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DOE/EA-1195

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ENVIRONMENTAL ASSESSMENT OF THE SANDIA NATIONAL LABORATORIES DESIGN, EVALUATION, and TEST TECHNOLOGY CENTER at TECHNICAL AREA III KIRTLAND AIR FORCE BASE ALBUQUERQUE, NEW MEXICO

FINAL

U.S. Department of Energy
Albuquerque Operations Office

Finding of No Significant Impact: Sandia National Laboratories Design, Evaluation, and Test Technology Center at Technical Area III, Kirtland Air Force Base, New Mexico (DOE/EA-1195)

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LIST OF ACRONYMS AND ABBREVIATIONS

Term	Definition
°C	degree Celsius
°F	degree Fahrenheit
%	percent
ACGIH	American Conference of Governmental Industrial Hygienists
AIA	Albuquerque International Airport
Bldg.	building
CFR	Code of Federal Regulations
dB	decibel
dBA	decibels on the A-weighted scale
DETT Center	Design, Evaluation, and Test Technology Center
DOE	Department of Energy
EPA	Environmental Protection Agency
G	acceleration of gravity
GHA	ground hazard area
HVAR	High Velocity Aircraft Rocket
KAFB	Kirtland Air Force Base
LIHE	Light-Initiated High Explosive Facility
Linac	Linear accelerator
mm	millimeter
mrem	one-thousandth roentgen equivalent man (millirem)
MV&SCTC	Model Validation and System Certification Test Center
NMED	New Mexico Environment Department
OSHA	Occupational Safety and Health Administration
PEIS	Programmatic Environmental Impact Statement
PHA	Preliminary Hazards Assessment
RCRA	Resource Conservation and Recovery Act
RMMA	Radioactive Materials Management Area
SASN	silver acetylide-silver nitrate
SBSS	Science-Based Stockpile Stewardship
SNL/NM	Sandia National Laboratories
SS&M	Stockpile Stewardship and Management
SWMU	Solid Waste Management Units
TA	Technical Area (Technical Areas I-V)
TTF	Thermal Treatment Facility

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EXECUTIVE SUMMARY

Introduction

The U.S. Department of Energy (DOE) is responsible for ensuring that the United States nuclear weapons remain safe, secure, and reliable. Ongoing and proposed activities are directly related to a Presidential directive mandating that the DOE develop the means to meet these responsibilities in the absence of nuclear testing.

The purpose of the DOE action is to support a primary DOE mission of ensuring that the nation's nuclear weapons systems meet the highest standards of performance, safety, and reliability. There is a need to retain and enhance the technical research, testing, and evaluation capabilities while minimizing operating costs at Sandia National Laboratories/New Mexico (SNL/NM).

Sandia National Laboratories are located in Bernalillo County, New Mexico, southeast of the City of Albuquerque, and inside Kirtland Air Force Base (KAFB). The Sandia organization associated with this Environmental Assessment is the Design, Evaluation, and Test Technology Center (DETT Center) at Technical Area (TA) III. At the nearest point, the DETT Center facilities are approximately 6.5 miles (10.5 kilometers) east of downtown Albuquerque and encompass an area of approximately 2,554 acres (1,034 hectares).

The DETT Center is a complex of experimental facilities where sophisticated, full-scale, functional tests of weapons systems, subsystems, and their components are conducted. Test data from these tests also support the Science-Based Stockpile Stewardship activities. DOE's stewardship program is a management strategy to ensure the safety and reliability of the enduring United States' nuclear weapons stockpile in the absence of nuclear testing and reduced budgets for systems level testing. The program utilizes computer-based methods coupled with scientific understanding (of weapon phenomenology) as a substitute for underground nuclear testing, to compensate for limitations imposed by reduced opportunities and lower budgets for full-scale testing programs. DETT Center facilities also perform tests required by the Nuclear Regulatory Commission to certify nuclear material shipping containers in accordance with Title 10 Code of Federal Regulations (CFR) Part 71, *Packaging and Transportation of Radioactive Material*.

Currently, ongoing programs at DETT Center at TA III include:

- Conducting tests and activities in support of the development of predictive technology for stockpile surveillance.
- Conducting tests and activities in support of the development of predictive technology of weapon behavior.
- Conducting system level tests for certification of weapons systems and subsystem designs.
- Conducting tests in support of Sandia's customer requirements such as certification of shipping containers for nuclear materials.
- Conducting periodic facility, equipment, and other test support maintenance at eleven DETT Center facilities.

NO ACTION ALTERNATIVE

The No Action Alternative would be to continue operating the DETT Center facilities at current levels of activity. This would include:

- Continuing to perform tests and experiments needed to study weapons systems, subsystems, and components in support of the Science-Based Stockpile Stewardship program.
- Continuing to perform facility maintenance on an as-needed basis in order to ensure that each facility is in a state of readiness to support customers and the range of tests for the Science-Based Stockpile Stewardship program.
- Continuing to make changes and upgrades to equipment and facilities in order to maintain a high state-of-readiness to support sophisticated testing programs.

PROPOSED ACTION

The Proposed Action consists of:

- Continuation of existing operations conducted at the DETT Center at TA III.
- Consolidation of shock tube explosive testing at the 10,000-Foot Sled Track.
- Conduct Shock Tube tests at the 10,000-Foot Sled Track with quantities of explosives up to 1,000 pounds (454 kilograms).
- Make modifications to the test support facilities at the impact zone of the 10,000-Foot Sled Track to support consolidation of Shock Tube testing programs.
- Construction and operation of the Model Validation and System Certification Test Center.

ALTERNATIVES CONSIDERED BUT ELIMINATED FROM DETAILED ANALYSIS

Two alternative considered but eliminated from detailed analysis are:

- Discontinuation of testing and operations.
- Relocation of all testing.

These alternatives were eliminated from analysis because they do not meet the DOE's need for action.

ENVIRONMENTAL CONSEQUENCES OF THE PROPOSED ACTION and NO ACTION ALTERNATIVES

Topics identified in the section on the Affected Environment were dismissed from further consideration because they did not have the potential to actually be affected by the Proposed Action. Accordingly, health and safety, air quality, and noise consequences were selected for more in-depth analyses. Bounding tests have been selected to evaluate the upper limit of the effects on environment from DETT Center testing activities. The bounding tests and their environmental consequences are discussed in Section 4.0.

Health and Safety Effects

Potential health and safety hazards based on the proposed test activities and operations include

- Exposure to air emissions
- Exposure to depleted uranium
- Exposure to fragments and noise

Computed exposure levels are used as a basis for comparison with occupational exposure standards. In all cases, personnel are protected by established procedures and occupational exposure standards are not exceeded.

Air Quality Effects

Air quality consequences include:

- Engine and fugitive dust emissions by vehicles.
- Gases and particles emitted by booster rocket motors.
- Gases and particles emitted by explosives testing.
- Vapors from solvents and chemical preparations.
- Potential airborne uranium.
- Pyrolytic decomposition products from the Radiant Heat Complex.

A comparison of the projected annual contaminant emission rates with New Mexico Environment Department and Albuquerque Environmental Health Department Air Pollution Control Division standards indicates that projected rates would comply with the air quality standards.

Noise and Vibration Effects

Noise and vibration are created as a result of testing activities with rocket motors, explosives, and large caliber guns. Noise of testing likely would be overshadowed by the background noise outside KAFB from aircraft, traffic, and other sources so that the public likely would not be aware of any noise effects. The workforce is protected by Standard Operating Procedures that include routine use of hearing protection equipment and other protective measures. Damaging vibrations from explosives testing would not extend beyond the DETT Center area in TA-III.

Cumulative Effects

Cumulative effects of air quality and noise for present and reasonably foreseeable actions of a similar nature were evaluated for the geographical area. With regard to air quality and noise, the effects of the Proposed Action, when combined with those effects of similar actions, do not result in cumulatively significant impacts. Evaluations determined that air emission rates do not degrade local air quality, and all air quality parameters are within regulatory compliance limits. Evaluations of noise effects demonstrate that health and safety measures employed at test facilities protect employees from adverse effects of high sound levels and that sound emissions rapidly dissipate within the confines of KAFB. Sounds reaching urban areas outside KAFB would be negligible due to the overshadowing effect of background noise produced by aircraft approaching and departing the Albuquerque International Airport and vehicular traffic.

Environmental Justice

There would not be an environmental justice issue because of the low level of impacts to human populations.

ABNORMAL EVENTS

Evaluation of three abnormal events, selected to measure the range of effects and consequences associated with DETT Center Operations, demonstrates that routine operating procedures are capable of protecting personnel, property, and the environment from accidents related to testing activities. In addition, the events would have a negligible effect outside of the KAFB boundary.

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1.0 PURPOSE AND NEED

1.1 BACKGROUND

The U.S. Department of Energy (DOE) is responsible for ensuring that U.S. nuclear weapons remain safe, secure, and reliable. Presidential directive has mandated that DOE develop the means sufficient to meet these responsibilities. Ongoing and proposed activities at the Design, Evaluation, and Test Technology Center (DETT Center) at Technical Area (TA) III, Sandia National Laboratories (SNL/NM) Albuquerque, New Mexico are directly related to this mandate.

The DETT Center is a complex of experimental facilities where sophisticated, full-scale functional tests of weapons systems, subsystems, and their components are conducted. Test data also support the Science-Based Stockpile Stewardship (SBSS) activities of the DOE. DOE's SBSS is a management strategy to ensure the safety and reliability of the enduring United States' nuclear stockpile in the absence of nuclear testing and reduced budgets for systems level testing. SBSS utilizes computer-based methods coupled with scientific understanding (of weapon phenomenology) as a substitute for underground nuclear testing and to counter the limitations imposed by reduced opportunities and lower budgets for full-scale testing programs. DETT Center facilities also perform tests required by the Nuclear Regulatory Commission to certify nuclear material shipping containers in accordance with Title 10 Code of Federal Regulations (CFR) Part 71, *Packaging and Transportation of Radioactive Material*.

Currently, ongoing programs at DETT Center at TA III include:

- Conducting tests and activities in support of the development of predictive technology for stockpile surveillance.
- Conducting tests and activities in support of the development of predictive technology of weapon behavior.
- Conducting system level tests for certification of weapons systems and subsystems designs.
- Conducting tests in support of SNL/NM customers such as certification of shipping containers.
- Conducting periodic facility, equipment, and other test support maintenance at eleven DETT Center facilities.

1.2 PURPOSE AND NEED

The purpose of the DOE action is to support a primary DOE mission of ensuring that the nation's nuclear weapons systems meet the highest standards of performance, safety, and reliability. There is a need to retain and enhance the technical research, testing, and evaluation capabilities while minimizing operating costs. SNL/NM is responsible for the management of critical experimental and full-scale system test capabilities to maintain an effective nuclear deterrent.

Goals to be attained:

- Retain full-scale test capabilities of weapon systems, subsystems, and components in response to testing needs as they are identified.
- Provide data and methods to support refinement of advanced computer modeling technology.

- Advance predictive technology of weapons systems behavior and refine the use of computer modeling techniques.
- Increase knowledge of weapon behavior in order to create confidence in new predictive capabilities.
- Improve data collection and analysis capabilities to support the computer modeling efforts for predictive technology purposes.
- Retain full-scale test capabilities for certification of nuclear material shipping containers in accordance with Federal performance standards and test capabilities for design certification of weapons systems and subsystems components.

2.0 DESCRIPTION OF ALTERNATIVE ACTIONS

2.1 SUMMARY

Environmental testing at SNL/NM consists of test activities designed to replicate stresses from extreme conditions such as high and low temperatures, water impact, explosion, high speed, collision impacts, and violent vibrations under controlled conditions. These tests are used in support of the SBSS goals to develop computer-based models to predict the functioning of weapons systems and system components. They also are used to support other Federal agencies and private industry testing requirements where extreme environmental conditions are needed for research and development partnerships in technology, manufacturing, and energy development.

Three specific bounding test scenarios were selected to examine the consequences of DETT Center operations on health and safety, air quality, and the noise environment. A bounding test is an example of a test scenario that produces the upper limit of effects for environmental impact analysis purposes. The bounding tests to be analyzed were selected from past testing activities of the DETT Center at TA-III and are representative of the testing activities that are conducted at the facilities described in Section 2.2.

Section 2.2 describes the current, on-going range of activities and their associated facilities which have evolved over the last 40 years. These current activities constitute the No Action Alternative. Section 2.3 describes the Proposed Action that fully responds to the purpose and needs of Section 1.0. Section 2.5 defines other conceptual alternatives considered but dismissed. The following is a summary of the alternatives.

No Action	• Continuation of the current operations described in Section 2.2.
Proposed Action	• Continuation of all the activities described in Section 2.2. • Some increased testing (Table 1) at the 10,000-Foot Sled Track. • Some construction activities to relocate and consolidate certain shock tube explosive test programs at the sled track together with some additional testing (Section 2.3.1). • Construction and operation of the Model Validation and System Certification Test Center (MV&SCTC) (Section 2.3.2).
Alternatives Considered and Dismissed	• Discontinue testing • Relocate testing

Environmental safety and health protective measures are a routine part of all operations. These measures are discussed in Section 2.2.13 and are incorporated into the consequences analysis in Section 4.0.

Table 1. Activity Description of DETT Center Facilities Including Proposed Action

Facility	Outdoor Test Activity	Frequency of Outdoor Tests	Other Activities	Rad. or Haz. Mat'l. Used
1) Sled Track Complex	Rocket Motor Firings	100 large motors/year 300 small motors/year	Explosives, energetic materials testing, and handling, sonic booms, debris removal. Construction to support all test activities	Yes
	Explosive Tests	4 @ 250 lb 32 @ 50 lb 43 @ 25 lb 160 @ 1-15 lb		Yes
	Collision Impacts	100/yr, max 6,500 fps		Yes
** Addition of Shock Tubes at the south end of 10,000-Foot Sled Track	Explosive Tests	12 @ 1,000 lb **		Yes
** Modification of various DETT Center test beds	—	—		No
2) Centrifuge Complex	Explosive Tests	3/yr 1.5 lb max	Assembly, maintenance and debris removal for all activities	Yes
	Collision Impacts	50/yr 16 k G-lb max 50/yr 160 k G-lb max		No
3) Terminal Ballistics Complex Indoor Firing Range	Small Arms Fire	None	Assembly and maintenance, and debris removal for all activities	No
Outdoor Firing Range	Rocket Motor Firings	1 Nike/year		Yes
	Explosive Tests	40 lb max		Yes
	Large Arms Fire	155-mm 60/yr		Yes
	Small Arms Fire	800 rnds/day, up to 50 caliber		Yes
4) Drop/Impact Complex Drop Tower	Collision Impacts	100 yr, max 9,000 lb	Assembly, maintenance, handling energetic materials, and debris removal for all activities	Yes
Water Impact	Collision Impacts	2-3/year		No
Sled Track	Rocket Motor Firing	42 small motors/yr		Yes
5) Radiant Heat Complex	Combustion Studies	None	Assembly, maintenance, and debris removal for all activities	No

Table 1. (Continued)

Facility	Outdoor Test Activity	Frequency of Outdoor Tests	Other Activities	Rad. or Haz. Mat'l. Used
6) Light-Initiated High Explosive	None	None	Explosives, energetic materials testing, RCRA-permitted waste treatment facility	Yes
7) Labs, Shops, and Offices				
a) Model Validation and System Certification Test Center**	None	None	Test control and data collection center, cal/machine shop, light assembly and maintenance	No
b) Mechanical Shock Complex Bldg. 6570	None	None	Mechanical shock tests of weapons components	Yes
c) Vibration/Acoustic Complex Bldgs. 6560, 6610, 6650	None	None	Mechanical & acoustic vibration testing of components and systems	Yes
d) Pressure Lab, Bldg. 6730	None	None	Simulate static, dynamic & cyclic environments	Yes
e) Radiography Lab, Bldg. 6635	None	None	X-ray	Yes
f) Photometrics Lab, Bldg. 6540	None	None	Photography support and film processing	Yes

** Denotes facility or event included in the Proposed Action only. All other facilities are included in both the Proposed Action and the No Action Alternative.

@ - at
fps - feet per second
G-lb - G-pounds
Haz. - hazardous
k - thousand
lb - pounds
Mat'l. - materials
max - maximum
mg - milligrams
mps - meters per second
NA - not applicable
Org. - organization
Rad. - radioactive
rnds - rounds
TBD - to be determined
yr - year

2.2 NO ACTION ALTERNATIVE/CURRENT OPERATIONS

The No Action Alternative would be to continue operating the DETT Center facilities as described in this section. Operations specifically include the following elements:

- Continuing to perform tests and experiments needed to study weapons systems, subsystems, and components in support of the SBSS at the frequency of testing shown in Table 1.
- Continuing to perform facility maintenance and repairs on an as-needed basis in order to ensure that each facility is in a state of readiness to support the required range of tests for the SBSS and customers of DETT Center safely. This includes basic maintenance such as grading test pads and roads, removing vegetation, and erecting test fixtures.
- Continuing to make changes and upgrades to equipment and facilities in order to maintain a high state-of-readiness to support sophisticated testing programs. This includes one-for-one replacement of test equipment, replacement of damaged equipment, and upgrading obsolete equipment as required.

The following discussion describes the existing eleven DETT Center facilities and their corresponding activities. Test frequency data are provided in tabular form in Table 1 in which the levels of No Action and Proposed activities are presented for comparison. Figure 1 shows the locations of the DETT Center facilities at TA-III.

2.2.1 SLED TRACK COMPLEX

The facilities in the Sled Track Complex are shown in Figure 1 as locations 6, 14, 15, 16, and 17, and include two sled tracks, a 10,000-foot long track and a 2,000-foot long track. Operations conducted at the 10,000-foot and 2,000-foot tracks are essentially the same, with most operations being conducted at the 10,000-foot track. The foundation for the 10,000-Foot Sled Track includes a trough between the rails for holding water. The water is used as braking system to stop sleds that are intended to be reused. Test packages are carried on sleds designed to slide on metal runners. The sleds are propelled by various types of rocket motors to velocities ranging from about 100 feet per second (30 meters per second) up to 6,500 feet per second (1.981 meters per second) (SNL 1994a).

