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Environmental
Assessment

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Single Stage
Rocket Technology
DC-X Test Program



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Strategic Defense
Initiative Organization

June 1992

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**ENVIRONMENTAL
ASSESSMENT**

Prepared in Support of The
Single Stage Rocket Technology (SSRT) Test Program
DC-X Environmental Assessment

**THE STRATEGIC DEFENSE
INITIATIVE ORGANIZATION (SDIO)**

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13. ABSTRACT (Maximum 200 words) This document presents an assessment of the potential environmental consequences of the development and subsequent validation of the single stage rocket technology (SSRT) using a subscale vehicle that is capable of vertical takeoff and landing. Findings from the assessment determined no significant impact will result from conducting the SSRT program.				
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Cover Sheet

Responsible Agency

Strategic Defense Initiative Organization (SDIO)

Proposed Action

Single Stage Rocket Technology (SSRT) Test Program at White Sands Missile Range (WSMR), New Mexico.

Responsible Individual

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Designation

Environmental Assessment

Abstract

The National Environmental Policy Act (NEPA), the Council on Environmental Quality (CEQ) regulations implementing NEPA (40 CFR Parts 1500-1508), and U.S. Department of Defense (DoD) Directive 6050.1 direct that decision-makers take into account environmental consequences when authorizing or approving major federal actions. This environmental assessment (EA) evaluates the environmental consequences of conducting activities for the SSRT test program.

The purpose of the proposed action is to provide SDIO with a suborbital, recoverable rocket (SRR) capable of lifting up to 3,000 pounds of payload to an altitude of 1.5 million feet; returning to the launch site for a precise soft landing; with the capability to launch for another mission within three to seven days. To support these requirements, the proposed action involves validation and testing of a DC-X vehicle. Component assembly of the vehicle will take place at Scaled Composites, Inc., Mojave, CA; Chicago Bridge and Iron, Cordova, AL; Pratt & Whitney, West Palm Beach, FL, Aerojet, Sacramento, CA; and McDonnell Douglas Space Systems Company, Huntington Beach, CA. Static test firing activities will occur at NASA/White Sands Test Facility (WSTF), WSMR, New Mexico, and launch activities will occur at White Sands Space Harbor (WSSH), WSMR, New Mexico. No significant impacts are anticipated to the environment at the engineering contractor facilities, NASA/WSTF, or WSSH.

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Summary

Summary

The Strategic Defense Initiative Organization (SDIO) was established to plan, organize, coordinate, direct, and enhance research and testing of technologies applicable to a Strategic Defense System (SDS) for ballistic missile defense. The research activities are collectively known as the Strategic Defense Initiative (SDI).

SDIO has identified the need for single stage rocket technology to support its mission of ballistic missile defense. To support this need, SDIO requires a suborbital recoverable rocket (SRR) capable of lifting up to 3,000 pounds of payload to an altitude of 1.5 million feet; returning to the launch site for a precise soft landing; with the capability for another mission within three to seven days.

SDIO is proposing to validate the concept of single stage rocket technology (SSRT) using a subscale vehicle (DC-X) that uses hydrogen and oxygen as vehicle propellants, is capable of vertical takeoff and landing (VTOL), and can launch, land, and launch again in a three to seven day timeframe.

The proposed action consists of: (1) component/vehicle fabrication, assembly, and ground tests at Scaled Composites, Inc., Mojave, CA; Chicago Bridge and Iron, Cordova, AL; Pratt and Whitney, West Palm Beach, FL; Aerojet, Sacramento, CA; and McDonnell Douglas Space Systems Company, Huntington Beach, CA; (2) preflight static test firing of the DC-X vehicle at NASA/White Sands Test Facility (WSTF) on White Sands Missile Range (WSMR); and (3) prelaunch static fire testing and a flight test series consisting of Hover flight, Expanded Hover flight, and Rotation flight at White Sands Space Harbor (WSSH) on WSMR. Minor modifications will be required to existing facilities at NASA/WSTF, and minor construction activities will be necessary at the WSSH for launch activities. Static fire testing is routine at NASA/WSTF and approximately 450 launches of all types occur annually at WSMR.

Alternatives considered, but not carried forward, included alternative launch vehicles, alternative test ranges, alternative ground test sites, alternative launch test sites, and the no action alternative. Based on the SDIO requirements of a vehicle capable of lifting up to 3,000 pounds to a 1.5 million foot apogee and capable of launching for another mission within three to seven days, a detailed study on alternative launch vehicles determined that the inherent operational flexibility of a SRR provides SDIO with the greatest capability at the lowest projected life-cycle cost.

Of the six test ranges considered, WSMR offered the best opportunity to site DC-X with minimal interference to surrounding facilities and operations. NASA/WSTF was selected as the ground test site because of its close proximity to WSMR and its support facilities that support both static firing and launch operations at WSMR. Within WSMR, the WSSH Columbia Site area was chosen for launch and landing operations because it is remote, with a hard, expansive, flat surface, and power and communication utilities are in place. The no action alternative would not support SDIO's mission requirements.

Potential impacts of the proposed action at NASA/WSTF and WSMR were assessed relative to the following environmental resources: physical setting and man-made environment; water resources; geology and soils; biological resources; threatened and endangered species; cultural resources; air quality; and noise. Infrastructure and safety were also assessed.

The analysis was conducted with respect to potential construction, static test firing, and launch and landing impacts. The analysis concluded that no significant impacts are anticipated to the environment from the proposed action at the engineering contractor facilities. Potential noise impacts will be avoided through the use of personal protection devices at the static fire testing and launch sites, and personnel will be trained in the handling/use of liquid propellants. Therefore, no significant impacts are anticipated at NASA/WSTF or WSMR.

Table of Contents

Table of Contents

	Page
1.0 Description of Proposed Action and Alternatives	1-1
1.1 Purpose and Need for the Proposed Action	1-1
1.2 Proposed Action	1-1
1.2.1 Program Description	1-1
1.2.1.1 Vertical Takeoff and Landing (VTOL) System	1-2
1.2.1.2 DC-X Activities	1-4
1.2.2 DC-X Vehicle Description	1-4
1.2.2.1 Propulsion System	1-4
1.2.2.2 Reaction Control System (RCS)	1-7
1.2.2.3 Composition of DC-X	1-7
1.2.3 DC-X Ground System Description	1-7
1.2.4 Component/Vehicle Fabrication, Assembly, and Ground Test Activities	1-8
1.2.4.1 Aeroshell	1-10
1.2.4.2 Propellant Tank Structure	1-10
1.2.4.3 Engines	1-10
1.2.4.4 Reaction Control System (RCS)	1-11
1.2.4.5 Vehicle Integration	1-11
1.2.5 PreFlight and Test Activities	1-12
1.2.5.1 Construction	1-12
1.2.5.2 Tests	1-16
1.2.6 Flight Test Activities	1-17
1.2.6.1 Construction	1-17
1.2.6.2 Flight Profiles	1-21
1.2.6.3 Recovery	1-26
1.2.7 Launch and Range Control	1-27
1.2.8 Ground and Flight Safety	1-27
1.2.8.1 NASA/White Sands Test Facility (WSTF)	1-27

1.2.8.2	White Sands Missile Range (WSMR)	1-28
1.2.8.3	Explosives Classification	1-31
1.2.8.4	Fuel Handling	1-31
1.2.8.5	Noise Protection	1-34
1.3	Alternatives	1-34
1.3.1	Alternatives Considered But Not Carried Forward	1-34
1.3.1.1	Alternative Launch Vehicles	1-35
1.3.1.2	Alternative Test Ranges	1-36
1.3.1.3	Alternative Ground Test Sites	1-39
1.3.1.4	Alternative Launch Test Sites	1-40
1.3.2	No Action	1-40
2.0	Existing Conditions	2-1
2.1	Component Assembly/Ground Test Locations	2-1
2.1.1	Scaled Composites, Inc.	2-1
2.1.2	Chicago Bridge & Iron	2-2
2.1.3	Pratt & Whitney	2-2
2.1.4	Aerojet Propulsion Division	2-2
2.1.5	McDonnell Douglas Space Systems Company (MDSSC)	2-3
2.2	Preflight and Flight Test Locations	2-3
2.2.1	NASA/White Sands Test Facility (WSTF)	2-3
2.2.1.1	Physical Setting and Man-Made Environment	2-3
2.2.1.2	Water Resources	2-5
2.2.1.3	Geology and Soils	2-6
2.2.1.4	Threatened and Endangered Species	2-6
2.2.1.5	Cultural Resources	2-7
2.2.1.6	Air Quality	2-9
2.2.1.7	Noise	2-9
2.2.1.8	Safety	2-9
2.2.2	White Sands Missile Range (WSMR)	2-10
2.2.2.1	Physical Setting and Man-Made Environment	2-10
2.2.2.2	Water Resources	2-11

2.2.2.3	Geology and Soils	2-11
2.2.2.4	Biological Resources	2-12
2.2.2.5	Threatened and Endangered Species	2-13
2.2.2.6	Cultural Resources	2-13
2.2.2.7	Air Quality	2-13
2.2.2.8	Noise	2-14
2.2.2.9	Infrastructure	2-14
2.2.2.10	Safety	2-14
3.0	Consequences	3-1
3.1	Proposed Action - Site-Specific Analysis Component	
	Assembly/Ground Test Location	3-1
3.1.1	Scaled Composites, Inc.	3-1
3.1.2	Chicago Bridge & Iron	3-2
3.1.3	Pratt & Whitney	3-2
3.1.4	Aerojet	3-2
3.1.5	McDonnell Douglas Space Systems Company	3-2
3.2	Proposed Action - Site-Specific Analysis Preflight and Flight	
	Test Locations	3-3
3.2.1	NASA/White Sands Test Facility	3-3
3.2.1.1	Physical Setting and Man-Made Environment	3-3
3.2.1.2	Water Resources	3-4
3.2.1.3	Geology and Soils	3-4
3.2.1.4	Threatened and Endangered Species	3-4
3.2.1.5	Cultural Resources	3-4
3.2.1.6	Air Quality	3-5
3.2.1.7	Noise	3-5
3.2.1.8	Safety	3-6
3.2.2	White Sands Missile Range	3-7
3.2.2.1	Physical Setting and Man-Made Environment	3-8
3.2.2.2	Water Resources	3-8
3.2.2.3	Geology and Soils	3-9
3.2.2.4	Biological Resources	3-9
3.2.2.5	Threatened and Endangered Species	3-10
3.2.2.6	Cultural Resources	3-10
3.2.2.7	Air Quality	3-11
3.2.2.8	Noise	3-11
3.2.2.9	Infrastructure	3-13
3.2.2.10	Safety	3-13
3.3	No Action Alternative	3-14

3.4 Cumulative Impacts 3-14

 3.4.1 Ground Impacts 3-14

 3.4.2 Static Fire Testing and Launch Impacts 3-14

3.5 Relationship Between Short-Term Use of Man's Environment and
the Maintenance and Enhancement of Long-Term Productivity 3-15

3.6 Irreversible or Irretrievable Commitment of Resources 3-15

3.7 Conflicts with Federal, Regional, State, Local, or Indian Tribe
Land Use Plans, Policies, and Controls 3-16

4.0 Agencies and Persons Consulted 4-1

5.0 Glossary and Acronyms 5-1

 5.1 Glossary 5-1

 5.2 Acronyms 5-4

6.0 References 6-1

7.0 List of Preparers 7-1

8.0 Distribution 8-1

 8.1 Department of Defense Agencies 8-1

 8.2 Federal, State, Local, and Other Government Agencies 8-3

 8.3 Related Participants 8-5

Appendices

A	Threatened, Endangered, and Sensitive Species Occurring or Potentially Occurring in Otero and Dona Ana Counties	A-1
B	Noise Analysis	B-1

Exhibits

1.1	Vehicle Concept and Advantages	1-3
1.2	White Sands Missile Range, New Mexico	1-5
1.3	Vehicle Configuration	1-6
1.4	Preflight & Test Activities Schedule	1-9
1.5	Overall Flow Diagram of DC-X Transport Activities	1-13
1.6	NASA/White Sands Test Facility - Propulsion Test Area 400	1-14
1.7	Modified Test Stand 402	1-15
1.8	White Sands Space Harbor — DC-X Launch and Landing Site	1-18
1.9	DC-X Ground Testing Site - General Arrangement	1-19
1.10	Launch Pad Plot Plan	1-20
1.11	Key Characteristics of Flight Test Series	1-22
1.12	Altitude Versus Down Range 45 Second Flight	1-23
1.13	Altitude Versus Down Range 110 Second Flight	1-24
1.14	Three Sigma Nominal DC-X Trajectory Contained Within a Three Mile Radius From the Launch Site	1-25
1.15	Fuel Properties	1-32
1.16	Selection of Launch and Landing Test Range	1-37
1.17	Sites Considered at White Sands Missile Range	1-41
1.18	Selection of Launch and Landing Site at White Sands Missile Range . . .	1-42

2.1	NASA/White Sands Test Facility	2-4
2.2	Selected Threatened and Endangered Species Habitat at White Sands Missile Range	2-8
3.1	Noise Impacts From DC-X Static Fire Testing at Propulsion Test Area 400	3-6
3.2	Noise Levels From DC-X Launch Tests at the Columbia Site Area	3-12

**Description of Proposed
Action and Alternatives**

1.0

1.0 Description of Proposed Action and Alternatives

Section 1.0, Description of Proposed Action and Alternatives (DOPAA), presents a description of the DC-X (Delta Clipper) test program, which is a component of the Single Stage Rocket Technology (SSRT) test program. The program is an activity proposed by the Strategic Defense Initiative Organization (SDIO). This section presents a description of the purpose and need for the proposed action; a technical description of the proposed action, including the background and concept behind the program; and a discussion of the program alternatives, specifically as those alternatives relate to the National Environmental Policy Act (NEPA) and the Council on Environmental Quality Regulations implementing NEPA (40 CFR Parts 1500-1508).

1.1 Purpose and Need for the Proposed Action

The Strategic Defense Initiative Organization (SDIO) has identified the need for single stage rocket technology to support its mission of ballistic missile defense. The purpose of the DC-X test program is to demonstrate the capability of meeting this need. Specifically, DC-X is designed to demonstrate low-cost, routine, rocket technology using single stage rocket vehicles to launch, land, and launch again in a three to seven day timeframe.

1.2 Proposed Action

The proposed action involves testing and validating the DC-X component of the SSRT program, as described below.

1.2.1 Program Description

The technology concept is to provide SDIO with a suborbital recoverable rocket (SRR) capable of:

- Lifting up to 3,000 pounds of payload to an altitude of 1.5 million feet (Ref #6);
- Returning to the launch site for a precise soft landing; and
- Launching for another mission within three to seven days.

The SSRT program involves a conceptual phase and subscale development of a DC-X vehicle. The conceptual phase has been completed and involved solicitation by SDIO of concepts/proposals for a vehicle design to meet the needs and goals of SSRT. SDIO has chosen to pursue the concept developed by McDonnell Douglas Space Systems Company (MDSSC), which consists of a vehicle that launches and lands vertically. Development of a subscale DC-X vehicle (the proposed action) follows the conceptual phase and consists of the following: to fully design, fabricate, test, and fly the subscale DC-X suborbital test vehicle to enhance confidence in a vertical takeoff and landing concept. DC-X will demonstrate:

- Interaction of engines, airframe, and launch pad at launch;
- Safe return to the launch site in event of engine failure;
- Automated touchdown within a small radius; and,
- Effect of vehicle shape and slipstream on engine performance, which includes:
 - Effective control of gust and wind-shear transients;
 - Rapid deployment of the vehicle with the goal of three to seven days; and
 - Rapid planning and loading of a new flight plan to flight computer.

The performance of the DC-X vehicle will demonstrate the feasibility of using single stage rocket technology for suborbital flight. The DC-X component of the SSRT test program is strictly a demonstration/validation of DC-X technology.

1.2.1.1 Vertical Takeoff and Landing (VTOL) System

Several different conceptual designs were considered for the DC-X test series during the conceptual phase. Vehicles with aerodynamic characteristics of high lift-to-drag ratios to achieve operational cross-range requirements were considered as well as a configuration that could be less sensitive to main propulsion system options. In addition, a vehicle and propulsion system were studied that would provide reduced flight loads both on ascent and entry-landing, allowing for the design of a lightly loaded vehicle structural system.

The vertical takeoff and landing (VTOL) system concept was chosen for DC-X after studying the benefits of other candidate approaches for meeting SDIO SSRT goals, objectives, and system performance requirements and costs. The studies concluded that

	DC-X	Classic VTOL	VTHL	HTOL
Low g's lightly loaded	Yes	No	No	No
Simple structure	Yes	Yes	No	No
All vertical processing	Yes	Yes	No	No
> 1200 nmi cross range	Yes	No	Yes	Yes
Hover abort mode RTLS	Yes	Yes	No	No
Compact landing site	Yes	Yes	No	No
Land at unpaved sites	Yes	Yes	No	No
Alt engine integration	Yes	No	Yes	Yes
Issues				
Long runways	No	No	Yes	Yes
Abort landing sites	No	Yes	Yes	Yes
High lateral landing g's	No	No	Yes	Yes
Launch erector required	No	No	Yes	Yes
Wing structures	No	No	Yes	Yes
Wing leading edges	No	No	Yes	Yes
Undercarriage trolley	No	No	No	Yes
VTOL Vertical Takeoff and Landing VTHL Vertical Takeoff and Horizontal Landing HTOL Horizontal Takeoff and Landing				

Source: MDSSC

Exhibit 1.1: Vehicle Concept and Advantages

the simple structural design of a VTOL vehicle was more suitable than a winged vehicle (Exhibit 1.1). The DC-X vehicle will launch and land vertically, be capable of suborbital flights, and demonstrate the cost and operability advantages of vertical takeoff and landing operations.

1.2.1.2 DC-X Activities

Activities required to support the DC-X test series are component/vehicle fabrication, assembly, and ground tests; preflight and test activities; and flight tests. Component/vehicle fabrication, assembly, and ground tests will occur at Scaled Composites, Pratt & Whitney, Chicago Bridge and Iron, and Aerojet. These components will be assembled off-site and then shipped to MDSSC at Huntington Beach, California for final integration and quality acceptance testing. The completed test vehicle will then be shipped to NASA/White Sands Test Facility (WSTF) for static firing and subsequently transported to the White Sands Space Harbor (WSSH) on White Sands Missile Range (WSMR) for preflight and flight activities (Exhibit 1.2). Minor modification of test facilities at NASA/WSTF and construction of launch and landing facilities at the WSSH will be required (Sections 1.2.5.1 and 1.2.6.1).

Since the DC-X is planned as a totally reusable vehicle, repetitive tests can be performed to substantiate design analysis, demonstrate concept performance, and gain operations experience. Using this approach, the final design for the operational prototype will be matured as only can occur through flight. DC-X will reduce the potential for risk for a suborbital, recoverable rocket through mitigation of technical problems.

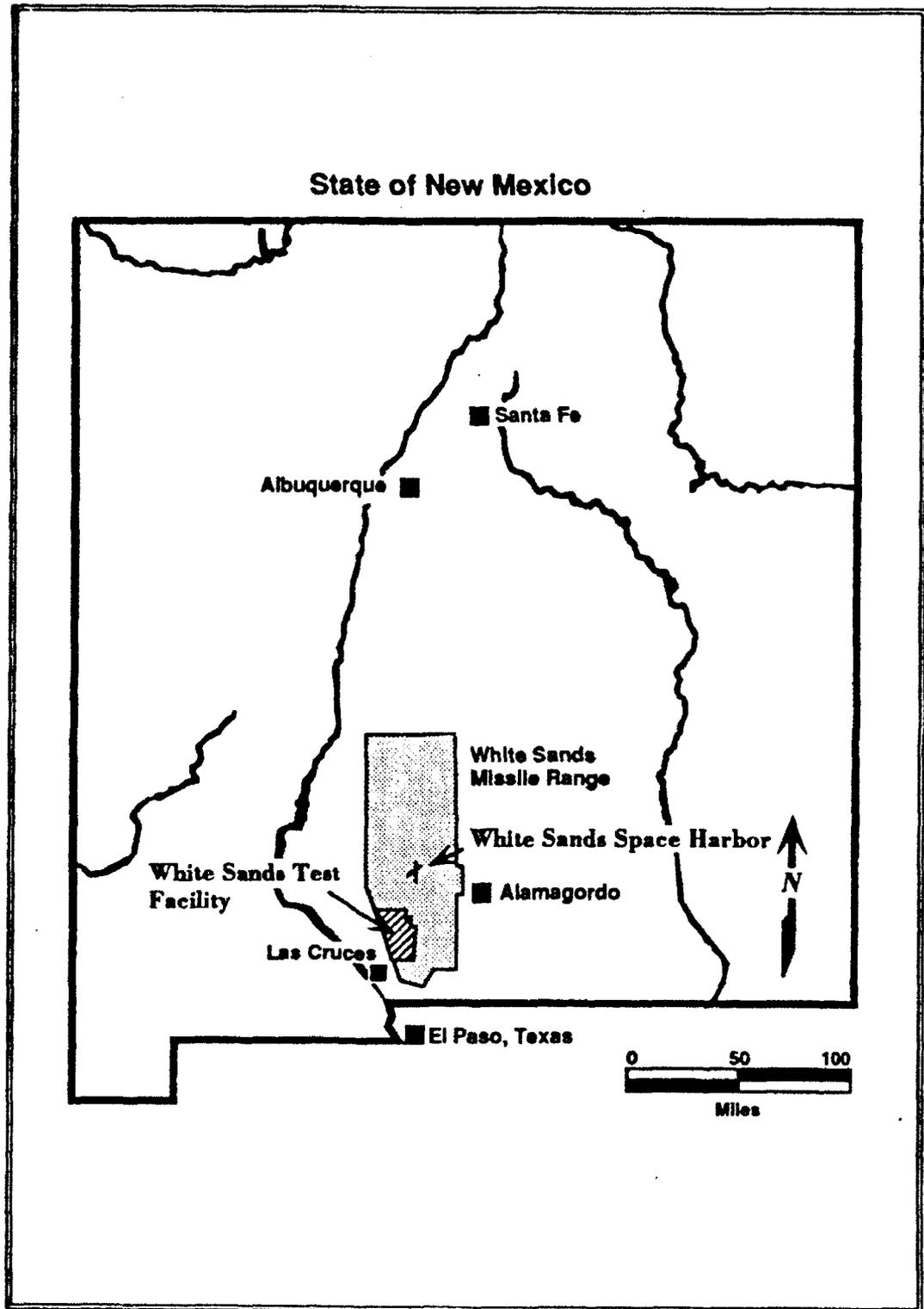
1.2.2 DC-X Vehicle Description

DC-X is a subscale test vehicle and is designed to demonstrate the capability of vertical takeoff and landing. The inboard profile of DC-X (Exhibit 1.3) has an overall dimension of approximately 40 feet tall by 13 feet wide (at the base). DC-X is a completely reusable vehicle, and will launch and land vertically at WSSH.

1.2.2.1 Propulsion System

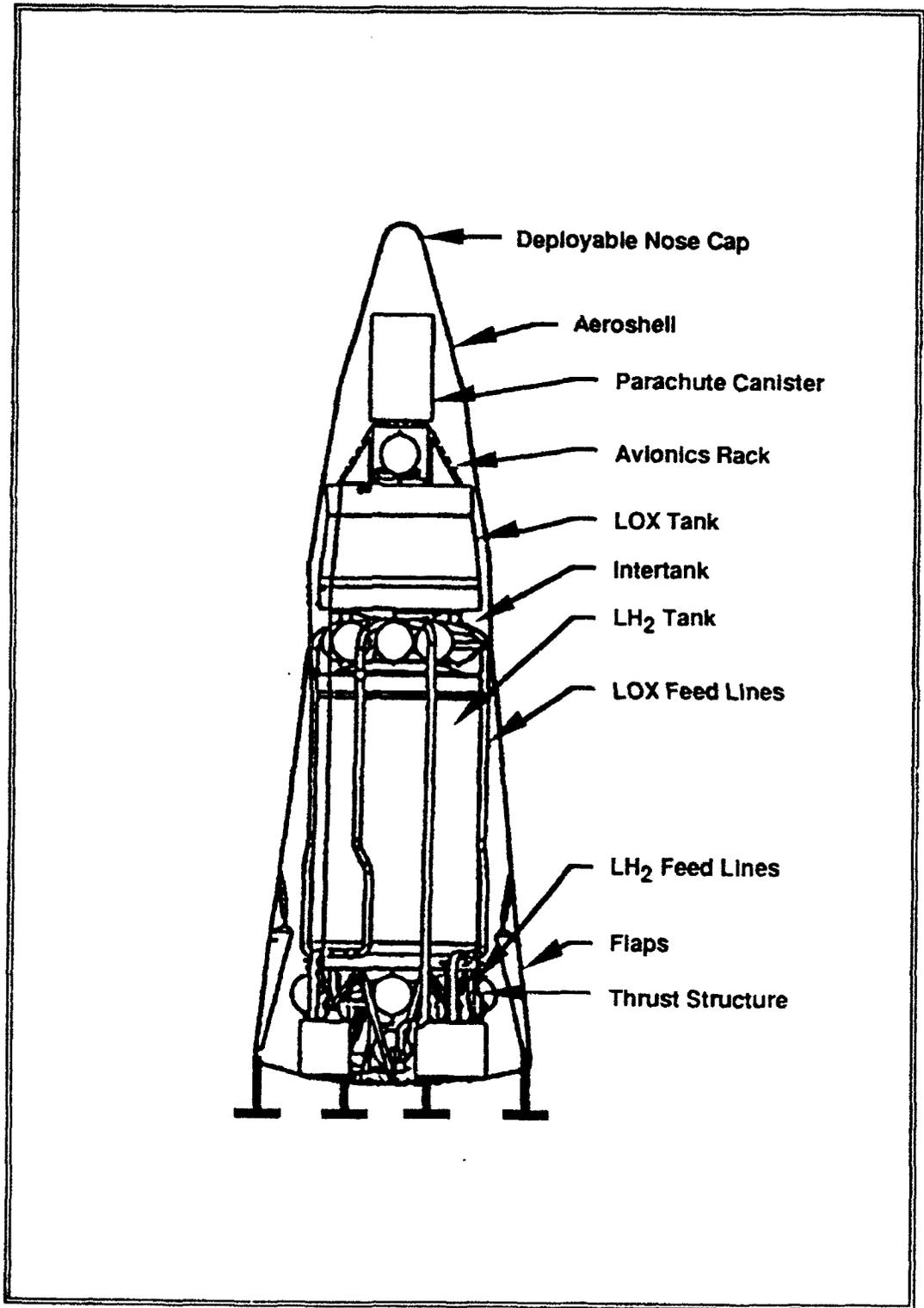
The propulsion system will consist of a liquid hydrogen (LH₂) tank and liquid oxygen (LO₂) tank, with propellant feed lines to four Pratt & Whitney RL-10A-5 engines (modified RL-10 engines). A leak detection system is being designed into the vehicle and ground processing equipment. The four engines are designed for gimbaling to provide directional thrust for attitude control for maneuvering during ascent and descent.

The propellant tanks are commercial grade cryogenic tanks with internal baffles to control propellants during flight maneuvers. The LO₂ tank requires no insulation, but the LH₂ tank will have an internal balsa wood and epoxy insulation to minimize boil off and prevent ice build-up. The tank structures are equivalent to American Society of Mechanical Engineers (ASME) coded pressure vessels. The cryogenic tanks will have multiple level sensors to control propellant loading at the high level and engine cutoff at the low level. Each tank will have a set of non-propulsive vents plus an overboard vent line to vent gases during engine chilldown and propellant loading.



Source: SDIO

EXHIBIT 1.2: White Sands Missile Range, New Mexico



Source: MDSSC

Exhibit 1.3: Vehicle Configuration

1.2.2.2 Reaction Control System (RCS)

The Reaction Control System (RCS), which controls vehicle maneuvering, consists of two modules located 180 degrees from each other. Each module consists of four thrusters (90 degrees apart in the Y-axis) that provide maneuvering during flight operations. On-board gaseous oxygen (GO_2) and gaseous hydrogen (GH_2) spheres, rated at 3,400 and 4,500 psi, respectively, provide the propellants for these thrusters.

1.2.2.3 Composition of DC-X

A graphite epoxy aeroshell provides the aerodynamic shape for the DC-X. The aeroshell consists of a forward and aft assembly. The forward assembly is the nose cone of the DC-X and houses the avionics suite and the parachute. The parachute would be deployed at designated points of the flight trajectory to safely land the DC-X in the event of an unplanned or commanded engine shutdown. The aft assembly consists of four vertical segments that form a truncated cone and attach to the aft thrust structure at one end and to the forward LO_2 tank at the other end. Five hydraulically driven flaps on the aft aeroshell provide flight control of the DC-X during the rotation flight. Attached to the aft aeroshell assembly are four landing gear struts that are deployed just before landing. The landing gears are in the retracted position during launch.

