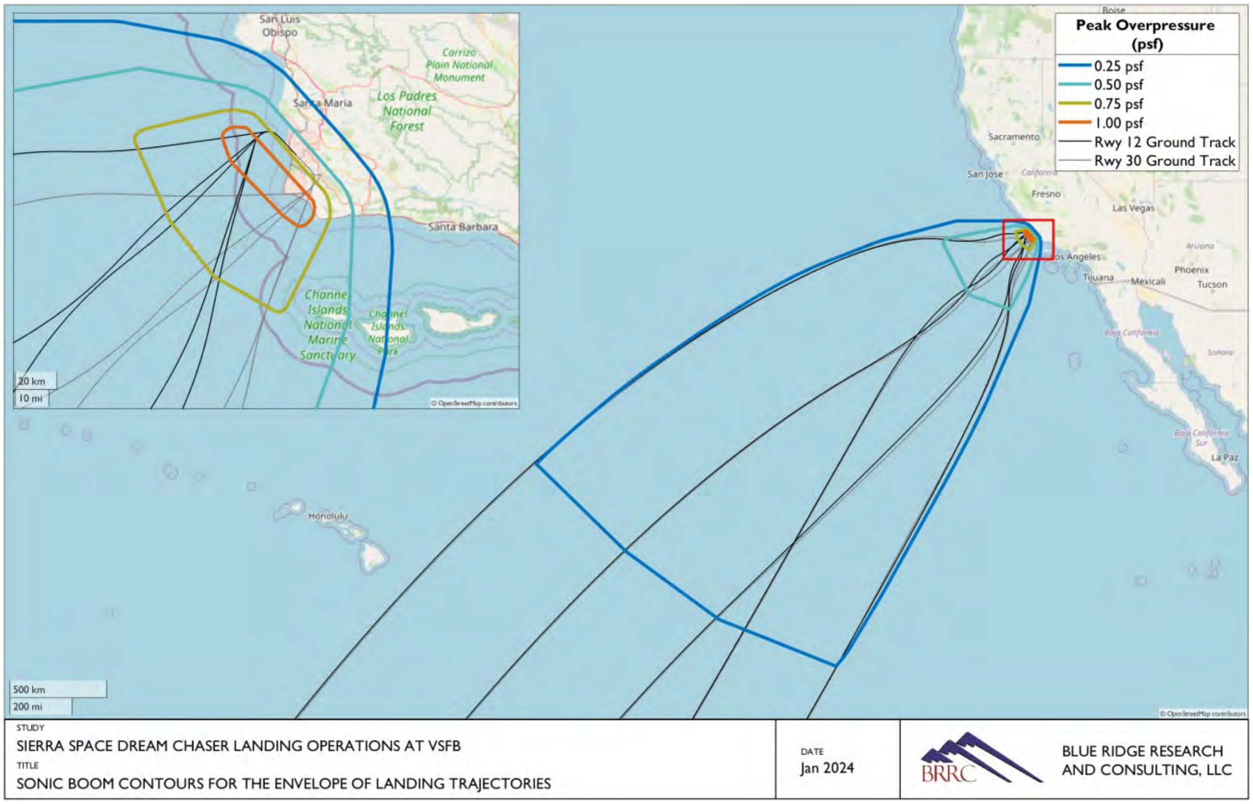

Figure 14. Sonic boom contours for the envelope of landing trajectories.

4.2 Sonic Boom Effects

The potential effects from sonic booms are evaluated in relation to human annoyance, physiological effects, hearing conservation, and structural damage.

4.2.1 Annoyance

C-weighted CNEL is used to evaluate the potential for long-term community annoyance by quantifying the cumulative exposure of individuals to sonic booms from the projected four annual nighttime landing operations of the Dream Chaser. The maximum C-weighted CNEL is calculated using the maximum C-weighted SEL modeled in PCBoom over the range of potential landing azimuths. For the projected operation tempo of four annual nighttime landings, the maximum C-weighted CNEL is 45 dBC, which is less than the significance threshold of 60 dBC for impulsive noise sources. Thus, the modeled Dream Chaser landing operations do not pose a significant impact with regards to human annoyance.