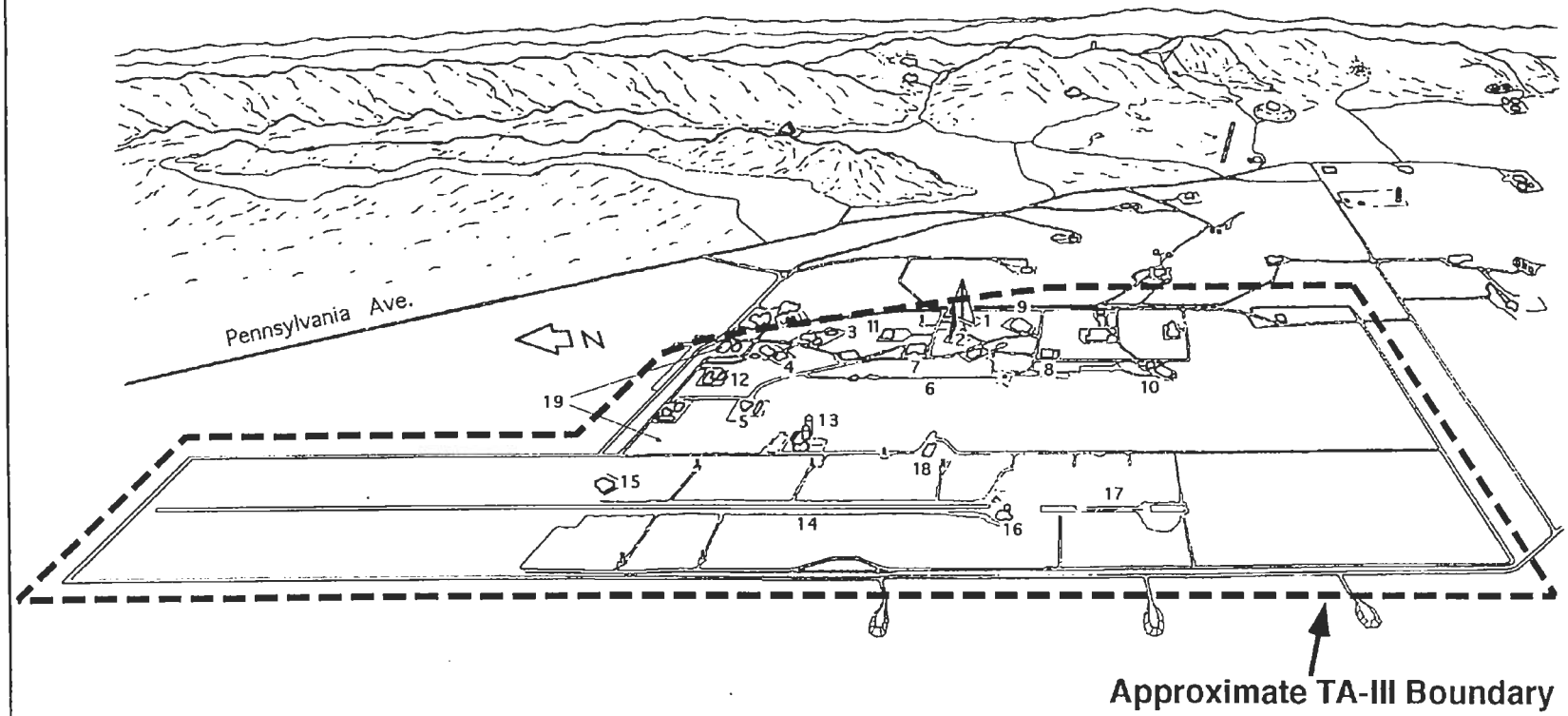
Figure 2 is a photograph of a typical rocket sled propelled by a cluster of rocket motors.

The function of the Sled Track Complex is to conduct the following types of tests:

- Collision-impact tests by accelerating the test package to impact a fixed target
- Reverse-impact tests in which the target is accelerated into a test package
- Parachute deployment tests
- Dynamic weapons firing tests
- Full function weapons deployment tests
- Sensor and telemetry system verification
- Tests involving explosives

During a typical year, about 50 test programs are conducted at the 10,000-Foot Sled Track. The 2,000-Foot Sled Track is used one or two times every year. The typical annual breakdown of testing activities under these programs are as follows:

- 100 large and 300 small rocket motors are fired



Key to facilities

1 Drop/Impact Complex (300' Drop Tower)
2 Drop/Impact Complex (185' Drop Tower)
3 Centrifuge Complex
4 Radiant Heat Complex
5 Photometrics Laboratory
6 2,000' Sled Track
7 Vibration/Acoustic Complex
8 Vibration/Acoustic Complex
9 Vibration/Acoustic Complex
10 Radiography Facility
11 Mechanical Shock Complex
12 Light-Initiated High Explosives Facility
13 Force and Pressure Laboratory
14 10,000' Sled Track
15 10,000' Sled Track Control
16 10,000' Sled Track Instrumentation Bunker
17 10,000' Sled Track Impact Area
18 Terminal Ballistics Facility
19 Proposed Locations of the Model Validation and System Certification Test Center

Figure 1. Facilities of DETT Center at Technical Area III

- 4 explosive material tests involve explosions with yields of 250 pounds, 32 tests involve explosions with yields of 50 pounds, 43 tests involve explosions with yields of 25 pounds, and 160 tests involve explosions with yields from 1 to 15 pounds
- 100 tests involve collisions with impact velocities up to maximum of 6,500 feet per second (1,981 meters per second)

The continuation of sled track operations also includes routine modification and testing of sled designs.

Sleds with attached test packages or targets are propelled from north to south starting at a launch point calculated to provide the terminal velocity required for the specific test. At a precalculated point near the south end of the track, test packages collide against fixed targets, accelerated targets collide with fixed test packages, or test packages are ejected into a free-flight trajectory impacting with targets at predetermined distances.

A rocket sled can be stopped by a barrier such as an earthen berm or steel barricade located at the end of the track or by a water braking system that allows the sled to be brought to a controlled, nondestructive stop. Following each test, any debris is collected and removed by SNL/NM personnel for evaluation and appropriate disposal.

2.2.2 TERMINAL BALLISTICS COMPLEX

The Terminal Ballistics Complex is shown in Figure 1 as location 18. The complex is used for ballistics research, projectile flights, terminal ballistics studies, armor performance, penetration tests of shipping containers and storage bunker wall designs, and fusing investigations using conventional and custom ammunition in test guns ranging in size from .17 caliber to 155-millimeter (mm). Typically 50 to 60 test programs are conducted each year of which most are small-caliber ordinance tests that are held indoors. Figure 3 shows the 155-mm "Long Tom" firing a projectile.

Building (Bldg.) 6750 is the primary building in the Terminal Ballistics Complex. It houses the main laboratory and the control room for the firing complex along with a small machine shop, office area, control center, small arms ammunition storage and assembly facilities, and an indoor firing range. The indoor firing range is used for controlled firing of small arms ammunition up to 20 mm in size. The complex also contains two smaller buildings used for propellant assembly and conditioning and four explosives storage igloos.

The Terminal Ballistics Complex also includes an outdoor firing range that extends in a southerly direction for approximately 984 feet (300 meters). This range is used for small as well as a large-caliber weapons tests. The outdoor range has a 155-mm "Long Tom" artillery gun permanently mounted in a revetment adjacent to Bldg. 6750. In addition, there is an outdoor solid rocket motor test stand to statically test motors up to 100,000 pounds of thrust. The typical annual breakdown of activities for test programs held outdoors is as follows:

- one solid rocket motor
- explosive material tests up to 40 pounds (18 kilograms)
- 60 rounds of 155-mm of artillery fire
- 800 rounds of small arms fire up to .50 caliber

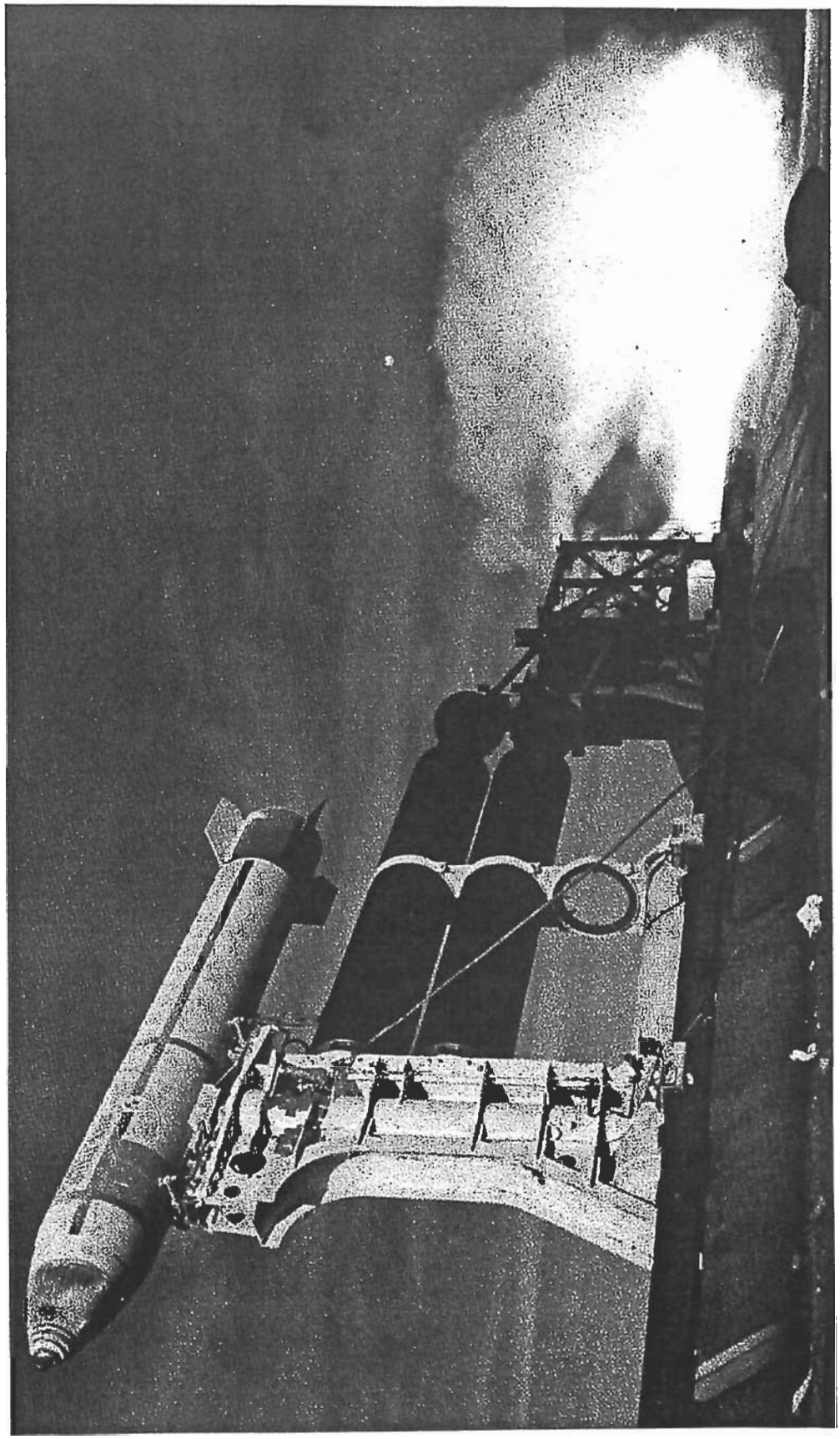


Figure 2. Typical Rocket Propelled Sled

2.2.3 *DROP/IMPACT COMPLEX*

The facilities in the Drop/Impact Complex are shown in Figure 1 as locations 1 and 2. The Drop/Impact Complex provides a controlled environment for high velocity impact testing on hard surfaces as well as water impact tests and underwater testing. The complex consists of two towers, a 300-foot tower (called the Water Impact) next to an artificial pool, 120 feet (37 meters) wide, 188 feet (57 meters) long, and 50 feet (15 meters) deep, and a 185-foot tower (called the Drop Tower) next to a hard prepared surface. A small water tank is used for small-scale impact testing to shoot scale models in the tank or the pool with a compressed gas gun. The complex also includes a short, approximately 600-foot-long (183 meter) rocket sled track.

Tests measure the effects of collision impacts to different objects such as warheads, torpedoes, and shipping containers. Tests are designed to simulate and evaluate special scenarios to aid in prototype development or performance assessment by predictive computer modeling. The Drop Tower is used approximately 100 times per year, and the Water Impact is used two or three times per year. Test objects may contain explosive squibs, which are initiators of explosives. They do not contain high explosives, but up to 1 pound (0.45 kilograms) of high explosive can be used for underwater detonation.

The Water Impact facilities are used to drop objects into the pool to study effects of water impacts. Objects can weigh up to 3,000 pounds (1,363 kilograms). They can either be dropped free-fall or can be accelerated by a rocket-assisted pull-down to strike the water from angles of 30 to 90 degrees. The Drop Tower is used to drop objects weighing up to 9,000 pounds (4,090 kilograms) onto prepared surfaces such as dirt, reinforced concrete, steel-plate, or a customer- specified target. The Drop Tower also is equipped with two cables stretched vertically between an anchor on the ground and the top of the tower. A drop carriage slides up and down the cables. Objects weighing up to 2,000 pounds (909 kilograms) are attached to the carriage in any orientation, which can be maintained to impact.

The typical annual breakdown of testing activities is as follows:

- 100 collision impacts of objects weighing up to 9,000 pounds (4,090 kilograms) at the Drop Tower
- 2-3 collision impacts at the Water Impact facility
- 42 small motors are fired per year

2.2.4 *CENTRIFUGE COMPLEX*

The Centrifuge Complex is shown in Figure 1 as location 3. The Centrifuge Complex was developed to simulate the forces of acceleration that are produced by missiles and aircraft. Approximately 100 tests are typically conducted annually and about 5 percent (2 to 3 test packages) entail the use of rocket motors or explosives up to 1.5 pounds (0.7 kilograms). Typical test packages include satellite systems, reentry vehicles, rocket components, sensing devices of weapons, and weapons systems components.

The complex has two centrifuge units. The 29-foot Indoor Centrifuge is located inside Bldg. 6526 as shown in Figure 4 and has the largest weight capacity of any centrifuge in the United States. It can subject test packages weighing up to 16,000 pounds (7,260 kilograms) to an acceleration force of 100 times the acceleration of gravity (100 Gs) or lighter weight packages up to 300 Gs. The

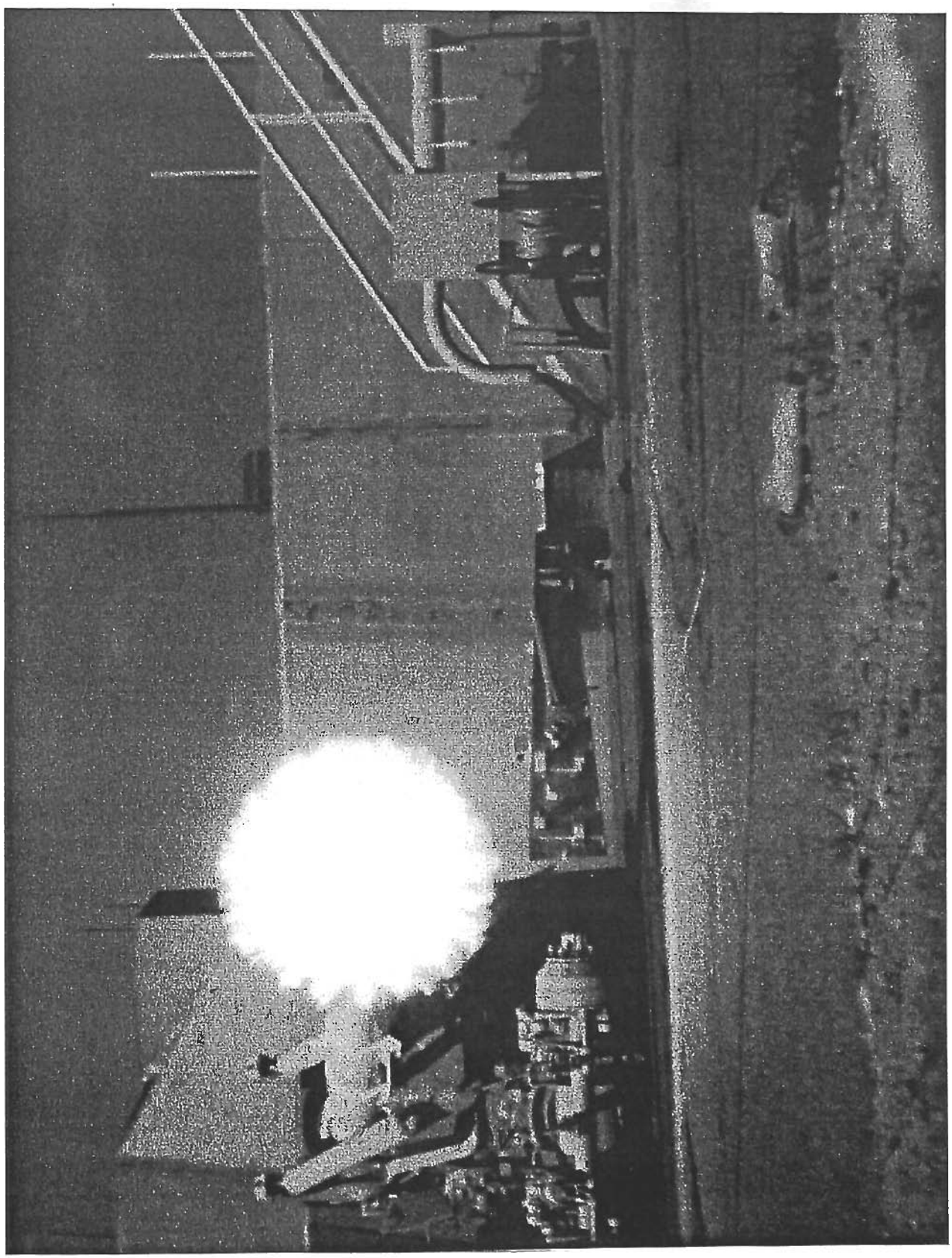


Figure 3. Long Tom Gun

35-foot Outdoor Centrifuge is located adjacent to Bldg. 6526 and can handle objects weighing up to 10,000 pounds (4,540 kilograms) and accelerations up to 240 Gs. This centrifuge is used for large-sized objects or objects with hazardous payloads such as those that are intentionally released to study the effects of the collision impact against a hard surface.

2.2.5 MECHANICAL SHOCK COMPLEX

The Mechanical Shock Complex is shown in Figure 1 as location 11. The Mechanical Shock Complex, located in Bldg. 6570, conducts mechanical shock tests on small electronic parts to full-sized weapons components using actuators and other shock testing machines. A mechanical shock test is a technique in which a test component is subjected to a controlled acceleration pulse. The actuators are test machines that use pneumatically driven pistons to accelerate a test object. The purpose of these tests is to determine if weapons components are capable of withstanding repeated normal and abnormal shock environments. Normal activities include engineering design and analysis, instrumentation calibration, data analysis, and laboratory testing procedures using the equipment described above.

