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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ACKNOWLEDGEMENTS

Although this report documents the New Mexico portion of the EPW Phase 2 Quick-Look study, the task and the solutions arrived at would would not have been possible without the work of many different agencies and the dedicated support of individuals too numerous to name. The agencies and their major contributions are listed below:

Agency	Contribution
DIA	
USGS	
ASD (Policy)	
Air Staff	
AFWL	
SAC	
ASD	
BMO	
GD	
MDAC	
DOE/AL	

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I. EXECU

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II. INTRODUCTION

Two hard target kill Phase 1 studies (Refs. 1 and 2) initially addressed the question of feasibility for an Earth Penetrating Weapon (EPW) against deep underground targets. The Phase 1 study recommended further work; on November 4, 1987 a joint Air Force, Navy, DOE Phase 2 study was initiated in part to take a "quick look", to be investigated and reported within four months, at "the feasibility of using modifications of existing weapons to provide an interim capability". (The study request and the DOE letter accepting the request are reproduced in Appendix [redacted]

DOE b(1)

This report describes the Phase 2 activities that support the feasibility and qualification of [redacted] modification as an early IOC, interim, deep underground target weapon. The report is organized by chapter as follows: the feasibility of effectively attacking the specified target set with a simple variant of an existing weapon is discussed in Chapter III, the bomb-to-warhead conversion process is described in Chapter IV, the penetrator-to-carrier integration process and qualification procedures for the warhead and weapon system are covered in Chapter V, and production, cost and schedule requirements are given in Chapter VI.

Long-term issues that are the focus of the continuing EPW Phase 2 study, such as new warhead designs, arms control issues, and new weapon systems are not discussed in this report, but will be included in the normal Phase 2 report at the conclusion of that activity.

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DOE b(1)

DoD b(2) b(3)

Table 1

DOE b(1)

III. SYSTEM FEASIBILITY

The feasibility of effectively attacking the specified target set with a simple variant of an existing weapon is discussed in this chapter. In June, 1988, the EPW Phase 2 Systems Analysis Working Group published an interim report that is included as Appendix C.

[redacted]

B. Targets.

The DIA was tasked by OSD(S&TNF) to provide target intelligence support to the Phase 2 study group. Due to classification issues concerning the target set, DIA resorted to describing the target characteristics in term of a "generic" set of target facilities. This approach was reviewed and approved at the Nov. 2, 1987 meeting of the OSD Strategic Systems Committee EPW panel (Ref. 5). The DIA target set data package was transmitted by OSD (S&TNF) to the study group on Nov. 30, 1987 (Ref. 6) [redacted] relative location, detailed geology, surface coverage by various features (such as buildings, water, trees, open areas), depth(s), facility structure type, size or extent of the facility, and the physical vulnerability or hardness of the facility.

[redacted]

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DOE b(3)

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[redacted] It is likely that such a delivery vehicle would have a [redacted] especially in the possible event that the strike on buried targets is subsequent to a major exchange [redacted]

D. Impact and Earth Penetration Survival.

The ability of the Earth Penetrator to survive the impact and earth penetration environments is essential to the success of the weapon system. Based on an extensive database, SNLA has developed empirical penetration equations (commonly called the S# equations; see Ref. 7) for predicting depth of penetration and peak axial loading of the penetrator.

An accurate description of the target near surface features is needed to assess the earth penetrability of a target. The quality of this assessment directly influences the confidence in Earth Penetrator survivability. Target source data (geological maps, well logs, coring reports, photo coverage and HUMINT data) have been assessed by experts from the DIA, CIA, USGS and the DOE national laboratories representing pertinent fields (geology, hydrology, rock mechanics, terradynamics) to provide the best estimate of geological features and penetrability index (S#) for each near surface layer of geology of each target. The S# is based, in part on the type of rock or soil, its density, unconfined compressive stress, layer thickness, and moisture content[2], as well as joint spacing and degree of weathering[3].

The estimated S numbers, coupled with the physical description of the earth penetrator (weight, diameter, nose shape) and the impact conditions, are input data to the penetration equations to estimate the depth of penetration and loads. The loads experienced by a penetrator is typically predicted and measured as "g's" of deceleration. The maximum predicted rigid body loads and associated shock spectra are then compared to the design capability of the Earth Penetrator to assess its survivability.