4.2.2 Physiological Effects

The unexpected, loud impulsive noise of sonic booms tends to cause a startle effect in people. However, when people are exposed to impulsive noises with similar characteristics on a regular basis, they tend to become conditioned to the stimulus and no longer display the startle reaction. People that experience sonic booms from Dream Chaser landing operations to VSFB may exhibit a range of behavioral effects (see Table 4), from no startle response (for levels less than 0.3 psf) to a startle response with body movements (for levels greater than 0.6 psf).

4.2.3 Noise-Induced Hearing Impairment

NIOSH [2] and OSHA [11] state that impulsive or impact noise levels should not exceed 140 dB peak sound pressure level, which equates to a sonic boom peak overpressure level of approximately 4 psf. The modeled Dream Chaser landing operations to VSFB generate peak overpressure levels up to 1.1 psf. Thus, the potential for hearing damage (with regards to humans) is negligible, as the modeled sonic boom overpressure levels are lower than the ~4 psf impulsive hearing conservation noise criteria.

4.2.4 Noise-Induced Vibration Effects on Structures

The potential for damage from sonic booms is generally confined to brittle objects, such as glass, plaster, roofs, and bric-a-brac, or structural elements that are in ill-repair. A large degree of variability exists in damage types and amounts, and much of the potential for damage depends on the sonic boom overpressure and the pre-existing condition of a structure. Generally, the potential for damage to well-maintained structures from sonic boom overpressures less than 2 psf is unlikely [3, 4]. The modeled Dream Chaser landing operations to VSFB generate peak overpressure levels up to 1.1 psf. Thus, the potential for structural damage is unlikely.

5 SUMMARY

This report documents the sonic boom analysis performed as part of Sierra Space's efforts on the environmental analysis for the proposed Dream Chaser landing operations at VSFB Runway 12/30. Sonic boom impacts were evaluated for a range of Dream Chaser landing trajectories for up to four annual nighttime landing operations to VSFB per year. The potential sonic boom impacts were evaluated on a single-event and cumulative basis in relation to human annoyance, physiological effects, hearing conservation, and structural damage.

The maximum modeled overpressure levels are predicted to be 1.1 psf for the California coastal region that experience sonic booms from Dream Chaser landing operations to VSFB. The proposed Dream Chaser landing operations do not pose a significant impact with regards to human annoyance as the noise exposure is less than the significance threshold. The potential for hearing damage (with regards to humans) is negligible, as the modeled sonic boom overpressure levels are lower than the impulsive hearing conservation noise criteria. The potential for structural damage is unlikely for well-maintained structures.

APPENDIX A BASICS OF SOUND

Any unwanted sound that interferes with normal activities or the natural environment is defined as noise. Three principal physical characteristics are involved in the measurement and human perception of sound: intensity, frequency, and duration [12].

- **Intensity** is a measure of a sound's acoustic energy and is related to sound pressure. The greater the sound pressure, the more energy is carried by the sound and the louder the perception of that sound.
- **Frequency** determines how the pitch of the sound is perceived. Low-frequency sounds are characterized as rumbles or roars, while high-frequency sounds are typified by sirens or screeches.
- **Duration** is the length of time the sound can be detected.

Intensity

The loudest sounds that can be comfortably detected by the human ear have intensities a trillion times higher than those of sounds barely audible. Because of this vast range, using a linear scale to represent the intensity of sound can become cumbersome. As a result, a logarithmic unit known as the decibel (abbreviated dB) is used to represent sound levels. A sound level of 0 dB approximates the threshold of human hearing and is barely audible under extremely quiet listening conditions. Normal speech has a sound level around 60 dB. Sound levels above 120 dB begin to be felt inside the human ear as discomfort. Sound levels between 130 and 140 dB are experienced as pain [13].

