Sierra Vista Spaceport

FEASABILITY STUDY 2024

LAUNCH ON DEMAND

Forward

This feasibility study is not just a document—it's a road map. A road map to a potential economic boom. The global space industry is rapidly expanding, and Sierra Vista has the opportunity to be at the forefront. If pursued, this opportunity could capture a portion of the staggering $570 billion space economy, a figure that is projected to grow to $1 trillion in just six years. This is not just a bright future but a transformational one for Sierra Vista.

The city council and its supporting community have taken the first step in this endeavor by commissioning Launch On Demand to provide the Sierra Vista Reentry Site Feasibility Study. Based on its location, Sierra Vista is situated to become a significant U.S. space reentry site. The Federal Aviation Administration (FAA) estimates that by 2028, the US will have reached 338 annual operations. While these space vehicle operations may represent a variety of missions and payloads, they all have one thing in common: They all require the support of launch and reentry sites on Earth.

Most FAA-licensed spaceports have been developed to support either horizontal or vertical launch. However, Sierra Vista can set itself apart by becoming the first dedicated FAA-licensed reentry site in the West. This is not just a distinction but a necessity, as payload operators seek geographically diverse sites to host reentry and landing. Payloads returning from space will require a highly skilled workforce, state-of-the-art facilities, and cutting-edge educational programs, all of which will benefit not only the city of Sierra Vista, but the entire state of Arizona.

The Sierra Vista Reentry Site Feasibility Study included a preliminary evaluation of the technical, environmental, safety, and economic factors required for an FAA License to Operate a Reentry Site under 14 CFR 433. The licensing process will require development of site plans, flight safety analysis, environmental evaluation, and consultation with the FAA Office of Commercial Space. The effort necessary to obtain a Reentry Site License from the FAA is estimated to require approximately 18–30 months from kickoff to final approval.

The Sierra Vista Reentry Site Feasibility Study provides valuable insight into many of the required activities and considerations involved in navigating the space economy's hills and valleys. Empowered with this analysis, Sierra Vista is well-positioned to take the next giant leap.

Burton H Catledge
Founder & CEO
Launch On Demand

Executive Summary

The commercial space industry in the U.S. is experiencing unprecedented growth, with the number of launches and reentries growing from 33 in 2020 to 113 in 2023. Growth is projected to continue and even accelerate, with the Federal Aviation Administration projecting 338 annual operations by 2028. There is a critical need for more launch and reentry sites to accommodate the increasing demand for access to space. The ability to return payloads from orbit is essential for industries as diverse as semiconductor manufacturing, satellite servicing, pharmaceuticals, cosmetics, and consumer food and beverage production. Sierra Vista Municipal Airport offers a site with potential advantages for reentry and landing of a winged vehicle similar to, but much smaller than, the Space Shuttle orbiter. BlackStar Orbital is developing a vehicle which, at about eight feet long, is roughly one-tenth of the size of the Shuttle and capable of landing on the existing runway at Sierra Vista. This feasibility study reviewed the proposed landing site, estimated vehicle operational and performance data, and public safety and environmental implications to assess the feasibility of operating a spaceport reentry site at Sierra Vista. Numerous experts in space operations, aviation, FAA reentry licensing, environmental assessment, and risk and safety reviewed the proposed operations and developed conclusions and recommendations. Key findings include:

- Sierra Vista Spaceport would support a robust national space launch infrastructure and protect and expand America's technological and economic interests in support of the U.S. Commercial Space Launch Act, National Space Transportation Policy, NASA's Space Act Agreement (SAA), and DoD policy under DoD Directive 3230.3.
- The project offers sustainable operations, low resource usage, minimum upfront construction, and economic and educational advantages.
- The proposed operations are expected to meet FAA requirements for safe reentry and landing of a vehicle similar to the BlackStar spaceplane.
- No potential significant impacts on the natural or human environment were identified.
- No airspace issues were identified that would preclude the proposed reentry operations based on air traffic safety or operational impacts.
- Recommended next steps include: Begin reentry site pre-application consultation with FAA; collaborate with BlackStar Orbital (or another operator) to develop a concept of operations; perform a full Flight Safety Analysis; establish spaceport plans and procedures; perform appropriate environmental analyses; and coordinate with domestic and international stakeholders to develop plans and agreements.

While the project requires additional technical evaluation and regulatory compliance work, the potential for significant economic and educational opportunities makes it a viable venture. The following sections will provide an in-depth analysis of the public safety, technical, economic, environmental, and airspace impact considerations that support this conclusion.

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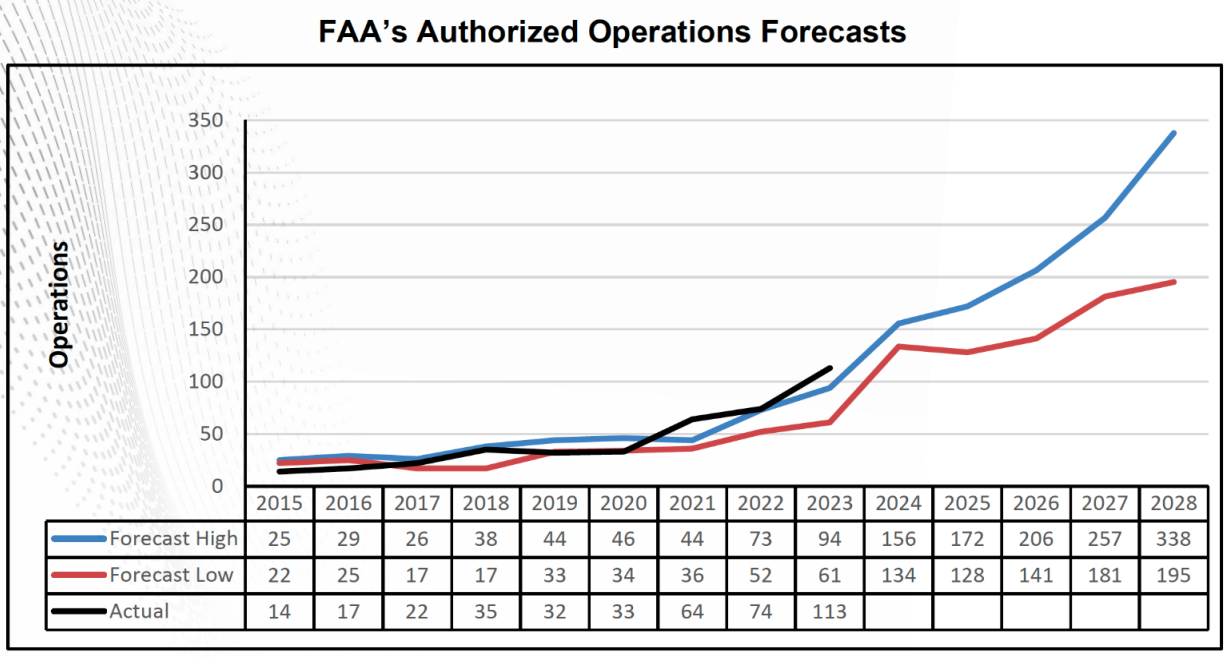
INTRODUCTION

The City of Sierra Vista, Arizona, is considering developing a commercial space reentry site. The proposed site includes an existing runway and infrastructure at Sierra Vista Municipal Airport (KFHU) and undeveloped portions of airport property. The proposed reentry site would have infrastructure development to support the proposed reentry activities. The City of Sierra Vista will determine whether to pursue a commercial reentry site license from the Federal Aviation Administration (FAA) under 14 CFR § 433.

Current State of Commercial Space

The commercial space industry has experienced extraordinary growth recently, with FAA-licensed launches and reentries more than tripling from 33 in 2020 to 113 in 2023. Thus far in 2024, FAA-licensed operations are on track to exceed 2023 operations by 20% or more. FAA forecasts that total annual commercial space operations could reach 338 by 2028 (Figure 1).



	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
Forecast High	25	29	26	38	44	46	44	73	94	156	172	206	257	338
Forecast Low	22	25	17	17	33	34	36	52	61	134	128	141	181	195
Actual	14	17	22	35	32	33	64	74	113					

Figure 1: FAA Commercial Launch and Reentry Operations Forecast.

As commercial space activity increases, there is growing demand for reentry services capable of returning payloads to Earth. The orbital microgravity environment is ideal for many scientific,

manufacturing, and experimental activities that require return of products and materials to Earth. One method of returning payloads to Earth is via a winged reentry vehicle capable of landing on a runway like a traditional aircraft or glider after being launched into space atop a traditional vertical-launch rocket. The most well-know spaceplane is NASA's Space Shuttle orbiter, which was retired from service in 2011, after 133 successful missions. The U.S. Space Force continues to operate the X-37B spaceplane in support of national security missions. Currently, next-generation commercial spaceplanes are in development at multiple operators, including Sierra Space, BlackStar Orbital, and ATRX.

National Interests

A reentry site at Sierra Vista would not only allow commercial launch providers to land and process reentry vehicles and payloads but would also create a significant economic boost. This development would meet the demand for lower cost returns from space and provide economic and technical benefits to the government and the private sector.

National Security Implications

The proposed reentry site is not just a local initiative but a strategic move in line with the principles and goals of the 2020 National Space Policy. This policy emphasizes the importance of developing robust, innovative, and competitive commercial space capabilities to ensure

the growth of a domestic commercial space sector that is globally competitive, supports national interests, and advances United States leadership. The development of domestic commercial space reentry sites furthers the goals of the 2020 National Space Policy by contributing to a stable, secure, and sustainable environment for space activities in the United States and providing supporting infrastructure to enable increased assurance of critical functions related to national space activities.

Sierra Vista Spaceport will further the intent of the US Commercial Space Launch Act, 51 USC 50901(b), to, in part, "protect the public health and safety, safety of property, and national security and foreign policy interests of the United States" while "strengthening and [expanding] the United States space transportation infrastructure, including the enhancement of United States launch sites and launch-site support facilities, and development of reentry sites, with Government, State, and private sector involvement, to support the full range of United States space-related activities."

Two of the public policy goals of the Act are:

- To promote economic growth and entrepreneurial activity through the use of the space environment and
- To encourage the United States private sector to provide launch and reentry vehicles and associated services

Sierra Vista Spaceport would support a robust national space launch infrastructure and protect and expand America's technological and economic interests in support of the U.S. Commercial Space Launch Act, National Space Transportation Policy, NASA's Space Act Agreement, and DoD policy under DoD Directive 3230.3.

GOALS AND OBJECTIVES

The proposed reentry site at the Sierra Vista Municipal Airport in Sierra Vista, Arizona, approximately 15 miles north of the Mexico border, is a key part of our plan to expand aerospace capabilities. The Sierra Vista Municipal Airport is one of only 18 joint-use airports in the United States, and the city benefits from the shared airfield facilities serving the joint interests of the city and the adjacent Fort Huachuca Army base.

Fort Huachuca is the state's most prominent military employer and an important economic driver for the city. While the city has a strong regional role in health care and education, there is a desire to expand and diversify the local economy by expanding aerospace capabilities at Sierra Vista Municipal Airport to include space vehicle reentry operations.

IMPROVE COCHISE COUNTY ECONOMIC DEVELOPMENT

As the commercial space industry expands rapidly in the United States, the need for more launch and reentry sites is becoming more urgent. Establishing a space vehicle reentry site at Sierra Vista would have numerous technological, educational, and economic advantages for the city. A company operating its spacecraft at Sierra Vista would bring the potential for a significant number of high-income jobs needed to support the space vehicle's design, flight, and processing. In addition, payloads returned and processed in Sierra Vista could expand the scope of business and educational opportunities in such diverse domains as biomedical, manufacturing, and defense.

DIVERSIFY THE LOCAL ECONOMY

The local economy is significantly dependent on Fort Huachuca, given its 12,000 military and civilian employees. Economic diversification will be necessary for Sierra Vista's future growth and prosperity. The Sierra Vista "Vision 2030" and the "Plan for Prosperity," which are city forward-looking documents, outline this need to diversify the local economy. Developing a reentry site at Sierra Vista would support building a diverse and resilient regional economic base that can adapt and prosper by adding high-tech aerospace activities to augment the existing economic drivers.

INCREASE SIERRA VISTA MUNICIPAL AIRPORT UTILIZATION

Commercial passenger flights do not currently serve Sierra Vista Municipal Airport. Airport operations consist primarily of US Forest Service (forest fire fighting), federal government non-military use, Civil Air Patrol, and limited miscellaneous commercial flights like Fed Ex and UPS. Adding spacecraft reentry operations to Sierra Vista Municipal Airport would provide much-needed spacecraft landing capacity to the United States while improving the utilization of existing airport infrastructure.

Bring Quality Employment Opportunities to Sierra Vista. One potential spacecraft operator at Sierra Vista is BlackStar Orbital, which is designing and developing the BlackStar spaceplane. The envisioned operations could initially bring approximately 50 jobs to the area, including high-value PhD and Aerospace Engineering positions. Cochise College in Sierra Vista offers several 4-year college degrees and is interested in developing technology partnerships with local industries when possible. BlackStar is interested in expanding its corporate operating manufacturing base at Sierra Vista, which could provide additional opportunities for academic collaboration with Cochise College.

BUILD REGIONAL TECHNOLOGY PARTNERSHIPS

When reentry operations begin at Sierra Vista, vehicle operators such as BlackStar will present networking and partnership opportunities with major Arizona universities such as Arizona State University (Phoenix) and University of Arizona (Tucson). Such partnerships offer increased academic and economic benefits and opportunities as students, engineers, and community representatives interact and build professional relationships.

A REENTRY SITE BRINGS SUSTAINABLE JOBS

Unlike industries that require undesirable increases in water use, a reentry site provides a sustainable alternative. A reentry facility is well-suited for the region because its water use, building footprint, environmental impact, and air traffic impacts are minimal.

SUPPORT EDUCATIONAL INSTITUTIONS

Vision 2030 states Sierra Vista's vision is to support educational institutions to increase skills and education levels throughout the community and workforce. Cochise College, University of Arizona, and Arizona State University are strong potential partners for this project. These local educational institutions can offer a valuable source of technical expertise for spaceport and reentry vehicle operations, while the spaceport and associated research, manufacturing, and processing activities offer opportunities for on-site internships and practical, hands-on training, fostering a mutually beneficial partnership between academia and industry.

PROMOTE THE GROWTH AND EXPANSION OF FORT HUACHUCA ACTIVITIES

Fort Huachuca is a well-established military base historically, geographically, and operationally. Large swaths of land surrounding the Fort are designated as test ranges for various military missions. The operations agenda can be expanded by adding a commercial spaceport component to include more complex electronic warfare, high-altitude training, and space events. Spaceport commercial companies will offer opportunities for both commercial and government payload providers to accomplish their missions in space and return to Sierra Vista for payload processing. Fort Huachuca is ideally suited for these missions due to its comparatively remote yet fully developed location.

MINIMUM INVESTMENT, MAXIMUM ROI

A reentry site at Sierra Vista represents an opportunity to achieve a maximum return on a minimum investment. The project offers sustainable operations, low resource usage, minimum upfront construction, and potential future growth. Sierra Vista offers a site that is substantially ready to support reentry operations. The runway is complete, the apron is fully installed up to

the proposed vehicle processing site, the building site is already sub-compacted to a depth of 5 feet, and utilities are, or will be, accessible at the site. No additional significant Sierra Vista investments are foreseen. As soon as a space vehicle operator begins activities at the site, the city and county will begin to see economic benefits such as hotel, restaurant, retail, and employment opportunities, and these benefits will extend during the startup phase and long into the future.

MULTIPLE OPERATORS

While BlackStar Orbital is the first spaceplane operator to express interest in using Sierra Vista Municipal Airport as a reentry site, other companies have similar vehicles in various stages of development. Once the Federal Aviation Administration licenses Sierra Vista as a reentry site, it is expected that operations will expand beyond a single operator and a single vehicle.

REENTRY VEHICLE CONCEPT OF OPERATIONS

Winged reentry vehicles are spacecraft that can be launched aboard a traditional vertical launch rocket, operate like a spacecraft in space, and then fly or glide through Earth's atmosphere and land like an aircraft. NASA's Space Shuttle Orbiter is the best known spaceplane, having operated from 1981 to 2011. The Boeing X-37 spaceplane, also know as the Orbital Test Vehicle, has been conducting missions since 2010, most recently launching aboard a SpaceX Falcon Heavy on December 28, 2023. Other winged reentry vehicles are in development, such as the Sierra Space Dream Chaser and the BlackStar spaceplane. BlackStar Orbital has expressed interest in potentially landing the BlackStar at Sierra Vista and conducting regular operations there. The BlackStar spaceplane is much smaller than NASA's retired Space Shuttle Orbiter, as well as the Dream Chaser, as illustrated in Figure 2.

