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Joint DoD/DOE Phase 2 Feasibility Study of a High Power Radio Frequency (HPRF) Weapon

Final Report (U)

20 February 1996

11/06/99

DEPARTMENT OF ENERGY DECLASSIFICATION REVIEW	
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QA Review J. Zarkin 11/9/99

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1651 First Street SE
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This report has been reviewed and approved for publication.

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JOHN R. CURRY, Colonel, USAF
Chief, Nuclear Weapons Integration Division

Lawrence Livermore National Laboratory	Los Alamos National Laboratory
Sandia National Laboratories NM	Sandia National Laboratories CA
Department of Energy	Headquarters Defense Nuclear Agency
United States Strategic Command	Air Force Space Command
Department of the Army	Nuclear Weapons Integration Division

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Classification sources:

DOE & DTRA (b)(1) & USAF

1. HPRF-1
2. Joint DOE/DOD Nuclear Weapons Classification Policy Guide, CG-W-5, Jan 84
3. Air Force Nuclear Weapons Security Classification Guide, Jun 85
4. Draft HPRF Program Security Classification Guide, Mar 1995

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DEPARTMENT OF THE AIR FORCE

AIR FORCE MATERIEL COMMAND (AFMC)
NUCLEAR WEAPONS INTEGRATION DIVISION

MEMORANDUM FOR SEE DISTRIBUTION

27 Feb 96

FROM: SA-ALC/NWI
1651 First Street SE
Kirtland AFB NM 87117-5617

SUBJECT: Joint DoD/DOE Phase 2 Feasibility Study of a High Power Radio Frequency (HPRF) Weapon Final Report, 20 February 1996

1. Attached is a copy of the Final Report for the Joint DoD/DOE Phase 2 Feasibility Study of a High Power Radio Frequency Weapon. My point of contact for this report is Mr Francisco Carrillo. If you have any questions please call Mr Carrillo at commercial (505) 846-6767 or DSN 246-6767.

2. This letter is **UNCLASSIFIED.**

JOHN R. CURRY, Colonel, USAF
Chief, Nuclear Weapon Integration Division

Attachment:
Joint DoD/DOE Phase 2 Feasibility Study
of a HPRF Weapon Final Report, 20 Feb 96,
including Distribution List (S-RD)(N)

[redacted]

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Joint DoD/DOE Phase 2 Feasibility Study of a High Power Radio Frequency (HPRF) Weapon

Final Report (U)

20 February 1996

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(U) Also, additional vulnerability data should be acquired to complete the following three tasks, but not part of the 12-month study.

)E & I
TRA
(3)
& I
SAF

[redacted]

CG HPRF-1

(U) ABSTRACT

(U) The High Power Radio Frequency (HPRF) Phase 2 Feasibility Study Group completed 30-months of work and the study was terminated. This final report documents the study findings, conclusions, and recommendations.

DTRA b(3) & USAF

[redacted]

CG HPRF-1

DOE

DOE

(U) An additional 12-month study should be conducted to complete the following two tasks.

DOE & DTRA b(3) & USAF

[redacted]

CG HPRF-1

(U) Executive Summary

1.0. (U) PURPOSE

(U) The purpose of this study was threefold.

[redacted]

DOE & DTRA b(3) & USAF

2.0. (U) BACKGROUND

A. (S-FRD) The Air Force conducted a Phase 0 Scoping Study from August 1989 to May 1990 examining enhanced bomber penetration through Soviet Integrated Air Defenses (IAD). [redacted] The High Power Radio Frequency (HPRF) Phase 1 Conceptual Study was conducted from January 1991 to April 1992 using bomber penetration through the Soviet IAD as the mission of interest. [redacted] The Air Force initiated a 30-month HPRF Phase 2 Feasibility Study in August 1992 requesting Department of Energy (DOE) participation through the Nuclear Weapons Council Standing and Safety Committee. [redacted]

CG HPRF-1 — DOE & DTRA b(3) & USAF

CG HPRF-1 — DOE & DTRA b(3) & USAF

DTRA b(3)

DTRA b(3) & DOE & USAF

CG HPRF-1

[redacted] CG HPRF-1 — DOE & DTRA & USAF b(3)

B.

- (U) Lack of required intelligence data. [redacted] CG HPRF-1 — DOE & DTRA & USAF b(3)

3.0 (U) STUDY RESULTS

[redacted] CG HPRF-1 — DOE & DTRA & USAF b(3) It is also within the payload mass capable of being carried by the missile and delivered to the target. [redacted] DOE b(3)

[redacted]

B. (S-FRD) Vulnerability Testing and Mission Analysis. [redacted] DOE & DTRA & USAF b(3) Damage was obtained on nine of the eleven systems.

[redacted] CG HPRF-1 — DOE & DTRA & USAF b(3) However, the weak link or critical system in each mission area was identified for the purpose of future exploitation.

[redacted] DOE & DTRA & USAF b(3) CG HPRF-1

CG HPRF-1

DOE & DTRA & USAF b(3)

[redacted]

CG HPRF-1

DOE & DTRA b(3) & USAF

C. (U) Systems Engineering. Numerous trade studies which compared the implementation issues associated with missile system integration were conducted. Conceptual designs for integrating each HPRF warhead candidate into the MM III missile system were developed. A wide range of packaging and system engineering options were explored. Strategies were developed for implementing the different options. No show stoppers were identified in trade studies performed among the various options. Key issues from a weaponization and safety standpoint are [redacted] (CG HPRF-1) and strategic ICBM system use control.

USAF b(1)

D. (U) Nuclear Surety. A Quality Function Deployment evaluation of the warhead candidate designs was conducted in the areas of nuclear detonation safety, operational safety, nuclear material dispersal, and use control. This approach provided a structured appraisal of each candidate's surety features and contributed significantly to design refinement throughout the study. Upon completion of the evaluations, the data were combined to obtain an overall evaluation. The data for each area were normalized to cover the same range of values and then weighted with customer-supplied weights. With the exception of New Mexico (NM)-4, which had the lowest overall score, there was surprisingly little spread in the scoring. This was due to different candidates having strengths in different areas causing scores to even out. NM candidates scored higher in nuclear detonation safety with the exception of NM-4. California candidates scored somewhat higher in operational safety and nuclear material dispersal. CAT-F Permissive Action Link candidates received the highest scores in use control.

4.0 (U) CONCLUSIONS

(U) The study confirmed the following conclusions.

[redacted]

CG HPRF-1

DOE & DTRA b(3) & USAF

5.0 (U) RECOMMENDATIONS

A. (U) An additional 12-month study should be conducted to complete the following two tasks.

DOE & DTRA b(3) & USAF

CG HPRF-1

B. (U) Also, additional vulnerability data should be acquired to complete the following three tasks, but not part of the 12-month study.

DOE & DTRA b(3) & USAF

CG HPRF-1

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TABLE OF CONTENTS

(All portions of this Table of Contents are UNCLASSIFIED).

TABLE OF CONTENTS (Continued)
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TABLE OF CONTENTS (Continued)

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ACKNOWLEDGEMENTS

(U) We would like to thank a very diverse group of people from many different organizations for the time and effort expended in this study. Please be aware that the following list of participants is not all inclusive. The involvement of those who are not listed here is also greatly appreciated.

(U) Executive Working Group

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(U) Warhead Design Working Group (WDWG)

[redacted] CG HPRF-1 — USAF b(1)

(U) Vulnerability Working Group (VWG)

[redacted] CG HPRF-1 — USAF b(1)

(U) Mission Analysis Working Group (MAWG)

[redacted] CG HPRF-1 — USAF b(1)

(U) Systems Engineering Working Group (SEWG)

[redacted] CG HPRF-1 — USAF b(1)

(U) Surety Working Group (SWG)

[redacted] CG HPRF-1 — USAF b(1)

(U) Requirements Working Group (RWG)

[redacted] CG HPRF-1 — USAF b(1)

(U) Members/advisors, and participants on one/or more working groups:

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Mr John Anderson, SNL NM
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Mr Ben Wosoogh, Navy SSPO
Dr FC Yang, KSC

[redacted]

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ACRONYMS

[redacted]

DOE b(3)

CG HPRF-1

USAF & DOE

BCP	Battalion Command Post

[redacted]

DOE b(3)

USAF & DOE & USAF

CG HPRF-1

DIA	Defense Intelligence Agency
DMA	Defense Mapping Agency
DNA	Defense Nuclear Agency
DoD	Department of Defense
DOE	Depamment of Energy
DOE AL	Department of Energy, Albuquerque Operations Office
DOE HQ	Department of Energy, Headquarters

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[redacted]

ACRONYMS (continued)

DOI	Direct Optical Initiation
DRAAG	Design Review and Acceptance Group
DSA	Dual Stronglink Assembly
DSSL	Detonator Safing Stronglink

[redacted]

USAF & DOE

USAF

DOE b(3)

SAF

CG HPRF-1

GCP	Group Command Post
GPS	Global Positioning System
GRP	Guidance Replacement Program
GTS	Gas Transfer System

[redacted]

CG HPRF-1

DOE & USAF b(3)

ACRONYMS (continued)

USAF

CG HPRF-1

DOE b(3)

IAD	Integrated Air Defense
ICBM	Intercontinental Ballistic Missile
IHE	Insensitive High Explosive
JSTPS	Joint Strategic Targeting Planning Staff
LANL	Los Alamos National Laboratory
LCC	Launch Control Center
LDI	Laser Diode Initiated
LED	Light Emitting Diode
LF	Launch Facility
LLCE	Limited Life Component Exchange
LLCW	Low Level Continuous Waveform
LLNL	Lawrence Livermore National Laboratory

DOE b(3)

RA-AF

CG HPRF-1

ACRONYMS (continued)

CG HPRF-1

[redacted]

OO-ALC	Ogden Air Logistics Center
OSD	Office of the Secretary of Defense
OUPs	Manned Repeater Stations
PAL	Permissive Action Link
PBV	Post Boost Vehicle
PEIS	Programmatic Environmental Impact Statement
PIP	Program Implementation Panel
PL	Phillips Laboratory
PSS/E	Power System Simulator/Engineering
PTP	Probability to Penetrate

[redacted]

CG HPRF-1

RCS	Radar Cross-Section
RF	Radio Frequency
RS	Reentry System
RV	Reentry Vehicle

ACRONYMS (continued)

RWG Requirements Working Group

[redacted]

DTRA- & USAF

CG HPRF-1

DOE b(3)

TEL Transporter/Erector/Launcher

TPD Terminal Protection Device

ACRONYMS (concluded)

TTL	Transistor-Transistor Logic
USSTRATCOM	United States Strategic Command
VWG	Vulnerability Working Group
WDWG	Warhead Design Working Group
WES	Warhead Electrical System

1.0 (U) INTRODUCTION

1.1 (U) BACKGROUND

CG HPRF-1

[redacted]

DOE & DTRA b(3)

Both events were canceled due, at least in part, to a perceived lack of interest by the Department of Defense (DoD).

[redacted]

DOE & DTRA b(3) & USAF

CG HPRF-1

USAF

RA (1) DOE

[redacted]
CG HPRF-1
DOE & DTRA b(3) & USAF

(S-FRD) The HPRF Phase 1 Conceptual Study was conducted during the time period of January 1991 through April 1992. [redacted]
USAF

DTRA – USAF
[redacted]
CG HPRF-1
DOE & DTRA b(3) & USAF

Table 1-1. [redacted]
CG HPRF-1
DTRA & USAF
DOE & DTRA b(3)

SECRET

[redacted]
CG HPRF-1
DOE & DTRA b(3) & USAF

[redacted] CG HPRF-1 DOE & DTRA & USAF b(3)

The Strategic Air Command concurred and requested that the Air Force initiate an HPRF Phase 2 Feasibility Study.

1.2 (U) TASKING

(S-FRD) In August 1992, SAF/AQ initiated the HPRF Phase 2 Feasibility Study and the Department of Energy (DOE) was invited to participate in September 1992 through the Nuclear Weapons Council Standing and Safety Committee (NWCSSC) (Appendix B). The tasking emphasized potential strategic missions. USAF [redacted] DOE & DTRA b(3) & USAF It was recognized that a balance would have to be struck between these three criteria. Five mission areas were identified in the tasking.

[redacted] CG HPRF-1 DOE & DTRA b(3) & USAF

- (U) Lack of required intelligence data.

[redacted] CG HPRF-1 DOE & DTRA & USAF b(3)

1.3 (U) NAVY TASKING AND INVOLVEMENT

(U) The Navy was tasked to participate in the study but only provided an observer (Appendix B). There was no official response from the Navy to the tasking.

1.4 (U) STUDY OBJECTIVE

(C-FRD) [redacted] CG HPRF-1 USAF DOE & DTRA & USAF b(3)

[redacted]

C6 HPRF-1

DOE & DTRA b(3) & USAF

1.5 (U) STUDY ORGANIZATION

(U) An Executive Working Group (EWG) was formed to guide the HPRF Phase 2 Feasibility Study. The membership of the EWG was made up of the chair of each working group and/or a representative of each participating organization. The organizations involved with this study and which provided EWG members were:

Headquarters Defense Nuclear Agency (HQ DNA)
Field Command Defense Nuclear Agency (FCDNA)
Sandia National Laboratories New Mexico (SNL NM)
Sandia National Laboratories California (SNL CA)
Lawrence Livermore National Laboratory (LLNL)
Los Alamos National Laboratory (LANL)
Headquarters Air Force Space Command (HQ AFSPC)
Headquarters Air Combat Command (HQ ACC)
US Strategic Command (USSTRATCOM)
Phillips Laboratory (PL)
San Antonio Air Logistics Center, Nuclear Weapons Integration Division (SA-ALC/NWI)
Space & Missile Center, Det 10 (SMC, Det 10)
Ogden Air Logistics Center (OO-ALC)
Department of Energy, Headquarters (DOE HQ)
Department of Energy, Albuquerque Operations Office (DOE AL)
US Army Armament Research, Development & Engineering Center (ARDEC)

(U) The study group was organized into six working groups as follows:

USAF b(1)

[redacted]

DTRA b(1)

USAF b(1)

CG HPRF-1

1.6 (U) CLASSIFICATION AND SECURITY

(C-FRD) The classification levels involved in the HPRF Phase 2 Feasibility Study cover a wide range. The classification guides for this study are listed on the inside of the front cover of this report.

DOE & USAF b(3)

DTRA b(2)

A draft HPRF Security Classification Guide was prepared to address those areas not clearly defined in the referenced classification guides and is included in Appendix C.

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2.0 (U) WARHEAD CANDIDATE DESIGNS

2.1 (U) INTRODUCTION

DOE & DTRA b(1) b(3) & USAF

DOE
&
DTRA
b(3)
&
USAF

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DOE
&
DTRA
b(3)
&
USAF

CG HPRF-1

UNCLASSIFIED

[redacted]

[redacted]

DOE & DTRA b(1) b(3) & USAF

CG HPRF-1

2.3 (U) HPRF WEAPON CANDIDATES

(S-FRD) Both USSTRATCOM and HQ AFSPC requested that the study group attempt to design and package their warhead candidates in the Mk12A or Mk21 reentry vehicle (RV). If successful, this would simplify the Air Force handling and maintenance procedures and it would allow for transparency during arms control inspections across the ICBM forces. [redacted] If the desired performance of an HPRF weapon could not be achieved in the Mk12A or Mk21 RV, USSTRATCOM and HQ AFSPC requested that other design and packaging options be considered.

DOE & DTRA b(1) & USAF

[redacted]

DOE & DTRA USAF b(3)

CG HPRF-1

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DOE
&
DTRA
&
USAF
b(3)

CG HPRF-1

UNCLASSIFIED [redacted]

CG HPRF-1

DOE & DTRA & USAF b(3)

USAF

A brief list of salient features of these HPRF candidates are listed in Table 2-1. Additional weapon design details can be found in Section 4.3 and References 11 and 12.

DOE & DTRA & USAF b(3)

DOE b(3)

DOE & DTRA & USAF b(3)

CG HPRF-1

DOE & DTRA & USAF b(3)

CG HPRF-1

(S-RD) Anticipating the less than optimal performance of warhead candidates packaged in the constrained geometry of the Mk12A/Mk21, the New Mexico team choose to pursue a less constrained design option, the NM-3 candidate. The imposed design constraints were to fit within the shroud of the MM III and to be at or below the payload mass capable of being carried by the missile and delivered to target.

DOE & DTRA USAF b(3)

CG HPRF-1

Table 2-1. (U) New Mexico and California HPRF Candidates.

DOE & DTRA & USA b(3

CG HPRF-1 (d-a, b)

DOE & DTRA b(3)

DOE & USAF b(3)

CG HPRF-1 (d-a, b)

DOE & DTRA b(3) & USAF

Figure 2-4.

DOE & DTRA b(3) & USAF

Figure 2-5.

DOE & DTRA b(3) & USAF

Figure 2-

DOE & DTRA b(3) & USAF

[redacted]

USAF

DOE & DTRA b(3)

[redacted]

DOE & DTRA b(3)

CG HPRF-1

DOE & DTRA b(3)

2.4 (U) WARHEAD CERTIFICATION

(S-RD) There is one additional issue that must be addressed in order to conclude the warhead design section, that being warhead certification. Traditionally, when the DoD has been interested in acquiring a new nuclear weapon system, the DOE Laboratories test their design candidates in underground nuclear tests at the Nevada Test Site (NTS). Nuclear testing of HPRF weapon candidates has not been part of the HPRF Phase 2 Study. [redacted]

DOE & DTRA b(3) & USAF

(U) The DOE Laboratories are researching the meaning of nuclear weapon certification in a no-testing environment. To date, the only clear outcome is that the confidence level in weapon performance in a no-testing environment will not be as high as it traditionally has been during the nuclear testing era. Additional findings of the weapon certification investigation are published in the Replacement Warhead Assessment Report.[16]

3.0 (U) VULNERABILITY TESTING AND MISSION ANALYSIS

3.1 (U) INTRODUCTION

(C-FRD) This chapter addresses the key questions for the HPRF study. [redacted]

DTRA b(3)

- (U) Intelligence documents and schematic diagrams of equipment-uncertainty range, ± 10³.
- (U) Level 1 plus visual inspection of equipment-uncertainty range, ± 10². [redacted]

CG HPRF-1

DOE & DTRA b(3) & USAF

(U) It was recognized at the commencement of the HPRF Phase 2 Study that the accuracy of and confidence level in the assessments improves as one moves from level 1 to 4 in the assessments. Accordingly, the study was scoped out at 30 months in order to provide ample time to collect as much vulnerability test data as resources would permit.

(U) The four mission areas and some of the vital target systems within each mission are provided below.

[redacted]

CG HPRF-1

DOE & DTRA b(3) & USAF

(S) Each of these missions and the associated target systems for each will be discussed in more detail later in this section. The community had essentially no vulnerability data on any of the target systems listed above prior to the Phase 2 Study. During the course of the Phase 2 Study, data were acquired on eleven related target systems [redacted]

DOE

DTRA b(3) & USAF

DOE

3.2 (U) HPRF STUDY TEST AND ANALYSIS PROGRAM

[redacted]

USAF

DOE & DTRA b(3)

CG HPRF-

DOE & DTRA USAF b(3)

CG HPRF-1

DOE & DTRA b(1), b(3)

USAF

USAF

DOE & DTRA b(1), b(3)

CG HPRF-1

(C-FRD) The results of the tests are difficult to capture in a concise manner because of the complexities associated with the tests.

DOE & DTRA b(1), b(3) USAF

CG HPRF-1

[redacted]

DOE & DTRA b(3) & USAF

CG HPRF-1

3.2.1 (U) Test Results

[redacted]

DOE & DTRA b(3)

CG HPRF-1

USAF

DOE & DTRA b(3)

The following paragraphs summarize the cases of mission critical failures.

[redacted]

DOE & DTRA b(3)

USAF

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DOE &
DTRA, b(3) &
b(1), USAF

[redacted]

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[redacted]

[redacted]

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DTRA b(1)

DOE

DOE & DTRA b(3)

USAF

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(U) Other general results that were noted are included below.

DOE & DTRA & USAF b(3)

CG HPRF-1

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[redacted]

[redacted]

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b(1) USAF - WHOLE PAGE

DTRA

DOE b(3)

DTRA b(1)

DTRA

DOE b(3)

UNCLASSIFIED

CG HPRF-1

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DOE & DTRA b(1) & USAF

[redacted]

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Figure 3-1. [redacted]

[redacted]

[redacted]

[redacted]

DOE & DTRA b(1) b(3) & USAF

CG HPRF-1

(U) Given the limitations of the analysis model based on low-level test data, one might question the value of low-level test data-based assessments. For the purpose of predicting the occurrence of damage and functional response, the model is questionable.

USAF / USAF

[redacted]

DOE & DTRA & USAF b(3)

CG HPRF-1

(U) The computed stresses are shown in Figure 3-2 through 3-4. From these figures, the following observations were made.

USAF

[redacted]

DOE & DTRA b(3)

CG HPRF-1

[redacted]

[redacted]

Table 3-5. [redacted]

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DOE & DTRA b(1) b(3)

b(1) USAF

DOE & DTRA

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CG HPRF-1

[redacted]

DOE & DTRA b(1) & USAF b(3)

[redacted]

[redacted] [redacted]

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CG HPRF-1

[redacted]

[redacted]

b(3) DOE &
DTRA
b (1) &
USAF

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CG HPRF-1

[redacted]

DOE &
b(3) DTRA
b(1) &
USAF

[redacted]

UNCLASSIFIED

UNCLASSIFIED

CG HPRF -1

[redacted]

DOE & DTRA b(1) b(3) & USAF

[redacted]

CG HPRF-1

(U) The following points associated with the test data are to be noted. In some cases, additional analysis is required.

DOE & DTRA b(1)

DOE & DTRA b(3)

b(1) USAF

[redacted]

CG HPRF-1

DOE & DTRA b(1), b(3)

USAF

3.3 (U) FOREIGN ASSET ASSESSMENT TEAM (FAAT) ANALYSIS

(U) The analytical assessments of systems and system elements described in the previous sections were generally based on a methodology developed by FAAT[23]. The FAAT was composed of members from government and industry. The FAAT charter was to perform effects assessments of foreign assets by working with the intelligence community. The FAAT was requested to support the HPRF during the early scoping study by identifying targets of interest and performing an assessment of these targets. The user and intelligence community assisted by providing target scenarios for four missions and the following target descriptions.

- (U) Target employment.
- (U) Operational features.
- (U) Countermeasures and effectiveness.
- (U) Mission critical electronic subsystems.
- (U) Genealogy/surrogating.
- (U) Target ranking.
- (U) Target construction features and electronics vintage.

CG HPRF-1 DOE & DTRA b(1) & USAF

[redacted] The methodology was largely "paper-based", but relevant experimental data was applied when available. Probabilistic tools are applied to obtain the probability-of-effect (P_E). The FAAT analyst introduced random, systematic and judgmental uncertainties to the assessment process in arriving at the system P_E. The FAAT results may be useful for the following reasons.