Because of the logarithmic nature of the decibel unit, sound levels cannot be simply added or subtracted and are somewhat cumbersome to handle mathematically. However, some useful rules help when dealing with sound levels. First, if a sound's intensity is doubled, the sound level increases by 3 dB, regardless of the initial sound level. For example:

$$50\text{ dB} + 50\text{ dB} = 53\text{ dB, and } 70\text{ dB} + 70\text{ dB} = 73\text{ dB.}$$

Second, the total sound level produced by two sounds with different levels is usually only slightly more than the higher of the two. For example:

$$50.0\text{ dB} + 60.0\text{ dB} = 60.4\text{ dB.}$$

On average, a person perceives a change in sound level of about 10 dB as a doubling (or halving) of a sound's loudness. This relation holds true for both loud and quiet sounds. A decrease in sound level of 10 dB represents a 90% decrease in sound intensity but only a 50% decrease in perceived loudness because the human ear does not respond linearly [12]. In the community, "it is unlikely that the average listener would be able to correctly identify at a better than chance level the louder of two otherwise similar events which differed in maximum sound level by < 3 dB" [14].

The intensity of sonic booms is quantified with physical pressure units rather than levels. Intensities of sonic booms are traditionally described by the amplitude of the front shock wave, referred to as the peak overpressure. The peak overpressure is normally described in units of pounds per square foot (psf). The amplitude is particularly relevant when assessing structural effects as opposed to loudness or cumulative community response. In this study, sonic booms are quantified by either dB or psf, as appropriate for the particular impact being assessed [15].

Frequency

Sound frequency is measured in terms of cycles per second or hertz (Hz). Human hearing ranges in frequency from 20 Hz to 20,000 Hz, although perception of these frequencies is not equivalent across this range. Human hearing is most sensitive to frequencies in the 1,000 to 4,000 Hz range. Most sounds are not simple pure tones, but contain a mix, or spectrum, of many frequencies. Sounds with different spectra are perceived differently by humans even if the sound levels are the same. Weighting curves have been developed to correspond to the sensitivity and perception of different types of sound. A-weighting and C-weighting are the two most common weightings. These two curves, shown in Figure 15, are adequate to quantify most environmental noises. A-weighting puts emphasis on the 1,000 to 4,000 Hz range to match the reduced sensitivity of human hearing for moderate sound levels. For this reason, the A-weighted decibel level (dBA) is commonly used to assess community sound.

Very loud or impulsive sounds, such as explosions or sonic booms, can sometimes be felt, and they can cause secondary effects, such as shaking of a structure or rattling of windows. These types of sounds can add to annoyance and are best measured by C-weighted sound levels, denoted dBC. C-weighting is nearly flat throughout the audible frequency range and includes low frequencies that may not be heard but cause shaking or rattling. C-weighting approximates the human ear's sensitivity to higher intensity sounds. Note, "unweighted" sound levels refer to levels in which no weighting curve has been applied to the spectra. Unweighted levels are appropriate for use in examining the potential for noise impacts on structures.

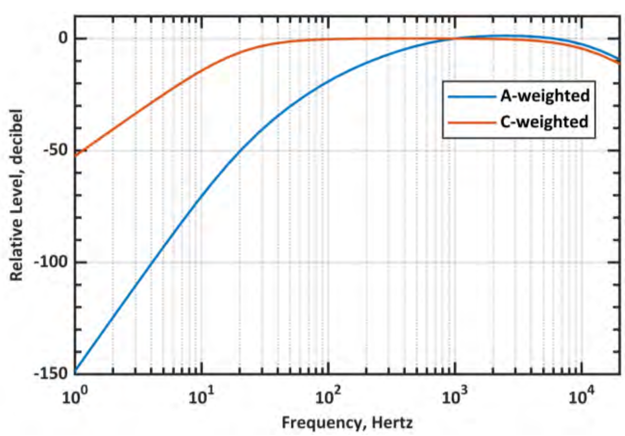

Figure 15. Frequency adjustments for A-weighting and C-weighting. [16]

Duration

The third principal physical characteristic involved in the measurement and human perception of sound is duration, which is the length of time the sound can be detected. Sound sources can vary from short durations to continuous, such as back-up alarms and ventilation systems, respectively. Sonic booms are considered low-frequency impulsive noise events with durations lasting a fraction of a second. A variety of noise metrics have been developed to describe noise over different time periods (See Appendix B).