Most of the components tested in these facilities are inert and contain no hazardous materials. Occasionally, however, some of the systems may contain small quantities of explosives. Between 1987 and 1996, about 2 percent of the test packages contained explosives. Explosive components normally are self-contained and present no hazard to personnel. Hazardous materials are never released during normal test procedures.

2.2.6 FORCE AND PRESSURE LABORATORY

The Force and Pressure Laboratory is shown in Figure 1 as location 13. The Laboratory is located in Bldg. 6730 at TA-III. The major purpose of this facility is to study the structural integrity of systems, assemblies, and electrical components. Approximately 150 to 200 tests are typically conducted annually. The facility can simulate static, dynamic, and cyclic environments as well as material behavior on a wide variety of test units and fixtures. Items tested vary from small electronic parts and assemblies to large structural frame members. Machines are used that measure the tensile and compression strength of items up to 500,000 pounds and generate pressures up to 40,000 pounds per square inch. The machines can test items in a temperature range of -2000 F to 6000 F.

Normal activities include engineering design and analysis, load cell calibrations, joint and weld strength tests, pressure vessel and component proof testing, time-dependent tests such as creep and fatigue, force-type proof and failure testing and data analysis. Most of the components tested in these facilities are inert and contain no hazardous materials. However, some of the systems may contain small quantities of explosives. Explosive components are self-contained and present no hazard to personnel.

2.2.7 PHOTOMETRICS LABORATORY

The Photometrics Laboratory is shown in Figure 1 as location 5. The Laboratory, located in Bldgs. 6710 and 6711, provide still, motion, and specialized photography for diverse applications in field and laboratory testing. Typical photometrics assignments include high-speed photography, ultra-high-speed photography, image-motion photography, infrared-imaging radiometry, Schlieren

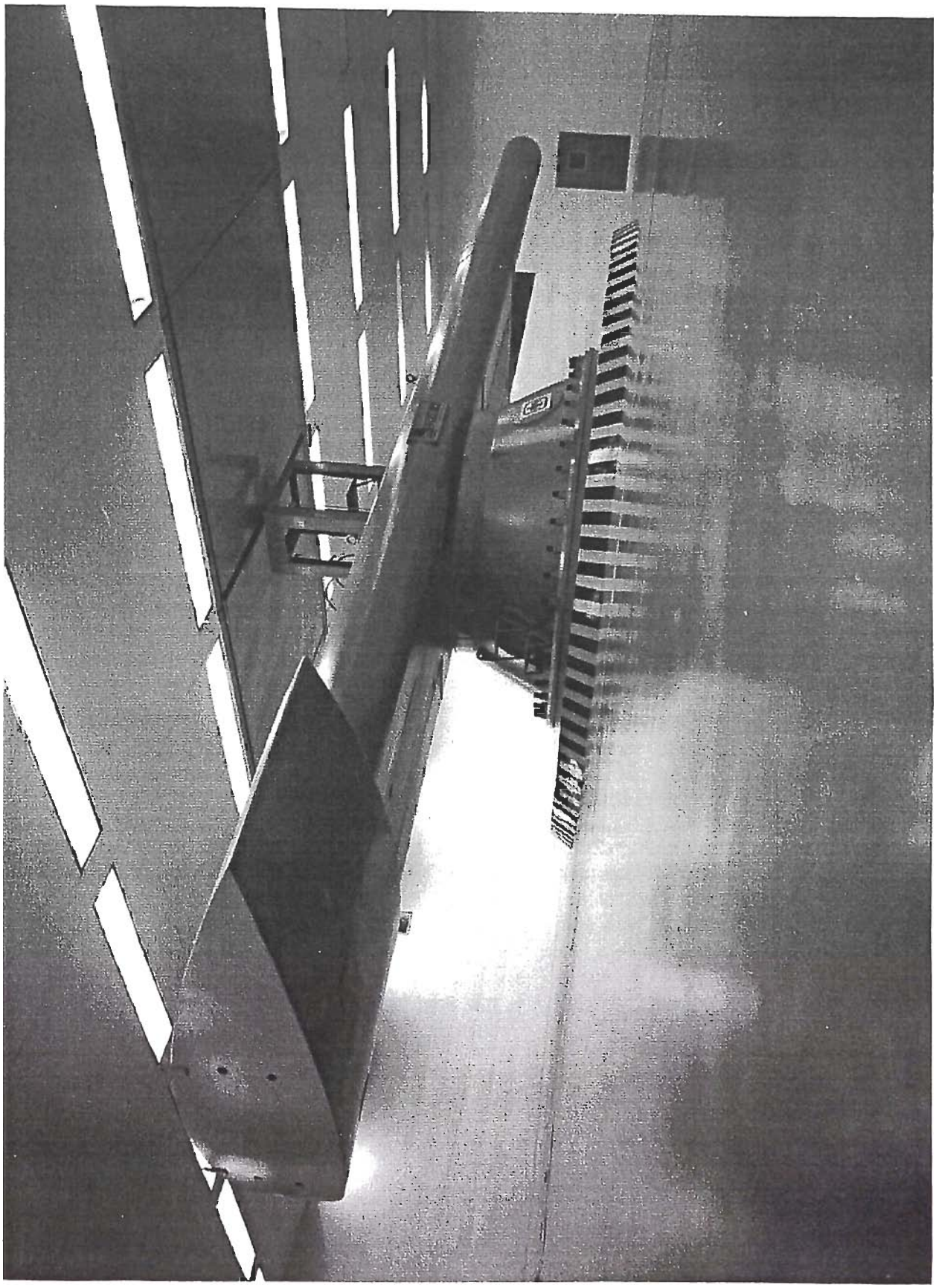


Figure 4. The 29-Foot Indoor Centrifuge

photography, and still and time-lapse photography. These capabilities are provided as services to other organizations throughout SNL,as well as throughout the U.S. at customer locations,to meet SNL's broad mission in research and development testing. The laboratories are used for storing various types of optical equipment, for testing and calibrating optical equipment, for fabrication and general repair of all photometric equipment, for general preparation or staging operations, for processing exposed photographic film, and for preparing videotapes of the processed film.

2.2.8 VIBRATION/ACOUSTIC COMPLEX

The facilities in the Vibration/Acoustic Complex are shown in Figure 1 as locations 7, 8, and 9. The Vibration/Acoustic Complex in Bldgs. 6560, 6650, and 6610 conducts vibration, shock, and acoustic simulations for a variety of components and systems such as electronic packages to full-sized weapons components. Common tests are random vibration, sinusoidal vibration, and a combination of vibration tests at temperatures ranging from -650F to 2500F. These simulations are used to determine how items respond to controlled vibration and acoustic stimuli, to define failure levels, to prove system integrity, to determine modes of vibration, or to verify theoretical computer models. Vibration tests are produced on electrodynamic or hydraulic shakers. The acoustic environment is created by the rapid expansion of nitrogen through a controlled nozzle, producing sound pressure levels up to 160 dB. This acoustic level is contained within Bldg. 6650. Many different types of systems are tested in these facilities, but the primary function is the simulation of dynamic environments for weapons systems. Test apparatus also have the capability to create high-displacement, low-frequency vibration and shock tests for simulating transportation environments. The types of systems that are tested include,but are not limited to,transportation containers, satellite systems, reentry vehicles, electronic packages, wind turbine blades, telemetry systems, rocket motors, and scale-model seismic structures. Most of the systems that are tested are inert and contain no hazardous materials, but about 3.5 percent of the systems contain explosives. The facility can be operated remotely for protection of personnel from these hazards. Consistent with safe operating procedures personnel are isolated from the acoustics test cell to protect them from any noise and asphyxiation hazards.

2.2.9 RADIANT HEAT COMPLEX

The Radiant Heat Complex is shown in Figure 1 as location 4. This general purpose thermal test facility provides either controlled temperatures (up to 3,9920F or 2,2000C) or programmed heat fluxes (up to 200 watts per square centimeter). Approximately 30 tests are typically conducted annually consisting of shipping containers, weapons systems components, and electronic packages. The tests performed here can determine failure levels, demonstrate system integrity, or verify thermal models. Simulated fire tests provide simultaneous control of both temperature and heat flux. The Radiant Heat Complex consists of three major structures located inside a fenced enclosure. Bldg. 6536 is the complex headquarters with the primary test facility in Bldg. 6538, which contains a large array of heat lamps. This closed building is ventilated using four roof-mounted exhaust fans that vent smoke at a height of 35 feet (11 meters) above ground. The Radiant Heat Explosive Bunker is constructed as a three-sided concrete structure and located more than 500 feet (152 meters) from Bldg. 6536.

2.2.10 RADIOGRAPHY FACILITY

The Radiography Facility is shown in Figure 1 as location 10. This facility is used by personnel to examine materials, joints, assemblies, and systems and subsystems for imperfections using x-ray

radiography and other nondestructive test techniques. It also is used to evaluate shipping containers using real-time radiography equipment. The facility is designed to radiograph large items and items that contain over 500 grams of explosives. The radiography equipment is capable of producing x-ray energies up to 10 million electron volts, which is needed for steel items up to 20 inches thick. High voltage is used in the operation of the x-ray equipment. The facility is enclosed by two separate wire fences. Personnel follow safe operating procedures for radiological protection.

2.2.11 LIGHT-INITIATED HIGH EXPLOSIVE FACILITY

The Light-Initiated High Explosive Facility (LIHE) is shown in Figure 1 as location 12. The LIHE Facility located in Bldg. 6715, is used to prepare and apply a thin coating of silver acetylide-silver nitrate (SASN),which is a sensitive, high-explosive material, to the surfaces of weapons components, subassemblies, and full assemblies. SASN is detonated by an extremely intense flash of light in the test cell area. Explosive force on a test package is measured to evaluate the effect of an external explosion on a weapons system component, a missile, a reentry vehicle, or other space vehicle.

In the LIHE facility, SASN is formulated by remote control and then sprayed onto the test package using a robotic arm. SASN is insensitive when wet, but becomes sensitive to intense light, impacts, or sparks when dry. Test package surfaces are not fragmented by the initiation of the SASN explosive; therefore, the only result of the detonation is a moderate air blast of predictable intensity. These tests are conducted inside the LIHE facility, in a room specially built for this purpose. During a test, there is no fragment or blast hazard outside of the building. The Thermal Treatment Facility, a Resource Conservation and Recovery Act (RCRA)-permitted facility for treating LIHE explosives material, is located at the LIHE. The Thermal Treatment Facility is used at the end of each experiment to clear the facility of SASN explosive materials. Figure 5 is a photograph of an explosives test at the LIHE Facility for a typical reentry weapon.

2.2.12 ROUTINE MAINTENANCE AND IMPROVEMENTS

Routine maintenance is necessary to ensure that the facilities operate effectively and safely. This includes making improvements to maintain the modern, state-of-the-art test and evaluation capability as discussed in Section 1.0. Facilities go in and out of service depending on customer demand, cost savings, and the need for maintenance. The following are examples of items that routinely would be accomplished for these purposes:

- Repairing, refurbishing, renovating, and upgrading obsolete equipment, test areas, storage yards, and buildings.
- Constructing and repairing small, temporary fixtures used for supporting test items.
- Disposing of broken equipment and debris such as concrete, wood, and other solid waste materials from post-test operations .
- Removing vegetation near test areas and buildings for fire prevention purposes.
- Repairing and regrading roads, outdoor test areas, and fire breaks.
- Taking facilities on- and off-line for maintenance and cost savings.
- Installing, repairing, and upgrading instrumentation, communications, and utility systems.
- Regrading for water drainage purposes.
- Erecting and removing temporary test setups made of soil, concrete, wood, and other typical construction materials.

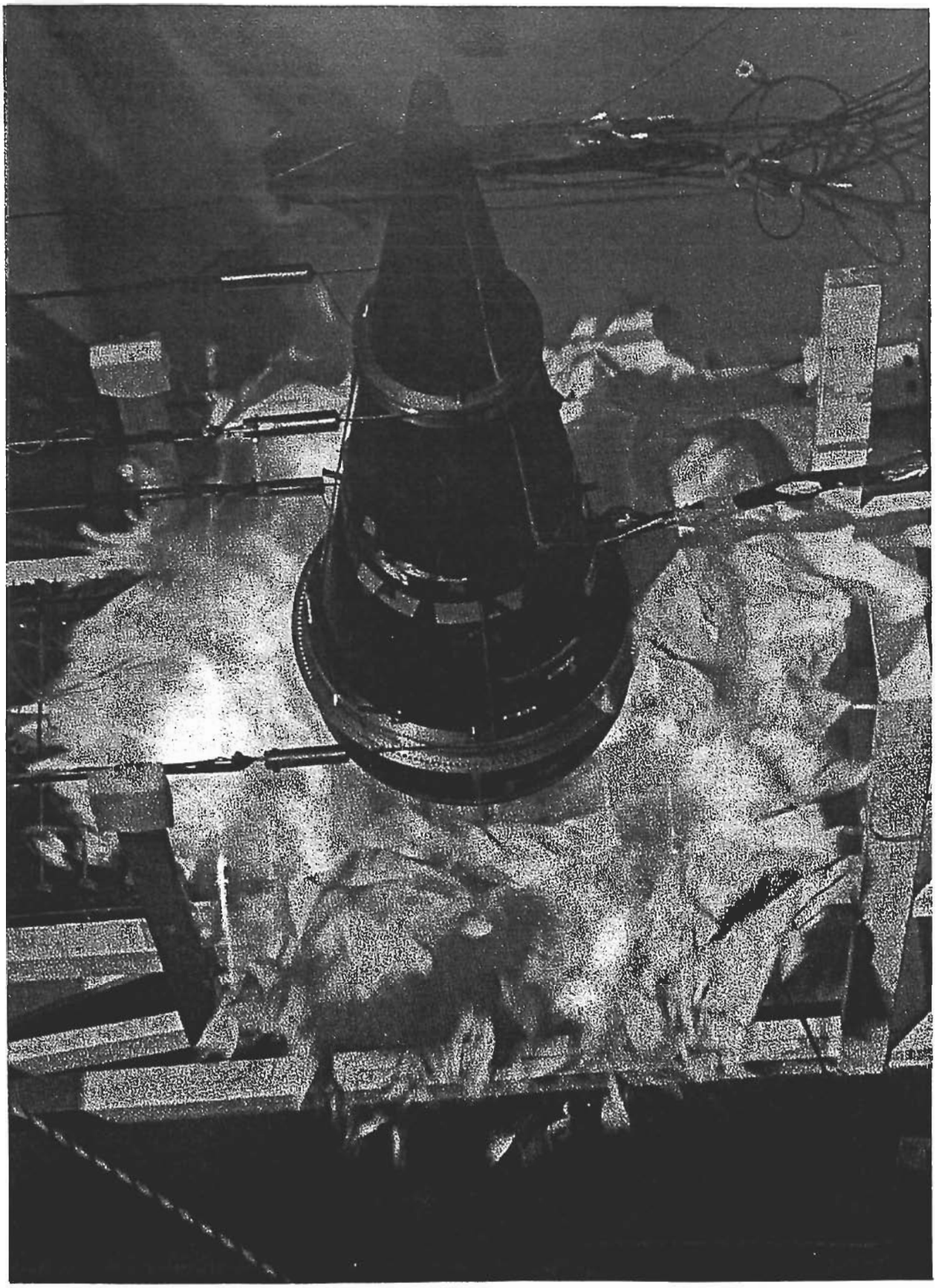


Figure 5. Photograph of Reentry Vehicle Explosives Test at LIHE Facility

2.2.13 PROTECTIVE MEASURES

SNL/NM maintains a comprehensive health and safety program to protect employees and to ensure compliance with established Federal and State regulations. Elements of the safety program at SNL/NM are directly relevant to the low incidence of accidents at DETT Center and to limiting effects of potentially hazardous tests.

SNL/NM Health and Safety Policies and Standards

Potentially hazardous conditions that could be encountered during testing are no different than hazards that have been encountered during testing conducted in the past. These include:

- Blast overpressures from explosives and rocket motors
- Fragments and projectiles
- Radiological and toxic materials
- Noise
- High voltage

Over the history of SNL/NM, tailored safety practices have evolved to deal specifically with hazards that are either commonplace or unique to each facility. As an example, noise is a common problem, but the noise produced by collision impacts of test packages propelled by rocket motors is unique to the Drop/Impact Complex and the Sled Track Complex. Safety practices are incorporated into the standard operating procedures of each facility. The 3-year-average accident/injury incidence rate for DETT Center is well below the 1993 national average of 2.4 cases per 200,000 man-hours (Jennings 1995). There have been no major injuries, permanent disabilities, or fatalities in over 25 years of DETT Center operation.

Protective Measures

Examples of protective measures include the following:

- Ground Hazard Areas - Ground Hazard Areas (GHAs) are delineated zones around test sites intended to restrict personnel from potentially hazardous operations. These areas reduce the potential exposure of personnel to noise, toxic air emissions, metal fragments, and other potentially hazardous conditions. In most cases, a GHA is the single most important means of protecting personnel. A GHA is enforced by a combination of warning lights and signs, spotters, fences, barricades, and gates to demarcate the GHA boundary. GHAs are particularly useful as buffer zones to protect individuals unfamiliar with the nature of potentially harmful tests and to reduce the potential exposure of personnel to noise, toxic air emissions, metal fragments, and other potentially hazardous conditions. This safety approach is used for all applicable test operations. Table 2 lists the GHAs by facility for various test operations. For example, the GHA at the Centrifuge Complex has a radius of 328 feet (100 meters) when the 35-Foot Outdoor Centrifuge is operated at less than 80 revolutions per minute.
- Hearing Conservation Program - Standards established by SNL/NM to protect personnel from hearing damage. The SNL/NM Hearing Conservation Program complies with DOE Order 5480.10, *Contractor Industrial Hygiene Program*, *OSHA Hearing Conservation Program* (found in 29 CFR 1910.95), and the ACGIH *Noise Standard* (found in the ACGIH Threshold Limit Values 1995-1996).
- Explosives Test Safety Program - Evaluates the risk from metal fragments including computer modeling of fragment trajectories.

- Weather Watch Program - Used to determine favorable atmospheric conditions for testing to minimize sound propagation and managing air pollutant dispersal.
- Restrictions on the Use of Airspace
- Safe Operating Procedures
- Waste Handling Procedures
- Removal of Dispersed Materials including Depleted Uranium and unburned propellant

2.3 DESCRIPTION OF PROPOSED ACTION

The Proposed Action would consist of the following:

- Continuation of all the activities described in Section 2.2.
- Increased testing (see Table 1) at the 10,000-Foot Sled Track.
- Construction activities to consolidate shock tube explosive test programs at the 10,000-Foot Sled Track together with some additional testing (Section 2.3.1).
- Construction and operation of the Model Validation and System Certification Test Center (MV&SCTC) (Section 2.3.2).