The avionics system features technology transfers from proven aircraft systems that enable autonomous control of the flight trajectory. Uplink commands will be designed into the system to accept a ground command control for engine shutdown in the event of a flight trajectory anomaly. Vehicle power during flight is provided by five 28 volt zinc oxide rechargeable batteries.

1.2.3 DC-X Ground System Description

The significant feature of the DC-X ground system is the mobility of the individual parts, which consist of four major segments: the propellant and pneumatic transfer system; mechanical support equipment; the Flight Operations Control Center (FOCC) complex; and the electrical power system. The majority of this system will initially be installed at NASA/WSTF to support the static firing operations, and will later be transported to WSSH for installation and checkout for launch operations.

The propellant and pneumatic transfer system consists of:

- LO_2 and LH_2 skid-mounted storage tanks with valves, regulators, and interconnect piping to interface with tankers that will transport the propellants to the launch site;
- LO_2 and LH_2 skid mounted valve complexes to provide flow control to the launch vehicle;

- Vacuum jacket piping connecting the storage tanks to the valve complexes and the valve complexes to the DC-X propellant umbilicals; and
- GHe, gaseous nitrogen (GN₂), GO₂, and GH₂ trailer mounted storage tanks, pneumatic control panels and the interconnect piping, including the piping to the vehicle pneumatic umbilicals.

The mechanical support equipment includes:

- Transportation and hoisting equipment for handling/erecting DC-X,
- Hydraulic checkout equipment for servicing the flap actuators and the engine gimbal actuators, and
- The launch mount that supports the DC-X at four hard points and houses the twelve umbilical services.

The FOCC complex consists of five trailers: the FOCC trailer, the Mobile Uninterrupted Power Supply (MUPS) trailer, the Telemetry and Tracking Acquisition System (TTAS) trailer, the MUPS Battery Backup trailer, and the FOCC administrative trailer. The FOCC trailer is a mobile blockhouse consisting of four personal computer workstations that provide command/control/monitoring of the vehicle during preflight, flight, and postflight operations. The FOCC has a transmitter and receiver that creates radio frequency (RF) link to the vehicle. Fiber optics interconnect (via power control panels at the launch site) the ground propellant/pneumatic transfer system and the DC-X. The electrical power system consists of fiber optics and copper cabling to the ground system and the launch vehicle. The FOCC is also linked to the WSMR Range Control Center to transmit/receive data. The FOCC is portable and will be utilized at both NASA/WSTF and WSSH.

1.2.4 Component/Vehicle Fabrication, Assembly, and Ground Test Activities

The major components of the DC-X include the aeroshell, propellant tank structures, RL-10A-5 engines, and the RCS thruster. Contractor facilities where these components will be fabricated or tested include Scaled Composites, Chicago Bridge and Iron, Pratt and Whitney, Aerojet, and MDSSC. The schedule for these activities is shown in Exhibit 1.4. A description of the engineering contractor activities follows (Ref #35, Ref #34, Ref #51, Ref #37, and Ref #33).

Facility	Location	Test Activity	Component Assembly	Preflight Tests	Flight Tests	Activity Time Frame
Scalco Composites, Inc	Mohave, CA	Fabrication of Aeroball	X			Delivery approximately 1 December 1992
Chicago Bridge and Iron	Cordova, AL	Propellant Tank Fabrication	X			7 February 1992 to 1 August 1992
Pratt & Whitney	West Palm Beach, FL	Modified RL-10 Engines	X			Testing will commence in June 1992 and continue intermittently through November 1992. Engine deliveries to MDSSC are scheduled for November and December 1992
Aerojet	Sacramento, CA	Development of Reaction Control System	X			Static hot fire testing of single thrusters March and April 1992, System static firings August 1992. Design, analysis, and procurement October 1991 to July 1992; System test data analysis October through November 1992
McDonnell Douglas Space Systems Co.	Huntington Beach, CA	Factory Integrated Systems Checkout	X	X		Start assembly work at Huntington Beach 1 August 1992; Checkout at Huntington Beach 1 October 1992 to 1 January 1993; Ship DC-X to NASA/PWSTP 8-15 January 1993
White Sands Test Facility	White Sands Missile Range, NM	Static Fire Testing		X		February 1993
White Sands Missile Range	White Sands Missile Range, NM	Flight Test Series			X	First launch scheduled for April 1993

Source: MDSSC

Exhibit 1.4: Preflight & Test Activities Schedule

1.2.4.1 *Aeroshell*

The aeroshell for the DC-X vehicle will be fabricated by Scaled Composites, Inc., in Mojave, California. The aeroshell will be composed of graphite epoxy, which is fabricated by impregnating graphite fibers with an epoxy material. Scaled Composites will also receive and install the landing gear into the lower aeroshell assembly. The four landing gears are retracted for launch and are deployed just prior to vertical landing.

Scaled Composites, Inc.—Scaled Composites will conduct activities in Hangar 78 at its Mojave facility. The activities at Scaled Composites will not necessitate modifications to existing facilities or construction of new facilities. Scaled Composites maintains baseline environmental and safety documentation for its facility, and all proposed activities will occur within the scope of this documentation. A toxic material will be used during production of the aeroshell. The facility has a RCRA permit and complies with proper management and disposal (Ref #35). The completed aeroshell will be shipped to MDSSC by commercial truck transportation.

1.2.4.2 *Propellant Tank Structure*

The LO₂ and LH₂ tanks are approximately 8 feet in diameter and will be fabricated and assembled by Chicago Bridge & Iron (CBI) in Cordova, Alabama. The tank material (2219 aluminum) and welding are standard in the industry. These tanks will be tested at full operating pressure and will be ASME rated. The tanks will be cryotested before being shipped to MDSSC at Huntington Beach for final installation. Small quantities of a toxic paint product may be used on the exterior of the tanks for shipping purposes.

Chicago Bridge & Iron—Tank construction at the CBI facility will not require modifications to existing facilities or the construction of new facilities. No additional personnel will be required to support the activities. CBI has a corporate environmental policy which governs activities at the Cordova facility, and also maintains existing safety standards which regulate activities at the facility. CBI is a conditional exempt small quantity generator under RCRA and is therefore not required to maintain a RCRA permit. No additional environmental permits are required for the facility (Ref #34). CBI has over 100 years of experience producing metal plate structures.

1.2.4.3 *Engines*

The four Pratt & Whitney RL-10A-5 engines will be modified from existing stock (RL-10 engines) and tested at the Pratt & Whitney facilities. The modification is to achieve thrust control required for DC-X. These engines have more than a 30-year history in the aerospace industry. The engines were used on the second stage of the Saturn 1B launch vehicle as part of the Apollo program in the 1960s. The RL-10 engines are currently used on the Centaur. Predicted reliability of an RL-10 engine is 0.9984 at a 90 percent confidence level (Ref #56).

Pratt & Whitney—Pratt & Whitney will perform DC-X program activities at its Palm Beach, Florida facility. Engine testing will include approximately 42 single engine firings at a maximum duration of three minutes. The firings will consume approximately 130 tons of LH₂ and 570 tons of LO₂. Pratt & Whitney has conducted test firings of LO₂/LH₂ engine systems at Palm Beach for over 30 years.

Engine systems testing is clearly a routine activity at the facility. No modifications to existing facilities or construction of new facilities will be required. No additional personnel will be required to support the DC-X program. Pratt & Whitney maintains a current RCRA permit for the facility, and all required environmental permits and policies are maintained in its Environmental Affairs Department. Pratt & Whitney maintains an existing facility-wide safety plan which governs all activities which occur at the facility.

1.2.4.4 Reaction Control System (RCS)

The RCS consists of four 500 pound thrusters that have been developed by Aerojet Propulsion Division for the National Aeronautical Space Plane (NASP). These thrusters utilize GO₂ and GH₂ to provide 100 millisecond pulses for attitude control. DC-X testing includes about 900 twenty-second duration firings consuming approximately 2.5 tons of GO₂ and 1.0 ton of GH₂.

Aerojet—RCS fabrication, assembly, and static testing will occur at Aerojet's facility in Sacramento, California, where they have been operating cryogenic facilities for the past 30 years. NASP testing was also conducted at this facility. Cryogenic testing is a routine activity at the facility. No modification to existing facilities or construction of new facilities will be required. No additional personnel will be required to support DC-X activities. All activities will occur in Test Area A, Building 30010, in Bays 4-6. Aerojet Propulsion Division has a current RCRA permit, and the required National Pollutant Discharge Elimination System (NPDES) and air permits to support DC-X activities. Aerojet has existing environmental documentation to meet Sacramento County Land Use, RCRA, and CERCLA requirements. In addition, all activities at Aerojet are conducted in accordance with existing safety directives, the emergency response plan, and the emergency contingency plan.

1.2.4.5 Vehicle Integration

The DC-X vehicle will be assembled at the MDSSC plant. The activities are initiated with a factory integrated systems checkout at MDSSC. This checkout follows the assembly of DC-X, which includes LO₂/LH₂ tank assembly, engine installation, RCS installation, and avionics and propellant/pneumatic piping installation. MDSSC will insulate the propellant tanks with balsa wood and an epoxy liner. After completing the integrated tests, the aeroshell will be installed on the core vehicle to check for proper fit.

McDonnell Douglas Space Systems Company—MDSSC will conduct DC-X activities at its Huntington Beach, California facility in Building 44. The structure will require

minimal modifications (internal changes to support the vehicle) which will not alter the footprint or the shell of the structure. No construction of new facilities will be required. No new personnel will be required to support the project. No environmental permits are required for the MDSSC facility. Materials rated as toxic or hazardous will not be used for the program at the facility. No specific safety permits are required for DC-X; however, routine safety measures will govern the activities.

1.2.5 PreFlight and Test Activities

After the DC-X vehicle has been assembled and tested at MDSSC, it will be shipped horizontally from the facility as two major assemblies (the core vehicle and the aeroshell) by commercial highway transport to NASA/WSTF on WSMR for preflight and test activities (Exhibit 1.5). Permits and escorts will be required to transport the wide loads from California to New Mexico. Static firing activities are proposed to begin in February 1993 (Exhibit 1.4) at NASA/WSTF, which is located north of Highway 70 on WSMR. Test Stand 402 will be modified for DC-X by making structural changes and installing piping for propellants and pneumatics. Static firing activities will partially simulate flight profiles and validate prelaunch checkout procedures. Incremental short duration firings of five to ten seconds will be followed by full duration firings that simulate the flight trajectories.

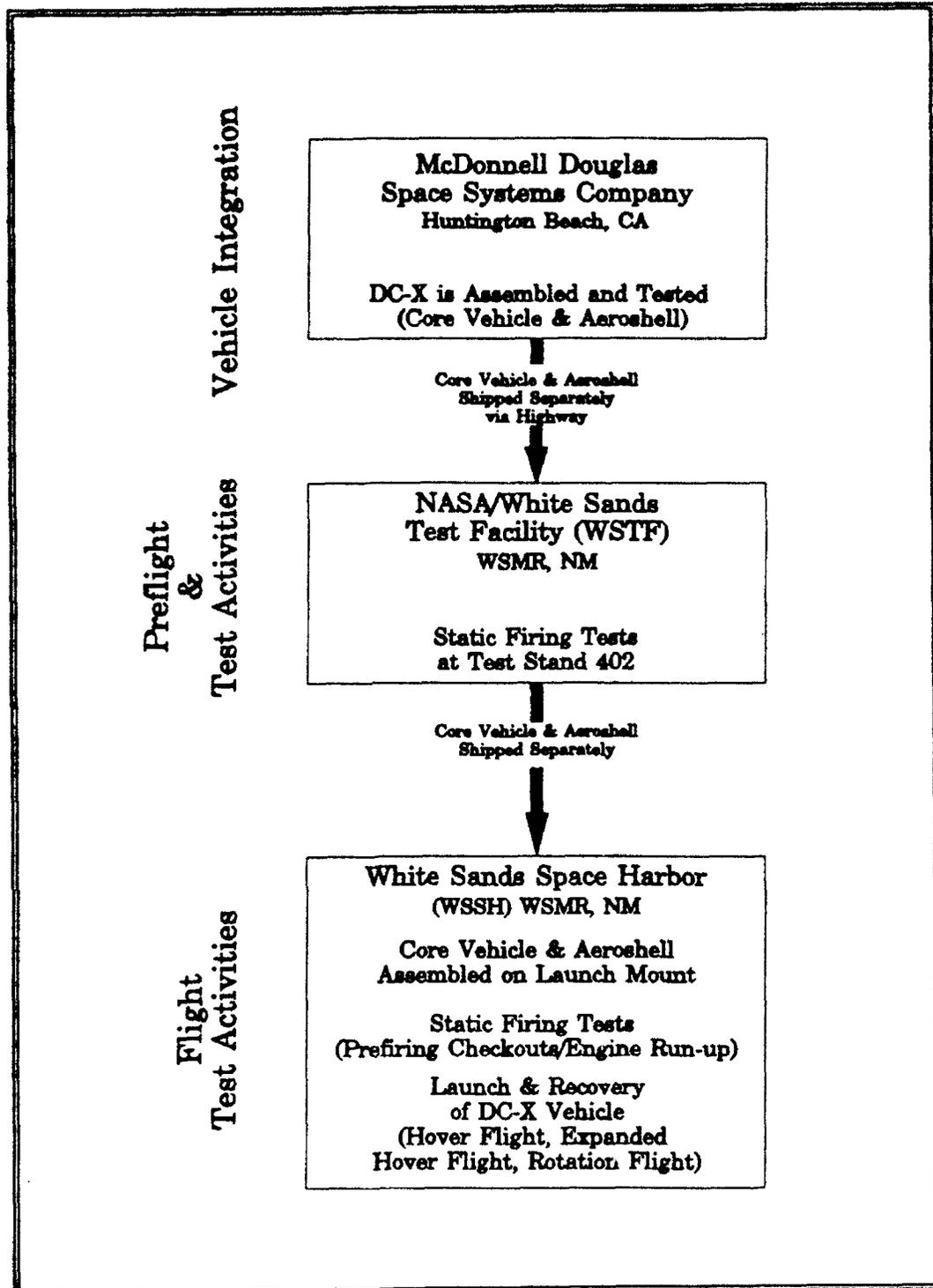
1.2.5.1 Construction

NASA/WSTF consists of two propulsion test areas, an industrial area, and an administrative area. The specific area of interest for DC-X is propulsion test area 400 (Exhibit 1.6), which consists of three altitude test stands, an ambient test stand, an altitude simulation system, and a 75 foot by 80 foot concrete blockhouse (Ref #14). Within the test area there is a facility support system consisting of helium and GN₂ storage/distribution system, a hypergolic storage/distribution system, and a breathing air distribution system (Ref #14).

The DC-X project will utilize the concrete blockhouse and modify ambient Test Stand 402 (Exhibit 1.7) for the DC-X static fire test program. Test Stand 402 is 33 feet by 33 feet square and 30 feet high with a removable enclosure to protect the stand from the weather. It was designed for vertical down firing of engines up to 25,000 pounds thrust (this will be modified for 50,000 pounds capacity) and includes a water-cooled flame bucket.

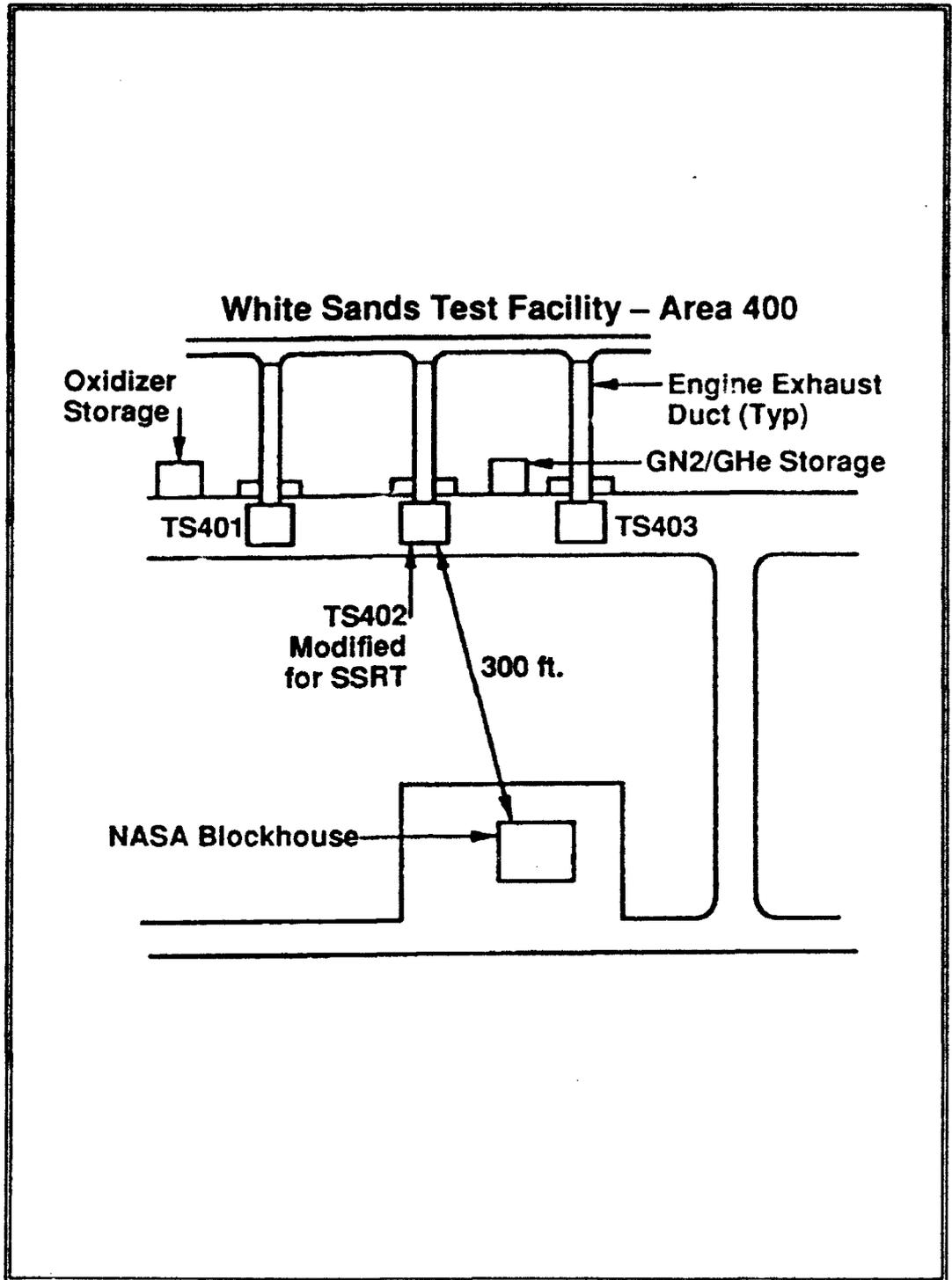
Modifications to Test Stand 402 consist of the following:

Controls- Install control capability to include emergency stop, vent, dump, etc. A system will also be installed and used to initiate an automatic shutdown if any of the critical engine or vehicle parameters exceed redline limits. Redline limits, essentially the mechanical limits of the vehicle, are monitored by pressure sensors.



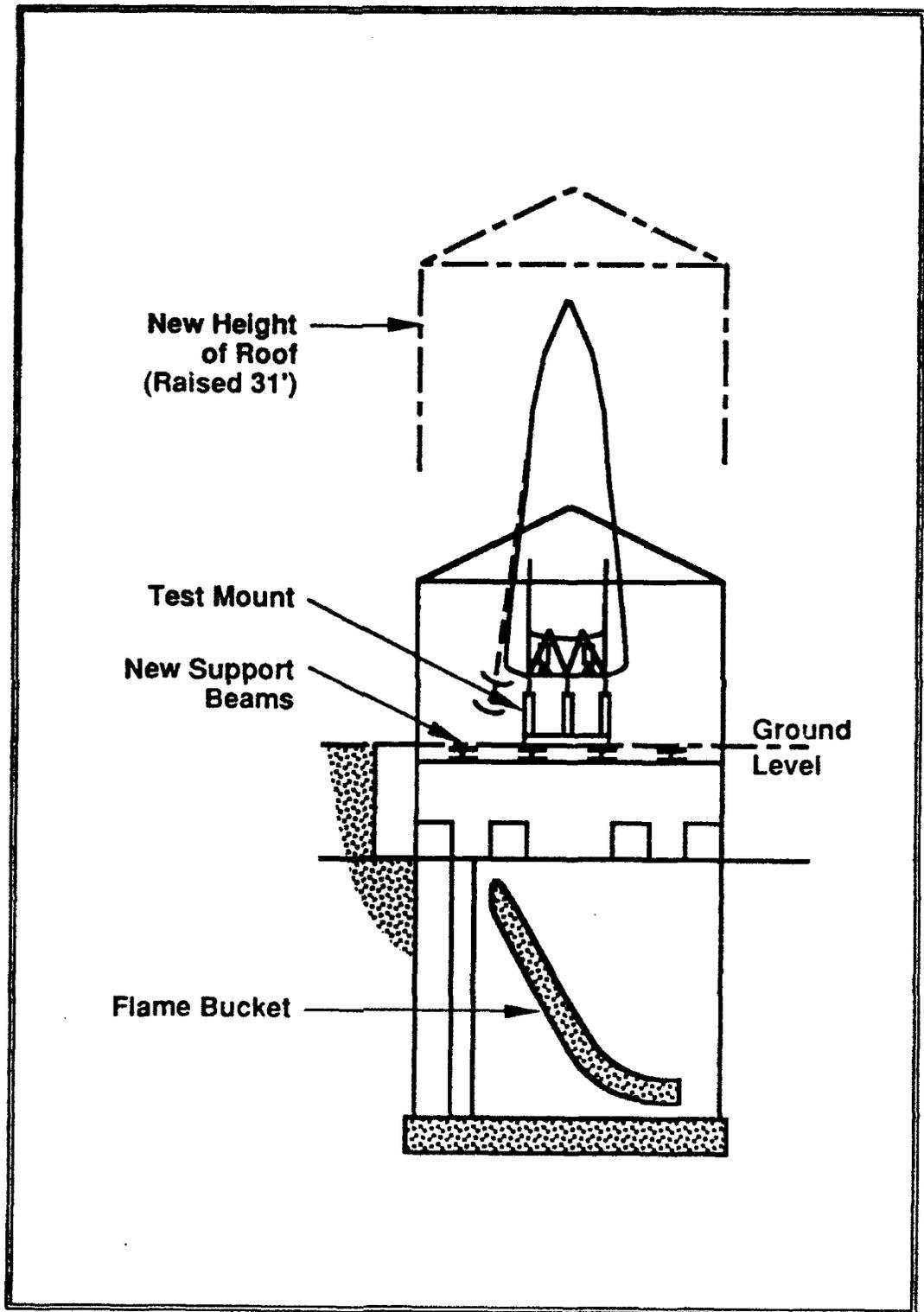
Source: MDSSC

Exhibit 1.5: Overall Flow Diagram of DC-X Transport Activities



Source: MDSSC

Exhibit 1.6: NASA/White Sands Test Facility - Propulsion Test Area 400



Source: MDSSC

Exhibit 1.7: Modified Test Stand 402

Modify Test Stand Outer Enclosure- Modify the structure of Test Stand 402 by raising the test stand roof to accommodate the test vehicle and to provide a comfortable environment for personnel.

Test Stand Floor Modification- Remove portions of the existing test stand floor to allow either the vehicle, or the water cooled diffusers, to penetrate. Stainless steel diamond plate and spill pans will be installed to protect the carbon steel structure for cryogenic spills in the event of a major leak.

National Electrical Code Requirements- De-energize (power shut-off) all extraneous test stand electrical systems. The remaining systems will be enclosed and purged with nitrogen to prevent combustion via a spark, or replaced with electrical box equipment. This is required for all electrical devices within 25 feet of the hydrogen system at ground level or below.

Cryogenic Vents- Design and install a hydrogen vent stack at Test Stand 402. The requirement for a vent stack and vent stack sizing depend on the amount of hydrogen to be vented.

Water System Modifications- Modify the existing FIREX fire extinguisher/system to provide adequate vehicle coverage and to provide cooling water for the RCS ducts and main engine diffusers.

RCS Water Cooled Turning Elbows- Provide water cooled turning elbows to deflect the RCS plume downward, through the floor of the test stand.

Hydrogen Ignition System- Design and install a hydrogen vent and ignition system for hydrogen vented during engine chardown.

Lightning Protection- Provide lightning protection using rods, etc., while the test vehicle is installed at Test Stand 402.

No construction modifications are required to adapt the NASA/WSTF blockhouse to provide DC-X static firing operations.

1.2.5.2 Tests

Following successful acceptance testing, the components will be assembled into their respective flight vehicle systems, and functionally and leak tested under ambient simulated flight conditions to ensure the functional integrity of the assembled systems.

Integrated functional checkout and simulated flight at ambient conditions will be repeated, followed by the loading of cryogenic propellants and pneumatics to flight levels. The main propellant tanks will be pressurized during the last few minutes prior to engine ignition. The four RL-10A-5 engines will initially be ignited at low thrust levels. Once

normal system operation has been verified, thrust levels will be increased and nominal flight systems profiles will be statically performed.

Following successful completion of the static test series, the DC-X core vehicle and aeroshell will be transported to the WSSH Columbia site (Exhibit 1.5) and assembled together on the launch mount. The pre-firing checkouts accomplished at the static firing site will then be essentially repeated to verify the flight readiness of the DC-X vehicle; that is, the four RL-10A-5 engines will be initially ignited at thrust levels less than required to achieve vehicle lift-off. Once normal systems operation has been verified, the DC-X flight test series will commence. This preflight engine run-up provides the last and best system checkout.

The evaluation of systems operational data after each flight will determine the amount of checkout required prior to the next flight. Unless the data indicate abnormal system performance, pre-mission checkout will be minimized.

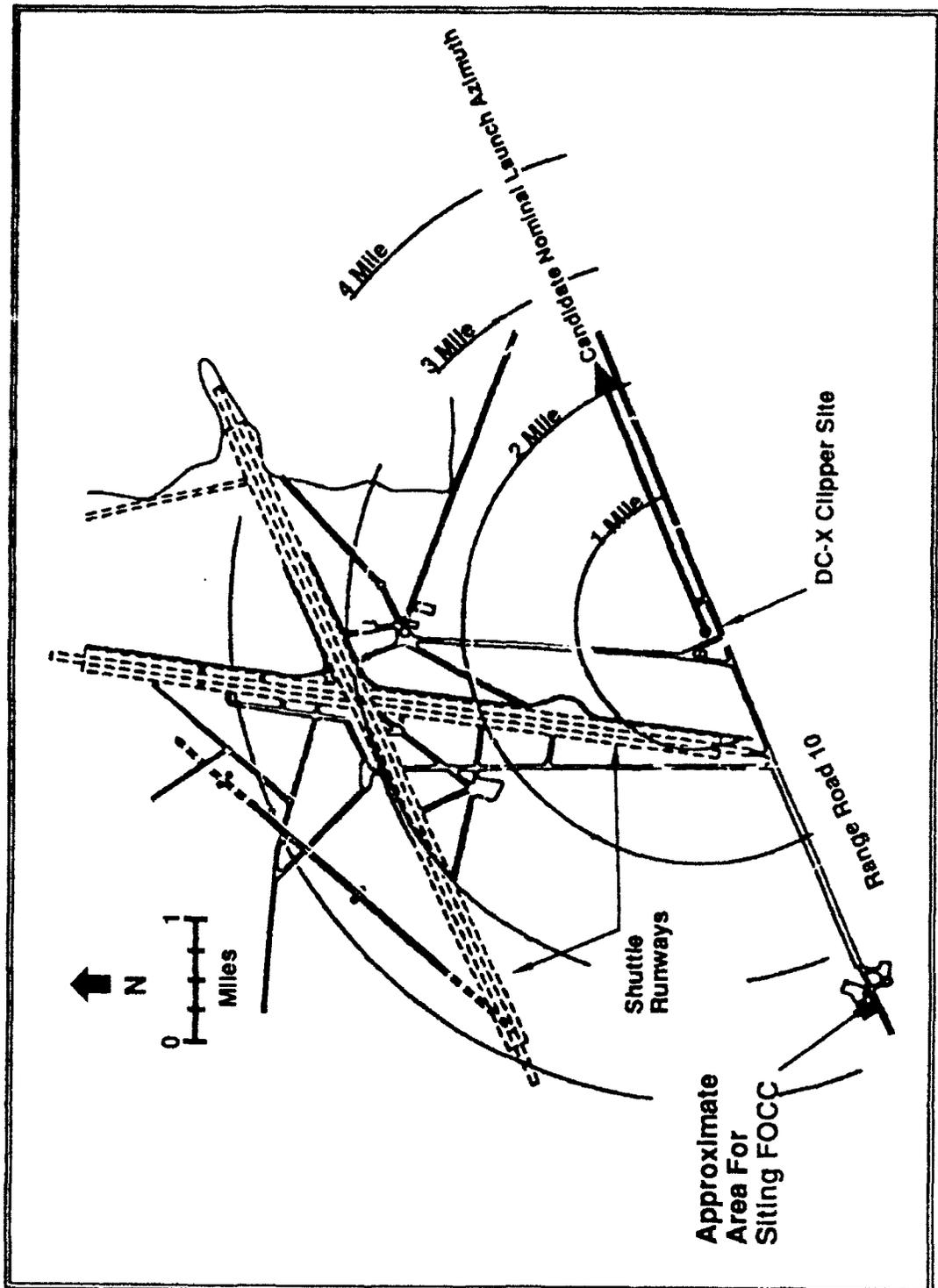
1.2.6 Flight Test Activities

The flight tests will be conducted at WSMR in April 1993 (Exhibit 1.4) at the WSSH Columbia site east of Highway 7 and north of Range Road 10 (Exhibit 1.8). This area consists of three 15,000 foot runways, a control tower, and support buildings for the Shuttle landing operations, and is operated by the Lyndon B. Johnson Space Center (JSC) at NASA. Three mission profiles are planned for DC-X: Hover flight; Expanded Hover flight; and Rotation flight.