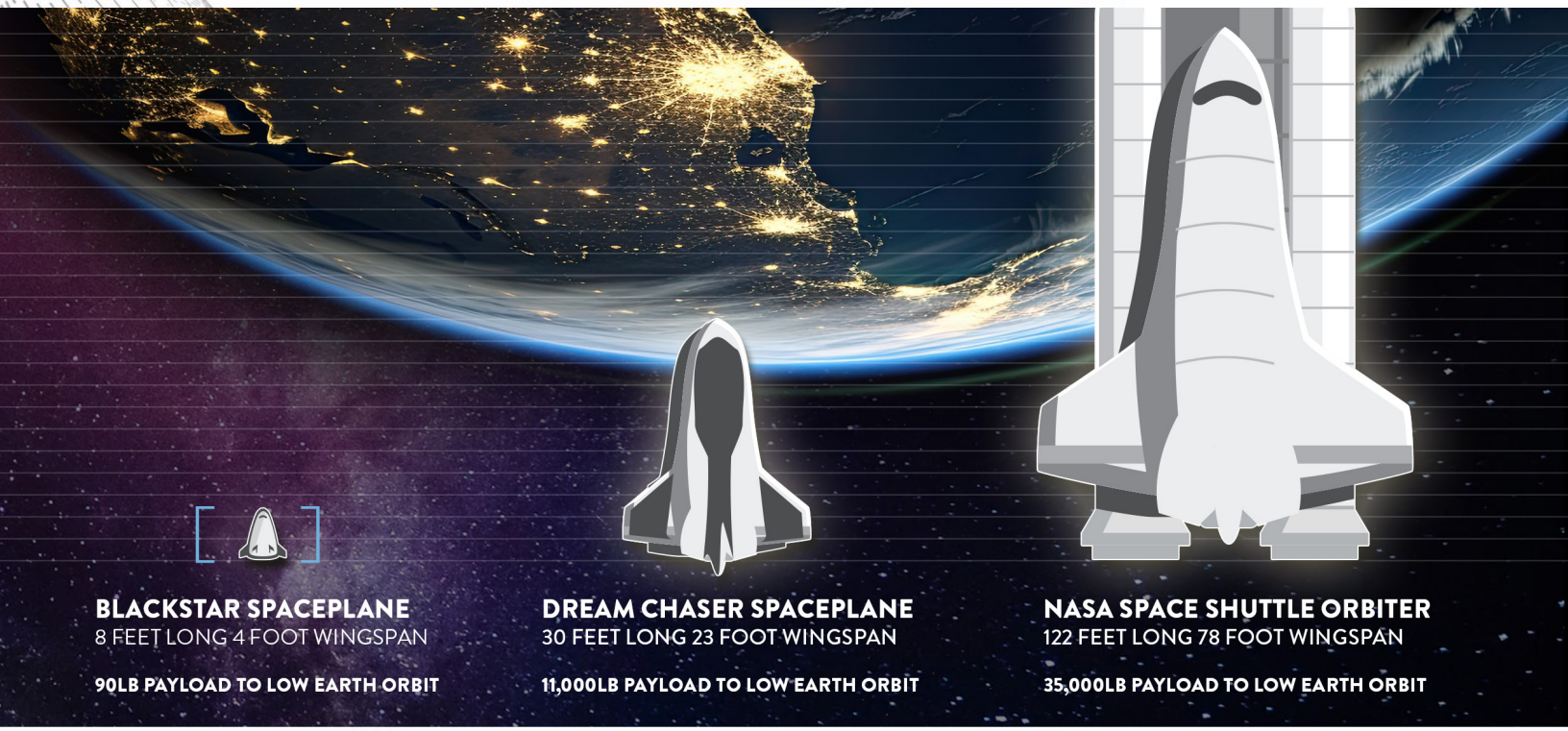


Figure 2: Size Comparison of Winged Reentry Vehicles.

The BlackStar is designed to operate as an uncrewed satellite or cargo shuttle. When operating as a satellite, the BlackStar would launch aboard a traditional rocket from any suitable launch

site, then remain in space while its onboard payload performs its mission. As a cargo shuttle, the BlackStar can carry payloads, such as CubeSats or nanosats, and deploy them in orbit. In both cases, the BlackStar would then reenter the Earth's atmosphere and glide, unpowered, to a runway landing similar to a traditional aircraft or glider. For a landing at Sierra Vista Municipal Airport, the BlackStar would follow a steep descent trajectory upon entering the National Airspace System (NAS). The portion of the gliding descent from 60,000 feet to the surface would likely occur within 20 nautical miles of the airport. As the BlackStar approaches the landing site and descends below 60,000 feet, it may perform "s"-turns or spiral maneuvers to lose altitude before lining up with the landing runway. The key events for a BlackStar mission, from launch to landing, are depicted in Figure 3.

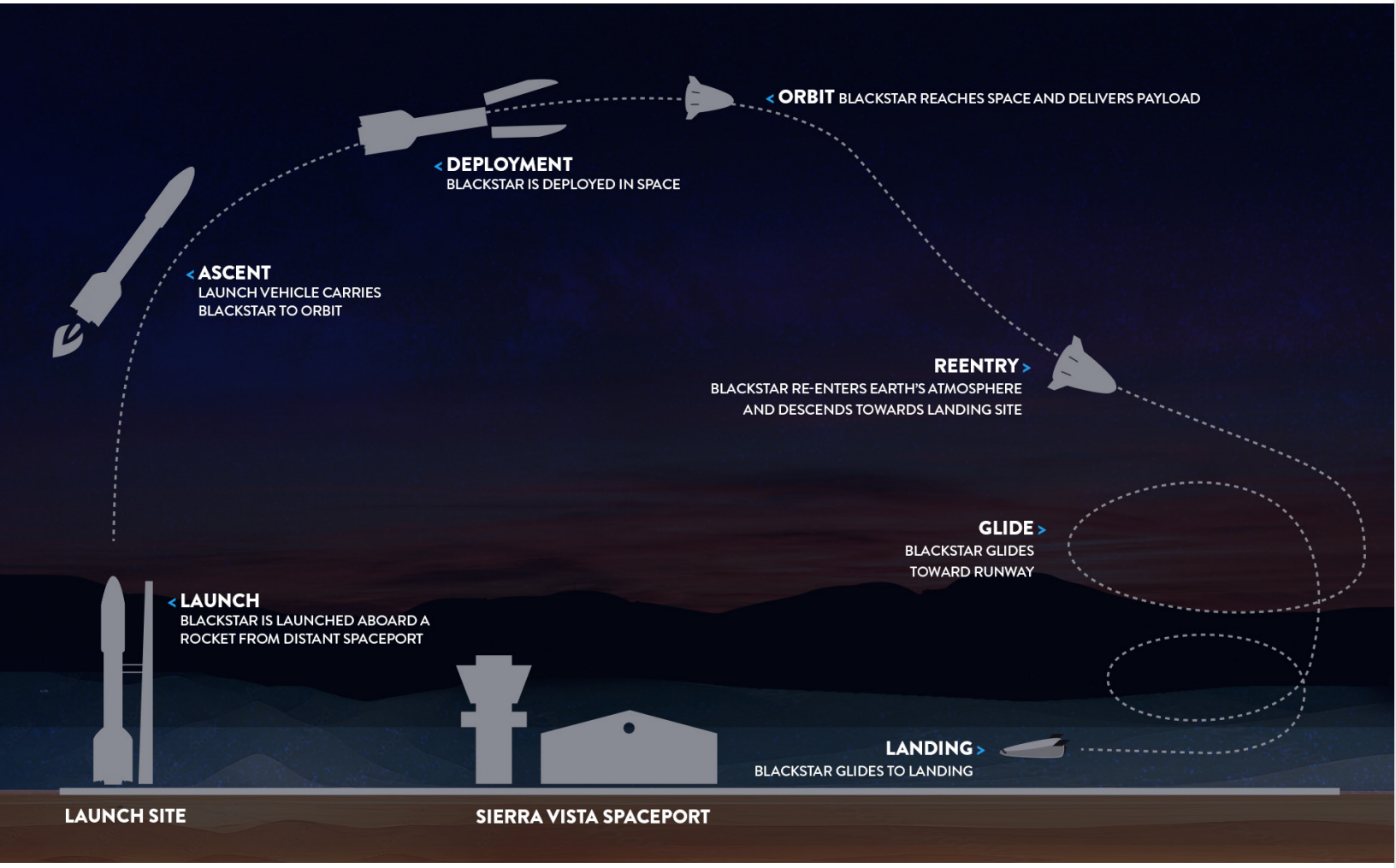


Figure 3: BlackStar Mission Concept of Operations.

PUBLIC HEALTH AND SAFETY

INTRODUCTION

The Sierra Vista Municipal Airport dates to the early 1980s, with the initial deed issued in 1982, in which the Department of the Army provided the initial land and an additional 43 acres in 1989. The City of Sierra Vista enjoys a long-term partnership with Fort Huachuca and Libby Army Airfield in operating a joint-use airport for military and civilian aircraft. The municipal airport is a critical economic driver offering access to the primary runway at 12,001ft, the third longest in Arizona. Additionally, the airfield is supported by restricted airspace supporting military operations, although civilian access to the airport is routinely conducted. Traditionally, the municipal airport supports general aviation activities, forest service tanker operations during fire season, and other non-routine civilian operations. The City of Sierra Vista has sought to increase the municipal airport's economic activity by supporting activities compatible with Fort Huachuca's crewed and uncrewed training missions. Reentry space operations would provide:

- Commercial business growth for the city
- High-tech job opportunities for area residents
- Opportunities for collaboration with Arizona educational institutions
- Minimal operational or environmental impacts to the airport

Reentry site requirements are outlined in 14 CFR § 433 (License to Operate a Reentry Site), however, FAA also uses public safety requirements found in 14 CFR § 420 (License to Operate a Launch Site) as part of their evaluation of public safety implications for reentry site licensing. For this feasibility study, the criteria outlined in § 420.23 - § 420.27, which discuss launch site location review, were analyzed. § 420.23 outlines the requirements for building a flight corridor. § 420.25 discusses performing a risk analysis on the flight corridor built to § 420.23 specifications. § 420.27 requires applicants to provide data, including trajectory data, population data, and casualty areas.

METHODOLOGY OVERVIEW

This feasibility study followed the equations outlined in 14 CFR § 420 Appendix B to create the flight corridor and the equations in 14 CFR § 420 Appendix C (6) to evaluate the flight corridor. 14 CFR § 420 Appendix B Table B-3 defines the requirements for line segment lengths to construct flight corridors for various size classes of orbital reentry vehicles. By definition, a "small" reentry vehicle can place a payload of 3,300 pounds or less into a 100-nautical mile low

Figure 4: BlackStar Spaceplane Concept.

earth orbit on a 90-degree inclination. Sierra Vista Municipal Airport intends to support reentry vehicles much smaller than the “small” size class described in 14 CFR § 420. Due to this, both the values of the “small” reentry vehicle presented in 14 CFR § 420 and values calculated from an actual reentry vehicle were evaluated.

VEHICLE DESCRIPTION

Final vehicle design and engineering specifications for the BlackStar reentry vehicle (Figure 4) were not available during this feasibility study. Instead, data from a representative reentry vehicle, approximately three times the size of the BlackStar reentry vehicle, was used for the flight corridor analysis.

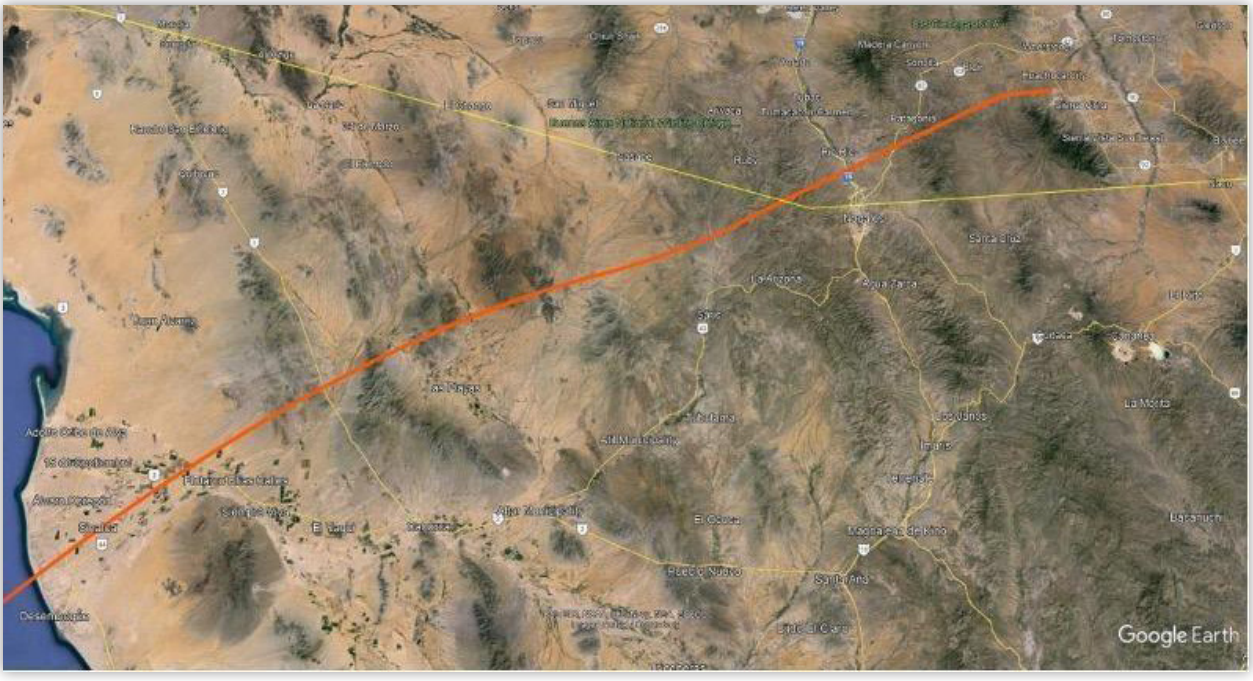


Figure 5: Sample Reentry Trajectory.

TRAJECTORY

A sample reentry trajectory was rotated and moved from another landing site to target the center of the Sierra Vista Municipal Airport runway. An overview of the entire trajectory is shown in Figure 5. The reentry azimuth is about 070 degrees before final alignment with the runway. Additional detailed views of the trajectory over North America and Sierra Vista are shown in Figure 6 and Figure7.

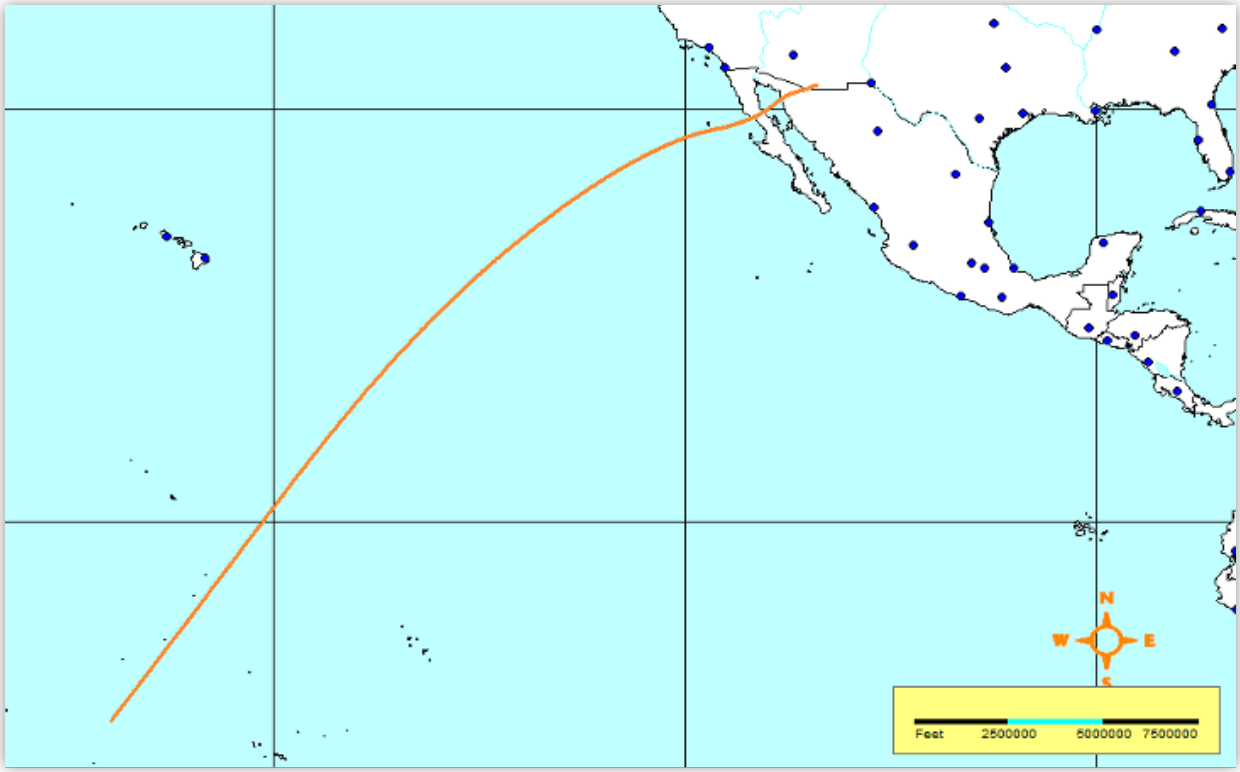


Figure 6: North America Trajectory.

Figure 7: Sierra Vista Trajectory.

FRAGMENT DATA

While not a prerequisite for the corridor analysis outlined in 14 CFR § 420, the availability of fragment data for the sample reentry vehicle had practical implications for the feasibility study. It allowed for reduced conservatism, where appropriate, thereby influencing the study's outcomes. The provided fragment file and the times when the file is active are shown in Table 1. Figure 8 and Figure 9 provide the cumulative number of fragments and the cumulative weight of fragments per beta in the fragment file, respectively. Based on this fragment data, the resulting casualty area for the sample reentry vehicle is 12,744 ft^2 (4.57e-04 mi^2).

Fragment File Name	Start Time	End Time
Low_UDC.frg2.csv	935	2000

Table 1: Fragment File Start and End Times.

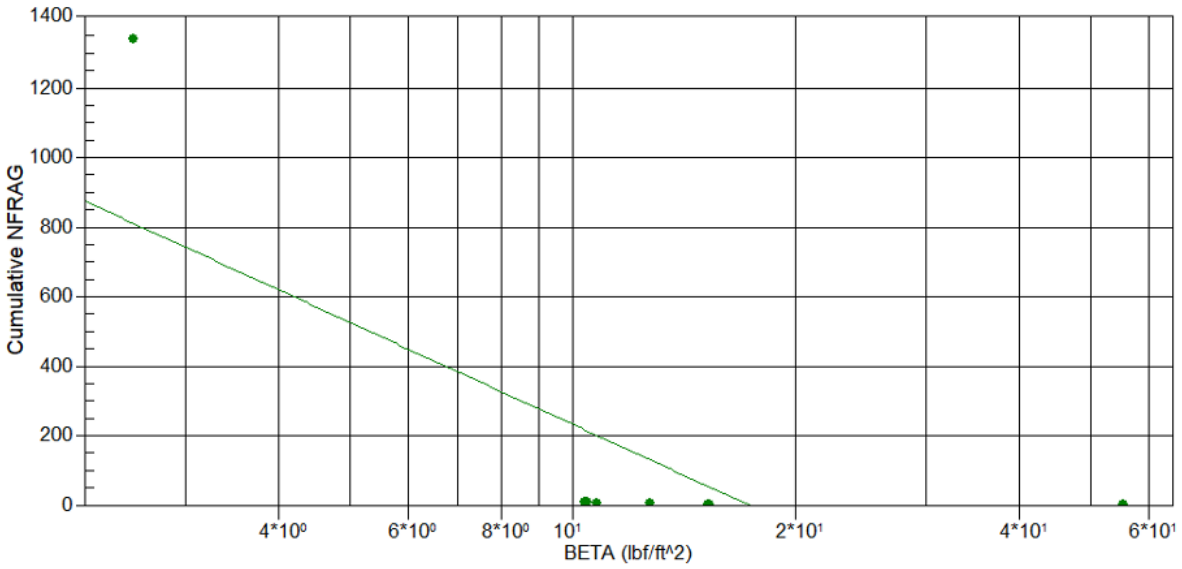


Figure 8: Cumulative Number of Fragments vs Beta at T=936s.