Common Sounds

Common sources of noise and their associated levels are provided for comparison to the noise levels from the proposed action.

A chart of A-weighted sound levels from everyday sound sources [17] is shown in Figure 16. Some sources, like the air conditioner and lawn mower, are continuous sounds whose levels are constant for a given duration. Some sources, like the ambulance siren and motorcycle, are the maximum sound during an intermittent event like a vehicle pass-by. Other sources like "urban daytime" and "urban nighttime" (not shown in Figure 16) are averages over extended periods [18]. Per the United States Environmental Protection Agency, "Ambient noise in urban areas typically varies from 60 to 70 dB but can be as high as 80 dB in the center of a large city. Quiet suburban neighborhoods experience ambient noise levels around 45-50 dB" [19].

A chart of typical impulsive events along with their corresponding peak overpressures in terms of psf and peak dB values are shown in Figure 17. For example, thunder overpressure resulting from lightning strikes at a distance of one kilometer (0.6 miles) is estimated to be near two psf, which is equivalent to 134 dB [20].

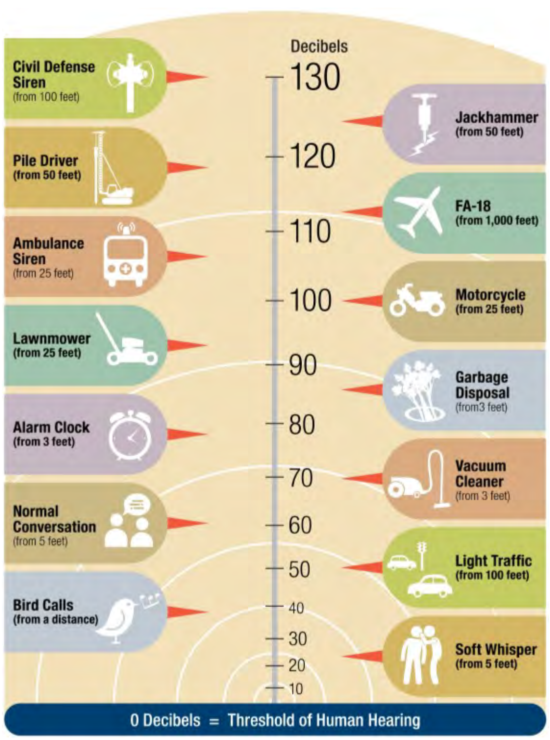

Figure 16. Typical A-weighted levels of common sounds. [21]

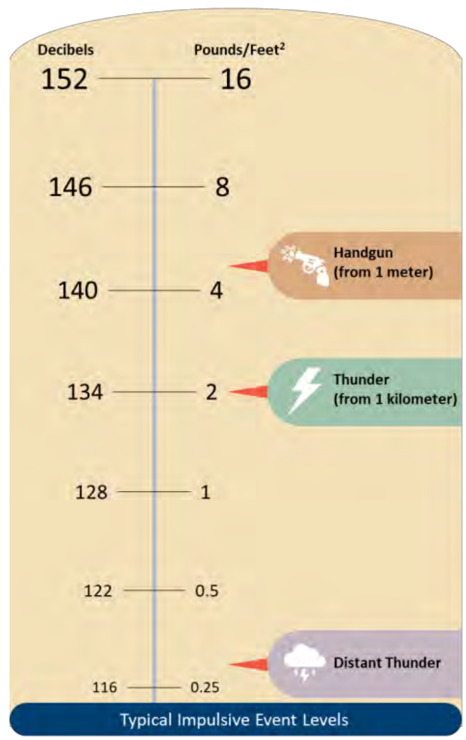

Figure 17. Typical impulsive event levels. [20]

APPENDIX B NOISE METRICS

A variety of acoustical metrics have been developed to describe sound events and to identify any potential impacts to receptors within the environment. These metrics are based on the nature of the event and who or what is affected by the sound. A brief description of the noise metrics used in this noise study are provided below.