- (U) Identifying applications that show promise.
- (U) Performing intra- and inter-group ranking.
- (U) Identifying blue and red surrogates for possible exploitation.
- (U) Identifying useful avenues for source development.
- (U) Identifying platform mission needs.

(U) The FAAT convened several times during the study and performed their zero-order assessments. Originally the HPRF Phase 2 was organized to test specific systems that were part of the four missions selected, however, most of the required systems were not available and other substitute systems were tested to obtain data for updating the FAAT models.

USAF b(1) DOE b(3) CG HPRF-1

[redacted]

(U) The major program findings and recommendations are as follows.

DOE & DTRA b(1) & USAF

[redacted]

CG HPRF-1

DOE & DTRA b(3), (1) & USAF

[redacted]

CG HPRF-1

USAF b(1)
DOE & DTRA b(3)

(U) [redacted]

CG HPRF-1

(U) Values of P_E obtained from an analysis and/or low-level testing should be recognized as unreliable for real-world predictions. Not only are analysis and low-level test-based predictions unreliable, but the uncertainties associated with these predictions are often too large to be useful in narrowing possible engagement outcomes. Nevertheless, analysis/low-level test-based predictions may prove useful as inputs to parametric engagement analyses (e.g., sensitivity studies). In addition, low level tests improve our knowledge of linear stresses that may be expected at critical locations inside the system.

[redacted]

DOE DTR & USA b(1)

[redacted]

DOE & DTRA & USAF b(3)

CG HPRF-1

3.5 (U) MISSION ANALYSIS

3.5.1 (U) [redacted]

DTRA b(1)

USAF

CG HPRF-1

3.5.1.1 (U) Simulation Model Description.

[redacted]

DOE & DTRA b(1), b(3)

USAF

CG HPRF-1

(U) [redacted]

DOE & DTRA b(3)

USAF

The performance of the system in the face of damage to some of its parts was then encoded in a script. In this way, partial operability of a system that suffered some damage was still a possibility.

[redacted]

USAF

DOE & DTRA b(1)

USAF

They did

OE
b(3)

CG HPRF-1

DTRA
b(1)

DOE
&
USAF
b(3)

CG HPRF-1 [redacted]

Figure 3-7.

Table 3-7. (U) Common Target Selection for HPRF Study.

CG HPRF-1

DOE & b(3)
DTRA
b(1) &
USAF

[redacted]

not deviate from the planned routes and did not react to any actions by defensive forces. No jamming or other counter-measures were employed.

[redacted]

DOE b(3)
&
DTRA b(1)
&
USAF

CC HPRF-1

CG HPRF-1

[redacted]

DOE & b(3) DTRA b(1) & USAF

3.5.1.3 (U) Baseline and Parametric Results.

[redacted]

DOE & b(3) DTRA b(1) & USAF

[redacted]

CG HPRF-1

[redacted]

DOE b(
&
DTRA
b(1),
b(3)
&
USAF

CG HPRF-1

DOE & DTRA b(3) & USAF

CG HPRF-1

USAF

DOE & DTRA b(3) & USAF

CG HPRF-1

USAF

Figure 3-9. (U) Penetration Analysis

[redacted]

DOE & DTRA b(3) b(1) & USAF

CG HPRF-1

3.5.2.1 (U) Mission/Target Description.

[redacted]

DOE b(& DTRA b(1) & USAF

DOE b(3)
&
DTRA
b(1)
&
USAF

CG HPRF-1

[redacted]

CG HPRF-1

DOE & DTRA b(1), b(3) & USAF

3.5.2.2 (U) Approach

[redacted] CG HPRF-1

DOE & DTRA b(1), b(3) & USAF

[redacted] Figure 3-11 illustrates the assessment methodology. The following paragraphs briefly summarize the key elements.

[redacted]

DOE & DTRA b(1), b(3) & USAF

CG HPRF-1

UNCLASSIFIED [redacted]

DOE & DTRA b(3) & USAF

ICG HPRF-1

[redacted] UNCLASSIFIED

[redacted]

DOE b(3) & DTRA b(1) & USAF

CG HPRF-1

3.5.2.3 (U) Results.

[redacted]

DOE b(3) & DTRA b(1) & USAF

CG HPRF-1

Unfortunately, there are so many variables and unknowns that formulation of such an MOE does not appear possible at this time.

CG HPRF-1

DOE & b(3) & DTRA b(3) & USAF

3.5.2.4. (U) Conclusions.

CG HPRF-1

DOE & DTRA b(3) US AF

[redacted]

CG HPRF-1

DOE & DTRA b(3) & USAF

3.5.3 (U) [redacted] CG HPRF-1

USAF

3.5.3.1 (U) Introduction.

[redacted]

DOE & DTRA b(3) & USAF

3.5.3.2 [redacted]

DOE & DTRA b(3)

DOE & DTRA b(3)

USAF

CG HPRF-1

DOE & DTRA b(3)

DOE & b(3)
DTRA b(1) & USAF

CG HPRF-1

DOE & DTRA

(S) Figure 3-15 illustrates how these elements are interconnected. [redacted]

3.5.3.2.1 [redacted]

b(3) b(1)

3.5.3.2.2 [redacted]

USAF

3.5.3.2.3 [redacted]

CG HPRF-1

3.5.3.3 [redacted]

CG HPRF-1

DOE & DTRA & USAF b(3)

DOE & DTRA b(1) b(3) & USAF

CG HPRF-1

Figure 3-15.

[redacted]

DOE b(3) & DTRA b(1) & USAF

CG HPRF-1

3.5.3.3.3 (U) Analysis.

[redacted]

DOE b(3) & DTRA b(1) & USAF

CG HPRF-1

The vulnerability inputs are

UNCLASSIFIED [redacted] TRA

DOE b(3)

b(1) & USAF

discussed later.

[redacted]

CG HPRF - 1

UNCLASSIFIED [redacted]

[redacted] DTRA b(1)

[redacted] DOE & USAF b(3)

[redacted] DTRA b(1)

CG HPRF-1

[redacted] DOE b(3) & DTRA b(1) & USAF

UNCLASSIFIED [redacted]

DOE
&
DTRA
6 (3)
&
USAF

6 (3)

CG HPRF-1

UNCLASSIFIED [redacted]

DOE b(3)
&
DTRA

b(1)
&
USAF

[redacted]

DOE b(3) & DTRA b(1) & USAF

CG HPRF-1

3.5.3.5 (U) Results and Conclusions.

CG HPRF-1

[redacted]

DOE b(3) & DTRA b(3) & USAF

UNCLASSIFIED [redacted]

DOE & DTRA b(3) b(1) & USAF

CG HPRF-1

USAF

DOE & DTRA b(3), b(1) & USAF

CG HPRF-1

UNCLASSIFIED [redacted]

UNCLASSIFIED [redacted]

DOE b(3) & F

DTRA

b(1) & USAF

CG HPRF-1

UNCLASSIFIED [redacted]

UNCLASSIFIED [redacted]

[redacted]

DOE b(3) & DTRA b(1) & USAF

CG HPRF - [redacted]

UNCLASSIFIED [redacted]

UNCLASSIFIED [redacted]

DOE b(3)
&
DTRA
b(1)
&
USAF

CG HPRF-1

USAF

UNCLASSIFIED [redacted]

DOE

DTRA
b(1
USAF

DOE

CG HPRF-1

USAF

DOE b(3) & DTRA b(1) & USAF

CG HPRF-1

C.G HPRF-1

DOE & DTRA b(3) & USAF

C.G. HPRF-1

DOE & DTRA b(3) & USAF

DOE

DTRA
6(3),
&
USAF

DOE

CG HPRF-1

DOE b(3) & DTRA b(1) & USAF

CG HPRF-1

3.5.4:2.3

DOE & DTRA b(3) & USAF

CG HPRF-1

DOE & DTRA b(3) & USAF

CG HPRF-1

USAF

DOE & DTRA b(3) & USAF

CG HPRF-1

[redacted]

DOE & DTRA b(3) & USAF

CG HPRF-1

USAF

[redacted]

CG HPRF-1

[redacted]

CG HPRF-1

DOE & DTRA b(3) & USAF

[redacted]

CG HPRF-1

DOE & DTRA & b(3) USAF

[redacted]

CG HPRF-1

DOE & DTRA b(3) & USAF

3.6 (U) VULNERABILITY AND MISSION ANALYSIS CONCLUSIONS AND RECOMMENDATIONS

3.6.1 (U) Conclusions

[redacted]

CG HPRF-1

DOE & DTRA b(3) & USAF

USAF

DOE b(3) & DTRA b(1)

[redacted] CG HPRF-1 Analysis combined with direct injection experiments is preferred since high fidelity simulation is not possible. DOE & DTRA & USAF b(3)

[redacted] CG HPRF-1 DOE b(3) & DTRA b(1) & USAF

High confidence results depend on high level testing of actual systems. Systems directly relevant to the missions considered were not available during the Phase 2 Study.

[redacted] CG HPRF-1 DOE b(3) & DTRA b(1) & USAF

3.6.2 (U) Recommendations

[redacted] CG HPRF-1 DOE b(3) & DTRA b(1) & USAF

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4.0 (U) SYSTEMS ENGINEERING

4.1 (U) INTRODUCTION

(S-RD) The Systems Engineering Working Group (SEWG) was organized to assess the issues associated with integrating the HPRF warhead into the MM III missile system. [redacted] CG HPRF-1 (d.a) — USAF, DOE & DTRA b(3); USAF

(U) Some of these designs only suggest the possible and are not optimized nor exhaustive. Features to be highlighted in one concept, might work equally well in other designs, but are shown only once for brevity. The final point designs will likely extract features from several different concepts.

4.1.1 (U) Technical Objectives

(S-FRD) The technical objectives of the SEWG were to document the information in a fashion that would provide a substantial starting point to subsequently develop this concept further. [redacted] DTRA b(1)

The engineering effort developed implementation strategies for several different options but did not rank order the design options or down-select the candidates. Selecting the final candidates will be done when the MCs are finalized and a warhead is chosen. The SEWG was responsible for concept design of the warhead exclusive of the nuclear explosive package (NEP).

4.1.2 (U) Methodology

[redacted] DOE b(& DTRA b(1) USAF

The Air Force is planning several changes for the MM III missile system: (1) "de-MIRVing" the missile, (2) replacing the guidance computer and (3) replacing some of the Mk12A/W78s with the Mk21/W87 warhead. The "de-MIRVing" and warhead replacement are dependent on ratification of START II. The guidance computer replacement is currently underway.

(S-FRD) The SEWG was divided into two design teams. The New Mexico team (Los Alamos National Laboratory (LANL) and Sandia National Laboratories New Mexico (SNL NM)) engineered the LANL warhead proposals, concentrating on their use in the Mk12A aeroshell and the California team (Lawrence Livermore National Laboratory (LLNL) and Sandia National Laboratories California (SNL CA)) investigated the integration issues associated with placing the LLNL warhead candidates into Mk21 aeroshells. Insight gained by one team was useful to both teams. The result is a data base that would permit engineering any candidate into either aeroshell. The New Mexico team also proposed a larger device which was not constrained by the Mk12A or Mk21. The New Mexico team designed a fixture for mounting the larger device directly on the MM III bus and provided its own aeroshell.

4.1.3 (U) Assumptions

(S-FRD) There were three major assumptions applied during the SEWG assessment. [redacted] CG HPRF-1

DOE & DTRA b(3) & USAF

(S-FRD) The secon[redacted] assumption, which applied to most of the candidate options, was that the HPRF warhead wou[redacted] be compatible with the Mk12A or Mk21 RV. This was partially driven by Air Force Operation[redacted]ecurity particularly during START inspections. [redacted] CG HPRF-1

DTRA b(1) & USAF

(U) The third assumption was that the MM III Single Reentry Vehicle (SRV) and Guidance Replacement Program (GRP) would be completed. Completing the GRP is critical because warhead safety intent signals, use control features, and the Mk21 interface depend on the new guidance computer. [redacted] CG HPRF-1

USAF, DOE & DTRA b(3)

4.1.4 (U) Constraints

[redacted]

DOE & DTRA b(3) USAF

Compatibility further requires that the electrical and mechanical interface of the existing RVs be maintained.

[redacted] CG HPRF-1

DOE & DTRA b(3) & USAF

(C) The third constraint involved incorporating use control features into the HPRF warhead. The DoD issued a new use control directive, i.e., DoD Directive S-3150.7, towards the end of the study. The directive imposed restrictions not identified in the tasking letter. Suggestions were provided for implementing the likely options and the integration issues were discussed.

4.2 (U) GENERAL INTEGRATION ISSUES

CG HPRF-1 (d.a)

DOE & DTRA b(3) & USAF

4.2.2 (U) Use Control

(C-FRD) There are technical options up to and including Category-F Permissive Action Link (CAT-F PAL) in the warhead. The implementation of use control for an existing strategic missile system, however, will require additional study. The issue is complicated by the fact that there is no consensus on the definition of a CAT-F comparable system referred to in DoD Directive S-3150.7. The study developed a methodology for addressing the relative benefits of increased use control coverage (incorporating use control features that operate during multiple stages of the Stockpile to Target Sequence (STS)). The strategy for determining a solution is very sensitive to the weight applied to the metrics used to assess the candidates (e.g. time of exposure, effectiveness of penalty, maturity of technology used, etc.). Additional study is needed to investigate details before any options can be selected.

4.2.3 (U) Nuclear Safety

DOE & b(3)

(U) The goal for nuclear safety was to propose designs with enhanced nuclear detonation safety (ENDS), insensitive high explosive (IHE), and fire resistant pit (FRP) technology. A variety of ENDS implementations are proposed. Some use stockpile technology and can be implemented immediately, while others are based on prototypes and may require additional development.

4.2.4 (U) Flight Performance

(S-FRD) Flight performance conclusions are based on calculations not flight tests,

DOE & DTRA b(3), USAF

4.2.5 (U) Warhead Packaging

CG HPRF-1 (d.a.b)

DOE & DTRA b(3) & USAF

4.2.6 (U) Missile Integration

(S-FRD) A major impact on the proposed designs is the requirement for use control. The specific category and coverage required will eliminate some of the options. Continuation of the GRP is important to determine the missile/warhead interface. The existence of the GRP is critical to implementing use control and nuclear safety. The payload support deck design interface with the HPRF candidate must be reviewed in order to minimize the impact on the delivery performance.

4.2.7 (U) Other Issues

CG HPRF-1 (d.b)

DOE & DTRA b(3) USAF

Questions of flight testing requirements, weapon system certification, reliability assessment, and stockpile certification for small quantities of warheads are also issues.

4.3 (U) ENGINEERING DESIGN DETAILS

CG HPRF-1 (d.a.b)

DOE & DTRA b(3) & USAF

CG HPRF-1 (d.a.b)

DOE & DTRA b(3) & USAF

In addition, issues associated with incorporating use control features and implementing the nuclear safety human-intent signal sub-system were explored.

CG HPRF-1

DOE & DTRA USAF b(3)

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SECRET-RESTRICTED DATA

Table 4-1. (U) Summary of Candidates Attributes.

CG HPRF-1 (d. a, b)

DOE & DTRA b(3), & USAF

SECRET-RESTRICTED DATA

UNCLASSIFIED [redacted]

Table 4-1. (U) Summary of Candidates Attributes (con't).

SECRET-RESTRICTED DATA

[redacted]

DOE & DTRA b(3) & USAF

SECRET-RESTRICTED DATA

DOE & DTRA

[redacted] As much as practicable, all mechanical (e.g. mass properties, mounting fixtures) and electrical features were to be maintained. The goal was to minimize customer costs across the board, including items such as flight testing, software certification, etc. Improving other features such as the safety theme or use control were not considered.

CG HPRF-1 (d.a,b) DOE & DTRA b(3) & USAF

[redacted] After the basic warhead/RV architectures were outlined, the use control features were incorporated. Additions to the WES were made to accommodate use control and the human intent signal sub-system. The electrical and mechanical interfaces for the warhead were copied from the Mk21. Any modifications were linked to the Mk21 SRV option for the MM III program controlled by the ICBM Warheads System Program Office. A common nuclear safety and use control theme is applied to all candidates.

DOE & DTRA b(3) & USAF

[redacted] All candidates emphasize nuclear safety, with a baseline theme of dual unique signal prearming, stronglink, weaklink, and exclusion region. DOE & DTRA & USAF

[redacted] A physically strong exclusion region in the form of a metal barrier is provided in the design of each candidate. DOE & DTRA USAF

CG HPRF-1 (d.a,d)

[redacted] DOE & DTRA USAF

CG HPRF-1 (d.a)

CG HPRF-1 (d.a,b)

[redacted] DOE & DTRA b(3) USAF

USAF, DOE & DTRA b(3)

[redacted]

CG HPRF-1 (d.a, b)

[redacted]

CG HPRF-1 (d.a, b)

(S-RD) The NM-1 and NM-1A designs match the stockpile weights and center of gravity (CG) more closely than the other concepts. As a result, a flight testing/qualification program may be avoided or at least minimized.

[redacted]

CG HPRF-1 (d.a, b)

DOE & DTRA b(3) USAF

[redacted]

CG HPRF-1 (d.a, b)

(S-RD) A basic design goal was a vehicle that was indistinguishable from the Mk12A/Mk21 RV when hidden beneath an opaque cover.

[redacted]

CG HPRF-1

DOE & DTRA b(3) USAF

[redacted]

CG HPRF-1

[redacted]

DOE & DTRA b(3) & USAF

CG HPRF-1 (d, a, b)

4.3.3 (U) Minimum-Modification (MIN-MOD) Designs

(U) The purpose of these MIN-MOD designs is to present warhead options that minimize the cost to the Air Force. The goal was to maintain the current warhead-to-missile interface and to eliminate the need for flight testing. Simply stated, a MM III could launch a MIN-MOD candidate as easily as either a Mk12A/W78 or a Mk21/W87.

US AF NO

[redacted]

US AF

DOE & DTRA b(3)

CG HPRF-1 (d, a, b)

CG HPRF-1

DOE & DTRA b(3) USAF

[redacted] The final payload specifica [redacted] were based on a trade study of payload weight to range (Figure 4-1). The selected values w [redacted] onsistent with the mission maximum range requirements.

CG HPRF- [redacted] 1, a,b)

DOE & DTRA b(3) & USAF

[redacted] The warhead mounts directly on top of the support structure. The RS module support platform has been modified in the past to hold different configurations of weapons. Modification of the platform for this new weapon will also be required.

DOE & DTRA b(3) USAF

[redacted]

CG HPRF-1 (d,a,b)

[redacted] The ascent shroud does not add significant weight to the system.

4.3.5 (U) Navy Packaging Excursions

DOE & DTRA b(3) USAF

[redacted]

CG HPRF-1

4.4 (U) SPECIFIC DESIGN INTEGRATION ISSUES

CG HPRF-1

DOE & DTRA b(3) & USAF

[redacted]

SAND93-1240
203.5
CG HPAF-1 (d.g)

DOE b(3) & DTRA b(1) & USAF

Figure 4-1.

4.4.2 (U) Use Control

(U) Use control themes have been developed using both current and developing technologies (See Table 4-2). The themes allow weapon use only when authorized by the National Command Authority (NCA) and prevent or delay unauthorized use. Absolute denial of the use of the weapon or the Special Nuclear Material (SNM) it contains, to a determined adversary, is not feasible with the condition that the penalties invoked will not harm personnel in the vicinity. This limitation leads the use control designs to focus on providing a time delay to allow security forces to recover possession of the weapon before it can be used in either the intended mode or an unintended mode.

(U) The hardware proposed to implement the use control theme ranges from stockpile examples to R&D technologies. It ranges from no PAL to CAT-D PAL to CAT-F PAL, and also includes CD and CAT-E PAL in appropriate assembly configurations.

Table 4-2. (U) HPRF Use Control Summary
(x = baseline condition)

[redacted]

CG HPRF-1 (d.e)

DOE b(3) & DTRA b(1) & USAF

(C-FRD) [redacted]

DTRA b(1)

CG HPRF-1 (d.e)

SAF b(1)

DTRA b(1)

4.4.3 (U) Warhead Electrical System (WES) and Safety Theme Integration

(U) Under the GRP, the missile guidance computer can be configured to accept a human intent signal from the launch control signal and deliver it to the HPRF warhead during third stage burn. In this scenario the environmental sensing signal generator (ESSG) will no longer be used. The intent signal will be sent to the warhead on the same interface cables formerly used by the ESSG signal.

(S-FRD) The baseline WES for the New Mexico designs uses a conservative approach. The volume for the WES components is adequate so that space and form factor requirements do not stress component design. The designs feature simple interconnections and stockpile hardware where possible. [redacted] USAF b(1)

[redacted] The proposed system designs allow all of the nuclear safety and use control hardware to be built directly into the package as opposed to an add-on to a current WES. The New Mexico baseline WES design features a Dual Stronglink Assembly (DSA). The DSA concept was designed and developed in the late 1980s to implement and optimize modern concepts of safety and control.

[redacted] DOE & DTRA b(3) & USAF

Implementation could be done either by keeping the designs separate as partitions of an overall single assembly, or by having a completely integrated design.

Table 4-3. (U) New Mexico WES Options

USAF b(1)

FOR OFFICIAL USE [redacted]

Safety Theme		Feature	Trajectory sensor
A	[redacted]	CDU+DSA	SESD
B	[redacted]	CDU+SSA+DSSL	SESD
C	[redacted]	DOI	SESD
D	[redacted]	MC 2969 SLS	MC 3160 ESD

FOR OFFICIAL USE ONLY

(U) The California designs all use the W87 WES modified to accommodate use control features, if desired, and a programmer to interface with the new functions. [redacted] DOE & DTRA b(3)

4.4.4 (U) Flight Performance

[redacted] DOE & DTRA b(3) & USAF

CG HPRF-1

[redacted]

CG HPRF-1 (d.a,b) DOE & DTRA & USAF b(3)

(U) A more extensive study was subsequently conducted by SNL.[30] The key difference was it looked at RVs with many different CG locations. [redacted]

CG HPRF-1 DOE & DTRA b(3) & USAF

(U) The recommendations from these flight performance studies can be summarized as follows. [redacted]

CG HPRF-1 DOE & DTRA & USAF b(3)

A flight-test program will be necessary to determine the actual gyroscopic reentry stability.

4.5 (U) SYSTEMS ENGINEERING CONCLUSIONS

(S-FRD) Numerous trade studies which compared the implementation issues associated with missile system integration were conducted. The systems engineering team developed conceptual designs for integrating each HPRF warhead candidate into the MM III missile system. Strategies were developed for implementing the different options. No show stoppers were identified by the trade studies. [redacted] The impact of use control was also studied; options up to and including CAT-F designs were considered. DOE & DTRA & USAF b(3)

[redacted]

DOE & DTRA b(3) & USAF

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UNCLASSIFIED

CG HPRF-1

[redacted]

[redacted]

DOE & DTRA b(3) & USAF

CG HPRF-1

[redacted] Finally, the reader should be reminded that not every variant satisfied every mission/warhead option.