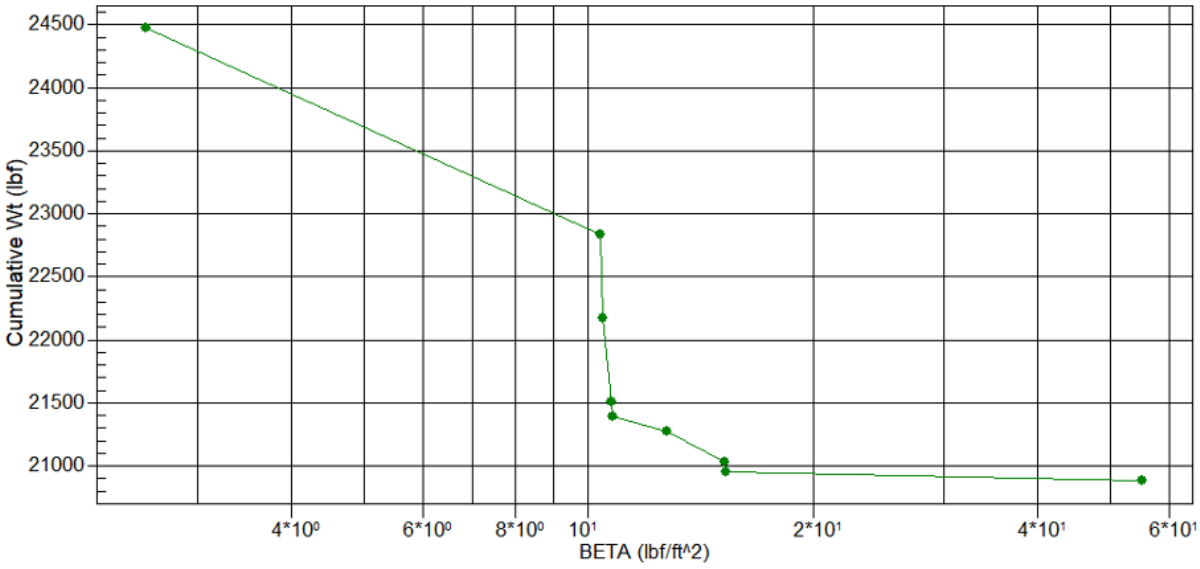


Figure 9: Cumulative Weight of Fragments vs Beta at T=936s.

PROBABILITY OF FAILURE

14 CFR § 420 Appendix C uses a value of 0.10 for the probability of failure. For this feasibility study, a probability of failure value was calculated based on the sample RV data. The probability of failure of the sample RV is shown in Figure 10. Since the probability of failure for the corridor methodology is a constant value, the probability of failure that correlated to

the most extended period of flight for sample RV (2.81e-06 / second) was used, and the most extended period of flight is also correlated to the times when the vehicle will fly over populated areas. The subsequent flight times are when the vehicle will fly over populated areas; however, the failure rates are lower (1.23e-06 / second and 1.22e-07 / second) and were not used to add conservatism. Reallocating the failure rate to the overall time resulted in a probability of failure of 0.004.

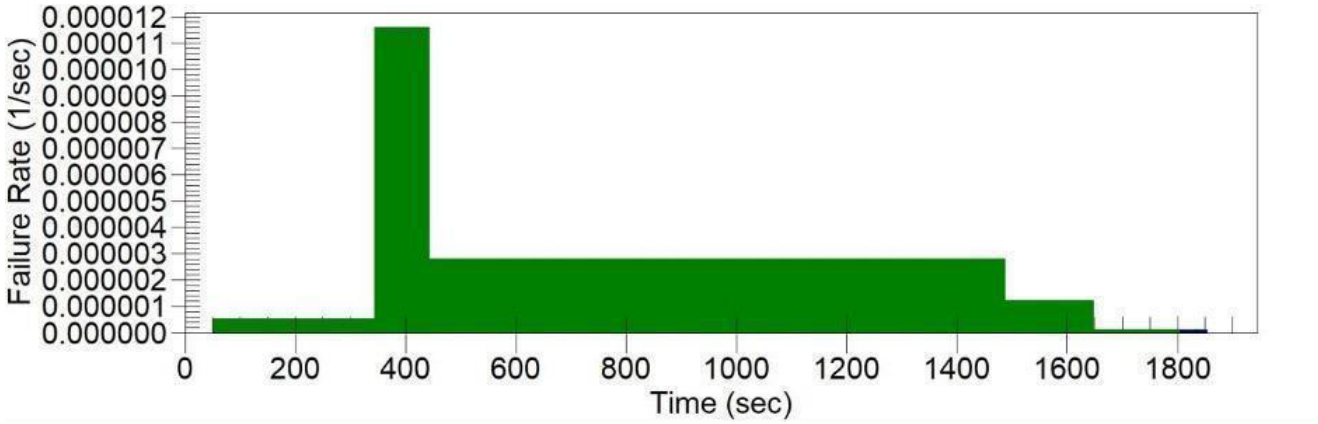


Figure 10: Probability of Failure for Sample Reentry Vehicle.

POPULATION DATA

Population data was obtained using Oak Ridge National Laboratory's LandScan-US database. LandScan is a model of global human population distribution. The population data was obtained using various parameters, such as geographic region, resolution, start and end time or duration, and sheltering model. Regions were specified by using a shapefile or break-up state vector file (BVEC) with the regions of extent.

14 CFR § 420 Appendix C (b)(2) requires the population data to be obtained for the area under the corridor. Additionally, population data up to and including 100 NM from the landing point are needed for the U.S. census block group level, while the downrange area is required at no more than 1 degree by 1-degree latitude/longitude grid coordinates. The input resolution for the corridor area up to 100 NM from the landing point was one mi^2. The resulting population data is plotted in Figure 11. The input resolution for the corridor area for the downrange area spanned between 0.25 mi^2 to 625 mi^2. The resulting population data is plotted in Figure 12 and Figure 13.

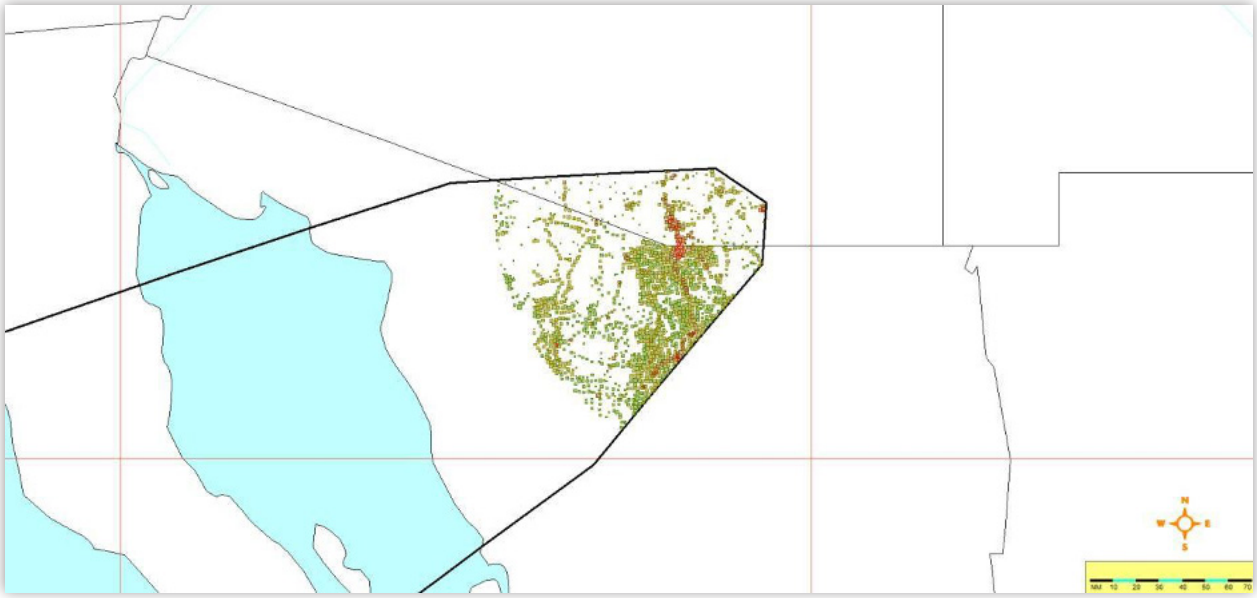


Figure 11: Population Data at 1 mi2 Resolution for the Corridor Area up to 100 NM from the Landing Point.

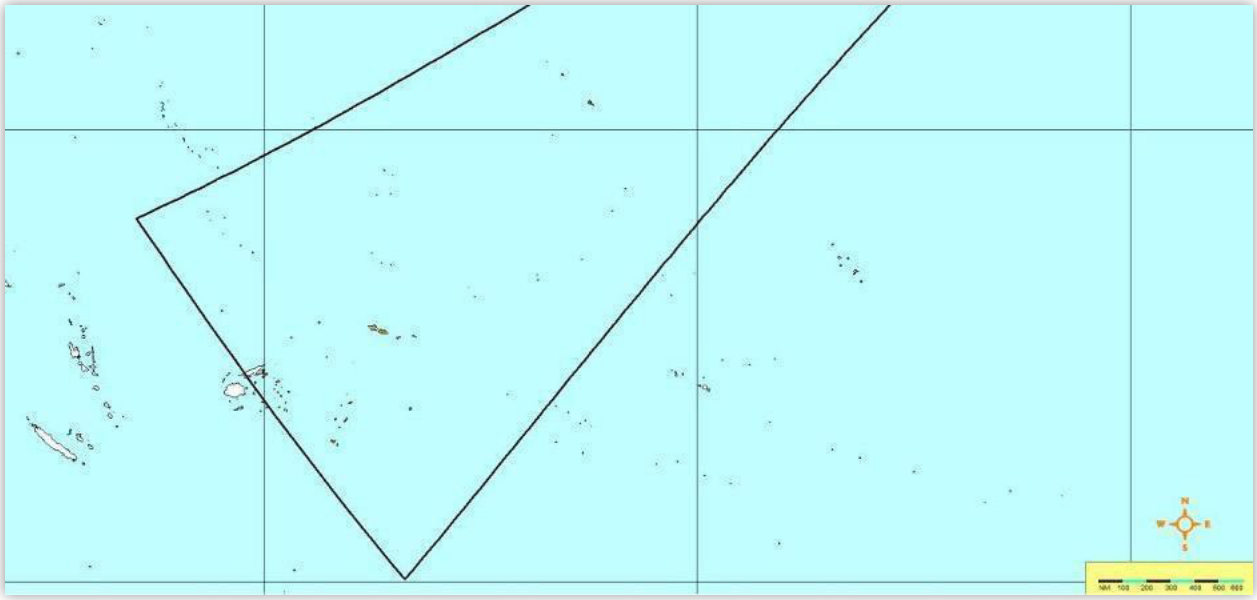


Figure 12: Population Data for the Downrange Corridor Area, Pacific Islands.

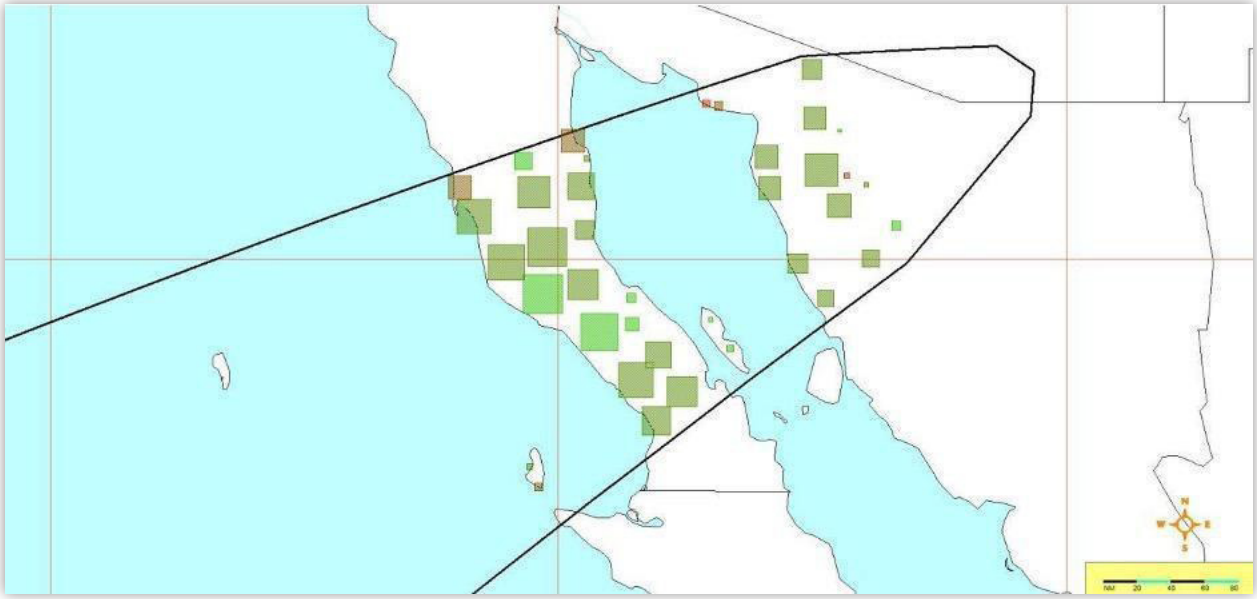


Figure 13: Population Data for the Downrange Corridor Area, Mexico.

DEFINING THE FLIGHT CORRIDOR

To define the flight corridor using the methods described in 14 CFR § 420 Appendix B, the center of the main runway at Sierra Vista Municipal Airport was utilized as the landing point, as shown in Figure 14. The corresponding latitude and longitude are 31.587565°N, -110.347599°E.

Figure 14: Sierra Vista Municipal Airport.

The debris dispersion radius (Dmax), overflight exclusion zone downrange distance (Doez), and flight corridor line segment lengths were selected using the “Small Orbital Launch Vehicles” value from Table A1 – Table A-3 in Part 420. The flight corridor parameters are shown in Table 2 The resulting flight corridor is shown in Figure 15.

Parameter	Value
D_{max}	1.20 nm
D_{oez}	3.30 nm
CF	39.45 nm
DE	117.87 nm
HI	1763.27 nm

Table 2: Flight Corridor Parameters.

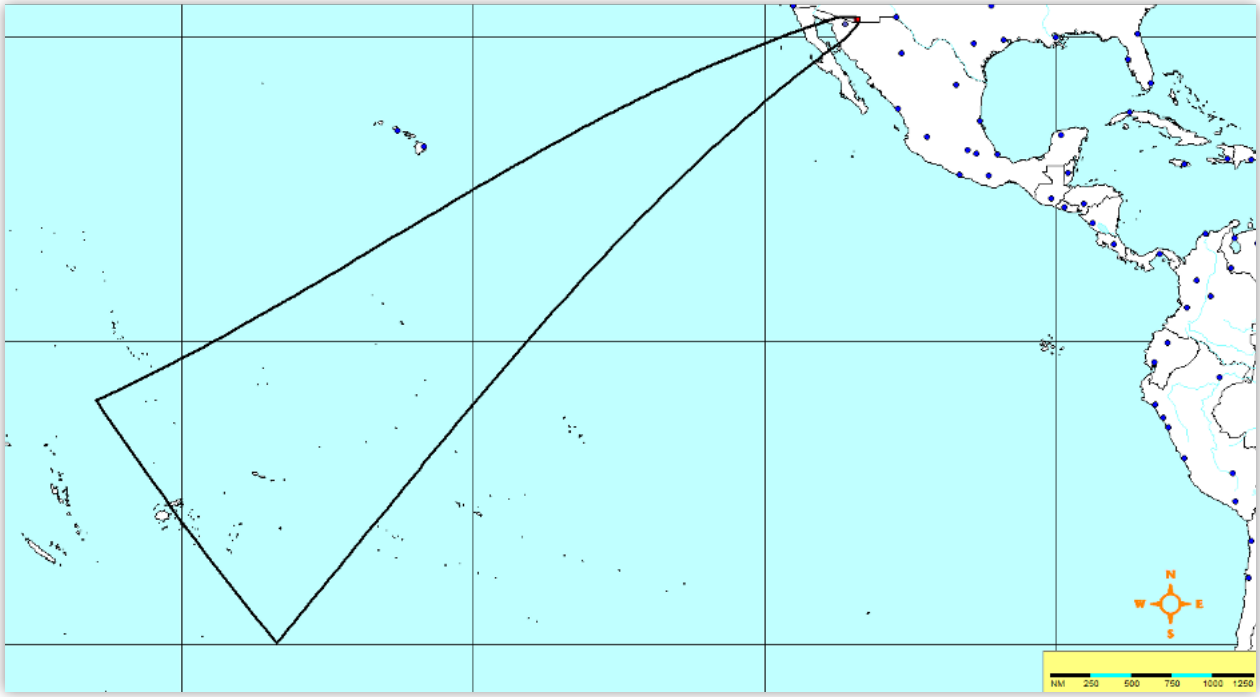


Figure 15: Flight Corridor Created Using § 420 Appendix B Equations.

EVALUATING THE FLIGHT CORRIDOR

The first evaluation performed used the values directly from 14 CFR Part 420 Appendix C. The inputs are described in Table 3.

Parameter	Value(s)
IIP Range	8 values per § 420 Table C-2
IIP Range Rate	8 values per § 420 Table C-2
Probability of Failure	0.10 per § 420 Appendix C (c)(5)(i)
Effective Casualty Area	3 Values per "Small Orbital Launch Vehicle" in § 420 Table C-3
IIP Range (for Effective Casualty Area)	3 Values per "Small Orbital Launch Vehicle" in § 420 Table C-3

Table 3. Evaluation 1 Inputs Summary.

Initial results indicated that the Expected Casualty (EC) calculations utilizing the values in Appendix C would yield overly conservative results that would not meet the requirements of § 420.25(b), which states the expected casualty must be below 1e-04. Therefore, the evaluation was performed utilizing the values based on the sample reentry vehicle to obtain more realistic results.