Analytical and numerical modeling efforts to date have been unable to provide credible predictions of penetrator loading and depth. Difficulties stem largely from the fact that detailed data on target geologies are required but are unavailable. Perhaps more fundamental is an inherent uncertainty regarding the geological features of hard rock targets because the random location of cracks can change penetrability significantly. Consequently the focus of efforts has resorted to empirical methods. Representative penetrators have been impacted upon a range of geologies thought to be representative of actual targets. The penetrators have been instrumented to allow measurements of axial and lateral loads in an effort to characterize the impacts. These tests have largely validated the empirical penetration formulae.

DOE b(1)

[2]These properties represent ideal, fracture-free rock that will be the least penetrable (have the lowest S#).
[3]The degree of fracturing can greatly enhance penetrability.

Moraine is typically of uneven thickness, and the underlying rock will have variations in penetrability over the area of probable impact. The combination of overburden thickness and local rock hardness at the actual point of impact will determine whether the [redacted] would survive or fail during penetration.

A statistical analysis was performed to determine the probability of successful penetration of the generic target. Varying factors considered were overburden thickness and condition (frozen or not) and rock hardness. It was assumed that the probability distribution of the thickness of overburden at the point of impact varied uniformly from 0 to 5 m.

Two normal probability distributions were assumed for the penetration index (S#), a nominal one ranging from 0.8 to 1.6, with mean value of 1.2, equal to the generic target specification used in the Phase 2 study, and a harder distribution, from 0.6 to 1.4, centered about 1.0. [redacted]

DOE b(3)

[redacted] Since survival varies at a given target due to the random nature of overburden thickness and rock penetrability at the actual point of impact, confidence in success could be improved by using several weapons.

E. Carrier Performance.

[redacted]

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[redacted]

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D. Safety Themes

The nuclear safety theme for the [redacted], covered in Ref. 3, is applicable to the [redacted] except for modifications described below. There are implications to both normal operating environments (in which both system reliability and nuclear safety must be assured) and abnormal environments (nuclear safety must still be assured). The safety themes summarized below are covered in more detail in Appendix C.

DOD b(1)(3)

1. Safety Theme [redacted]

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[redacted]

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V. QUALIFICATION PROGRAM

[redacted] Further detail is provided in Appendix D.

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A. Warhead Qualification Program

1. Penetration Demonstrations. [redacted] Test units were aircraft- or helicopter-dropped, or sounding rocket impacted onto realistic targets having various hardnesses. Impact parameters and deceleration data at various points in the warhead were [redacted]

DOE b(1)

2. Environmental Certification.

Pre-penetration Environment. [redacted]

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Penetration Environment. Simulated targets will be constructed, and instrumented test units will be impacted into the target to measure major component responses (fire set, programmer, etc.). Major components will then be separately qualified to the environments that exceed [redacted] certification levels.

DOE b(1) b(3)

2. Mechanical Interface.

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DOE b(1)

C. Weapon System Qualification.

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Further detail is provided in Appendix D.

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VII. CONCLUSIONS

The results of the studies, design, and testing done by Sandia Albuquerque and Los Alamos in support of an interim earth penetrating weapon substantiate the following conclusions.

1) An earth penetrating version is a feasible, near-IOC weapon

2) The modifications necessary to convert a to a are few and have low technical risk.

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IX. APPENDIX A

PHASE 2 REQUEST AND DOE RESPONSE LETTERS

DEPARTMENT OF DEFENSE
AND
DEPARTMENT OF ENERGY

NUCLEAR WEAPONS COUNCIL
STANDING COMMITTEE
WASHINGTON, DC 20301-3050

Mr. John L. Meinhardt
Acting Deputy Assistant Secretary
for Military Application
Department of Energy
Washington, DC 20545

10 SEP 1987

Dear Mr. Meinhardt:

(U) Request the Department of Energy join with the Department of Defense to conduct a Phase 2 Feasibility Study to develop weapons with a Hard Target Kill (HTK) capability for employment against deeply buried, hardened targets.

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DOE
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Department of Energy
Washington, DC 20545

OCT 2 1 1987

Honorable Robert B. Barker
Chairman, Nuclear Weapons Council
Standing Committee
U.S. Department of Defense
Washington, DC 20301-3050

Dear Dr. Barker:

This responds to your September 18, 1987, letter that requested the Department of Energy (DOE) join with the Department of Defense (DOD) in a Phase 2 Feasibility Study to identify weapons with a Hard Target Kill (HTK) capability for near-term and far-term employment against deeply buried, hardened targets.

The DOE is pleased to accept your request to establish feasible designs to hold this class of targets at risk. Based on the last two paragraphs of your request, the DOE will transition our support from the Navy "special" earth penetrating warhead (EPW) requirements study to this consolidated, joint service Phase 2 study. We do, however, have some concerns about the schedule constraints and the scope of the study outlined in your request.