Table 1 lists the proposed level of outdoor activities for each facility and indicates whether radioactive or hazardous materials are involved. The level of activities under No Action and the Proposed Action are identical, except for some additional tests at the 10,000-Foot Sled Track, as footnoted in the table.

2.3.1 10,000-FOOT SLED TRACK

The Proposed Action at the Sled Track includes the following items:

- Consolidating shock tube explosives testing programs of the presently nonoperational Thunder Range in the vicinity of the south end of the 10,000-Foot Sled Track. The shock tubes are lengths of pipe in which explosions at one end create a shock wave that impacts a test object at the other end. One shock tube is 12 feet (3.7 meters) in diameter and 80 feet (24.6 meters) long, and the second shock tube is 6 feet (1.9 meters) in diameter and 200 feet (61.4 meters) long.
- Making modifications to the test support facilities in the vicinity of the south end of the 10,000-Foot Sled Track to support consolidation of explosives shock tube testing programs. This would include minor construction activities such as grading foundation pads for the placement of the tubes, trenching for additional instrumentation cabling and electrical utilities, and installation of electrical utilities.
- Conducting shock tube tests at the 10,000-Foot Sled Track with quantities of explosives up to 1,000 pounds (454 kilograms).

2.3.2 MODEL VALIDATION & SYSTEM CERTIFICATION TEST CENTER

The proposed MV&SCTC would be a new test center to be located in TA-III. The MV&SCTC would centralize command and control capability along with modernizing a communications infrastructure. It would link the DETT Center at TA-III test facilities together with the modeling and simulation and experimental communities both internal and external to SNL/NM. The MV&SCTC would co-locate dispersed test command and control center functions, such as laboratories and shop functions (calibration, electronics and mechanical assembly, and machine shop), and staff offices to consolidate the experimental, validation, and system certification test capabilities of the DETT Center.

Table 2. Ground Hazard Radii for Outdoor Tests

Facility	Ground Hazard Areas
Centrifuge Complex	
< 80 rpm	328 ft (100 m)
> 80 rpm	656 ft (200 m)
< 1.5-lb explosive	656 ft (200 m)
Drop/Impact Complex	
Load rockets on sleds	23-degree cone around centerline of track 2,000 ft (609.6 m) in length with apex at northeast end plus 400 ft (121.9 m) radius at beginning of track
Pull down (300-ft Tower)	400 ft (121.9 m)
Drop tests (300-ft Tower)	400 ft (121.9 m)
Drop tests (185-ft Tower)	300 ft (91.4 m)
Sled Track Complex	
Loading rockets/preloaded sleds	1,250 (381 m)
Wiring rockets	1,250 ft (381 m) plus an 18-degree cone about centerline of track at apex of north end and extending south to the TA-III fence
Sled test velocities	
< 1,500 fps	1,250 ft (381 m) plus an 18-degree cone as described above
> 1,500 fps (recoverable sleds) Ejection tests > 750 fps Impact tests > 1,000 fps	1,250 ft (381 m) plus an 18-degree cone as described for wiring rockets; may extend to Isleta Pueblo Buffer Zone if required
Impact tests	2,700 ft (823 m) beginning at a point 1,350 ft (411.5 m) from the south end of the track
> 500 lbs residual unburned propellant, velocities > 4,000 fps, or special tests	Case-by-case but KAFB buffer zones commonly used in these cases
Terminal Ballistics Complex	
Large caliber	500 ft (152.4 m) plus a 15-degree cone about gun target axis extending south to TA-III fence. Shooting into targets with backstop; no barrel elevation.
Small arms	500 ft (152.4 m) to a maximum of 300 yards (274.3 m) down range. Shooting into targets with backstop; no barrel elevation.

fps – feet per second
ft – feet
lb – pounds
m – meters
rpm – revolutions per minute

2.3.2.1 Construction Activities

The MV&SCTC's proposed collocation of functions to a single site would be accomplished either through new construction of a facility or renovation of two existing facilities as discussed in this section. If proposed design and construction of a new facility would occur, it would contain approximately 16,000 gross square feet (1,486 square meters) of space. It would be located on a now vacant site near the northern border of TA-III shown in Figure 1 as proposed location 19 and in Figure 6 as location A. Associated parking and necessary site modifications would cover approximately 2.4 acres (1 hectare), whereas the maximum site disturbance due to construction activities is estimated at 4 acres (1.6 hectare). If two existing facilities are renovated, the proposed design would provide approximately 20,300 gross square feet (1,886 square meters) of space. These facilities are Bldg. 6584 and a portion of Bldg. 6587 located immediately west of the TA-III north security gate shown in Figure 1 as proposed location 19 and in Figure 6 as location B. Maximum anticipated site disturbance is less than one (1) acre (0.4 hectare) including associated parking and necessary site modifications.

The command and control system would be an integrated set of electronic subsystems and software tools that would allow all test-related functions to be performed from remote or local sites. Functions would include data acquisition, facility control, safety, one- and two-way video, audio, data, and telephone. The systems would be designed to accommodate the maximum amount of flexibility to meet future (10-, 15-, 20-year) needs and would be adaptable to technology migration over a 30-year life cycle.

Except for the construction of a foundation and erection of exterior walls, the remainder of the effects from either renovation activities or new construction would be very similar. For example, dust and noise would be generated by construction equipment under either option, and the same site preparations would be needed to place communications and utilities. It is estimated that between 5 to 7 miles (7.5 to 10.5 kilometers) of trenching and utility easement would be needed to lay fiber-optic cable and other communication systems between the MV&SCTC and the test facilities regardless of which construction option was selected. Trenching would be conducted along existing roads. Either option would be in areas where there would be minimal effects to the natural environment (SNL 1994b). Both locations have been surveyed for the presence of cultural resources (Hoagland 1992). No cultural resources were identified in these areas.

Specific measures for environmental protection would be part of the construction specifications. These contractural specifications would minimize noise, air and water contamination, erosion, and aesthetic degradation, as well as protect biotic resources. The potential for introducing contaminants such as fuel, lubricants, and other petrochemicals would be strictly controlled. In accordance with 36 CFR 800.4(d) the absence of cultural resources and effects shall be coordinated with the New Mexico State Historic Preservation Officer.

An updated survey for the presence of the burrowing owl (*Athene cunicularia*) would be performed at the site of new facility construction if this option were selected. Burrowing owls are neither threatened nor endangered: however, they are protected by the Migratory Bird Treaty Act, which prohibits disturbing the owls while they are nesting. If present, advance measures would be taken during the absence of the owls (mid-October through March) to prevent reuse of the burrows. These measures would likely consist of relocating prairie dogs (*Cynomys gunnisoni*) and covering the burrows.

2.3.2.2 *Operations/Activities*

With the presence of a modern communications infrastructure, the test center would collocate the following functions that currently are housed and/or duplicated in several facilities across TA-III:

- Command and control subsystem, hardware, software, equipment, electronics, etc.
- Presentation and support space for viewing remote-controlled tests/experiments
- Light-scale laboratories and machine shop (for assembly of test assemblies, calibration of field mobile units, and instrumentation, etc.)
- Administrative and technical offices and support space

A communications hub and associated equipment also would be housed in the facility.

2.3.2.3 *Integrated DETT Center at TA-III Operations*

When fully operational, the main test center would electronically connect the individual DETT Center test sites at TA-III to one another and to the new test center. It also would provide for modern communications for testing personnel to interface test data with customers, both internal and external to SNL/NM. The test center would provide standardized, centralized, consistent data acquisition, instrumentation, and command and control capabilities, and user interfaces, replacing current antiquated and nonstandardized systems that severely hinder cross-training of core personnel. These issues translate to increased difficulty and costs to maintain these systems as well as limiting the staff's ability to work closely with the modeling and simulation organizations within SNL and other locations.

2.4 *BOUNDING TEST PACKAGES*

The following are the bounding tests selected for analysis in Section 4.0, Environmental Consequences.

2.4.1 *Bounding Test 1 - Destruction of a Warhead Containing Depleted Uranium*

The purpose of conducting this test is to provide data to study the effects of collisions to warheads at increasing impact velocities. These tests provide important information used in computer-based predictive modeling evaluations and engineering design of weapons systems. Depleted uranium is used in the warhead because it closely matches weapons-grade special nuclear material in terms of density, thermal properties, and mechanical properties. Databases and computer models allow test data on depleted uranium to be analyzed to predict the consequences on actual weapons systems. This is considered a bounding test because the amount of depleted uranium and the speed of the rocket sled are at the upper test limits. The environmental issue to be analyzed in Section 4.1, *Health and Safety Effects*, is the exposure of the DETT Center personnel involved in testing to depleted uranium.

The test involves a warhead containing 50 pounds (22.67 kilograms) of depleted uranium, which is attached to a stationary test fixture at the south end of the 10,000-Foot Sled Track. The warhead is struck by a target that is attached to a rocket sled traveling at approximately 6,000 feet per second (1,828 meters per second). The warhead including the depleted uranium and the sled are destroyed and debris is scattered by the collision. Clean-up criteria are followed to remove fragments of depleted uranium.

2.4.2 *Bounding Test 2 - Seven Nike Rocket Motors*

The purpose of using multiple Nike rocket motors is to achieve the proper thrust to weight ratio in order for a sled to achieve the correct test velocity. The solid propellant of Nike motors contains

approximately 3.96 pounds (1.8 kilograms) of lead per motor. As the propellant burns, lead is emitted into the air with the rocket motor exhaust. This is considered a bounding test because seven Nikes would emit the largest amount of lead of any test at DETT Center facilities and seven Nikes have been used only once since 1985. The environmental issue to be analyzed is the air quality effects of this test. It will be examined in Section 4.2, *Air Quality Effects*.

2.4.3 Bounding Test 3 - Detonation of a Sprint Rocket Motor

The purpose of using a Sprint motor in a test is to obtain the necessary thrust in order to achieve the desired test impact velocity by the time the sled reaches the end of the sled track. This is considered a bounding test because the Sprint motor provides the most thrust of any single motor used on the track, and it contains the largest amount of propellant. The test accommodates the possibility that a motor could fail, possibly resulting in its detonation. In this specific case, the environmental issue to be analyzed in Section 4.3, *Noise Effects*, is the effects on the work force and the public from the detonation of an estimated 3,500 pounds (1,590 kilograms) of rocket propellant.

2.5 ALTERNATIVES CONSIDERED BUT DISMISSED FROM DETAILED ANALYSIS

Two alternatives were evaluated but were dismissed from further consideration for the reasons discussed below.

2.5.1 Discontinue Testing

Discontinuation of all testing was dismissed because it would not support DOE's stated purpose and need as discussed in Section 1.0. In addition, DETT Center is the only known unified complex that can create full-scale accident scenarios and other abnormal environments required for weapons certification. The complex also performs engineering evaluations of new nuclear materials shipping containers. These capabilities are vital to DOE, other Federal agencies, foreign governments, and private industry seeking to ensure the safe shipment of radioactive materials.

2.5.2 Relocate Testing

This alternative would also not meet DOE's stated purpose and need because critical testing would be interrupted during relocation activities. Further, the cost of constructing new facilities at a different location would outweigh any potential operating cost advantages. It would shift the environmental effects to another location and introduce new environmental impacts associated with the construction. Selection of alternative locations away from SNL/NM could worsen the minimal consequences of the Proposed Action. DETT Center is a complex of affiliated facilities used to support the SBSS Program and used for full-scale testing of systems and components. These evaluations often are conducted through a series of test events at different, but closely located, facilities. The entire complex provides the necessary range of capabilities to complete these programs in a timely manner. Relocating test facilities would disrupt the consistency of this testing process.

3.0 AFFECTED ENVIRONMENT

Section 3.0 discusses the environmental factors affected by the Alternatives. The general setting of DETT Center at TA-III facilities is presented in Section 3.1. Section 3.2 summarizes those factors that were considered but would be affected at inconsequential levels or not at all. Sections 3.3 and 3.4 address Air Quality and Noise respectively. These have the potential to be affected by the Alternatives and subsequently are evaluated in Section 4.0.

3.1 GENERAL SETTING

The DETT Center TA-III facilities are located at Sandia National Laboratories southeast of the City of Albuquerque, in Bernalillo County, in central New Mexico. At their nearest points, the DETT Center facilities are approximately 6.5 miles (10.5 kilometers) east of downtown Albuquerque. The facilities are inside Kirtland Air Force Base (KAFB) in an area set aside for use by SNL/NM by exclusive use and co-use agreements. Land west and south of KAFB serves as a buffer zone by agreements with the New Mexico State Land Office and Isleta Pueblo. DETT Center at TA-III encompasses 2,554 acres (1,034 hectares).

Albuquerque is the largest population center in Bernalillo County with a 1990 census of 398,492, and the closest population center to SNL/NM. Isleta Pueblo, bordering KAFB on the south, is the second nearest population center with a 1990 census of 2,915. An estimated total of 578,313 people live within a 50-mile (80-kilometer) radius of SNL/NM, including on-base residents of KAFB (DOC 1991). Figure 6 shows locations of SNL/KAFB in relation to Albuquerque International Airport, KAFB, New Mexico Trust Land, and Isleta Pueblo.

SNL/NM consists of five technical areas and several remote test areas encompassing 17,845 acres (7,227 hectares). KAFB is bisected by the Tijeras Arroyo and bounded by the City of Albuquerque to the north; the Manzano, Sandia, and Manzanita Mountains to the east; Isleta Pueblo to the south; and New Mexico State Trust Land to the west. KAFB has a mean elevation of 5,345 feet (1,629 meters) (SNL 1996).

3.2 ISSUES CONSIDERED AND DISMISSED

Table 3 summarizes the issues considered and the reasons why they were dismissed.

3.3 AIR QUALITY

With the exception of certain hazardous emissions, levels of common air contaminants were not monitored prior to 1994 (SNL 1993). Sufficient information to establish an air quality baseline for the DETT Center facilities at SNL/NM has not yet been collected. Conditions must be inferred from measurements conducted at nearby locations. (Continued on page 26).

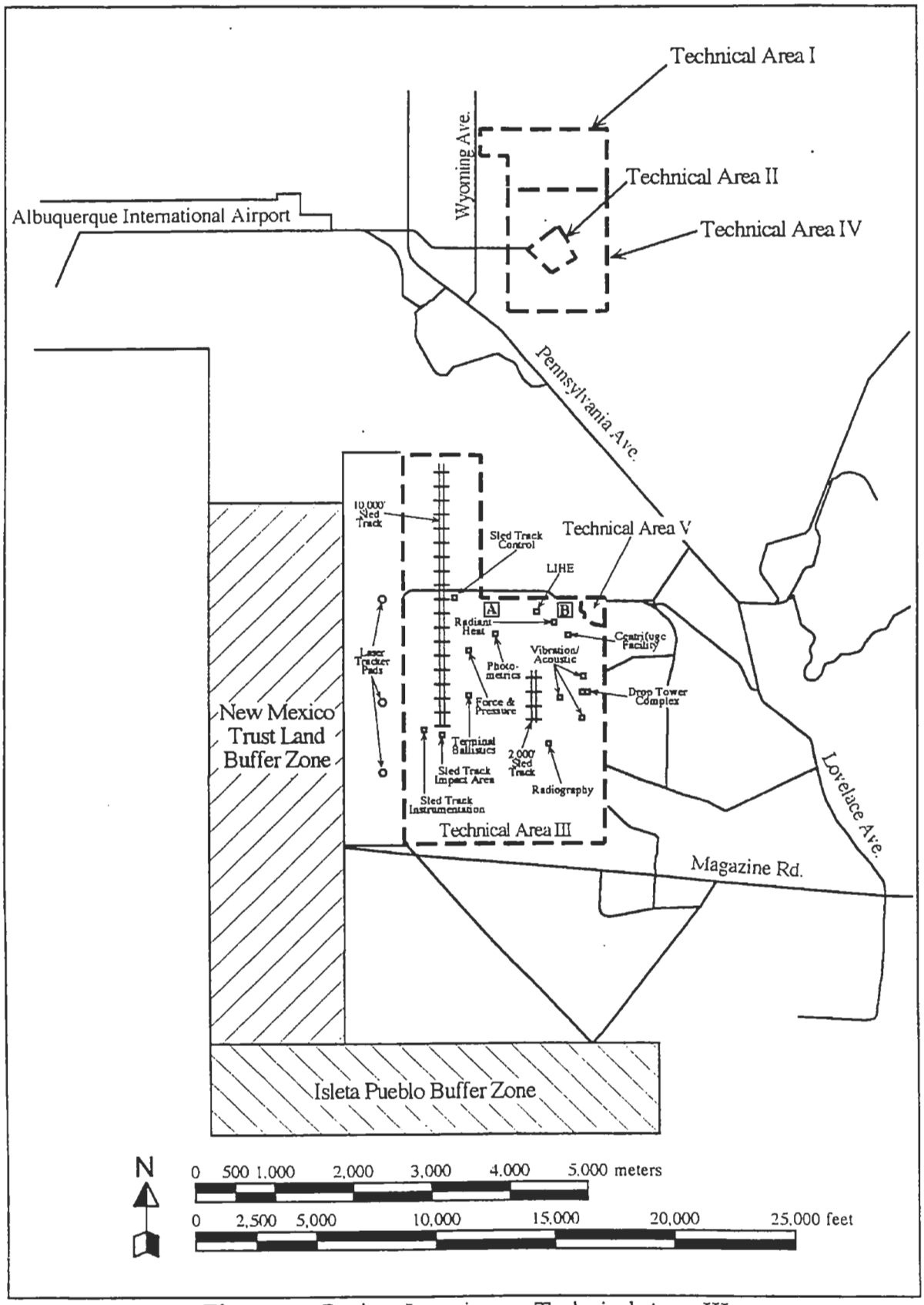


Figure 6. Project Location at Technical Area III

Table 3. Summary of Issues Considered and Dismissed

Issues Considered	Potential Concern	Reason for Dismissal from Further Consideration
Biological Resources	Destruction of habitat, generation of fugitive dust, off-road travel	Testing activities and construction would occur only in areas already disturbed by previous activities. Fugitive dust would be temporary. SNL/NM has a prohibition against off-road travel. No threatened or endangered species or unique habitat present. (SNL 1994b)
Cultural Resources	Damage to and destruction of cultural resources	Extensive surveys since 1971 have found no important cultural resources. Proposed Action testing and construction would be confined to those areas previously surveyed with no findings. (Hoagland 1990, 1992)
Energy and Utilities	Increased energy and utility use	Consolidation of many duplicate activities at the new MV&SCTC would reduce travel and support the energy savings initiative.
Transportation/Traffic	Increase transportation requirements and fuel consumption	Consolidation of many activities under the Proposed Action would reduce the amount of travel between outlying test facilities resulting in less traffic and less fuel consumption. (SNL 1991a)
Soils*	Contamination by lead and depleted uranium	Soil conditions have been minimally effected by 40 years of testing. Activities under the Proposed Action are representative of these past activities. Only small amounts of lead and depleted uranium would be released and are demonstrated not to have a detrimental effect on the current soil conditions. (GCL 1995)
Water Quality	Flood potential Contamination	None of the DETT Center facilities are subject to flooding. They lie outside of the U.S. Army Corps of Engineers delineated 100-year floodplain.
Waste Management	Additional waste disposal requirements	Most of the waste that would be generated is solid waste along with a small quantity of RCRA-generated hazardous waste items. The Quantity of RCRA-regulated waste that would be generated annually by the Proposed Action is estimated to be 662 lb. (300 kg). This represents 0.2 percent of the average annual amount produced by SNL of 70 tons (140,613 kg) and can be handled easily under the current capacity of the SNL/NM Waste Management Organization. (SNL 1994)

* In 1993, a voluntary corrective action at the Sled Track and at the Terminal Ballistics complexes took place to obtain health and safety data relative to surficial radiological hazards at these sites. Visible metal fragments and contaminated soil were removed and disposed of through this program (DOE 1994). The voluntary corrective action has left both facilities less contaminated. The voluntary corrective action study also concluded there is no health risk or environmental concern as long as cleanup criteria are periodically followed to eliminate fragments of depleted uranium.