The IIP range values were calculated using the downrange and crossrange values from the sample reentry vehicle trajectory. The IIP range rate was calculated using the velocity vector values from the sample reentry vehicle trajectory. These values and the resulting calculated values are shown in Tables 4 and 5. Based on the fragment data, the casualty area was calculated to be 4.57e-04 mi^2. The probability of failure was reduced to 0.004. With these input values, the resulting expected casualty was 6.23e-05. This value is under the 1e-04 threshold requirement prescribed by § 420.25(b).

Downrange Distance (NM)	Crossrange Distance (NM)	IIP Range (NM)	Velocity North (ft/s)	Velocity East (ft/s)	Velocity Down (ft/s)	IIP Rate (NM/s)
-322.983	552.752	640.197	11438.089	10106.850	150.459	2.512
-110.090	301.032	320.531	9289.830	5580.981	320.784	1.784
-51.798	151.730	160.328	6768.434	627.277	312.257	1.119
-37.297	71.176	80.356	4031.974	1749.076	314.958	0.723
-20.443	34.789	40.351	2927.311	970.739	386.320	0.508
-14.460	14.138	20.223	1981.895	529.649	363.014	0.338
-7.495	-6.673	10.035	340.580	690.415	321.158	0.127
-2.526	-4.421	5.091	-502.778	298.496	234.658	0.096

Table 4: Updated IIP Range and IIP Rate.

Parameter	Value(s)
IIP Range	Column 3 in Table 4-2
IIP Range Rate	Column 7 in Table 4-2
Probability of Failure	0.004
Effective Casualty Area	4.57e-04 mi^2
IIP Range (for Effective Casualty Area)	Effective casualty area is for the entire trajectory

Table 5: Sample Reentry Vehicle Inputs Summary.

PUBLIC SAFETY SUMMARY AND CONCLUSION

A preliminary public safety feasibility analysis was performed for the proposed Sierra Vista Municipal Airport reentry site using sample reentry vehicle data. Population data was developed based on 14 CFR § 420 requirements. While the 14 CFR § 420 Appendix C input values produced overly conservative results that did not meet the FAA maximum permissible collective risk threshold of 1e-04, the sample reentry vehicle trajectory resulted in an acceptable expected casualty risk, indicating that Sierra Vista Municipal Airport may be an adequate location for a reentry site. Further evaluation can be done in the form of a sensitivity study to determine if additional alternative reentry azimuths may also result in acceptable collective risk.

ENVIRONMENTAL REVIEW

INTRODUCTION

An environmental desktop review was performed for a potential reentry site at Sierra Vista Municipal Airport in Sierra Vista, Cochise County, Arizona (*the Project Area*). The Project Area is approximately 17.4 acres of land located within the approximately 1,400-acre footprint of the Airport. The following sections detail the purpose, the involved parties, the scope of services, the findings, and the limitations and exceptions associated with this Desktop Review.

PURPOSE

The desktop review aims to evaluate nearby properties or facilities with potentially hazardous materials and petroleum storage or impacts and document onsite environmental impacts to the Project Area that could complicate planned infrastructure improvements. This desktop review comprises field reconnaissance, a supplemental electronic database search of the Project Area and the adjacent areas of the Airport, and a review of relevant environmental records provided by federal, state, and local regulatory agency databases and the Airport, where available. This desktop review is, therefore, limited to observable conditions that indicate whether a property or facility offers sufficient risk to the Project Area to recommend additional investigation. In addition, if properties or facilities that appear on relevant environmental databases indicate hazardous materials or petroleum impacts, the assessor may recommend further investigation. Historical research into past uses of the Project Area or past uses of properties along the Project Area should be included in this desktop review scope of work.

ACTIVITIES

This desktop review included the activities listed below:

1. Coordinate site access with the Airport authorities.
2. Attend an initial coordination meeting at the Airport for an in-person meeting with the City of Sierra Vista and relevant parties of the Airport at the onset of the feasibility analysis.
3. Attend other project-related virtual meetings as needed.

4. It reviews federal, state, and local regulatory agency databases for the Project Area and nearby properties. This review aims to evaluate the possible environmental impact on the Project Area from current or historical on- and off-site activities. Databases will identify locations of known hazardous waste sites, landfills, leaking underground storage tanks, permitted facilities that utilize underground storage tanks, and facilities that use, store, or dispose of hazardous materials.

5. Conduct a site visit to the Project Area and perform an environmental reconnaissance with a qualified Arizona-registered geologist or Environmental Engineer. Document potential hazardous materials handling, storage, and disposal practices. In addition, the Project Area reconnaissance will document areas of potentially contaminated surficial soil or surface water, possible sources of polychlorinated biphenyls (PCBs), underground and aboveground storage tanks, and possible sources of contamination from activities at the Project Area and adjacent properties. Features will be shown on a site map and included in the report.

6. Review reasonably ascertainable local regulatory agency files for the Project Area and adjacent properties. Review reasonably ascertainable historical documents, including aerial photographs and topographic maps, as appropriate.

7. Prepare a desktop review report including findings, opinions, and conclusions.

This desktop review is intended to cover only some aspects of a Phase I Environmental Site Assessment outlined in the ASTM International (ASTM) E1527-21. Furthermore, the following represents additional out-of-scope items concerning this Desktop Review and, therefore, are not addressed: asbestos, lead-based paint, radon, lead in drinking water, wetlands, regulatory compliance, cultural and historical risk, industrial hygiene, health and safety, ecological resources, endangered species, indoor air quality, and high-voltage power lines. In addition, this desktop review does not address interpretations of zoning regulations, building code requirements, or property title issues.

LOCATION AND DESCRIPTION OF PROJECT AREA

The Project Area consists of approximately 17.4 acres of land within the northern portion of the Sierra Vista Municipal Airport, located at 2100 Airport Avenue in Sierra Vista, Cochise County, Arizona.

The Project Area is located within the northwest quarter of Section 20, Township 21 South, Range 20 East, of the Gila and Salt River Baseline and Meridian, in Cochise County, Arizona. Properties near the Project Area include predominantly light industrial and federal land.

RECONNAISSANCE OF PROJECT AREA AND LIMITED GEOLOGIC DATA

On May 21, 2024, the Project Area field reconnaissance was conducted. The reconnaissance involved a walking tour of the Project Area and visual observations of adjacent properties. The City of Sierra Vista and Airport personnel provided access to the Project Area and answered general questions regarding the Project Area and the overall Airport facilities. Photographs taken during the reconnaissance of the Project Area are included in Appendix B. During the reconnaissance, the weather was sunny, with a temperature of approximately 86 degrees Fahrenheit.

The following paragraphs discuss the usage of facilities and property observed during the reconnaissance to be within or adjacent to the Project Area.

PROJECT AREA

The Project Area is located on the northern portion of the Sierra Vista Municipal Airport. Utilities available in the vicinity include electricity provided by Sulphur Springs Valley Electric Cooperative, natural gas provided by Southwest Gas, water provided by two domestic water source wells, and sanitary sewer services provided by the City of Sierra Vista.

At the time of the Project Area reconnaissance, the southwestern portion of the Project Area was observed as concrete-covered and included the tarmac area, which included a helicopter landing area and a Jet A fuel refueling tanker truck with an approximately 5,000-gallon capacity tank. The concrete pad and tarmac area appeared to be in good condition, and no staining or indications of fuel leaks were observed. The remaining northern portion of the Project Area appeared as gravel covered with a retention basin on the north-northwestern portion. Underground utility hubs, electrical panels, a water hose bib, and a fire hydrant were observed in the southern portion of the Project Area. According to the City of Sierra Vista and Airport personnel, much of the Project Area had been leveled with imported soil and gravel from other areas of the Airport. No documentation was provided by Sierra Vista or Airport personnel regarding the origins or placement of the imported gravel and soil fill. No significant staining or discoloration was observed on the gravel-covered areas of the Project Area. Some minor staining regions (less than 1 foot diameter) were observed near the utility hubs.

Historically, PCBs (a group of hazardous substances and suspected human carcinogens) were widely used as an additive in cooling oils for electrical components, including electrical transformers. One pad-mounted transformer was observed on the southern portion of the Project Area and just north of the concrete pad of the tarmac. The pad-mounted transformer was labeled as non-PCB-containing and appeared in good condition, with no staining, damage, or corrosion observed.

A block-walled well pad area, including a groundwater well, a water tank, and an associated shed, was observed on the eastern portion of the Project Area. According to information reviewed by the Arizona Department of Water Resources (ADWR), the well is known as Airport Well Site #2 (Well ID 55-562352) and is owned by the City of Sierra Vista. According to Sierra Vista personnel, the well is one of two utilized for domestic water production at the Airport. No evidence of underground storage tanks was observed within the Project Area.

ADJACENT TO THE PROJECT AREA

The properties adjacent to the Project Area included the remaining portions of the Sierra Vista Municipal Airport, the Libby Army Airfield, Fort Huachuca, and vacant land. The adjacent areas are further described below:

North:
Vacant Land

South:
The Sierra Vista Municipal Airport tarmac and runway areas with the Libby Army Airfield and Fort Huachuca areas beyond.

East:
The Sierra Vista Municipal Airport parking lot and terminal. The team observed an aboveground fuel tank farm approximately 1,500 feet east of the Project Area and 250 feet north of the conventional hanger. The fuel tank farm was enclosed with a chain-link fence and consisted of five aboveground storage tanks of 15,000-gallon capacity. Two tanks contained Jet A fuel, and three contained 100LL fuel. Additionally, a self-service fuel facility was observed, located adjacent to the southeast side of the terminal building, with one aboveground storage tank of 5,000 gallons and containing 100LL fuel.

In addition, an aboveground water storage tank with an approximately 60,000-gallon capacity and an approximately 1,000-gallon water tank was observed within the fenced area of the Airport Well Site #1 (Well ID 55-505189) just west of the fuel tank farm area.

West:
The Sierra Vista Municipal Airport tarmac and runway areas and vacant land beyond.

The environmental database report prepared for the Project Area vicinity identified multiple facilities. For a discussion of these database listings and their significance to the Project Area, see Section 7 of the report to follow.

LIMITED GEOLOGIC DATA

Based on data obtained from wells located within an approximately one mile radius of the Project Area, the depth to groundwater in the vicinity of the Project Area is approximately 430 feet below the ground surface (bags). Based on a review of readily available groundwater information, the regional groundwater flow direction in the vicinity of the Project Area is generally towards the east; however, a subsurface evaluation still needs to be conducted to confirm the local groundwater flow direction in the vicinity of the Project Area.

According to the 2021 United States Geological Survey 7.5–Minute Topographic Quadrangle Fort Huachuca, Arizona, the approximate elevation of the Project Area is 4,650 feet above sea level. The United States Department of Agriculture, Natural Resource Conservation Service online web soil survey was reviewed to obtain soil data for the Project Area. The soil in the Project Area consists of the White House complex, with 1 to 30 percent slopes.

RESULTS OF REGULATORY AGENCY LIST REVIEW

A computerized environmental database search was performed, with results summarized in an Area Study dated May 13, 2024. The Area Study included a summary of the review of federal, state, and local environmental databases. A copy of the Area Study, which consists of a description of the assumptions made and approaches to the database search, in addition to the results, is provided in Appendix D. The review was conducted to evaluate whether land use within the Project Area or in the Project Area vicinity has been identified as having experienced significant unauthorized releases of hazardous substances or other events with potentially adverse environmental effects to the Project Area. The survey area defined in the Area Study includes the entirety of Sierra Vista Municipal Airport; however, it should be noted that the Project Area, encompasses only approximately 17.4 acres of land located on the northern portion of the Area Study boundary. Fifty-seven listings were identified in the Area Study within the standard ASTM search radii (up to one mile for some databases). Of these listings, approximately seven were within one-eighth of a mile of the Project Area.

A summary of the standard environmental database search results and results of other environmental databases searched that have listings within or adjacent to the Project Area are presented in the following table.

Database Name	Agency	Minimum Search Distance	Total Properties Plotted
Federal Records			
NPL / Proposed NPL / Department of Defense (DOD) Sites	USEPA	Project Area and adjacent	3
Delisted NPL	USEPA	Project Area and adjacent	0
Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS) List / CERCLIS No Further Remedial Action Planned (NFRAP)	USEPA	Project Area and adjacent	0
Resource Conservation and Recovery Act (RCRA) Hazardous Waste Generators	USEPA	Project Area and adjacent	0
RCRA Corrective Action Treatment, Storage, and / or Disposal Facilities (CORRACTS TSDFs)	USEPA	Project Area and adjacent	0
RCRA Non-CORRACTS TSDFs	USEPA	Project Area and adjacent	0
Emergency Response Notification System (ERNS) Database	USEPA	Project Area and adjacent	0
Superfund Enterprise Management System (SEMS)	USEPA	Project Area and adjacent	0
Superfund Enterprise Management System (SEMS)-Archive	USEPA	Project Area and adjacent	0
State and Local Records			
Arizona Water Quality Assurance Revolving Fund Sites (WQARF)	ADEQ	Project Area and adjacent	0
Superfund Program List (SPL)	ADEQ	Project Area and adjacent	1
Solid Waste Facilities/Landfill (SWLF) Lists, Operating and Closed	ADEQ	Project Area and adjacent	0
Institutional / Engineering Control Databases	ADEQ	Project Area and adjacent	0
Brownfields/Voluntary Remediation Program (VRP)	ADEQ	Project Area and adjacent	0

List of Aboveground Storage Tanks (AST)	Department of Building and Fire Safety	Project Area and adjacent	2
Registered Underground Storage Tank (UST) List (Includes Tribal Records)	ADEQ	Project Area and adjacent	2
Leaking Underground Storage Tank (LUST) Lists (Includes Tribal Records)	ADEQ	Project Area and adjacent	0
Arizona National Priorities List (NPL)	ADEQ	Project Area and adjacent	0
Arizona State Hazardous Waste Sites (SHWS)	ADEQ	Project Area and adjacent	0
Arizona Enforcement	ADEQ	Project Area and adjacent	0
Additional Environmental Record Sources			
RCRA Compliance Facilities	ADEQ	Project Area and adjacent	0
Hazardous Materials Incidents Emergency Response Logbook	ADEQ	Project Area and adjacent	0
Drywells Registration Database (includes Tribal Records)	ADEQ	Project Area and adjacent	0
Environmental Permits Database	ADEQ	Project Area only	0
Voluntary Environmental Mitigation Use Restrictions (VEMURs), Declaration of Environmental Use Restrictions (DEURs), and Environmental Liens	ADEQ	Project Area only	0
Drycleaners	ADEQ	Project Area and adjacent	0
Enforcement and Compliance History Online (ECHO)	EDR	Project Area	0
Federal Facility Index System/Facility Registry System (FINDS)	USEPA	Project Area and adjacent	4
EMAPS	ADEQ	Project Area	6
Brownfields	ADEQ	Project Area and adjacent	0
Indian Reservation	USEPA	Project Area and adjacent	0

The following paragraphs describe incidents and facilities identified in the Area Study report that are within or immediately adjacent to the Project Area, discuss their regulatory status, and assess potential environmental impacts to the Project Area, if any.

According to the Area Study report, three of these areas or facilities were identified within the Project Area boundary, and approximately 7 of these listings or facilities were identified adjacent to the Project Area, under database listings including the AZ DOD, DOD, EMAPs, ENFORCEMENT, and SPDES. These areas or facilities are discussed in the following paragraphs:

Fort Huachuca: The Fort Huachuca listing was located just north of the project area. This listing is located west of Sierra Vista in southeastern Arizona on the western flank of the San Pedro River Valley; Fort Huachuca consists of an irregularly shaped area of 115 square miles bisected by Arizona State Highway 90. The installation is divided into the Cantonment area, the Libby Army Air Field, and the East, West, and South Ranges, where military training operations are conducted.

- DOD and SPL: According to information provided by the Area Study, groundwater monitoring activities were reported as ongoing in association with the South Range Landfill, which consisted of two intermittently used trenches from 1940 to 1975. The South Range Landfill was approximately 5.2 miles south of the Project Area. Groundwater monitoring for the South Range Landfill continues, and no exceedance has been reported. In January 2018, the Final Decision Document for the Minefield Near the Airport was signed. The Eastern Artillery Range 2 in-fill transect report was submitted to ADEQ in February 2018 to support the RI amendment. ADEQ and USACE are discussing the findings and acceptable risks. The Site Characterization/Corrective Action Completion Report for the Vehicle Maintenance Facility LUST site was submitted in May 2018 for review. The following Five-Year review was completed in 2019 and included groundwater monitoring for the East Range Shaft and South Range Landfill.
- COSV Municipal Airport Outfall Normal Drainage: This was located in the northern portion of the Project Area.
- EMAPs: The facility was listed under the ADEQ online EMAP database systems, including various facilities under ADEQ interest or jurisdiction. The COSV Airport Outfall Normal Drainage listing is associated with a stormwater discharge point. There is no additional information regarding this discharge point or if stormwater sampling is required at this location.

COSV Municipal Airport: The COSV Municipal Airport listing was marked along the northwestern boundary of the Project Area; however, it is associated with the entire Airport.

- EMAPs: EMAPs is a Geographic Information System (GIS) database system of environmental data maintained by ADEQ. The COSV Municipal Airport is listed because it is under ADEQ jurisdiction and has environmental data, including fuel storage tanks and airport activities, that are outside the Project Area.
- SPDES: COSV Municipal Airport was identified in the SPDES database under a Construction General Permit with a Closed application status.
- COSV Municipal Airport Outfall Existing Slope AZ: The COSV Municipal Airport Outfall Existing Slope AZ adjoined the Project Area to the north.
- EMAPs: The facility was listed under the ADEQ online EMAP and AZURITE database systems, which includes various facilities under ADEQ's interest or jurisdiction. The COSV Municipal Airport Outfall Existing Slope AZ listing is associated with a stormwater discharge point—no additional information regarding this discharge point or if stormwater sampling is required at this location.
- COSV Municipal Airport Outfall Natural Existing SL: The COSV Municipal Airport Outfall Natural Existing SL adjoined the Project Area to the northwest.
- EMAPs: The facility was listed under the ADEQ online EMAP database system, including various facilities under ADEQ interest or jurisdiction. The COSV Municipal Airport Outfall Natural Existing SL listing is associated with a stormwater discharge point—no additional information regarding this discharge point or if stormwater sampling is required at this location.
- Libby Army Airfield Perimeter Fence Outfall: This Outfall was located in the northern portion of the Project Area.
- EMAPs: The facility was listed under the ADEQ online EMAP and AZURITE database systems, which include various facilities under ADEQ's interest or jurisdiction. The Libby Army, Airfield Perimeter Fence Outfall listing, is associated with a stormwater discharge point. There is no additional information regarding this discharge point or whether stormwater sampling is required at this location.
- Sierra Vista Municipal Airport: Sierra Vista Municipal Airport was located at 2500 Aviation Boulevard, adjacent to the Project Area to the southeast.
- EMAP: EMAPs is a Geographic Information System (GIS) database system of environmental data maintained by ADEQ. The COSV Municipal Airport is listed because it is under ADEQ jurisdiction and has environmental data, including fuel storage tanks and airport activities, that are outside the Project Area.
- ENFORCEMENT: The facility was listed on the enforcement database with one notice of violation, issued on December 3, 2014, in association with AZPDES Stormwater Permitting; however, the notice of violation has been closed.