One concern is related to the study group's ability to meet the 4-month deadline for the portion of the study to identify near-term warhead options. In order to meet this timeline, we believe that a validated DOD target base and nuclear effects model for use in analyzing the effectiveness of EPWs must be available at the start of this joint effort. We request that every effort be taken by the appropriate DOD agencies to accomplish this task in order to assure timely completion of the study on the schedule you have established. Additionally, to meet the tight schedule, we suggest that every effort be made to narrow the near-term options early in the study if the analyses show that a delivery mode is not favorable. This will allow the study to focus on the most feasible options and encourage a timely response.

b(1)(3) [redacted] DOE b(3)

RESTRICTED DATA

Celebrating the U.S. Constitution Bicentennial — 1787-1987

DOE
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DOE
b(3)

The DOE is pleased to join with DOD in this nationally important task. We will work with your study manager to resolve our concerns and look forward to timely completion of each portion of the Phase 2 study.

Sincerely,

John L. Meinhardt
Acting Deputy Assistant Secretary
for Military Application
Defense Programs

X. APPENDIX B

PHASE 2 STUDY GROUP ANNOTATED BRIEFING

JOINT DOD-DOE PHASE 2 STUDY OF EARTH PENETRATOR WEAPONS (U)

- - INTERIM CAPABILITY REPORT - -

MAJ. JAMES M. LEONARD, AFWL

(THIS CHART IS UNCLASSIFIED)

RESTRICTED DATA/CNWDI
NOFORN/WNINTEL

CONTAINS CONTRACTOR
PROPRIETARY INFORMATION

BRIEFING OUTLINE

(U) The Department of Defense (DOD) has directed the study of Earth Penetrator Weapons (EPWs) and has formally asked the Department of Energy (DOE) to participate. The DOE formally accepted and a joint phase 2 study group, consisting of several agencies from within both Departments, was formed to carry out this task.

(U) The outline shown here highlights the main areas of this annotated briefing, which addresses the quick-look status of the phase 2 at the four-month point.

QUICK-LOOK STATUS REPORT AT THE FOUR-MONTH POINT (U)

DOE b(1)

REQUESTED DOD INPUT TO SUPPORT PHASE 2 STUDY (U)

UNDER SECRETARY OF DEFENSE (POLICY)

DEFENSE NUCLEAR AGENCY

- **(U) LED THE EFFORT TO DEVELOP WEAPON EFFECTS MODELS**

DEFENSE INTELLIGENCE AGENCY

- **(U) PROVIDED VALIDATED, GENERIC TARGET SET**

STUDY TARGET SET (U)

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DOE b(3)

DOE b(3)

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GROUND RULES AND ASSUMPTIONS

(U) This study, like any study, is built on a foundation of groundrules and assumptions. These are enumerated in the following paragraphs.

(U) The weapons effects results are subject to the target-set descriptions provided. If the generic target set descriptions were to change than our result (and possibly our conclusions) might also change. As you will see later in the briefing, however, the recommended solution is insensitive to some of the target parameters.

(U) The ground shock propagation model from DNA was used for our baseline analyses. These calculations were verified as reasonable by using 2-dimensional, first-principle codes at the DOE laboratories.

(S) Policy guidance to the study group eliminated [redacted] from consideration as EPW carriers.

DOD b(1)(3)

[redacted]

DOD b(1)(3)

[redacted]

DOD b(1)(3)

GROUND RULES AND ASSUMPTIONS (U)

- (U) DIA GENERIC TARGET SET
- (U) DNA SHOCK PROPAGATION MODEL
- (U) OSD POLICY GUIDANCE
- [redacted]

DOD b(1)(3)

- (U) CANDIDATE SURVIVES SURFACE PENETRATION
- (U) USE OF RELATIVE DAMAGE EXPECTANCY (RDE)

DOD b(3)

[redacted]

COMPARISON OF WEAPON SYSTEMS TO COUNTER DEEPLY BURIED TARGETS (U)

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WARHEAD SELECTION PARAMETERS (U)

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WARHEAD SELECTION PARAMETERS (U)

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DELIVERY SYSTEM/WARHEAD SELECTION PARAMETERS (U)

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FINDINGS ARE INSENSITIVE TO CHANGES IN CURRENT ESTIMATES OF SEVERAL KEY PARAMETERS (U)

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FINDINGS ARE INSENSITIVE TO CHANGES IN CURRENT ESTIMATES OF SEVERAL KEY PARAMETERS (U)