Sound Exposure Level

Sound exposure level (SEL) is a composite metric that represents both the intensity of a sound and its duration. Individual time-varying noise events have two main characteristics: a sound level that changes throughout the event and a period of time during which the event is heard. SEL provides a measure of the net impact of the entire acoustic event, but it does not directly represent the sound level heard at any given time. Mathematically, it represents the sound level of a constant sound that would generate the same acoustical energy in one second as the actual time-varying noise event. For sounds that typically last more than one second, the SEL is usually greater than the L_{max} because a single event takes seconds, and the maximum sound level (L_{max}) occurs instantaneously. A-weighted sound exposure level is abbreviated as ASEL.

Day-Night Average Sound Level and Community Noise Equivalent Level

Day-Night Average Sound Level (DNL) is a cumulative metric that accounts for the SEL of all noise events in a 24-hour period. To account for increased sensitivity to noise at night, DNL applies an additional 10 dB adjustment to events during the acoustical nighttime period, defined as 10:00 PM to 7:00 AM. DNL represents the average sound level exposure for annual average daily events. DNL does not represent a level heard at any given time but represents long term exposure to noise.

CNEL is a variation of DNL specified by law in California (21 CCR § 5006). CNEL has the 10 dB nighttime penalty for events between 10:00 p.m. and 7:00 a.m. but also includes a 4.8 dB penalty for events during the evening period of 7:00 p.m. to 10:00 p.m. The evening penalty in CNEL accounts for the added intrusiveness of sounds during that period.

The abbreviations of DNL and CNEL typically refer to A-weighted levels. C-weighted DNL is abbreviated as CDNL and C-weighted CNEL is stated as such. For impulsive sounds with significant low-frequency content such as sonic booms, CDNL or C-weighted CNEL is preferred over (A-weighted) DNL or CNEL.

Peak Overpressure

For impulsive sounds, the true instantaneous peak sound pressure level (L_{pk}), which lasts for only a fraction of a second, is important in determining impacts. The peak overpressure of the front shock wave is used to describe sonic booms, and it is usually presented in psf. Peak sound levels are not frequency weighted.

APPENDIX C SONIC BOOM MODELING

A vehicle creates sonic booms during supersonic flight. The potential for the boom to intercept the ground depends on the trajectory and speed of the vehicle as well as the atmospheric profile. The sonic boom is shaped by the physical characteristics of the vehicle and the atmospheric conditions through which it propagates. These factors affect the perception of a sonic boom. The noise is perceived as a deep boom, with most of its energy concentrated in the low frequency range. Although sonic booms generally last less than one second, their potential for impact may be considerable.

A brief sonic boom generation and propagation modeling primer is provided in Section C.1 to describe relevant technical details that inform the sonic boom modeling. The primer also provides visualizations of the boom generation, propagation, and ground intercept geometry. An overview of the sonic boom modeling software used in the study, PCBoom, and a description of inputs are found in Section C.2.

C.1 Primer

When a vehicle moves through the air, it pushes the air out of its way. At subsonic speeds, the displaced air forms a pressure wave that disperses rapidly. At supersonic speeds, the vehicle is moving too quickly for the wave to disperse, so it remains as a coherent wave. This wave is a sonic boom. When heard at ground level, a sonic boom consists of two shock waves (one associated with the forward part of the vehicle, the other with the rear part) of approximately equal strength. When plotted, this pair of shock waves and the expanding flow between them has the appearance of a capital letter "N," so a sonic boom pressure wave is usually called an "N-wave." An N-wave has a characteristic "bang-bang" sound that can be startling. Figure 18 shows the generation and evolution of a sonic boom N-wave under the vehicle.