(U) It is recommended for any future work on new, silo-based warheads, that a mutually agreed upon definition of 'CAT-F PAL comparable protection" consistent with Reference 31 be determined at the onset of the study.

5.0 (U) NUCLEAR SURETY

5.1 (U) INTRODUCTION

(U) Nuclear surety normally encompasses three subjects: (1) nuclear safety, (2) use control, and (3) physical security. Nuclear safety deals with nuclear detonation safety and radiological material dispersal, principally plutonium. It involves design concepts and methodologies for the prevention of unintended nuclear detonation of, or the dispersal of radiological material from, nuclear weapons. Use control involves concepts and features designed to prevent unauthorized use while allowing authorized use when directed by the National Command Authority (NCA).

(S-RD) The Surety Working Group (SWG) defined four areas of surety for evaluation: (1) nuclear detonation safety, (2) operational safety, (3) nuclear material dispersal (plutonium and tritium), and (4) use control. The SWG addressed nuclear safety and use control for all of the proposed warhead design concepts but did not address physical security. This is the fi [redacted] use control has been addressed in a Phase 2 Study for a silo-based strategic system [redacted]

CG HPRF-1 (d.a) DOE & DTRA b(3) & USAF

(U) The evaluation approach was to employ Quality Function Deployment (QFD) methodology to the warhead candidate designs as provided by the Systems Engineering Working Group (SEWG). The QFD methodology is a structured process which involves the assessment and rating of alternate designs and processes from conceptual design to production. For a Phase 2 Study, only the parts of the process which compare the design concepts and their evaluation are involved. The results of nuclear surety are presented below in an abbreviated form. The complete results are included in the SWG report.[32]

5.1.1 (U) Requirements

5.1.1.1 (U) Nuclear Safety

(U) Nuclear warheads are built to basic nuclear safety standards prescribed by the DOE (DOE Directive 5610.10).

5.1.1.2 (U) Use Control

(U) The requirements for command and control in the HPRF Military Characteristics (MCs) include use control. These use control requirements are consistent with DOE and DoD policies and directives,[31,33] and the FARR Study recommendations.[34]

5.1.2 (U) Special Concerns and Unique Issues

[redacted]

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DOE & DTRA b(3) & USAF

CG HPRF-1 (d. a, b)

5.2 (U) NUCLEAR DETONATION SAFETY

5.2.1 (U) Introduction, Approach, and Evaluation Criteria

(U) The DOE and DoD share responsibility for nuclear safety. The draft MCs and the Stockpile-to-Target Sequence (STS) include requirements for nuclear detonation safety. The candidate warheads are designed to meet the STS and MC requirements and to provide the required levels of protection against inadvertent nuclear detonation in the absence of specified safety-critical inputs. The DoD must assure protection against unintentionally generating those specific safety-critical inputs (warhead enabling stimuli in normal and abnormal environments plus the warhead arming signals in normal environments) to a level commensurate with the assured protection provided by the HPRF warhead design.

(C-FRD) The Warhead Design Working Group (WDWG) and SEWG provided the candidate designs including safety themes to the SWG for evaluation. The safety themes are based on a number of safety principles including isolation, incompatibility, and inoperability of detonation critical components from enabling energy (e.g., electrical or optical). In addition, first-principle approaches include exclusion regions, exclusion region barriers, stronglinks, weaklinks, collocation, and unique signals.

DOE & DTRA b(3) & USAF

CG HPRF-1

(U) The nuclear explosive package (NEP) is one-point safe for all candidates, and for all except NM-4, incorporates IHE and an FRP. In all the safety themes, there are two stronglink switches, in series, to exclude electrical energy from the firing set until intended. One of these is opened by a human intent unique signal, the other by a unique signal from a trajectory-activated environmental sensor. The human intent signal is provided in conjunction with the emergency action message enabling launch. Weaklinks, in most cases the firing set capacitor, are designed to fail and preclude firing before the exclusion region fails in an abnormal environment. For Direct Optical Initiation (DOI), the stronglink prevents laser output until intended rather than isolating external energy. The associated thermal weaklink is a critical optical component in the laser.

(U) Each safety theme defines three safety subsystems; human intent, trajectory and arming, each with an assumed safety level of one in 10^3 in STS environments.

5.2.2 (U) New Mexico Candidate Safety Themes

(U) Table 5-1 lists safety theme options for the New Mexico warhead candidates. [redacted]

DOE & DTRA b(3)

Table 5-1. (U) New Mexico Safety Theme Options.

FOR OFFICAL [redacted]

Safety Theme	[redacted]	Distinguishing Features	Trajectory sensor
A		CDU + DSA	SESD
B		CDU + SSA + DSSL	SESD
C		DOI	SESD
D		[redacted]	[redacted]

USAF b(1)

DOE b(3)

CG HPRF-1

FOR OFFICAL USE OFFICAL

(U) Safety Theme A is depicted schematically in Figure 5-1. It features a Capacitive Discharge Unit (CDU) firing set in conjunction with a Dual Stronglink Assembly (DSA). The DSA is the distinguishing component in this system. It is packaged within the firing set and preserves the exclusion barrier's electrical energy isolation by gating arming power to the CDU via interrupted transformer magnetic coupling. In the normal state, the transformer core is physically interrupted (cut in two) and rotated 90° so that the halves lie in orthogonal planes. The magnetic field is thus disrupted and only an insignificant amount of electrical energy can be coupled from the primary windings to the secondary windings. In order to transfer energy through the transformer in the enabled state, the magnetic circuit must be completed by inserting a magnetic material into the gap between the cores. Two non-magnetic wheels are inserted between the transformer halves. A ferrite window is placed in each wheel for each transformer. When both wheels are rotated into the correct positions by the unique signal drives from their respective safety subsystems, the ferrite windows complete the magnetic circuit. The wheels containing the ferrites are rotated by electromechanical drive mechanisms. The trigger signal also passes through the DSA and is magnetically coupled to provide the firing signal.

(U) Safety Theme B (Figure 5-2), with the Detonator Safing Stronglink (DSSL) and Single Stronglink Assembly (SSA) provides better isolation nearer the detonators and thus provides better bypass protection, but it has additional drive cable penetrations into the exclusion region.

(U) Safety Theme C (Figure 5-3) uses Direct Optical Initiation (DOI) and offers more potential detonator safety. It uses an optical weaklink.

[redacted]

DOE & DTRA b(3)

5.2.3 (U) California Candidates Safety Theme

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[redacted] It features a Mechanical Safing and Arming Device and an Environmental Sensing Device (ESD) similar to that on the W87, but tailored to the trajectory characteristics of the MM III.

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DTRA, USAF

5.2.4 (U) Evaluation of the Safety Themes

(U) Each of the warhead candidates was evaluated based upon eight criteria that were agreed upon by the nuclear safety assessment team. These attributes are intended to address only nuclear detonation safety. Technical risk was not evaluated as a separate criteria in the assessment. In addition, these eight evaluation criteria were assigned weights in the range from 1-10, since some of them were judged more important than others. Each of the weapon candidates was evaluated for each of the eight criteria and given a rating between -2 and +2.

5.2.4.1 (U) Evaluation Criteria

(U) The eight evaluation criteria and their assigned weights are as follows. [redacted]

[redacted]FIDENTIAL

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5.2.4.1.1 (U) Exclusion Region Thermal Robustness.

(U) A measure of the ability of the exclusion region to maintain integrity and provide isolation during or following exposure to high temperatures. The key features here are the use of high melting point materials for all elements of the barrier and minimization of the impact of joints and penetrations. Weight = 10.

5.2.4.1.2 (U) Exclusion Region Mechanical Robustness.

(U) A measure of the ability of the exclusion region to maintain integrity and provide isolation when exposed to such mechanical environments as crush, impact, vibration or puncture. The key features here are the use of high strength and ductile materials for all elements of the barrier and strong joints between exclusion region elements. Weight =10.

5.2.4.1.3 (U) Stronglink Resistance to Bypass.

(U) A measure of the thermal, mechanical and electrical robustness of the stronglink and its attachment to the exclusion barrier. A magnetic stronglink is seen as having better electrical high voltage standoff capability than a mechanical switch or a typical ESD because it is not susceptible to high-voltage arcing. A welded attachment is usually better than an attachment with screws. A protected location is preferable to cantilevering from the end of the firing set. Large physical size, strength, and thermal integrity are advantageous. Weight =8.

5.2.4.1.4 (U) Stronglink Location.

(C-FRD) A criteria which measures the location of stronglinks at the firing set versus the detonators. There is believed to be an advantage to locating the stronglink as close as possible to the physics package so that protection may be maintained even if the fire set is torn away or the exclusion barrier is otherwise compromised. Weight =8.

5.2.4.1.5 (U) Weaklink(s).

(U) A measure of an element or component that is necessary to produce a nuclear detonation, that becomes irreversibly inoperable at an environmental stress level lower than that which will threaten the exclusion region (including stronglinks). Weight =6.

5.2.4.1.6 (U) Discrimination Level of Stronglinks.

(U) A measure of the methods for introducing or generating the unique signal and the discrimination ability of the stronglink actuator. An electromechanical discriminator is rated better than an inertial ESD. Weight =5.

5.2.4.1.7 (U) Resistance to Direct Multipoint Initiation.

(U) A criterion measured by lack of electrical paths to the high explosive other than the intended mode through the detonators (lack of or well protected penetrations into exclusion region). The lack of possible alternate electrical paths and well designed penetrations is important, because nuclear detonation can only be achieved for a one point safe NEP by initiating the main charge explosive at more than a single point, either at multiple discrete points or along a line or surface. Weight =5.

5.2.4.1.8 (U) Insensitivity of Detonators.

(U) A criteria measured by insensitivity to energy applied to the detonators which includes signal amplitude, waveform, and uniqueness. DOI, Slapper detonators, and explosive bridge wires are in decreasing order of insensitivity. Weight =2.

(U) Table 5-2 is the evaluation or Pugh matrix for the safety themes presented against the evaluation criteria and weighting.

5.2.5 (U) Nuclear Detonation Safety Summary and Conclusions

(U) Based upon the assessment methodology described, the weighted totals for the six HPRF safety themes fall into three general groups. New Mexico candidate safety themes A, B, and C scored 76, 83, and 78 respectively. The two California candidate safety themes received weighted totals of 28 and 38. New Mexico candidate safety theme D had a weighted total of -28. These three general groups represent the evolution of safety technology over time. Candidate D scored the lowest since it utilizes first generation ENDS technology. The first generation ENDS technology has been improved upon and enhanced through the development of better stronglinks and barriers. The California candidates, which are based upon W87 technology, fell in the middle of the scoring range due to the utilization of enhancements like detonator safing. The remaining three New Mexico candidates, which use the most current safety enhancements, scored the highest by better implementation of safety technology.

5.3 (U) OPERATIONAL SAFETY

5.3.1 (U) Introduction - QFD Approach, Definitions, and Evaluation Criteria

(S-RD) The QFD evaluation of operational safety started with the use of the House of Quality (HOQ) rather than with a Pugh matrix. [redacted] Criteria have not been developed for evaluating this feature, and the HOQ serves to identify appropriate measures for doing so. The HOQ and its application to defining the measures is fully described in the SWG Final Report.[32]

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5.3.2 (U) Warhead Candidate Operational Safety Evaluation

(U) The rating system developed for the candidates is based on a 0, ±1, ±2 scale, applied to the measures from the HOQ, as defined in Table 5-3. Table 5-4 defines important operational safety design elements of the proposed warhead candidates. Table 5-5 lists the measure values for each of the warhead candidates. The next step in the process is to create the Pugh matrix. Table 5-6 is the unweighted Pugh or evaluation matrix. Table 5-7 is the weighted Pugh matrix. The evaluation criteria on the left are the measures from the HOQ. The importance is a weighting factor derived from the HOQ. The warhead candidates are listed in the row across the top of the Pugh matrix.

[redacted]

Table 5-2. (U) Nuclear Detonation Safety Evaluation Matrix.

EVALUATION CRITERIA	We
ER THERMAL ROBUSTNESS	1
ER MECHANICAL ROBUSTNESS	10
SL BYPASS RESISTANCE	8
STRONGLINK LOCATION	8
WEAKLINKS	6
SL DISCRIMINATION	5
DIRECT INITIATION RESISTANCE	5
INSENSITIVITY OF DETONATORS	2
TOTALS (UNWEIGHTED)	
WEIGHTED TOTALS	

[redacted]

Weightings are from 1 to 10, 10 being the best

Rankings are from -2 to +2, +2 being the best

DOE b(3)

[redacted]

[redacted]

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Table 5-3. (U) Measure Evaluation Criteria.

[redacted]

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[redacted]

[redacted]

[redacted]

Table 5-5. (U) Candidate Warhead Design Parameters.

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[redacted]

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[redacted]

[redacted]

[redacted] DOE b(3) & DTRA & USAF

Table 5-7. (U) Operational Safety Evaluation (Weighed Pugh).

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[redacted]

5.3.2.1 (U) Interpretation of the Evaluations

(S-RD) In interpreting the results of the QFD exercise, the "Bottom Line" of the evaluation matrix should not be regarded as a final report card. Rather differences in the totals of the candidates should be examined to determine what features caused the difference. They may indicate features which, if adopted by other candidate designs, might significantly improve their overall score. In fact, some of this clearly occurred during the course of the study. Both the NM and CA teams made changes in their design concepts throughout the study. As a result, the spread in totals is less now than in earlier iterations.

DOE & DTRA USAF b(3)

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(S-RD) The weighted Pugh operational safety evaluation, Table 5-7, gives a much larger spread (-24 to +16) than the unweighted version (-2 to +2).

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[redacted]

CG HPRF-1

5.4 (U) NUCLEAR MATERIAL DISPERSAL

5.4.1 (U) Introduction

(S-RD) This section presents the evaluation of the candidate designs for safety with respect to the accidental dispersal of radioactive material.

DOE & DTRA & USAF b(3)

[redacted]

CG HPRF-1 (d.a,b)

5.4.2 (U) Candidate Designs and Evaluation for Tritium Dispersal

(C-RD) Table 5-8 lists features, or measures, for which the candidate designs differ and which may affect dispersal safety.

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[redacted]

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[redacted]

[redacted]

Table 5-8. (U) [redacted]

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[redacted]

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[redacted]

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(U) [redacted]

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DOE & DTRA b(3)

(U) Table 5-11 contains the weights for the various design features, applies these to the scores in Table 5-10, and provides a total score for each design. The weights indicate how important one feature is relative to the others. In the absence of a lengthy and detailed analysis that indicates the relative importance of each design feature, and lacking the design detail that would make such an analysis possible, the assignment of weights to each design feature can only be subjective. [redacted]

CG HPRF-1

USAF b(1)

5.4.3 (U) Nuclear Material Dispersal Conclusions

(U) Taking the dispersal of all radioactive materials into account, candidate NM-4 does not have IHE or FRP and has a higher risk of Pu dispersal [redacted]

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[redacted]

CG HPRF-1 (d, a, b)

DOE & DTRA b(3)

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[redacted]

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DTRA & USAF

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Table 5-10. (U) Unweighted Evaluation Matrix for Tritium Dispersal Safety.

[redacted]

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[redacted]

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CG HPRF-1 (d.a, b)

5.5 (U) USE CONTROL

5.5.1 (U) Introduction

(U) One of the taskings of the HPRF Phase 2 Study was to investigate possible warhead use control options. This is the first time that warhead use control has been considered for a silo-based strategic system, although it was considered for the Small ICBM.[35] The HPRF use control tasking was a direct result of the FARR Study.[34] In April 1990 the Senate Armed Services Committee formally requested the Secretary of Defense to perform "an independent and objective top-to-bottom review of current fail-safe procedures." A Federal Advisory Committee was appointed in March 1991 to conduct a comprehensive and independent review of the DoD Nuclear Command and Control Structure. The FARR Study concluded that protection equivalent to that afforded by CAT-F PAL should be required in all new weapon systems. A DoD Directive[31] was issued on 20 June 1994 in response to the FARR Study recommendations. Previously, DOE issued a policy memorandum[33] mandating that all new warheads shall have positive measures against deliberate unauthorized use while in DOE custody. There are, however, differences between how DOE has treated warhead use control and the policy outlined in the DoD Directive. DOE has treated warhead use control as self-contained within the warhead. The DoD Directive also includes weapon system level physical security and procedures as use control measures to achieve "protection comparable to CAT-F PAL". While possible approaches involving physical security and procedures as well as the DOE approaches were discussed, the proposed use control themes in this study are all based upon warhead implementations. This conservative approach was the result of both the late arrival of the DoD Directive in the course of the study and the difficulty of defining what is meant by "protection comparable to CAT-F PAL".

(U) Interface issues for implementing CAT-F PAL comparable use control were briefly reviewed. A preliminary conclusion was that there appears to be no show stoppers to the implementation of use control up to and including CAT-F PAL through the launch control center (LCC) and missile system communications. Issues involving code interfaces, National Security Agency involvement, nuclear certification, and software changes required were not addressed. The new missile guidance computer appears to have sufficient capacity at present, but future availability could change.

5.5.2 (U) Use Control Categories and Use Denial

(U) Use control is defined as the positive measures that allow the authorized use, and prevent or delay unauthorized use of nuclear weapons. In the DoD weapon system context, use control is accomplished through a combination of weapon system design features, operational procedures, security, and system safety rules. In contrast, DOE's definition of use control includes warhead design features only and excludes physical security and procedures. In the DOE context, coded control and use denial form the basis of use control. The PALs are a family of devices and subsystems designed to reduce the possibility of obtaining nuclear detonation from a nuclear warhead without the use (insertion) of a controlled numerical code.

DOE & DTRA & USAF b(3)

DOE & DTRA b(3)

USAF

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5.5.3 (U) Use Control Themes and Implementation

(U) Use control themes have been developed using both current and developing technologies. The themes allow use only when authorized by the National Command Authority (NCA) and prevent or delay unauthorized use of the weapon. Absolute denial of the use of the weapon or the Special Nuclear Material (SNM) it contains, to a determined adversary, is not feasible with the condition that the penalties invoked will not harm personnel in the vicinity. This limitation leads the use control designs to focus on providing a time delay to allow security forces to recover possession of the weapon before it can be used in either the intended or nonintended mode.

5.5.4 (U) Use Control Themes for the New Mexico Design Candidates

(C-FRD)

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CG HPRF-1 (d.e) See p. 82

USAF b(1)

5.5.5 (U) Use Control Themes for the California Design Candidates

DOE & DTRA & USAF b(3)

CG HPRF-1 (d.e)

DOE & DTRA b(3)

USAF CG HPRF-1 (d,e)

Table 5-13. (U) California Candidate Use Control Summary.

CG HPRF-1 (d,e) See p. 82

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5.5.6 (U) Warhead Candidate Evaluation

(FOUO) Evaluation of the warhead candidate's use control features includes both engineering and use control specific figures of merit (measures). The engineering measures are strategic radiation, technology risk, maturity of concept (application risk), and interface issues. The strategic radiation measure indicates how likely the use control system is to introduce radiation induced problems. Technology risk is a measure of the risk incurred by using unproved technology in the use control system. Maturity of concept is a measure of how well the use control system designs are developed. Interface issues is a measure of the difficulty of interfacing a given use control system with the missile system. The use control specific measures are STS coverage, coded control, penalty effectiveness and code/key management. STS coverage is a measure of how well use control functions in all stages of the STS. Coded control is a measure which identifies the presence of coded control or lack of it. Code/Key management measures the ease of the recode and rekey operations. All the candidate designs are rated between ± 2 for the measures that are weighted between 0-10. NM-1 was chosen as the baseline design. Tables 5-14 and 5-15 are the evaluation matrices for use control for the New Mexico and California candidates, respectively. Only the representative CA5-1,3 and CA2-1,2 offerings were evaluated.

5.5.7 (U) Use Control Conclusions

(FOUO) Tables 5-14 and 5-15 show that the CAT-F candidates received the highest total scores in the use control assessment. CG HPRF-1 (d,e) USAF b(1) Both the NM and CA teams provided candidates with high total weighted scores. Only five of the seven figures of merit provided discrimination between most of the candidates. USAF b(1) Of the five figures of merit that provided discrimination, strategic radiation and code/key management are less important because of their low weights. The remaining three figures of merit; technology risk, maturity of concept, and STS coverage, are discussed below.

DOE & DTRA & USAF b(3)

[redacted]

CG HPRF-1 (d.e)

Table 5-14. (U) Pugh Matrix for New Mexico Candidates.

[redacted]

DOE & DTRA & USAF b(3)

[redacted]

CG HPRF-1 (d.e)

[redacted]

Table 5-15. (U) Pugh Matrix for California Candidates.

[redacted]

DOE & DTRA & USAF b(3)

CG HPRF-1 (d.e)

[redacted]

(C-FRD) The maturity of concept or application risk figure of merit concerns the risk apparent in implementing the chosen technology. The highest scores were awarded for an application that is much like that in an existing weapon or a complete design such as the W89 or W91

DOE & DTRA & USAF b(3)

CG HPRF-1 (d.e)

Use control during manufacturing and dismantlement was not considered in this study, although it should be treated in any further study.

DOE & DTRA & USAF b(3)

CG HPRF-1 (d.e)

DOE & DTRA

[redacted] All the designs except NM-4 provided at least coded control for the entire life of the warhead, which is lacking in the warheads now used in the MM III system. Such control was called for by the FARR Study. Establishing a communication path between the LCC and the warhead appears feasible, but interface issues remain to be resolved before a warhead with use control can be deployed with the MM III system. There will be substantial cost to the Air Force which has not been considered in this analysis. [redacted]

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DOE & DTRA & USAF b(3)

5.6 (U) SURETY CONCLUSIONS

(U) A QFD evaluation of warhead candidates in surety was conducted in the areas of nuclear detonation safety, operational safety, nuclear material dispersal, and use control. This approach provided a structured appraisal of the candidate's surety features and contributed significantly to design refinement throughout the study. Two California candidates CA2-3 and CA5-4 (described in the SEWG Final Report[27]) were presented too late to be evaluated by the SWG.

(U) In nuclear detonation safety, the most current designs (the NM candidates other than NM-4) scored the highest. [redacted]

DOE & DTRA b(3)

DOE & DTRA & USAF b(3)

CG HPRF-1

(U) In the area of use control, both teams presented candidates which scored comparably. The CAT-F PAL candidates scored highest. The emphasis in the approach to use control was at the warhead level rather than systems level.

(U) Upon completion of the analysis for each of the five areas of surety covered in this evaluation, the data were combined to obtain an overall evaluation. The data for each area were normalized to cover the same range of values and then weighted with the customer supplied weights. With the exception of NM-4, which had the lowest overall score, there was surprisingly little spread in the scoring. An examination of the Overall Evaluation Pugh Matrix revealed that this was due to different candidates having strengths in different areas causing scores to even out.