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FINDINGS ARE SENSITIVE TO (U)

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FINDINGS ARE SENSITIVE TO (U)

- (U) DIA GENERIC TARGET SET DEFINITION
  - TARGET LOCATION AND EXTENT

DEMONSTRATED CAPABILITIES [redacted] (U)

[redacted]

DOE b(1)

DOE b(3)

DOE b(1) (3)

DEMONSTRATED CAPABILITIES (U)

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PERFORMANCE VALIDATION (TESTING) NEEDED (U)

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PERFORMANCE VALIDATION (TESTING) NEEDED (U)

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INTERIM SOLUTION CONCLUSIONS (U)

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DOE b(1)

FOCUS OF THE CONTINUING PHASE 2 STUDY (U)

(S) The focus of the continuing phase 2 study should emphasize detailed examination of rigid earth penetrator weapons. New warheads, designed specifically for this application, can be optimized for the EPW mission (eg. size, weight, yield, fuzing, g-level tolerances, download trade-offs). DOE developmental programs are well underway, including nuclear development tests. The utility of a rigid EPW should be examined and optimized to an individual (specific) carrier system(s).

FOCUS OF THE CONTINUING PHASE 2 STUDY (U)

- (S) DETAILED EXAMINATION OF LONG-TERM RIGID EPWs
  - NEW, OPTIMIZED WARHEADS
  - DESIGNS TAILORED SPECIFICALLY FOR THE EPW MISSION
  - DEVELOPMENTAL PROGRAMS WELL UNDERWAY
- (S) EXISTING OR CURRENTLY PROGRAMMED CARRIERS
  - MOBILE ICBMs
  - B-2: GRAVITY DROP
  - TRIDENT II
  - ADVANCED STAND-OFF MISSILES

LONG-TERM ROBUST RIGID EPW OFFERS (U)

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b(1)

LONG-TERM ROBUST RIGID EPW OFFERS (U)

- (U) GREATER VARIETY OF POTENTIAL DELIVERY SYSTEMS

- (U) OPTIMIZED WARHEAD DESIGN

RECOMMENDATIONS (U)

DOE b(1)

[redacted]

b(1)

DOE b(3)

RECOMMENDATIONS (U)

RECOMMENDATIONS (Cont'd)

(S) We recommend that the continuing phase 2 study examine rigid EPWs for the indicated delivery systems. A delivery system down-select, however, should include evaluation of PLS, PTP, IOC, costs and force structure implications. Time is needed by the study group if this is to be quantified in the same manner as the interim solution. Alternatively, the DOD could specify an appropriate carrier (or carriers) for a carrier-specific phase 2 (or phase 2's).

RECOMMENDATIONS CONT'D (U)

FOR THE LONG-TERM SYSTEM

- (U) CONTINUE PHASE 2 STUDY TO INVESTIGATE FEASIBILITY OF RIGID EPWs
- (S) DELIVERY SYSTEM SELECTION TO OPTIMIZE/INCREASE CONFIDENCE IN HOLDING DEEPLY BURIED TARGETS AT RISK
  - KEY CONSIDERATIONS: PLS, PTP, IOC, COST, FORCE STRUCTURE
- (S) TIME NEEDED BY STUDY GROUP TO NARROW C

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CR MM9O OI NRM RSE C IVSEL ITG R E N
F R FG H

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DOE b(3)

DOD b(1)(3)

(2) (U) SC-DR-72-0523, Empirical Equations for Predicting Penetration Performance in Layered Earth Materials for Complex Penetrator Configurations, C.W. Young. The "soil equations" in this reference were used in all target geologies, except for the case with the concrete surface layer. See the minutes to the Phase 2 meeting on 13 January 1988 for penetration of thin concrete layer.

SURFACE PENETRATION IS A CONCERN AT CERTAIN TARGETS

* In urban areas

  — Buildings or competent rubble may cause high structural loads; however

    — Reliable penetration of pavement and incompetent rubble may be possible by slowing down weapon

    — Sufficient open areas may be available for targeting purposes

* At targets where competent rock is near the surface

  — Penetration may result in excessive loads unless the weapon is slowed down

VG 9. (U) We used impact velocities expected to meet operational and penetrator-survival requirements.

DOE b(3)

WE USED IMPACT VELOCITIES EXPECTED TO MEET OPERATIONAL AND PENETRATOR-SURVIVAL REQUIREMENTS

DoD b(1)(3)

VG 9a. (U) "Depth of Penetration and Maximum Decelerations etc".