RECORDS REVIEW

Reasonably ascertainable documents for the Project Area were requested from the Arizona Department of Environmental Quality (ADEQ) and reviewed. Documentation regarding the storage of hazardous materials or environmental records associated with the Project Area or the Airport was requested from the City of Sierra Vista Municipal Airport; however, at the time of writing this report, no hazardous materials or environmental records were provided by the City of Sierra Vista Municipal Airport.

According to the ADEQ records reviewed that were associated with the Airport adjacent to the Project Area, five steel underground storage tanks (USTs) and two fuel dispenser islands located approximately 1,000 feet southeast of the Project Area were removed from the Airport in March 1990. The UST capacities included a 10,000-gallon capacity UST, two 4,000-gallon capacity USTs, one 3,000-gallon capacity UST, and one 2,000-gallon capacity UST, all constructed of steel and reportedly contained gasoline. According to the ADEQ records reviewed, the USTs were closed by removal between March 7 and 8, 1990, and soil samples were collected two feet below the USTs on each end of the UST excavation for a total of ten samples. No visible contamination was documented; however, no laboratory data was included in the ADEQ records for the UST removal. Due to the distance from the Project Area, it is unlikely that contamination from these USTs, if present, would significantly impact the Project Area at this time.

ENVIRONMENTAL REVIEW FINDINGS AND CONCLUSIONS

The following presents a summary of findings associated with the desktop review performed for the Project Area, including known or suspected environmental conditions related to the Project Area:

- At the time of the Project Area reconnaissance, the southwestern portion of the Project Area was observed as concrete-covered and included the tarmac area, which included a helicopter landing area and a Jet A fuel refueling tanker truck with an approximately 5,000-gallon capacity tank. The concrete pad and tarmac area appeared to be in good condition, and no staining or indications of fuel leaks were observed. The remaining northern portion of the Project Area appeared as gravel covered with a retention basin on the north-northwestern portion. Underground utility hubs, electrical panels, a water hose bib, and a fire hydrant were observed in the southern portion of the Project Area. According to the City of Sierra Vista and Airport personnel, much of the Project Area had been leveled with imported soil and gravel from other areas of the Airport. No documentation was provided by Sierra Vista or Airport personnel regarding the origins or placement of the imported gravel and soil fill. No significant staining or discoloration was observed on the gravel-covered areas of the Project Area. Some minor staining

areas (less than 1 foot diameter) were observed near the utility hubs.

- One pad-mounted transformer was observed on the southern portion of the Project Area and just north of the concrete pad of the tarmac. The pad-mounted transformer was labeled non-PCB-containing and appeared in good condition, with no staining damage or corrosion observed.
- A block-walled well pad area, including a groundwater well, a water tank, and an associated shed, was observed on the eastern portion of the Project Area. According to information from ADWR, the well is known as Airport Well Site #2 (Well ID 55-562352) and is owned by the City of Sierra Vista. According to Sierra Vista personnel, the well is one of two utilized by the Airport for domestic water production.
- No evidence of underground storage tanks within the Project Area was observed.
- The Area Study report included some environmental database listings within the Project Area, and the Project Area is adjacent to the Fort Huachuca DOD, SPL, and AZDOD facility listings. Other facilities identified adjacent to the Project Area included EMAP, ENFORCEMENT, and SPDES listings. Further facilities were identified in the AST, UST, and FINDS databases. Based on the type of database listings, additional information reviewed, including ADEQ records reviewed, and the relative distance of these listings to the Project Area, these facilities are unlikely to have impacted the Project Area.
- Properties adjacent to the Project Area included vacant land to the north; portions of the Sierra Vista Municipal Airport, the Libby Army Airfield, and Fort Huachuca to the south; the Sierra Vista Municipal Airport parking lot and terminal to the east; and the Sierra Vista Municipal Airport tarmac and runway areas with vacant land beyond to the west.
- The Sierra Vista Municipal Airport parking lot and terminal. An above-ground fuel tank farm was observed, approximately 1,500 feet east of the Project Area and 250 feet north of the conventional hanger. The fuel tank farm was enclosed with a chain-link fence and consisted of five above-ground storage tanks of 15,000-gallon capacity. Two tanks contained Jet A fuel, and three contained 100LL fuel. A self-service fuel facility was also observed, located adjacent to the southeast side of the terminal building, with one above-ground storage tank of 5,000 gallons containing 100LL fuel.
- In addition, an above-ground water storage tank of approximately 60,000-gallon capacity was observed, as well as an approximately 1,000-gallon water tank located within the fenced area of the Airport Well Site #1 (Well ID 55-505189), which was observed just west of the fuel tank farm area.
- According to the ADEQ records reviewed that were associated with the airport adjacent to the Project Area, five steel USTs and two fuel dispenser islands located approximately 1,000 feet southeast of the Project Area were closed by removal between March 7 and 8, 1990, and soil samples were collected two feet below the USTs on each end of UST

excavation for a total of ten samples. No visible contamination was documented. However, no laboratory data was included in the ADEQ records for the UST removal. Due to the distance from the Project Area, it is unlikely that contamination from these USTs, if present, would significantly impact the Project Area at this time.

- Requests were made to the City of Sierra Vista Municipal Airport for documentation regarding storage of hazardous materials or environmental records associated with the Project Area or the Airport; however, at the time of writing this report, no records were provided by the City of Sierra Vista Municipal Airport.

ENVIRONMENTAL REVIEW RECOMMENDATIONS

The purpose of the Desktop Review was to evaluate whether sufficient risks exist from properties located within or adjacent to the Project Area to warrant further investigation. The information reviewed for this report documented no significant environmental impacts within the project area. However, imported soils from other areas of the Airport were reportedly used to level the Project Area and need to be tested. We recommend subsurface soil sampling of the imported material before or concurrent with the development of the Site to rule out potential subsurface soil contamination associated with the imported soils. Based on the information reviewed for this report, facilities adjacent to or near the Project Area do not appear to have significantly impacted it or warrant further investigation.

ENVIRONMENTAL CONSIDERATIONS

PROJECT DESCRIPTION

BlackStar Orbital Technologies Corporation (BlackStar) plans to build a manufacturing facility at Sierra Vista Municipal Airport in 2024. Once the facility is constructed, BlackStar intends to create and refurbish the first of several spacecraft there. The BlackStar vehicle is a reusable satellite that acts as a payload or part of a payload lifted into space via another company's rocket. Once its mission is completed, the spacecraft will perform a reentry over southern Arizona as an un-propelled aircraft similar to a glider or resembling the former NASA Space Shuttle, using less than 5,000 feet to land at the Sierra Vista Municipal Airport successfully. The vehicle would be towed or moved from the runway to the facility in some other manner.

The planned facility, as of now, would be approximately 24,000 square feet with access to the currently existing apron and the parking lot, which would include truck and loading access. For decontamination purposes, building a separate stand-alone rinse area or structure is discussed. Water from the rinse area would be contained, removed from the site, and disposed of following industry-standard procedures.

The proposed facility would employ approximately 50 people, many of whom would be Sierra Vista residents. BlackStar anticipates one or two missions per quarter, increasing in frequency over the first couple of years. It is anticipated that the first mission landings would garner a lot of public and media attention.

PROJECT DEVELOPMENT CONSIDERATIONS

Environmental Requirements

The operation of the space reentry facility is contingent on a Federal permit issued by the Federal Aviation Administration (FAA). This permit constitutes a Federal nexus and requires compliance with the National Environmental Policy Act (NEPA). The City of Sierra Vista is seeking a License to Operate a (Spaceport) Reentry Site (14 Code of Federal Regulations [CFR] Part 433). Under these guidelines, the City must provide the FAA with sufficient information to analyze the environmental impacts associated with the proposed operation of a reentry site. The information provided must be adequate to enable the FAA to comply with the requirements under NEPA, the Council on Environmental Quality Regulations for implementing the procedural provisions

of NEPA, 40 CFR Parts 1500–1508, and the FAA's procedures for considering environmental impacts, FAA Order 1050.1F. The following sections of this report provide a high-level summary of the ecological issues identified to date and the additional analyses and documentation that may be required to support the FAA permit authorization.

Species Investigation

The Arizona Game and Fish Department (AZGFD) Arizona Environmental Online Review Tool Report (the report) and the USUS Fish and Wildlife Service (FWS) Information for Planning and Consultation (IPaC) website were reviewed on May 29, 2024, to determine whether sensitive species or habitats potentially occur in the project area and to obtain a list of Federally protected species that could happen in the project area.

In addition to a site visit conducted on May 21, 2024, recent aerial photography was reviewed to identify existing terrain and habitat conditions in the project area. The project area comprises an airport facility northwest of Sierra Vista, Arizona, and north of Fort Huachuca, a US Army installation. The runways are part of a shared-use agreement between the City and Fort Huachuca. Although the airfield is a joint-use facility, BlackStar would operate solely on the municipal side of the airport.

Natural terrain is found just outside the project area. Vegetation is limited to areas outside of the runway and airport facilities. The aerial shows that the airport is primarily surrounded by natural habitat for wildlife. The proposed location of the BlackStar facility has been previously graded and now supports low-stature grasses, shrubs, and forbs, including some non-native species.

The AZGFD report identified the following species protected under the Endangered Species Act (ESA) (Threatened, Endangered, Proposed, Candidate, or Candidate Conservation Agreement species) occurring within 3 miles of the project limits.

Candidate species:

- Monarch butterfly (Danaus plexippus)

Listed Threatened species:

- Yellow-billed cuckoo (Coccyzus americanus)
- Chiricahua leopard frog (Rana chiricahuensis)
- Northern Mexican garter snake (Thamnophis eques megalops)

Species of Concern:

- Mexican long-tongued bat (Choeronycteris Mexicana)
- Pale Townsend's big-eared bat (Corynorhinus townsendii pallescens)
- Huachuca golden aster (Heterotheca rutteri)

- Lesser long-nosed bat (Leptonycteris yerbabuenae)
- Western small-footed myotis (Myotis ciliolabrum)
- Fringed myotis (Myotis thysanodes)
- Cave myotis (Myotis velifer)

The FWS IPaC official species list identified 11 Threatened (T), Endangered (E), and Candidate (C) species that may be present in the project area if suitable habitat is present:

- Jaguar (Panthera onca) – E
- Ocelot (Leopardus pardalis) – E
- Cactus ferruginous pygmy-owl (Glaucidium brasilianum cactorum) – T
- Mexican spotted owl (Strix occidentalis lucida) – T
- Northern aplomado falcon (Falco femoralis septentrionalis) – E; Experimental Population,

Non-Essential

- Yellow-billed cuckoo – T
- Monarch butterfly – C
- Arizona eryngo (Eryngium sparganophyllum) – E
- Canelo Hills ladies'-tresses (Spiranthes delitescens) – E
- Huachuca water-umbel (Lilaeopsis schaffneriana var. recurve) – E
- Wright's marsh thistle (Cirsium wrightii) – T

No suitable habitat is present for these 11 species within the project limits; therefore, the project is not expected to affect them. In addition, there are no critical habitats within the project area. Additionally, three fish species were included in the IPaC report.

There are no lakes or streams present within the project area.

The project limits contain potentially suitable habitats for migratory birds, including a detention pond known to attract birds. If any trees are trimmed or removed during the bird breeding season, generally spring through summer, compliance with the Migratory Bird Treaty Act would be required.

A Biological Evaluation should be prepared to fully address the reentry site's potential impacts on protected species. The report should include sections addressing native plants, wildlife, and species protected under the ESA and the Migratory Bird Treaty Act. Similarly, species-specific protocol surveys or ESA Section 7 consultation with the FWS would likely be optional, meaning 'no affect' determinations would be likely.

WETLAND AND RIPARIAN AREAS

A review of recent aerial photography, the AZGFD Report, and the FWS National Wetlands Inventory indicated no emergent wetland areas in the project area.

However, Figure 16 indicates five riverine habitats intersect with the Sierra Vista Municipal Airport, four of which have a classification code of R4SBC and one that has a classification code of R4SBJ (FWS 2019):

System Riverine (R): The Riverine System includes all wetlands and deepwater habitats contained within a channel, with two exceptions: (1) wetlands dominated by trees, shrubs, persistent emergents, emergent mosses, or lichens, and (2) habitats with water containing ocean-derived salts of 0.5 ppt or greater. A channel is an open conduit, either naturally or artificially created, that periodically or continuously contains moving water or forms a connecting link between two bodies of standing water.

Subsystem Intermittent (4): This subsystem includes channels that contain flowing water for only part of the year. When the water is not flowing, it may remain in isolated pools, or surface water may be absent.

Class Streambed (SBSB): Includes all wetlands within the Intermittent Subsystem of the Riverine System and all channels of the Estuarine System or the Tidal Subsystem of the Riverine System that are completely dewatered at low tide.

Water Regime Intermittently Flooded (J): The substrate is usually exposed, but surface water is present for variable periods without detectable seasonal periodicity. Weeks, months, or even years may intervene between periods of inundation. The dominant plant communities under this Water Regime may change as soil moisture conditions change. Some areas exhibiting this Water Regime do not fall within our wetland definition because they need hydric soils or support hydrophytes. This Water Regime is generally limited to the arid West.

Water Regime Seasonally Flooded (C): Surface water is present for extended periods, especially early in the growing season, but is absent by the end of the growing season in most years. The water table after flooding ceases is variable, extending from saturated to the surface to a water table well below the ground surface.

Although one of these washes appears to cross through the proposed BlackStar facility's location, it has been diverted to a detention basin, and the outflow is routed around the airport. Construction and operation of the facility would not impact these mapped riverine systems.

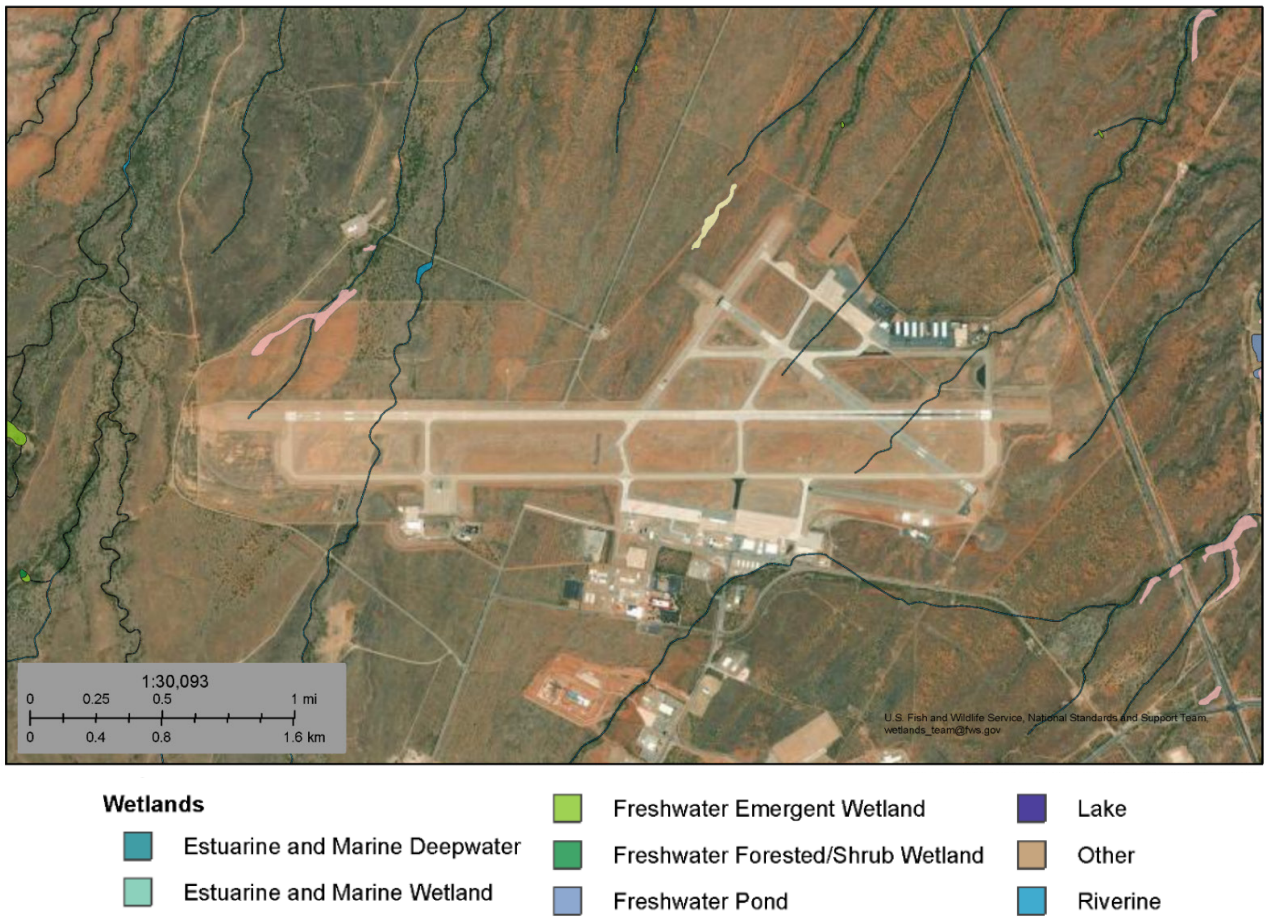


Figure 16: Map of wetlands inventory of project area; from FWS 2019.

FLOODPLAIN ENCROACHMENT

A review of the Federal Emergency Management Agency Flood Insurance Rate Maps (04003C2128F, 04003C2129F, 04003C2127F, and 04003C2126F) dated August 28, 2008, indicated that there are no designated 100-year floodplains or Special Flood Hazard Areas with Base Flood Elevations present within the area. Coordination with the floodplain administrator regarding the project is optional.