The standards of the Albuquerque Environmental Health Department Air Pollution Control Division promulgates regulations with respect to ambient air quality in the vicinity of SNL/NM. This organization also monitors compliance with Federal and State air quality regulations and has set up several ambient air sampling stations throughout the city. These stations include a site 2 miles (3 kilometers) northwest of SNL/NM that monitors particulate matter, ozone, carbon monoxide, and nitrogen oxides. No pollutants measured at the station near SNL/NM in 1992 and 1993 exceeded the established limits (SNL 1996).

The New Mexico Administrative Code, Title 20, Part 11.04 (20 NMAC 11.04), entitled "General Conformity," implements Section 176(c) of the Clean Air Act, as amended, (42 U.S.C. 7401 et seq.) and regulations under 40 CFR 51, subpart W, with respect to conformity of general federal actions in Bernalillo County. Bernalillo County has been designated as a maintenance area for carbon monoxide under the National Ambient Air Quality Standards and is in attainment for other federally regulated pollutants. 20 NMAC Part 11.04.II.1.2, paragraph B, establishes the emission threshold of 100 tons per year for carbon monoxide.

Much of the time, it is likely that ambient conditions at DETT Center are similar to those in the surrounding semi-rural areas of the county rather than to those in Albuquerque. For example, dust is more of a problem during periods of strong westerly winds because of the large tracts of sparsely vegetated land to the west of DETT Center.

A 1992 emissions inventory at SNL/NM showed that of 189 hazardous air pollutants listed in the Clean Air Act Amendments of 1990 only 20 are used at SNL/NM in quantities exceeding 1,000 pounds per year (454 kilograms) per year. Of these 20 chemicals, DETT Center facilities use methanol, acetone, and chloroform. However, the typical aggregate annual use is less than 10 gallons (38 liters) per year or less than 80 pounds (36 kilograms).

In 1992, SNL/NM undertook a four-month intensive background air monitoring program to measure concentrations of both radioactive and nonradioactive ambient air pollutants from suspected sources across SNL/NM (SNL 1996). The results were used to evaluate whether SNL/NM is contributing significantly to local air quality degradation and whether SNL/NM is in compliance with applicable Federal, State, and local ambient air quality standards. In addition, the results were used to determine whether a long-term monitoring program is warranted to prove continued compliance with the Clean Air Act Amendments of 1990 and DOE regulations. The main emphasis of the 1992 background study was to establish the baseline levels at which airborne pollutants are present in and around SNL/NM. For this purpose, volatile organic compounds, acid gases, and particulate matter levels were monitored at selected locations around the periphery of TA-I in areas of the highest chemical usage and the heaviest automobile traffic. Data from this monitoring program are used in Section 4.2 to discuss air quality effects and in Section 4.4 to discuss cumulative effects.

3.4 NOISE

The rocket motors, guns, and explosives used at DETT Center test facilities produce sound of short duration, usually of less than 3 seconds per event, and make only a small contribution to the overall noise background. A survey of baseline noise levels was conducted in 1992 (SNL 1992) for SNL/KAFB. It found that the background noise at SNL/NM and DETT Center is dominated by the noise from civil and military aircraft approaching or departing Albuquerque International Airport (AIA). Major runways are oriented east/west and north/south. Landing and takeoff flight patterns pass directly over SNL/NM, as well as many of the residential areas adjacent to KAFB. Survey results indicate that the maximum hourly average noise levels coincided with periods of peak airport

operations, and noise levels at different locations at SNL/NM correlated directly with proximity to aircraft approach and departure patterns.

Most of the noise monitoring at SNL/NM has been done at TA-II where the average noise level has been measured at 54 decibels on the A-weighted scale (dBA) with peak values as high as 102 dBA (SNL 1992). TA-II is much closer to aircraft approach and departure patterns of AIA than is TA-III; therefore, the average value at TA-III likely would be lower. Also, TA-II is closer to residential areas so that the noise measured at TA-II provides some indication of how noise from aircraft affects adjacent residential neighborhoods.

The nearest residential areas to TA-III fall within the 65 to 75 dBA contours for the day-night average noise level. Analysis indicates an average aircraft noise level within TA-III in the range of 64 to 68 dBA would be expected during the work day. The day-night average, including the 10-dBA penalty for nighttime noise, would be expected to be 68 to 70 dBA.

The next most important noise source was found to be motor vehicles. Vehicular traffic noise was estimated to result in an average day-night noise level of 66 dBA within TA-III at a distance of 100 feet (30 meters) from the main access road. Road noise decreases by 15 dBA for each 10-fold increase in distance. At the Sled Track, approximately 1.8 miles (3 kilometers) from the main road, the road noise level is negligible compared with aircraft noise.

In addition, other sources of noise contribute to the background level. Generators occasionally are used at several sites within TA-III. Using the typical noise level of 76 dBA at 50 feet, (15.2 meters) generator noise is negligible compared with aircraft and vehicles at distances greater than 400 feet (120 meters) away.

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4.0 ENVIRONMENTAL CONSEQUENCES

This section examines potential consequences to the existing environment associated with the Alternatives. Section 3.2 discussed issues considered and dismissed. Accordingly, the only effects at issue in this section are those related to health and safety, air quality, and noise as described in the following subsections.

The effects of the Proposed Action would be very similar to those of the No Action Alternative with only minor increases in air emissions and noise. These increases would result from the slightly higher levels of sled track activities and the minor effects associated with construction of the MV&SCTC. **Because the Proposed Action would result in only small changes and effects to the base condition of No Action, effects for both the Proposed Action and the No Action are discussed in the context of the Proposed Action.**

4.1 HEALTH AND SAFETY EFFECTS

Table 4 displays sources, by facility, of potential health and safety hazards based on the DETT Center test activities and operations shown in Table 1 on page 4. These potential hazards include

- exposure to air emissions
- radiological and toxicological effects of depleted uranium
- exposure to fragmentation and noise

Table 4 contains computed exposure levels used as a basis for comparison with occupational exposure standards.

4.1.1 EXPOSURE TO AIR EMISSIONS

A complete description of the methodology used in evaluating the potential exposure of the work force to airborne emissions of test activities is contained in *Air Quality Investigations of the Sandia National Laboratories, Coyote Canyon Test Complex, Albuquerque, New Mexico, 1995* (PSL 1995a). The model, which was used to calculate exposure levels in Table 4, used assumptions about atmospheric conditions, the location of personnel, and the sources of emissions in order to compute the highest credible concentrations at the closest location where DETT Center personnel are allowed to be present. The model assumed that workers would be 1,000 feet (305 meters) away from a test, which is closer than the GHA established by DETT Center GHA safety polices for large tests and in many cases personnel would be farther away (see Table 3).

On the basis of the analysis, no OSHA standards would be exceeded including the standard for lead for the following reasons:

- OSHA air contaminant exposure standards were established to protect workers during 8-hours of continuous exposure per day.
- The DETT Center workforce is not exposed to air contaminants for 8-hours per day. Their exposure is limited by the number of tests that can be conducted daily. Operational requirements typically limit the number of tests to one (1) or two (2) per day so that the workforce's length of exposure to contaminants would be less than 15-minutes per day.

Table 4. Potential Health and Safety Hazards by Facility Activity

Facility & Source of Potential Hazard	Potential Hazard	Calculated Exposure Level See Note	Applicable OSHA Standard
10,000-Foot Sled Track			
Rocket motor firing	Airborne emissions		
	Aluminum oxide	2.4 mg/m^3	15 mg/m^3
	Carbon monoxide	0.8 - 8.9 ppm	25 ppm
	Hydrogen chloride	2.0 mg/m^3	7.0 mg/m^3
	Sulfur dioxide	0.013 ppm	0.5 ppm
	Lead *	0.05 - 0.22 mg/m^3	0.03 mg/m^3
	Noise		
	Rocket motors	~140 dB	140 dB
	Sonic booms	~140 dB	140 dB
Explosive testing	Airborne emissions		
	1,000 pounds TNT	~140 dB	140 dB
	Carbon monoxide	6.9 ppm	25 ppm
	Noise		
	1,000 pounds TNT	~140 dB	140 dB
	Fragments	NA	NA
	Depleted uranium		
	Radiation	<51.9 mrem	
	Toxicity	0.00176–0.00206 mg/m^3	0.5 mg/m^3
Collision impacts	Noise	~140 dB	140 dB
	Depleted uranium		
	Radiation	<51.9 mrem	
	Toxicity	0.00176-0.00206 mg/m^3	0.5 mg/m^3
Maintenance/Operations	Depleted uranium		
	Radiation	<51.9 mrem	,
	Toxicity	0.00176-0.00206 mg/m^3	0.5 mg/m^3
	Noise	76-91 dBA	85 dBA **
Centrifuge Complex			
Operating centrifuge	Noise	71-91 dBA	85 dBA
Explosive testing	Airborne emissions		
	Carbon monoxide	NA	25 ppm
	Lead	NA	0.03 mg/m^3
	Fragments	NA	NA
Collision impacts	Noise		85 dBA
	Collision impacts	105 dB	140 dB
	1.5-pounds TNT explosives	126 dB	140 dB
Terminal Ballistics Complex			
Indoor firing range	Airborne emissions		
	Lead	0.007 mg/m^3	0.03 mg/m^3
	Noise		
	Small arms	98 - 128 dB	140 dB
Outdoor firing range	Airborne emissions		

Facility & Source of Potential Hazard	Potential Hazard	Calculated Exposure Level See Note	Applicable OSHA Standard
	Small arms	98 - 128 dB	140 dB
Outdoor firing range	Airborne emissions		
	Carbon monoxide	0.18 mg/m^3	25 mg/m^3
	Lead	0.007 mg/m^3	0.03 mg/m^3
	Noise		
	40-pounds TNT explosives	~ 140 dB	140 dB
	Large guns	~ 140 dB	140 dB
	Depleted uranium		0.5 mg/m^3
Drop/Impact Complex			
Drop Tower	Noise		
	Explosives testing		
	< 1.5-pounds TNT	126 dB	140 dB
	Collision impacts	125 dB	140 dB
Water Impact	Collision impacts	109 dB	140 dB
Sled track/rocket motor firing	Airborne emissions		
	Carbon monoxide	0.4 ppm	25 ppm
	Hydrogen chloride	0.5 mg/m^3	7.0 mg/m^3
	Sulfur dioxide	0.005 ppm	0.5 ppm
	Noise	~ 140 dB	140 dB
Radiant Heat Complex			
	Airborne emissions		
	Carbon monoxide	0.03-0.90 mg/m^3	29 mg/m^3
	Hydrogen cyanide	0.005 mg/m^3	11 mg/m^3
	Total hydrocarbons	0.25-0.27 mg/m^3	None
	Noise		
	Explosives testing		
	< 1 pounds TNT	128 dB	140 dB
Model Validation and System Certification Test Center			
	Noise		
	Construction activities	76-91 dBA	85 dBA

Note: Actual airborne emissions would probably be less than shown because computations were standardized for the smallest GHA, which is a distance of 1,000 feet (305 meters). Noise levels were calculated at each site's GHA boundary.

OSHA - Occupational Safety and Health Administration
* - OSHA Lead Standard Action Level is 0.03 mg/m^3 averaged over 8-hours.
** - The 140 dB level is the standard for impulse noise use to evaluate explosives and gun fire. The 85 dBA is the standard for 8-hour exposure period.

~ - approximately
lb - pounds
mg/m^3 - milligram per cubic meter
pCi/m^3 - picocuries per cubic meter
ppm - parts per million
dB - decibel
dBA - A-weighted decibel

- The computed levels in Table 4 are the highest levels that would be present at the GHA boundary, and they are not averaged over an 8-hour period. If they were averaged over this period, the values would be even less than shown. Without performing these computations, the values in Table 4 are all well below the corresponding OSHA 8-hour standards except for lead. When the highest lead concentration (0.22 milligrams per cubic meter) is averaged over an 8-hour period, the resultant level of 0.0275 milligrams per cubic meter is less than the OSHA Action Limit (0.30 milligrams per cubic meter) and the OSHA Lead Standard (0.50 milligrams per cubic meter).
- Exposure to lead in soil along the Sled Track is another potential source of lead exposure for the work force. Computations to evaluate this potential source of exposure were made, and the results indicate that there are no scenarios where a concentration would exceed the OSHA Lead Standard action level. The level of lead in the soil has been measured and found to be within the range of 6 to 22.4 milligrams of lead per kilogram of soil, which is the background range expected for central New Mexico (GCL 1995).

4.1.2 Assessment of the Radiological and Toxicological Effects of Depleted Uranium

Depleted uranium is a radioactive, toxic, and carcinogenic chemical. Personnel working at the south end of the 10,000-Foot Sled Track would have the potential to be exposed by contact with contaminated soil primarily by inhalation of contaminated soil. Activities that might lead to exposure include vehicular movement along unpaved roads, removal of test debris, and erection of test fixtures.

The potential radiological effects to the work force are based on the level of radioactivity in the soil and conservative estimates of airborne dust levels as discussed in *Air Quality Investigations of the Sandia National Laboratories, Coyote Canyon Test Complex, Albuquerque, New Mexico, 1995* (PSL 1995a). A conservative estimate is that the radiological dose would not exceed 20 milliroentgen-equivalent-man (mrem) per year. This compares with a maximum allowable occupational dose limit per individual of 5 rem (5,000 mrem) per year and an allowable dose limit to the public of 100 mrem per year (SNL 1991a). For comparison purposes, an average chest x-ray produces a dose of about 10 mrem. The additional cancer risk to the work force would be less than 1 additional fatal cancer for every 10,000 years of operation at the 20 mrem rate of exposure.

Potential toxicity effects from depleted uranium compounds also are possible because inhalation of depleted uranium is known to cause lung disease. The airborne uranium particulate concentrations that could be generated by wind and vehicles would be 1.76 to 2.06 micrograms per cubic meter or a factor of 100 times less than the allowable 8-hour daily exposure level of 200 micrograms per cubic meter as defined by OSHA and ACGIH health standards. Additional information regarding the presence of depleted uranium is in the *Environmental Assessment of the Environmental Restoration Project at Sandia National Laboratories/New Mexico* (DOE 1996).

4.1.3 Exposure to Fragmentation and Noise Hazards

Approximately 25 tests each year are planned involving cased explosives. These are tests that would present the greatest risk of fragmentation. A military bomb is an example of a cased explosive where the explosive material inside a bomb is surrounded by a metal case that is intended to fragment upon explosion. Most of these tests would occur at the 10,000-Foot Sled Track. The risk of being struck by a fragment that could cause injury or death to employees or to the general public, including

commercial aircraft, from these events is calculated to be 2.3 x 10^{-7} per year or one (1) event in 4,350,000 years of operation. The computations used to derive this risk level are available for review in *Noise and Vibration Investigations of Coyote Canyon Test Complex, Albuquerque, New Mexico, 1995* (PSL 1995b).

Other possible circumstances that could produce metal fragments are a collision between a rocket sled and a target or an unintentional high-order explosion of rocket motors or payload of high-explosives. There also are circumstances in which an uncased explosive could propel debris such as stones and pieces of test apparatus from a test area. However, this debris typically would have a shorter range than metal fragments from cased explosives.

The risk from fragments under any circumstances would be minimal because of a formal SNL/NM Explosives Test Safety Program that evaluates each test on a case-by-case basis. One of the program's elements includes computer modeling of fragment trajectories to establish a safety envelope. This is accomplished by using a computer code described in SAND91-0277, *Explosively Driven Missile Trajectory Parameters for Various Fragment Materials and Velocities* (SNL 1991b). The computer code takes into account parameters that would influence a fragment's trajectory such as fragment size, geometry, and weight. A safety envelope establishes safe distances for test observers and manned instrumentation sites. A GHA and a system of manned roadblocks and unmanned barriers demarcate the controlled area. Therefore, there is essentially no risk that fragments would travel beyond the boundary. As additional protection, fragment barriers sometimes are employed to intentionally stop fragments or impede their flight.

Warnings regarding the restriction of airspace above the DETT Center facilities are included in the Federal Aviation Administration publication *Notices to Airmen* as well as in the operations manual of the Albuquerque International Airport (AIA 1994). DETT Center takes additional precautions to post aircraft observers prior to testing to assure that aircraft have not accidentally strayed into the observed airspace. If this were to occur, the test would be delayed until the aircraft was clear of the area.

Noise

Safety envelopes or GHA boundaries also are established for hearing protection purposes as well as for safety against fragments. The effects of noise on the work force and the public from explosives testing, as well as other activities under the Proposed Action, are discussed more thoroughly in Section 4.3, *Noise Effects*.

4.1.4 BOUNDING TEST 1

Background for Bounding Test 1 was first introduced in Section 2.4.1. The purpose of the analysis is to evaluate the upper limit of impacts on the health and safety of the workforce from exposure to depleted uranium. The analysis of the Bounding Test case considers possible exposure scenarios and makes radiological and toxicological estimates of exposure to determine if OSHA, ACGIH, and SNL occupational exposure standards would be exceeded.

The methodology for the assessment is from *Environmental Assessment of General-Purpose Heat Source Safety Verification Testing, DOE/EA-1025* (DOE 1995). That report evaluated the effects of releasing 7.9 pounds (3.6 kilograms) of depleted uranium at the 10,000-Foot Sled Track from a collision impact test; whereas in the Bounding Test analysis, the impact of releasing 50 pounds (22.67 kilograms) is evaluated. The methodology of DOE/EA-1025 is summarized before the discussion of the

Bounding Test case to explain the working scenarios that were developed to perform the exposure assessment.