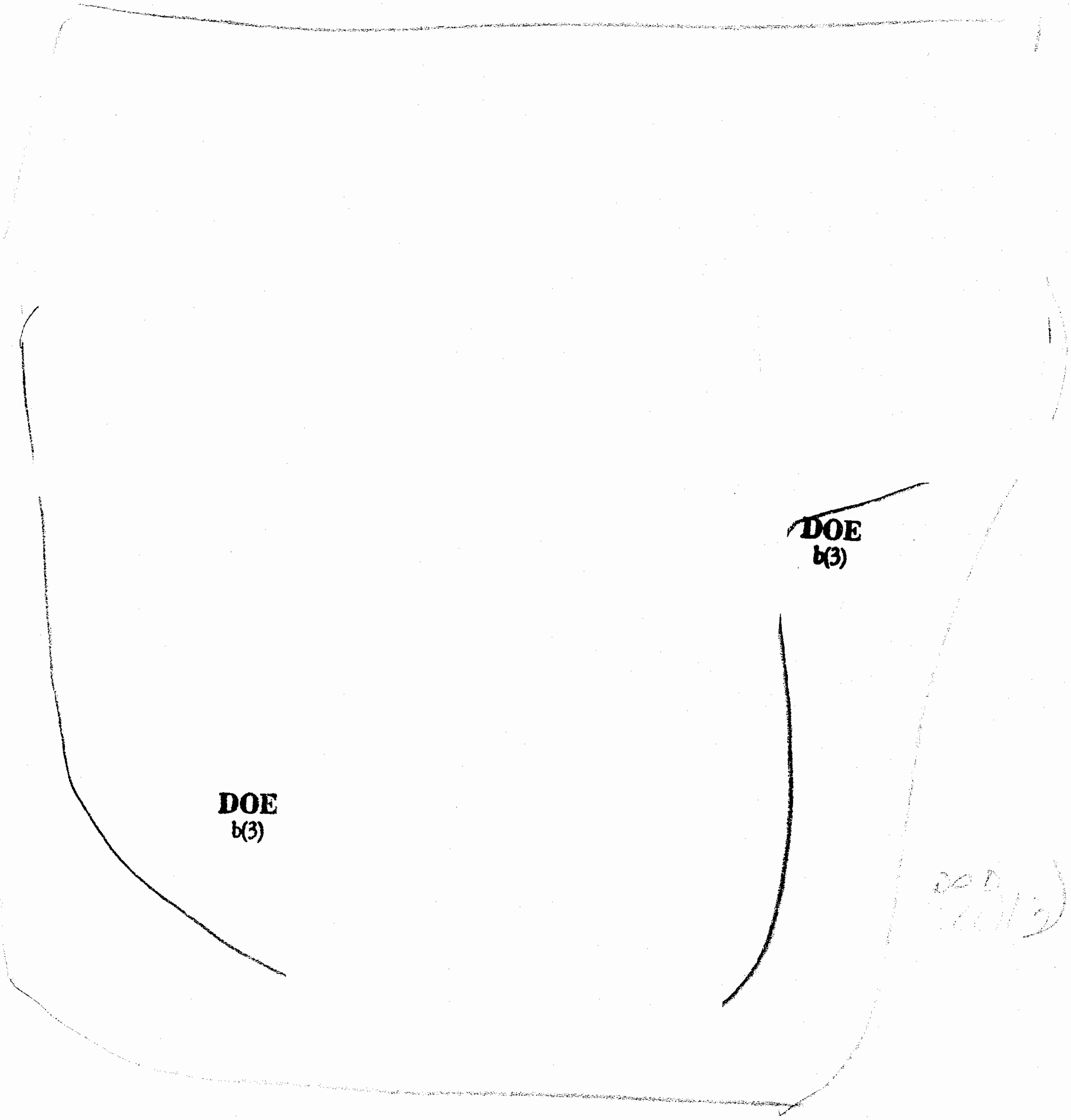
(U) This vugraph is a table of the DOBs, in meters, and the maximum decelerations, in g's, that each of the six EPWs would experience penetrating four generic target geologies with the appropriate impact velocity indicated in vugraph 9. These values were predicted by the Young/SNLA methodology.

DEPTH OF PENETRATION AND MAXIMUM DECELERATIONS FOR INTERIM - SOLUTION EPWs

Depth of Penetration (m)/Maximum Deceleration (g)

DOE b(1)

DOD (b)(3)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VG 15. (U) These are the observations derived from this effectiveness analysis.