1.2.6.1 Construction

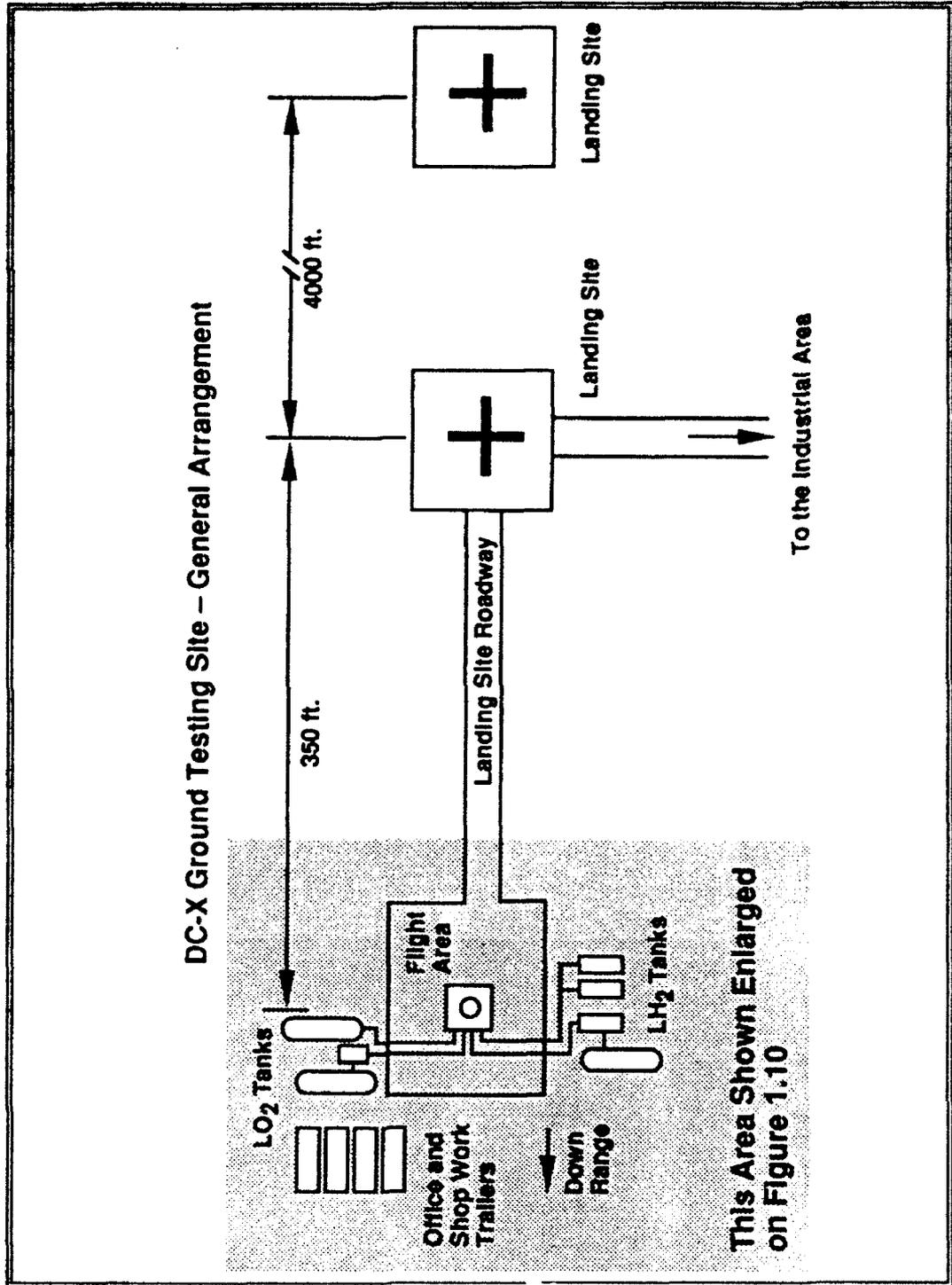
The WSSH facilities to be used for the DC-X flights consist of three main areas: the launch pad area designated as the DC-X Clipper site; the landing area; and the FOCC and parking area (Exhibit 1.9). WSSH is operated by NASA/JSC as an emergency landing area for the Shuttle Orbiter and ongoing Shuttle training.

The launch pad for DC-X is located on an existing concrete pad adjacent to the area designated as the "Columbia Site", and is located just off of Range Road 10. This pad was built for servicing the Shuttle Orbiter, but has been abandoned for a new servicing site located west along Range Road 10. Excavation will occur to construct trenches 1.0 foot deep. The launch pad plot plan is shown in Exhibit 1.10 and shows schematically the location of mobile ground support equipment such as fuel/oxidizer storage tanks, valve complexes, pneumatic storage tanks, power distribution panels, and a launch mount. Equipment not directly required for launch operations, such as office trailers, equipment trailers, and temporary sanitation facilities will be located in the launch pad immediate area. The launch pad area will consist of a concrete foundation, aprons, trenches, and roadways.



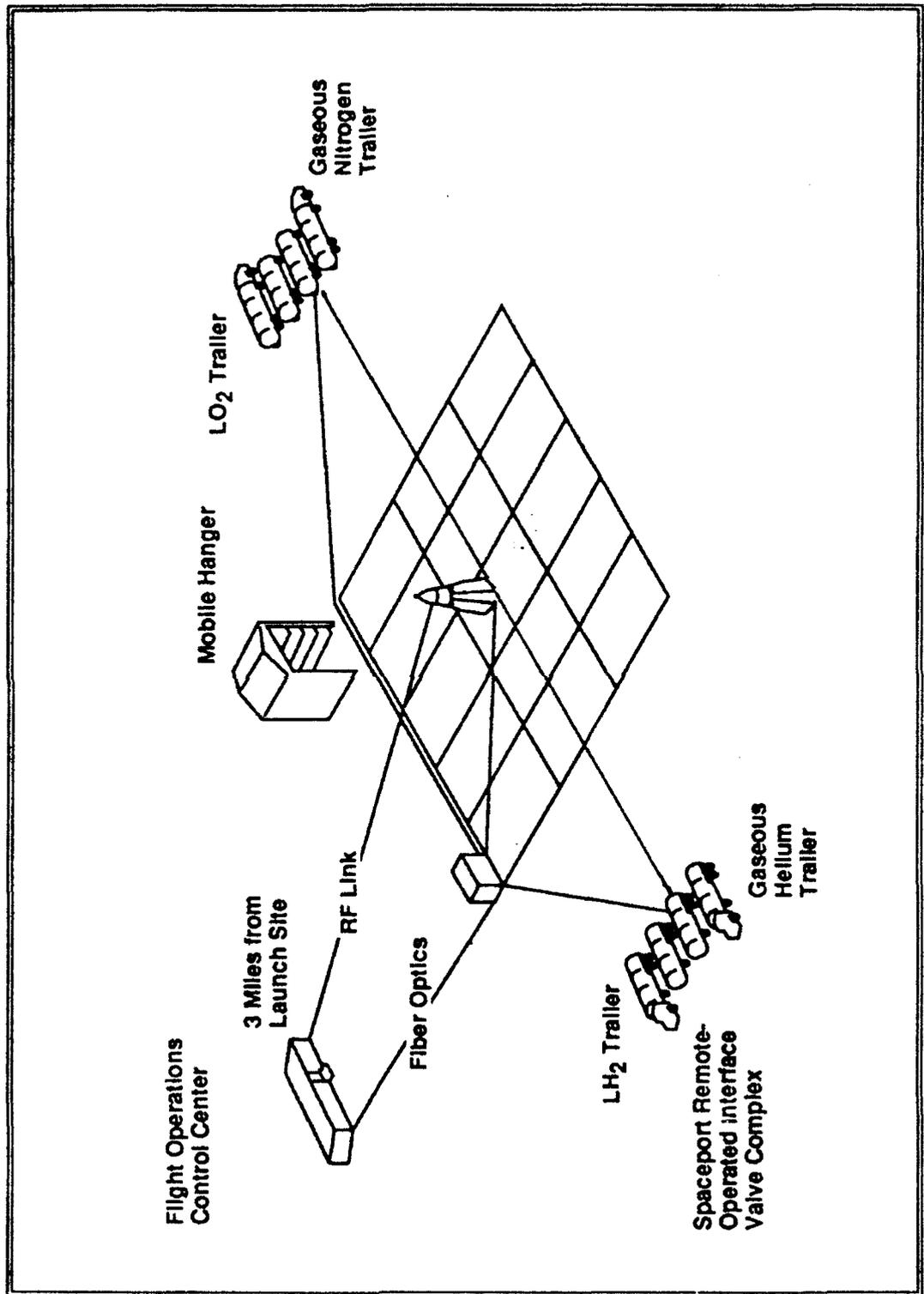
Source: MDSSC

Exhibit 1.8: White Sands Space Harbor — DC-X Launch and Landing Site



Source: MDSSC

Exhibit 1.9: DC-X Ground Testing Site-
General Arrangement



Source: MDSSC

Exhibit 1.10: Launch Pad Plot Plan

Two landing areas will be constructed. The landing pad for the Hover flight is a 100 foot by 100 foot by six inch landing pad to be constructed 350 feet from the launch pad (Exhibit 1.9). This nominal landing area is based on a 78 degree candidate launch azimuth for the initial DC-X hover flights. The landing surface is concrete with a special top coat material to inhibit concrete spalling from heat from the rocket engines during the DC-X descent. An access road will be constructed from the launch pad to the landing area. The roads will be 24-40 feet wide and elevated 6 to 12 inches to provide access to the areas after substantial rains. The surface will be prepared, but does not require paving.

A second landing area will be prepared and sited approximately 4,000 feet from the launch pad to accommodate the Rotation flight test series. Additional access roads will be constructed to this landing site.

The FOCC area will be located approximately three miles from the launch pad to prevent damage to equipment and injury to personnel from falling debris in the event of a DC-X catastrophic failure. This area will be located adjacent to the existing NASA Service area along Range Road 10. A prepared surface will be provided for parking the FOCC trailers and adjacent to existing power and communication utilities. Electrical power will be provided by power lines located south of the FOCC. The lines will be aerial lines until they reach Range Road 10; at this point they will be buried in the subsurface to the FOCC area. Command/control interface with the DC-X will be by redundant fiber optic links.

1.2.6.2 Flight Profiles

The proposed action involves three series of flight tests. These include: Hover flight; Expanded Hover flight; and Rotation flight. Multiple flights are planned for each type of flight test. The flight test sequence is focused on satisfying the program objectives via system and subsystem functional verification.

Exhibit 1.11 summarizes some of the key characteristics of the three flight test series including total flight time, maximum altitude, maximum mach number, maximum dynamic pressure (Q), and maximum vehicle axial and lateral accelerations (Az). Launch of DC-X will not occur if the ground wind speed is greater than 20 feet per second or the wind speed at 20,000 feet altitude is greater than 75 feet per second. The landing sites for the Hover flight test series and Rotation flight test series are 350 feet and 4,000 feet up range from the launch site, respectively.

The Hover flight test series is characterized by low vehicle loads and mach numbers. It will verify the "controllable vertical takeoff and landing" objective of the demonstration program and a number of detailed functional guidance, navigation, and control capabilities associated with the prelaunch, ascent, rotation, and landing flight phases. The flight will achieve an altitude of approximately 600 feet. Exhibit 1.12 depicts the altitude versus downrange characteristic for a 45 second flight test.

Flight	Time (sec)	Altitude (ft)	Mach # (nd)	Q (psf)	Axial (g's)	Az (g's)
Hover	45	600	0.06	6	1.25	0
Expanded Hover	110	5,000	0.20	60	1.75	0
Rotation	180	26,000	0.55	170	1.95	0.8

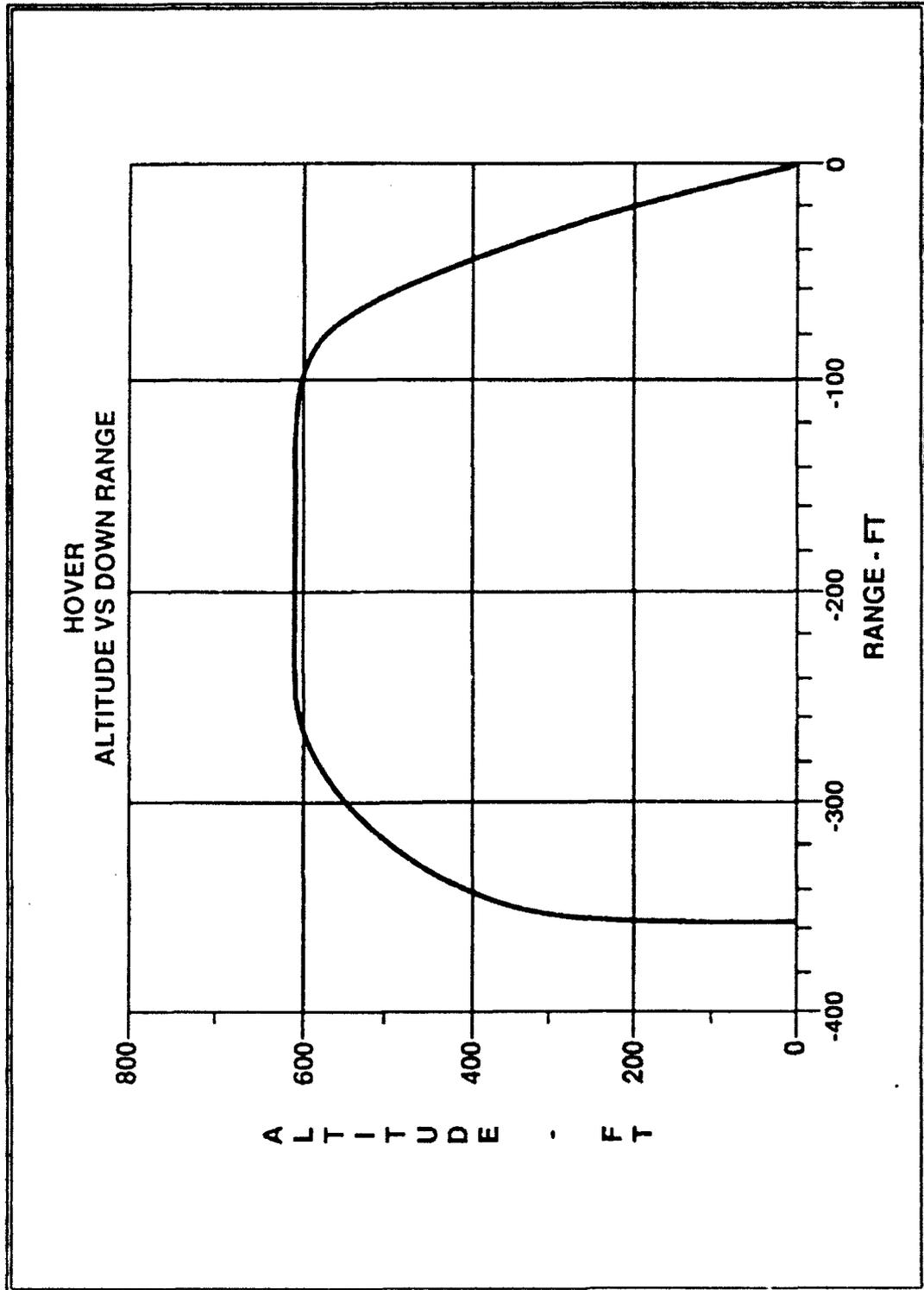
Exhibit 1.11: Key Characteristics of Flight Test Series

The **Expanded Hover** flight test series expands the dynamics envelope relative to the Hover series in terms of velocities and loads. While the prelaunch and flight functions are the same, this series permits the demonstration of the "rapid turnaround" program objective. The vehicle will climb to an altitude of approximately 5,000 feet during the flight. The altitude versus down range characteristic for a 110 second flight test is given in Exhibit 1.13.

The **Rotation** flight test series demonstrates the "controllable vehicle rotation maneuver" program objective. It will verify flight performance during the rotation phase of flight, that period when the vehicle is rotated from its reentry orientation to a vertical orientation in preparation for landing. This series significantly increases the dynamics envelope relative to the two hover series, and exercises the vehicle aerodynamic actuation subsystems. The Rotation flight mission is an ascent flight to 22,000 feet altitude, a descent to 20,000 feet, a rotational maneuver to orient DC-X vertically, throttling up of the engines at 400 feet, and a descent to a landing site 4,000 feet from the launch site. The mission is a continuous burn trajectory lasting 180 seconds in a candidate northeasterly direction. Engine shutdown will occur after the soft touchdown. Following each flight, the complete DC-X vehicle will land vertically and be transported in a vertical position by land back to the launch site. At the launch site, the vehicle will be erected vertically onto the launch mount and prepared for its subsequent flight.

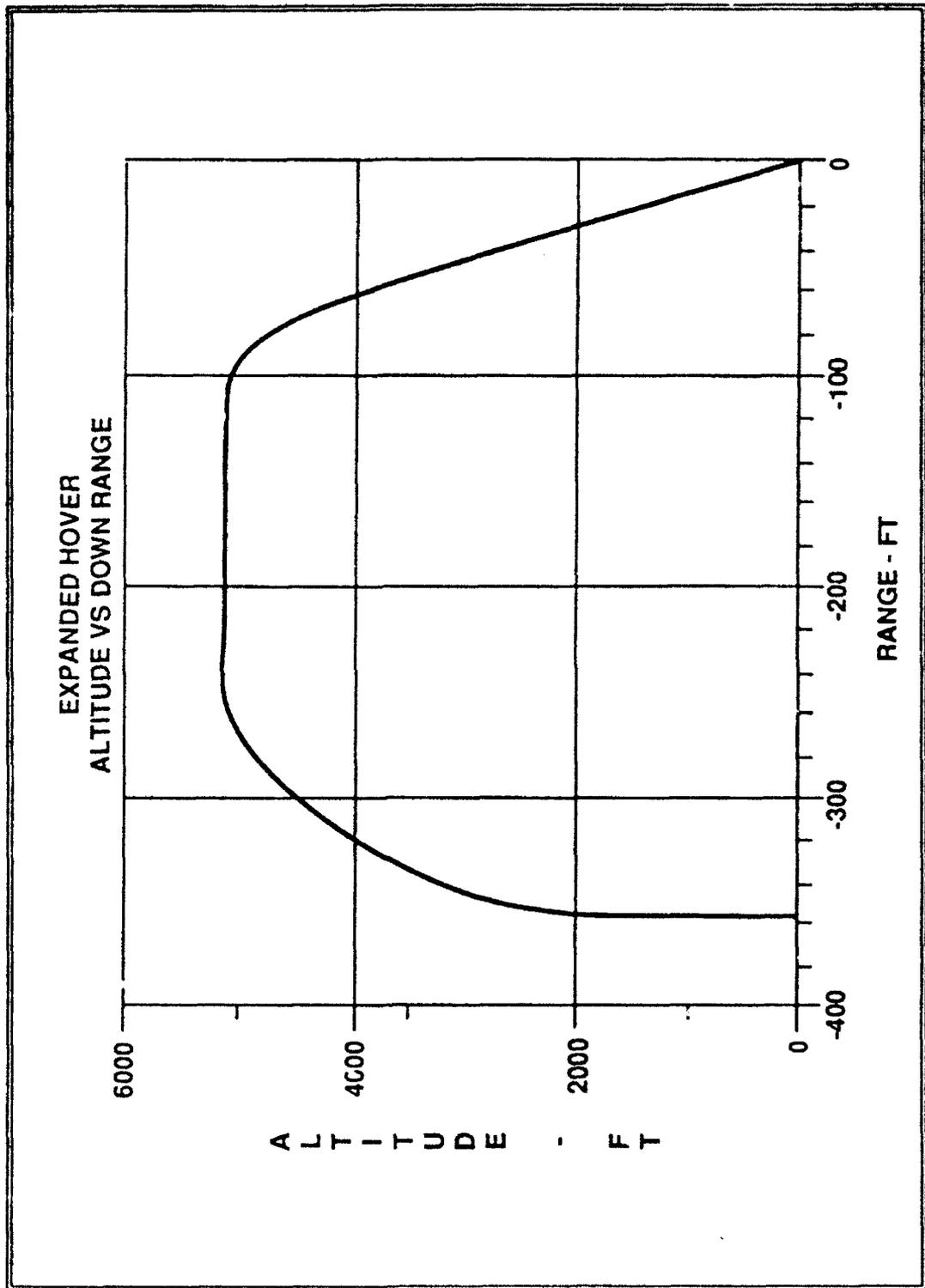
The DC-X flight vehicle does not have a destruct system. The vehicle has an onboard fault detection, isolation, and recovery (FDIR) capability to identify and respond to flight hardware and software. This includes the ability to turn off the main engines, deploy the parachute recovery system (PRS), and deploy the landing gear in the event of flight problems. In addition, a non-destructive engine cut-off system also exists which consists of ground and onboard elements. This system provides a parallel capability to turn off the main engines and deploy the PRS and landing gear based upon ground sensing of anomalous conditions during flight.

Flight Anomalies— The current three sigma nominal DC-X trajectory will be contained within a three mile radius from the launch site, based on analyses for bounding case trajectory anomalies and debris dispersion resulting from catastrophic failure (Exhibit 1.14). The bounding case trajectory anomalies include loss of vehicle control and deployment of the Parachute Recovery System (PRS), as described below.



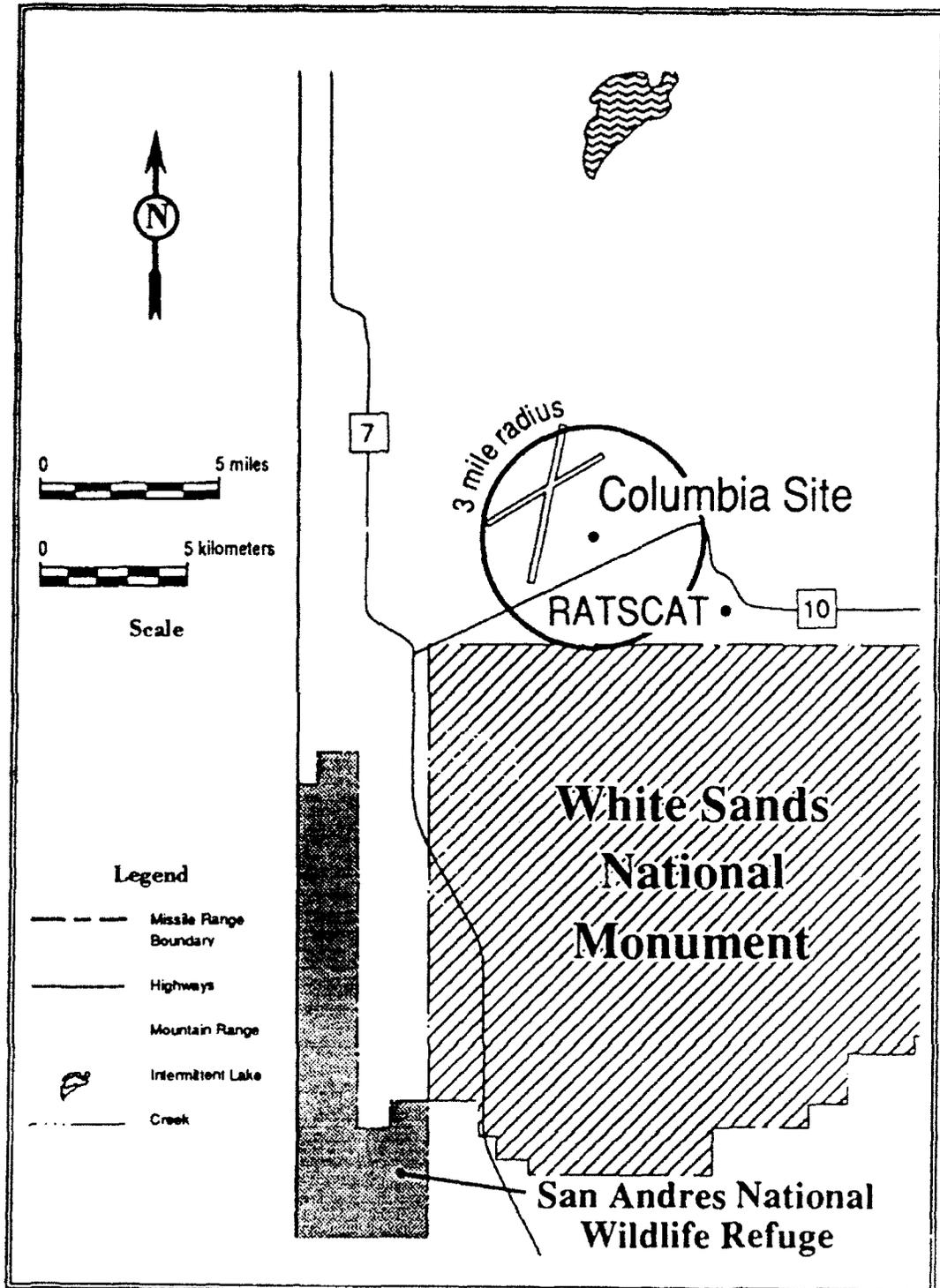
Source: MDSSC

Exhibit 1.12: Altitude Versus Down Range 45 Second Flight



Source: MDSSC

Exhibit 1.13: Altitude Versus Down Range 110 Second Flight



Source: MDSSC

Exhibit 1.14: Three Sigma Nominal DC-X Trajectory Contained Within a Three Mile Radius From the Launch Site

Loss of Vehicle Control— Under this type of flight anomaly trajectory, control of the vehicle is lost during flight. The vehicle may undergo pitch plane tumbling and thrusting (pitch up plus engine cut-off failure), or it may obtain and hold Alpha = 90 degrees while thrusting (pitch up plus engine cut-off failure). Under each case, the dispersion area is contained within the three mile radius cited above. Additional flight anomaly scenarios include losing guidance but maintaining control and losing control during ascent and rotation. Results from these projections are also contained within the three mile radius.

Deployment of Parachute Recovery System— A second type of flight anomaly trajectory involves deployment of the parachute recovery system. Deployment of the PRS is coupled with engine cut-off. Under this scenario, a flight anomaly is detected and the nose cone is released and ejected. A small drogue chute is deployed to orient the vehicle vertically. This chute automatically cuts loose, the main chutes are ejected, and the vehicle floats to the ground for a soft landing. Upon landing, the main chute automatically cuts loose so the vehicle will remain stationary and will not be dragged on the ground by wind. The distance the DC-X vehicle will be carried downrange is primarily a function of the vehicle altitude when the PRS system is deployed, sink rate capabilities, and prevailing winds. The winds vary with season and altitude.

Catastrophic Failure- Debris dispersion from catastrophic failure involves failure of the vehicle at altitudes less than 5,000 feet, and a hard landing of the vehicle because the parachute recovery system is ineffective at altitudes less than 5,000 feet. Again, the dispersion area resulting from this scenario is contained within the three mile radius cited above.

Probability Analyses- In addition to the three sigma dispersion analysis, it was necessary to calculate the probability of impact from these failure scenarios to any facilities within the three mile radius. The Flight Operations Control Center (FOCC) is currently planned to be located 3 miles west along Range Road 10, near Route 7. The probability that the DC-X vehicle will impact the FOCC has been calculated to be less than 3×10^{-13} . The probability of exceeding the three mile radius was calculated to be 6.91×10^{-10} . Therefore, since the RATSCAT facility is located 3.71 miles from the Columbia Site, a probability analysis for impacts on RATSCAT was not conducted.

1.2.6.3 Recovery

As stated above, the current three sigma nominal DC-X trajectory will be contained within a three mile radius from the launch site. Therefore, recovery operations for DC-X are projected to occur within the Alkali Flat at WSMR. This includes all potential debris recovery in case of a catastrophic event. Hydraulic servicing would be minimal, if any, since all propellants on board are non-toxic. Since DC-X is reusable, the DC-X will land in the vertical mode and will be recovered. Any residual propellants on board will boil off and vent to the atmosphere. Independently the propellants are benign. This is analogous to storage tank boil off venting, which is standard in the cryogenic industry.