DOE & DTRA b(3)

5.7 (U) SURETY RECOMMENDATIONS

(U) The only recommendation that the SWG had was in the use control area. Both the SWG and the SEWG grappled with the issue of "What is CAT-F PAL comparable protection?" This issue was never clearly resolved. The study group provided "best effort" use control themes in the absence of a clear, official definition for the warhead candidate designs which could be construed to meet the requirements of the DoD Directive. It is recommended for any future work on new, silo-based warheads, that a mutually agreed upon definition of "CAT F PAL comparable protection" be determined at the onset of the study.

(U) Efforts were also made during the study to identify missile system warhead use control interfaces. It appears that it is possible to provide PAL control through the missile system. However, costs and the practicality of doing so were not investigated due to lack of funds.

DOE & DTRA b(1)

6.0 (U) REQUIREMENTS

(U) The Requirements Working Group (RWG) was responsible for developing and documenting two primary products; the HPRF Military Characteristics (MC) and the Stockpile-to-Target Sequence (STS) documents. The RWG was further tasked to document any unique issues associated with the HPRF warhead. The HPRF Phase 2 Feasibility Study showed there were unique issues to the HPRF warhead when compared with other standard warheads as well as issues related to the current situation of nuclear weapons development. In preparing the MC and STS documents, it became apparent that these issues needed to be addressed. These issues are documented in Section 7 of this report.

6.1 (U) MISSION NEED STATEMENT

(U) A Mission Need Statement is required to document a mission deficiency. There was a tentative statement prepared (SAC XO5-91, dated 10 September 91), but it was never finalized.

6.2 (U) MILITARY CHARACTERISTICS (MC)

(U) The MCs cover the performance requirements and physical characteristics for those parts of the HPRF warhead that are the sole responsibility of the DOE to design, develop, certify, and produce. The MCs become design requirements only after formal DOE acceptance at Phase 3. Prior to that time, they are draft goals of the Air Force requirements. The draft MCs are provided in Appendix D. The draft MCs were written to ensure any unresolved issues get addressed during future development activities. The MCs were prepared in a two column format to allow the documentation of remarks/comments associated with a specific MC in the right hand column. The purpose of this format is to ensure any concerns and/or issues related directly to that MC are fully documented and not lost. These comments address the MCs only.

6.3 (U) STOCKPILE-TO-TARGET SEQUENCE (STS)

(U) The STS document provides the DOE with Air Force requirements, design goals, and supplemental data which amplify the MCs by providing additional detailed information necessary for development of the HPRF warhead. [redacted] The STS is a living document and should continue to be reviewed and updated, as necessary, to reflect the most current data.

DTRA b(1)

6.4 (U) STOCKPILE TESTING AND RELIABILITY

6.4.1 (U) Systems Evaluation

(U) The DOE and its laboratories plan for and develop a Systems Evaluation Program (SEP) on all their weapons. The SEP consists of testing newly built weapons (New Material Testing) and weapons withdrawn from the stockpile (Stockpile Testing). Both flight and laboratory tests are normally conducted. [redacted] CG HPRF-1

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[redacted]

DOE & DTRA b(3)

[redacted] Over 20 years, weapon components and aeroshells will be consumed for testing and must be replaced, but compared to the initial build, the material to support sampling is small.

[redacted]

DOE & DTRA b(3)

[redacted] Stockpile sampling now becomes a large part of the overall weapon cost. Hence samples from small stockpiles are perceived as having a very high cost for the benefit they provide. As stockpiles decrease, the percentage becomes even more extreme. [redacted] CG HPRF-1 There is a recognized need to address the issue, and some preliminary thoughts are offered for consideration.

DOE, b(3) DTRA

DOE, DTRA, USAF b(3)

- (U) It is still believed to be important to select some samples for testing in environments and/or flight.
- (U) To assure high reliability, it is important to consider design features that will accommodate testing at the users facilities. This may be implemented as: built-in test capability, or field testing rather than testing at Pantex.
- (U) Increasing design redundancy by installing redundant components in the weapon or by redundant targeting may help meet the reliability objectives for the mission.

- (U) Use of components (or modules) that are common with other systems, and tested in other systems, may help.

6.4.2 (U) Reliability

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associated with the stockpile program discussed above, the DoD will have to determine what the lowest acceptable reliability will be for this system. This may require a trade study to determine what is the acceptable reliability based on cost in Phase 2A.

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7.0 (U) RELATED ISSUES

(U) The HPRF weapon system is new and it requires a specific warhead designed for a specific purpose. Issues that need to be addressed are covered here as related issues. These issues are addressed only to the extent appropriate at this time. Most issues are addressed more thoroughly elsewhere in the report.

7.1 (U) STRATEGIC ARMS REDUCTION TREATY (START) IMPLICATIONS

(C-FRD) Both USSTRATCOM and HQ AFSC requested that the candidates be packaged to the greatest extent possible in either the Mk12A or Mk21 RVs. This was partially driven by Air Force operations security particularly during START inspections. [redacted] This requirement has been documented in the draft MCs, but may have to be further defined in Phase 2A. Currently, this requirement severely limits the design options available.

7.2 (U) WARHEAD CERTIFICATION

7.2.1 (U) Yield Certification: Procedures and Precedents

(U) Current nuclear warhead certification procedures are based on a series of agreements which can be traced from the original "1953 Agreement" ("An Agreement between the Atomic Energy Commission and Department of Defense for the Development, Production, and Standardization of Atomic Weapons", March 21, 1953) through a series of supplementary agreements, to the set of agreements negotiated among the weapon laboratories in the 1990-1993 period (Table 7-1). These agreements describe a review and acceptance process which is embedded in the Joint DoD/DOE weapon development program phases, shown in Figure 7-1. Warhead certification, a formal responsibility of the cognizant laboratory directors, is the final step of this multi-year process.

(U) Formal weapon certification is the final step in a weapon development program, in which an initial design concept is taken through increasing levels of definition by the efforts of a multi-disciplinary team. Development of a design is based on extensive use of calculational models and a major testing program, of which nuclear testing has historically been an important, but by no means the only component. Non-nuclear testing has a wide array of techniques, including hydrodynamic testing of primary components, engineering testing (for both performance and safety) of both non-nuclear and nuclear components over the range of stockpile environments, materials testing, and operational testing to verify interface compatibility and performance in real flight environments. Results of calculations, non-nuclear testing, and constraints imposed by production and interface requirements are combined as a design is developed to increasing levels of definition.

Table 7-1. (U) Agreements Forming the Basis for Current Warhead Certification Procedures.

"An Agreement between the Atomic Energy Commission and Department of Defense for the Development, Production, and Standardization of Atomic Weapons," March 21, 1953.
Supplement to 1953 Agreement. An updated agreement is now under review.
"Policy and Procedures for Certifying High-Yield Nuclear Warhead Designs for Stockpile," S.S. Hecker and J.H. Nuckolls, June 15, 1990.
"Inter-Laboratory Peer Review for Nuclear Weapon Development." T.P. Seitz and L. Woodruff, December 18, 1991.
"Amended Agreement on Inter-Laboratory Peer Review," W.J. Shotts, E.E. Ives, and T.P. Seitz, February 26, 1993.

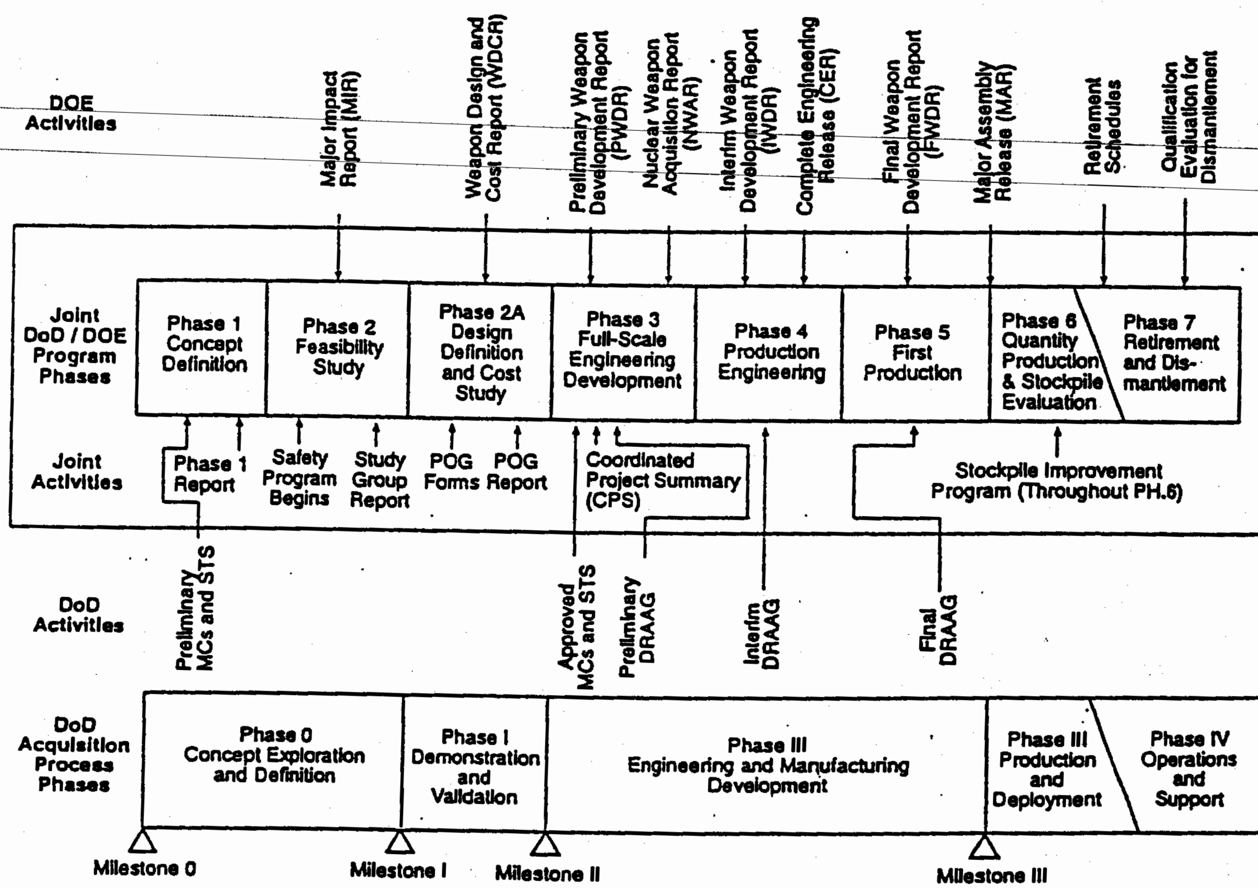

Figure 7-1. (U) Joint DoD/DOE Nuclear Weapon Program Phases and DoD Acquisition Process Phases Compared.

(U) Historically, a parallel nuclear testing program has verified the performance of the developing design. Nuclear tests have included the relevant "weaponization" features defined at the time, and have also been used to establish performance under extreme conditions, including aged gas, hot and cold temperature extremes, and simulated performance in an over-initiated fratricide environment. In addition, nuclear testing of components in Defense Nuclear Agency (DNA) tunnel tests has been used to verify performance in hostile nuclear environments, principally x-ray environments in recent years. Since the late 1970's, "production confidence" nuclear testing has been done with warheads off the assembly line, and stockpile confidence testing has been performed on warheads which had been deployed for some time on their delivery vehicles.

(S-FRD) The warhead certification process, including the parallel DoD review by the Design Review and Acceptance Group establishes that a warhead has met the MCs. The formal requirements for certification have evolved over time, in large part due to restrictions on nuclear testing. For example, the third agreement in Table 7-1 relates specifically to the lack of full yield testing opportunities for yields above 150 kt under the Threshold Test Ban Treaty. In a sense, certification of a new warhead under conditions of no nuclear testing is an extension of this concept. (See Section 2.4.)

(C-RD) During the 1958-61 Nuclear Test Moratorium, 13 warheads were in development with the prospect that no nuclear testing would be allowed. A review of warhead development during that period suggests possible lessons for the HPRF warhead assessment.

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- (U) Peer review was viewed in 1960 as critical for avoiding errors and for providing assurance to the military. It would be equally important today.

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(U) The technical basis for the certification of warheads in the current stockpile has been vigorous experimental and analytical programs that included the ability to conduct nuclear tests as required. The basis for future warhead certification will consist of several elements: data from above-ground experiments; data from previous nuclear tests that incorporated the same or related designs or technologies; numerical simulation of experiments and of warhead performance; and peer review.

(U) While each of these played a role in previous certifications, the key element was nuclear testing. Without the ability to conduct nuclear tests, the relative importance of the other elements increases. The final balance among them will depend on certain factors that will be characteristic of the particular nuclear design, including: the availability of relevant nuclear test data, the applicability of above-ground experiments to key design issues, and the applicability of available calculational techniques.

(U) The consequences of the inability to conduct nuclear tests will be manifested in two ways. First, the uncertainties associated with the estimates of expected performance will be greater.

Secondly, the degree of confidence that warhead performance will be unaffected by a previously unrecognized factor will be diminished.

7.3 (U) USE CONTROL

(S-FRD) Use control will be an area of significant importance during Phase 2A. A new DoD Directive S-3150.7 "Controlling the Use of Nuclear Weapons," dated 20 June 1994 was issued. [redacted] Other DoD policies and procedures for use control are defined in the "General Characteristics for Permissive Action Links Used with Nuclear Weapons." Whether these requirements should be included in the MCs has been a topic of discussion. The DoD Directive S-3150.7 is a DoD requirement for new systems and there is still a question of whether the HPRF warhead will be considered a new system or a modification of a previous warhead. Implementation of this requirement may limit design options. The current MM III missile system including warheads does not incorporate this new DoD requirement and to incorporate could be very costly. [redacted]

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[redacted] The Drell Panel in 1990 agreed that the ICBM weapon systems incorporate system level positive enable systems which they felt accomplished the same type of "use control" that PALs provide. (See Sections 4.4.2 and 5.5.)

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7.5 (U) FRATRICIDE

(S-FRD) Fratricide as defined in this document is the killing of one weapon by action of another friendly weapon. Depending on the mission of HPRF, fratricide from friendly HPRF warheads may cause a concern. [redacted]

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7.6 (U) OPERATIONAL FLEXIBILITY

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7.8 (U) INTEGRATED ARMING, FUZING AND FIRING (AF&F)

(U) The AF&F system is a DoD responsibility. In the interest of cost savings and time as it relates to the Phase 2 Study, the DOE agreed to investigate a possible integrated AF&F for the HPRF weapon system. The DOE integrated AF&F integrates the AF&F with the warhead electrical system (WES) which reduces the overall size of the two independent systems. The interface between the AF&F and WES has to be defined in such a way to determine how much the DoD has to reimburse the DOE for the DoD portion dealing with the AF&F versus the WES. Although the Air Force has not used an integrated AF&F, there is considerable data available to evaluate the use of one as the Navy has been doing it this way for many years. (See Section 4.4.3.)

7.9 (U) WARHEAD LIFETIME

[redacted] DOE b(3)

7.10 (U) DOE PRODUCTION AND TECHNOLOGY BASE

(U) Nuclear weapons will remain a vital component of US national security policy. As such, their maintenance and support will remain DOE's primary responsibility. To fulfill this responsibility, DOE must have technological capabilities to monitor, diagnose, repair and if necessary, replace any nuclear/nonnuclear component in the enduring stockpile. Inherently, these capabilities must be supported by knowledgeable trained personnel with access to appropriate tools and specialized equipment. Furthermore, this type of expertise must be maintained and continuously improved through training and recruitment of the required talent for the foreseeable future.

(U) The reconfiguration of the DOE nuclear weapons complex requires an innovative approach to support and maintain the enduring stockpile as well as any new developments. [redacted] DOE & DTRA b(3)

(U) In September 1993, DOE finalized plans to consolidate its nonnuclear operations. Three donor sites (Pinellas, Mound, and Rocky Flats) are in the process of transferring personnel, equipment, and records to other sites within the nuclear weapons complex. Currently, the capability to manufacture pits is being established at LANL and the manufacturing of primaries is to continue at the Pantex plant. The manufacturing of secondaries remains at the Oak Ridge plant. However, the reconfiguration of nuclear operations and additional reconfiguration of nonnuclear operations in the DOE weapons complex is currently being studied. Options under consideration will be published early in 1996 in a Draft Programmatic Environmental Impact Statement (PEIS) for Stockpile Stewardship and Management. The final PEIS is to be published in the fall of 1996. Further details on DOE reconfiguration and production capability can be found in Appendix F.

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8.0 (U) STUDY RESULTS

8.1 (U) WARHEAD CANDIDATE DESIGNS

(S) Both the USSTRATCOM and HQ AFSPC requested that the study group attempt to design and package their warhead candidates in the Mk12A or Mk21 RVs. If successful, this would simplify the Air Force handling and maintenance procedures and it would allow for transparency during arms control inspections across the ICBM forces.

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If the desired performance of an HPRF weapon could not be achieved in the Mk12A/Mk21, USSTRATCOM and HQ AFSPC stated that other design and packaging options could be considered.

(U) LANL proposed three basic HPRF candidates and LLNL proposed two basic candidates. These candidates are listed in Table 8-1. There are several engineering variations of these basic candidates described in the Systems Engineering Section 4.

Table 8-1. (U) HPRF Candidates.

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8.2 (U) VULNERABILITY TESTING AND MISSION ANALYSIS

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[redacted] After analyzing the vulnerability test data, the target systems were modeled and mission effectiveness analyses were performed.[36] The magnitude of the uncertainties associated with the vulnerability assessments developed for the target systems in each of the mission areas, precluded mission effectiveness conclusions.

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[redacted] Detailed test reports exist that describe in depth the test conditions, caveats, and results.

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(S) The study was unable to conclusively assess the effectiveness of an HPRF weapon in damaging target systems.

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In addition, by analyzing the damage that occurred across all of the systems that experienced damage, a determination must be made to assess whether the level of understanding of the conditions and mechanisms by which damage occurred is sufficiently mature to enable the application of these results to other systems that have not been tested.

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8.3 (U) SYSTEMS ENGINEERING

(U). Numerous trade studies which compared the implementation issues associated with missile system integration were conducted. Conceptual designs for integrating each HPRF warhead candidate into the MMIII missile system were developed. A wide range of packaging and system engineering options were explored. Strategies were developed for implementing the different options. No show stoppers were identified in trade studies performed among the various options.

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8.4. (U) NUCLEAR SURETY

(U) A Quality Function Deployment (QFD) evaluation of the warhead candidate designs was conducted in the areas of nuclear detonation safety, operational safety, nuclear material dispersal, and use control. This approach provided a structured appraisal of each candidate's surety features and contributed significantly to design refinement throughout the study. Upon completion of the evaluations, the data were combined to obtain an overall evaluation. The data for each area were normalized to cover the same range of values and then weighted with customer-supplied weights. With the exception of NM-4, which had the lowest overall score, there was surprisingly little spread in the overall scoring. This was due to different candidates having strengths in different areas causing scores to even out. NM candidates scored higher in nuclear detonation safety with the exception of NM-4. CA candidates scored somewhat higher in operational safety and nuclear material dispersal. CAT-F PAL candidates received the highest scores in use control.

9.0 (U) CONCLUSIONS AND RECOMMENDATIONS

9.1 (U) CONCLUSIONS

(S) The study confirmed the following conclusions.

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In addition, by analyzing the damage that occurred across all of the target systems that experienced damage, a determination must be made to assess whether the level of understanding of the conditions and mechanisms by which damage occurred is sufficiently mature to enable the application of these results to other systems that have not been tested.

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9.2 (U) RECOMMENDATIONS

(U) An additional 12-month study should be conducted to complete the following two tasks.

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(U) Also, additional vulnerability data should be acquired to complete the following three tasks, but not part of the 12-month study.

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7. Maj R.F. Kropf, Capt W.A. Lamb, and Capt K.K. Millage, "High Power Radio Frequency (HPRF) Phase 1 Study, Final Report (U)", Office of Aerospace Studies report OAS-TR-92-1 (S/RD/CNWDI/NF), April 1992.

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12. "HPRF Phase 2 Study LLNL Warhead Design Working Group Final Report Input (U)", LLNL COPD 95-002, March 22, 1995.

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APPENDICES

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APPENDIX B - TASKING

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DEPARTMENT OF DEFENSE
AND
DEPARTMENT OF ENERGY

NUCLEAR WEAPONS COUNCIL
STANDING COMMITTEE
WASHINGTON, DC 20301-3050

11 AUG 1992

Rear Admiral W.G. Ellis
Deputy Assistant Secretary
for Military Application
Department of Energy
Washington, DC 20585

Dear ~~Admiral Ellis~~ Jerry:

DOE & DTRA b(3)

CG HPRF-1

b(1) USAF

DOE & DTRA b(3)

(U) I request the Phase 2 Study Group present its goals, strategy, and milestones to the NWCSC within 90 days of initiation of

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"Unauthorized disclosure subject to administrative and criminal sanctions.

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the Phase 2. In addition, I request the Study Group report at least yearly to the NWCSC on their progress and conclusions.

CG HPRF-1

DOE & DTRA & USAF b(3)

Sincerely,

John H. Birely
Acting Chairman

Enclosure

cc:
SAF/AQQ
AF/XOO
CNO (OP-65)
CNO (OP-91B)

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DEPARTMENT OF DEFENSE
AND
DEPARTMENT OF ENERGY

NUCLEAR WEAPONS COUNCIL
STANDING COMMITTEE
WASHINGTON, DC 20301-3050

11 AUG 1992

MEMORANDUM FOR CHIEF OF NAVAL OPERATIONS (OP-65)

SUBJECT: High Power Radio Frequency (HPRF) Weapon Phase 2
Warhead Study

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(U) For this reason, I request the Navy join the Air Force in the HPRF Phase 2 Feasibility Study so that the study group can investigate both the ICBM and SLBM basing options.

John H. Birely
Acting Chairman

cc: SAF/AQQ
DAMO

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"Unauthorized disclosure subject to administrative and criminal sanctions. Handle as Restricted Data in foreign dissemination. Section 144b, Atomic Energy Act 1954."

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DEPARTMENT OF THE AIR FORCE
WASHINGTON DC

OFFICE OF THE ASSISTANT SECRETARY

SAF/AQQ
Pentagon Rm 4E342
Washington DC 20330-1000

AUG 3 1 1992

MEMORANDUM FOR AFMC/XR

SUBJECT: Phase 2 Warhead Feasibility Study of a Strategic High Power Radio Frequency (HPRF) Weapon (U) -- ACTION MEMORANDUM

(U) Request the Office of Aerospace Studies (OAS) initiate and lead for the Air Force a joint DOD/DOE Phase 2 Warhead Feasibility Study to investigate the development of a Strategic High Power Radio Frequency (HPRF) weapon. The Study Group will complete the effort in 30 months. OAS should schedule a kickoff meeting within 30 days. In addition, within 90 days after the kickoff meeting, the Chairman of the Study Group will report to the Nuclear Weapons Council Standing Committee (NWCSC), through SAF/AQQS, on the study goals, strategy, and milestones. In particular, this report should address the plan for validating the lethality methodology.