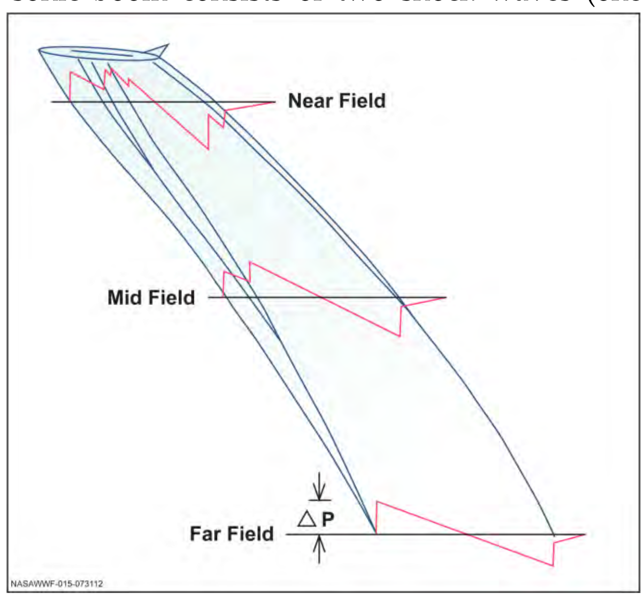

Figure 18. Sonic boom generation and evolution to N-wave. [22]

For aircraft, the front and rear shock are generally the same magnitude. However, for rockets, in addition to the two shock waves generated from the vehicle body, the plume itself acts as a large supersonic body, and it generates two additional shock waves (one associated with the forward part of the plume, the other with the rear part) and extends the waveform duration to as large as one second. If the plume volume is significantly larger than the vehicle, its shocks will be stronger than the shocks generated by the vehicle.

Figure 19 shows the sonic boom wave cone generated by a vehicle in steady (non-accelerating) level supersonic flight. The wave cone extends toward the ground and is said to sweep out a "carpet" under the flight track. The boom levels vary along the lateral extent of the "carpet" with the highest levels directly underneath the flight track and decreasing levels as the lateral distance increases to the cut-off edge of the "carpet."

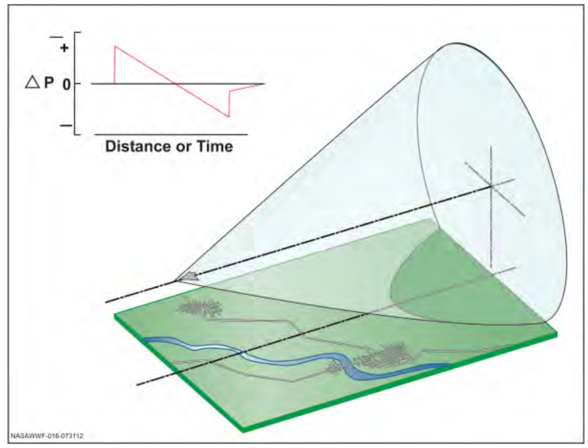

Figure 19. Sonic boom carpet for a vehicle in steady flight. [23]

Although the wave cone can be calculated from an aircraft-fixed reference frame, the ray perspective is more convenient when computing sonic boom metrics in a ground-fixed observer's reference frame [24]. Both perspectives are shown in Figure 20. The difference in wave versus ray perspectives is described for level, climbing, and diving flight, in the PCBoom Sonic Boom Model User Guide [24]:

> Sonic boom wave cones are not generated fully formed at a single point in time, instead resulting from the accumulation of all previous disturbance events that occurred during the vehicle's time history. […] Unlike wave cones, ray cones are fully determined at a single point in time and are independent of future maneuvers. They are orthogonal to wave cones and represent all paths that sonic boom energy will take from the point they are generated until a later point in time when they hit the ground. The ray perspective is particularly useful when considering refraction due to atmospheric gradients or the effect of aircraft maneuvers, where rays can coalesce into high amplitude focal zones.
>
> When the ray cone hits the ground, the resulting intersection is called an "isopemp." The isopemp is forward-facing [as shown in Figure 20] and falls a distance ahead of the vehicle called the "forward throw." At each new point in the trajectory, a new ray cone is generated, resulting in a new isopemp that strikes the ground. These isopemps are generated throughout the trajectory, sweeping out an area called the "boom footprint."