DC-X instrumentation will provide the necessary data by RF link to the FOCC to verify that all systems are safe before personnel are allowed to approach the DC-X landing area.

1.2.7 Launch and Range Control

Existing and new facilities at WSMR will be used for launch and range control through utilization of the FOCC (Section 1.2.3). The newly created WSMR Space Operations Directorate (SPO) is the SSRT sponsor at WSMR and will provide:

- Program management for WSMR activities;
- Flight and ground safety requirements through coordination with National Range Operations;
- Funding to WSMR activities;
- Launch and facilities support services through coordination with various WSMR activities; and
- Scheduling and documentation through coordination with National Range Operations.

The National Range Operations Directorate will provide aerospace instrumentation, data collection/reduction, mission scheduling, test control, launch interrupt commands, and in-flight engine cut-off commands. The range is linked to the FOCC to relay data received from the ground and flight systems during prelaunch activities. The Range is in contact with DC-X during flight operations for range control. The FOCC will be located east of WSMR Highway 7 and north of Range Road 10 near the NASA Shuttle Servicing area. Building 300 at the WSMR Post area, the Range Control Center, will be used for range control.

1.2.8 Ground and Flight Safety

1.2.8.1 NASA/White Sands Test Facility (WSTF)

Ground safety is under the jurisdiction of NASA/WSTF and testing will not proceed if safety requirements are not met by flight vehicle design and construction. The safety program at NASA/WSTF is governed by the NASA JSC WSTF Safety Manual (WSTF 15.4) and Executive Order 12196 directing compliance with the Occupational Safety and Health Act of 1970. For NASA/WSTF, the Manager and Safety Officer will be responsible for implementing and maintaining a safety program for SSRT test program consistent with the NASA JSC WSTF Safety Manual. The Safety Officer will be the primary point of contact at NASA/WSTF and will provide safety policy and technical guidance. The facility will be monitored by the Safety Officer for any safety violations and hazards.

NASA/WSTF has developed hazardous operations procedures and requirement for facility personnel. Test personnel will be certified to perform assigned tasks; while personnel performing functions that require special skills will be certified in accordance with appropriate skill certification requirements (i.e., hazardous activities and propellants). All NASA/WSTF personnel are given a safety orientation, prior to beginning work, and will wear appropriate safety equipment. The "buddy system" will be employed in areas where potentially hazardous situation exists. Appropriate safeguards and precautions will be implemented. Personnel safety distances and protective measures will be incorporated in the safety plan.

1.2.8.2 White Sands Missile Range (WSMR)

Ground and flight safety is under the jurisdiction of WSMR and testing will not proceed if safety requirements are not met by flight vehicle design. For WSMR flights, safety requirements are defined by memorandum from the National Range Operations Directorate, Operations Control Division, WSMR (Ref #24).

To comply with WSMR safety regulations, the SSRT program participants are required to submit five documents to WSMR safety personnel: a preliminary site plan; a final site plan; safety standing operating procedures (SSOP); a safety assessment report; and a missile flight safety operational plan (MFSOP). Submission of these documents is in accordance with:

- DoD Directive 3200.11;
- Army Regulation (AR) 700-107;
- WSMR Regulation No. 385-15;
- WSMR Regulation No. 385-17 (flight safety); and
- Chapter 12, WSMR Range Users Handbook 1990 (Missile Flight Safety)

The preliminary site plan consists of nine major elements:

- Description of the project;
- Project locations;
- Other nearby facilities;
- Project installation boundaries;

- Proximity of public highways, transmission lines, and distribution lines;
- Proximity of electrical substations, if any;
- Use and occupancy of launch area;
- Explosive items (including quantity, distances); and
- Explosive classes.

The final site plan consists of the following elements:

- Site plan compared against range master plan;
- Drawings, plot plans: including foundation drawings for launch mounts, paving and access road details;
- Lightning protection systems;
- Static grounding systems;
- Vehicle hangar;
- Exact location/distances to other facilities, public roads, distribution lines;
- Flight complex; and
- Details of support trailer installations.

The safety standing operating procedures (SSOP) are due to WSMR from the SSRT program one month prior to performing hazardous operations. The hazardous operations consist of propellant loading from highway tankers to the launch pad storage tanks; pressurizing gas storage tanks; propellant loading of DC-X; pressurizing DC-X gas bottles; pressurizing DC-X tanks; DC-X handling and erection; and securing DC-X after landing. The preliminary plan includes the following elements:

- Description of each hazardous operation and how it will be safely performed;
- An operator's statement showing an understanding of the SSOP;
- A supervisor's statement of understanding of the SSOP;

- A hazard analysis of each explosive operation (matrix format);
- Signature of approval from the contractor, Chief of the WSMR Safety Office, and Director, SPO; and
- Material Safety Data Sheets (MSDSs) for all hazardous materials.

The safety assessment report is due one month prior to performing operations at WSMR and includes the following elements:

- A summary of Contractor's Project hazard analysis;
- A preliminary system analysis;
- A subsystem description (engine and cryogenic tanks, etc);
- Systems analysis;
- An operational hazard analysis;
- Can include hazard analysis matrix from SSOP; and
- Signature approval by contractor prior to forwarding to TECOM and WSMR for approval.

The flight safety plan consists of five principal elements. The first element is administrative information, which identifies the test/mission, key personnel, control site, mission support, and associated support planning. The second element defines the vehicle to be used in the flight. The third element describes the engine cut-off method and verification procedures/restraints. The fourth element, test operational concepts, identifies the flight, test events, (e.g. communication verification) test limits (e.g. launch angle), and operating limits. The fifth element, range derived requirements, identifies requirements for roadblocks and evacuation, tracking sites, and other requirements such as post launch data requirements.

WSMR flight safety ensures that the flight plans meet range safety requirements, calculates the predicted flight path using reasonably foreseeable adverse wind conditions to establish the limits of the vehicle dispersion pattern, and calculates the predicted flight hazard and dispersion areas using reasonably foreseeable performance anomalies. As the designated safety official at the launch site, the Flight Safety Officer allows launch of the vehicle only when he/she is satisfied that all safety parameters have been met.

WSMR National Range Operations monitors the trajectory from the ground in all tests. Flight safety is maintained through tracking and up-link command circuits which can command engine cut-off, if necessary. The DC-X incorporates equipment to provide an uplink command to cut-off the four engines and deploy parachutes for safe landing of DC-X.

1.2.8.3 Explosives Classification

There are no solid propellant motors and a minimal amount of ordnance on the DC-X vehicle. In the event of an in-flight anomaly, the DC-X vehicle initiates a system to cut-off the propulsion system and deploy recovery parachutes. Therefore, the only ordnance on the DC-X is approximately 20 grams of Class C explosive required to deploy the drogue chute, cut the reefing lines, and disconnect the parachutes after landing. The parachute system will not be armed until the launch pad area is clear of personnel. Inadvertent activation of the parachute ordnance will not result in a hazard to the vehicle or personnel.

1.2.8.4 Fuel Handling

The DC-X is a liquid fueled vehicle utilizing liquid and gaseous hydrogen and oxygen for both its main propulsion and reaction control systems. Union Carbide in Ontario, California will provide LH_2 and Tri-Gas Corporation plants in Odessa, Texas and Albuquerque, New Mexico will provide LO_2 for the DC-X program (Ref #50). The DC-X main propulsion tanks will contain a maximum of 2,700 pounds of liquid hydrogen and 16,000 pounds of liquid oxygen in the launch condition. In addition, the DC-X reaction control system propellant tanks will contain 100 pounds of gaseous oxygen and 20 pounds of gaseous hydrogen. The propellants are loaded one to two hours prior to launching the DC-X vehicle.

Based on Army Regulation (AR) 385-64 and Army Material Command Regulation (AMCR) 385-100, the Inhabited Building Distance (IHBD) for liquid oxygen is 1,725 feet and for liquid hydrogen is 685 feet (based on 60% of the liquid and gaseous propellants converted to Class 1.1 explosive (TNT)). The Intraline Unbarricaded distance for personnel is 780 feet from liquid oxygen and 300 feet from liquid hydrogen. These distances are based on the following fuel loads for the ground tanks: 13,700 gallon tank capacity for LO_2 and 14,000 gallon tank capacity for LH_2 . The WSMR Safety Division recommends using a separation of 780 feet between liquid oxygen and liquid hydrogen at WSSH.

The handling/use of liquid propellants has safety issues for personnel because of the cryogenic properties of the propellants and other unique characteristics (Exhibit 1.15). Liquid hydrogen ignites easily when mixed with air (Ref #2). Hazards associated with liquid hydrogen include fire, explosion, asphyxiation, and exposure to extremely low temperatures (Ref #2). Hydrogen fires are also difficult to detect because hydrogen burns with an almost invisible flame (Ref #2). Liquid hydrogen can only be transported by

Liquid Hydrogen (LH ₂)			
Propellant Physical Properties and Appearance	Explosivity/Reactivity Flammability/Flare	Health Hazard Toxicity and Corrosivity	Precautionary Measures
<p>Boiling Point @ 1 atm -423.0F(-252.8C) Freezing Point @ 1 atm -434.5F(-259.2C) Critical Pressure 188 psia (12.8 atm) Critical Temperature -399.8F (-239.9C) Vapor Density @ 68F(20C), 1 atm 0.003229 lb/cu ft Specific Gravity (air=1) @ 68F(20C), 1 atm 0.0696 Specific Gravity (H₂O=1) @ boiling point, 1 atm 0.0710 Liquid Density @ boiling point, 1 atm 4.432 lb/cu ft Solubility in Water @ 68F(20C), 1 atm 1.82% by volume</p> <p>General Appearance—LH₂ is colorless, odorless, and at an extremely cold temperature.</p>	<ul style="list-style-type: none"> Stable; noncorrosive; small amount of ignition energy required to ignite flammable mixture containing hydrogen; wide flammability range. Fire and explosion are the primary hazards. 	<ul style="list-style-type: none"> Toxic, but may produce asphyxiation by reducing oxygen concentrations. Burns with an almost invisible flame. Personnel may therefore be injured because the flame is difficult to detect visually. Extensive tissue damage or cold burns can result from exposure to the extremely low temperatures of liquid hydrogen. An unconfined hydrogen/air mixture will burn when ignited and may explode. 	<ul style="list-style-type: none"> Use chemical safety goggles, protective clothing, and loose fitting gloves of impermeable material when handling liquid hydrogen. Prevent skin contact and provide adequate ventilation. Train personnel prior to handling/ use of liquid hydrogen. Two personnel should be present when handling liquid hydrogen. Prevent the formation of flammable or explosive mixtures through system evacuation and purging. Eliminate ignition sources such as sparks from electrical equipment, static electricity sparks, open flames, or any hot object in excess of 900F. Buildings should be electrically grounded. Fire and explosion hazards can be controlled by preventing the formation of combustible fuel-oxidant mixtures and removing potential sources of ignition. If fire occurs, prevent spreading by shutting off the flow of gas and allow the remaining hydrogen to burn until it is consumed.

Sources: Ref #2 and #5

Exhibit 1.15: Fuel Properties

Liquid Oxygen (LO ₂)			
Propellant Physical Properties and Appearance	Explosivity/Reactivity Flammability/Pure	Health Hazard Toxicity and Corrosivity	Precautionary Measures
Boiling Point @ 1 atm -297.3F(-183.0C) Freezing Point @ 1 atm -361.8F(-218.8C) Critical Pressure 737 psia (50.1 atm) Critical Temperature 181.1F (-118.4C) Vapor Density @ 70P (21.1C), 1 atm 0.08279 lb/cu ft Specific Gravity (air=1) @ 68F(20C), 1 atm 1.10 Liquid Density @ boiling point, 1 atm 71.23 lb/cu ft Specific Gravity (H ₂ O=1) @ boiling point, 1 atm 1.14 Solubility in Water @ 77F(25C), 1 atm 3.16% by volume General Appearance—LO ₂ is pale blue, odorless, and at an extremely cold temperature.	<ul style="list-style-type: none"> Stable and non-flammable, but readily supports combustion. A strong oxidizer, it reacts with most organic materials and metals. 	<ul style="list-style-type: none"> Non-toxic under usual conditions. Thermal contact can cause severe skin burns and deep freezing with extensive destruction of tissue. Hazards of liquid oxygen include potential overpressurization, vaporizing into large volumes of gas in inadequately vented equipment, and possible combustion if it contacts incompatible materials. 	<ul style="list-style-type: none"> Provide adequate ventilation, prevent contact with exposed skin, keep work areas clear of combustible materials. Train personnel prior to handling/ use of liquid oxygen. Use chemical safety goggles, face shields, and loose fitting gloves of impermeable material when handling liquid oxygen. Prevent entrapment of liquid in closed systems.

Sources: Ref #3 and #4

Exhibit 1.15: Fuel Properties

private and contract carriers, and liquid oxygen can be transported by highway or rail, but not by air (Ref #2). Liquid hydrogen is flammable and liquid oxygen is an oxidizer that quickly accelerates combustion of flammable materials. Therefore, if vapors from these containers mix there is a high risk of explosion.

Liquid oxygen is extremely cold, non-flammable, a strong oxidizer, nontoxic under usual conditions, and reacts with most organic materials and metals (Ref #4). Hazards associated with liquid oxygen include exposure to cold temperatures (can cause severe skin burns), overpressurization, vaporizing into large volumes of gas in inadequately vented equipment, and possible combustion if it contacts a noncompatible material. Water shipments of liquid oxygen are restricted by the Coast Guard (Ref #4).

All personnel are prevented from entering the hazard area after the vehicle has been loaded and pressurized with propellants. The hazard area is monitored during prelaunch and launch countdowns to ensure that no personnel are within the safety area. If personnel are present in the safety area, launch countdowns will be halted until the area is cleared.

1.2.8.5 Noise Protection

The major source of launch vehicle noise is from the interaction of the exhaust jet with the atmosphere. Both the acoustic power and the frequency spectrum of launch vehicle noise are affected by the rocket engine size (thrust level), the specific impulse of the engine, and the engine design characteristics. Noise is discussed in Sections 2.2.1.6, 2.2.2.8, 3.1.3.6, and 3.1.4.8.

1.3 Alternatives

Extensive analyses were conducted to evaluate potential alternate launch vehicles, test ranges, ground test sites, and launch sites. No alternatives to the proposed action successfully met the criteria for SDIO's need as defined in Section 1.1.

1.3.1 Alternatives Considered But Not Carried Forward

Prior to proceeding with the DC-X Program, SDIO investigated alternative launch vehicles to determine if an existing rocket configuration could meet the needs of SDIO as defined in Section 1.1. In addition, alternative test ranges at which the SSRT program could potentially occur were examined. In each case, operational criteria necessary for successful implementation of the SSRT program were not met, thus eliminating them from further consideration. Therefore, these alternatives were not carried forward for environmental analysis.

1.3.1.1 Alternative Launch Vehicles

The SSRT program office performed a detailed study (Ref #6) to determine current suborbital launch vehicle capabilities to support known and projected SDIO requirements. This included an economic analysis to determine cost differentials between using current expendable vehicles and a reusable vehicle (SRR). The throttleability and propellant load variability of an SRR gives this single vehicle type the capability to launch various payload weights, within the vehicle design parameters, over multiple mission profiles (trajectories).

Most current suborbital launch vehicles are solid fueled, expendable vehicles primarily relying on a finite supply of surplus government boosters. Each launch vehicle must be tailored specifically to the given experiments' or programs' needs (a specific payload weight and trajectory). Should those needs change during the course of development, either the original launch vehicle must be adapted or another launch vehicle chosen and procured. This causes the schedule to slip and adds to the program costs.

SDIO examined the family of suborbital vehicles capable of lifting up to 3,000 pounds to a 1.5 million foot apogee (approximately 420 NM) (Ref #6). The study identified no existing vehicle configuration capable of meeting SDIO program requirements. Suborbital rockets and configurations reviewed included, but were not limited to, the following:

- Talos/Castor I
- Terrier/Black Brant
- Castor I
- Castor with boost assist
- Black Brant
- Sergeant-Hydoc
- Talos/Sergeant
- Sergeant
- Nike/Orion
- Aries

In addition, the inherent operational flexibility of an SRR provides SDIO with the greatest capability at the lowest projected life-cycle cost. Therefore, SDIO decided to proceed with the SSRT program, and continue the SSRT SRR study to further refine the mission requirements and the SRR's ability to meet these requirements.

As identified in Exhibit 1-1 in Section 1.2.2, SDIO evaluated several vehicle concepts before choosing the DC-X vehicle as proposed by MDSSC. DC-X vehicle materials, fuels, components, and takeoff and landing technologies are predicated upon the DC-X vehicle design. The engines are an integral component of DC-X vehicle design, and only liquid oxygen and liquid hydrogen can be used in these engines as fuels. Therefore, there are no alternative fuels for the engines of the DC-X vehicle.

1.3.1.2 Alternative Test Ranges

During the process of selecting candidate test ranges, international sites were not considered because they presented operational control issues. Sites in the Continental U.S. (CONUS) were screened to eliminate sites that were known to have concerns of availability, limitation of range space, interference from on-going operations and/or problems associated with security or safety of population areas. This screening resulted in the selection of six ranges that could accommodate DC-X.

A Kepner-Tregoe (KT) trade study was conducted by the SDIO program office to evaluate these potential test ranges for the DC-X program (Ref #53). This evaluation first prioritizes and ranks specific selection criteria on a scale of one to ten for each alternative. The scores are then totaled for all of the criteria points. The following six locations were evaluated for the KT study:

- Eastern Space and Missile Center (ESMC), Patrick AFB, Florida;
- Western Space and Missile Center (WSMC), Vandenberg AFB, California;
- Edwards AFB, Rosamond, California;
- Eglin AFB, Mary Esther, Florida;
- Hawaii (Barking Sands Pacific Missile Range Facility), Kauai, Hawaii; and
- White Sands Missile Range (WSMR), New Mexico.

The selection criteria, in order of priority, are as follows:

- Minimal environmental impact;
- Feasibility of an acceptable flight corridor;
- Non-interference from external operations;
- Availability of range support facilities;
- Availability of off-site infrastructure;
- Accessibility to launch site;
- Availability of manpower resources;
- Existing sources for consumables; and
- Minimal weather impact.

The methodology and results for evaluating the six ranges against the selection criteria are shown in Exhibit 1.16. The KT study results identified WSMR as the preferred location for flight test activities, based on high marks for minimal environmental impact, feasibility of an acceptable flight corridor, and available range support facilities. Even when the highest priority selection criterion, minimal environmental impact, is equally weighted between all sites, WSMR is still the preferred range.

Several factors were considered in the analysis for minimal environmental impacts, as described below:

Criteria	Wt (%)	Range 1	Range 2	Range 3	Range 4	Range 5	Range 6
Minimum environmental impact	.20	4(.80)	2(.40)	3(.60)	4(.80)	9(1.8)	2(.40)
Flight corridor feasibility	.15	4(.60)	3(.45)	6(.90)	5(.75)	8(1.2)	3(.45)
Non-interference from external operations	.12	5(.60)	4(.48)	5(.60)	3(.36)	5(.60)	6(.72)
Available range support facilities	.12	8(.96)	8(.96)	6(.72)	4(.48)	9(1.08)	3(.36)
Off-site infrastructure availability	.12	8(.96)	6(.72)	5(.60)	4(.48)	6(.72)	4(.48)
Launch site accessibility	.10	6(.60)	7(.70)	7(.70)	5(.50)	8(.80)	4(.40)
Available manpower resources	.07	7(.49)	6(.42)	8(.56)	5(.35)	7(.49)	3(.21)
Existing sources for consumables	.04	7(.28)	5(.20)	3(.12)	3(.12)	6(.24)	2(.08)
Minimum weather impact	.03	8(.15)	6(.18)	6(.18)	5(.15)	6(.18)	7(.21)
Total Score	1.00	5.64	4.71	5.23	4.14	7.56	3.51
Total Score - minimum environmental impact weighted equally among all cases	.20	4.84	5.31	5.63	4.34	6.76	4.11
Alternative Ranges	Conclusions						
1. ESMC 2. WSMC 3. Edwards AFB 4. Eglin AFB 5. WSMR 6. Barking Sands, Hawaii	Range 5, White Sands Missile Range, scored highest overall for the selected environmental criteria, and is therefore the chosen launch and landing range for DC-X. This was still true even when the priority selection criterion, minimum environmental impact, was weighted equally among all cases and the total scores were recalculated.						

Exhibit 1.16: Selection of Launch and Landing Test Range

The environmental issues associated with launch facilities focused on the propellants and gases. The DC-X uses LH_2 and LO_2 as propellants, which are non-toxic and otherwise benign to the environment. Safety hazards do exist for these propellants but there is a large data base of data on the safe distances and other methods for mitigating the safety risks. These propellants were first used on a large-scale with the Saturn/Apollo project in 1960 and are currently used on the Shuttle project. The analysis considered primarily the safety risks for the different candidate sites. Quantity distances were based on the requirement to assume a 60% mixture of propellants.

- ESMC is bounded by water and existing/operational launch pads. Decommissioned launch pads LC 34 and LC 37 are the only open areas for these propellants and this area has been preliminarily reserved for future Heavy Lift Launch Vehicle (HLLV).
- WSMC is also bounded by water, as well as the city of Lompoc. The only reasonable/available area for SSRT would be in the southern sector just below SLC-6. Overfly limitations from launches from the north made this location unattractive. WSMC scored low on minimal environmental impact because of disturbance to flora and fauna.
- The logistics of transporting propellants to Hawaii (Barking Sands) could require construction of an LH₂ and LO₂ production plant somewhere on the islands. This was not considered feasible or desirable.
- WSMR offered the best opportunity to site DC-X with minimal interference to surrounding facilities and operations. WSMR scored high on minimal environmental impact because of its remoteness to inhabited areas and the siting of DC-X is far distant from environmentally sensitive areas (such as the bighorn sheep).

The alternatives analysis included an operations assessment to determine if the range could support a three to seven day launch to landing turnaround of DC-X, which is a major objective of the program.

- WSMR—The Columbia Site, selected for the DC-X test flight series, is remote. Activities at WSMR will not impinge on the DC-X program, and the DC-X activities will not impinge on WSMR activities. It will be necessary to evacuate the DC-X area for some missile launches, but careful planning and scheduling will help to minimize these occurrences. Adequate telemetry/monitoring and tracking/radar support systems exist at WSMR. The flat terrain in the DC-X launch area is good for optics and provides significant opportunities for expanding the flight envelope and landing at a number of sites within WSSH. The existing infrastructure consists of an extensive rail system and a nearby airport at Holloman AFB. Another subtle advantage of WSMR is its 4,000 foot elevation. Launching from this elevation provides a higher weight to performance efficiency for DC-X launches. This lowers costs per launch.
- ESMC—This range would have several operational restrictions for DC-X. The projected launch schedules for the ELVs and Shuttle make it difficult to schedule range time and launches. The range regulations are detailed and stringent and not conducive to "aircraft" type operations planned for DC-X.
- WSMC—Past studies on the Advanced Launch System (ALS) for siting a HLLV launch site at WSMC determined that operational requirements of on-going

operations was a major factor to siting. In addition to the numerous Indian burial grounds, there are some constraints unique to WSMC. The main Los Angeles to San Francisco rail line passes through the range and has priority over launch operations. Studies were conducted to relocate the rail line and it was determined that cost was prohibitive. Also, the offshore oil pumping platforms are a significant consideration in selection of flight trajectories from WSMC. Overflight conditions from existing launches limit siting options and frequent operational interruptions are possible.

- Eglin AFB and Edwards AFB—These bases are located near populated areas and are unattractive because of the issues associated with noise and overflight. These sites are also primarily used for military aircraft and flight tests with bombings/weaponry, with a large number of sorties each day. This could potentially result in compatibility conflicts.
- Barking Sands— Barking Sands is advantageous because it enables launches in both equatorial and polar azimuths. This is very necessary for a HLLV, but not for DC-X because the DC-X trajectory is suborbital to a 22,000 altitude, extends less than one mile down-range, and the vehicle lands 350 feet uprange. The major disadvantage is the cost of logistics for equipment, manpower, and consumables to support launches.

Some other factors that affected the selection of WSMR are:

- NASA/WSTF is located on WSMR and has an existing static firing test facility ideal for DC-X.
- WSMR is fairly isolated from populated areas and is surrounded by very remote large land expanse that is government property.

1.3.1.3 *Alternative Ground Test Sites*

Static firing facilities were also evaluated for DC-X. Sites considered included NASA/MSFC, Edwards AFB and NASA/WSTF. To minimize the cost and logistics of shipping DC-X from the MDSSC Huntington Beach facility to the ground test site and then to the launch site (WSMR), this study was integrated with the results of the KT study of test ranges for flight test activities (Section 1.3.1.2). NASA/WSTF was selected as the ground test site because it is located on WSMR and its support facilities such as laboratories, cleaning facilities, machine shops, and high bay assembly areas that support both static firing and launch operations at WSMR. Although NASA/MSFC has existing LO₂/LH₂ facilities, availability of test stands is questionable, and logistics would be costly and time consuming.

1.3.1.4 Alternative Launch Test Sites

Given that WSMR was selected as the DC-X test range, a KT trade study was conducted to evaluate candidate sites within the boundaries of WSMR. The focus of this study was the need to avoid impinging on the White Sands National Monument.

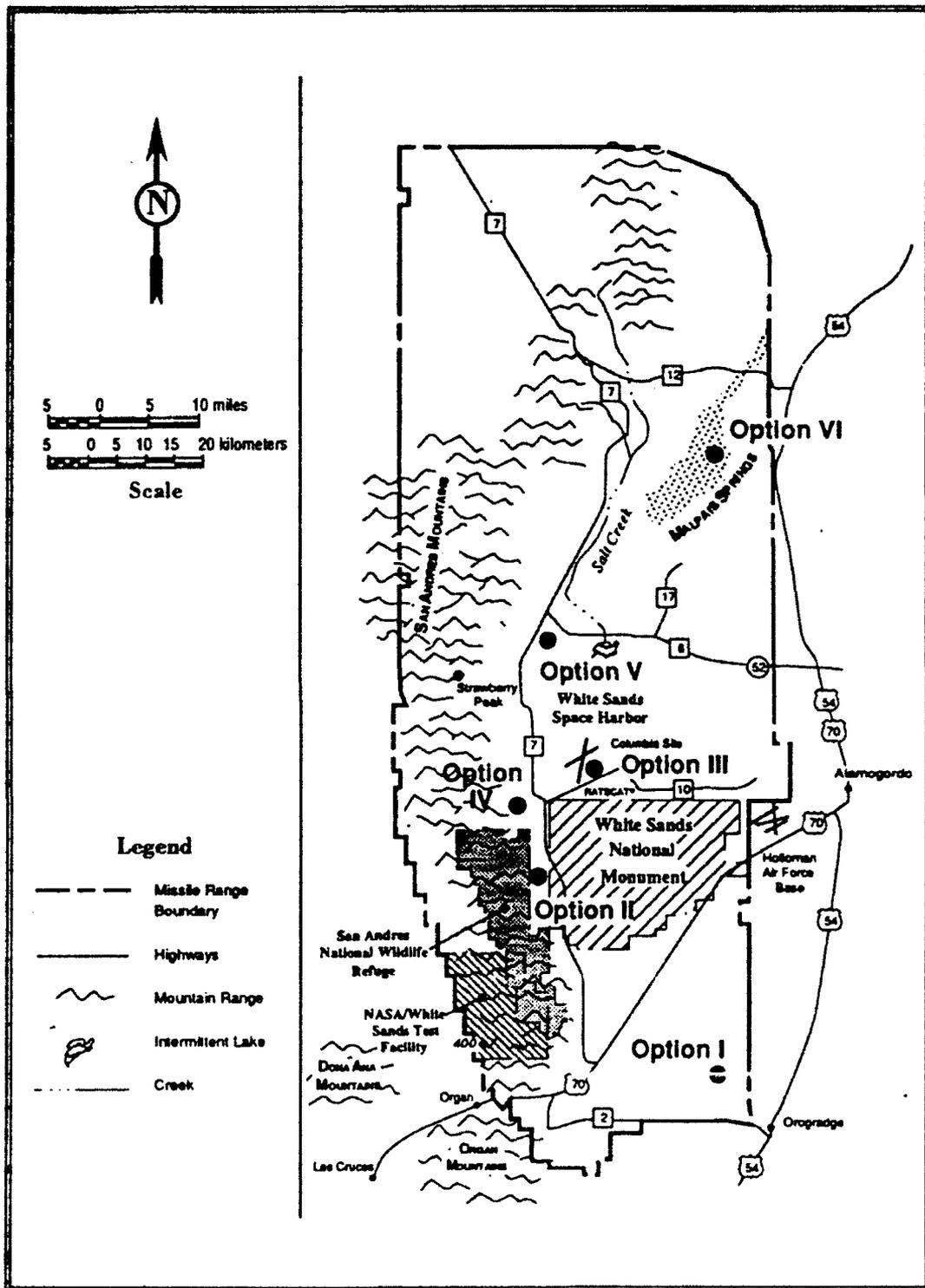
The six options evaluated are shown in Exhibit 1.17. The trade study results are shown in Exhibit 1.18. The selection criteria are ranked with minimum impact to SSRT from the Range as the highest priority criterion. The results show that the area at the WSSH Columbia Site (Option 3) is the best location for DC-X launch and landing operations because it is remote, yet accessible by the up range roads, and power and communication utilities are in place. In addition, the hard, expansive, flat surface will minimize site preparation for construction. The area is also located far enough uprange to minimize interference from launches from sites to the south along Nike Road. Launches from the south may still overfly the WSSH. Evacuations will be necessary, but will not interfere with DC-X activities.