DOE/EA-1025 Methodology Summary

If the depleted uranium in the warhead shattered in the impact test and scattered over a surface area, personnel exposure is possible from contact with contaminated soil primarily through inhalation of contaminated dust. According to DOE/EA-1025, dust would be generated by wind, by work-related vehicular traffic, and by construction vehicles as well as by the following work activities:

- repairing the soil embankment used as a target backstop
- removing the test fixture that held the warhead
- preparing the site for another test

The dust would contain a fraction of depleted uranium, and a worker's exposure would depend on the concentration of depleted uranium and dust in the air while in the work area.

Baseline soil concentrations at the 10,000-Foot Sled Track were determined from data of a soil sampling study completed in 1992 (GCL 1995). The health and safety assessment for releasing 7.9 pounds (3.6 kilograms) of depleted uranium assumed that this amount would be added to amount already present. The radioactivity of the soil from the depleted uranium also was determined from the 1992 study and verified by computation. DOE/EA-1025 used two different concentration levels of depleted uranium in the soil to assess radiological and toxicity effects.

In order to estimate the amount of dust generated by work activities, five (5) work activity scenarios were developed for the radiological assessment and two (2) scenarios were developed for the toxicity assessment based on normal operations activities as conveyed by Sled Track Complex personnel. EPA methods were used to compute the dust levels that would be generated by worker activities, work-related vehicle movements, and by wind (EPA 1992). The time personnel work in the area contaminated by the release of the depleted uranium was broken down in order to achieve a reasonable estimate of their exposure over an eight-hour work day. An example of a scenario from the toxicity assessment indicates how exposure time is estimated. These criteria are as follows:

- A soil concentration of 60.62 micrograms of depleted uranium per gram (of soil). (This value is the mean soil concentration plus one (1) standard deviation above the mean found during the 1992 study and would represent the highest credible soil concentration for exposure)
- Personnel working for 7.5 hours while a 12 mph wind generates an airborne uranium concentration of 0.273 micrograms per cubic meter.
- Work-related vehicular traffic through the area for up to 30 minutes daily generates an additional airborne uranium concentration of 2.06 micrograms per cubic meter.

DOE's RESRAD computer code was used to compute radiological doses based on the exposure times and soil radioactivity. RESRAD is a computer model developed by Argonne National Laboratory (DOE 1993) for the purpose of evaluating the radiological health effects from soil as well as other environmental parameters that are contaminated by radioactive materials.

To assess the Bounding Test, the same soil baseline conditions and soil concentrations, scenarios, and computer models from DOE/EA-1025 are used.

Bounding Test 1 - Radiological Exposure Assessment

If the 50 pounds (22.67 kilograms) of depleted uranium in the warhead shattered in the impact test and scattered over a surface area, personnel exposure is possible from contact with contaminated soil primarily through inhalation of contaminated dust. In the Bounding Test the depleted uranium is

Table 5. Potential Radiation Doses and Health Risks to Workers under the Bounding Test[a]

Dust Level ($1g/m^3$)	Activity Level (pCi/g) [b]	Dose (mrem/yr) [c]	Increased Individual Cancer Risk
50 (Corresponds to Primary Ambient Air Quality Standard for yearly average for particulates)	11.5 (average in contaminated area)	0.14	$5.6x10^{-8}$
4,500 (Resulting from very dry soil with wind speed at threshold necessary to raise dust)	11.5 (average in contaminated area)	3.49	$1.4x10^{-6}$
4,500 (Resulting from very dry soil with wind speed at threshold necessary to raise dust)	42.4 (average measured value plus one standard deviation, i.e., >80% of all measured values plus the newly released material)	7.03	$2.8x10^{-6}$
34,000 (Resulting from major surface disturbance of very dry soil)	11.5 (average in contaminated area)	26.0	$1.0x10^{-5}$
34,000 (Resulting from major surface disturbance of very dry soil)	42.4 (average measured value plus one standard deviation, i.e., >80% of all measured values plus the newly released material)	51.9	$2.1x10^{-5}$

a assumes a two-month program (320 working hours in the Sled Track impact area)
b picocuries per gram
c milliroentgen equivalent man per year (mrem/yr)

assumed to be scattered equally over an area of 328 feet x 328 feet x 2 inches (100 meters x 100 meters x 5 centimeters), and the additional amount of depleted uranium in the soil (to the baseline) of that area would be 16.82 micrograms per gram (of soil).

Table 5 identifies the dust levels used to compute the radiation doses and the individual cancer risk by RESRAD for each work activity scenario. An individual who spent 320-hours (40-days) per year working in the contaminated area would be exposed to a maximum of 51.9 millirem/year. This is the highest credible case among the scenarios considered. The results are well below the annual 5 rem (5,000 millirem) limit of the SNL radiological health program. The additional risk of cancer to an individual would be 2.1 x 10^{-5}. This is equivalent to one additional cancer for 47,620 years of operation, which also is extremely low.

Bounding Test 1 - Toxicity Exposure Assessment
Table 6 is from DOE/EA-1025 and shows the high and low 8-hour time-weighted average concentration computed for the work activity scenarios before the postulated Bounding Test.

Table 6. Time-Weighted Averages for Uranium Exposure

Length of Exposure (T)	Level of Exposure ($1g/m^3$) (C)	Time-Weighted Average Exposure ($1g/m^3$)	OSHA and ACGIH Standards ($1g/m^3$)
		Scenario 1	
7.5 hours	0.273	0.39	200
0.5 hours	2.06		
		Scenario 2	
7.5 hours	0.034	0.14	200
0.5 hours	1.76		

Data Source: DOE 1995

Both OSHA and ACGIH Standards allow exposures to a concentration of 200 micrograms per cubic meter as averaged over an eight-hour day (DOE 1995). The soil concentration and the operational activities selected for Scenario 1 produced the highest credible exposure estimate of only 0.39 micrograms of depleted uranium per cubic meter. The criteria for this scenario are as follows:

- A soil concentration of 60.62 micrograms of depleted uranium per gram (of soil).
- Personnel working for 7.5 hours while a 12 mph wind generates an airborne uranium concentration of 0.273 micrograms per cubic meter.
- Work related vehicular traffic through the area for up to 30 minutes daily generating an additional airborne uranium concentration of 2.06 micrograms per cubic meter.

The operational activities of Scenario 2 produced a more typical exposure estimate of 0.14 micrograms per cubic meter of air. Its criteria are as follows:

- A soil concentration of 0.08 micrograms per gram (of soil)
- Personnel working for 7.5 hours while a 12 mph wind generated an airborne uranium content of 0.034 microgram per cubic meter.
- Work related vehicular traffic through the area for up to 30 minutes daily generating an additional airborne uranium concentration of 1.76 micrograms per cubic meter.

The conclusion of DOE/EA-1025 found that neither the OSHA nor the ACGIH occupational health standards for uranium would be exceeded.

By assuming that 50 pounds (22.67 kilograms) of depleted uranium in the warhead scattered equally over an area of 328 feet x 328 feet x by 2 inches (100 meters x 100 meters x 5 centimeters) by a collision impact test, the additional amount of depleted uranium in the soil as a result of the Bounding Test would be 16.82 micrograms per gram (of soil). Using the same scenarios from DOE/EA-1025, a worker's exposure would not exceed the OSHA and ACGIH standards of 200 micrograms per cubic meter for an eight hour day for the Bounding Test. In terms of the criteria in Scenario 1, a worker's daily exposure would be computed to increase to 0.50 micrograms per cubic meter. In terms of Scenario 2, the exposure would increase to 0.18 micrograms per cubic meter while performing the same activities after the Bounding Test.

Bounding Test Conclusion

The evaluation of the Bounding Test finds that the potential exposure of personnel working at the 10,000-Foot Sled Track would be well below SNL's radiological health protection standard as well as below the OSHA and ACGIH toxicity exposure standards.

The impacts on personnel exposure would be even less than the estimates for the following reasons:

- Under RMMA policies, when depleted uranium is released, steps are taken to collect identifiable pieces for subsequent disposal by the SNL Waste Management Organization. This action reduces the amount of depleted uranium at a site which further reduces the potential exposure of personnel.
- The computations of this assessment used values that reflected the higher end of a range of values for uranium concentrations and for dust levels. This was done purposely to produce a high exposure estimate (or in other words a conservative estimate) in order to learn whether occupational standards could be exceeded. Since this was shown not to be the case, it is likely that personnel exposure is less than those computed by this assessment.

4.2 AIR QUALITY EFFECTS

Total annual emissions and time-averaged emission concentrations for the Proposed Action were computed on the basis of the frequency of test activities shown in Table 1 on page 4 (PSL 1995a). The air quality assessment considered a wide variety of sources including:

- Engine and fugitive dust emissions by vehicles
- Gases and particles emitted by booster rocket motors at the Sled Track Complex and the Drop/Impact Complex
- Gases and particles emitted by explosives testing
- Vapors from solvents and chemical preparations
- Potential airborne uranium at the 10,000-Foot Sled Track and Terminal Ballistics Complex
- Pyrolytic decomposition products from Radiant Heat Complex

The results of these computations also are used to discuss cumulative effects on air quality in Section 4.4.1 and individual effects to personnel discussed in Section 4.1. The results of the computations are displayed in Tables 7 and 8.

Comparing the annual contaminant production levels of the DETT Center facilities with New Mexico Environment Department and Albuquerque Environmental Health Department Air Pollution Control Division standards indicate that projected contaminant levels would be far lower than levels of regulatory concern (PSL 1995a).

Table 7. Summary of Air Contaminants Emitted Annually Under the Proposed Action at DETT Center
Quantities in tons per year

Activity	AAPCD Sig. Emission Rate	Vehicles	Sled Track: Rocket Motors	Sled Track: Explosives	Drop/ Impact Complex	Terminal Ballistics Complex	Radiant Heat	LIHE	Centri-fuge	Solvents/ Chemicals	Space Heating	Totals
Carbon monoxide	100	0.62	1.97	3.23	0.2	0.32	0.06	0.003	0.16		0.1	6.663
Particulates	25	1.96		1.75			0.35				0.01	4.07
Nitrogen oxides	40	0.24						0.006			0.38	0.626
Sulfur dioxide	40	0.05	0.001		0.002							0.053
Lead	0.6		0.008			0.004						0.012
Potassium hydroxide	a		0.001		0.003							0.004
Hydrogen chloride	a		0.21									0.21
Aluminum oxide	a		0.26									0.26
Hydrogen cyanide	a			0.11			0.001		0.005			0.116
Ammonia	a			0.12					0.006			0.126
Organic Vapors	40							0.130		0.12		0.25
Chlorine	a				0.08			0.017				0.097
Hydrogen sulfide	10					0.02						0.02
Methane	a			0.06		0.001			0.003			0.064
Hydrocarbons	40	0.08		0.5			0.07		0.02		0.02	0.69
Totals		2.95	2.45	5.77	0.285	0.345	0.481	0.156	0.194	0.12	0.51	13.261

AAPCD - Albuquerque Air Pollution Control Division
a - Not specifically regulated

Table 8. Predicted Maximum Average Concentrations of Air Contaminants for the First Hour After a Test Event
(in micrograms per cubic meter)

Source	Sled Track Complex	Drop/Impact Complex	Terminal Ballistics Complex	Radiant Heat Complex	LIHE
Carbon monoxide	15,500	2,940	11,180	900	7.5
Particulates[a]	3,710			1,350	86
Nitrogen oxides					8.6
Sulfur dioxide	76.4	37.2	7.2		
Lead	217	35.2	44.1		
Potassium hydroxide	78.1	38.2	8.1		
Hydrogen chloride	3,010				
Aluminum oxide	3,710				
Hydrogen cyanide	68			5.3	
Ammonia	72				
Organic Vapors					230
Hydrogen sulfide					86
Methane	37				
Hydrocarbons	304			271	

a Includes nongaseous exhaust products when appropriate

Concentrations of contaminants also would be negligible outside the boundaries of the DETT Center. In fact, concentrations are low enough that it is unlikely levels would be measurable in the general community. The Proposed Action would result in the emission of approximately 7 tons of carbon monoxide, which is well below the 100-ton/year threshold. The following sections discuss the emissions of air contaminants by facility, including Bounding Test 2, first introduced in Section 2.6.2, with seven Nike motors tested at the 10,000-Foot Sled Track.

4.2.1 Sled Track Complex

Gases and particles emitted by explosives during testing at the Sled Track Complex are by far the largest source of emissions of the DETT Center facilities. Explosives testing annually produces an estimated 3.23 tons (2.92 metric tons) of carbon monoxide, 1.75 tons (1.59 metric tons) of particulate matter, 0.11 tons (0.10 metric tons) of hydrogen cyanide, 0.12 tons (0.11 metric tons) of ammonia, 0.06 tons (0.05 metric tons) of methane, and 0.5 tons (0.4 metric tons) of nonmethane hydrocarbons. Together, they produce an estimated 5.77 tons (5.24 metric tons) of emissions per year. In contrast, vehicle emissions and the emissions from rocket boosters together annually produce almost the same amount of emissions. Of the 13.261 tons (12.041 metric tons) produced per year at the DETT Center facilities combined, the Sled Track Complex accounts for 8.22 tons (7.47 metric tons) or approximately 62 percent of the total emissions. But even at these projected emission levels, the amounts are far below the levels at which an emission permit would be required to operate the facility (PSL 1995a). According to the July 1996 Environmental Baseline Update, emissions from SNL/NM facilities, which include the Sled Track Complex, do not degrade local air quality and all air quality parameters are within regulatory compliance guidelines (SNL 1996).

4.2.2 *Terminal Ballistics Complex*

The majority of the emissions of the Terminal Ballistics Complex is the result of small arms ammunition testing. The total annual emissions accounts for only 2.6 percent of the total emissions of the DETT Center facilities.

4.2.3 *Drop/Impact Complex*

Gases and particles emitted by booster rocket motors account for most of the emissions at the Complex. The total annual emissions accounts for only 2.2 percent of the total emissions of the DETT Center facilities.

4.2.4 *Radiant Heat Complex*

The Radiant Heat Complex emits 3.6 percent of the total air emissions from the DETT Center. Most of the material is particulate matter in the form of soot. Smaller amounts of carbon monoxide and hydrocarbons also are emitted, some of which are considered hazardous air pollutants under the Clean Air Act. Exposure to all emissions, including hazardous air pollutants, are below regulatory limits.

4.2.5 *Model Validation and System Certification Test Center*

The only anticipated emissions for the MV&SCTC would be small amounts of solvents,used for minor cleaning of test package surfaces prior to attaching instrumentation,and carbon monoxide and nitrogen oxides from space heating requirements. It is anticipated through the consolidation of facilities that the distribution of emissions as shown in Table 8 would be slightly reapportioned, but that the total annual emissions would not change.

4.2.6 *Light-Initiated High Explosive Facility*

Explosive wastes from the LIHE processes are incinerated in the Thermal Treatment Facility located within the LIHE facility security area. The thermal destruction of waste explosives is approved by a State of New Mexico RCRA, Part B permit (Permit NM 5890110518-2, November 1994). The Thermal Treatment Facility burns explosive waste streams and emits carbon monoxide, acetone vapors, and gaseous emissions,containing some silver,from explosives detonation. The total emissions of 0.156 tons per year is approximately 1.1 percent of the total emissions from the DETT Center facilities.

4.2.7 *Bounding Test 2*

This test case was introduced in Section 2.4.2, as Bounding Test 2, to examine the effects on air quality when a rocket sled at the 10,000-Foot Sled Track is propelled by seven Nike rocket motors. This is considered a bounding test because seven motors have been used in an experiment only once since 1985. The U.S. EPA computer model INPUFF is used for assessing the effects of this case. The methodology and detailed analysis of this case is found in *Air Quality Investigations of the Sandia National Laboratories, Coyote Canyon Test Complex, Albuquerque, New Mexico* (PSL 1995a). The results are summarized below.

The air quality standards for lead emissions applicable to this assessment are the Significant Monitoring Concentration (0.1 microgram of lead per cubic meter of air based on a 3-month average) and the Ambient Air Quality Standards (1.5 micrograms of lead per cubic meter of air based on a 3-month average). The standards are regulated by the Albuquerque Environmental Health Department Air Pollution Control Division.

The resulting concentration on the day of the test is far below these standards. Computer modeling indicates that a 24-hour average concentration would be 0.032 micrograms of lead per cubic meter of air. Therefore, the quarterly (90-day) average would be far less than the modeled 0.032 microgram per cubic meter and would fully comply with air quality standards.

4.3 NOISE AND VIBRATION EFFECTS

Noise and vibration are created as a result of testing activities with rocket motors and explosives at the Sled Track Complex and large caliber guns at the Terminal Ballistics Complex. Some of these activities are demonstrated to have the potential to affect the work force at DETT Center, but measures are included to ensure that hearing damage to personnel will not occur. Under some circumstances, the noise produced by test events could be heard outside of KAFB. These circumstances would include multiple rocket motors, explosives, and large caliber guns. The effects on the public depend on the loudness of the sound and the aggregate frequency of tests of all DETT Center facilities and favorable atmospheric conditions to transmit sound. In most cases, the sound outside KAFB of testing resembles a dull thud or a short burst (less than three seconds) of sound. Background noise outside KAFB from aircraft, traffic, and other sources masks most DETT Center activities.

The noise from DETTC Center testing with multiple rocket motors, explosives, and large caliber guns would have minimal effects on the nearby communities because of their short duration and because the impulsive sound is concentrated in the lower frequency range. Low frequency sounds (less than 200 Hertz) are not perceived as well as sounds between 200 and 8,000 Hertz because the human ear hears the higher frequencies better. A loud steady or continuous sound above 85 dB would produce significant effects on exposed people. For example, it would render conversation nearly impossible. A single impulsive sound, even as high as 130 to 140 dB, produced by a sonic boom, explosion, or collision impact test is concentrated in the low frequencies that are relatively unimportant in oral communication. In addition, brief sounds tend to be masked by continuous sounds. City background noise, e.g. vehicular traffic, would further reduce the effects of noise from testing. Although impulsive noise may produce a startle reaction in some people, the effects on the public would be minor.

Only the effects of large-scale events and Bounding Test 3 from Section 2.4.3 will be discussed in the following sections. To a lesser degree, small caliber weapons, vehicles, maintenance and operational activities, acoustical vibration tests, and construction also produce noise, but the effects of these events would be limited to the work force at DETT Center. Standards have been established to protect the work force. On the basis of these standards, such as SNL's Hearing Conservation Program, exposure of the work force does not exceed allowable exposure limits (SNL 1995).