(S) The NWCSC has approved the Air Force request for this study and asked the DOE to join the study. At the request of the Deputy Assistant Secretary of Defense (Policy), the study will consider possible SLCM delivery of the HPRF weapon. To accomplish this additional goal, the NWCSC has asked the Navy to join the study. We expect that the Navy will have a significant role in the study, and may designate a deputy chairman for the study group. This letter includes the NWCSC letters to DOE and the Navy as attachments.

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b(1) USAF

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(U) The SAF/AQQ point of contact for this effort is Lt Col Charles R. Martin, SAF/AQQS, DSN 223-6303 or (703) 693-6303.

Patrick P. Caruana

PATRICK P. CARUANA, Major General, USAF
Director of Strategic, SOF, and
Airlift Programs
Assistant Secretary for Acquisition

3 Atch
1. NWCSC Letter to DOE (SFRD)
2. NWCSC Letter to Navy (SFRD)
3. Nominal Warhead Parameters (SFRD)

cc: OAS(AFMC)

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Department of Energy
Washington, DC 20585

This document consists of 1 pages
No. 7 of 20 copies, Series A

SEP 14 1992

MEMORANDUM FOR Manager, DOE Albuquerque Field Office
Director, Los Alamos National Laboratory
Director, Lawrence Livermore National Laboratory
President, Sandia National Laboratories

Request you join the Air Force in a Phase 2 feasibility study of a High Power Radio Frequency (HPRF) weapon. The tasking guidance for this study is enclosed. The Office of Aerospace Studies will lead the study. You should plan to complete the study in 30 months.

CG HPRF-1

Therefore, the Air Force recommended to proceed to a Phase 2 feasibility study.

DOE & DTRA & USAF b(3)

Joe Gazda, Weapons Development and Acquisition Division (DP-251), (301)903-2984, will oversee and coordinate DOE participation in the study.

W. G. Ellis
Rear Admiral, U.S. Navy
Deputy Assistant Secretary
for Military Application
Defense Programs

Enclosure:
Phase 2 Tasking Guidance for High
Power Radio Frequency Weapon (S/FRD)

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No. 7 of 27 copies, Series A

September 4, 1992

Phase 2 Tasking Guidance for
High Power Radio Frequency Weapon (U)

This tasking guidance is for a Joint Department of Defense (DOD) and Department of Energy (DOE) Phase 2 Feasibility Study of a High Power Radio Frequency (HPRF) weapon. This study is a follow on to the recently completed Joint DOD/DOE HPRF Phase 1 Study (Reference 1). The purpose of this study is twofold: (1) perform aboveground testing to acquire the necessary failure-level vulnerability test data on foreign assets, and (2) perform a feasibility study on weapon concepts that can provide the failure-level output. The Phase 2 study period is 30 months.

The initial emphasis of the study will be to: (1) gather the vulnerability test data; (2) validate and, if necessary, improve vulnerability assessment models; and (3) improve and expand the Phase 1 mission analysis.

The DOE laboratories should coordinate and integrate their vulnerability test plans with those of the DOD.

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Initially, the study group will use the W78/Mk12A and W87/Mk21 Military Characteristics (MC) and Stockpile-to-Target Sequence (STS) environments for engineering trade studies. Similarly, engineering trade studies for a Submarine Launched Ballistic Missile delivery system will use warhead MC's and STS as identified by the Navy. [redacted] CG HPRF-1 [redacted] Pit reuse will be considered for the Phase 2 candidates, and all candidates will meet the April 1990 DOE Use Control Policy and DOE Nuclear Explosive and Weapon Safety Program Order 5610.10. — DOE & DTRA & USAF b(3)

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*Navy identified parameters may be different.

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The Acting Chairman of the Nuclear Weapons Council Standing Committee (NWCSC) requests the Phase 2 Study Group present its goals, strategy, and milestones to the NWCSC within 90 days of initiation of the Phase 2 study. Further, the Acting Chairman requests the Study Group report at least yearly to the NWCSC on its progress and conclusions.

At least 4 months prior to the end of the study the preferred weapon candidates will be submitted for peer review and as an input for a Major Impact Report (MIR).

The Phase 2 report will include descriptions of each weapon candidate, the results from the engineering trade studies, and results from the peer review. The MIR or an executive summary of the MIR should be an appendix in the Phase 2 report. For each candidate, the report will include: (1) details of safety and use control themes, and (2) any concerns that might arise from the current underground nuclear testing policy. The overall Phase 2 report format and contents should follow the guidelines shown in DOD Instruction 5030.55, dated January 21, 1974, enclosure 4.

Reference:

1. "High Power Radio Frequency (HPRF) Phase 1 Study (U) Final Report," 15 April 1992, OAS-TR-92-1

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DEPARTMENT OF DEFENSE
UNITED STATES STRATEGIC COMMAND

[redacted]

COPY FOR YOUR INFORMATION

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23 JUN 1994

Reply To:
USSTRATCOM/J5
901 SAC BLVD STE 2E10
OFFUTT AFB NE 68113-6500

MEMORANDUM FOR THE DIRECTOR OF LONG RANGE POWER PROJECTION, SOF, AIRLIFT & TRAINING PROGRAMS

Subject: High Power Radio Frequency (HPRF) Study (U)

1. (S) The USSTRATCOM Staff recently received a briefing on the status of the HPRF Phase 2 Study. We appreciate the effort that has gone into this study, and believe the end product will contribute significantly to our understanding of systems vulnerability and the value of this tactic. The briefing generated considerable interest.

2. (U) If possible, given time and budget constraints, we would like the following questions to be addressed in the Phase 2 Study.

CG HPRF-1

DOE & DTRA & USAF b(3)

b. (SFRD) What information, and conclusions, can the study provide regarding the vulnerability of U.S. systems?

3. (U) The inclusion of this information will greatly enhance the usefulness of the study. I would appreciate your support for this request.

4. (U) My POC for this study is Mr. Stan Gooch, J533, DSN: 271-5254.

DAVID M. GOEBEL
Rear Admiral, USN
Director, Plans and Policy

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[redacted]

CLASSIFIED BY: CG-W-5, JAN 84
DECLASSIFY: N/A

[redacted]

[redacted]

DEPARTMENT OF THE AIR FORCE

WASHINGTON DC [redacted]

OFFICE OF THE ASSISTANT SECRETARY

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Rec'd 8 Aug 94

MEMORANDUM FOR SA-ALC/NWI

FROM: SAF/AQQS
1060 Air Force Pentagon
Washington DC 20330-1060

SUBJECT: USSTRATCOM/J5 Memorandum, dated 23 Jun 1994, Subject: High Power Radio Frequency (HPRF) Study

The subject memorandum, provided as an attachment, expresses interest in the ongoing HPRF Phase 2 Study. It also asks that the study address two specific questions of interest to USSTRATCOM.

Request you prepare a response to these questions for USSTRATCOM at the conclusion of the study, or earlier if possible. We believe the HPRF Phase 1 study provides some information and that the current study, as already planned, will provide additional information for answering these questions . The response should be separate from the study's final report or other documents, but it should include references to supporting information in these documents as appropriate. This tasking does not change the scope, budget, or schedule of the Phase 2 study.

The SAF/AQQ point of contact for this action is Lt Col Bill Mullins, SAF/AQQS(N), DSN 223-6303

[signature]

THOMAS B. GOSLIN, Colonel, USAF
Chief, Long Range Power Projection Division
DIR/Long Range Power Projection, SOF, Airlift
and Training Programs

Attachment:
USSTRATCOM/J5 Memorandum,
dated 23 Jun 1994

cc: SA-ALC/NW
USSTRATCOM/J5

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Unclassified when attachment is withdrawn

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APPENDIX C - HPRF SECURITY CLASSIFICATION GUIDE - DRAFT

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APPENDIX D - MILITARY CHARACTERISTICS

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MILITARY CHARACTERISTICS
FOR THE
HIGH POWER RADIO FREQUENCY
(HPRF) WARHEAD (U)

DRAFT
January 1996

NUCLEAR WEAPONS INTEGRATION DIVISION
NUCLEAR WEAPONS DIRECTORATE
SAN ANTONIO AIR LOGISTICS CENTER
AIR FORCE MATERIEL COMMAND
1651 FIRST STREET SE
KIRTLAND AIR FORCE BASE, NEW MEXICO 87117-5617

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MILITARY CHARACTERISTICS FOR THE HIGH POWER RADIO FREQUENCY (HPRF) WARHEAD (U)

DRAFT
January 1996

TABLE OF CONTENTS

(All portions of this Table of Contents are UNCLASSIFIED.)

CHARACTERISTICS	REMARKS/COMMENTS
1.0 (U) GENERAL.	
1.1 (U) Purpose. These Military Characteristics (MCs) define the Department of Defense (DoD) requirements for a High Power Radio Frequency (HPRF) nuclear warhead.	1.1 (U) The MCs were written in a two column format. The left hand column contains the MC requirement and the right hand column is used to document any remarks/comments associated with the MC requirement. The purpose for this format is to ensure any concerns and/or issues identified during Phase 2 are fully documented. These comments are intended to address the MCs only.
1.2 (U) Contingencies. Should it appear impractical for the Department of Energy (DOE) to meet any of these MCs, or should it appear meeting any criterion specified herein will delay the initial operational capability, modify the delivery rate, or increase the warhead cost by an amount deemed by the joint DoD/DOE HPRF Warhead Project Officers Group to be unreasonable, immediate notification shall be made to the Nuclear Weapons Council Standing and Safety Committee (NWCSSC).	
1.3 (U) Definitions.	1.3 (U) Definitions for the RV, RS, and RSA are defined specifically for the HPRF warhead design purposes and may not be the same definitions for other warheads. The STS reflects the same definitions.
DOE & DTRA & USAF b(3) [redacted] JCG HPRF-1 (d.a)	
1.3.2 (U) The reentry vehicle (RV) is the DoD provided structure to contain DOE warhead components as well as the arming, fuzing, and firing (AF&F).	1.3.2 (U) The AF&F is a DoD responsibility. An integrated AF&F is a concept being considered by the Air Force. This concept would have to be fully documented (i.e. responsibility, definition, etc).

1.3.3 (U) The RS is defined to be the RV and DOE warhead components as well as the AF&F within the structure.

1.3.3 (U) The AF&F is a DoD responsibility. An integrated AF&F is a concept being considered by the Air Force. This concept would have to be fully documented (i.e. responsibility, definition, etc).

1.3.4 (U) The Reentry System Assembly (RSA) is defined as the mated RS, Deployment Module and Ascent Shroud.

1.3.5 (U) The Deployment Module is defined as the structure which includes the payload bulkhead support for mounting the RVs and chaff dispensers.

1.3.6 (U) The Ascent Shroud is defined as the low-drag aerodynamic shape which covers the arrangement of payload RVs during powered flight in the atmosphere.

1.4 (U) Competing Characteristics. In the event compliance with these MCs results in design conflicts, the HPRF Warhead POG shall evaluate design options on a case-by-case basis and forward recommended changes to the NWCSSC for approval. Trade-offs for reasons of technical feasibility and cost may be made with the guidance and approval of the HPRF Warhead POG and NWCSSC.

1.4.1 (U) Highest priority will be given to nuclear safety.

DOE & DTRA & USAF b(3)

JCG HPRF-1 (d.a)

1.5 (U) Warhead Endurance. It is desired the warhead have an inherent endurance obtained as a result of design considerations which address: warhead lifetime consistent with the weapon delivery system lifetime and the ability to replicate the warhead at a future date. Therefore, the design, development, and production of the warhead must be well documented, and involve processes which, to the extent practical, allow replication at a future date.

2.0 (U). WARHEAD CHARACTERISTICS.

2.1 (U) General Requirements.

2.1.1 .(U) The warhead shall be designed to interface with the RS with interface details coordinated by the HPRF Warhead POG.

2.1.2 (U) The handling, storage, and transportation requirements as denoted in the HPRF Warhead STS document shall be compatible with existing systems as close as practical.

2.2 (U) Operational Requirements.

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2.2.4 (U) Provisions which allow instrumentation for operational testing shall not degrade performance, physical considerations, interface capability or safety of the war reserve unit.

2.3 (C-FRD) Physical Requirements. The HPRF warhead shall have the following physical characteristics. The final dimensions, configuration and weight distribution of the warhead shall be defined by the HPRF Warhead POG during the development program consistent with the performance and design requirements. [redacted] CG HPRF-1

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[redacted] CG HPRF-1

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2.3.1 (U) The maximum weight shall be TBD.

2.3.1 (U) TBD will be determined in Phase 2A.

2.3.2 (U) The maximum length shall be TBD.

2.3.2 (U) TBD will be determined in Phase 2A.

2.3.3 (U) The maximum diameter shall be TBD.

2.3.3 (U) TBD will be determined in Phase 2A.

2.3.4 (U) The center of gravity shall be located at TBD.

2.3.4 (U) TBD will be determined in Phase 2A.

2.4 (U) Functional Requirements.

2.4.1 (U) The warhead shall respond and operate properly within the required reliability requirements of paragraph 2.6 when signals and power specified in the interface control document are supplied to the DoD/DOE interface.

2.4.2 (U) The warhead shall not require functional testing.

2.4.3 (U) Operational testing using joint DoD/DOE test assembly units without nuclear materials is required. Provisions which allow instrumentation for this testing shall not degrade test reliability or nuclear safety as determined by the HPRF Warhead POG.

2.5 (U) Environment and Vulnerability Requirements.

2.5.1 (U) The warhead reliability and nuclear safety shall not be degraded in the normal environments specified in the HPRF Warhead STS document.

2.5.2 (U) The warhead nuclear safety should not be degraded in the abnormal environments specified in the HPRF Warhead STS document.

2.6 (U) Reliability Requirements. The following reliability requirements apply to the warhead in the normal environments specified in the HPRF Warhead STS document.

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CG HPRF-1

2.7 (U) Nuclear Safety Requirements. The warhead design requires positive measures to prevent premature detonation in normal and abnormal environments as defined in the HPRF Warhead STS document.

2.7.1 (U) The warhead shall contain a human intent unique signal driven stronglink which shall prevent prearming until the unique signal is received. The warhead shall contain features which preclude arming until the warhead experiences environments and events associated with normal missile flight and receipt of a nuclear arming signal from the missile. At least two independent signals shall be required to arm the warhead and at least one signal shall be continuous. The warhead design shall allow arming to occur as late in the functional sequence as practical.

2.7.2 (U) In the event of a high explosive one point initiated detonation, the probability of achieving a nuclear yield greater than the equivalent of 4 lbs of TNT shall not exceed 1 in 10^6. This feature must be inherent in the nuclear system design.

2.7.3 (U) The probability of a premature nuclear detonation of the warhead for the specified normal environments in the HPRF Warhead STS document shall not exceed the following.

2.7.3.1 (U) One in 10^9 per warhead lifetime in the absence[1] of the warhead prearming (intent) stimulus, the enabling (environmental) stimulus, and the warhead arming signals.

2.7.3.2 (U) One in 10^6 per warhead lifetime after application of the prearming stimulus, but in the absence[1] of the enabling stimulus and the warhead arming signals.

2.7.3.3 (U) One in 10^3 per event[2] after application of prearming and enabling stimuli, but in the absence[1] of the warhead arming signals.

2.7.4 (U) The probability of a premature nuclear detonation of the warhead, during and after exposure to the abnormal environments described in the HPRF Warhead STS document, shall not exceed the following.

2.7.4.1 (U) One in 10^6 per occurrence in the absence[1] of the warhead prearming and enabling stimuli.

2.7.4.2 (U) One in 10^3 per occurrence after application of the prearming stimulus, but in the absence[1] of the enabling stimulus.

2.7.5 (U) Upon removal of arming power, the warhead firing set shall automatically discharge the energy in its storage devices to a safe level within 10 seconds in the normal environments specified in the HPRF Warhead STS document.

[1](U) The DoD system is responsible for ensuring the absence of critical prearming and enabling stimuli, and warhead arming signals.
[2](U) An event is the application of a prearm command and deliberate deployment (weapon launch or release).

2.7.6 (U) Warhead subsystems shall fail in a predictable manner in the abnormal environments specified in the HPRF Warhead STS document.

2.7.7 (U) The intrinsic radiation output from the warhead shall be as low as reasonably achievable during all pre-launch stages of the STS.

CG HPRF-1 (d, a, b)

DOE & DTRA & USAF b(3)

The DOE shall provide the DoD with this information as measured.

2.7.8 (U) Prior to prearming, no prearming and arming circuits shall function when exposed to monitoring current (100 ma or less).

2.7.9 (U) Credible configurations of warheads with intact pits shall remain subcritical (no nuclear reaction) in normal environments, and when immersed in or flooded internally with water, as specified in the HPRF Warhead STS document.

2.7.9 (U) Questions were raised during the Phase 2 Study on the definition of credible configurations. Credible configurations for a single HPRF warhead are defined in the STS; however, there is no definition for credible configurations of multiple warheads. This may have to be defined during Phase 2A.

2.7.10 (U) An undamaged warhead shall be compatible with features to contain plutonium for as long as reasonably achievable in a fuel fire as specified in the HPRF Warhead STS document.

2.7.11 (U) War reserve warheads will be identified with conspicuous permanent markings per established DOE procedures.

2.7.12 (U) The warhead shall be designed so all electrical explosive devices exposed during handling and maintenance shall be insensitive to electrostatic discharges as defined in the HPRF Warhead STS document.

2.7.13 (U) To the maximum extent practical, the warhead shall:

DOE & DTRA & USAF b(3)

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2.7.13.2 (U) Facilitate EOD render-safe procedures with minimal need for sophisticated equipment and keep the hazard risk to EOD personnel as low as reasonably achievable.

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CG HPRF-1 (d,b)

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2.7.13.4 (U) Not present high explosive, chemical, or other personnel hazards during maintenance, handling, and other operations in normal environments.

2.7.13.5 (U) Include provisions for the probability of high explosive detonations and plutonium dispersal to be in as low as reasonably achievable in abnormal environments.

2.7.13.6 (U) Include human engineering characteristics to reduce the opportunity for personnel error including, but not limited to, all maintenance and EOD operations.

2.7.14 (U) All material used in the warhead design shall be chemically compatible in normal HPRF Warhead STS environments.

2.7.15 (U) The warhead shall contain no electrical power source, either dormant or active, which could arm or fire the warhead detonating system.

[redacted]

2.8 (U) Maintenance, Monitoring and Equipment Requirements.

DOE & DTRA & USAF b(3)

2.8.1 (U) Warhead Maintenance. The warhead shall be designed for ease of maintenance.

2.8.1.1 (U) The warhead shall require no scheduled maintenance between the shortest LLCE interval.

2.8.1.2 (U) The warhead shall be designed so field level maintenance, handling, and inspections can be accomplished in the normal HPRF Warhead STS environmental conditions. As a goal, the warhead shall be designed so only existing nuclear certified special and test equipment, and standard mechanics' tools are required for all field-level maintenance, handling, and inspection tasks.

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2.8.1.3 (U) The warhead shall be designed to keep personnel safety hazards as low as reasonably achievable during Stages 1 through 5 of the HPRF Warhead STS document.

2.8.1.3 (U) This includes exposure during maintenance to all warhead coatings, materials, and compounds.

2.8.1.4 (U) Provisions shall be made for ease of assembly/disassembly of the RS so repair or component retrofit of the warhead can be achieved.

2.8.2 (U) DOE-Supplied Equipment.

2.8.2.1 (U) DOE-supplied equipment to be used with this warhead shall be capable of functioning in the same normal environments as the warhead, as defined in Stages 1 through 5 of the HPRF Warhead STS document.

2.8.2.2 (U) If required, newly developed DOE equipment shall be as compatible as possible with existing warheads. To the extent practical, all such equipment shall be kept to a minimum and be compact, lightweight, transportable by common carrier, adequately identified, provided with operating instructions, and designed to keep the opportunity for human error as low as reasonably achievable.

2.8.2.3 (U) As a goal, the DOE maintenance and support equipment will require no calibration or be self-calibrating.

2.8.2.4 (U) Any DOE warhead shipping and storage container for DoD use shall be compatible with the warhead storage, transportation, and handling systems identified in the HPRF Warhead STS document. Specific container requirements will be defined in a separate, jointly approved requirements document. If additional requirements are driven by DoD use of this container, funding details will be addressed in a DOE/DoD Memorandum of Understanding for the Division of Responsibilities.

2.8.3 (U) Maintenance Procedures.

2.8.3.1 (U) The RS shall be compatible with removal from, or installation on, an RSA in less than TBD hour(s), with a goal of TBD minutes as defined in the HPRF Warhead STS document.

2.8.3.2 (U) The DOE-defined warhead maintenance and LLCE procedures shall be compatible with the requirements of the HPRF Warhead STS document. All maintenance activities must be performed within TBD 8 hour shift(s). To support this requirement, the LLCE will take no longer than TBD hours, with a goal of TBD hours, once the warhead has been placed in the maintenance stand and all preparatory actions have been accomplished.

2.8.3.3 (C-FRD) Provisions shall be made for relatively simple replacement of LLCs by the Services with a minimum of special facilities or controlled environments.

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CG HPRF-1(d,a)

DOE & DTRA b(3)

2.8.4 (U) Monitoring. Weapon system serial numbers and other data as determined by the HPRF Warhead POG shall be obtained from the warhead by either visual, electronic or optical means.

DOE & DTRA & USAF b(3)

CG HPRF-1 (d,e)

2.9 (S-FRD) Inclusion of the following two documents in the MCs was a topic of considerable discussion. (See Section 7.3 of the HPRF Warhead Phase 2 Study Final Report).

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APPENDIX E - STOCKPILE TO TARGET SEQUENCE

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AIR FORCE

STOCKPILE-TO-TARGET SEQUENCE

FOR THE

HIGH POWER RADIO FREQUENCY (HPRF) WARHEAD (U)

PHASE 2 STUDY

January 1995

DRAFT

NUCLEAR WEAPONS INTEGRATION DIVISION

Air Force Materiel Command

Kirtland Air Force Base, NM

SUBJECT TO EXPORT CONTROL LAWS

This document contains information for the manufacturing or using munitions of war. Exporting this information or release of it to foreign nationals living in the United States without first obtaining an export licence violates the International Traffic in Arms Regualtions. Under 22 UCSG 2778, such a violation is punishable by up to two years in prison and by a fine of $100,000.

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NUCLEAR WEAPONS INTEGRATION DIVISION
Air Force Materiel Command
Kirtland Air Force Base
New Mexico

This Stockpile-to-Target Sequence (STS) is classified SECRET - RESTRICTED DATA because it contains nuclear weapon design data and information concerning operational strategy. It does not contain Critical Nuclear Weapons Design Information (CNWDI).