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(U) It is important to note that this study did not consider PLS, WSR, or several other factors which routinely must be accounted for in force application. RDE is not DE, so the numbers we show are only relative, not absolute.

DOE b(1)

VG 16. (U) We found that the effectiveness of the four best-performing weapons is insensitive to changes in several important parameters.

DOE b(1)

THE EFFECTIVENESS OF THE FOUR BEST-PERFORMING WEAPONS IS INSENSITIVE TO CHANGES IN SEVERAL IMPORTANT PARAMETERS

DOE b(1)

DOE b(3)

VG 16a. (U) "Even for the deepest level at Target 3ABC etc".

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DOE b(3)

VG 17. (U) The results are sensitive, however, to a few key parameters.

(U) The numbers of weapons required and the carrier of choice could both be affected by changes in the PTP values, which we considered, as well as by several matters which we did not consider, such as weapon-system reliability, target-location error, and prelaunch survivability*.

RESULTS ARE SENSITIVE TO

* Penetrator impact survival

    — targets in rock

    — developmental tests are recommended

* Target location error, PTP, WSR, and PLS

    — affects the number of weapons

    — affects the choice of carrier

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VG 18. (U) A long-term option would offer increased confidence in success from several points of view.

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XII. APPENDIX D

NUCLEAR SAFETY THEMES

1.

The complete safety theme for the is provided in

reexamined below to assess the effect of this modification as well as the effect of replacing the radar nose section and the aluminum center case section with an integral steel case.

The implications of this new application of a on the safety theme require examination of the following system characteristics:

<u>Delivery Vehicle.</u>

<u>Warhead Electrical Inputs</u>. Most electrical inputs to the

<u>Delivery Vehicle</u>. The was designed for use as an aircraft delivered gravity device and has been evaluated for response to aircraft accident scenarios.

DOE b(3)

DOE b(3)

DOE b(1)

DOE b(1)

DOE b(3)

DOE b(1)

DOE b(1)

[redacted]

2. [redacted]

The complete Safety Theme for the [redacted]s provided in the Final Development Report for the [redacted] Bomb (Ref. 8).

[redacted]

The implications of this new application of a [redacted] on the Safety Theme are (detailed discussion will follow):

[redacted]

The nuclear-critical components are enclosed the same conductive case, with electrical access through a Lightning Arresting Connector, and the entire assembly sealed to limit the entry of fluids.

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Table E2. Nuclear Environments Comparison

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[redacted]

<u>Penetration Environment</u>. Simulated targets will be constructed, and instrumented test units will be impacted into the target to measure major component responses (fire set, programmer, etc.). Major components will then be separately qualified to the environments that exceed [redacted] certification levels.

[redacted]

<u>Warhead Qualification Test Schedules</u>. Figure E3 presents test schedules for [redacted] qualification.

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<u>Launch, Free Flight and Fuzing Timelines</u>.

The launch and free flight time line for the baseline subsurface fuzing mission is shown in Figure E5. Characteristics of the launch and free flight through creation of the D1/D2 word (aka ESD word) will not be changed by the

DOE b(3)

DOE b(3) & b(1)

[redacted]

DOE b(1)

Mechanical Interface. [redacted] This scheme would not affect the existing RV/missile interface.

DOE b(1)

Operational Profile and Electrical Interface. [redacted] primary concern of this interface is to minimize modification of the various components in order to provide an operational system in the least amount of time. The intent is to use existing components and electrical signals.

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DOE b(3)

Impact Condition Control.

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[redacted]

Neither of these subsystems development programs require integration with the interim penetrator. [redacted]

3. Joint Test Program.

[redacted] All tests will be joint DOE/contractor tests. [redacted] The electromagnetic environments (EMR and EMP) will be covered in a ground test. [redacted] The design demonstration will be the only tests involving detonation of the warhead high explosives.

[redacted]

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[redacted]

DOE b(1)

DOD b(3)

DOE b(1)

DOE b(1) (3)

XIV. APPENDIX F

PENETRATION DEMONSTRATION TESTS

A. [redacted] A total of four tests have been conducted. [redacted] e [redacted]

DOE b(1)

DOE b(1)

1. <u>Test Unit Description</u>.