SECTIONS 401 AND 404 OF THE CLEAN WATER ACT

A review of recent aerial photography, the FWS National Wetland Mapper, and Esri topographic maps indicated that small sections of the northern, western, and southern portions of the Sierra Vista Municipal Airport/Libby Army Airfield extend through a more extensive drainage system connected to the Babocomari River, located approximately 3 miles to the north of the project

area. The Babocomari River is considered a Waters of the United States (WUS); tributaries to the Babocomari River may also be regarded as WUS. During the preparation of the NEPA document, a field review should be conducted to delineate the boundaries and determine the characteristics of any tributary that may be impacted during construction. The project would likely be permitted under a Nationwide Permit if these tributaries are affected.

SECTION 6(F) OF THE LAND AND WATER CONSERVATION FUND ACT

This does not apply to the project.

SECTION 4(F) OF THE U.S. DOT ACT

This does not apply to the project.

SOCIAL AND ECONOMIC IMPACTS

Title VI of the Civil Rights Act of 1964 and related statutes assure that individuals are not excluded from participation in, denied the benefit of, or subjected to discrimination based on race, color, national origin, age, sex, or disability under any program or activity receiving Federal financial assistance. Executive Order 14096 on environmental justice (EJ), dated April 21, 2023, mandates that agencies examine adverse cumulative impacts of pollution, climate change, and other burdens that disproportionately impact communities of color and low-income communities, in addition to addressing research and data gaps to identify public health risks when a federal decision is involved (with an emphasis on Tribal communities).

The project would be constructed on lands currently owned by the city and operating as an existing airport facility; therefore, high and adverse human health or environmental effects on minority and low-income populations would not be expected. Further analysis under Title VI and EJ analysis will be conducted during the preparation of the NEPA document.

Mission landings will likely attract media and local public interest to Sierra Vista, which will likely have a positive economic impact on local restaurants, hotels, and other businesses.

CULTURAL AND HISTORIC RESOURCES

This project would be considered an undertaking subject to review under the Arizona State Historic Preservation Act of 1982, as well as Arizona Revised Statutes §41-841 and §41-861. The project area would be defined as the project limits where ground-disturbing activities would occur. The project area could also include adjacent historic buildings and structures (if any) that might be affected by improvement-related alterations to their settings.

The online cultural resources database for Arizona, known as AZSITE, was reviewed to determine whether the project area had been previously surveyed and whether previously known cultural resources were present. The overview presented here is a summary of the AZSITE review and is not a complete Class I inventory because it needs to include the required tables and graphics showing the previous surveys and known sites.

According to AZSITE and Figure 17, large portions of the project area have been previously surveyed. Nineteen projects have previously been conducted, covering approximately 50% of the Sierra Vista Municipal Airport/Libby Army Airfield. The most recent project was conducted in 2013 by Statistical Research, Inc. (2014-330 ASM).

Per the Arizona State Historic Preservation Office Guidance Point No. 5, projects conducted more than ten years prior are considered inadequate as conditions in the area have likely changed, or buildings or structures that were not old enough for consideration may now need to be evaluated.

Although there are approximately 48 previously recorded sites within and directly outside of the project area, only six sites directly intersect the boundary of the airport/project area (Table 6). Additionally, eight newly recorded sites are in the airport's surrounding area. The area of interest for the current project (see Figure 17) does not have any known archaeological sites within it; however, that airport area has yet to be surveyed entirely according to the previous projects available in AZSITE.

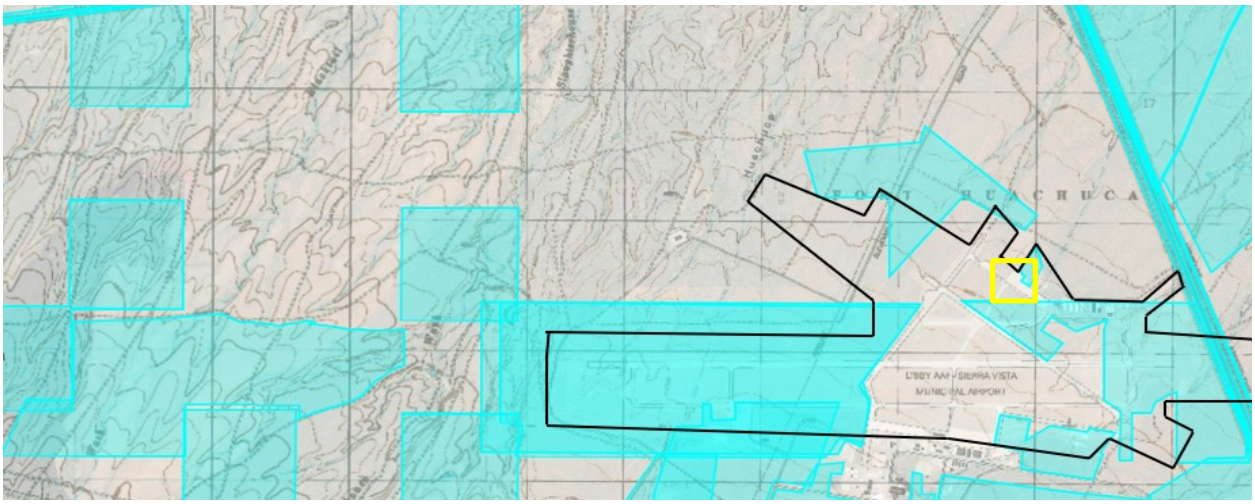


Figure 17: Sierra Vista Municipal Airport Wetlands Inventory Map.

Site No.	Site Type	Cultural Affiliation	NRHP Eligibility
AZ EE:7:23(ASM)	Undefined rock feature	Unknown	Not evaluated
AZ EE:7:24(ASM)	Dump	Euroamerican	Not evaluated
AZ EE:7:25(ASM)	Undefined rock feature	Unknown	Not evaluated
AZ EE:7:26(ASM)	Undefined rock feature	Unknown prehistoric	Not evaluated
AZ EE:7:176(ASM)	Road trail	Euroamerican	Eligible (SHPO)
AZ EE:7:381(ASM)	Artifact scatter	Euroamerican	Not Eligible (SHPO)

Key: NRHP = National Register of Historic Places; SHPO = State Historic Preservation Office.

Table 6. Archaeological Sites Directly Intersecting or within the Sierra Vista Municipal Airport Boundary.

The proposed BlackStar project area should be fully surveyed during the NEPA process to determine whether any cultural resource sites may be impacted during the site's development. Based on the type and extent of known sites in the vicinity of the airport, it is not anticipated that the surveys would result in significant findings.

SCENIC OR HISTORIC ROAD

No State or Federally designated scenic or historic road was identified within the project limits or in the project area.

WILDERNESS AREA

The nearest designated wilderness area is the Dos Cabezas Mountain Wilderness area, 65 miles northeast of the Sierra Vista Municipal Airport/Libby Army Airfield. No impacts are anticipated.

NOISE

The proposed reentry site is a joint-use municipal and U.S. Army airport. The proposed reentry vehicle would function as a glider upon landing (i.e., not under mechanical power). The reentry event itself would not contribute additional noise above what is already occurring in the surrounding environment. The reentry vehicle would produce a sonic boom; however, the anticipated noise generated from the boom is expected to be no greater than that of a handgun. The sonic boom would occur approximately 10–20 nautical miles west of Sierra Vista, at 60,000–90,0000 feet. Under these conditions, the noise generated from the reentry is anticipated to be negligible.

ENVIRONMENTAL CONSIDERATIONS CONCLUSION

The above-mentioned environmental considerations were made from a desktop review of the project area. These considerations should be incorporated into any further environmental analysis of the project area. The NEPA document prepared to support the FAA license will review these resources in more detail; however, this initial assessment did not identify any potential significant impacts on the natural or human environment.

Although this preliminary analysis focuses on the site's development and operation as BlackStar proposed, the conclusions and recommendations herein would apply to any comparative space reentry operator the City of Sierra Vista is considering.

GEOTECHNICAL EVALUATION

PROJECT LOCATION AND DESCRIPTION

The project site is located within the bounds of and forms a portion of the Sierra Vista Municipal Airport and Libby Army Airfield (FHU) at 2100 Airport Avenue, approximately 4 miles northwest of the City of Sierra Vista. The proposed site boundary within the FHU is depicted in Figure 18.

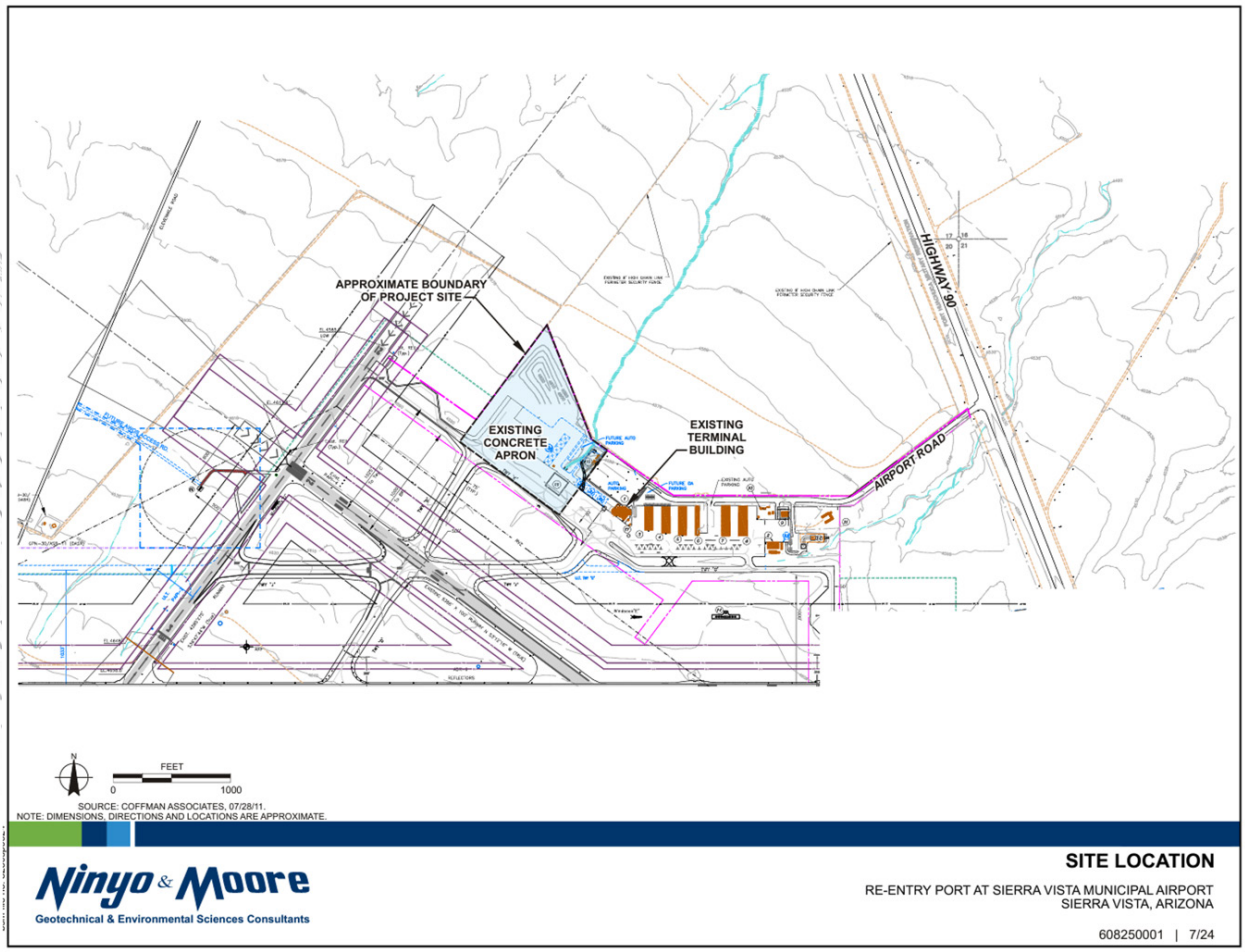


Figure 18: Site Location.

BlackStar Orbital Technologies Corporation (BlackStar) proposes building a manufacturing facility within the project site. Once construction of the facility is finished, BlackStar plans to utilize it to create and refurbish spacecraft. BlackStar's spacecraft vehicle is a reusable satellite that acts as a payload or part of a payload lifted into space via another company's rocket. The vehicle will be 4 to 7 feet long. Once its mission is done, it will perform a re-entry to FHU as an

un-propelled aircraft similar to a glider or even more resembling the former National Aviation and Space Agency's (NASA) Space Shuttle and needing less than 5,000 feet of the FHU runway length to land successfully. The vehicle would then be towed or, in some other manner, moved from the runway to the planned facility.

The manufacturing facility will be constructed within the project site and is currently planned to be approximately 24,000 square feet. It will have access to the currently existing apron (Taxiway K) and the parking lot for truck loading. There is also a plan to build a separate stand-alone rinse area/structure for decontamination purposes.

Engineering plans for the facility were not available at this time. However, we anticipate it will be a hangar-type structure with office space/building. We also assume it will be supported on shallow foundations (spread and continuous footings) with a slab on grade or a concrete mat foundation, and little to no site grading will be needed to establish the design grades.

FHU DESCRIPTION

The following description of the FHU is based on our review of the "Airport Master Plan for Sierra Vista Municipal Airport, Sierra Vista Arizona, prepared by Coffman Associated, Inc. and dated April 25, 2013 (Master Plan). The FHU is a military/civilian joint-use airport facility. A portion of the airport has been deeded to the City of Sierra Vista for civilian use. Both military and civilian operators use runways and taxiways, while landside facilities (hangars, terminals, offices) are separate. Military facilities are generally located on the airport's south side, and civilian facilities are usually on the north.

LANDSIDE AND SUPPORT FACILITIES

The civilian portion of the airfield now encompasses approximately 72 acres and features landside and support facilities, including a terminal building, aircraft storage hangars and parking, fueling facilities, and other storage and maintenance amenities. The airside facilities are directly associated with aircraft operations, including runways, taxiways, lighting, markings, navigational aids, and weather reporting.

RUNWAYS

FHU has three runways briefly described below:

- Runway 8-26 is the primary runway. It is oriented east-west and measures 12,001 feet long by 150 feet wide. This runway's pavement is constructed of Portland cement concrete (PCC) and is reportedly in good condition (more details below). The runway has a weight-bearing capacity of 75,000 pounds for single-wheel aircraft (S), 200,000

pounds for dual-wheel aircraft (D), 450,000 pounds for dual tandem-wheel aircraft (2D), and 700,000 pounds for double dual tandem wheel aircraft (2D2).

- Runway 12-30 is the crosswind runway. It is 5,366 feet long by 100 feet wide and is oriented northwest to southeast. This runway's pavement is constructed of PCC and asphaltic concrete (AC) and is reportedly in good condition. The runway's weight-bearing capacities are 46,000 pounds S, 106,000 pounds D, 137,000 pounds 2D, and 172,000 pounds 2D2.
- Runway 3-21 is the shortest and narrowest runway available at FHU. It is 4,285 feet long and 75 feet wide. This PCC/AC paved runway is in poor condition and has no reported weight-bearing capacity.

Helipad

A 40-foot by 40-foot AC paved helipad (H1) is located on the northeast side of the airfield, immediately east of the general aviation landside facilities. The helipad is equipped with perimeter lighting and is primarily used for medical transport.

Taxiways

The taxiway system at FHU consists of a full-length parallel taxiway and partial-parallel taxiways serving Runway 8-26, as well as entrance/exit, access, and connector taxiways serving the runways and apron areas. Taxiway P, the full-length taxiway serving the primary Runway 8-26, is located on the runway's south side and provides access to the military-use areas. Taxiways J and K are partial-parallel taxiways north of the primary runway, giving access to/from the general aviation area. Taxiways A, B, C, D, F, and S serve as connector/access taxiways that support Runway 8-26 from the south, while Taxiways D, G, J, and K serve as connectors to various points north of Runway 8-26. A portion of Taxiway K has a PCC paved apron located within the project site, as described from now on. The main taxiways have PCC pavement, while the support taxiways typically have AC surfacing.

Pavement Condition

The Arizona Department of Transportation (ADOT) maintains the Arizona Airport Pavement Management System (APMS). The APMS uses the U.S. Army Corps of Engineers' Micropaver program to generate a five-year pavement preservation program. Visual inspections are conducted every three years to evaluate a pavement condition index (PCI) rating for runway,

taxiway, and apron pavement sections by Federal Aviation Administration (FAA) Advisory Circular (AC) 150/5380-6. PCI ratings range from 0 (failed) to 100 (excellent). Due to the joint-use nature of FHU, the APMS data is limited to the taxiways and apron areas used exclusively for general aviation operations. In 2022, the Army Dams and Transportation Infrastructure Program (ADTIP) inspected the airfield's runways and associated taxiways to evaluate PCIs for these pavement sections. Per the inspection results, PCI for each of the runways and the Taxiway K apron at FHU was as follows:

- Runway 8-26 (excluding blast pads): 78 to 99;
- Runway 12-30 (excluding blast pads): 78 to 99;
- Runway 3-21 (excluding blast pads): 25 to 45 and
- Taxiway K concrete apron: 86 to 100.

This aforementioned rating system also evaluates the subgrade strength designated as A (high), B (medium), C (low), or D (ultra-low). A subgrade of class A would be considered very strong, such as cement-stabilized clay. A subgrade of class D would be very weak, similar to uncompacted soil. According to this classification, the runway subgrades are described as class A to B. The basis for the evaluation was not provided.

AREA TOPOGRAPHY

According to the Fort Huachuca (2021), Arizona, 7.5-Minute United States Geological Survey (USGS) Topographic Quadrangle Map and the topographic data in the Master Plan, the average FHU elevation is approximately 4,720 feet relative to mean sea level (MSL). The topography near the site generally slopes from the southwest down to the northeast. The project area's average elevation is approximately 4,580 feet MSL. However, the Mater Plan depicts a mound or stockpile of over 40-foot height within the northern portion of the project site.

HISTORIC AND AERIAL PHOTOGRAPH REVIEW

For this project, several aerial photographs from Historicaerials.com (Nationwide Environmental Title Research [NETR], 2016) and Google Earth™ were reviewed.