The Columbia Site was used the only time the Shuttle landed at WSMR for servicing the Orbiter. Since then, the site has been abandoned for Shuttle operations due to operational deficiencies, and operations have been relocated west along Range Road 10.

The surrounding terrain at alternative option sites would require extensive site preparation to provide level landing sites due to five to ten foot high sand mounds. Although options 4, 5, and 6 are suitable choices because of the terrain and remoteness from other operations, logistics would be very difficult because they are located 60 to 70 miles from the WSMR post area. This would result in extensive loss of time during the work day.

1.3.2 No Action

The no action alternative for the SSRT program is not to develop and test the DC-X vehicle. By implementing the no action alternative, the SSRT program would not proceed and concept definition for a suborbital recoverable rocket (SRR) would not proceed. As a result, SDIO would continue to rely on existing suborbital rockets to support SDIO mission requirements.



Source: MDSSC

Exhibit 1.17: Sites Considered at White Sands Missile Range

Criteria	Wt (%)	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6
Minimize environmental impact - no regulatory violations - mitigable for DC-X	NA	OK	Maybe	OK	OK	OK	OK
	.09	8(.72)	7(.63)	10(.90)	7(.63)	8(.72)	6(.54)
Feasible landing surface profile	.10	5(.50)	8(.80)	10(1.00)	8(.80)	7(.70)	8(.80)
Maximize access, minimize logistics	.15	10(1.00)	9(1.35)	8(1.20)	2(.30)	7(1.05)	3(.45)
Minimize impact to/from ongoing operations	.10	10(1.00)	5(.50)	5(.50)	10(1.00)	5(.50)	7(.70)
Maximum use of existing infrastructure	.15	10(1.50)	5(.75)	8(1.20)	5(.75)	7(1.05)	2(.30)
Minimize impact to SSRT from range	.50	7(.35)	8(.40)	8(.40)	10(.50)	5(.50)	9(.45)
Access to WSMR instrument sites	.05	10(.50)	8(.40)	9(.45)	9(.45)	10(.50)	6(.30)
Minimize ground safety impact at range	.15	5(.75)	8(1.20)	8(1.20)	9(1.35)	8(1.20)	10(1.00)
Total Score	1.00	7.50	7.01	8.07	6.78	6.66	6.14
Options		Conclusions					
<ol style="list-style-type: none"> 1. Near 'Rampart' along Range Road 259 2. Near 'Seahorn' along Range Road 7 3. At WSSH along Range Road 10 4. Near 'Pond' along Range Road 3 5. Near 'Rhodes Canyon' along Highway 6 6. Near 'Wood' along Highway 12 		Options 1 and 3 appear to have a great advantage over the other alternatives. Option 3 offers the best solution to having an autonomous ground processing system, and provides an existing and expansive level surface for the nominal landing site, as well as alternate landing sites.					

Exhibit 1.18: Selection of Launch and Landing Site at White Sands Missile Range

**Existing
Conditions**

2.0

2.0 Existing Conditions

The existing conditions encompass the physical attributes of locations that potentially are affected by the proposed action and no action alternative. Existing conditions include the physical setting, as well as air quality, noise, and safety considerations. For the SSRT DC-X EA, the pertinent locations include off-site contractor facilities associated with DC-X component fabrication and development, as well as on-site locations where the ground, preflight, and flight tests of DC-X will occur. The Lightweight Exoatmospheric Projectile (LEAP) EA (Ref #24) and High Endoatmospheric Defense Interceptor (HEDI) EA (Ref #21) provide general information on the existing conditions at White Sands Missile Range; as such, these documents are incorporated, where appropriate, by reference.

2.1 Component Assembly/Ground Test Locations

Information regarding the technical operations of component assembly/ground test participants in the SSRT DC-X test program was obtained using questionnaires distributed to contractor facilities (Ref #35, Ref #34, Ref #51, Ref #37, and Ref #33). The engineering contractors are Scaled Composites, Inc., Chicago Bridge & Iron, Pratt & Whitney, Aerojet, and McDonnell Douglas Space Systems Company (MDSSC). The goal of the questionnaires was to identify current facility activities, the existing environment, activities pertaining to the SSRT DC-X program, and the status of environmental compliance.

The questionnaire required specific information from contractors on environmental and safety documentation (including permits), Resource Conservation and Recovery Act (RCRA)/Superfund status, and potential to impact the following environmental resources: physical setting and man-made environment, water resources, geology and soils, air quality, noise, biological resources, threatened and endangered species, cultural resources, infrastructure, hazardous materials and wastes, and safety. Not all environmental media applied to each contractor facility location reviewed. The information collected from the contractor facilities is summarized below.

2.1.1 Scaled Composites, Inc.

As noted in Section 1.2.4.1, Scaled Composites will fabricate and assemble the DC-X aeroshell at its Mojave, California facility. The facility is located approximately one mile from Mojave, on the Mojave Airport in the desert. The facility is surrounded by sixty other businesses.

The Scaled Composites facility is referred to as Hangar 78, and consists of an 18,000 square foot hangar with an 18,000 square foot annex. The entire facility and land encompass approximately one acre of land. Scaled Composites employs approximately seventy five people at the facility, which has been at the location since 1982.

The facility is not considered habitat for threatened or endangered species. No wetlands, floodplains, prime agricultural land, archaeological or historic sites, or wilderness areas are present on the facility. The facility has not been cited by EPA for regulatory violations and is not on the National Priorities List.

2.1.2 Chicago Bridge & Iron (CBI)

As identified in Section 1.2.4.2, CBI will fabricate and construct the propellant tanks at its Cordova, Alabama facility. The facility is located 35 miles northwest of Birmingham on the Black Warrior River. The facility consists of three structures each 95 feet wide and up to 900 feet long encompassing 270,000 square feet (Ref #39).

The facility is not considered habitat for threatened or endangered species. No wetlands, floodplains, prime agricultural land, archaeological or historic sites, or wilderness areas are located on the facility property. The facility has not been cited by the EPA for regulatory violations and is not on the National Priorities List (Ref #34).

2.1.3 Pratt & Whitney

As identified in Section 1.2.4.3, Pratt & Whitney will modify, test, and supply four RL-10A-5 engines for the DC-X vehicle at its facility in Palm Beach, Florida.

Endangered plant life and wetlands exist on the undeveloped portion of the site. These resources are regulated by county ordinances. No archaeological or historic sites or prime agricultural land are located on the facility. The facility is not on the National Priorities List.

2.1.4 Aerojet Propulsion Division

As identified in Section 1.2.4.4, Aerojet will fabricate, assemble, and test the RCS at its facility in Sacramento, California. The activity will occur in Test Area A, Building 30010.

The facility is not considered habitat for threatened or endangered species. No wetlands or archaeological or historic sites are present at the facility. The Sacramento facility is on the National Priorities List, but current operations are in compliance with all Federal, state, and local regulations.

2.1.5 McDonnell Douglas Space Systems Company (MDSSC)

As identified in Section 1.2.4.5, MDSSC will conduct DC-X activities at its Huntington Beach, California facility. The facility is located in an industrial park encompassing several acres and employs over 10,000 people.

The facility is not considered habitat for threatened or endangered species. No archaeological or historic sites, prime agricultural land, wetlands, wilderness areas or floodplains are located on the facility. The facility has not been cited by the EPA or state regulators for regulatory violations. The facility is not on the National Priorities List.

2.2 Preflight and Flight Test Locations

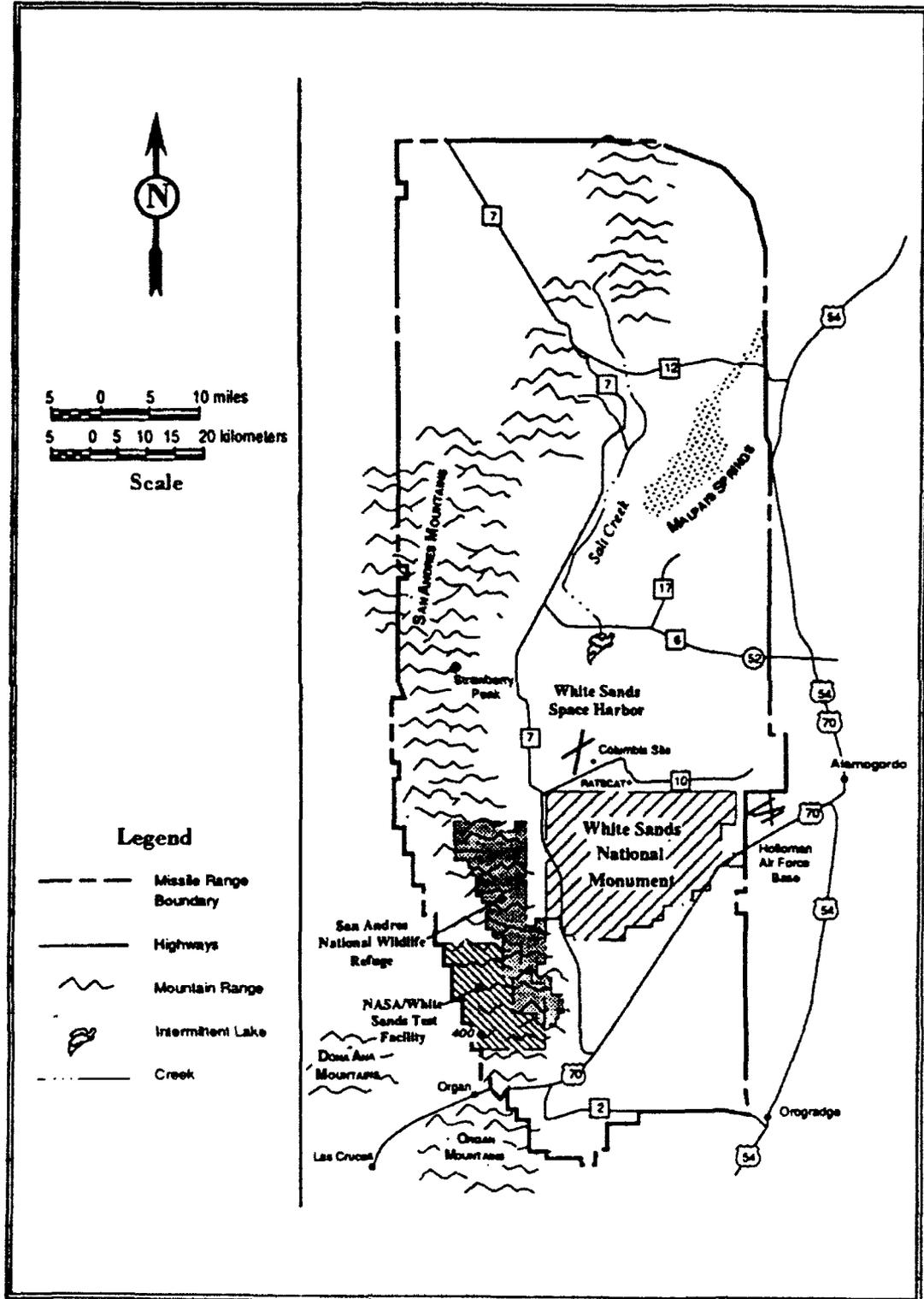
This section includes a discussion of the two locations (NASA/White Sands Test Facility and White Sands Missile Range) where preflight and flight test activities will occur for the DC-X flight test series (Exhibit 2.1). A description of the physical setting and various environmental characteristics is identified for each area.

2.2.1 NASA/White Sands Test Facility (WSTF)

The NASA/White Sands Test Facility was established within White Sands Missile Range in 1963 by the National Aeronautics and Space Administration (NASA) Manned Spacecraft Center (Ref #25). The original purpose of this facility was to conduct hazardous testing for the Apollo Spacecraft Propulsion Systems. The site is operated by NASA under a memorandum of agreement between NASA, the Department of Defense, Bureau of Land Management, and the Department of Agriculture, Agricultural Research Service. Activities at NASA/WSTF include developmental and operational tests of spacecraft propulsion systems and subsystems; special component and systems environmental evaluations; specialized laboratory tests; and coordinating NASA test programs at WSMR (Ref #25).

2.2.1.1 *Physical Setting and Man-Made Environment*

NASA/WSTF is located on the western side of the San Andres Mountains, six miles north of U.S. Highway 70 and 20 miles northeast of Las Cruces. The facility occupies approximately 59,000 acres on the southwestern part of White Sands Missile Range (Ref #16). Only 3,000 acres are actively used by NASA; the remainder is used as a buffer zone (Ref #16). The San Andres National Wildlife Refuge borders NASA/WSTF to the east, and the Jornada Experimental Range, operated by the Department of Agriculture, borders NASA/WSTF to the west. The largest community near NASA/WSTF is Las Cruces in Dona Ana County.



Source: MDSSC

Exhibit 2.1: NASA/White Sands Test Facility

Population growth in the vicinity of Las Cruces has increased consistently over the past decade from 46,999 in 1980 to 56,000 in 1989 (city only). Population in Dona Ana County for the same period increased from 96,340 to 128,000. According to the U.S. Department of Commerce, the Las Cruces metropolitan area registered as the eighth fastest growing Metropolitan Statistical Area (MSA) in the U.S. between 1980-1987, with an increase in population of 37 percent (Ref #24). Ninety-four percent of the population in Dona Ana County resides in the Las Cruces MSA (Ref #24).

NASA/WSTF Propulsion Test Area- NASA/WSTF propulsion test activities are conducted in seven test stands, involve long-duration high altitude simulation, data acquisition and test control, and tests with solid and liquid rocket systems (Ref #19). Over 300 engines have been tested with more than 2 million firings. Facilities include two office buildings; five warehouses; an emergency center; a medicine dispensary; control centers for each test area with the following: a digital data, acquisition, and control system; real-time data monitoring; data storage; data reduction; data analysis functions; and a computer system (Ref #25, Ref #19). The test stands are located in adjacent Propulsion Test Areas (300 and 400) in the northeast corner of NASA/WSTF, north of NASA/WSTF Materials Test Area. Test Area 300 has two atmospheric, down-firing static test stands, and one altitude simulation, down-firing test stand. Test Area 400 has two vertical down-firing altitude simulation test stands (401 and 403), one horizontal test stand (405), and one vertical down-firing atmospheric static test stand (402).

Static fire testing will occur at Test Stand 402, which is located between Test Stands 401 and 403. Test Stand 402 is 33 feet by 33 feet square and 30 feet high; has a removable enclosure and roof; can accommodate vertical down-firing engines up to 25,000 pound thrust; and has a water-cooled flame bucket below the stand (Ref #19).

Test area 400 also includes test stand support buildings, a test control building, and support facilities (Ref #16). The DC-X program will utilize concrete blockhouse 400, a 75 foot by 80 foot structure that will provide the following services: data acquisition and control systems, firing control consoles, etc. Facility support systems include 2,200 and 6,000 psi helium and 3,000 psi gaseous nitrogen storage and distribution systems; hypergolic propellant conditioning, storage, and distribution subsystems; and a breathing air distribution system (Ref #19).

2.2.1.2 Water Resources

Surface Water- Large surface lakes and streams are almost non-existent within White Sands Missile Range boundaries, including the NASA/WSTF area. However, numerous intermittent streams, seeps, and temporary pools occur at higher elevations of the surrounding mountain ranges (Ref #24). Waterbodies are not present in Propulsion Test Area 400, and there are no perennial stream flows. Water does flow in deep arroyos (gullies) during and after rain storms (Ref #16).

Groundwater- The water table at NASA/WSTF is approximately 400 feet below the surface (Ref #16, Ref #42). NASA/WSTF water is supplied by two groundwater wells operated by NASA approximately 3 miles offsite.

2.2.1.3 *Geology and Soils*

NASA/WSTF is located in the Mexican Highland Section of the Basin and Range Province, within the Rio Grande Rift Zone (Ref #16). This zone is typified by mountain ranges and basins between or among mountains. NASA/WSTF topography includes part of the San Andres Mountains, alluvial fans, and the Jornada del Meurto Basin.

The western one-third of NASA/WSTF has a slope of four to five percent and is characterized by deep, dry, gullies and washes (Ref #16). The rest of NASA/WSTF extends into the San Andres Mountains and consists of small low hills of carbonate rocks. The top alluvial layers at NASA/WSTF contain silt, sand, gravel, and boulders (Ref #16).

Approximately eleven different soil types are present within NASA/WSTF (Ref #22). Test Stand 402 is located in the Tencee-Nickel association, steep (Ref #22). This association consists of approximately 45 percent Tencee very gravelly loam, and 40 percent Nickel gravelly fine sandy loam. The Tencee soil is a moderately sloping to steep soil on ridges and saddles of the landscape, and the Nickel soil is a rolling to steep soil on broken areas of the landscape (Ref #22). The Tencee series is within 1.5 feet of bedrock; more than 5 feet above the seasonal high water table; and within 1 foot of the surface. The Nickel series is more than five feet above bedrock and the seasonal high water table, and within five feet of the surface. Both soil types have low risk of corrosion to concrete and severe limitation to shallow excavations (Ref #22).

2.2.1.4 *Threatened and Endangered Species*

Section 7(a)(2) of the Endangered Species Act (ESA) requires Federal agencies "in consultation with and with the assistance of" the Secretaries of the Interior and Commerce, to insure that their actions are "...not likely to jeopardize the continued existence of any endangered species or threatened species or result in the destruction or adverse modification of the critical habitat of such species..."

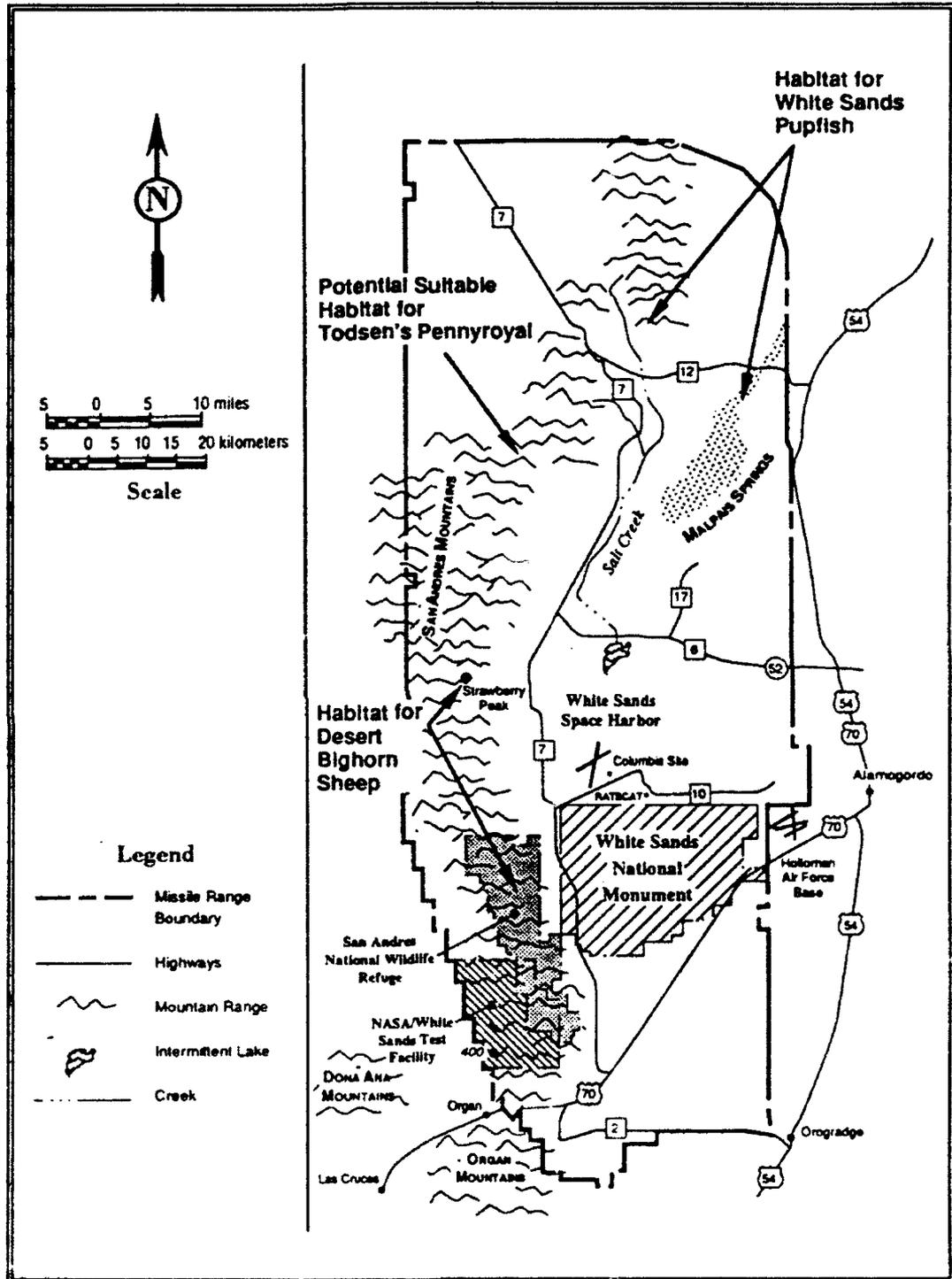
A list of threatened and endangered species in the State of New Mexico is included in Appendix A. Coordination was initiated with the New Mexico field office of the U.S. Fish and Wildlife Service (USFWS), the New Mexico Department of Game and Fish, and the New Mexico Department of Natural Resources. No threatened and endangered species are known to occur in Propulsion Test Area 400. However, there are several species in the WSMR area (including NASA/WSTF) that are routinely considered for actions at the Range. Present resources include the following:

- Todsens's pennyroyal (*Hedeoma todsenii*), a Federally endangered species, occurs in Rhodes Canyon.
- The White Sands pupfish, endemic to the Tularosa Basin, is a state endangered listed species (Group 2) and a Federal Candidate Category 2 species, is found in Malpais Spring, Lost River, Salt Creek, and Mound Springs.
- Desert bighorn sheep (*Ovis canadensis*), a state endangered species, with the majority of animals located in the San Andres National Wildlife Refuge. A small population of approximately nine animals is located at Strawberry Peak north of the Refuge (Exhibit 2.2). An extended discussion of the desert bighorn is found in the High Endoatmospheric Defense Interceptor (HEDI) Environmental Assessment (Ref #21).
- The Aplomado falcon (*Falco femoralis*), a Federally listed endangered species, and is also listed as locally extinct by the State of New Mexico, is usually found in grasslands, brushy prairies, and yucca flats (Ref #23).

2.2.1.5 Cultural Resources

Section 106 of the National Historic Preservation Act (NHPA) requires Federal agencies to consider the affects of their proposed actions on historic properties, which are defined as any properties included in, or eligible for inclusion in, the National Register of Historic Places. Section 106, which is implemented by 36 CFR 800, specifies that a Federal agency must consider the effects of the proposed undertaking on properties eligible for, or listed in, the National Register of Historic Places, and afford the Advisory Council on Historic Places the opportunity to comment.

At NASA/WSTF 14 historic sites, 75 prehistoric sites, and 3 sites with both prehistoric and historic components have been identified (Ref #1). The National Park Service conducted a national survey in 1981 on sites connected with the early U.S. space program, and in 1984 completed two phases of a national historic landmark theme study (Ref #27). The purpose of these studies was to identify key sites associated with the development of spaceflight and the landing of man on the moon (Ref #27). The 1984 study evaluated more than 300 resources across the U.S., including rocket engine and development test facilities. The 1984 study identified 25 national historic landmarks and one nationally significant site that were listed on the National Register of Historic Places in 1985 (Ref #27). Test Stand 402 was determined ineligible for inclusion on the National Register. These activities were coordinated with the New Mexico State Historic Preservation Office.



Source: MDSSC

Exhibit 2.2: Selected Threatened and Endangered Species Habitat at White Sands Missile Range

2.2.1.6 Air Quality

Climatological Conditions- Climate at NASA/WSTF is characterized as high steppe/desert, and is influenced by the mountains to the east of the facility. NASA/WSTF experiences wide fluctuations in minimum temperatures. Average annual precipitation is 8 inches, and the wettest months are July and August. Average annual temperature is 60 degrees Fahrenheit (F) (Ref #16).

Ambient Air Quality- Air quality is regulated under the Clean Air Act (CAA). According to requirements in the CAA, the United States Environmental Protection Agency (EPA) has established National Ambient Air Quality Standards (NAAQS) for six criteria pollutants: carbon monoxide, particulate matter (PM) 10 (suspended particulates less than 10 microns in diameter), sulfur dioxide, nitrogen dioxide, ozone, and lead. The only applicable NAAQS for the DC-X program is PM 10. The primary and secondary standard for the PM 10 annual arithmetic mean is 50 $\mu\text{g}/\text{m}^3$, and the primary and secondary standard for the PM 10 24-hour maximum is 150 $\mu\text{g}/\text{m}^3$. The New Mexico ambient air quality standards for total suspended particulates are an annual geometric mean of 60 $\mu\text{g}/\text{m}^3$, and a 24-hour average of 150 $\mu\text{g}/\text{m}^3$ (Ref #20).

Air quality permits for testing are not required at NASA/WSTF and the area around NASA/WSTF is in attainment for all NAAQS (Ref #1, Ref #42).

2.2.1.7 Noise

Noise is defined as undesirable sound. For a general description on noise, see Appendix B. The decibel (dB), the standard unit for sound measurement, represents the acoustical energy present in the environment. For environmental noise measurements, an A-weighting filter is commonly used (dBA), which filters the frequency spectrum of sound levels as the human ear naturally does.

There is a four and one-half mile buffer zone between NASA/WSTF and the closest residence. The steam generator in the 400 Area is a major source of noise at NASA/WSTF (100-180 dB), emitting approximately 140 dB at the ejector. Other sources of noise at NASA/WSTF include engine and motor testing at Test Areas 300 and 400, vehicles, air handlers, and construction equipment (Ref #1). An ongoing hearing conservation program is being conducted within NASA/WSTF (Ref #16, Ref #42).

2.2.1.8 Safety

A complete discussion of these requirements and steps for implementation is located in Section 1.2.8.1.

2.2.2 White Sands Missile Range (WSMR)

White Sands Missile Range is a national range that supports missile testing and development programs for the Army, Navy, Air Force, NASA, and other federal agencies (Ref #24). The U.S. Army Test and Evaluation Command (TECOM) maintains operational control over the Range. Missile development and testing at the Range began in September 1945 under the name White Sands Proving Ground (WSPG). The name was changed to WSMR on May 1, 1958. Since its inception, WSMR has conducted over 37,000 missile launches, including over 1,000 high altitude launches (Ref #24).

WSMR currently averages approximately 450 rocket and missile launches annually, with launches varying in size from hand-held Stinger missiles to high-altitude research rockets (Ref #24). SDI launched 17 rockets during FY 91 under the HEDI Program (Ref #47). Twenty-two launches are projected for SDI in FY 92.

2.2.2.1 Physical Setting and Man-Made Environment

WSMR is located in southcentral New Mexico within the Tularosa Basin, and includes two million acres in Dona Ana, Otero, Socorro, Sierra, and Lincoln Counties. The Tularosa Basin is a closed, natural depression without drainage (Ref #46). The installation is approximately 100 miles long and 40 miles wide. Principal facilities at WSMR include the post headquarters area, the Rhodes Canyon Range Center, North Oscura Range Center (SRC), and the Tularosa Range Camp. The largest community near WSMR Post is Las Cruces (Ref #24).

The launch site for the DC-X vehicle is in the area of the "Columbia Site," located in the Alkali Flats of the Tularosa Basin, directly south and east of the WSSH, just north of White Sands National Monument, east of the San Andres Mountains, and northwest of the Radar Target Scatter (RATSCAT) facility operated by the Air Force. The Columbia Site area at WSMR, under agreement with WSMR, is operated by NASA. The WSSH became part of WSMR in 1952 and is located approximately 45 miles north of WSMR Post (Ref #29). The site was originally referred to as the Northrup Strip. This area was used in the 1940s for target drone projects and consists of two hard-packed gypsum strips that cross in an "X" pattern (Ref #29). It has been designated as a backup landing strip for the Shuttle program since the 1970s, and the landing strips were enlarged to handle Shuttle training and emergency landings. In March 1982 Space Shuttle Columbia landed at WSSH.