In the first three tests, a [redacted] centercase was modified to accept a steel penetrator nose in place of the conventional [redacted]

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DOE
b(3)

Figure F1. Pre-test Hellbender II Penetrator

[redacted]

2. Instrumentation.

All four Hellbender test units used two independent onboard data recorders. One package was the standard [redacted] Joint Test Assembly (JTA) flight recorder. Its function was to record critical AF&F signals and timing. It was installed in the normal location inside the centercase assembly along with the components that it monitored. The second recorder was used to measure the impact deceleration. For the first three test units, this package was installed in the steel penetrator nose. [redacted] For the Hellbender I test unit, it monitored one internal accelerometer and four strain gauges mounted on the inside surface of the penetrator nose. For the ensuing assemblies, the recorder monitored the same internal accelerometer, a triaxial accelerometer on the firing set and strain gauges mounted on the inside surface of the aluminum centercase. In every instance, both data recorders were passive

DOE b(3)

and could be interrogated only after the test unit was recovered and disassembled. Note that both recorders were required to survive the earth penetrator environment in order to make the prescribed measurements.

3. Test Description.

All of the Hellbender tests were conducted at the Tonopah Test Range (TTR). In each instance, the objective was to subject the test unit to a realistic earth penetrator environment and demonstrate its ability to survive and function. For Hellbender I, III and IV, the delivery vehicle was a CH53 Marine helicopter. [redacted] missile). The Hellbender II test unit was delivered by a Twin Otter aircraft. This was used because none of the military helicopters were able to fly at the necessary release altitude for the desired impact velocity. All drops were controlled by voice command from the TTR Control Tower. The impact telemetry recorder was activated with a control box onboard the delivery vehicle. The [redacted] electrical system and the JTA flight recorder were initiated by the pullout actuator mounted in the penetrator tail. Flash bulbs on the test unit provided a visual indicator at the moment when the pullout actuator had been operated. For Hellbender I, the target at Tonopah was a dry playa known as Antelope Lake. The actual impact point was relatively hard soil (S# = 4) and completely devoid of rocks or gravel. The target for Hellbender II was much harder (S# = 2.4) at a region on a different playa called Browns Lake. The Hellbender III and IV target was a concrete pad built on the Main Lake at TTR. At the actual impact point, the concrete was 11 in. thick and had been cured to 5000 psi. The pad contained up to 2 in. diameter aggregate but no reinforcing steel. The soil under the structure had layers ranging from soft (S# = 6) to very hard (S# = 1.2).

All of the drop tests were recorded in flight with high speed tracking cameras and with high resolution fixed cameras at impact. All test units were recovered immediately after each test (see Fig. F2).

DOE b(3)

The units were then returned to Sandia National Laboratories for disassembly and JTA flight recorder interrogation. A complete bench test of the electrical system was then conducted to further verify the JTA flight recorder measurements.

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Figure F2. Recovery Operation for Hellbender III

4. **Test Results.**

DOE b(1)

DOE b(1)

1. **<u>Test Unit Description</u>**

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2. Instrumentation.

The standard JTA flight recorder was used to monitor critical AF&F signals just as it was used in the Hellbender test series. For the air drop test unit only, the penetration environment data recorder was not used. DOE b(1)

The test unit was instrumented with several transducers including triaxial accelerometers, roll-rate gyroscopes and a magnetometer. DOE b(1)

In addition to monitoring aerodynamic stability, the telemetry was used to initiate rocket staging, ball locks, spin rockets, B61-7 electronics and JTA flight recorder. The TM package also incorporated an arm/safe circuit interrupt for personnel safety during pre-test activities.

3. Test Description.

[redacted] The test unit was loaded on a cradle that was strapped to the cargo door of the C-130. At the appropriate time, the door was opened and the unit was dragged out of the bay by a parachute. After a predetermined length of time (7 sec), the parachute and spacer section were jettisoned via the ball-lock joint. [redacted] The selected target was the southwestern end of Antelope Lake. The actual impact point was relatively soft (S# 4.6). High speed tracking cameras were used to record the drop and also to obtain accurate trajectory and impact information. Since the potential impact area was large, no fixed ground cameras were employed.

DOE b(1)

[redacted] The unit separated smoothly from the second stage and decelerated through the critical trans-sonic regime. The actual trajectory was somewhat lower and shorter than predicted. The final impact point was a hard (S# = 3.0) feature known as Pedro Lake. The impact velocity was about 100 fps higher than predicted which resulted in a fairly severe earth penetrator test.

DOE b(1)

4. Test Results.

[redacted]

1.3.3 Size and Weight for Compatibility with the Missile

1.3.4 Yield

1.3.5 HE Safety

1.3.6 Plutonium Dispersal Safety

1.3.7 Minimum Use of Reactor Products

1.3.8 Operational Simplicity

1.3.9 Intrinsic Radiation

1.3.10 Minimum Maintenance

2. Warhead Characteristics

2.1 General Considerations

2.1.1 The nuclear warhead package will consist of the nuclear system, warhead electrical system, earth penetrating warhead case, and appropriate mechanical and electrical interfaces with the missile.