An aerial photograph dated 1956 depicted the military portion of the FHU with a single runway and few taxiways. The northern portion of FHU was undeveloped land. Images dated 1978 through 1984 depicted a runway system that was different from the present configuration and progressive development of the civilian airport landside and support facilities. Images dated 1992 through 1996 depicted the present configuration of the runways and development of the taxiways, including Taxiway K. Evidence of grubbing and vegetation clearance were observed within the project area. An image dated 2003 depicted the concrete apron on Taxiway K. Images dated 2006 through 2019 depicted the stockpile in place within the northern portion of the project site. An aerial photograph dated 2023 depicted the stockpile being removed and a

graded rectangular area northwest of the site. The area north of the Taxiway K apron appeared to have been covered with asphalt millings.

GEOTECHNICAL BACKGROUND REVIEW

Eighteen available geotechnical reports about the project site and adjacent FHU areas were reviewed. A detailed summary of the reviewed documentation is presented in Attachment A. Below is a summary of the subsurface geotechnical conditions prevailing within the study area based on the documents above:

- Subsurface soils typically include clayey sand, sandy clay, and silty sand in dense to very dense or hard conditions.
- In many borings, very dense zones of gravel/cobbles/boulders were encountered at variable depths, causing auger refusal.
- Zones of carbonate cementation (caliche) were observed in many borings.
- The clayey soils are of low to high plasticity. Some of them exhibit moderate.
- Hydro-compression or expansive potential.

It needs to be mentioned that many of the reviewed documents do not clearly distinguish between native alluvial and man-placed fill soils. Native alluvial deposits seem to prevail in the area. However, undocumented or poorly documented fill areas have been recently created, as mentioned in the Site Visit and Observations section below.

SITE VISIT AND OBSERVATIONS

View of parking lot west of Terminal Building (facing north).

On May 21, 2024, a site visit was conducted to the project area to meet with the stakeholders, including the FHU civilian operators and managers, and to observe the surficial geology, topography, and existing site conditions.

The project site terrain was relatively flat and occupied primarily by existing civilian facilities, including the terminal building, box hangars, vehicular parking areas, water well/storage tank and pump unit, concrete apron associated with Taxiway K, and an undeveloped land northeast of the apron. The surface adjacent to the apron was covered with a relatively thin layer of asphalt millings.

According to the FHU technical staff, the currently vacant area was backfilled about two years ago, with soils stockpiled within the FHU area as earthwork surplus from past grading and construction projects.

View of Pump Unit, Parking Lot, Box Hangars (facing east).

The total depth of the fill placed is unknown. However, as reported by the FHU staff, 42 inches of fill were placed in lifts and compacted to a specified compaction level.

GEOLOGY AND SUBSURFACE CONDITIONS

The following sections summarize general geologic observations and review existing geologic data.

Geologic Setting

The project site is located in the Mexican Highland Section of the Basin and Range physiographic province, which is typified by broad alluvial valleys separated by steep, discontinuous subparallel mountain ranges. The mountain ranges generally trend north-south and northwest-southeast. The basins consist of alluvium with thicknesses extending to several thousands of feet.

The basins and surrounding mountains were formed approximately 10 to 18 million years ago during the mid to late Tertiary. Extensional tectonics formed horsts (mountains) and grabens (basins) with vertical displacement along high-angle normal faults. Intermittent volcanic activity also occurred during this time. The surrounding basins are filled with alluvium from the

erosion of the surrounding mountains and river deposition. Coarser-grained alluvial material was deposited at the margins of the basins near the mountains.

The area's surface geology is described as quaternary surficial deposits consisting of unconsolidated to strongly consolidated alluvial deposits. This unit includes coarse, poorly sorted alluvial fan and terrace deposits on middle and upper piedmonts and along large drainages, sand, silt, and clay on alluvial playas (Arizona Geological Survey, 2000).

According to the Natural Resources Conservation Service (NRCS) Web Soil Survey by the United States Department of Agriculture, the project area is characterized by the soil unit described as the White House complex. It is a mixed-fan alluvium consisting of gravelly loam, clay, gravelly clay loam, loamy sand, and clay loam. Loam is an agricultural soil classification of clay, silt, and sand.

This unit is characterized by a significant percentage of gravelly material, typically classified as clayey or silty sand with gravel and clayey gravel with fines content (percentage passing the No. 200 US sieve) between 20 and 70 percent. The plasticity index values typically vary between 3 and 20. The prevailing hydrologic group includes group C, indicating a slow infiltration rate when thoroughly wet. These soils consist chiefly of soils with a layer that impedes the downward movement of water or soils with moderately fine texture. These soils are also characterized by a slow rate of water transmission. The soil map with detailed descriptions of the soil engineering properties by NRCS is included in Attachment C.

Subsurface Conditions

Based on the review of the historic geotechnical reports and our field reconnaissance, the subsurface soils generally include man-made fills and native alluvial deposits consisting of dense to very dense silty and clayey sands with gravel, clayey gravel, and hard sandy clays. In native alluvial deposits, zones of caliche cementation and pockets of cobbles with possible boulders should also be anticipated.

Groundwater

Based on sound data from the Arizona Department of Water Resources well Site ID 313444110211701 located at the Libby Airfield, the depth to groundwater was measured to be about 600 feet below ground surface (bgs) on October 31, 2023. Groundwater levels can fluctuate due to seasonal variations in precipitation, flows in nearby washes, irrigation, groundwater withdrawal or injection, and other factors. In addition, perched water conditions may exist in some areas, particularly close to existing washes. In general, groundwater is not expected to be a project design and construction constraint.

GEOLOGIC HAZARDS

The following sections describe potential geologic hazards at the site, including land subsidence, earth fissures, and faulting.

Land Subsidence and Earth Fissures

Groundwater depletion due to groundwater pumping has caused land subsidence and earth fissures in numerous alluvial basins in Arizona. It has been estimated that subsidence has affected more than 3,000 square miles and has caused damage to various engineered structures and agricultural land (Schumann and Genualdi, 1986). From 1948 to 1983, excessive groundwater withdrawal has been documented in several alluvial valleys where groundwater levels have been reportedly lowered by up to about 500 feet. With such large depletions of groundwater, the alluvium has undergone consolidation, resulting in large areas of land subsidence.

In Arizona, earth fissures are generally associated with land subsidence and pose an ongoing geologic hazard. They generally form near the margins of geomorphic basins where significant amounts of groundwater depletion have occurred. Reportedly, earth fissures have also formed due to tensional stress caused by differential subsidence of the unconsolidated alluvial materials over buried bedrock ridges and irregular bedrock surfaces (Schumann and Genualdi, 1986).

Based on field reconnaissance and review of the referenced material, there are no known earth fissures at the surface of the subject site. Based on fissure maps published by the Arizona Geological Survey, the closest earth fissure study area with documented earth fissures is approximately 40 miles northeast of the site within the Elfrida Study Area (AZGS, 2014). Continued groundwater withdrawal in the area may result in subsidence and the formation of new fissures or the extension of existing fissures. While the future occurrence of land subsidence and earth fissures cannot accurately be predicted, these phenomena are not expected to be a constraint to the construction of this project.

Continued groundwater withdrawal in the area may result in subsidence, the formation of new fissures, or the extension of existing fissures. While the future occurrence of land subsidence and earth fissures cannot accurately be predicted, these phenomena are not expected to constrain the construction of this project.

FAULTING AND SEISMICITY

The site lies within the Sonoran zone, a relatively stable tectonic region in southern Arizona, southeastern California, southern Nevada, and northern Mexico (Euge et al., 1992). This zone is characterized by sparse seismicity and few Quaternary faults. Based on our field observations

and review of readily available published geologic maps and literature, no known active faults are underlying the subject site or adjacent areas.

The closest fault zone to the site is the Huachuca fault zone, situated approximately 8 miles to the southeast of the site (Pearthree, 1998). The Huachuca fault zone is a series of north-to-northwest trending faults. Lower and middle Pleistocene alluvial-fan deposits have been displaced; however, upper Pleistocene and Holocene deposits are not faulted. The youngest fault rupture occurred 100,000 to 200,000 years ago. The slip-rate category of this fault is less than 0.2 millimeters per year. Therefore, the probability of damage from seismically induced ground surface rupture is considered low.

The proposed improvements should be designed according to the requirements of the governing jurisdictions and applicable building codes. Table 7 presents the seismic design parameters for the site by International Building Code (IBC) guidelines and adjusted maximum considered earthquake (MCE) spectral response acceleration parameters evaluated using California's Office of Statewide Health Planning and Development (OSHPD) Seismic Design Maps (web-based).

Site Coefficients and Spectral Response Acceleration Parameters	Values
Site Class	D
Site Coefficient, F_a	1.599
Site Coefficient, F_v	2.4
Mapped Spectral Response Acceleration at 0.2-second Period, S_s	0.251 g
Mapped Spectral Response Acceleration at 1.0-second Period, S_1	0.078 g
Spectral Response Acceleration at 0.2-second Period Adjusted for Site Class, S_{MS}	0.402 g
Spectral Response Acceleration at 1.0-second Period Adjusted for Site Class, S_{M1}	0.188 g
Design Spectral Response Acceleration at 0.2-second Period, S_{DS}	0.268 g
Design Spectral Response Acceleration at 1.0-second Period, S_{D1}	0.125 g

Table 7: International Building Code Seismic Design Criteria.

PRELIMINARY GEOTECHNICAL CONSIDERATIONS

Based on our subsurface evaluation, laboratory testing, and data analysis, the proposed construction is feasible from a geotechnical standpoint. The preliminary geotechnical considerations include the following:

- The near-surface deposits should generally be excavated to planned depths using heavy-duty earthmoving construction equipment. However, zones of cobbles, possible boulders, and caliche cementation should be anticipated in some areas, which may result in difficult and slower excavation rates or call for more aggressive excavation techniques.
- Soils of variable relative densities may be sensitive to moisture content fluctuations.
- Imported soils and soils generated from on-site excavation activities that exhibit a relatively low plasticity index (PI) can generally be used for engineered fill. However, due to their high plasticity and coarse gradation, some on-site soils may only be suitable for re-use as engineered fill if processed.
- New structures may be supported on shallow foundations proportioned for light to moderate bearing pressures overlying a zone of engineered fill.
- New slabs-on-grade/equipment pads, flatwork, and pavements may be supported on a zone of engineered fill.
- Based on well data provided by the Arizona Department of Water Resources (ADWR), groundwater has been historically measured at a depth of 600 feet bgs. Groundwater levels can fluctuate due to seasonal variations, precipitation, flows within nearby washes or drainages, irrigation, and other factors. In general, groundwater is not expected to be a project design and construction constraint.
- No known geologic hazards are reported underlying or immediately adjacent to the site.

PRELIMINARY GEOTECHNICAL RECOMMENDATIONS

The preliminary recommendations presented in this report are based on background research and a review of pertinent data, field observations, and experience on similar projects. These initial recommendations are unsuitable for the final design and are subject to change as additional information is obtained. A complete geotechnical evaluation is needed for the final design. The preliminary recommendations should be applied to this study as described above. In general, the future design and construction means and methods should be by applicable Maricopa Association of Governments (MAG) Uniform Standard Specifications and Details for Public Works Construction (Standard Specifications), as modified by the City of Sierra Vista, as well as relevant Federal Aviation Administration (FAA) Advisory Circulars (AC), and in particular AC No: 150/5370-10H Standard Specifications for Construction of Airports.

Site Preparation

Vegetation and debris from the clearing operation should be removed from the site. Demolition debris and obstructions that extend below the finish grade, if present, should be removed from the site and deposited in an approved landfill area.

After a rough grade has been achieved and before placement of fill, the exposed subgrade should be visually checked for debris, organic matter, and other unsuitable materials. If unsuitable subgrade soils are encountered at subgrade level during earthwork operations, these soils should be improved as noted below or removed within the proposed pavement areas and replaced with engineered fill.

The on-site geotechnical representative should carefully evaluate any areas of soft or wet soils observed during the site preparation activities prior to placing grade-raise fill or other construction. Drying or over-excavation of some materials may be appropriate.

Excavation

Much of the planned improvements are expected to be near the existing grades. However, new fill embankments and excavations may be needed for subsurface utilities, basements, and similar improvements. The soil conditions within the project site are expected to consist of native alluvium and fill deposits. Based on background review and experience in the general project area, excavation of fill and alluvium can generally be accomplished with conventional heavy-duty earthmoving equipment in good operating condition. However, difficult excavation conditions should be anticipated in very dense, gravelly, and cemented soils, which will slow the excavation rate and call for more aggressive excavation techniques. These locations, if any, should be evaluated during the final design.

Temporary Slopes

Sidewalls of temporary excavations should only be anticipated to stand near-vertical with sloughing. Therefore, the contractor should provide safely sloped excavations or an adequately constructed and braced shoring system, in compliance with Occupational Safety and Health Administration (OSHA) regulations, for employees working in an excavation that may expose them to the danger of moving ground. For planning purposes and according to OSHA soil classifications, “Type C” soil should be considered for this project. This corresponds to a temporary slope inclination no steeper than 1.5:1 (H: V) up to an excavation depth of 20 feet. Deeper excavation should be subject to separate stability analyses. During excavation, OSHA regulations should evaluate soil classification and excavation performance in the field.

General Suitability of Site Soils

It is anticipated that the engineering characteristics of on-site soils should be sufficient for the construction and performance of the proposed improvements, assuming mitigation of unsuitable soils is performed. The background review and visual observations indicate that the near-surface soils predominantly consist of clay, silt, and sand with variable gravel content. Many soils will be suitable for use as engineered fill and pavement subgrade on this project. However, high plasticity and very coarse gradation may call for mitigation.

Clayey soils are susceptible to volume change with changing moisture content, which should be anticipated within the project limits. These types of soils generally provide poor subgrade support and should be mitigated in sensitive areas. Mitigation for these soils could include over-excavation and replacement, blending with other non-cohesive or relatively low-plasticity soils, treatment with lime or Portland cement/lime, or other methods. Furthermore, clayey soils may create a corrosive environment for ferrous metals.

In addition, screening of oversize particles such as cobbles and boulders should be performed for engineered fill applications.

Subgrade Preparation

As stated previously, the site soils generally consist of dense to very dense silty, clayey sand, gravel, and sandy clays. It is recommended that the new shallow foundations be supported on a zone of engineered fill that extends 1 to 3 feet below the bottom of the foundations. This over-excavation zone should extend a horizontal distance from the edge of the new foundation that is equal to the depth of the over-excavation.

In addition, it is recommended that the new slabs-on-grade/equipment pads, pavements, and flatwork be supported on 6 to 12 inches of moisture-conditioned and compacted engineered fill. The fill thickness should be measured from the bottom of the aggregate base (AB) layer, where applicable. This subgrade improvement should extend laterally 6 to 12 inches beyond the new slabs-on-grade/equipment pads, pavements, and flatwork footprint.

Engineered fill soils should be moisture-conditioned to within 0 to +3 percent of the optimum mechanically compacted to generally 95 percent of the maximum dry density as evaluated in compliance with ASTM D698. Engineered fill should generally be placed in 8-inch-thick loose lifts such that after compaction, each lift is firm and non-yielding under the weight of construction equipment.

After the over-excavation described above is finished and before the placement of engineered fill, exposed surfaces from excavations should be carefully evaluated for the presence of soft, loose, or wet soils that still need to be removed as part of the improvement process. This evaluation should consist of probing and visual observation of the excavation bottom. Based on this evaluation, additional remediation may be needed. This could include further scarification of the exposed surface. The geotechnical consultant should address this additional remediation, if needed, during the earthwork operations.

Cut Slopes and Embankments

Based on visual observations, it is recommended that cut slopes in soils be no steeper than 2:1 Horizontal: vertical (H: V) for planning purposes. Unprotected embankment fill slopes should be on the order of 3:1 (H: V) or flatter. Flatter slopes will promote some re-vegetation. Slopes protected with slope paving should not exceed 1.5:1 (H: V). Slope angles should be evaluated for stability during the final design.

If exposed and left unprotected, slopes may rill and erode over time. Silty soils and soils containing fine sand are more susceptible to erosion. Laying slopes back to 3:1 (H: V) will decrease runoff velocity and reduce the likelihood of severe erosion. Adequate drainage and temporary erosion control covering could minimize erosion problems and promote post-construction vegetation. Plating the slopes with gravelly material will reduce precipitation impact and slow erosion rate. Other erosion control measures could also be considered.

Earthworks Factors

Earthwork factors are estimated based on experience with nearby sites with similar geologic settings. A shrinkage factor of about 5 to 15 percent is anticipated to be used for preliminary planning purposes. This value should be used over the project area for estimating earthwork volumes and should be expected to vary.

Shallow or Continuous Foundations

Spread or continuous footings should be supported at 18 inches below the finished grade, bearing on engineered fill according to the recommendations presented in this report. Continuous footings should have a width of 16 inches or more, and isolated column footings should have a width of 24 inches or more. For static conditions, footings may be designed using the allowable net bearing pressure of 2,000 to 3,000 pounds per square foot (psf). The allowable soil bearing pressure may be increased by one-third when considering total loads, including short-duration loads, such as wind or seismic forces.

Total and differential settlement of 1 inch and 1/2 inch over a horizontal distance of 40 feet, respectively, may occur. These settlements are contingent on the preparation of soils underlying the footings based on the recommendations contained in this report.

Foundations bearing on engineered fill and subject to lateral loadings may be designed using an ultimate coefficient of friction of 0.3 to 0.4 (total frictional resistance equals the coefficient of friction multiplied by the dead load). An ultimate passive resistance value of 300 to 400 psf per foot of depth may be used. The ultimate lateral resistance can be taken as the sum of the frictional resistance and passive resistance, provided that the passive resistance does not exceed one-half of the total allowable resistance. The passive resistance may be increased by one-third when considering short-duration loads such as wind or seismic forces. The foundations should be proportioned such that the resultant force from lateral loadings falls within its kern (i.e., middle one-third).

Corrosion

Based on a review of available soil corrosion test results and experience in the area, the onsite materials should be considered corrosive to ferrous metals and have negligible to moderate sulfate exposure to concrete.

For planning purposes, it is recommended that special consideration be given to the use of heavy-gauge, corrosion-protected, underground steel pipe and other connections, if any, that are planned. As an alternative, plastic pipe or reinforced concrete pipe could be considered. A corrosion specialist should be consulted for further recommendations. In addition, it is recommended that Type II cement be used to construct concrete structures at this site. Due to potential uncertainties about using reclaimed irrigation water or topsoil that may contain higher sulfate contents, pozzolan or admixtures designed to increase sulfate resistance may be considered.