Alkali Flats are level, undrained, dry ponds or lakes in an arid region, predominantly composed of gypsum (soft hydrous calcium sulfate). These flats are extremely alkaline with little ground cover. The Alkali Flats slope no more than 0.01 feet per 100 feet. The terrain at the Columbia Site area is typical of Alkali Flat topography and consists of very flat, hard gypsum. Structures currently at the site include a concrete servicing pad and a windbreak. These will be removed for the DC-X program.

The Columbia Site area is located approximately two to three miles north of the border of White Sands National Monument. This part of the Monument is characterized by an Alkali Flat that is not easily accessible and infrequently explored by visitors to the Monument (Ref #43). The visitor center for the Monument is located in the southeastern part of the Monument, approximately 15 miles west of Alamogordo, New Mexico.

2.2.2.2 *Water Resources*

Surface Water- Large surface lakes and streams are almost non-existent within White Sands Missile Range boundaries; however, numerous intermittent streams, seeps, and temporary pools occur at higher elevations of the surrounding mountain ranges (Ref #24). Few places with permanent surface water exist in the Tularosa Basin. There are some playa lakebeds on WSMR, including Lake Lucero, a saline playa located approximately 10 miles south of the Columbia Site. A few permanent springs and small streams are present on WSMR including Salt Creek, Mound Spring, and Malpais Spring, and there are some permanent streams draining the Sacramento Mountains and Otero Mesa to the east (Ref #24).

The Columbia Site area is located on a dry lakebed and there is no perennial water at the site. Due to the hard, impermeable ground surface, water ponds on the surface after rain storms. This is a temporary condition, and the ponds usually do not persist for more than several days (Ref #26). There is a tendency for the Alkali Flats to be subjected to widespread shallow sheet flooding after thunderstorms (Ref #26).

Groundwater- The Tularosa Basin has limited good quality groundwater supplies concentrated along the base of the Sacramento Mountain range at the eastern end of the basin, and the Organ Mountains at the western end of the basin (Ref #24). However, the majority of groundwater supplies in the Basin are classified as saline, with approximately 98 percent consisting of dissolved solids in excess of 35,000 mg/l, comparable to sea water salinity levels. It is typical within the Alkali Flats for the water table to be within a depth of 5 feet (Ref #22). Therefore, water at WSSH is brought in by truck.

2.2.2.3 *Geology and Soils*

Regional Geology- The Tularosa Basin is located in the Mexican Highland Section of the Basin and Range Physiographic Province. The Basin is approximately 140 miles long and 40 miles wide, and the basin floor is relatively flat. It is characterized by interbedded limestone and sandstone sequences with some intrusion of volcanic material including basalt flows and granite rock (Ref #24). The basin is bounded by the Organ, San Andres, and Franklin Mountains to the west, by the Sierra Oscura Mountains to the north, and by the Sacramento, Sierra Blanca, and Heuco Mountains to the east. The Jarilla Mountains lie at the south end of the Tularosa Basin and are separated from both Sacramento and Organ ranges by broad stretches of desert lowland (Ref #24). The average elevations of the mountains bordering WSMR vary from approximately 5,500 to 9,000 feet mean sea level (MSL) (Ref #24).

Surficial geology in the Tularosa basin primarily consists of unconsolidated bolson, alluvial, and eolian deposits. The Jarilla mountains consist of Cretaceous and Tertiary intrusive rocks. The San Andres Mountains to the west consist of Pre-Cambrian, Cretaceous, and Tertiary igneous intrusive rocks and metamorphic facies (Ref #24).

Soil Resources- Soil resources at the Columbia Site area are classified as G₁ level soil, which is defined as gypsum land consisting of gypsum deposits overlying lacustrine sediments on broad level floors of a relic lake (Ref #25). The alkali soil results from a shallow water table (usually within six feet of the surface) and compacted gypsum soils with very low permeability. The soil typically has slopes less than 1% and is poorly drained. Due to the high gypsum content, it is not possible to classify permeability, soil pH, and shrink/swell potential. This soil has severe limitations for shallow excavations because the water table is so high. The gypsum is about one foot thick on the perimeter of the lakebed and more than twelve feet near the center. The surface is level and smooth, and water may pond in low areas after it rains.

Elevation for this soil type ranges from 3,885 to 3,975 feet and runoff is slow (Ref #22). Water erosion is a slight hazard, but gypsum particle blowing is a high hazard. Lack of ground cover makes the site susceptible to erosion by winds. Due to the corrosivity of gypsum, there is a high risk of corrosion to concrete.

2.2.2.4 Biological Resources

Vegetation- The only vegetation that occurs in level gypland is a sporadic iodine bush (*Allenrolfea occidentalis*). This species occurs where the gypsum is less than 3 feet deep and the water table is near the surface (Ref #22). Vegetation is scarce on the Alkali Flats because it is a harsh environment due to the alkaline conditions of the soil and susceptibility to flooding (Ref #26). At the nearby RATSCAT site, small quantities of the following plant species have been recorded: pickleweed, Indian ricegrass (*Oryzopsis hymenoides*), and salt cedar (*Tamarix gallica*). It has been estimated that overall ground cover adjacent to Range Road 10 is less than 20 percent (Ref #26).

A site visit conducted on January 16, 1992 determined that no vegetation is present on the dry lakebed at the Columbia Site area.

Terrestrial Wildlife- The San Andres National Wildlife Refuge in the San Andres Mountains and White Sands National Monument are abundant in wildlife resources. Wildlife in the Alkali Flats, however, is scarce due to the extreme environmental conditions (Ref #26). At the nearby RATSCAT site, however, the bleached lesser earless lizard (*Holbrookia maculata ruthveni*) has been known to occur in areas of adequate cover (Ref #26).

According to the Soil Survey of White Sands Missile Range (Ref #22) level gypland soil type has no wildlife or livestock grazing values. No wildlife species are known to inhabit

the Columbia Site, and a site visit conducted on January 16, 1992 verified that no wildlife resources were present.

Aquatic Resources- Water resources at the site are described in Section 2.2.2.2. Due to a lack of perennial surface water at the Columbia Site, aquatic resources are not present.

Wetlands- Since the Tularosa Basin is a very arid region, wetlands are uncommon. There are emergent wetlands associated with some permanent springs, such as the Mound and Malpais Springs, and playa basins have associated wetlands (Ref #24). However, no wetlands are present at the Columbia Site area.

2.2.2.5 *Threatened and Endangered Species*

Vegetation and wildlife are nonexistent at the Columbia Site. The FOCC will be located at the edge line of sparse vegetation (grasses). No threatened and endangered species are known to exist in either area.

2.2.2.6 *Cultural Resources*

For a general description of cultural resources located at WSMR, see Section 2.2.1.7 of the Lightweight Exoatmospheric Projectile (LEAP) Test Program EA (Ref #24). The Trinity Site at WSMR (where the world's first atomic weapon was exploded) is a National Historic Landmark and is listed on the National Register of Historic Places. The New Mexico cultural property register also lists the Army Blockhouse/V-2 Gantry Crane (also a National Historic Landmark) and the 500K Static Test Stand (Ref #24).

The U.S. Army has entered into a Programmatic Memorandum of Agreement (PMOA) with the Advisory Council on Historic Preservation (ACHP), and the New Mexico State Historic Preservation Office. Compliance with Section 106 of the National Historic Preservation Act for the SSRT program falls within the purview of this PMOA. Pursuant to the PMOA, an Historic Preservation Plan (HPP) has been developed for WSMR.

Large cultural resource sites are known to occur on the border of the lakebed area near WSSH, along Range Road 7. Cultural resources are also present along Range Road 10.

2.2.2.7 *Air Quality*

Climatological Conditions- Severe weather at WSMR is uncommon. Precipitation, occurring in the form of heavy summer rainstorms, is insufficient for any growth except desert vegetation. Considerable runoff occurs from nearby mountains during prolonged wet spells, occasionally producing intermittent lakes which may persist for several months (Ref #24).

The Tularosa Basin climate is arid with an average annual rainfall of 10 inches and mean annual temperature of 60 degrees F. The mean minimum winter temperature is 36 degrees F and the mean maximum summer temperature is 94 degrees F. Climate characteristics include abundant sunshine, low humidity, scant rainfall, and a mild winter season.

Ambient Air Quality- The WSMR area experiences periodic exceedances of the CAA NAAQS suspended particulate standard. The primary source of particulates at WSMR is fugitive dust generated by wind blowing across barren terrain. Frequent severe gypsum particle sandstorms peak during the spring and early summer months, which is also the time of peak sand movement (Ref #26).

2.2.2.8 *Noise*

Noise sources resulting from WSMR activities include weapons firings, supersonic flights, missiles systems tests, radar equipment, and heavy equipment operations. These activities are not located near surrounding communities, and are in compliance with noise emission standards (Ref #24). A hearing conservation program has been implemented at WSMR to protect personnel working at the range.

2.2.2.9 *Infrastructure*

WSMR manages its own water treatment and storage and wastewater collection and treatment systems. Solid waste is collected and disposed in landfills that are approved by the Environmental Improvement Division of the State of New Mexico (Ref #24).

Natural gas is supplied to WSMR by the El Paso Natural Gas Company. El Paso Electric Company provides approximately 90 percent of the installation's electrical needs. Previous environmental documentation does not identify significant utility and infrastructure issues at WSMR.

White Sands Space Harbor is adjacent to existing access roads, facility power, and base ground communication systems.

2.2.2.10 *Safety*

A complete discussion of these requirements and steps for implementation is located in Section 1.2.8.2.

Consequences

3.0

3.0 Consequences

The purpose of this section is to identify potentially significant impacts, if any, resulting from implementing the proposed action and the no action alternative. The consequences of implementing the proposed action are described in Sections 3.1 and 3.2, and the consequences of implementing the no action alternative are described in Section 3.3.

The methodology employed to identify potential impacts, if any, of implementing the proposed action or no action alternative involved three phases. First, a determination was made, after implementation of the engineering/environmental practices and safety measures described in Section 1.0, whether the proposed action would result in any impacts to the environmental resources described in Section 2.0.

In the second phase, it was determined if these impacts were potentially significant, as defined in 40 CFR Part 1508.27. The emphasis is to determine both the context in which the action will occur and the intensity of the action. The action was reviewed in the context of various laws and regulations to determine if impacts exceeded defined threshold levels (e.g., NAAQS, violation of an Army noise regulation, etc.). Potential impacts resulting from implementing the proposed action that did not meet these criteria for a potentially significant impact were considered to have no significant impacts on the evaluated resources.

Finally, for any impacts from the proposed action that were potentially significant, it was determined whether mitigation measures could be implemented to reduce the impacts to less than significant levels. An analysis of the cumulative impacts resulting from the proposed action are reviewed in Section 3.4.

3.1 Proposed Action - Site-Specific Analysis Component Assembly/Ground Test Location

The environmental questionnaire distributed to the engineering contractor facilities as described in Section 2.1 was used to evaluate the compatibility of SSRT technologies and required activities with the environment at those facilities and current facility activities. The findings of the analyses are summarized below:

3.1.1. Scaled Composites, Inc.

As identified in Section 1.2.4.1, the Scaled Composites facility will not require modification for the proposed action. The activities will occur within the context of routine operations at the facility. As identified in Section 1.2.4.1, required environmental and safety permits, including a RCRA permit, are maintained and current.

As noted in Section 2.1.1, no sensitive environmental conditions have been identified at the facility. Therefore, *no significant impacts* to existing environmental conditions resulting from the proposed action are expected.

3.1.2 Chicago Bridge & Iron

As identified in Section 1.2.4.2, the CBI facility will not require modification or expansion to support the proposed action. The proposed activities will occur within the context of routine operations at the facility. All required environmental and safety procedures are in place that govern activities at the facility. As noted in Section 2.1.2, no sensitive environmental conditions have been identified at the facility. Therefore, *no significant impacts* to existing environmental conditions resulting from the proposed action are expected.

3.1.3 Pratt & Whitney

As identified in Section 1.2.4.3, the Pratt & Whitney facility at Palm Beach will not require modifications or expansion to support the proposed action. The proposed activities will occur within the context of routine activities at the facility. As noted in Section 2.1.3, the facility contains habitat for endangered plant species. However, the proposed action will not necessitate disturbance to these resources. The facility has not been cited for violation of federal, state, and local laws protecting these resources. Therefore, *no significant impacts* to existing environmental conditions resulting from the proposed action are expected.

3.1.4 Aerojet

As identified in Section 1.2.4.4, the Aerojet facility will not require modification or expansion to support the proposed action. The proposed activities will occur within the context of routine operations at the facility, and environmental and safety policies are in effect which regulate these activities. As noted in Section 2.1.4, no sensitive environmental resources are present at the facility. Although the facility is on the National Priorities List, SSRT activities neither take place on the contaminated area nor do the activities contribute to the contamination that led to the facility's listing. Therefore, *no significant impacts* to existing environmental conditions resulting from the proposed action are expected.

3.1.5 McDonnell Douglas Space Systems Company (MDSSC)

As identified in Section 1.2.4.5, the MDSSC facility (Building 44) will require only minor modifications and no new construction to support the proposed action. The proposed action will occur within the context of routine activities at the facility. As noted in Section 2.1.5, no sensitive environmental conditions or resources have been identified at the facility. MDSSC is in compliance with all federal, state and local

regulations protecting the environment. Therefore, *no significant impacts* to existing environmental conditions resulting from the proposed action are expected.

3.2 Proposed Action - Site-Specific Analysis Preflight and Flight Test Locations

This section evaluates the proposed action at the specific preflight (NASA/White Sands Test Facility) and flight (White Sands Missile Range) test locations. Each facility was evaluated relative to environmental resources that potentially are affected by the proposed action. Due to the different activities to be conducted at each location, the analysis involved different environmental parameters.

The environmental resources examined at NASA/White Sands Test Facility and White Sands Missile Range involved physical setting and man-made environment; water resources; geology and soils; biological resources; threatened and endangered species; cultural resources; air quality; noise; infrastructure; and safety. For each of these resource areas at both locations, potential impacts from the proposed action were evaluated separately for construction and test activities.

3.2.1 NASA/White Sands Test Facility

Preflight static test activities will occur at Test Stand 402 in Propulsion Test Area 400 at NASA/WSTF as discussed in Section 2.2.1.1. Static fire testing activities are routine activities at this facility. The activities associated with static fire testing were evaluated for the resource areas as cited above and are described below.

3.2.1.1 Physical Setting and Man-Made Environment

Physical setting and man-made environmental considerations include potential effects on the socioeconomic environment (e.g., land use). Potential impacts from the proposed action to the present use of Test Stand 402, condition of the test stand and Propulsion Test Area 400, proposed alterations to Test Stand 402, and potential conflicts with adjacent land uses were evaluated. Potential impacts include both construction activities to the test stand and implementation of static test firing activities within the test stand.

Present Use and Condition- Modifications to the test stand involve upgrading fire/propellant systems, and modifications to the test stand roof and floor. The test stand is an ambient test stand and is supported by propellant systems. Therefore, activities for the proposed action are consistent with its present use.

Proposed Alterations- The test stand was designed with a removable enclosure and roof to accommodate large test vehicles, so the modifications for the DC-X vehicle are within the scope of test stand activities. Therefore, *no significant impacts* are anticipated to the structure of Test Stand 402.

Adjacent Land Use- Use of Test Stand 402 for static fire activities is consistent with present and adjacent land use; therefore, *no significant impacts* to adjacent land use are anticipated.

3.2.1.2 *Water Resources*

Surface Water- Water resources are not present within Test Area 400. Therefore, *no significant impacts* to surface water are anticipated during static fire testing.

Groundwater- In the unlikely event that the LO₂ or LH₂ tanks leaked or the propellants were accidentally spilled, the propellants would vaporize quickly and would not infiltrate into groundwater resources (Ref #12). Therefore, *no significant impacts* to groundwater resources are anticipated.

3.2.1.3 *Geology and Soils*

Construction activities were evaluated for their potential to alter the local geology and soils were evaluated for potential contamination from propellant handling and use activities. All modifications will be to Test Stand 402; therefore, *no significant impacts* on the local geology and soils from construction are anticipated. Again, in the unlikely event that the fuel tanks leaked or the propellants were accidentally spilled, the propellants would evaporate quickly and would not infiltrate into the ground (Ref #12). Therefore, *no significant impacts* to soil resources are anticipated.

3.2.1.4 *Threatened and Endangered Species*

No threatened and endangered species are known to inhabit the Test Stand area. Therefore, *no significant impacts* to threatened and endangered species are anticipated during static fire testing. Potential noise impacts from static fire testing activities on the desert bighorn sheep are discussed in Section 3.2.1.7.

3.2.1.5 *Cultural Resources*

A total of 89 historic/prehistoric sites have been identified at NASA/WSTF. However, the proposed action does not involve intrusion on these resources and will therefore not affect these resources. As discussed in Section 2.2.1.5, Test Stand 402 was determined ineligible for inclusion on the National Register of Historic Places. Therefore, *no significant impacts* to cultural resources are anticipated from construction modifications to the test stand.

Activities for DC-X will only occur at the test stand; therefore, *no significant impacts* are anticipated for cultural resources from the proposed action.

3.2.1.6 Air Quality

Construction activities at NASA/WSTF are limited to the Test Stand structure; therefore, *no significant impacts* to air quality from construction are anticipated. Amendment 1 to the Institutional Environmental Impact Statement for Space Shuttle Development and Operations prepared by the Shuttle Project Office at Kennedy Space Center (Ref #12) analyzed the environmental effects of LO₂ and LH₂ emissions. The EIS concluded that the exhaust products from these propellants are basically water. Therefore, *no significant impacts* from exhaust emissions from static test firing are anticipated.

3.2.1.7 Noise

The sound pressure produced by a static rocket motor or rocket engine test firing is similar to an actual launch. However, the sound pressure received at a given distance from the test location will vary less over the course of a test firing because the motor or engine is stationary. Sound pressure levels will typically be lower at distant receivers due to ground and barrier attenuation.

Noise levels produced during DC-X static motor test firings have been estimated for nearby community and wildlife receptors and are shown in Exhibit 3.1. These estimates are conservative since they exclude terrain shielding and attenuation or attenuation due to test stand configuration or operation.

NASA/WSTF personnel located outdoors within 820 feet of the test stand will be required to wear hearing protection devices to protect them from sound levels in excess of 115 dB, during tests lasting less than 15 minutes. Hearing protection can include soft ear plugs and/or exterior noise reducing ear muffs, as well as protection within enclosed facilities. However, test firing induced exterior noise levels are not expected to exceed 115 dBA for 15 minutes.

As discussed in Section 2.2.1.7, the existing steam generator in the 400 Area is a major source of noise at NASA/WSTF (100-180 dB), emitting approximately 140 dB at the ejector. Static test firing activities will produce less noise than the steam generator. The noise emitted from the generator is not audible to the communities of Organ or Las Cruces. Community noise exposure (up to 57 dBA, maximum) will be short-term, and is approximately equivalent to the noise level produced by a car passing by at a distance of 100 feet. Therefore, *no significant impacts* to community noise exposure from static fire testing activities are anticipated.

Noise levels within the San Andres National Wildlife Refuge have been calculated to assess potential project related noise impacts on the indigenous desert bighorn sheep (*Ovis canadensis*) population in the San Andres Mountains. Guidelines and criteria for assessing noise impacts on wildlife have not yet been established.

Receptor	Distance (miles)	Sound Level (dB)(*)	Sound Level (dBA)**
Wildlife Refuge (near)	5	77	64
Wildlife Refuge (far)	20	53	31
State Husbandry Ranch	15	59	39
WSMR Post Area	12	63	45
Town of Organ	7	72	57
City of Las Cruces	15	59	39

NOTE: THESE PROJECTIONS DO NOT INCLUDE ATTENUATION FROM GROUND INTERACTION, TERRAIN SHIELDING, OR TEST STAND CONFIGURATION. THEREFORE, ACTUAL NOISE LEVELS WILL BE LESS THAN WHAT IS DEPICTED IN THE TABLE.

(*) Un-weighted sound levels.
(**) A-weighted sound levels.

Exhibit 3.1: Noise Impacts From DC-X Static Fire Testing at Propulsion Test Area 400 ()*

The "dBA" noise descriptor is intended to simulate the human frequency perception of sound. Frequency sensitivity of big horn sheep is discussed in the LEAP EA (Ref #24).

Research has shown that the effects of noise on animals are highly species dependent and that the degree of the effect may vary widely, even within a particular species. Research on the long-term effects of noise on each particular species is the best guideline to assess significance criteria for potentially sensitive species. However, in lieu of this information, reasonable protection may be provided if exposure guidelines for people are met. The sheep in the Refuge may notice short-term sound levels (up to 64 dBA). The noise impact on wildlife in the San Andres mountain range would be similar to distant thunder storms, with a more constant duration. Therefore, *no significant impacts* to the bighorn sheep from noise generated from static fire testing are anticipated.

3.2.1.8 Safety

Safety issues are addressed largely because of the potential impacts to human health and safety. Safety issues at NASA/WSTF involve the following:

- Shipping and handling of gaseous helium and nitrogen and the liquid propellants, including propellant ground storage tank filling operation; propellant loading operations, including chilldown prior to initiating fill operations; and propellant drain operations.
- Pneumatic ground storage and vehicle loading operations of gaseous oxygen and gaseous hydrogen.
- Handling and erection of DC-X to emplace and remove the test article from Test Stand 402.

The hazards associated with liquid hydrogen and liquid oxygen are briefly described in Section 1.2.8.4. The propellants will be loaded directly from tankers used to transport propellants from the source facilities into the propellant tanks at the test stand.

Another safety issue involves storage and loading operations of gaseous oxygen and gaseous hydrogen. To prepare the propellants as fuels for DC-X, they must first be pressurized with gaseous helium prior to loading onto the vehicle. There is potential for explosion when the tank pressure is more than one-quarter of the total tank pressure (Ref #40). Safety is the primary issue when the propellants are being pressurized. As identified in Section 1.2.8.1, personnel safety distances and protective measures will be incorporated in the safety plan.

The safety issues associated with DC-X handling are the degree of difficulty in hoisting the test article high enough to clear the Test Stand 402 structure, and the lowering of the test article onto its supports. The crane operator does not have full visual contact with DC-X at all times and must rely heavily on communications with the load master.

As identified in the referenced safety documentation, facilities will be monitored by the NASA/WSTF safety officer for any safety violations and hazards, which would be immediately corrected. Medical and firefighting personnel will be available for emergency response. Facilities where explosion or fire could occur will be equipped with fire hoses and extinguishers. Detection of releases of colorless and odorless gases will be incorporated as a safety measure. All persons assigned to duties that could require them to encounter a hazardous situation will be trained in the use of safety equipment and be familiar with escape routes and procedures. As a result of the measures incorporated into the proposed action, *no significant impacts* to human health and safety are anticipated.

3.2.2 White Sands Missile Range

To minimize potential effects on the WSMR area environment, the DC-X light series will be conducted within operational criteria of on-going launch activities at the Range. Launch operations potentially affect land use, geology and soils, water resources, air

quality, noise, biological resources, threatened and endangered species, cultural resources, infrastructure (of test location), hazardous materials and wastes, and safety. Each resource area was evaluated individually for construction and launch operations to determine potential environmental issues that could result from the proposed action. A detailed summary of these findings is described below.

3.2.2.1 Physical Setting and Man-Made Environment

Physical setting and man-made environmental considerations include potential effects on the socioeconomic environment (e.g., land use). Impacts to the present use of the Columbia Site area, condition of the launch site and White Sands Space Harbor, proposed alterations to the Columbia Site area, and potential conflicts with adjacent land uses were evaluated.

Present Use and Condition- The Columbia Site is currently not being used at the Range; therefore, *no significant impacts* are anticipated for conflicts with existing land use. The facility is located approximately 3.7 miles north of the RATSCAT facility and White Sands National Monument. With a candidate northeasterly launch trajectory, DC-X operations are not anticipated to interfere with land use at either location. Therefore, *no significant impacts* are anticipated with these facilities.

Proposed Alterations- Except for construction of the launch and landing pads, access roads, and possible excavation of fiber optic cable, the DC-X ground system is mobile, minimizing the amount of ground disturbance; therefore, *no significant impacts* to the Columbia Site area physical setting are anticipated.

Adjacent Land Use- The site is located adjacent to the Columbia Site, which has been abandoned for servicing the Shuttle Orbiter. The White Sands Space Harbor is a backup landing strip for the Shuttle program. The WSSH is currently being used almost daily for Shuttle training operations, usually in the afternoon. Although the WSSH would have to be evacuated for DC-X activities, *no significant impacts* are anticipated for adjacent land uses.

3.2.2.2 Water Resources

Surface Water- No water resources are present within the Columbia Site area or the dispersion area; therefore, *no significant impacts* to surface water during construction and launch activities are anticipated. Access roads to the launch and landing areas will be elevated 6 to 12 inches to provide access to the area after substantial rains in case of widespread shallow sheet flooding.

Groundwater- In the unlikely event that the LO₂ or LH₂ tanks leaked or the propellants were accidentally spilled, the propellants would vaporize quickly and would not infiltrate groundwater resources (Ref #12). Therefore, *no significant impacts* to groundwater resources are anticipated.

3.2.2.3 *Geology and Soils*

Construction activities were evaluated for their potential to alter the local geology and soils were evaluated for potential contamination from propellant handling and use.

As described in Section 2.2.2.3, soil resources at the Columbia Site area consist of very hard, flat gypsum. Due to the flat surface and minimum excavation activities required, construction activities will have *no significant impacts* on the local geology.

Construction activities also will occur at the end of the summer and into the fall months, (not during the peak period of sandstorms), which will help minimize gypsum dust generated from construction activities.

Gypsum is highly corrosive and can corrode concrete. Although the launch and landing pads will be constructed of concrete, DC-X activities will occur over a relatively short timeframe. Therefore, corrosive effects will not impact DC-X activities.

To communicate between the DC-X vehicle and the Flight Operations Control Center using a hardwire link, fiber optic cable must be either laid on the surface or installed in the subsurface. There is a potential for Oryx to graze on aboveground cable, but this is unlikely because the Columbia Site area is not a habitat for Oryx. Excavation would be required to install part or all of the cable below ground. As cited in Section 2.2.2.3, Alkali Flats often have a high water table, which may limit shallow excavations. However, *no significant impacts* to soils are anticipated from this activity because installation of fiber optic cable is common practice at WSMR (Ref #40), and cable can be laid just under the ground surface.

Again, in the unlikely event that the LO₂ or LH₂ tanks leaked or the propellants were accidentally spilled during launch activities, the propellants would evaporate quickly and would not infiltrate the ground. Therefore, *no significant impacts* to soil resources are anticipated.

3.2.2.4 *Biological Resources*

Vegetation- No vegetation is present within the Columbia Site area; therefore, construction and launch activities will have *no significant impacts* on vegetation. The FOCC will be located near the edge line of vegetation; therefore, *no significant impacts* on vegetation are anticipated.

Vegetation on the Alkali Flats in general is sparse (Ref #26), and the three sigma dispersion area (which is contained within a 3 miles radius from the launch site) falls entirely within the lake bed, therefore, *no significant impacts* to vegetation are anticipated in case of flight anomalies during the DC-X flight test series.

Terrestrial Wildlife- No habitat exists for wildlife resources in the harsh environment at the Columbia Site area, and no wildlife species are known to inhabit the Columbia Site. Wildlife from other parts of the Range may pass through the Columbia Site area, but would be transient due to the lack of habitat resources. Therefore, due to the lack of habitat resources, *no significant impacts* to terrestrial wildlife from construction and launch activities are anticipated.

Terrestrial wildlife within the Alkali Flats in general is scarce and the three sigma dispersion area (which is contained within a 3 mile radius from the launch site) falls entirely within the lake bed; therefore, *no significant impacts* are anticipated in case of flight anomalies during the DC-X flight test series.

Aquatic Resources- There is no perennial water within the Columbia Site area; therefore, *no significant impacts* to aquatic resources are anticipated from construction and launch activities.

Although some aquatic resources are present on WSMR, none of these resources occur within the three sigma dispersion area (which is contained within a 3 mile radius from the launch site). Therefore, *no significant impacts* to aquatic resources are anticipated in case of flight anomalies during the DC-X flight test series.

Wetlands- As stated in Section 2.2.2.4, wetlands in the Tularosa Basin are uncommon, and are not present at the Columbia Site. Therefore, *no significant impacts* to wetlands are anticipated from construction and launch activities.

3.2.2.5 *Threatened and Endangered Species*

No vegetation or wildlife are present at the Columbia Site area, and no threatened or endangered species are known to occur at the site. The pupfish, Aplomado falcon, Todsens' pennyroyal, and desert bighorn sheep are not located within the three mile radius from the launch site that contains the three sigma dispersion area; therefore, *no significant impacts* to these species are anticipated from launch activities. Potential noise impacts from launch/flight activities on the desert bighorn sheep are discussed in Section 3.2.2.8.

3.2.2.6 *Cultural Resources*

Sites of prehistoric human occupation or use are not expected to exist in alkali soils (Ref #25). Since the Columbia Site is composed of alkali soils, the site has low potential for cultural resources. Therefore, *no significant impacts* to cultural resources from construction activities are anticipated. The three sigma dispersion area will be contained within a three mile radius from the launch site, which also falls within the Alkali Flats; therefore, *no significant impacts* to cultural resources from launch activities are anticipated.