Table 9 summarizes noise levels produced by test activities at the point of generation, locations adjacent DETT Center facilities, and locations close to the boundary of KAFB. The table also includes locations at KAFB that are accessible by the public, such as the Golf Course. Values in this table have been extracted from *Noise and Vibration Investigations of the Sandia National Laboratories, Coyote Canyon Test Complex, Albuquerque, New Mexico, 1995* (PSL 1995b). That document contains the computational methods and mathematical formulas used in deriving values for the assessment of noise produced by:

- Rocket motor firings, sonic booms, and collision impacts
- Explosive testing
- Indoor/outdoor firing ranges
- Maintenance and operation of other DETT Center facilities

- Construction activities

Large-scale noise-producing events, such as explosions, generate a pressure wave that is an atmospheric phenomenon, but analogous to the ripples produced when a stone is thrown into a still body of water. The sudden increase in atmospheric pressure produced by these traveling pressure waves, called overpressure, is initially greater than the ambient atmospheric pressure and is responsible for disturbances such as noise and for building damage such as glass breakage.

Ground vibrations are propagated in a similar fashion; however, only a large explosive test would be able create vibrations that would be noticeable far beyond the point of detonation. Ground vibration would likely be an annoyance to communities at the boundary of KAFB if levels reached or exceeded 0.2 inch per second. Nicholls, Johnson, and Duvall (1971) stated that the annoyance potential is based on the frequency of the vibration. The threshold range where vibration is viewed as "unpleasant" varies from 0.1 inch per second to 4 inches per second. For the typical frequencies generated by explosives (6 hertz to 40 hertz), the threshold for annoyance ranges from 0.2 inch per second to 0.5 inch per second.

An attribute of these phenomena is that they gradually diminish with distance. In addition, other factors at SNL/NM help to lessen the effects from noise produced by testing. As stated, the Weather Watch Program is used by KAFB meteorologists to help engineers select a time for testing when atmospheric conditions are least favorable to propagate sound, as when it is overcast or there is an inversion.

4.3.1 Noise from Sled Track Complex

Because of the safety precautions in place to protect against hearing damage, evaluations of rocket motor firings, sonic booms, and collisions demonstrate that these events would not expose employees and test observers to noise levels in excess of established occupational safety and health standards. Effects of noise on the public is determined by computing noise levels at the boundaries of KAFB and at the nearest areas accessible by the public. These areas are KAFB housing along Pennsylvania Avenue, the Sandia Golf Course and Riding Club, the Four Hills Mobile Home Park, and the Isleta Pueblo. Noise of sled track activities would be the loudest along the KAFB western boundary because it is the closest to the Sled Track Complex.

Rocket motor firings, collision impacts, and sonic booms are the result of activities at the 10,000-Foot Sled Track and, to a far lesser degree, tests at the 2,000-Foot Sled Track. The potential effects to the environment would be greater from the activities at the 10,000-Foot Track because of the larger scope of test operations; therefore, only the consequences of 10,000-Foot Track will be evaluated in the following discussions.

Effect of Rocket Motors

Even though the ignition and burning time of a rocket motor typically only lasts from one to three seconds, the noise produced is defined as a continuous noise (SNL 1995). Table 10 shows that the maximum allowable exposure based on the SNL and ACGIH hearing conservation standards for time periods of 1.76 and 3 seconds. Exposure for more than 1.76 seconds at 127 dB and more than 3.52 seconds at 124 dB requires hearing protection.

Table 9. Summary of Noise Impacts of DETT Center Test Activities at Important Locations (dB)

Facility	Times per Year	Source	GHA Boundary	MH	TP	WB	Isleta Pueblo Boundary	GC	RC	Centrifuge Complex	Terminal Ballistics Complex	Drop/ Impact Complex	Security Ent. Main Gate TA-III	TA-V	10,000-Ft. Sled Track Control Bldg.
10,000-Ft. Sled Track															
Explosive wgt. (lb TNT)															
50	32	151	131	96	96	109	102	103	103	113	123	115	110	111	114
250	4	156	136	101	102	114	108	108	108	118	128	120	115	116	119
1,000	10	161	140	106	106	119	112	113	113	123	132	125	120	120	123
Rocket motors (#'s type)															
25 HVARs		137	119	100	100	101	96	103	103	107	121	107	106	106	125
1 Sprint	<1	155	137	118	119	120	115	122	122	126	140	126	125	124	143
Sonic boom	100	149	131	112	112	114	109	116	116	120	134	120	118	118	137
Collision impacts		145	127	102	102	109	104	106	106	113	123	115	111	111	115
Centrifuge Complex															
Explosives	3	140	126	88	88	93	87	100	100	140	113	116	122	122	107
Collisions	50	117	105	76	76	78	75	83	83	117	93	95	101	101	88
Motors	3	86	64	35	35	37	34	42	42	76	52	54	60	60	47
Terminal Ballistics Complex															
Explosive wgt. (40 lb TNT)	10	150	140	97	98	108	100	106	105	118	150	119	114	114	119
Outdoor Firing Range															
155-mm gun		151	140	107	107	121	123	114	114	128	151	128	120	120	121
.30 caliber gun		100	80	47	48	54	48	52	52	61	90	62	58	58	62
Drop/Impact Complex															
Rockets		135	117	92	92	100	93	98	99	113	107	135	108	111	104
Collision impacts	100	119	109	76	76	84	77	83	83	97	91	119	92	95	88
Radiant Heat Facility															
Explosive wgt. (<1 lb TNT)	15	139	128	88	88	92	85	100	99	125	105	111	121	121	106
** Model Validation and System Certification Test Center construction activities															
Range of Noise Levels under Ambient Conditions (NOTE 1)		a	b	c	a	a	a	a	a	a	a	a	a	a	a

** Denotes facility included in the Proposed Action only, and not in No Action Alternative. All other facilities are included in both the Proposed Action and the No Action

MH - Military housing along Pennsylvania Ave. at KAFB
TP - Mobile home park in Four Hills area
WB - Western boundary of KAFB
GC - Golf course at SNL/NM
RC - Riding club at SNL/NM

Data Source: PSL 1995b

Isleta Pueblo boundary located south of SNL/NM. There are no residences along this boundary.

NOTE 1:

a Area remote from most noise sources except distant aircraft and vehicular traffic. Noise range is 40-65 dBA.

NOTE 1 (con't.)

b Affected by aircraft operating from AIA. Expected noise range 76-93 dBA.

c Affected by aircraft operating from AIA. Expected noise range 90-102 dBA.

Table 10. Allowable Exposures to Continuous and Impulse Noise

Continuous Sources		Impulse Sources	
Noise Level (dB)	Time (seconds)	Noise Level (dB)	Time (seconds)
127	1.76	140	1 or less
124	3.52	-	-

Data Source: 1994-1995 ACGIH Noise Threshold Limit Values (ACGIH 1995)

Noise produced by 25 High Velocity Aircraft Rocket (HVAR) motors would reach 119 dB at the GHA boundary, which is below the maximum standard of 127 dB. This means that the work force would not be at risk for hearing damage because no one is permitted to be closer than the GHA boundary or they are protected by heavily reinforced concrete buildings. For some infrequently used motors, such as Sprints, supplemental hearing protection may be required even outside the GHA. These cases are evaluated and appropriate measures are taken as required.

Table 9 also shows noise levels at areas where the public has access. The results of the computations indicate that noise levels would decrease over distance so that at the nearest housing areas and other areas such as the Sandia Golf Course, noise levels likely would not be noticed above the noise of aircraft from AIA and vehicular traffic. To emphasize this point, noise from a Sprint rocket motor,the largest and loudest motor that could be used at the Sled Track,is computed to be 110 dB and 105 dB at the Four Hills Mobile Home Park and the Golf Course, respectively. All other motors would be far quieter than the Sprint. For comparison purposes, the noise of an automobile horn is approximately 115 dB at 10 feet (3 meters) (SNL 1995).

Sonic Booms

The 10,000-Foot Sled Track is the only facility capable of producing a sonic boom while conducting testing operations. Sonic booms may be produced when a sled exceeds the speed of sound. A sonic boom is considered an impulse noise, and the maximum allowable level of exposure is 140 dB. To ensure that the work force is aware of these tests, alerts are routinely issued so that appropriate precautions can be taken. Precautions such as remaining indoors, evacuating the area, or wearing hearing protection devices are adequate protection from a sonic boom. The work force would not be at risk for hearing damage because no one is permitted to be closer than the GHA boundary or they are protected by heavily reinforced concrete buildings. The distance from the track to the KAFB western boundary is approximately 4,265 feet (1,300 meters). As shown in Table 9, the noise produced by a sonic boom would be 114 dB at the KAFB boundary. The number of sonic booms is dependent on the need for high speed tests. On the basis of historical information, approximately 60 percent of the tests would produce a sonic boom or they would occur about 30 times per year.

The effect on the public at the boundary of KAFB would be minor. As stated, a single impulsive sound from a sonic boom is concentrated in the low frequencies that are relatively unimportant in oral communication. In addition, brief sounds tend to be masked by continuous sounds. City background noise, e.g. vehicular traffic, would further reduce the effects of noise from testing.

Collision Impacts
Collision impacts between test packages and targets would result in noise. Only a fraction of the energy from the collision would be dissipated acoustically. Most of the energy would be dissipated through mechanical deformation of the test package or target, heating or melting of the article, and conduction or dissipation through the earth. Noise levels from collisions were estimated by using a pile driver as an example to compare energy dissipation during an impact. The result is a conservative estimate of a 130 dB sound level at a distance of 82 feet (25 meters) from the impact point.

Noise from collisions would be well within the limits of 140 dB for impulsive sound. Moreover, the GHA radius for impact tests would be set at 1,350 feet (412 meters) from the impact point. Since personnel are required to remain outside the GHA, they would not be exposed to injurious noise levels. At the Sled Track Control Building (Bldg. 6741), the level would be approximately 95 dB. At the Gibson Boulevard entrance, it would be approximately 83 dB, and at the western boundary of KAFB it would be 109 dB.

The effect on the public at the boundary of KAFB would be minor as already stated because the impulsive sound is short in duration and is concentrated in the low frequencies that are relatively unimportant in oral communication and tend to be masked by continuous sounds of background noise from the City.

Effects of Explosives Testing
The limit of testing would be 1,000 pounds (454 kilograms) of TNT equivalent at the 10,000-Foot Sled Track. By definition noise produced by an explosion is an impulse noise. The 1,000 pounds (454 kilogram) test would be conducted about 12 times per year.

Concerns for noise exposure from explosives testing are similar to those discussed for rocket motors, collision impacts, and sonic booms. Computations demonstrate that noise levels would decrease over distance enough that the work force would not be exposed to noise levels that would cause damage or injury. This is apparent from the values in Table 9 for the GHAs of the Sled Track and for nearby facilities. None of these locations would experience noise levels above 138 dB. The largest test with 1,000 pounds (454 kilograms) of explosives would produce noise levels ranging from 127 to 138 dB in adjacent test areas. At the western boundary of KAFB, the noise level is expected to reach 119 dB. In other locations outside the KAFB boundary the noise levels are not expected to exceed 106 dB.

As stated, the effect on the public at the boundary of KAFB would be minor because the impulsive sound from explosives testing is short in duration and is concentrated in the low frequencies that are relatively unimportant in oral communication and tend to be masked by continuous sounds of background noise from the City. Shock tube tests may produce a startle reaction in some people, but the overall effects on the public would be minor.

Vibration
Explosive testing causes propagation of ground vibration. Propagation rates above 0.2 inch per second can be a source of annoyance to human receptors (Nicholls, Johnson, and Duvall 1971).

On the basis of the analysis by PSL (1995b), damaging vibrations from explosive testing would not extend beyond the DETT Center area in TA-III for the largest explosive test and in most cases vibration effects would probably not extend beyond the immediate point of detonation at the Sled Track.

Table 11 displays the distances that vibrations would travel for the maximum quantity of explosives that would be tested at each facility. As shown, a ground vibration velocity of 0.2 inch per second would radiate 4,813 feet (1,523 meters) from the point of detonation of 1,000 pounds (454 kilograms) at the Sled Track. The range of ground vibrations estimated for each site are contained in Table 11.

Table 11. Range of Ground Vibrations

Site	Maximum Yield (kg TNT)	Vibration Annoyance Radius [a] (0.2 ips) (ft)	Vibration Damage Radius [b] (2 ips) (ft)
10,000-Foot Sled Track	454	5,000	1,581
Terminal Ballistics Complex	88	1,000	315

kg - kilograms
ips - inches per second
ft - feet
m - meters

Data Source:
a Goff and Novack (1977)
b Nicholls, Johnson, and Duvall (1971)

As shown in Figure 6, no residential areas would be encompassed within the 0.2 inch per second radius. Facilities within the damage radius at DETT Center are designed to withstand the effects of explosives testing; therefore, workers would not be at risk.

4.3.2 Noise from Terminal Ballistics Complex

Explosives Testing

The explosive limit for testing at the Terminal Ballistics Complex is 40 pounds (18.2 kilograms) of TNT equivalent. Computations demonstrate that noise levels would decrease over distance sufficiently that the work force would not be exposed to conditions above the 140 dB limit established by the hearing conservation standards. This is apparent from the values in Table 9 for the GHAs at the Terminal Ballistics Complex and for adjacent sites. The nearest DETT Center facilities are the 10,000-Foot Sled Track and the Force and Pressure Laboratory, and the noise level at either location would be approximately 119 dB. The boundary most affected by the Terminal Ballistics Complex is the western boundary where the explosion would produce a noise level of approximately 108 dB. These tests would occur approximately 10 times per year.

Vibrations from explosive testing with 40 pounds (18.2 kilograms) of TNT equivalent would not extend beyond the Terminal Ballistics Complex boundary. As shown in Table 11, these levels would not be perceptible to the general public at the KAFB boundary. A ground vibration velocity of 0.2 inch per second would radiate 1,000 feet (305 meters) from the point of detonation, and this distance is well within the boundaries of KAFB.

Effects of Indoor/Outdoor Weapons Firing Ranges

The Terminal Ballistics Complex contains an indoor firing range at Bldg. 6750, and an outdoor range for weapons testing that extends in a southerly direction approximately 984 feet (300 meters). The noise produced by weapons is defined as an impulse noise. For occupational hearing conservation purposes, the maximum permitted level of exposure is 140 dB.

For safety purposes each range is configured so that most tests would be conducted by remote control. Bldg. 6750 is a reinforced concrete structure with separate rooms for test control purposes and an indoor range. Occasionally, small caliber weapons would be hand-held during tests. When this occurs, personnel wear hearing protection equipment in accordance with the SNL/NM Hearing Conservation Program. Attenuation of noise by the building and use of hearing protection equipment protects personnel from noise and blast effects.

In the recent past, the outdoor range predominantly has tested small-caliber weapons. These weapons would pose no hazards to personnel in adjacent facilities because there is sufficient distance between facilities to attenuate noise to nonhazardous levels. The facility also has a 155-mm "Long Tom" artillery gun located adjacent to Bldg. 6750. Large-caliber artillery tests have not been conducted in the past several years. As shown in Table 1, approximately 60 large arms firings per year would occur. Personnel in adjacent DETT Center structures are protected from excess noise levels by established operating procedures (SNL 1991a). Table 12 displays distances at which the sound level is equal to 140 dB for three directional aspects of the gun.

Table 12. Distances from 155-mm Gun Where Sound Pressure Level Reaches Indicated Levels
Reaches Indicated Levels

Aspect	Distance from source where: SPL = 140 dB
Front (along muzzle axis)	3,708 ft
Side (90 degrees to axis)	1,184 ft
Rear (180 degrees to axis)	479 ft

dB - decibel
ft - feet
SPL - sound pressure level

The loudest noise is downrange from the muzzle, which would be pointed south in the direction of the unoccupied buffer of KAFB and Isleta Pueblo. At that boundary, the sound level would be 97 dB. To the side and the rear of the artillery piece, noise levels above 140 dB would not extend beyond the Terminal Ballistics Complex GHA boundary. At the western boundary of KAFB, that noise level would be 97 dB. The data in Table 13 show A-weighted peak sound levels and unweighted sound pressure levels at other locations such as KAFB housing and the Four Hills Mobile Home Park. The frequency spectrum produced by large caliber guns as well as by explosions and by sonic booms are rich in low frequency tones. The A-weighted values in the table approximate a human hearing response to low-frequency sound. In addition, the frequency detected by a listener will decrease as the distance

Table 13. Sound Pressure Levels of the 155-mm Gun Predicted for DETT Center Facilities and Locations Accessible to the Public

Site	Distance from Gun Site (m)	SPL (dB)	L_A (dBA)
KAFB Housing	6,580	107	78
Four Hills Mobile Home Park	6,400	107	79
KAFB Western Boundary	3,140	121	97
KAFB Southern Boundary	8,300	123	97
Drop/Impact Complex (Bldg. 6510)	1,460	128	108
Sled Track Control Building (Bldg. 6741)	1,280	121	101
Centrifuge Complex (Bldg. 6526)	1,460	128	108
Sled Track (Bldg. 6742)	800	143 [a]	127 [a]

Outdoor sound levels
a Indicates sound level requiring hearing protection

dB - decibels
dBA - decibels on the A-weighted scale
L_A - A-weighted sound level
m - meters
SPL - sound pressure level

from the source increases because higher frequencies are attenuated more strongly by the atmosphere (NIOSH 1973). As an example, to the listener at the KAFB Housing Area, the noise from the 155-mm gun would have the intensity of 78 dBA.

The neighborhoods in the table are located approximately 180 degrees from the direction of fire. The data in Tables 12 and 13 demonstrate the directional dependence of the sound of artillery. There would be a noise reduction of approximately 20 dB at 180 degrees to the direction of fire, which is confirmed by the studies of Falch (1984) and Pater (1981). Noise levels at the neighborhoods would be approximately 78 to 79 dBA and would resemble a low-pitched dull thud. As compared to 85 dBA produced by a heavy truck at 45 feet (13.7 meters) (SNL 1995), the effects may not be distinguishable above normal background conditions.

In the immediate vicinity of Terminal Ballistics Complex and at the south end of the 10,000-Foot Sled Track noise levels of 140 dB or greater would be present. However, for safety reasons, personnel in adjacent areas are protected by established procedures (SNL 1991a).

4.3.3 Noise from Drop/Impact Complex

The noise produced by rocket motor firings and collision impacts are less than at other DETT Center facilities such as the 10,000-Foot Sled Track. This is because the scope of testing requires far fewer rocket boosters, and no explosives are detonated for test purposes.

Noise levels at the Drop/Impact Complex and at surrounding DETT Center facilities are shown in Table 9. Noise levels would be 135 dB at the Complex and would decrease to 117 dB at the GHA boundary. Noise levels would further decrease over distance sufficiently that at the nearest housing areas, and other areas such as the Sandia Golf Course, they would range between 92 and 99 dB. These levels would be less than noise of aircraft from AIA and vehicular traffic.