WARNINGS

This material contains Restricted Data as defined in the Atomic Energy Act of 1954. Its dissemination or disclosure without authorization is prohibited.

When U.S. Government drawings, specifications, or other data are used for any purpose other than a definitely related Government procurement program, the Government thereby incurs no responsibility nor any obligation whatsoever and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data is not to be regarded by implication or otherwise, as in any manner licensing the holder or any person or corporation or conveying any rights or permission to manufacture, use, or sell any patented invention that may in any way be related thereto.

This document is made available for study with the understanding that proprietary interests in and relating thereto will not be impaired. In case of apparent conflict or any other questions between the Government's rights and those of others, notify the Judge Advocate, Air Force Materiel Command.

In addition to security requirements which apply to this document and must be met, each transmittal outside the agencies of the U.S. Government must have prior approval of the Nuclear Weapons Integration Division (SA-ALC/NWIW), 1651 1st St SE, Kirtland AFB, New Mexico 87117-5617.

Contracting Disclaimer

Nothing in this STS may be construed to constitute a change to any contract. Any questions concerning allowability under, or changes to, any contract must be resolved by the government contracting officer before proceeding in any manner which might obligate the government beyond any existing contract.

COORDINATION PAGE

The following executive study group of the HPRF Phase 2 Study, representing their respective organizations, have reviewed this WXX STS and have been given an opportunity to provide comments/inputs.

Nuclear Weapons Integration Division
Mr Keith Baird

Headquarters, Defense Nuclear Agency
Dr George Baker

Headquarters, AFSPACECOM
Maj John Valverde

Los Alamos National Laboratory
Dr Michael Bernardin

Lawrence Livermore National Laboratory
Dr Joe Sefcik

Sandia National Laboratories, California
Dr Jim Hogan

Nuclear Weapons Integration Division
Mr Francisco Carrillo

Field Command, Defense Nuclear Agency
Capt John Warzinski

Phillips Laboratory
Mr Sam Gutierrez

Sandia National Laboratories, New Mexico
Dr Jerry Cuderman

Det 10, Space Missile Center
Capt David Sanders

USSTRATCOM
Maj Steven Langer

Department of Energy, Albuquerque
Mr Dennis Umsler

FOREWORD

Purpose of the Stockpile-to-Target Sequence (STS): The STS is a "living document" that is written and updated by the Department of Defense (DoD). The purpose of the STS is defined by the following points:

A. This STS was prepared by the SA-ALC/NWIW in accordance with the guidelines of the joint DoD/DOE Technical Manual 50-20, Procedures for Preparation and Use of Stockpile-to-Target Sequences for Nuclear Weapons[1] and the provisions of DoD Directive 3150.1, 27 December 1983.[2]

B. TM 50-20 directs the preparation of the STS by the cognizant Military Department "to provide the DOE and the military Service agencies with requirements, design goals, and supplemental data which amplify the MC's by providing additional detailed information necessary for development of a nuclear weapon. This will include the description of the logistics, deployment concepts, and associated environments."[1]

C. "Changes to the STS will be approved by the executive study group and will be published by the cognizant Military Department. The cognizant Military Department shall inform the Nuclear Weapons Council Standing and Safety Committee (NWCSSC), before approval, of changes that may require significant additional resources or delay initial operational capability."[2]

D. "The DOE will use approved STS, STS changes, revisions, and addenda as requirements documents in the development or modification of nuclear weapons."[1]

E. When new STS requirements are declared, warhead redesign and/or additional analytical and testing efforts do not necessarily need to be initiated; however, the warhead capabilities must be evaluated against these new STS requirements and an assessment should be provided by the DOE to the SA-ALC/NWI for evaluation by the DoD. If the capabilities of the warhead against these new STS requirements are not available, the estimated time, extent, and cost of analysis and testing which are required to evaluate the weapon capabilities against the new STS requirements should be provided by the DOE to the DoD through the executive study group or the SA-ALC/NWI.

F. The DOE and its contractors will note all STS requirements which they do not consider credible by noting the specific requirement in the dissenting opinion section at the end of this STS prior to endorsing revisions or changes to the NWCSSC Phase 3 approved STS.

G. Dissenting opinion issues will be worked by the executive study group to reach resolution. If they cannot resolve the issue or the issue has a significant impact on the system, they will handle this in accordance with the procedures in the joint DoD/DOE Technical Manual 50-20 and DoDD 3150.1. Ultimately, the issue could involve a credible environment which the warhead is unable to meet. If so, it could result in a limitation statement in the warhead Major Assembly Release (MAR), redesign, or requalification of the warhead or a study package being forwarded to the NWCSSC for resolution.

Approval: The original STS was reviewed by the POG and formally approved by the Nuclear Weapons Council Standing and Safety Committee on __________.

Historical Record of Revisions/Changes

TABLE OF CONTENTS
(All portions of this Table of Contents are UNCLASSIFIED)

LIST OF FIGURES

(All portions of this List of Figures are UNCLASSIFIED)

DTRA b(1)

LIST OF FIGURES (concluded)
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LIST OF TABLES

(All portions of this List of Tables are UNCLASSIFIED)

LIST OF ABBREVIATIONS AND ACRONYMS
(All portions of this List of Abbreviations and Acronyms are UNCLASSIFIED)

A/C	Aircraft
AFFF	Aqueous Film Forming Foam
AFLC	Air Force Logistics Command
AFSPC	Air Force Space Command
AGL	Above Ground Level
AS&I	Assembly, Surveillance and Inspection (Building)
AVDS	Aviation Depot Squadron
AVE	Aerospace Vehicle Equipment
CDS	Command Disablement System
CINC	Commander in Chief
CNWDI	Critical Nuclear Weapons Design Information
CONUS	Continental United States
DM	Deployment Module
DoD	Department of Defense
DoDD	Department of Defense Directive
DOE	Department of Energy
DOE/AL	Department of Energy/ Albuquerque Operations Office
DSW	Directorate of Special Weapons
[redacted]	[redacted]
ICAO	International Civil Aviation Organization
IFD	
IHE	Insensitive High Explosive
IOC	Initial Operational Capability
JCS	Joint Chiefs of Staff
JMEM	Joint Munitions Effectiveness Manual
LCC	Launch Control Center
LLCE	Limited Life Component Exchange
LST	Local Standard Time
LRU	Line Replaceable Unit
MAF	Missile Alert Facility
MAR	Major Assembly Release
MC	Military Characteristics
MFD	Military First Destination
MHU	Munitions Handling Unit
MIL-STD	Military Standard
MMS	Munitions Maintenance Squadron
MOB	Main Operating Base
MSL	Mean Sea Level
MUNS	Munitions Squadron
nmi	nautical mile
NWCSSC	Nuclear Weapons Council Standing and Safety Committee
OS	Operational Storage
OSD	Office of the Secretary of Defense
PAL	Permissive Action Link
PBV	Post Boost Vehicle
POG	Project Officers Group
PRR	Pulse Repetition Rate
PT	Payload Transporter
QRA	Quick Reaction Alert
RH	Relative Humidity
RS	Reentry System
RSA	Reentry System Assembly
SA-ALC/NWI	San Antonio Air Logistics Center /Nuclear Weapons Integration
SD	Standard Deviation
SDE	Silicon Dose Equivalent
SL	Sea Level
S/SC	Storage and Shipping Container
SRV	Single Reentry Vehicle
SST	Safe Secure Trailer
START	Strategic Arms Reduction Treaty
STS	Stockpile-to-Target Sequence
T&H	Test and Handling
TBD	To Be Determined
TM	Technical Manual
TO	Technical Order
USAF	United States Air Force
WES	Warhead Electrical System
WR	War Reserve
WSA	Weapons Storage Area

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SECTION 1
(U) INTRODUCTION

1.1 (U) General. This Stockpile-to-Target Sequence (STS) presents the sequence of events and environments that the WXX High Power Radio Frequency (HPRF) nuclear warhead may encounter from its entry into the stockpile through its delivery to target. For the purpose of this document the environmental definitions become effective starting when the WXX HPRF warhead assembly, in its shipping container, is transported to the "military first destination". This document provides the Department of Energy (DOE) criteria necessary for the development of the warhead and its support equipment. The Military Characteristics (MCs) specifies requirements and references this STS. The military service agencies may also use the STS as logistic support criteria and as a training document for the support community and service commanders. Significant logistical, maintenance and operational events are included for clarity; however, this document is not intended to serve as criteria for design of the missile or the reentry system.

1.2 (U) References. In most cases, the information is quoted from DoD/DOE publications. Reference numbers are enclosed in brackets, [ ], and a full description of the source document is listed at the end of this STS. Most references are on file with the Nuclear Weapons Integration Division (SA-ALC/NWIW) and are available for review if needed.

1.3 (U) Revision and Retirement. The data presented in this STS are the best currently available and will be updated periodically with approval from the WXX HPRF Project Officers Group to reflect the latest defined logistical, operational, and environmental requirements as the weapon system develops. Letter changes may be used as an interim means for STS revision. Interim changes/revisions will be coordinated and approved in accordance with the joint DoD/DOE Technical Manual 50-20 [1]. Suggested changes or additions to the information presented in this STS should be forwarded to SA-ALC/NWIW, 1651 1st St SE, Kirtland AFB, NM 87117-5617. This STS is a living document and will be maintained and updated throughout the life of the WXX warhead until the last WXX HPRF is withdrawn from the stockpile.

1.4 (U) Units of Measure. The primary units of measure used in this STS will be SI units. However, the English system of pounds, inches, feet, and degrees Fahrenheit may appear in some information contained in this STS.

1.5 (U) Definitions. Standard terms used in this STS are defined in TO 11N-4-1 [3] and illustrated in Figure 1-1. Special uses defined below are uniform throughout this document.

1.5.1 (U) DOD Custody. DOD custody occurs at "military first destination" as defined in TO 11N-100-2 [4].

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by the reentry vehicle designers are described in Figure 1-2.

1.5.3 (U) Reentry Vehicle (RV). The reentry vehicle is the DoD provided structure to contain DOE warhead components as well as arming, fuzing, and firing.

1.5.4 (U) Reentry System (RS). The RS is defined to be the RV and DOE warhead components as well as AF&F within the structure.

1.5.5 (U) Reentry System Assembly (RSA). The RSA is defined as the mated RS, Deployment Module and ascent shroud.

1.5.6 (U) Ascent Shroud. The Ascent Shroud is defined as the low-drag aerodynamic shape which covers the arrangement of payload RVs during powered flight in the atmosphere.

1.5.7 (U) Deployment Module (DM). The Deployment Module is defined as the structure which includes the payload bulkhead support for mounting the RVs and chaff dispensers.

1.5.8 (U) Post Boost Vehicle (PBV). The post boost vehicle is defined as: stage IV, including the DM, with the RS attached to the DM, and the residual portion of the ascent shroud which remains attached to the DM after the ascent shroud has been jettisoned. The missile guidance system and related equipment is installed in stage IV.

1.5.9 (U) Missile. The missile consists of the RS, ascent shroud, PBV and the assembled booster.

1.5.10 (U) Reentry Vehicle Axes Notation. The axes system and sign conventions used

1.6 (U) Weapon System Description.

1.6.1 (S) Missile System. The LGM-30G is the Aerospace Vehicle Equipment (AVE) which is associated with the Minuteman III (MMIII). The LGM-30G missile consists of a three stage solid propellant booster, propulsion system rocket engine (PSRE), missile guidance system (MGS), RSA and missile integrating hardware. Each missile is stored and launched from an underground Launch Facility (LF) which is controlled from a manned Missile Alert Facility (MAF) or alternatively from the Airborne Launch Control Center (ALCC). MM III missiles are deployed at four wings with one to four squadrons in each wing. Each wing is supported by a Strategic Missile Support Base (SMSB). Each squadron includes fifty LFs and five MAFs. Each MAF controls and monitors at least 10 LFs. Any two MAFs are capable of launching any of the squadrons' missiles individually, in salvo, in partial salvo, or in ripple mode. Each missile is capable of storing trajectory and fuzing data for four preselected target sets. Each target set can have up to three different targets.

1.6.2 (U) Single Reentry Vehicle (SRV). To meet the Strategic Arms Reduction Treaty (START) requirements, no more than one RV may be carried with each missile system.

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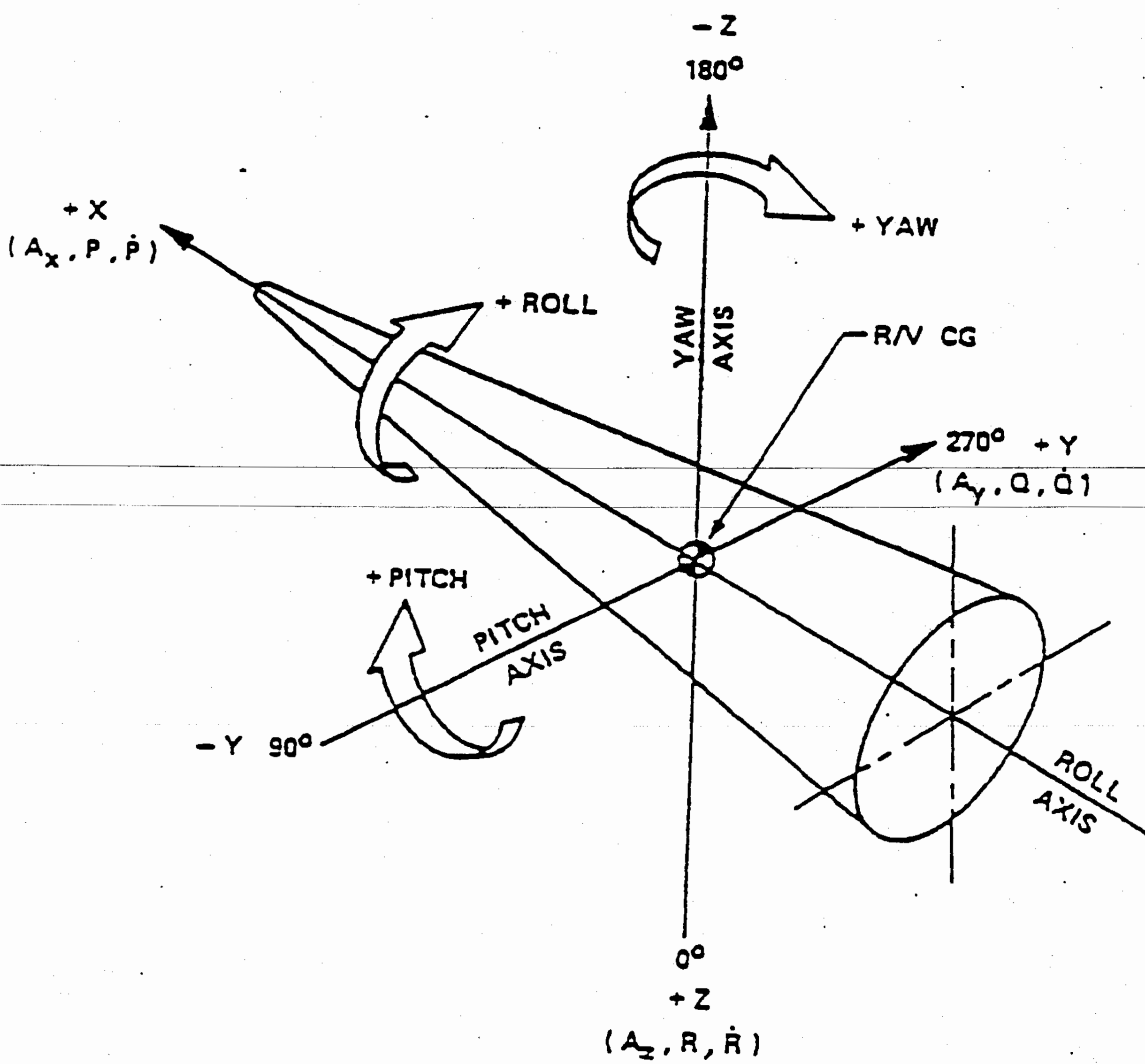

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Figure 1-2 Reentry Vehicle Roll, Pitch and Yaw Axis Definition (U)

SECTION 2
(U) LOGISTIC AND EMPLOYMENT CONCEPTS

2.1 (U) Logistics Plan. The information in this section is descriptive only and is not a statement of requirements. Logistical support for the MM III missile system, as it relates to the WXX HPRF War Reserve (WR) warhead, will generally be consistent with procedures presently employed with similar systems, although some changes to current procedures may be required. New technical development in warhead logistic support procedures should be accomplished jointly by the DoD/DOE and incorporated into this document. Logistical support is based upon concepts developed by the Air Force Materiel Command (AFMC), Air Combat Command (ACC), and the Air Force Space Command (AFSPC). The Directorate of Nuclear Weapons (DNW) at San Antonio Air Logistics Center (SA-ALC) is the focal point for nuclear ordnance logistics support and will act as Nuclear Ordnance Commodity Manager (NOCM) for the warheads, arming and fuzing system, warhead test and handling equipment, and associated support equipment.

2.2 (U) Logistics Flow. A description of the warhead logistics flow for the MM III/WXX system is shown in Figure 2-1 and Table 2-1 respectively.

2.2.1 (U) Department of Defense (DOD) Contractors. DOD contractors will provide RS subassemblies and associated components to the DOE. They will also provide RS components to Air Force facilities for final RSA assembly.

2.2.2 (U) Department of Energy (DOE). The Department of Energy (DOE) has full responsibility for the WXX HPRF warhead assembly until it is delivered to the DOD. Within the DOE facility, the DOD components and subassemblies will be mated with the DOE nuclear components to form the WXX HPRF warhead assembly.

2.2.2.1 (U) Shipping Configurations. The DOE will ship the warhead assembly, in a DOE provided shipping and storage container (S/SC), by safe secure trailer (SST) to either the Munitions Squadron or to the Weapons Storage Area (WSA) at the Main Operating Base (MOB).

2.2.2.2 (U) Container Compatibility. The warhead S/SC shall be compatible with present military transportation systems, handling and storage procedures for nuclear warheads, and military support equipment as close as practical.

2.2.2.3 (U) DOE Procured Test Equipment. Appropriate warhead test and handling equipment, warhead trainers, and the necessary spares to support the nuclear warheads will be routed through SA-ALC/NW for distribution to the MUNS or WSA.

2.2.3 (U) Military First Destination (MFD). The WXX HPRF warhead assembly will be shipped to the appropriate MFD in a DOE-provided shipping container. The MFD can either be the depot Munitions Squadron (MUNS) or the host Strategic Missile Support Base (SMSB). When the warheads arrive at the MFD, acceptance check and inspections will be performed. The WXX HPRF warhead assembly will be stored, within its shipping container, in a storage facility. Required maintenance for the warheads, including Limited Life Component Exchange (LLCE), could be provided by the TBD in accordance with existing DOE/DOD agreements. If warheads were sent to the MUNS, the MUNS, when directed, will

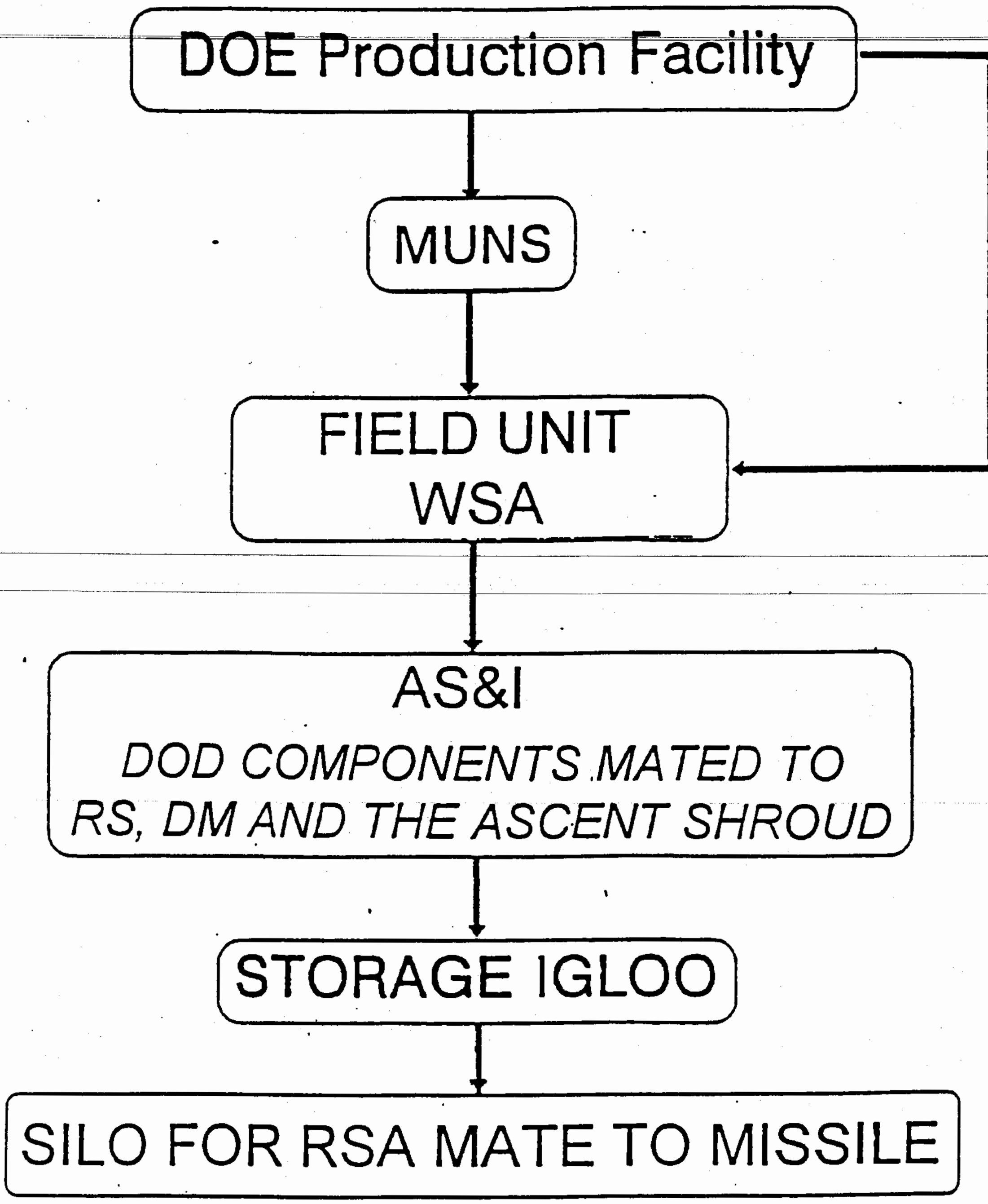

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Figure 2-1 Warhead Logistic Flow Diagram (U) provide the SMSB with the required number of warheads. The warheads will be stored at the SMSB in the weapon storage area (WSA). Depot level maintenance will be provided for warhead test and handling equipment, warhead trainers, spares, and DOD provided support equipment.