As indicated in Exhibit 1.10, the fiber optic cable will extend three miles between the Flight Operations Control Center and the launch pad area. This corridor is located on the Alkali Flats, so it also has a low potential for cultural resources. Therefore, *no significant impacts* to cultural resources are anticipated from any excavation activities associated with installing cable in the subsurface.

As currently planned, the FOCC will be located on a gravel parking lot, which is a previously disturbed area. Therefore, *no significant impacts* to cultural resources are anticipated. If the location of the FOCC is changed, however, an archaeological survey would need to be conducted per Section 106 of the National Historic Preservation Act (and would require coordination with the New Mexico State Historic Preservation Office (SHPO)) due to the presence of cultural resource sites along Range Road 10.

If any cultural resources are discovered during construction activities, personnel will protect artifacts and features in place and will notify the WSMR Environmental Services Division and New Mexico SHPO immediately of any finds. These resources would be evaluated and treated per the WSMR Historic Preservation Plan and 36 CFR Part 800.11.

3.2.2.7 Air Quality

As stated in Section 3.2.1.6, the exhaust products from LH₂ and LO₂ are basically water. Water can be considered a pollutant in the upper atmosphere because of its natural low concentration. However, the DC-X flight test series will not occur in the upper atmosphere. Therefore, *no significant impacts* to air quality from exhaust emissions for launch activities are anticipated. Minimal construction activities are required for the launch/landing area; therefore, *no significant impacts* to air quality from construction activities are anticipated.

3.2.2.8 Noise

Potential noise impacts from the SSRT launch vehicle include noise during test firings, liftoff, ascent through the atmosphere, and descent back through the atmosphere. In general, launch vehicle noise is high-intensity and generates acoustic energy over a broad frequency spectrum (1 Hertz (Hz) to 150,000 Hz). However, a major portion of the total acoustic energy is comprised of low frequency components (under 1,000 Hz) and low frequency noise is considered less harmful and annoying to humans.

Sound power levels for the SSRT DC-X launch vehicle have been calculated (Exhibit 3.2). The majority of the acoustic energy produced during launch is low frequency energy (approximately 74 percent of the acoustic energy is between 31 Hz and 1,000 Hz (Ref #57)). Noise level estimates assume point source divergence and the standard day (59 degrees F - 70% RH) atmospheric absorption rate. It should be noted that these estimates should be conservative since they do not include any terrain shielding attenuation.

WSMR personnel located within 820 feet of the launch pad will require hearing protection devices to protect them from short-duration sound levels in excess of 115 dB. Therefore, *no significant impacts* to human health and safety are anticipated from noise. Launch tests will not impact local communities because the test site is remote; therefore, *no significant impacts* from noise are anticipated for local communities.

Noise levels produced during DC-X launch tests have been estimated for nearby wildlife receptors in the San Andres mountain range (Exhibit 3.2). Sensitive wildlife (including

Receptor	Distance (miles)	Sound Level (dB)(*)	Sound Level (dBA)(**)
Wildlife Refuge (near)	10	66	49
Wildlife Refuge (far)	25	48	25
Strawberry Peak Area	15	59	39

NOTE: THESE PREDICTIONS DO NOT INCLUDE ATTENUATION FROM GROUND INTERACTION OR TERRAIN SHIELDING. THEREFORE, ACTUAL NOISE LEVELS WILL BE LESS THAN WHAT IS DEPICTED IN THE TABLE.

(*) Un-weighted sound levels.
 (**) A-weighted sound levels.

Exhibit 3.2: Noise Levels From DC-X Launch Tests at the Columbia Site Area

desert bighorn sheep) in the San Andres mountain range may notice short-term elevated sound levels (44-68 dBA). The majority of the sound is comprised of low-frequency energy, which would sound similar to distant thunder but would have lower overall sound levels. The noise impact on wildlife in the San Andres mountain range would be similar to that produced by thunder storms. Therefore, *no significant impacts* to the desert bighorn sheep from noise are anticipated.

In the event of a launch failure noise levels greater than those during normal launch could be expected. Although sound levels may be greater than under normal conditions, the majority of the impact would be associated with the blast wave. The hearing conservation and safety measures, presently in effect at WSMR, developed to protect facility personnel from explosive failures will also provide protection against potential launch failure noise impacts.

3.2.2.9 Infrastructure

A small number of personnel (Ref #20) will be required to support flight test activities; therefore, there will be *no significant impacts* to the local communities. Approximately 20 personnel will be required for construction activities. Construction equipment will include approximately 12 vehicles, 2 cranes, 2-3 forklifts, and 2 flatbeds. Adequate roads, housing and other support services such as utilities are available at the installation and nearby communities for work crews and technical staff during the test flight series. Temporary sanitation facilities will be located in the launch pad immediate area. Therefore, *no significant impacts* on infrastructure are anticipated.

3.2.2.10 Safety

Again, safety issues are addressed largely because of the potential to affect human health and safety. Safety issues and procedures discussed in Section 1.2.8.2 and for WSMR will address the following:

- Handling/transportation/use of liquid propellants,
- Accidental explosion of the vehicle on the launch pad or immediately after launch,
- Failure of vehicle engines at altitudes less than 5,000 feet, and
- Gypsum dust.

To preclude problems and avoid accidents, the work force training and operator certification programs include quality control inspections, spill prevention, control and countermeasure plans, contingency plans, and active operations monitoring.

For flights below 5,000 feet, the DC-X vehicle will not carry parachutes on-board because the parachute cannot be deployed in time to safely land the vehicle. Therefore, if anomalies occur during flight below 5,000 feet, the vehicle will impact the ground surface and may explode, depending on the amount of propellant remaining onboard. Safety concerns involve both the ground surface impact of the vehicle and explosion potential. As previously stated, SSOP procedures identify measures to prevent serious consequences from such a failure.

In accordance with the measures identified in Section 1.2.8.2, facilities will be monitored by the WSMR safety officer for safety violations and hazards, which, if found, would be immediately corrected. Medical and firefighting personnel will be available for emergency response. Facilities where explosion or fire could occur will be equipped with fire hoses and extinguishers. Detection of releases of colorless and odorless gases will be incorporated as a safety measure. Whenever hazardous operations might occur, a safety zone is established in advance and noninvolved persons will be dismissed from

the area. All persons assigned to duties that could require them to encounter a hazardous situation will be trained in the use of safety equipment and be familiar with escape routes and procedures.

WSMR will add infrared detectors and surveillance cameras to detect potential hydrogen fire during ground testing and after return from flight (Ref #40).

As a result of the safety measures incorporated into the proposed action (Section 1.2.8), which incorporate the elements described above, *no significant impacts* to human health and safety are anticipated.

3.3 No Action Alternative

As specified in Section 1.3.2, the no action alternative for the DC-X test program is not to develop and test the DC-X vehicle. No environmental consequences are associated with implementing the no action alternative. A consequence of implementing the no action alternative is not to proceed with development of DC-X Prime. Implementation of the no action alternative, therefore, does not support the SDIO need for single stage rocket technology to support SDIO's mission of ballistic missile defense. This alternative is therefore not the preferred alternative.

3.4 Cumulative Impacts

Cumulative impact is defined as "the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future action regardless of what agency (Federal or non-Federal) or person undertakes such other actions." (40 CFR Part 1508.7). Cumulative impacts for ground, static fire testing, and launch activities are summarized below.

3.4.1 Ground Impacts

All ground activities associated with the SSRT DC-X test program are routine activities within the facilities at which they occur (except for handling of LO₂ and LH₂ propellants at WSSH). DC-X is the only vehicle that will be using liquid hydrogen and liquid oxygen as propellants at WSMR. No additional employees will be hired to perform DC-X related work at NASA/WSTF or WSMR. All contractor facilities participating in the DC-X test program are required to comply with federal, state, and local regulations designed to protect environmental resources. Compliance with these regulations ensures that DC-X activities will not contribute to cumulative environmental impacts at the contractor facilities and other ground activity locations.

3.4.2 Static Fire Testing and Launch Impacts

Operationally, launch activities are within the historical norm of WSMR activities, and WSMR has conducted over 37,000 missile launches, averaging approximately 450

launches per year. Since 17 SDIO launches occurred in FY 1991 and 22 SDIO launches are projected for FY 92, launch activities are also within the range of normal operations for SDIO. Static fire activities at NASA/WSTF are within the historical norm of NASA/WSTF, as NASA/WSTF has tested over 300 engines and conducted over 2 million firings. Debris dispersion areas for the DC-X test program are separate and distinct from dispersion areas for other program test launches at WSMR.

The environmental analyses demonstrate it is very unlikely that impacts will occur to any environmental media. There are no significant impacts associated with either air quality or noise for static fire activities at NASA/WSTF or launch activities at WSMR. A description of the reliability of the RL-10A-5 engines used in the DC-X flight test series is provided in Section 1.2.4.3. The reliability of the engines is very high.

Based on all of these factors, static fire and launch activities will not contribute to cumulative impacts at NASA/WSTF or WSMR.

3.5 Relationship Between Short-Term Use of Man's Environment and the Maintenance and Enhancement of Long-Term Productivity

The SSRT test program largely involves the use of existing facilities and resources. As identified in Section 1.0, private contractors involved in the program will use existing structures and facilities to support their respective activities. In addition, preflight and flight test activities will take place at White Sands Missile Range. As noted in Section 2.2.2, WSMR has been supporting similar activities since 1945. Consequently, the SSRT test program will result in no net loss of any significant environmental resources (e.g., prime agricultural land, wetlands, historical properties) or significant amounts of natural resources.

3.6 Irreversible or Irrecoverable Commitment of Resources

Implementing the proposed SSRT test program will not result in impacts on threatened or endangered resources or archaeological or historic properties. In addition, the action will not result in changes in land use, or cause loss of habitat for plants or animals.

Irrecoverable commitment of some resources will be required to support the program. The resources would include raw materials to fabricate the various components of the DC-X vehicle and ground support systems. This commitment will be small-scale in nature, and not substantively different from similar activities carried out on a routine basis.

3.7 Conflicts with Federal, Regional, State, Local, or Indian Tribe Land Use Plans, Policies, and Controls

As previously stated, all activities to support the SSRT test program, at both private and government facilities, will occur within existing areas and structures previously used for similar purposes. All activities at private contracting facilities are in compliance with local plans and ordinances. Preflight and flight test activities will take place at WSMR. Similar activities have occurred at the Range since 1945 and pose no threat to tribal land or surrounding land uses.

**Agencies and
Persons Consulted**

4.0

4.0 Agencies and Persons Consulted

Dennis Ditmanson
White Sands National Monument
Alamogordo, New Mexico

John Klingel
New Mexico Department of Game and Fish
Santa Fe, New Mexico

Karen Lightfoot
New Mexico Department of Natural Resources
Santa Fe, New Mexico

Jerry Roehm
U.S. Fish and Wildlife Service
Albuquerque, New Mexico

Lynn Sabastion
New Mexico State Historic Preservation Office
Santa Fe, New Mexico



BRUCE KING
GOVERNOR

STATE OF NEW MEXICO
OFFICE OF CULTURAL AFFAIRS
HISTORIC PRESERVATION DIVISION

VILLA RIVERA BUILDING
228 EAST PALACE AVENUE
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THOMAS W. MERLAN
DIRECTOR

HELMUTH J. NAL
CULTURAL AFFAIRS OFFICER

May 21, 1992

Major Thomas A. Ladd
Director
Environment and Safety
Environmental Services Division
U.S. Army White Sands Missile Range
ATTN: STEWS-ES-E (Robert J. Burton)
White Sands Missile Range, New Mexico 88002-5048

Re: Single Stage Rocket Technology - DC-X Test Program

Dear Major Ladd:

At your request, I have reviewed the Preliminary Final Environmental Assessment for the Single Stage Rocket Technology DC-X Test Program (SSRT) proposed by the Strategic Defense Initiative Organization. Concept validation testing is scheduled to occur at the NASA White Sands Test Facility and in the vicinity of Columbia Site on White Sands Missile Range. The purpose of this review is to determine what effect this undertaking may have on significant cultural resources.

I concur with your assessment that SSRT testing at WSTF and WSMR will have no effect on any historic properties. No properties entered in or determined eligible for inclusion in the National Register of Historic Places will be affected by described project activities. Static engine test stand 402 at WSTF was evaluated for potential National Register eligibility because of its association with the Apollo Program. It was determined that TS402 was ineligible for inclusion in the National Register. No other potentially eligible buildings or structures at WSTF or WSMR will be affected.

I also agree with your determination that locating SSRT launch and recovery facilities in a dry alkali lake bed near Northrup Strip will result in a very low probability that significant archaeological resources will be affected. As stated in your evaluation, previous archaeological survey data and geomorphological evidence virtually preclude the possibility the significant archaeological site will be found within the project areas of effect.

Locating the Flight Operations Control Center (FOCC) on a disturbed gravel parking lot adjacent to Range Road 10 and installing the fiber optic cable from the FOCC to the launch facility in existing roadways and the lake bed, as proposed in the

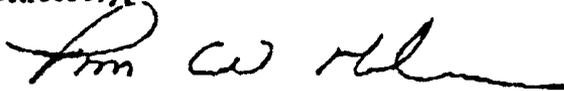
Major Thomas A. Ladd
May 21, 1992
Page 2

Environmental Assessment, will also have no effect on archaeological properties. However, I understand that the decision to locate the FOCC at this site is not final and further consultation with this office may be required if another location is selected. This requirement will also apply to any other project facilities that must be relocated.

In spite of the efforts to locate SSRT facilities in areas with a very low probability of affecting cultural resources, it is possible that buried archaeological manifestations will be uncovered by construction activities. If any such discoveries are made, project personnel should be advised to protect artifacts and features in place and to notify the WSMR Environmental Services Division this office immediately of any such finds. Cultural resources discovered during construction will be evaluated and treated in accordance with the provisions of the WSMR Historic Preservation Plan and 36 CFR Part 800.11.

Thank you for the opportunity to consult with you on the described undertaking. Provided that you have no further questions regarding my comments and there are no changes in the location of project facilities, this determination of no effect should conclude our consultation on this matter.

Sincerely,



Thomas W. Merlan
State Historic Preservation Officer

TWM:DER:bc/Log 35735



UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
Ecological Services
Suite D, 3530 Pan American Highway, NE
Albuquerque, New Mexico 87107

May 22, 1992

Cons. #2-22-92-I-230

Commander
U.S. Army White Sands Missile Range
ATTN: STEWS-ES-E (Mr. Rosales)
Building T-150
White Sands Missile Range
New Mexico 88002-5040

Dear Mr. Rosales:

This responds to a letter from Ms. Janet Friedman, Dames and Moore Special Services, dated April 30, 1992, requesting our review of the Preliminary Final Environmental Assessment (PFEA) for the Single Stage Rocket Technology (SSRT) DC-X test program and our concurrence with a finding of no significant impact to fish and wildlife resources.

We have reviewed the PFEA for the proposed action which includes a comprehensive analysis of potential impacts on rare, sensitive, or threatened and endangered species. The PFEA concludes that the proposed action will result in no adverse impact to any species federally listed or proposed to be listed as threatened and endangered. The U.S. Fish and Wildlife Service concurs with this finding.

The PFEA also states that no adverse impacts to the San Andres population of desert bighorn sheep will result from the proposed SSRT testing program. Static fire tests at the NASA test site will occur at a distance of five miles from the San Andres National Wildlife Refuge. Noise levels at the closest refuge boundary are expected to be no greater than 64 dBA. Columbia site, proposed for the Hover, Expanded Hover, and Rotation flight tests, is at least ten miles from any known sheep areas, and expected noise levels would not exceed 49 dBA. In addition, in the event of a catastrophic failure of the SSRT, the nominal three-sigma dispersion area is within a three-mile radius of Columbia site which is more than seven miles from any bighorn sheep. Therefore, we find that the proposed program will not adversely impact the San Andres population of desert bighorn sheep.

Commandor

2

If we can be of further assistance, please call Mr. Gerry Roehm at
(505) 883-7877.

Sincerely,



Jennifer Fowler-Propst
Field Supervisor

cc:

Director, New Mexico Department of Game and Fish, Santa Fe, New Mexico
Director, New Mexico Energy, Minerals and Natural Resources Department,
Forestry and Resources Conservation Division, Santa Fe, New Mexico
Regional Director, U.S. Fish and Wildlife Service, Fish and Wildlife
Enhancement and Refuges and Wildlife, Albuquerque, New Mexico
Refuge Manager, U.S. Fish and Wildlife Service, San Andres National Wildlife
Refuge, Las Cruces, New Mexico

GOVERNOR
Bruce King



DIRECTOR AND SECRETARY
TO THE COMMISSION
Bill Montoya

STATE OF NEW MEXICO
DEPARTMENT OF GAME & FISH

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STATE GAME COMMISSION
JAMES H. (JAMES) KOCH, CHAIRMAN
SANTA FE

THOMAS P. ARVAS, C.D., VICE-
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BOB JONES
CROW FLATS

J.W. "JOHNNY" JONES
ALBUQUERQUE

BRUCE WILSON
MERRILL PARK

DAVID M. SALMAN
LA CUEVA

ANDREA MAES CHAVEZ,
NAVAJO DAM

May 19, 1992

RE: Single Stage Rocket Technology DC-X Program

Mr. Joaquin Rosales, NEPA Coordinator
U.S. Army, White Sands Missile Range
ATTN: STEWS-BS-E (Bldg. T-150)
White Sands Missile Range, New Mexico 88002-5048

Dear Mr. Rosales:

Thank you for affording the Department of Game and Fish (Department) the opportunity to comment on the Draft Preliminary Final Environmental Assessment, Single Stage Rocket Technology DC-X Test Program (DEA). Based on the information provided in the DEA, we anticipate no significant impact to wildlife or its habitat. The use of hydrogen and oxygen as a fuel may, in the long-term, provide significant environmental benefits by reducing the need for fossil fuels and fuels which produce noxious by-products.

The Department, however, does take exception with information in the "Community Noise Exposure Guidelines" table (Appendix B, Exhibit B.3, page B-5, from ANSI S3.23-1980, Sound Level Descriptors For Determination Of Compatible Land Use). The table indicates that considerable noise is compatible with "Extensive natural wildlife and recreation areas." The Department believes man-caused noise is least compatible with natural wildlife and recreation type land. Not only is wildlife disturbed by noise, but quietness is one of the important qualities which visitors to this type of land seek. Potential disturbance to wildlife has been addressed elsewhere in the document. We recommend dropping this line from the table and addressing potential noise impact to recreation lands separately.

Mr. Joaquin Rosales

-2-

May 19, 1992

Appendix A, "Threatened, Endangered, and Sensitive Species Occurring or Potentially Occurring in Otero and Doña Ana Counties" contains some errors and omissions, more specifically:

- Mississippi kite (Ictinia mississippiensis) has been removed from the state-endangered list.
- Reticulate Gila monster (Heloderma suspectum) is state-listed (E1) and has been collected in Doña Ana County.
- Sacramento Mountain salamander (Aneides hardii) occurs in Otero County, but not on White Sands Missile Range.
- Common ground-dove (Columbina passerina) is state-listed (E1) and occurs in Doña Ana County.
- Doña Ana talussnail (Sonoralla todsoni) is state-listed (E2) and occurs in Doña Ana County.

Lists of state-endangered wildlife for each of these counties and species accounts for several of the species are enclosed.

Thank you again for the opportunity to comment on the Single Stage Rocket Technology DC-X Program. If you have any questions, please contact Jon Klingel (827-9912) of this Department.

Sincerely,


Bill Montoya
Director

BM/jtk
Enc.

cc: Jennifer Fowler-Propst (Ecological Services Supervisor, USFWS)
Wain Evans (Assistant Director, NMGF)
Andrew Sandoval (HEL Division Chief, NMGF)
Robert Jenks (Environmental Section Chief, NMGF)

**NEW MEXICO
STATE ENDANGERED WILDLIFE**

**STATE ENDANGERED SPECIES
BY COUNTY**

Includes species known or highly likely to occur

Excludes historical only (pre 1960) occurrence

NEW MEXICO STATE ENDANGERED WILDLIFE

DONA ANA COUNTY

14 Species

Gila reticulate monster

olivaceous cormorant

bald eagle

spionado falcon

peregrine falcon

whooping crane

common ground-dove

(southwestern) willow flycatcher

Bell's vireo

gray vireo

Sairo's sparrow

(Organ Mts.) Colorado chipmunk

(desert) bighorn sheep

Dona Ana talussnail

Heloderma suspectum

Phalacrocorax olivaceus

Haliaeetus leucocephalus

Falco femoralis

Falco peregrinus

Grus americana

Columbina passerina

Empidonax traillii extimus

Vireo bellii

Vireo vicinior

Ammodramus bairdii

Eutamias quadrivittatus australis

Ovis canadensis mexicanus

Sonorella tcdsani

NEW MEXICO STATE ENDANGERED WILDLIFE

OTERO COUNTY

11 Species

White Sands pupfish

Cyprinodon tularosa

Sacramento Mountain salamander

Aneides hardii

bald eagle

Haliaeetus leucocephalus

common black-hawk

Buteogallus anthracinus

aplomado falcon

Falco femoralis

peregrine falcon

Falco peregrinus

Bell's vireo

Vireo bellii

gray vireo

Vireo vicinior

Baird's sparrow

Ammodramus bairdii

(Penasco) least chipmunk

Eutamias minimus atristriatus

meadow jumping mouse

Zapus hudsonius

State of New Mexico
ENERGY, MINERALS and NATURAL RESOURCES DEPARTMENT
Santa Fe, New Mexico 87505



BRUCE KING
GOVERNOR

11 May, 1992



ANITA LOCKWOOD
CABINET SECRETARY

Janet Friedman
Dames & Moore Special Services
7101 Wisconsin Avenue, Suite 700
Bethesda, Maryland 20814

Dear Ms. Friedman,

Thank you for the opportunity to comment on Preliminary Final Environmental Assessment for the Single Stage Rocket Technology DC-X test program. Upon review of the materials you sent, none of which indicated the presence of plants of concern to the state at proposed construction sites, we see no need for further comment from our office at this time.

If you have any questions, please do not hesitate to call Karen Lightfoot or Bob Sivinski, Endangered Species Botanists for the State of New Mexico.

Sincerely,

Raymond R. Gallegos
State Forester

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5.0 Glossary and Acronyms

5.1 Glossary

aeroshell	A protective, all-covering shell for a spacecraft entering an atmosphere from space at high speeds.
alluvial fans	A fan-shaped accumulation of sediment deposited by flowing water alluvium deposited at the mouth of a ravine.
apogee	The point of maximum altitude during aircraft flight attained by an earth satellite.
aquifer	A water-bearing rock, rock formation, or group of rock formations.
arroyos	A deep gully cut by an intermittent stream; dry gulch.
avionics	The science and technology of electronics applied to aeronautics and astronautics.
cryogenic	Pertaining to extremely low temperature.
decibel	A standard unit of noise measurement; the relative loudness of a sound.
downrange	The trajectory for the initial inclination and azimuth of DC-X after launch.
drogue chute	A small parachute used to slow down a re-entering spacecraft or satellite prior to deployment of the main parachute; a small parachute used to pull a main parachute from its storage pack.
endangered species	A species in danger of extinction throughout all or a significant portion of its range.
eolian	Pertaining to, caused by, or carried by the wind.

epoxy	Any of various usually thermosetting resins capable of forming tight cross-linked polymer structures characterized by toughness, strong adhesion, and high corrosion and chemical resistance, used especially in surface coatings and adhesives.
facies	The general aspect or outward appearance, as of a given growth of flora.
footprint	An outline of the area of dispersion.
hypergolic	Igniting spontaneously on contact of its components. Used of a rocket fuel.
intraline un-barricaded distance	The minimum distance required between a particular liquid fuel and personnel not protected by physical structures such as berms, etc.
lacustrine	Of or pertaining to lakes, living or growing in lakes.
launch azimuth	The horizontal angular distance from a fixed reference direction to a position, object, or object referent, as to a great circle intersecting a celestial body, usually measured clockwise in degrees along the horizon from a point due south.
mach	The ratio or speed of an object to the speed of sound in the surrounding medium.
nose cone	The forwardmost and usually separable section of a rocket or guided missile, shaped to offer minimum aerodynamic resistance and often bearing a protective cladding against heat.
ordnance	Military weapons collectively, along with ammunition and the equipment to keep them in good repair.
oxidizer	A substance that oxidizes or induces another substance to oxidize, to combine with oxygen.
playa	A nearly level area at the bottom of a desert basin, sometimes temporarily covered with water.

pneumatic	Pertaining to gases.
reefing lines	Tied down to lessen the area exposed to the wind
spill pans	A substance to run or fall out of a container.
threatened species	A species that is likely to become endangered within the foreseeable future.
thrusters	The forward directed force developed in a jet or rocket engine as a reaction to the rearward ejection of fuel gases at high velocities.
trajectory	The path of a moving particle or body, especially such a path in three dimensions.
uprange	The opposite direction from downrange and used to describe the landing site for DC-X.
wetlands	Wetlands are defined as those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions (33 CFR Part 328.3).