Collision Impacts

Many of the tests at the Drop/Impact Complex are impact tests of test packages dropped from the towers. The maximum noise level is computed to be 119 dB at the source, which would decrease to 109 dB at the GHA boundary. This level is well below the 140 dB limit for impulsive sound; therefore, there are no impacts to personnel.

4.3.4 BOUNDING TEST 3

This bounding test examines the consequences of noise produced by a Sprint motor failure causing the motor to detonate at the 10,000-Foot Sled Track with an estimated 3,500 pounds (1,590 kilograms) of propellant. This case has occurred only once in the history of the track. A Sprint motor also is the most powerful single motor used at the track. For these reasons, this is considered a bounding test. The effects of blast overpressure are evaluated in the following section.

The methodology for estimating blast overpressure is explained in detail in *Estimating Air Blast Characteristics for Single Point Explosions in Air with a Guide to Evaluation of Atmospherics Propagation and Effects*, (ANSI 1983). The means to calculate the overpressure are specified in the *SNL ES&H Manual* (SNL 1991).

The Sprint motor would produce a 140 dB sound pressure level over a radius of 10,433 feet (3,180 meters) from the 10,000-Foot Sled Track. Figure 6 shows the ground features encompassed in the radius. No residential areas are encompassed in the radius. Personnel working within this radius are protected by standard procedures (SNL 1991). The effects on personnel at the sled track would be minimal because they would be protected inside buildings. Most personnel in TA-III away from the sled track would be alerted to the test under standard operating polices. People that are outdoors would likely be startled by the blast, but would not experience hearing damage from such a single blast event. Most facilities at TA-III are designed to withstand the overpressure of blasts so that windows are not likely to be broken.

4.4 CUMULATIVE EFFECTS

This section assesses the effects of implementing the Proposed Action in conjunction with the effects of present and reasonably foreseeable actions of a similar nature on KAFB. These actions are located at or within 7.4 miles (11.8 kilometers) from the middle of the DETT Center. Issues analyzed that could have cumulative effects consist of air quality and noise.

4.4.1 AIR QUALITY

Other actions outside the DETTC Center boundaries that were included in the *Sandia National Laboratories/New Mexico Environmental Baseline Update, July 1996*, as sources producing air

emissions such as nitrogen oxides, carbon monoxide, sulfur dioxide, volatile organic compounds, and particulate matter consist of the following:

- Hazardous Waste Management Facility
- Sol se Mete Rocket Sled Track
- Thermal Treatment Facility
- Lurance Canyon Burn Site
- Radiant Heat Complex
- Five (5) Steam Boilers
- Microelectronics Development Laboratory
- Melting and Solidification Facility

According to the *July 1996 Baseline Update*, emissions from SNL/NM facilities, which includes these actions and the DETT Center, do not degrade local air quality, and all air quality parameters are within regulatory compliance guidelines (SNL 1996). Therefore, the incremental impact of the Proposed Action when added to those from actions of a similar nature would be within regulatory limits.

4.4.2 NOISE

The discussion of noise effects of the alternatives in Section 4.1.3, beginning on page 32, demonstrates that health and safety measures employed at test facilities protect employees from adverse effects of high sound levels and that sound emissions are rapidly dissipated within the confines of KAFB. Sounds reaching urban areas outside KAFB would be negligible due to the masking effect of background noise produced by aircraft approaching and departing the AIA and vehicular traffic.

Other actions producing short, impulse noise similar to the Proposed Action are as follows:

- The Explosive Devices Test Facility, Bldg. 9930 in Thunder Range,that conducts approximately 500 tests per year with explosives ranging from 1 milligram to 100 pounds (45 kilograms) of TNT equivalent. This facility's current contribution to noise is greater than the alternatives considered except for the Sled Track Complex and the Terminal Ballistics Complex.
- The Bldg. 9920 Complex conducts explosive and impacts tests. However, this facility currently is operating at only 10 percent of historic levels and ultimately may be decommissioned. Its current contribution to noise would be a small fraction of that reported for the DETT Center.

These two facilities are located immediately east of the DETT Center.

Additional organizations that conduct similar testing using explosives and weapons include the following:

- SNL/NM at Sol se Mete Canyon Aerial Cable Facility
- The DOE at the Weapons Training Center
- SNL/NM at the Explosive Ordinance Disposal Site
- The Defense Special Weapons Agency
- Explosive Component Facility (tests conducted indoors)

Sounds from these actions, particularly from the Sol se Mete Aerial Cable Facility, have a negligible impact on the surrounding communities for many of the same reasons as the Proposed Action as well as the attenuating effects of intervening mountains, canyons, and vegetation. Because of a combination of factors including the long distances of some major actions of the DETT Center (up to 7.4 miles or 11.8 kilometers), the negligible impacts on the surrounding communities, and the absence of coincident

timing of tests, their effects would not be additive. Consequently, these actions would not enter into the cumulative effects analysis.

The incremental impact of the Proposed Action when added to those impacts from actions of a similar nature (Bldgs. 9920 and 9930) would be minor. This is due to the low frequency of events from both the Proposed Action and related actions and the short cumulative duration (average of 10 seconds per day or less) of impulse noise, when considered in the context of virtually continuous background noises such as military and civilian aircraft and vehicular traffic. In addition, measures employed to protect health and safety at all facilities would preclude additive effects.

Based on the preceding discussions for air quality and noise, the effects of the Proposed Action, when combined with those effects of other actions defined in the scope of this section, do not result in cumulatively significant impacts.

4.5 ENVIRONMENTAL JUSTICE

As a result of Executive Order 12898 (February 11, 1994), Federal agencies are responsible for identifying and addressing the possibility of disproportionately high and adverse effects of their programs and activities on minority and low-income populations. The analysis conducted in Section 4.0 of the potential consequences of the alternatives considered demonstrated that impacts to surrounding populations would be minor to negligible. Therefore, based on the low level of impacts to human populations, there would not be an environmental justice issue.

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5.0 ABNORMAL EVENTS

Three abnormal events were selected to evaluate the range of effects and consequences associated with DETT Center Operations. A grass fire at the Sled Track Complex was selected as a High Probability and Low Consequence event. The failure of a rocket sled at motor ignition was selected to represent a Low Probability and High Consequence event. A methanol spill was selected as an Occupational Safety Accident.

5.1 GRASS FIRE

Rocket motor boosters contain a solid propellant that burns at extremely high temperatures. The exhaust exits from a nozzle at the rear of the motor as shown in Figure 2. Occasionally, small pieces of the burning propellant also exit the nozzle and could cause the grass along the Sled Track to ignite. These pieces of propellant typically are slivers approximately 2 to 4 inches (5 to 10 centimeters) long and approximately 0.5 inch (1.2 centimeters) in diameter.

A grass fire is not unexpected and many times small fires extinguish themselves. However, precautions are taken to ensure that any fire is extinguished as soon as it is safe to enter the track area following a test. Typically, this is accomplished by hand with track personnel using a water-charged fire extinguisher and picking up the pieces of propellant. In addition, the KAFB fire department is alerted prior to a test and would be called if a fire cannot be extinguished by hand. The fire department has been called only 5 times in 30 years of Sled Track operation. Small fires have been common and the number is not recorded.

Other fire prevention precautions are taken such as preventing brush and grass from growing close to the track and buildings. The road network also acts as a fire break helping to prevent a fire from spreading beyond the immediate Sled Track area.

5.2 FAILURE OF ROCKET SLED AT MOTOR IGNITION

A credible but low probability accident at the DETT Center that would have high consequences is analyzed in this section. Such an accident at the Sled Track Complex would be the catastrophic failure of a sled at engine ignition with subsequent release and uncontrolled flight of the rocket motors. This event could result from the failure of a structural component of the sled or conceivably from the explosion of one of the motors of a multi-motor sled. The probability of injury on any given test is computed to be 1 (one) in 3.74 million. This probability analysis is discussed in the following evaluation.

Between 1979 and 1992, SNL conducted over 2,300 tests involving rocket-powered sleds.. Several hundred additional tests were conducted at the track using free-flying rockets, but these were not included in the analysis. The total number of rocket sled tests that have been performed since the construction of the 2,000-foot track is considerably larger, but complete data are not available. Only one accident of the type analyzed has occurred with that occurrence being in 1962, early in the history of sled track testing at SNL. It can be argued that experience gained during the ensuing years has reduced the probability of accidents computed for this case.

Using standard statistical techniques, an occurrence of 1 (one) event in 2,300 tests is sufficient to establish that the expected occurrence rate is between 1 (one) in 2,400 and 1 (one) in 2,208 with 95

percent confidence. The highest occurrence rate for the 95 percent confidence interval, 1 (one) in 2,208 was used for the risk analysis. If the total number of sled track tests were known, the accident rate would be demonstrated to be even lower.

Should an accident occur, the highest probability of an injury would result from a sled with the largest number of motors. As many as 25 HVAR or Zuni motors are used on a single sled. Most of the motors used at the Sled Track Complex originally were designed as propulsion systems for various military weapons systems. In the design configuration, each motor was attached to a warhead or upper stage assembly and had stabilizing fins or some other stabilization mechanism. At the Sled Track Complex, only the motor sections are used. Without stabilization and additional forward weight of a warhead, the motors are aerodynamically unstable. In free-flight, the bare motors rapidly begin to tumble, which greatly reduces their range. The HVAR motor was used as the basis for this analysis.

A sled failure could have significant consequences only if it were to occur at or before motor ignition. The momentum of the motors would keep them moving along the track should they be released once the sled has appreciable kinetic energy. They then would land within the GHA. If released at ignition, the bare motors would tend to travel in the direction of the initial thrust vector, which could conceivably be in any direction. Because of their initial horizontal alignment along the track, it would still be more likely that the motors would travel generally along the track than in other directions.

In general, the probability that a motor would land at a given distance from the launch point decreases with increasing distance from the launch point. Mathematically, the probability with distance would be described as a normal or "bell" curve. To simplify the computation, three zones were used in this analysis. It was estimated that the maximum range that could be reached credibly by an unstabilized HVAR motor would be 1,056 yards (1,000 meters). The probability of a motor landing between the launch point and 211 yards (330 meters) down range was taken to be 0.68, the probability of landing between 211 yards (330 meters) and 712 yards (670 meters) was taken to be 0.27, and the probability between 712 yards (670 meters) and 1,056 yards (1,000 meters) was taken to be 0.05. These probabilities approximate a normal curve. For a 25-HVAR sled, 17 motors would be expected to land within the first zone, 7 within the second zone, and 1 (one) within the third zone. It was further assumed that a landing motor would injure any person within 15 feet of its impact point. If the motor were to land on a building, debris dislodged by the impact could conceivably affect people within a 15-foot radius, and if the motor were to land on bare earth, secondary missiles, soil and rocks thrown up by the impact, could cause injury within a similar area. A motor on a horizontal trajectory would injure any person along its path, but motors initially traveling horizontally would have a very short range and would not be expected to travel outside the 1,250-foot GHA.

The first zone considered is entirely within the GHA and would be unpopulated. The second zone was assumed to contain 10 people. There are very few facilities within 2,188 feet (667 meters) of the sled track that would be expected to have personnel present during sled track testing. The third zone was assumed to contain 20 people. The eastern portion of the third zone would be well within TA-III, and northern, southern, and western portions would be within normally unpopulated areas.

Using these assumptions, the probability that a person would be killed or injured as a result of an accident, should it occur, would be 5.9×10^{-4} or 1 (one) in 1,696. Most tests use far fewer rocket motors, so the probability usually would be smaller. As discussed above, a conservative estimate of the probability of the accident occurring, based on actual experience, is less than 1 (one) in 2,208. Therefore, the probability of an injury resulting from catastrophic sled failure at engine ignition on any given test would be less than 1 (one) in 3.74 million.

5.3 METHANOL SPILL

Test preparations would require small amounts of organic solvents for miscellaneous purposes such as spot cleaning surfaces prior to applying an adhesive. Most products are in 1 gallon (3.8 liters) or smaller containers, including methanol, methyl ethyl ketone, toluene, tape-drive head cleaner, electronics spray cleaner, and denatured alcohol. Since chemical use is small, the level of exposure to workers would be minimal; no exposure to uninvolved workers or off-site exposure to the public would be expected. A spill of the entire contents of a container would represent a credible situation that would create the greatest exposure to personnel. However, even spillage of an entire container of any of these substances is unlikely to cause substantial release to the environment.

For example, if the entire contents of a 1 gallon (3.8 liters) bottle of methanol were spilled in a room with the following dimensions, 25 feet (7.58 meters) by 40 feet (12.3 meters) by 9 feet (2.73 meters), the vapor level would be approximately 8,940 parts per million. Acute exposure to a high concentration of methanol is known to cause damage to the optic nerve through the inhalation and absorption of methanol by the blood stream. This concentration exceeds the OSHA and ACGIH standards; however, it is unlikely that this exposure has the potential to cause damage to eye sight. The peak blood methanol level would be estimated to be 29.95 milligrams per 100 milliliters of blood. An initial blood level in excess of 100 milligrams per 100 milliliters would be required for irreversible effects such as damage to the eyes and optic nerve to occur (Casarett and Doull 1993). Methanol also is a flammable liquid and can form explosive mixtures. Even if one gallon of methanol were to be spilled, the resultant average concentration of 8,941 parts per million would be less than the Lower Explosive Limit of 6 percent (60,000 parts per million).

In the situation in which a gallon container is accidentally broken, personnel would seek to contain the spill and call the appropriate hazardous response team for clean-up assistance. These actions would reduce personnel exposure. No release to the environment through floor drains or similar pathways would be expected.

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6.0 PERSONS AND AGENCIES CONTACTED

Person and Agency	Subject
Albuquerque International Airport	
Airport Manager Barry Kamhoot	Flight Operations
State of New Mexico	
Department of Game and Fish Bill Montoya, Director Sandy Williams John Pittenger	Threatened and Endangered Species
Energy, Minerals and Natural Resources Department Karen Lightfoot	Threatened and Endangered Species
Health and Environment Department Patrick C. Jennings	Occupational Safety and Health
Historic Preservation Division Office of Cultural Affairs Dave Riley	Historic Preservation Information
U.S. Department of Agriculture	
Forestry Service - Cíbola National Forest C. Phil Smith, Forest Supervisor Beverly deGruyter, Biologist Joe Tainter, Archaeologist	Threatened and Endangered Species Biological Survey Procedures Cultural Resources Surveys
U.S. Department of the Interior	
Fish and Wildlife Service Ecological Services Jennifer Fowler-Propst, Field Supervisor Brian Hanson	Threatened and Endangered Species
Nuclear Regulatory Commission	
John Austin	SECY 81-576 Document Information on Low Level Depleted Uranium Contamination Radiation Dose Calculations
David Fauver	Radiation Dose Calculations

Person and Agency	Subject
Kelsey-Sebold Clinic, P.A.	
NASA/Johnson Space Center Arnold Orsak	Radiation Safety Radiation Dose Calculations
Motorola Corporation	
Richard Knowlson	Health and Safety of Lead Exposure
Pueblo of Isleta	
Governor's Office Alvino Lucero	Historic Property Locations
Pueblo of Sandia	
Governor's Office Alex Lujan	Historic Property Locations

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8.0 GLOSSARY

Attenuation: The decrease with distance of a quantity, such as the reduction of noise over distance or the reduction of light intensity over distance from a source.

Compression test: A test to determine the compression strength, usually applied to materials of high compression strength but low tensile strength, in which a specimen is subjected to increasing compression forces until failure occurs.

Creep: A slow change over time or usage caused by stress. Buckling that may occur when a compression load is maintained on a member over a long period of time leading to creep, which eventually reduces the member's bending stiffness.

Curie: A unit of radioactivity or measure of radioactivity defined as 3.7×10^{10} disintegrations per second

Decibel: A unit for describing the level of a noise source typically measured by a sound level meter or computed using mathematical equations. It is abbreviated as dB.

Decibel A-weighted scale: A modification of the standard sound pressure level scale that better approximates the response of the human ear.

Depleted uranium: Uranium having a smaller percentage of uranium^{235} than the 0.7% found in natural uranium.

Fatigue test: A test to determine the range of alternating stress that a material can withstand without breaking.

Fiber-optic circuit: A path for data transmission in which light acts as the information carrier and is transmitted through an optical cable called a waveguide.

G force: A unit of acceleration equal to 9.80665 meters per second per second or approximately 32.17 feet per second per second. A 1 (one) G-force means that in one second an item gains a speed of 9.8 meters per second.

Gram: A unit of mass in the metric scale equal to 0.001 kilograms or 0.035 ounce.

Linac: A linear accelerator, which is a machine that can accelerate electrons, protons or heavy ions in a straight line by action of alternating currents. A linac can be used to produce x-rays. The x-rays are used to produce x-ray photographs for nondestructive examination of various mechanical structures.

Overload: A load on a structure that is greater that for which it is designed.

Ozone: A highly reactive form of oxygen (O_3). Considered an air pollutant in the lower atmosphere because it is a powerful irritant. In the upper atmosphere, naturally occurring ozone absorbs harmful ultraviolet radiation.

Pyrolysis: The breaking apart of complex molecules into simpler units by use of heat, as in the pyrolysis of heavy oil to make gasoline.

REM: An abbreviation of roentgen-equivalent-man. A unit of ionizing radiation that is equal to the amount that produces the same damage to humans as 1 roentgen of high voltage x-rays.

Roentgen: The international unit of x-radiation or gamma radiation equal to the amount of radiation that produces in one cubic centimeter of dry air at 00C and standard atmospheric pressure ionization of either sign equal to one electrostatic unit of charge.

Schlieren photography: The use of refraction effects induced by small changes in air density to photograph and analyze air-flow patterns.

Sonic boom: A noise caused by a shock wave that emanates from an aircraft or other object traveling at or above the speed of sound, which is approximately 1,100 feet per second or about 738 miles per hour.

Squib: Small pyrotechnic device designed to ignite a rocket motor or explosive charge.

Systems level testing: Any combination of equipment, instrumentation, software, etc., that is designed to function together as a complete system. Testing of a complete system is accomplished to evaluate its functionality. Systems may stand-alone or be part of a larger system.

Tensile strength: The maximum stress a material subject to a stretching load can withstand without tearing.

TNT equivalent: A measure of the energy released in the detonation of an explosion, expressed in terms of the weight of TNT that would release the same amount of energy when exploded.

Volatile organic compounds: Compounds of hydrogen and carbon often used in air pollution discussions to refer to compounds other than methane. Regulated as an air pollutant because photochemical reactions involving these chemicals give rise to ozone.