2.2.4 (U) Weapon Storage Area (WSA). The WSA will be provided by the using organization and is manned by AFSPC personnel. Figure 2-2 shows the typical orientation of the WSA. Upon arrival at the WSA the warhead assembly, in its S/SC, is taken to the RS AS&I receiving and inspection area where the container is inspected for damage, and the warhead serial number is verified. After a satisfactory inspection, the unit may be placed in temporary storage in a DOE shipping container or prepared for assembly with RS components. The RS components arrive at the WSA as major subassemblies in DOE or DOD shipping containers. The RS is assembled and tested at the munitions facility by AFSPC personnel. The RS and the ascent shroud are mated to the DM to complete assembly of the RSA. The RSA, in a nose-up position, is mounted on a pallet for transportation. The RSA is stored in the storage facility or transported to the silo for mating to the missile. The RSA is capable of being transported only in the vertical position.

2.2.5 (U) Launch Silo. The Payload Transporter (PT) moves the RSA from the AS&I to the launch silo. Here it is transferred in the RSA carriage from the container into the emplacer. An environmental cover provides some protection to the RSA during transfer. The RSA carriage is locked to the emplacer rails, the RSA sling is attached to the emplacer hoist and the RSA is lowered into the silo and attached to stage IV of the missile. Acceptance checks are made and the missile is readied for strategic alert. Figures 2-3 and 2-4 show the PT Van and the PT III Van.

2.3 (U) Storage. The RS and the RSA encounter a variety of storage environments within the STS flow of events. The length of time associated with the storage requirements will also vary. At the WSA, the WXX HPRF, in its S/SC, will be subjected to ambient, uncontrolled temperature and humidity within the storage igloo. All other storage environments will be controlled to the extent of the design requirements for the structure.

2.4 (U) Transportation and Handling. The warhead, while in the S/SC, RS, or RSA, will be subjected to many types of transportation and handling equipment. Methods of transportation and handling are given in Table 2-1.

2.5 (U) **Maintenance.** The three levels of authorized maintenance are organizational, intermediate and depot; however, maintenance should be accomplished at the lowest possible level and it should be simple, safe, and use existing support equipment where practical.

2.5.1 (U) Organizational. Line Replaceable Unit (LRU) removal and replacement will be performed by AFSPC crews at the organizational level. This level of maintenance will restore a missile to alert status or prevent loss of alert status. No RSA or RS maintenance actions will take place at the organizational level.

2.5.2 (U) Intermediate. Intermediate level maintenance is performed by TBD personnel in the WSA. The AS&I will be the key maintenance repair area for RS/RSA and will be the only facility accomplishing RS/RSA build-up and repair activities. Maintenance activities on the RS which could affect DOE components will be

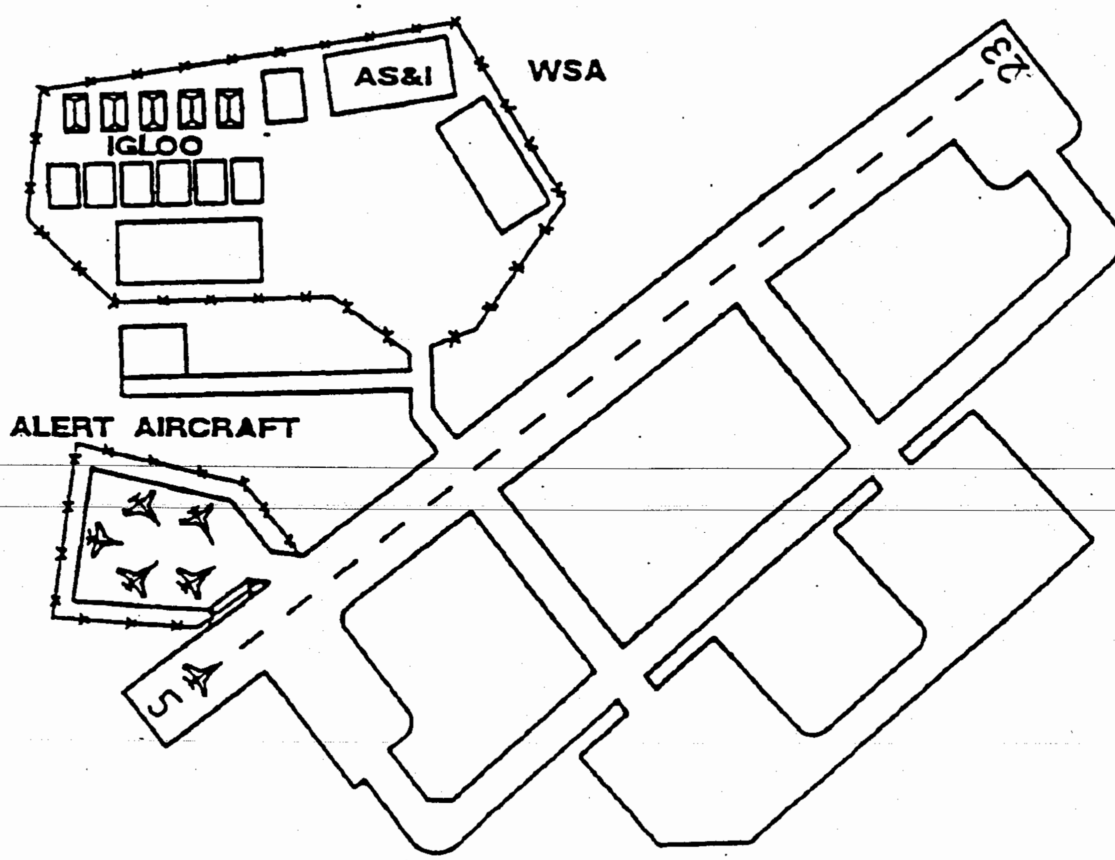

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Figure 2-2 Typical Orientation of Weapons Storage Area (WSA) (U)

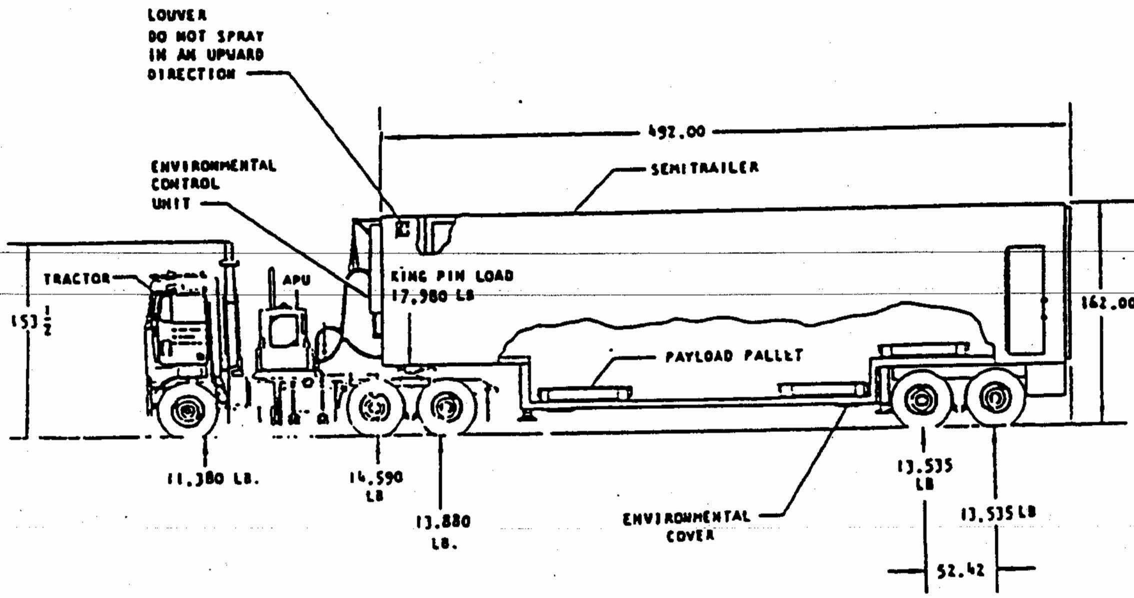

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Figure 2-3 Payload Transporter (PT) Van (U)

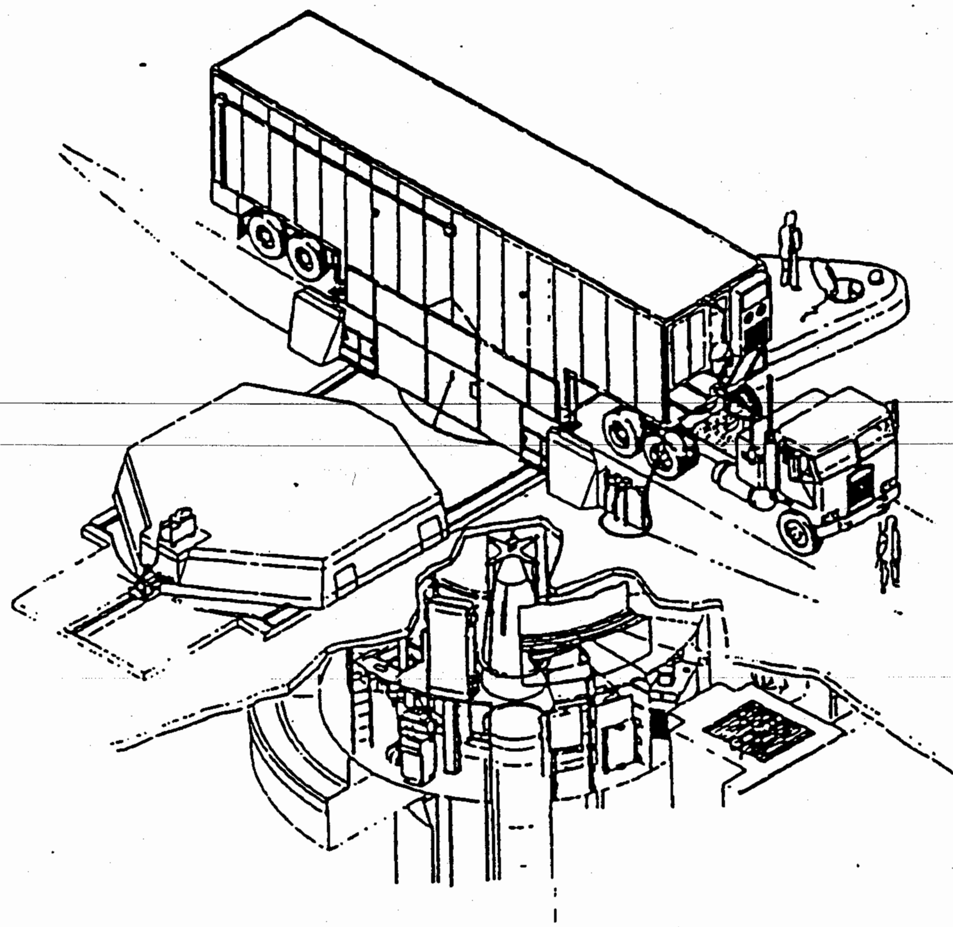

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Figure 2-4 Payload Transporter (PT) III Van (U)

TRANSFER POINT	PRIMARY METHOD	SECONDARY METHOD	CONFIGURATION
DOE TO OSS OR MOB	SAFE SECURE TRAILER		
OSS UNLOAD/LOAD AREA (SST) TO STORAGE OR MAINTENANCE AREA	25 FT FLATBED 40 FT FLATBED	FORKLIFT	WARHEAD ASSEMBLY IN SHIPPING AND STORAGE CONTAINER
WSA UNLOAD/LOAD AREA (SST) TO AS&I FACILITY	FORKLIFT		
OSS STORAGE TO 25/40 FT FLATBED	FORKLIFT		
OSS TO FLIGHTLINE	25 FT FLATBED 40 FT FLATBED		
OSS TO MOB	MILITARY AIR CARGO		
AIRCRAFT TO 25/40 FT FLATBED	FORKLIFT		
FLIGHTLINE TO AS&I FACILITY	25 FT FLATBED 40 FT FLATBED 40K LOADER		
AS&I FACILITY	FORKLIFT	OVERHEAD HOIST	
SHIPPING CONTAINER TO RS MAINTENANCE STAND	OVERHEAD HOIST WITH RS MATING AND HANDLING SLING		WARHEAD ASSEMBLY
RS MAINTENANCE STAND TO BALL-LOCK STAND			REENTRY SYSTEM
BALL-LOCK STAND TO RSA MAINTENANCE STAND		NONE	REENTRY SYSTEM ASSEMBLY
RSA MAINTENANCE STAND TO RSA PALLET	OVERHEAD HOIST		
RSA PALLET TO PAYLOAD TRANSPORTER	PAYLOAD TRANSPORTER HOIST	NONE	
RSA TO MISSILE SITE	PAYLOAD TRANSPORTER	NONE	
PAYLOAD TRANSPORTER TO MISSILE	PAYLOAD TRANSPORTER HOIST	NONE	

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Table 2-1 Methods of Transportation and Handling (U) limited to LLC exchanges using approved procedures, support equipment and inspection and handling of the WXX warhead.

2.5.3 (U) Depot. Depot level maintenance is any necessary maintenance that cannot be performed at the organizational and intermediate levels. However, any authorized intermediate level maintenance can be performed at the depot level. Depot level maintenance is only performed at the DOE facilities.

2.5.4 (U) Recycle and Sampling. Warheads may be returned to DOE for quality assurance testing or for modifications that cannot be done in the field. Warheads will also be returned to DOE for extensive repair or retrofits when beyond the capabilities of the field unit or MUNS.

2.5.5 (U) Limited Life Component Exchange (LLCE). The time between LLCE will be optimized considering operational and logistical requirements and DOE costs. The LLCE will be accomplished by TBD personnel at TBD. Replacement procedures will be included in the appropriate 11N series technical orders and published concurrent with or prior to shipment of the first warhead to the MUNS or WSA.

2.6 (S-FRD) Employment Concepts. The following sections address the anticipated employment concepts for the MM III/WXX HPRF weapon system.

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2.6.2 (S-RD) Weapon Readiness Status. [redacted]

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2.6.3 (U) Alert Status. The alert status for the MM III is called strategic alert. Missiles in the strategic alert condition are capable of being launched 30 seconds after receipt of the execute launch command (ELC) from the LCC. The status and safety of the missile and RS will be determined by remote electrical monitoring.

2.6.4 (U) Trajectory. The following sections address the flight and staging, reentry, and fuzing options for the weapon system.

2.6.4.1 (U) Flight and Staging. [redacted]

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2.6.4.2 (U) Reentry. [redacted]

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[redacted]

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SECTION 3
(U) ENVIRONMENTAL REQUIREMENTS

3.1 (U) General. The following describes the format and methodology used throughout Section 3.

3.1.1 (U) Environmental Specifications. The environments specified in this section of the STS may be experienced by the warhead throughout its stockpile life. **Information contained within these sections are provided for information purposes acquired from the W78 STS dated November 1994 [11].**

3.1.2 (U) Stages of Environments. The format for defining the logistical and operational environments in this section is to specify seven logistical and operational stages.

3.1.3 (U) STS Definitions of Environments. In this STS, the term "Environments" will have the following definitions, quoted from T.O. 11N-4 [3] wherever possible.

3.1.3.1 (U) Credible Environment. Any environment that a user anticipates in the deployment of the weapon, with approval of the WXX HPRF POG, will be considered a credible environment...

3.1.3.2 (U) Normal Environment. The expected logistical and operational environments as defined in a weapon's STS and MCs which the weapon is required to survive without degradation in operational reliability.

3.1.3.3 (U) Abnormal Environment. Those environments as defined in a weapon's STS and MCs in which the weapon is not expected to retain full operational reliability. However, the safety requirements as stated in the MCs must be met.

3.1.4 (U) Stages of the STS. The logistic and delivery operations are divided into seven stages. These stages are characterized as follows:

3.1.4.1 (U) Stage 1: Transportation. The warhead is transported in its DOE shipping container on a truck/trailer or aircraft.

3.1.4.2 (U) Stage 2: Storage. The warhead is either stored in its DOE shipping container, or as an element of the RS or RSA.

3.1.4.3 (U) Stage 3: Handling and Assembly. The warhead, RS, and RSA will be assembled and handled with the aid of equipment authorized by the Air Force. Movement of the warhead (in shipping container) and palletized RS/RSA configurations between the WSA and storage facility will be accomplished by forklift.

3.1.4.4 (U) Stage 4: Transportation Handling. Operations include transporting RSA to and from the silo in a PT van and mating/ demating to the missile.

3.1.4.5 (U) Stage 5: Preflight. RSA installed on missile in silo.

3.1.4.6 (U) Stage 6: Powered Flight. From ignition to apogee. For nuclear environment considerations, from ignition to apogee. (Incorporate altitudes and stage separation including RS)

3.1.4.7 (U) Stage 7: Ballistic Flight. From apogee to detonation.

3.1.5 (U) Standards for STS Environments. The environments used in this STS will follow these standards unless otherwise noted.

3.1.5.1 (U) Configuration. The environment specified is that applied to the external boundaries of any assembled configuration containing the warhead during the applicable stage unless otherwise stated. Table 3-1 displays how to use each environment table.

3.1.5.2 (U) Level of Environments. During initial system design, warhead level environments are not always available and system level estimates are included. When this is the case, the external boundary of the configuration will be specified.

3.1.5.3 (U) Descriptions of Data. In this STS, the actual environments or environmental requirements will be used as the limits for data. Weapon designers will account for their own margin of safety in design and reliability computation. Where a figure contains data that are intensified or incorporate a safety margin, the extent of the intensification will be noted in the figure.

3.1.5.4 (U) Environmental Specifications. Environmental specifications and operational requirements will change over time. In particular, the method of presentation for climatic conditions has been changed from MIL-STD-210B (1974)[5] to the current MIL-STD-210C (1987).[6] In a very few cases, the new data may have made the environmental specifications more stringent. Definitions used in MIL-STD-210C are as follows:

3.1.5.4.1 (U) One percent extreme/risk/value is an environment which occurs roughly 1 percent of the time, e.g., if a temperature occurs or is exceeded for an average of seven hours in a 31 day month (744 hours). A 5, 10, and 20 percent (extreme/risk/value) can be defined in like manner.

3.1.5.4.2 (U) 10, 30, and 60 year extremes are long-term climatic values that are expected to occur at least once, for a short duration (less than three hours), during approximately 10, 30, and 60 years of exposure.

3.1.5.4.3 (U) MIL-STD-210C recommends that design and testing efforts generally consider the 1 percent extreme data points rather than the most extreme values ever recorded. This assumes acceptance of some level of degradation under conditions of maximum environmental stress. Engineering analyses and cost/capability trade-offs will be required to determine the final design parameters of a munition. Some areas where the 1% extreme is not recommended as guideline are:

- extreme cold temperature - use 20% extreme;
- rainfall - use 0.5% extreme;
- hail - use 0.1% extreme where human life is involved; and
- pressure - use most extreme values.

3.1.5.5 (U) Multiple Effects. The compounding of effects caused by both natural and induced environments may be more than the sum of the individual effects and must be considered. Any situations of worst case synergism must be examined. Fragmentation, dropping, or crush prior to or during exposure to a fire with subsequent exposure to fire fighting chemicals is an example.

3.2 (U) Normal Environments. The following sections describe the single normal environments for the WXX HPRF warhead.

3.2.1 (U) Normal Biological Environments. A summary of normal biological environments is presented in Table 3-2.

3.2.2 (U) Normal Thermal Environments. A summary of normal thermal environments is presented in Table 3-3.

3.2.3 (U) Normal Pressure Environments. A summary of normal pressure environments is presented in Table 3-4.

3.2.4 (U) Normal Humidity Environments. A summary of normal humidity environments including absolute and relative humidity is presented in Table 3-5.

3.2.5 (U) Normal Precipitation Environments. A summary of normal precipitation environments is presented in Table 3-6.

3.2.6 (U) Normal Wind Environments. A summary of normal wind environments is presented in Table 3-7.

3.2.7 (U) Normal Suspended Particles Environments. A summary of normal suspended particles environments is presented in Table 3-8.

3.2.8 (U) Normal Chemical Environments. A summary of normal chemical environments is presented in Table 3-9.

3.2.9 (U) Normal Electromagnetic Radiation Environments. A summary of normal electromagnetic radiation environments is presented in Table 3-15.

3.2.10 (U) Normal Electrical Environments. Normal electrical environments include lightning and electrostatic discharge and are summarized in Table 3-17.

3.2.11 (U) Normal Mechanical Environments. These environments are described in terms of shock, vibration, acceleration, and acoustics. Shock is considered to be rapidly changing large accelerations of short duration.

3.2.11.1 (U) Normal Shock Environments. A summary of normal shock environments is provided in Table 3-18.

3.2.11.2 (U) Normal Vibration Environments. A summary of normal vibration environments is provided in Table 3-19.

3.2.11.3 (U) Normal Acceleration Environments. A summary of normal acceleration environments is provided in Table 3-22.

3.2.11.4 (U) Normal Acoustic Environments. A summary of normal acoustic environments is provided in Table 3-24.

3.2.12 (U) Normal Nuclear Environments. Nuclear environments are those environments caused by a nuclear event. They are presented in this STS in four categories--blast, thermal, radiation and electromagnetic pulse (EMP). Table 3-25 summarizes these environments.

Stage	Environment
1 Transportation	*If there are no line between stages in any column, the requirement applies to all stages*
2 Storage	
3 Handling & Assembly	
4 Transportation Handling	
5 Preflight	*If there are lines between stages in any column, the requirement applies to the stages bounded by the lines.*
6 Powered Flight	
7 Ballistic Flight	

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Table 3-1 Warhead Configurations (U)

<table>
<tr><th>Stage</th><th>Biological</th></tr>
<tr><td>1
Transportation</td><td rowspan="3">Exposure to mold, fungus, and bacterial growth as encountered in tropical climates

Favorable conditions which permit growth of fungus and bacteria are:

moisture content of nutrient 8% and up;
moisture content of air 70-100% RH;
temperature 10-38°C;
pH range 4-7; and
nutrient elements required for fungi C, H, N, S, K, Mg, P, plus trace elements.

Light is not required.

Other conditions including severe cold can permit biotic growth.