Exploration for Final Design

It is recommended that a geotechnical exploration plan be prepared and submitted and a subsurface geotechnical evaluation be performed for the final design phases of the project. The geotechnical evaluation should generally conform to the relevant industry guidelines and address the project's geotechnical components. These components include planned cut and fill slopes, excavations, re-use of site materials, subgrade improvement, foundations, pavements, detention/retention basins, and other drainage and water harvesting improvements.

Field geotechnical explorations are anticipated to include geotechnical borings and test pits. These explorations may be enhanced by additional geophysical surveys, including field electrical resistivity soundings or seismic refraction surveys. Field infiltration or percolation tests should be performed to support the design of retention/detention basins or water harvesting features.

AIRSPACE COMPATIBILITY

AIRPORT SUMMARY

Sierra Vista Municipal Airport (KFHU) is a joint use civil-military airport which shares access with Fort Huachuca U.S. Army installation. The city of Sierra Vista controls buildings and property located on the north side of the airfield as pictured in Figure 19 near taxiway J.

Figure 19: Sierra Vista Municipal Airport (KFHU).

Adequate space is available for manufacturing, storage, processing, and maintenance facilities for at least one reentry vehicle operator northeast of taxiway K. The primary runway (08/26) with a length of 12,001' is sufficient to accommodate reentry vehicles such as the Sierra Space Dream Chaser or the BlackStar spaceplane. Additionally, BlackStar Orbital Technologies has signed an agreement with the City of Sierra Vista to begin construction on a new production and maintenance facility near taxiway K.

Annual airfield operations, according to the 2024 Sierra Vista Airport Municipal Airport Master Plan (DRAFT), have declined from over 128,000 in 2018 to about 111,000 in 2023, as shown in Table 8

Calendar Year	Military	Air Carrier	General Aviation	UAS	Total Operations
2018	58,671	5,899	20,407	43,393	128,370
2019	62,050	5,381	23,021	44,852	135,304
2020	52,401	4,985	17,772	51,110	126,268
2021	55,772	5,836	17,095	40,088	118,791
2022	56,953	5,363	21,962	31,941	116,219
2023	56,481	5,394	28,211	21,082	111,168

Table 8: KFHU Annual Operations

Operations are forecast to grow approximately one percent annually, to approximately 142,400 by 2043. The projected growth is driven by continued use of KFHU for military operations, including UAS, as well as the FAA's positive outlook for general aviation and air taxi activity nationwide.

Currently, horizontal launch and/or reentry of space vehicles are not included in airport forecasts due to the relatively new nature of these types of operations. The operational cadence of reentry operations at KFHU is expected to be up to one landing per month initially.

AIRSPACE STRUCTURE

Sierra Vista Municipal Airport is served by at Air Traffic Control Tower (ATCT) and associated Class D airspace that operates from 0600Z Monday to 0600Z Saturday. KFHU does not have any published Standard Instrument Departures (SIDs) or Standard Terminal Arrival Routes (STARs). FAA's Albuquerque Air Route Traffic Control Center (ARTCC) handles radar arrival and departure control for Instrument Flight Rules (IFR) traffic arriving and departing KFHU. There are several Restricted Airspace areas defined in the vicinity of KFHU, including R-2303A, R2303B, R2303C, and R-2312, as depicted in Figure 20.

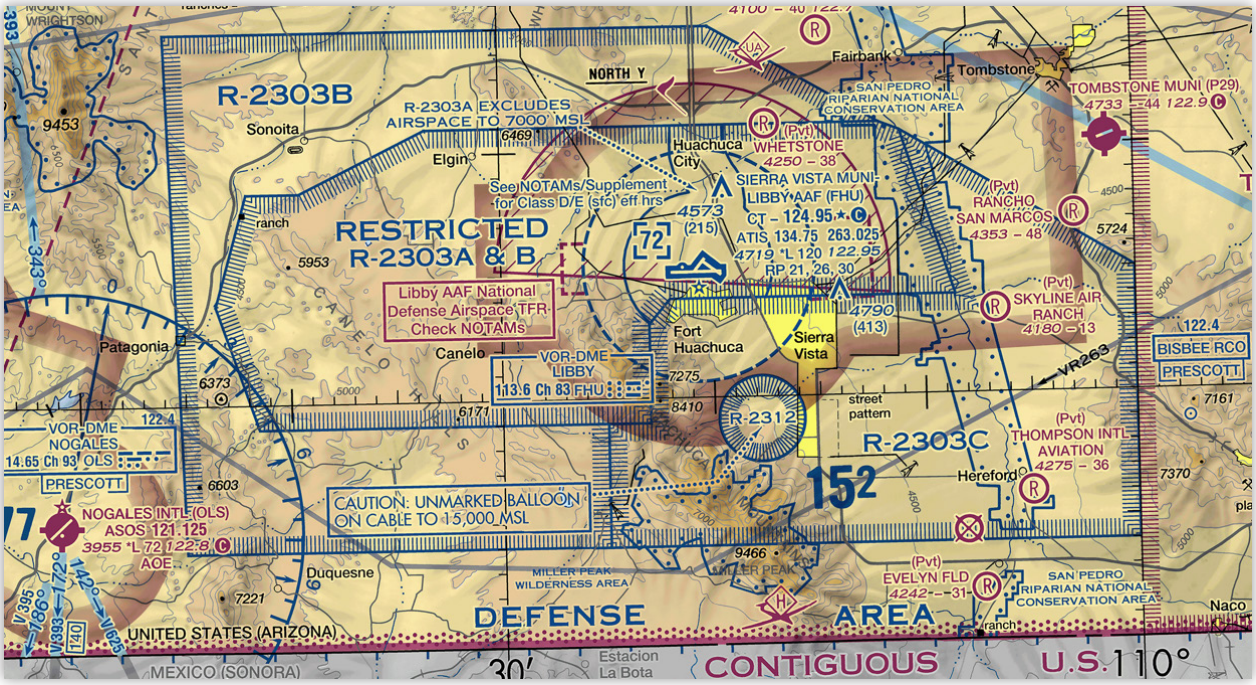


Figure 20: Sierra Vista Municipal Airport and Nearby Restricted Airspace.

The low-altitude airspace structure surrounding the airport does not present any major challenges to integrating reentry vehicle descent and landing operations at KFHU. The proximity of the Mexican border approximately 15NM to the south would require coordination and appropriate agreements with SENEAM, the air navigation service provider in Mexico. Coordination and agreements with DoD entities for use of Restricted airspace in the vicinity of KFHU would also be necessary. Figure 21 depicts KFHU and low-altitude airspace structure.

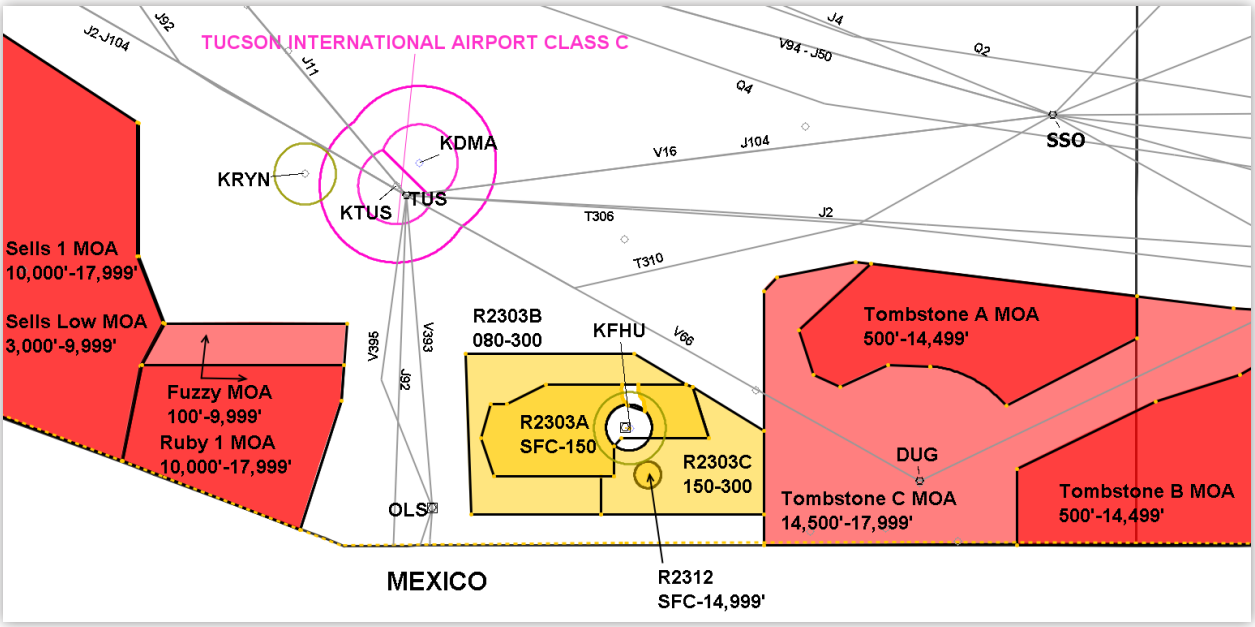


Figure 21: KFHU Low-Altitude Airspace Structure .

Similarly, the high-altitude route structure (Jet airways and Q-Routes) does not overly KFHU, and would not present substantial challenges for reentry vehicle descent and landing (Figure 22). However, a full Flight Safety Analysis would be required for the reentry vehicle trajectory, which could result in hazard area NOTAMs that do impact some low- and high-altitude routes. Such closures would likely be of short duration, and their impact would be dependent on the time of day and day of week of the reentry. Given the relative infrequency of reentry operations, the air traffic impact is projected to be minimal.

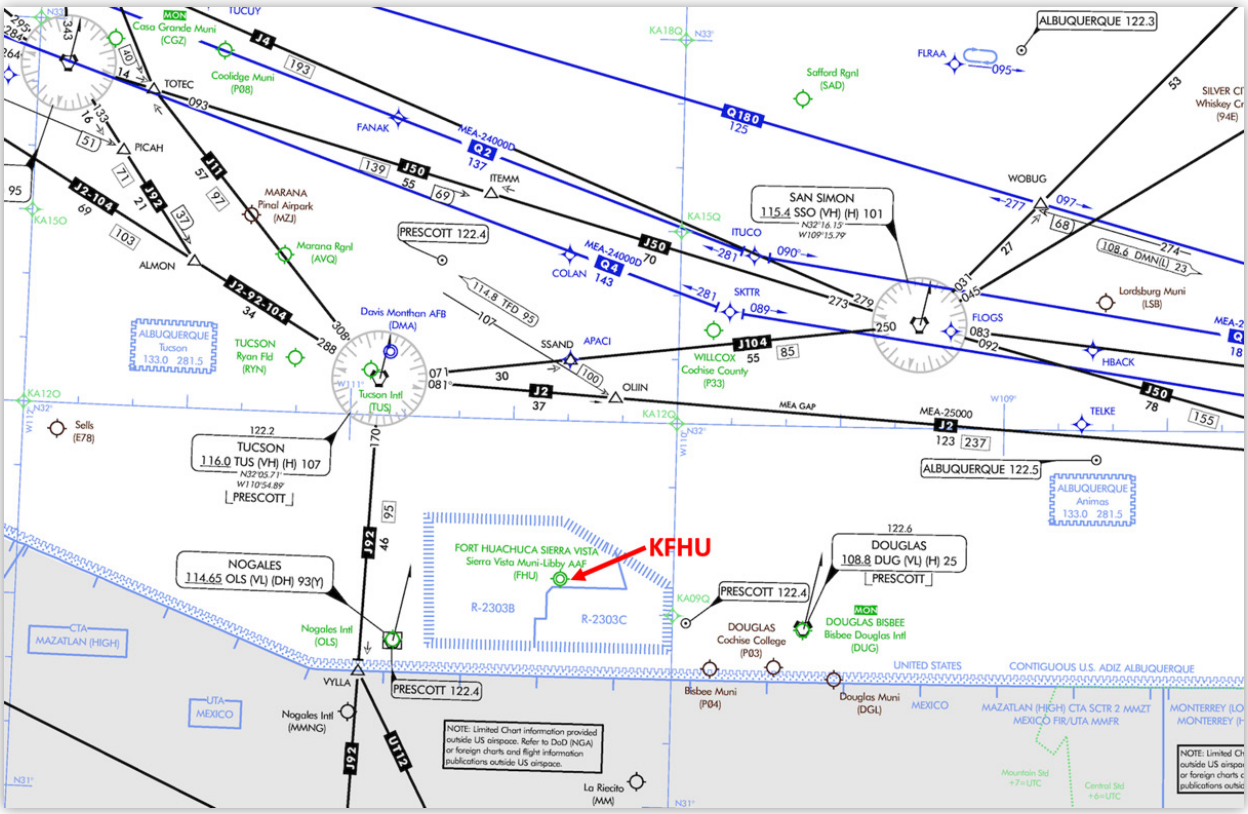


Figure 22: High-Altitude Route Structure.

AIRSPACE ANALYSIS

Preliminary review of the airspace and route structure in the vicinity of KFHU did not identify significant airspace constraints that would preclude routine reentry landing operations. Further analysis will be required when more detailed reentry vehicle and trajectory information is available in order to reach final conclusions. However, the initial assessment suggests:

- **Airport Impact:** A reentry vehicle landing at Sierra Vista Municipal Airport using Runway 08/26 would be expected to be conducted similarly to other aircraft arrivals. The BlackStar spaceplane is small and unpowered during landing, meaning it will produce no engine noise or exhaust in the terminal area. While final design details for

the BlackStar are not yet available, similar vehicles have been designed with a landing skid instead of a nose wheel. This normally results in the vehicle being unable to taxi off the runway after landing. This is an expected part of the operation, and a support vehicle would be available to tow the BlackStar off the runway within a few minutes of landing. This could result in a short period of runway unavailability, but is not expected to disrupt other airport operations significantly.

- **Arrival/Departure Procedure Impact:** None - there are no published SIDs or STARS for KFHU.

- **Impact upon Airways and Route Structure:** The glide and landing portion of the BlackStar reentry profile is not expected to directly conflict with established low- or high-altitude routes. A detailed Flight Safety Analysis would be required as part of any FAA-issued reentry license, and would result in an aircraft hazard area that would need to be temporarily closed by NOTAM during the reentry and landing. The exact location and dimensions of such a NOTAM cannot be defined at this time, but any impact to establish air traffic flows are expected to be minimal. It is possible that Mexican airspace could be affected by such closures, necessitating coordination with SENEUM.

- **Impact upon Special Activity Airspace (SAA):** SAA may be affected during a reentry and landing at Sierra Vista Municipal Airport. Coordination with the appropriate DoD entity would be necessary to schedule any necessary operational adjustments. The airspace most likely to be affected is R-2303A and R-2303B. A Letter of Agreement (LOA) would likely be required as part of any FAA reentry license issued to BlackStar or any other operator. Procedures may also be defined in an LOA between Sierra Vista and Fort Huachuca or other DoD entities.

- **FAA Facility Input:** Albuquerque ARTCC (ZAB) provided initial review and comment for the proposed Sierra Vista reentry site. ZAB personnel identified the likely need to coordinate use of R-2303A and B, as previously identified. ZAB did not identify any significant challenges or impacts to ATC operations.

Airspace Compatibility Conclusion

Reentry operations being considered by the City of Sierra Vista should not have any major or significant impact on aviation operations located within this area. Letters of Agreement with airspace stakeholders would be required as part of FAA reentry site licensing, and would also be required as part of any vehicle operator's FAA reentry license. Airspace stakeholders

are expected to include FAA Airports District Office, FAA Space Operations (AJR-1800), FAA Albuquerque ARTCC (ZAB), Fort Huachuca Army Airfield, SENEAM, and any other entities that may be identified during the FAA licensing process. No airspace issues were identified that would preclude the proposed reentry operations based on safety or operational impacts.

RECOMMENDATIONS FOR NEXT STEPS

In order to obtain a Reentry Site license from the FAA, Sierra Vista would need to submit an application in accordance with 14 CFR §413, License application procedures, and 14 CFR §433, License to operate a reentry site. In addition, FAA often requires reentry site operators to demonstrate compliance with certain public safety requirements in 14 CFR §420, License to operate a launch site. Key milestones and activities for the reentry site license process are:

- Conduct Pre-application consultation with FAA, as required by 14 CFR §413.5
- Collaborate with BlackStar Orbital, or any other reentry vehicle operator, to establish a concept of operations and identify vehicle operational and performance data necessary for public safety and risk evaluation required by 14 CFR §420 and §433
- Perform a Flight Safety Analysis to demonstrate compliance with FAA public safety requirements for the proposed operations
- Establish plans and procedures for site operations, mishap response, explosive or hazardous material handling, and any other necessary activities
- Perform environmental analyses sufficient to enable the FAA to comply with the requirements of the National Environmental Policy Act, 42 U.S.C. 4321 et seq. (NEPA), the Council on Environmental Quality Regulations for Implementing the Procedural Provisions of NEPA, 40 CFR Parts 1500-1508, and the FAA's Procedures for Consideration Environmental Impacts, FAA Order 1050.1D
- Coordinate with U.S. and Mexican stakeholders to establish agreements for ensuring the safety of the public in areas of land, sea, and air affected by the proposed operations

LIMITATIONS

This report is intended exclusively for use by the client. Please note it is essential to use this document in its entirety, as individual sections may not provide a complete picture of the project.

The geotechnical and environmental reports of services detailed in this document adhere to current industry standards. Both evaluations were conducted under the appropriate care expected of professionals within the project area of their respective fields. Please note, however, that this document does not guarantee the accuracy of its conclusions, recommendations, or opinions.

Due to the limited scope of these evaluations, certain subsurface or environmental conditions were not fully captured. Additional exploration or assessments might be necessary to address potential uncertainties or concerns related to structural issues, hazardous materials, or other factors beyond the scope of this report.

The geotechnical section is intended for preliminary design purposes. Future consultants are advised to conduct independent evaluations of subsurface conditions to ensure the accuracy and sufficiency of the information provided in this report.

The conclusions, recommendations, and opinions presented in the aforementioned reports are based on an analysis of the observed site conditions and relevant literature. It is important to understand that natural processes or human activities can affect site conditions, and applicable laws and regulations may evolve.

If any discrepancies arise between the reported conditions and those encountered during the project, or if you have any questions about the content, interpretations, or completeness of either the geotechnical or environmental sections, please contact Launch on Demand for further evaluation and recommendations.

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