5.2 Acronyms

ACHP	Advisory Council on Historic Preservation
AFB	Air Force Base
AMCR	Army Material Command Regulation
APD	Aerojet Propulsion Division
AR	Army Regulation
ASME	American Society of Mechanical Engineers
Az	Lateral Acceleration
BLM	Bureau of Land Management
c/o	Construction/Operation
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
dB	Decibel
dBA	Decibel (A-weighted)
DC-X	Delta Clipper-X
DNL	Day/Night Noise Level
DOA	Department of Army
DoD	Department of Defense
DOPAA	Description of Proposed Action and Alternatives
DOT	Department of Transportation
EA	Environmental Assessment
ECIS	Environmental Critical Issues Summary
EIAP	Environmental Impact Analysis Process
EIS	Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
EQSD	Explosive Quantity Safety Distance
ERINT	Extended Range Interceptor
ESMC	Eastern Space and Missile Center
F	Fahrenheit
FDIR	Fault Detection, Isolation, and Recovery
FIREX	Fire Extinguisher/System
FOCC	Flight Operations Control Center
FONSI	Finding of No Significant Impact
ft	Foot/Feet
g	Gravity Force
GH ₂	Gaseous Hydrogen
GHe	Gaseous Helium
GN ₂	Gaseous Nitrogen
GO ₂	Gaseous Oxygen
GSO	Ground Safety Officer
GU	Gypsum Land, Level (soil classification)

HLLV	Heavy Lift Launch Vehicle
HEDI	High Endoatmospheric Defense Interceptor
HPP	Historic Preservation Plan
HTOL	Horizontal Takeoff and Landing
IHBD	Inhabited Building Distance
JSC	Lyndon B. Johnson Space Center
km	Kilometer
KT	Kepner-Tregoe
LC	Launch Complex
Ldn	Day-Night average sound level
LEAP	Lightweight Exoatmospheric Projectile
Leq	Average sound level
LH ₂	liquid Hydrogen
LN ₂	Liquid Nitrogen
LO ₂	Liquid Oxygen
M	Mach
MAB	Missile Assembly Building
MDSSC	McDonnell Douglas Space Systems Company
MFSOP	Missile Flight Safety Operation Plan
mg/l	Milligrams Per Liter
mg/m ³	Milligrams Per Cubic Meter
MOA	Memorandum of Agreement
MSA	Metropolitan Statistical Area
MSL	Mean Sea Level
NA	Not Applicable
NAAQS	National Ambient Air Quality Standards
NASA	National Aeronautics and Space Administration
NASP	National Aeronautical Space Plane
NEPA	National Environmental Policy Act
NIOSH	National Institute of Occupational Safety and Health
NMFS	National Marine Fisheries Service
NOI	Notice of Intent
NOMTS	Naval Ordnance Missile Test Station
NPDES	National Pollutant Discharge Elimination System
NRO	National Range Operations
NWR	National Wildlife Refuge
OSHA	Occupational Safety and Health Administration
PCB	Polychlorinated Biphenols
PM ₁₀	Particulate Matter Less Than 10 Microns in Diameter
POL	Petroleum Oil and Lubricants
PPM	Parts Per Million
PRS	Parachute Recovery System
psf	Pounds Per Square Foot
psi	Pounds Per Square Inch
Q	Maximum Dynamic Pressure

RATSCAT	Radar Target Scatter Facility
RCRA	Resource Conservation and Recovery Act
RCS	Reaction Control System
RF	Radio Frequency
ROD	Record of Decision
ROI	Region of Influence
RR	Range Road
SCS	Soil Conservation Service
SDI	Strategic Defense Initiative
SDIO	Strategic Defense Initiative Organization
SDIO/TNE	Strategic Defense Initiative Organization/Test and Evaluation
SDS	Strategic Defense System
sec	Second
SHPO	State Historic Preservation Officer
SOP	Standard Operating Procedure
SPL	Sound Pressure Level
SRR	Suborbital Recoverable Rocket
SSOP	Safety Standard Operating Procedures
SSRT	Single Stage Rocket Technology
SSTO	Single Stage To Orbit
TBD	To Be Determined
TECOM	U.S. Army Test and Evaluation Command
TLV	Threshold Limit Value
TM	Technical Manual
TVP	Technology Validation Program
ug/m ³	Micrograms Per Cubic Meter
USASDC	U.S. Army Strategic Defense Command
USDA	U.S. Department of Agriculture
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
VTHL	Vertical Takeoff and Horizontal Landing
VTOL	Vertical Takeoff and Landing
WSMC	Western Space and Missile Center
WSMR	White Sands Missile Range
WSNM	White Sands National Monument
WSPG	White Sands Proving Ground
WSSH	White Sands Space Harbor
WSTF	White Sands Test Facility (NASA)
wt	Weight

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6.0

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**Appendix
Threatened and Endangered Species**

A

Appendix A Threatened, Endangered, and Sensitive Species Occurring or Potentially Occurring in Otero and Dona Ana Counties

Species	Status		Habitat and Distribution
	State	Federal	
Fish			
White sands pupfish <i>Cyprinidon tularosa</i>	E2	2	Restricted to Salt Creek, Lost River, and Malpais and Mound Springs
Mollusk			
Dona Ana talussnail <i>Sonorella todseni</i>	E2		Occurs in Dona Ana County
Reptiles			
Texas horned lizard <i>Phrynosoma cornutum</i>		2	(**) Arid and semi-arid open country with sparse plant growth
Reticulate Gila monster <i>Heloderma suspectum</i>	E1		Has been collected in Dona Ana County
Birds			
White-faced ibis <i>Plegadis chihi</i>		2	Irrigated land, freshwater marshes; may fly over site
Western snowy plover <i>Charadrius alexandrinus nivosus</i>		2	Alkali flats and marshes possible possible transient north of Lake Lucero
Mountain plover <i>Charadrius montanus</i>		2	Semi-arid grasslands, plains, plateaus

Species	Status		Habitat and Distribution
	State	Federal	
Long-billed curlew <i>Numenius americanus</i>		3C	High plains, rangelands, salt marshes possible transient near Malpais Spring
Interior least tern <i>Sterna antillarum athalassos</i>	E2	E	Beaches and sandbars; has been sighted at Bosque del Apache
Ferruginous hawk <i>Buteo regalis</i>		2	(**) Arid plains, open woodlands
Swainson's hawk <i>Buteo swainsoni</i>			(**) Dry plains, open foothills rangeland, open forest
Aplamado falcon <i>Falco femoralis septentrionalis</i>		E	(*) Arid brushy prairie, yucca flats; recently seen at WSMR in grasslands south of Malpais
Common black hawk <i>Buteogallus anthracinus</i>	E2		Riparian habitat
Bald eagle <i>Haliaeetus leucocephalus</i>		E	Lakes and rivers; has been observed on west side of Sacramento Mountains
Peregrine falcon <i>Falco peregrinus anatum</i>	E1	E	(*) Mountains and open country; has been observed on WSMR
Whooping crane <i>Grus americana</i>	E2	E	Freshwater streams and marshes Bosque del Apache, may fly over site
Western yellow-billed cuckoo <i>Coccyzus americanus occidentalis</i>			River thickets, willows, mesquite
Arizona Bell's vireo <i>Vireo bellii</i>	E2		Dense riparian habitat, yucca flats
Gray vireo <i>Vireo vicinor</i>	E2		Bushy mountain slopes, mesas scrub, oak, juniper

Species	Status		Habitat and Distribution
	State	Federal	
Baird's sparrow <i>Ammodramus bairdii</i>	E2		(*) Long grass prairie; possible in playas
Varied bunting <i>Passerina versicolor</i>	E2		(*) Shrublands, especially dense mesquite, in canyon bottoms
Olivaceous cormorant <i>Phalacrocorax olivaceus</i>	E2		Breeds and resident in Rio Grande valley, transient in Alamogordo area
Willow flycatcher <i>Empidonax trailli extimus</i>	E2	1	(**) Occurs statewide in spring/autumn, migrations during breeding season occurs in riparian communities
Common ground-dove <i>Columbina passerina</i>	E1		Occurs in Dona Ana County

Mammals

Occult (little brown) bat <i>Myotis lucifugus occultus</i>		2	Buildings, mine tunnels, beneath bridges, in rock crevices
Southwestern cave bat <i>Myotis veleifer brevis</i>		2	Caves, mine tunnels
Spotted bat <i>Euderma maculatum</i>	E2	2	Ranges from riparian and pinyon-juniper to spruce-fir forests; not observed east of Rio Grande
Desert bighorn sheep <i>Ovis canadensis</i>	E1		Arid rocky mountains in open habitat San Andres Mountains are key habitat area
Black-striped (Penasco) least <i>Eutamias minimus atristriatus</i>	E1		Disjunct in Sacramento Mountains mostly in northern mountains; habitat varies, from agricultural areas to juniper woodland, ponderosa pine forest, up to lower spruce-fir zone

Species	Status		Habitat and Distribution
	State	Federal	
Organ Mountains chipmunk <i>Eutamias quadrivittatus australis</i>	E2	2	Southern subspecies known to occur in Organ and Oscura Mountains; occurs in ponderosa pine and juniper-oak-mixed shrub communities
Meadow jumping mouse <i>Zapus hudsonius luteus</i>	E2	2	Lush communities near streams and in wet meadows, from Valleys to mountains
Black-tailed prairie dog <i>Cynomys ludovicianus arizonensis</i>		2	Dry upland grasslands; limited to Otero: Mesa area, east of SMES-ETM site
White sands pocket gopher <i>Geomys arenarius brevirostris</i>			Grasslands and roadsides in White Sands National Monument
White Sands wood rat <i>Neotoma micropus leucophaea</i>		2	Limited to White Sands National Monument

Plants^(a,b)

Family - Apiaceae (Umbelliferae)

Threadleaf false carrot <i>Aletes filifolius</i>	P1		Canyons and open slopes (5500-7500 ft), in pinyon-juniper
Desert parsley <i>Pseudocymopterus longiradiatus</i>	P1		Sandy or rocky ground in deep canyons, usually in shade

Family - Asteraceae (Compositae)

Spoonleaf rabbitbrush <i>Chrysothamnus spathulatus</i>	P1		Pinyon-juniper zone and foothills with creosote bush (4400-7000 ft)
Vasey's bitterweed <i>Hymenoxys vaseyi</i>	P1		Dry hills (4500-6500 ft) flowers September to November
Gypsum scalebroom <i>Lepidospartum burgessii</i>	(E),T	2	Gypseous ridges and flats (4000 feet)

Species	Status		Habitat and Distribution
	State	Federal	
Organ Mountain aster <i>Machaeranthera amplifolia</i>	P1		Rocky canyons in mountains; (6000-7000 ft)
Nodding cliff daisy <i>Perityle cernua</i>	(E),T	2	Cliffs of igneous rock (5000-8800 ft) 4
Threadleaf horsebrush <i>Tetradymia filifolia</i>	P1		Limestone and gypseous soils, soils, usually in pinyon-juniper woodland
Family - Boraginaceae			
Payson's hiddenflower <i>Cryptantha paysonii</i>	P1		Open slopes on limestone soils, flowers April to June (4000-7000 ft)
Family - Brassicaceae (Cruciferae)			
Gray sibara <i>Sibara grisea</i>	(E),T	3C	On and at the base of limestone limestone cliffs (4500-6000 ft); flowers May-June
Family - Cactaceae			
Night-blooming cereus <i>Cereus greggi</i>	(E),T		(*) Gravelly or silty areas in washes or flats (3000-5000 ft); flowers June
Lee's pincushion cactus <i>Coryphantha sneedii leei</i>	(E),E	E	Rocky slopes of lime-stone mountains (4000-6000 ft); flowers April to Sept.
Sneed's pincushion cactus <i>Coryphantha sneedii sneedii</i>	(E),T	T	Limestone slopes, ledges, and ridgetops (4100-5900 ft); flowers Spring and Fall
Sheer's pincushion cactus <i>Coryphantha scheeri</i>	(E),E		(*) Open plains and flats often in alluvial soils (3000-5000 ft); flowers June to Sept

Species	Status		Habitat and Distribution
	State	Federal	
Kuenzler's hedgehog cactus <i>Echinocereus fendleri kuenzleri</i>	(E),E	E	Limestone ledges, rock cracks, and gentle slopes in or just below juniper woodland (6000 ft); flowers May
Lloyd's hedgehog cactus <i>Echinocereus lloydii</i>		E	Sandy or gravelly soils (3000 ft) population described in Jarilla Mountains currently not considered <i>E. lloydii</i> (Earnest 1989)
Villard's pincushion cactus <i>Escobaria villardii</i>	(E),T		On limestone (4500-6000 ft); known only from San Andres Mountains; flowers May-June
Sandberg's pincushion cactus <i>Escobaria sandbergii</i>	(E),T		Rocky hillsides (6000-7500 ft) flowers May-June (= <i>Coryphantha</i>)
Southwestern barrel cactus <i>Ferocactus wislizenii</i>	P1		(*) Rocky, sandy gravelly slopes in deserts, grasslands, or canyons (3000-5000 ft); flowers March to August
Wright's pincushion cactus <i>Mammillaria wrightii wrightii</i>	(E),T		(*) Gravelly or sandy hills, plains, desert grasslands to pinyon-juniper (3000-7000 ft); flowers August to October
Sandy prickly pear <i>Opuntia arenaria</i>	(E),T	2	(*) On and among sandy dunes, sandy floodplains in arroyos (3500-4500 ft.) flowers May-June
Grama grass cactus <i>Toumeyia papyracantha</i>	(E),T		Sandy soils in grama grass and galleta grasslands (5000-7300 ft); flowers April-June (= <i>Pediocactus</i>)

Species	Status		Habitat and Distribution
	State	Federal	
Family - Caryophyllaceae			
Plank's catchfly <i>Silene plankii</i>	P1		Crevices and pockets in protected cliff faces of igneous rock (5000-6500 ft) flowers July to September
Family - Cucurbitaceae			
Smooth cucumber <i>Sicyos glaber</i>	P1		(*) Lower to middle elevations of Organ Mountains (5000-6000 ft) flowers July to September
Family - Euphorbiaceae			
Candelilla <i>Euphorbia antisyphilitica</i>	(E)		Locally abundant in limestone deserts and gravelly slopes; flowers June-July
Family - Fabaceae (Leguminosae)			
Castetter's milkvetch <i>Astragalus castetteri</i>	P1		Limestone soils in pinyon-juniper, canyons and dry washes of western slopes of San Andres Mts.; (5000-6000 ft)
Guadalupe Mountain <i>Sophora gypsophila guadalupensis</i>	(E), T	2	Dry limestone slopes with one seeded mesquite juniper (5000-6400 ft)
Family - Hydrophyllaceae			
Cliff nana <i>Nama xylopodum</i>	P1		Cracks and crevices of limestone boulders and scarps (4500-6000 ft) flowers May to September
Family - Lamiaceae (Labiatae)			
Grayish white giant hyssop <i>Agastache cana</i>	P1		On rocky slopes and in crevices of ledges in low mountains (5250-6225 ft); flowers mid-July to August

Species	Status		Habitat and Distribution
	State	Federal	
Todsen's pennyroyal <i>Hedeoma todsenii</i>	(E),T	E	In gravelly limestone soils on steep slopes under scattered pines (6600 ft)
Supreme sage <i>Salvia summa</i>	T		Shaded ledges and cracks among rocks on steep limestone canyon slopes (5000 ft)
Family - Loasaceae			
Gypsum blazing star <i>Mentzelia perenis</i>	PI		Gypsum deposits, limestone hills with gypsum lenses in lower juniper zone (5400 ft)
Family - Malvaceae			
Wright's globemallow <i>Sphaeralcea wrightii</i>	T		Rocky slopes in arid grassland or desert (4000-6000 ft); flowers July to September
Family - Martyniaceae			
Dune unicorn plant <i>Proboscidea sabulosa</i>	(E),T	2	(*) Deep sands of mostly stabilized dunes, desert scrub, often with mesquite (3000- 3500 ft)
Family - Onagraceae			
Organ Mountains evening primrose <i>Oenothera organensis</i>		T	Restricted to seeps and springs (5700-7600 ft)
Family - Papaveraceae			
Sacramento prickly poppy <i>Argemone pleiacantha pinnatisecta</i>	(E),E	E	Rocky canyon bottoms and slopes (5000-7000 ft); flowers May to August

Species	Status		Habitat and Distribution
	State	Federal	
Family - Plumbaginaceae			
Blue limonium <i>Limonium limbatum</i>	(E)		In saline flats, depressions, associated with alkaline soils (3000-6000 ft); flowers June to August
Family - Poaceae			
Curleaf needlegrass <i>Stipa curvifolia</i>	T		Limestone rims and steep slopes (4000-5600 ft); flowers April to May
Family - Polygalaceae			
Mescalero milkwort <i>Polygala rimulicola mescalerorum</i>	(E),T	2	Cracks of sandy, limestone cliffs (5100 ft); flowers June to September
Family - Portulacaceae			
Longstemmed talinum <i>Talinum longipes</i>	(E),P1		(*) Dry hills at lower elevations; flowers July to August
Family - Scrophulariaceae			
Alamo beard tongue <i>Penstemon alamosensis</i>	(E),T	2	Canyon bottoms, crevices, and pockets in rocky limestone hillsides (5000 ft); flowers May to June

(**) Known to occur in mesquite sand dune habitat type (BLM IHICS system).

(*) Habitat of White Sands Missile Range SMES-ETM site appears suitable for occurrence.

(a) Only plant species occurring below 6000 ft are included in this list.

(b) Status (E) refers to category of New Mexico Natural Resources (1985); other state status categories are from New Mexico Native Plants Protection Advisory Committee (1984).

Sources:

Earnest 1989

New Mexico Department of Game and Fish 1988

New Mexico Native Plants Protection Advisory Committee 1984

New Mexico Natural Resources Department 1985

New Mexico Natural Resources Department 1989

Norwick 1989

U.S. Army 1987

U.S. Army 1989

USFWS 1987a

USFWS 1987b

USFWS 1989

Status Codes

State

Categories used by New Mexico Game and Fish Department

- E1 Endangered (group 1) - Animal species whose prospects of survival or recruitment within the state are in jeopardy.
- E2 Endangered (group 2) - Animal species whose prospects of survival or recruitment within the state are likely to become jeopardized in the foreseeable future.

Category used by New Mexico Natural Resources Department

- (E) Endangered - Plant taxon which is on the federal list of threatened or endangered species; or species which are rare or widespread across their entire range but whose survival in New Mexico is jeopardized.

Categories used by New Mexico Native Plants Protection Advisory Committee 1984

- E Biologically endangered - Plant taxon of very restricted distribution and which is seriously declining and in danger of rapid extinction throughout its range.
- T Biologically threatened - Plant taxon of restricted distribution or which has potential for rapid extinction throughout all of its range.
- P1 Priority 1 - Endemic or of restricted distribution in New Mexico, being commercially exploited, and usually being eradicated in much of its historic range.

Federal

- E Endangered - A species in danger of extinction throughout all or a significant portion of its range.
- T Threatened - A species which is likely to become endangered within the foreseeable future.

- 1 - Taxa for which the Service has enough substantial information on biological vulnerability and threat(s) to support proposals to list them as endangered or threatened species. Proposed rules have not yet been issued because this action is precluded at present by other listing activity.
- 2 Candidate, category 2 - Information indicates that proposing to list as endangered or threatened is possibly appropriate, but substantial data on biological vulnerability and threats are not currently known to support the immediate preparation of rules. Further biological research and field study will be necessary to ascertain the status and/or taxonomic validity of the taxa in Category 2.
- 3 Candidate, category 3 - Former candidate, rejected because persuasive evidence of extinction (3a), does not represent taxa meeting legal definition of Endangered Species Act (3b), or more widespread than previously thought (3c).

**Appendix
Noise**

B

Appendix B

Noise Analysis

The standard unit of noise measurement is the decibel (dB). The decibel scale compresses the full range of acoustic energy by comparing logarithms of the level with respect to 0.0002 microbar, the level considered to be the threshold of human hearing Exhibit B.1. For environmental noise measurements, an A-weighting filter is commonly used (dBA). A-weighting filters the frequency spectrum of sound levels as the human ear naturally does (A-weighting attenuates low and high frequency energy similar to the way people hear sound).

The "equivalent level" (Leq), averages (by energy content) varying sound levels over a time interval into an overall level which if continuous (versus the time varying levels), over the same time period, contains the same amount of acoustic energy. Studies indicate that the A-weighted Leq correlates well with the degree of annoyance, hearing loss, and interference that is generated by different levels of noise exposure.

The day-night sound level (Ldn) is the A-weighted Leq over twenty-four hours, which includes night-time penalties. The Ldn includes a 10 dBA addition to night-time sound levels (between 2200 and 0700 hours) because noise during the night is considered more problematic than day-time sounds. The Ldn is the most widely used community noise metric and is endorsed by groups such as the Environmental Protection Agency (EPA), Department of Transportation (DOT), Department of Defense (DOD) and Department of Housing and Urban Development (HUD). U.S. Army regulations, Chapter 7 AR 200-1, also specify using the Ldn metric in facility noise exposure analysis.

How people perceive a given sound depends on the following measurable physical characteristics.

Intensity: The intensity is a measure of sound level magnitude which is often equated with loudness. In general, a ten decibel increase in intensity is generally considered as a doubling of the perceived loudness of a sound.

Frequency Content: Sounds are typically comprised of energy distributed over a variety of frequencies. Pure tones have all the energy in a narrow frequency range. Sounds with the majority of energy between 2000 and 8000 Hertz are perceived as more noisy than sounds of equal pressure level outside this range.

SPL	Example Noise Source	Comments
140	Large Rocket Booster (nearby)	Permanent Hearing Damage
135	Artillery Fire (@ 10 ft.)	
130	Jet Engine (nearby)	Threshold of Pain
125	Indoor Shooting Range	
120	Jet Take Off (near runway)	OSHA & ACGIH Limits ¹ Threshold of Discomfort
115	Hard Rock Band (near stage)	
110	Accelerating Motorcycle (nearby)	
105	Pile Driver (@ 50 ft.)	
100	Loud Auto Horn (@ 10 ft.)	OSHA 8-Hour Limit ACGIH 8-Hour Limit
95	Ambulance Siren (@ 100 ft.)	
90	Noisy Urban Street	
85	Noisy Factory	EPA Hearing Effects Limit ² FHWA, FAA, HUD Guidelines ³
80	School Cafeteria	
75	Garbage Disposal (@ 3 ft.)	EPA Residential Goal
70	Freight Train (@ 100 ft.)	
65	Auto Traffic (near freeway)	
60	Average Urban Area	
55	Inside Department Store	
50	Average Business Office	
45	Light Auto Traffic (@ 100 ft.)	
40	Average Residential Interior	
35	Quiet Suburban Area (@ night)	
30	Quiet Rural Area	
25	Concert Hall (background)	
20	Average Whisper	
15	Recording Studio	Threshold of Hearing
10	Leaves rustling in Wind	
5	Human Breathing	
0	Mosquito Flying (@ 3 ft.)	

- 1 Occupational Safety & Health Administration (OSHA) and American Conference of Governmental Industrial Hygienists (ACGIH) considers 115 dBA (Leq) as the limit for 15 minute (7.5 min for ACGIH) exposure during an 8-hour work day. OSHA considers 90 dBA (8-hr Leq), ACGIH considers 85 dBA (8-hr Leq) as the limit for 8-hour exposure during a work day.
- 2 Environmental Protection Agency (EPA) considers 70 dBA (24-hr Leq) as the threshold of potential hearing effects and 55 dBA (Ldn) as a goal for residential land use.
- 3 Federal Highway Administration (FHWA) considers 67 dBA (1-hr Leq), Federal Aviation Administration (FAA) considers 65 dBA (Ldn), and Department of Housing and Urban Development (HUD) considers 65 dBA (Ldn) to be acceptable for residential land use.

Exhibit B.1: Logarithmic Difference Between Various Sound Levels

Duration per day	OSHA TWA* (dBA)	ACGIH TWA* (dBA)
8 hours	90**	85
4 hours	95	90
2 hours	100	95
1 hour	105	100
30 minutes	110	105
15 minutes	115***	110
7.5 minutes	-	115***
Peak Impulse Level	140	140
<p>* Time Weighted Averages. ** OSHA requires a hearing conservation program if workplace noise exposures exceed 85 dBA for an 8-hour TWA, this is equivalent to a fifty percent dose of the 90 dBA criteria. *** Maximum TWA noise exposure.</p>		

EXHIBIT B.2: OSHA & ACGIH Noise Exposure Criteria

Temporal Pattern: The temporal nature of sound includes factors such as continuity, fluctuation, impulsiveness, and intermittency. Sounds that are increasing in level are judged to be somewhat louder than those decreasing in level. Impulsive and intermittent sounds are usually perceived to be noisier than the actual sound level.

Significance Criteria

Occupational noise exposure guidelines have been promulgated by OSHA (29 CFR 1910.95) and the American Conference of Governmental Industrial Hygienists (ACGIH) to protect employees from suffering occupationally related hearing damage. ACGIH criteria are considered guidelines while OSHA criteria are regulated under the Department of Labor. Both criteria are based on the duration of exposure (Time Weighted Averages), allowing higher noise exposures for shorter durations. OSHA and ACGIH noise exposure criteria are described in Exhibit B.2.

Community noise exposure guidelines have been developed by several federal agencies including, EPA, DOT, DOD, and HUD. These guidelines are typically based on 24-hour averaged levels, which account for the overall land use within a community and typically include night-time penalties to account for sleep disturbance. Although the Ldn does not highlight the impact of short-term, high amplitude noise levels, it does provide

a basis to evaluate the overall noise environment within the community. With respect to community health effects (hearing protection), a 24-hour Leq of 70 dBA is recommended by EPA as a noise exposure level for the general public that will not cause hearing damage with an adequate margin of safety. Community noise levels exceeding OSHA standards would pose a risk to public health and welfare and would be considered a significant impact. Community noise exposure guidelines are described in Exhibit B.3. Exhibit B.4 describes the effects of noise on people living in residential areas.

Guidelines and criteria for assessing wildlife impacts have not yet been established. Research on the long-term effects of noise on each particular species is the best guideline to assess significance criteria for potentially sensitive species. However, in lieu of this information, reasonable protection may be provided if exposure guidelines for people are met.

A noise problem exists when sound levels cause frequent interference or a significant risk to health and welfare. The key issues with respect to noise are:

- Occupational Exposure
- Community Exposure
- Wildlife Exposure

Occupational Noise Exposure

Occupational noise exposure criterion are based on exposure duration and sound level magnitude. This time-level dependency represents a dose effect which allows employees to sustain an incremental increase of five decibels for each halving of exposure time. If the eight-hour equivalent noise level exceeds 85 dBA, which is considered a 50% dose of the OSHA criteria, then hearing conservation and control programs must be implemented in the workplace. Noise levels above the standard can usually be mitigated through the use of hearing protection and/or worker shielding (in reinforced or insulated buildings). Launch noise impacts will require hearing protection measures within close proximity to the launch area.

Community Noise Exposure

Community noise exposure evaluates the risk to public health and welfare. The community noise exposure is evaluated by calculating a facility's yearly-averaged, daily noise levels (year-averaged Ldn). The yearly average results in an average daily dosage that accounts for periods when very little noise occurs and also periods when high noise exposures are present.

Land Use	Yearly Day-Night Average Sound Level in Decibels									
	50	55	60	65	70	75	80	85	90	
Residential — single family, extensive outdoor use	C	MC	MC	I	I	I	I	I	I	
Residential — multiple family, moderate outdoor use	C	C	MC	I	I	I	I	I	I	
Residential — multi-story, limited outdoor use	C	C	MC	W1	W1	I	I	I	I	
Transient lodging	C	C	C	MC	W1	I	I	I	I	
School classrooms, libraries, religious facilities	C	C	MC	W1	W1	I	I	I	I	
Hospitals, clinics, nursing homes, health-related services	C	C	MC	W1	W1	I	I	I	I	
Auditoriums, concert halls	C	C	MC	I	I	I	I	I	I	
Music shells	MC	MC	MC	I	I	I	I	I	I	
Sport arenas, outdoor spectator sports	C	C	MC	MC	I	I	I	I	I	
Neighborhood parks	C	MC	MC	MC	I	I	I	I	I	
Playgrounds, golf courses, riding stables, water recreation, cemeteries	C	C	MC	MC	MC	I	I	I	I	
Office buildings, personal services, business and professional	C	C	C	MC	MC	I	I	I	I	
Commercial — retail, movie theaters, restaurants	C	C	C	MC	MC	I	I	I	I	
Commercial — wholesale, some retail, industrial manufacturing, utilities	C	C	C	C	MC	MC	I	I	I	
Livestock farming, animal breeding	C	C	C	MC	MC	I	I	I	I	
Agriculture (except livestock)	C	C	C	C	C	MC	MC	I	I	

¹ - From the American National Standards Institute ANSI S3.23-1980 (Sound Level Descriptors For Determination Of Compatible Land Use) However, these guidelines are for information only and are not part of the standard.

C - Compatible
 W1 - With Insulation
 MC - Marginally Compatible
 I - Incompatible

EXHIBIT B.3: Community Noise Exposure Guidelines¹

Dry-Night Average Sound in Decibels	Hearing Loss	Speech Interference			Annoyance ¹	Average Community Reaction ²	General Community Attitude Towards Area
		Indoor		Outdoor			
		Percentage Sentence Intelligibility	Distance in Meters for 95% Sentence Intelligibility	Percentage of Population Highly Annoyed ³			
75 & above	may begin to occur	98%	0.5	37%	very severe	Noise is likely to be the most important of all adverse aspects of the community environment.	
70	will not likely occur	99%	0.9	23%	severe	Noise is one of the most important adverse aspects of the community environment.	
65	will not occur	100%	1.5	15%	significant	Noise is one of the important adverse aspects of the community environment.	
60	will not occur	100%	2.0	9%	moderate	Noise may be considered an adverse aspect of the community environment.	
55 & below	will not occur	100%	3.5	4%	slight	Noise considered no more important than various other environment factors.	

¹ "Speech Interference" data are drawn from the following tables in the United States Environmental Protection Agency's (USEPA) "Levels Document"; Table 3, Figure D-1, Figure D-2, Figure D-3. All other data from the National Academy of Science 1977 report "Guidelines for Preparing Environmental Impact Statements on Noise, Report of Working Group 69 on Evaluation of Environmental Impact of Noise."

² Depends on attitudes and other factors.
³ The percentages of people reporting annoyance to lesser extent are higher in each case. An unknown small percentage of people will report being "highly annoyed" even in the quietest surroundings. One reason is the difficulty all people have in integrating annoyance over a very long time.

⁴ Attitudes or other non-acoustic factors can modify this. Noise at low levels can still be an important problem, particularly when it intrudes into a quiet environment.

NOTE: Research implicates noise as a factor producing stress-related health effects such as heart disease, high-blood pressure and stroke, ulcers and other digestive disorders. The relationships between noise and these effects, however, have not as yet been quantified.

EXHIBIT B.4: Effects of Noise on People (Residential Land Uses Only)

Wildlife Exposure

Wildlife impacts are often very difficult to identify. Noise affects wildlife and other animals in many ways. These effects can be categorized as primary, secondary, or tertiary. Primary effects are direct physical auditory changes, such as eardrum rupture, temporary and permanent hearing threshold shifts, and the masking of auditory signals (including noises made by potential mates, predators, and prey). Secondary effects of noise on wildlife potentially include such non-auditory effects as stress, behavior changes, interference with mating, and detrimental changes in the ability to obtain sufficient food, water, and cover. Tertiary effects of noise are the direct result of both primary and secondary effects, and include population decline, loss of important habitat, and in extreme cases, potential species extinction.

Research has shown that the effects of noise on animals are highly species dependent and that the degree of the effect may vary widely, even within a particular species. Each species has evolved both physically and behaviorally to fill a role within a stable ecosystem. An animal's ability to distinguish auditory signals is often significant in its ability to survive. Animals rely on hearing to avoid predators, obtain food, and communicate with members of their own species and other animals. Animal response to a given noise event or series of events can also vary widely, due to a variety of factors including age, sex, physical condition, time of day and year, situation, previous exposure to the event, noise level, and frequency spectrum.

Impacts can occur if local or seasonal wildlife habitat are threatened by elevated noise levels. Significant impacts could include, loss of habitat, mating interference, and physiological stress. Impacts that contribute to the demise of a protected species are considered very significant.

References

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- Society of Automotive Engineers. 1975. Standard Values of Atmospheric Absorption as a Function of Temperature and Humidity. SAE ARP 866A.

USAF & US Dept. of the Interior. 1988. Effects of Aircraft Noise and Sonic Booms on Domestic Wildlife: A literature Synthesis.

U.S. Army Regulation AR-200