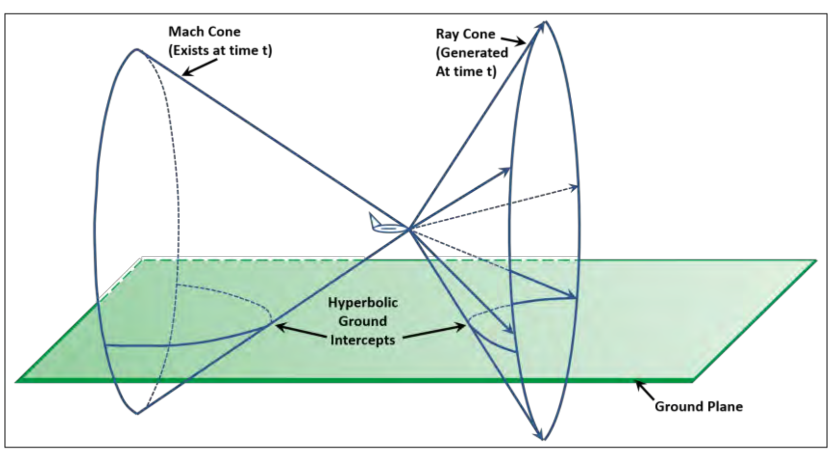

Figure 20. Mach cone vs ray cone viewpoints.

Figure 19 and Figure 20 may give the impression that the boom footprint is generally associated with rays generated from the bottom of a vehicle. This is the case for vehicles at moderate climb and dive angles, or in level flight as shown in Figure 20. For a vehicle climbing at an angle steeper than the ray cone half angle, such as in the left image of Figure 21, rays from that part of its trajectory will not reach the ground. This is important for vertical launches, where the ascent stage of a launch vehicle typically begins at a steep angle. In these cases, sonic booms are not expected to reach the ground unless refracted back downwards by gradients in the atmosphere. Conversely, if a vehicle is in a sufficiently steep dive, such as in the right image of Figure 21, the entire ray cone may intersect the ground, resulting in an elliptical or even circular isopemp. This is of importance for space flight reentry analysis, where descent may be nearly vertical.

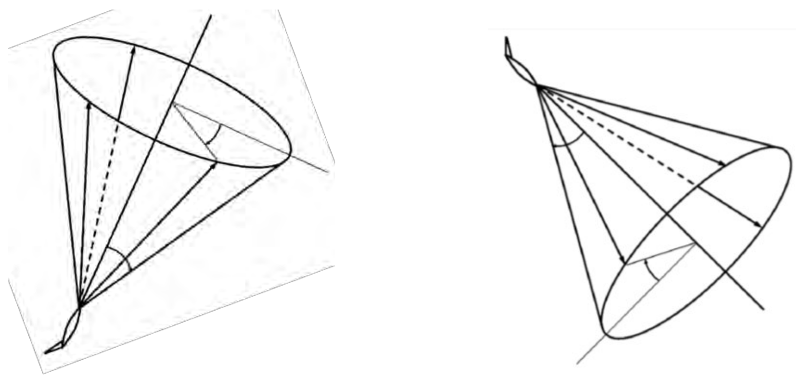

Figure 21. Ray cone in climbing (left) and diving (right) flight.

C.2 PCBoom

The single-event prediction model, PCBoom 6.7b [25-27], is a full ray trace sonic boom program that is used to calculate the magnitude, waveform, and location of sonic boom overpressures on the ground from supersonic flight operations. Additionally, BRRC uses a custom version of PCBoom 6.7b that implements proper plume physics.

Several inputs are required to calculate the sonic boom impact, including the geometry of the vehicle, the trajectory path, and the atmospheric conditions. These parameters along with time-varying thrust, drag, and weight are used to define the PCBoom starting signatures used in the modeling. The starting signatures are propagated through a site-specific atmospheric profile that includes the mean temperature, wind speed, and wind direction [28].

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