2.1.2 Warhead and missile system interface definitions shall be developed and coordinated through the Project Officers Group.

2.2 Operational Considerations.

2.2.1

DOE b(3)

2.5 Environmental and Vulnerability Considerations. The warhead shall survive, without reduction of specified design reliability or safety, the normal logistical and operational environments delineated in the Stockpile-to-Target Sequence (STS).

2.6 Reliability Considerations. The warhead shall have a reliability of TBD for all normal environments as defined in the Stockpile to Target Sequence (STS).

2.7 Safety Considerations. The warhead nuclear safety objectives require positive measures to prevent accidental or inadvertent arming and firing.

2.7.1 In the event of a detonation initiated at any one point in the warhead high explosive, the probability of achieving a nuclear yield greater than the energy equivalent of four pounds of TNT shall not exceed one in a million (1 in 10^6).

2.7.2 The probability of a premature nuclear detonation of the warhead for the normal logistical and operational environments described in the STS shall not exceed:

2.7.2.1 After stockpile entry, but prior to authorized prearm of the warhead (as defined in the STS), and in the absence of warhead initial enabling stimuli*, warhead final enabling stimuli*, and warhead battery initiate signal, 1 in 10^9 per warhead lifetime.

* Warhead enabling stimuli generally are unique signals and/or unique environments that operate

2.7.4 All warhead external connectors will be designed to accept and be provided with seal protected caps which preclude introduction of signals into the warhead without breaking of the seal and removal of the cap.

2.7.5 The warhead design shall:

2.7.5.1 Following DoD/DOE coordinated render safe procedures, the warhead shall meet the requirements of 2.7.3.

2.7.5.2 Minimize personnel exposure to radiological, high explosive, chemical toxicity or other hazards during maintenance, handling, and other operations in normal environments. High explosive and radiological hazards to personnel should be minimized when the warhead is subjected to abnormal environments.

2.7.6 Upon removal of the arming signal(s) to the main firing set, the firing set shall automatically revert to a safe condition within 10 minutes.

2.7.7 Warhead arrays shall remain subcritical in all planned operational configurations and under accident situations stated in the STS.

2.7.8 The intrinsic radiation output of the warhead shall be as low as reasonably achievable to minimize hazards to personnel during all phases of the STS. A desired goal, based on joint DoD/DOE weapon system tradeoff studies, is no more than TBD millirem per hour (mrem/h) total with no more than (TBD) mrem/h resulting from neutrons and measured at a distance of 1 m from the centerline of the warhead. The DOE shall provide the DoD with details of the intrinsic radiation output of the warhead as specified by project officer's group.

2.7.9 War reserve warheads will be identified with permanent and integral markings.

2.8 Maintenance and Equipment Considerations.

2.8.1 It is desired that the warhead require no maintenance or functional checking during the period between limited life component replacements. If maintenance or checking is necessary, the warhead shall be designed to permit accomplishment of these tasks while loaded on the launch platform, while in storage, or at Service Storage Facilities or their equivalent by qualified DoD personnel and shall require a minimum of time and specialized tools and equipment.

2.8.2 DOE supplied equipment to be used with this warhead will be capable of withstanding the same environmental conditions required of the warhead in areas where they are to be used together.

2.8.3 The warhead shipping and storage container shall be compatible with present military transportation systems and handling and storage procedures as described in the STS.

2.9 Command and Control

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[redacted]

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XVI. ACRONYMS AND TERMS

DOE b(1)

EMP	Electromagnetic Pulse
EMR	Electromagnetic Radiation
EPW	Earth Penetrating Weapon
ESD	Environmental Sensing Device
ICU	Interface Control Unit
IHE	Insensitive High Explosive
IMF	Integrated Maintenance Facility
JTA	Joint Test Assembly
MIU	Missile Interface Unit
MMII	Minuteman II Missile
OAS	Offensive Avionics System
OSD	Office of the Secretary of Defense
OST	Operational Suitability Test
PTP	Probability to Penetrate (defenses)
RV	Reentry Vehicle
REG	Retarded Ground
SAC	Strategic Air Command
S&TNF	Strategic & Theater Nuclear Forces
STS	Stockpile-To-Target Sequence

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DOE b(1)

RS5161/88/274, Series A, 182 Pages, SRD, 40 Copies, 7/1/88
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