The warhead may experience external attack by all kinds of mold and fungus for periods up to the length of the inspection cycle.</td></tr>
<tr><td>2
Storage</td></tr>
<tr><td>3
Handling &
Assembly</td></tr>
<tr><td>4
Transportation
Handling</td><td rowspan="4">N/A</td></tr>
<tr><td>5
Preflight</td></tr>
<tr><td>6
Powered Flight</td></tr>
<tr><td>7
Ballistic Flight</td></tr>
</table>

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Table 3-2 Normal Biological Environments (U) [7,8]

Stage	Thermal	
1 Transportation	Worldwide temperatures: 1% high 49°C 20% low -51°C Temperature Shock: 49°C or -51°C to/from 20°C Maintenance: Normal 20°C	
2 Storage	Igloo: -18°C to 27°C; see Figure 3-1.	
3 Handling & Assembly	Same as Stage 1	CG HPRF-1 ?
4 Transportation Handling	TBD	
5 Preflight		
6 Powered Flight		
7 Ballistic Flight		

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Table 3-3 Normal Thermal Environments (U) [6,9,11]

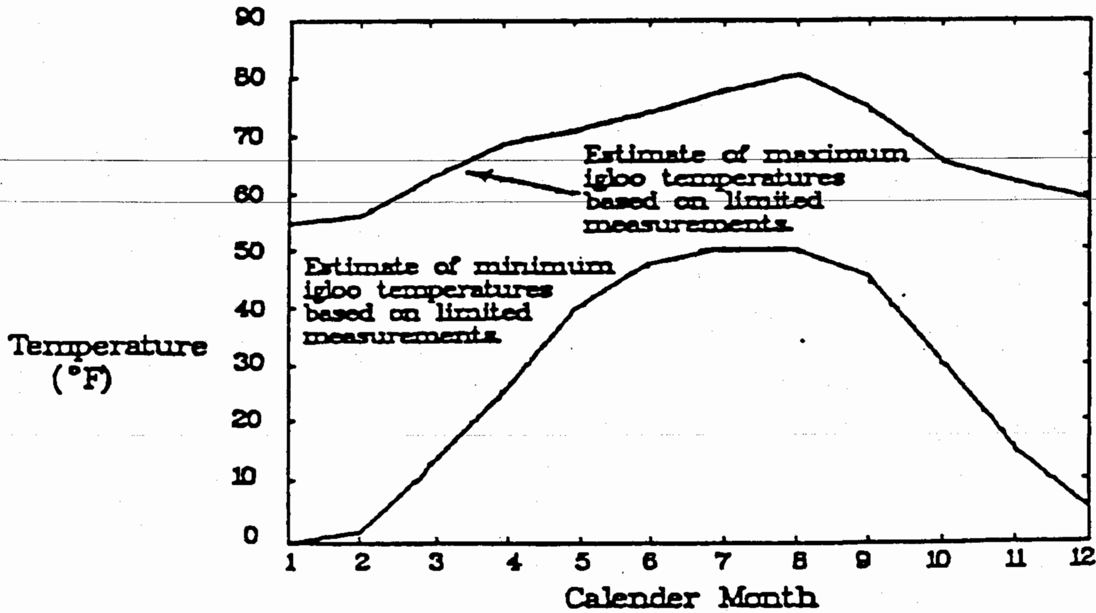

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Figure 3-1 Igloo Storage Temperatures (Hot and Cold) (U)

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Stage	Pressure	
1 Transportation	Sea Level:	The worldwide surface record high atmospheric pressure is 1083.8 mb. The worldwide surface low atmospheric pressure recorded was 870 mb in the eye of a typhoon.
2 Storage	1.8 km Extremes: (6 kft)	High: 840 mb Low: 750 mb
	Pressurized Cargo A/C:	Kept at nominal 586 mb.
	Pressure Shock:	586 mb to 190 mb in 3 seconds (decompression at 12 km est.)
3 Handling & Assembly	Air Density Extremes:	High: 1.783 kg/m^3 - highest recorded Low: 0.707 kg/m^3 @ 4.5 km
4 Transportation Handling	TBD	
5 Preflight		
6 Powered Flight	High: 1083.8 mb - highest recorded Low: 0 mb - exoatmospheric. 1.08 - 0 kg/cm^2 in about 120 sec.[11]	
7 Ballistic Flight	0 kg/cm^2 for up to 55 min.[11] Low: 0 mb - exoatmospheric.	

Note: MIL-STD-210C bases low atmospheric pressure and low surface density on the highest elevation contemplated for ground military operations: 4572m.

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Table 3-4 Normal Pressure Environments (U) [6,10,11]

Stage	Humidity
1 Transportation	High Absolute: 1% extreme: 30,000 ppm @ 37-41°C Low Absolute: 1% extreme: 5.2 ppm @ frost point of -26°C
2 Storage	High RH with High Temperatures: (1%) 100% @ 26 to 27°C High RH with Low Temperatures: (20%) 100% @ -51°C
3 Handling & Assembly	Low RH with High Temperature: 3% @ 49°C Low RH with Low Temperature: Not available
4 Transportation Handling	
5 Preflight	
6 Powered Flight	
7 Ballistic Flight	

USAF b(1)
DOE b(3)

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Table 3-5 Normal Humidity Environments (U) [6]

<table>
<tr><th>Stage</th><th>Precipitation</th></tr>
<tr><td rowspan="6">1
Transportation</td><td>Rainfall: The highest rainfall rates occurring 0.5, 0.1 and 0.01 percent of the time were estimated to be 0.6, 1.4 and 2.8 mm/min, respectively.</td></tr>
<tr><td>Raindrop Concentrations per cubic meter are:

<table>
<tr><th>Rate</th><th colspan="6">Drop Diameter Range (mm)</th></tr>
<tr><th>(mm/min)</th><th>0.5 to 1.4</th><th>1.5 to 2.4</th><th>2.5 to 3.4</th><th>3.5 to 4.4</th><th>4.5 to 5.4</th><th>5.5 to 6.4</th></tr>
<tr><td>0.6</td><td>1154</td><td>260</td><td>26</td><td>2</td><td><1</td><td><1</td></tr>
<tr><td>1.4</td><td>1608</td><td>520</td><td>77</td><td>8</td><td><1</td><td><1</td></tr>
<tr><td>2.8</td><td>2057</td><td>863</td><td>170</td><td>25</td><td>3</td><td><1</td></tr>
<tr><td>7.2</td><td>2779</td><td>1595</td><td>440</td><td>91</td><td>16</td><td>3</td></tr>
<tr><td>31.2</td><td>4121</td><td>3547</td><td>1514</td><td>487</td><td>135</td><td>34</td></tr>
</table></td></tr>
<tr><td>Snow: Blowing Snow: 1% extreme: 1.6×10^{-2} kg/m^2 - sec
Snow Load: 10% probability: 48 kg/m^2 for 24 hrs (total 480 mm)</td></tr>
<tr><td>Distribution of Blowing Snow Particle Sizes:

<table>
<tr><th></th><th colspan="13">Effective Diameters (micrometers)</th></tr>
<tr><th></th><th>23 to 34</th><th>35 to 46</th><th>47 to 58</th><th>59 to 70</th><th>71 to 82</th><th>83 to 94</th><th>95 to 106</th><th>107 to 118</th><th>119 to 130</th><th>131 to 142</th><th>143 to 154</th><th>155 to 166</th><th>167 to 178</th></tr>
<tr><td>Percent</td><td>.60</td><td>1.3</td><td>5.0</td><td>15</td><td>22</td><td>21</td><td>16</td><td>9.7</td><td>4.7</td><td>2.5</td><td>1.0</td><td>.70</td><td>.50</td></tr>
</table></td></tr>
<tr><td>Ice Accretion: 10 year extremes:
75 mm glaze, specific gravity 0.9
150 mm hard rime, specific gravity 0.6
150 mm soft rime, specific gravity 0.2</td></tr>
<tr><td>Hail: Density 900 kg/m^3.
Terminal Velocity: 57.5 m/sec
Max recorded: 142 mm in diameter</td></tr>
<tr><td>2
Storage</td><td>N/A</td></tr>
<tr><td>3
Handling & Assembly</td><td>Same as Stage 1</td></tr>
<tr><td>4
Transportation Handling</td><td rowspan="4">N/A</td></tr>
<tr><td>5
Preflight</td></tr>
<tr><td>6
Powered Flight</td></tr>
<tr><td>7
Ballistic Flight</td></tr>
</table>

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Table 3-6 Normal Precipitation Environments (U) [6]

Stage	Wind
1 Transportation	Surface Winds: 1% extreme: 1 min steady: 22 mps gust: 32 mps
2 Storage	N/A
3 Handling & Assembly	Same as Stage 1 N/A during indoor maintenance
4 Transportation Handling	N/A
5 Preflight	
6 Powered Flight	
7 Ballistic Flight	

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Table 3-7 Normal Wind Environments (U) [6]

Stage	Suspended Particles
1 Transportation	Sand and Dust: Size: 0.1 to 1000 μm; most airborne particles smaller than 74 μm Hardness: 1 to 9 Mohs Typical Concentrations: 0.177 gm/m^3 (natural conditions) 1.06 gm/m^3 (surface vehicles/unpaved road) Airborne Salt: pH 8.1 - 8.3 (in air) Size: 0.1 - 20 μm radius; 98% larger than 8 μm Concentration: rain: approx. 1 ppm limited to altitudes below 3 km; 33-40 parts/1000 in coastal areas Fallout: estimated between 1.8-45 kg/acre/year in U.S.
2 Storage	Expected to be less than 10% of that for Stage 1
3 Handling & Assembly	Same as Stage 1 Same as Stage 2 during indoor maintenance.
4 Transportation Handling	N/A
5 Preflight	
6 Powered Flight	
7 Ballistic Flight	

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Table 3-8 Normal Suspended Particles Environments (U) [6,12]

Stage	Chemicals
1 Transportation	Surface preservatives/solvents/thinners for maintenance: As specified in the appropriate Technical Orders; see Table 3-10. Fuels: See Table 3-11. Exposure will involve only limited areas Fire Fighting Chemicals: See Table 3-12.
2 Storage	Hydraulic Fluids: Air Force approved hydraulic fluids and their chemical characteristics are contained in MIL-H-5605E and MIL-H-83282. Lubricants: Aircraft engine lube oils and their chemical characteristics are specified in MIL-L-7808J. Representative lubricants are listed in Table 3-13.
3 Handling and Assembly	Exposure will involve only limited areas for up to 48 hr. Natural: Ozone; see Table 3-14.
4 Transportation Handling	N/A
5 Preflight	N/A
6 Powered Flight	N/A
7 Ballistic Flight	N/A

Note: Incidental exposure to these chemicals can be treated as normal environments when followed by maintenance procedures specified in the appropriate Technical Order.

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Table 3-9 Normal Chemical Environments (U) [6,13,14,15,16]

Cleaning Solvents

Cleaning Solvent	Remarks	Expected Exposure Times	Expected Exposure Areas
Isopropyl Alcohol	Removes fungus growth from rubber surfaces	5 min	Limited areas
5% solution of germicidal and fungicidal disinfectant	Removes fungus growth from unpainted surfaces.		
Trichloroethylene*	For cleaning painted surfaces only		

Thinners

Thinners		Expected Exposure Times	Expected Exposure Areas
Acetone Dope and Lacquer Methyl Isobutyl Ketone* Toluene*	Aliphatic Naphtha Methyl Ethyl Ketone* Mineral Spirits Xylene*	5 min	Limited areas (not total inundation)

Surface Preservatives

Surface Preservation	Surface	Constituents	Remarks
Alodine*	Aluminum	Nitric Acid Chromium Trioxide	Protects aluminum alloy parts from corrosion. Primarily used for touch-up work on previously coated surfaces.
Chromic Acid Solution*	Magnesium	10 gm Chromium Trioxide 7.5 gm Calcium Sulfate 1.0 liter water	For repair of magnesium surfaces with scratches that expose bare metal. Coating should be followed by an organic finish.
(Kit, resin-acid)	Steel	80 v/o resin compound 20 v/o acid compound v/o = % by volume	For repair of cadmium or zinc plated steel surfaces with scratches or other defects. Coating should be followed by an organic finish.
Primer	——	Vinyl-Zinc Chromate	Used as required.
Organic Finish	——	Vinyl-Alkyd Paint	
Epoxy Resin Epoxy Polyamide Polyurethane Coating Compound	——	——	For repairing surface preservations.

*Under Review

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Table 3-10 Representative Maintenance Chemicals (U) [13]

Jet Fuels	Remarks	Expected Exposure Duration	Expected Exposure Areas
JET A	Commercial fuel: military aircraft may be refueled with JET A in emergency situations.	5 min	Limited areas (not total inundation)
JP-4	Standard fuel for all military aircraft in the United States.	5 min	
JP-9 JP-10	Standard fuel for cruise missiles.	5 min	
<u>Others</u> Gasoline and Diesel Fuel	Contact with these fuels would only occur during Stage 1-4.	5 min	

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Table 3-11 Fuel Exposure Environments (U) [13]

	Expected Exposure Times	Expected Exposure Areas
Aqueous Film Forming Foam (AFFF)	2-4 hours	Limited areas (not total inundation)
Fresh Water	5-60 minutes	
Carbon Dioxide		
Bromochlorodifluoromethane (Halon 1211)		
Bromotrifluoromethane (Halon 1301)		
Dry Chemicals (primarily sodium bicarbonate expelled by carbon dioxide)		
Alkali-Metal-Salt (Met-L-X)		
Calcium Chloride (Metal fires only)		
G-1 Powder (Graphited foundry cake)		
Potassium Bicarbonate (Purple K-Powder)		

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Table 3-12 Fire Fighting Chemicals (U) [13]

Castrol 399	PQ Turbine Oil 4236
Brayco 880	PQ Turbine Oil 4706
Delta Jet Lube 7808	AO Syn Jet III
Exxon Turbo Oil 2389	PQ 4707
Hatcol 1278	RM 248A
Hatcol 1280	Rm 272
Matrex AF Oil 01	Turbonycoil 160
Matrex AF Oil 02	Royco 808
Matrex AF Oil 07	Aeroshell Turbine Oil 308
PQ Turbine Oil 8365	Technolube Synturbo #3
PQ Turbine Oil 9900	Synturbo #3B

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Table 3-13 Representative Lubricants (U) [16]

Altitude (km)	Ozone Concentration ($\mu g/m^3$)
0	220
1	205
2	190
4	170
6	170
8	460
10	735
12	865
14	975
16	1110
18	1075
20	845

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Table 3-14 Ozone Concentrations at Altitudes (U) [6]

Stage	Electromagnetic Radiation
1 Transportation	See Table 3-16 and Figure 3-2.
2 Storage	Assumed to be negligible in earth-covered igloos.
3 Handling & Assembly	See Table 3-16 and Figure 3-3. See Figures 3-2, 3-4 and 3-5.
4 Transportation Handling	
5 Preflight	TBD
6 Powered Flight	
7 Ballistic Flight	

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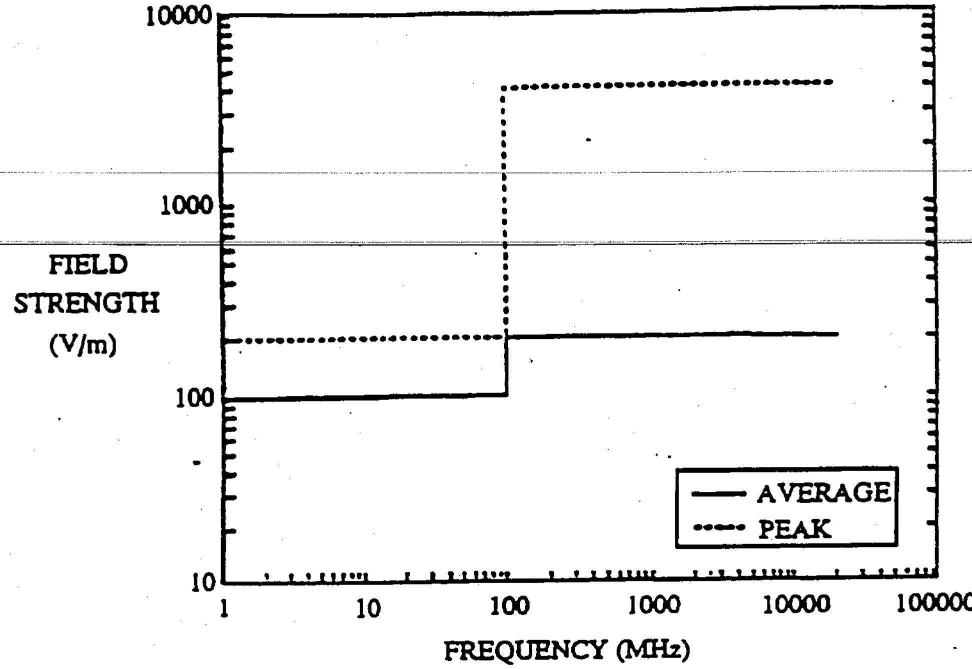
Table 3-15 Normal Electromagnetic Radiation Environments (U) [17-23]



Note: For testing purposes only, assume maximum duty cycle of 5% and a pulse repetition frequency of 2500 Hz.

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Figure 3-2 EMR Field Strengths for Stages 1-4 (U) [20-22]

Frequency (MHz)	Power Density (mW/cm^2)	Electric Field Strength (V/m)	Magnetic Field Strength (A/m)
0.01 - 3	100	632	1.58
3 - 30	$900/f^2$	6.32 (30/f)	0.158 (30/f)
30 - 100	1.0	63.2	0.158
100 - 1000	f/100	63.2 ($f^{0.5}/10$)	0.158 ($f^{0.5}/10$)
100 - 300,000	10	200	0.5

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Note: These levels are averaged over any six-minute period of operation and represent the maximum permissible exposure limits in restricted areas for human exposure to radiofrequency radiation.

Table 3-16 Average EMR Field Strengths in Stages 1-4 (U) [18]

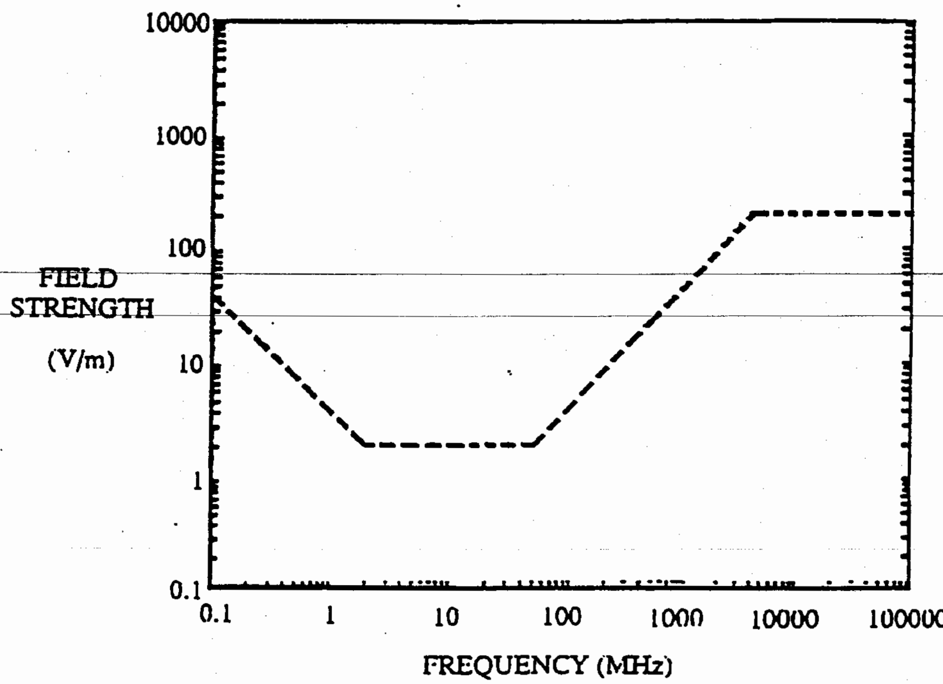

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Figure 3-3 Peak EMR Field Strengths in Stage 3 Handling & Assembly (U) [19]

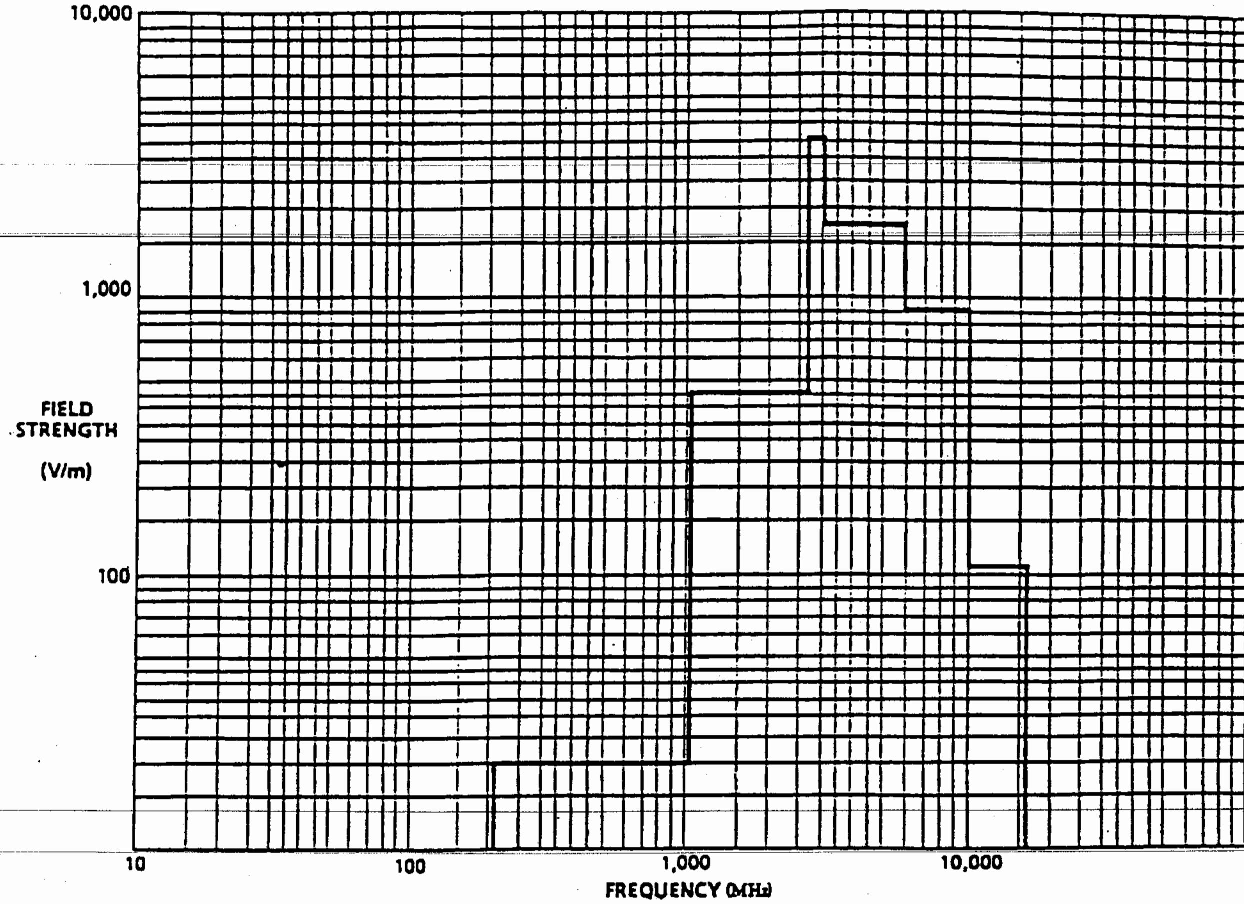

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Figure 3-4 Peak EMR Field Strengths in Stages 3 and 4 - ACC Base (Typical) (U) [17]

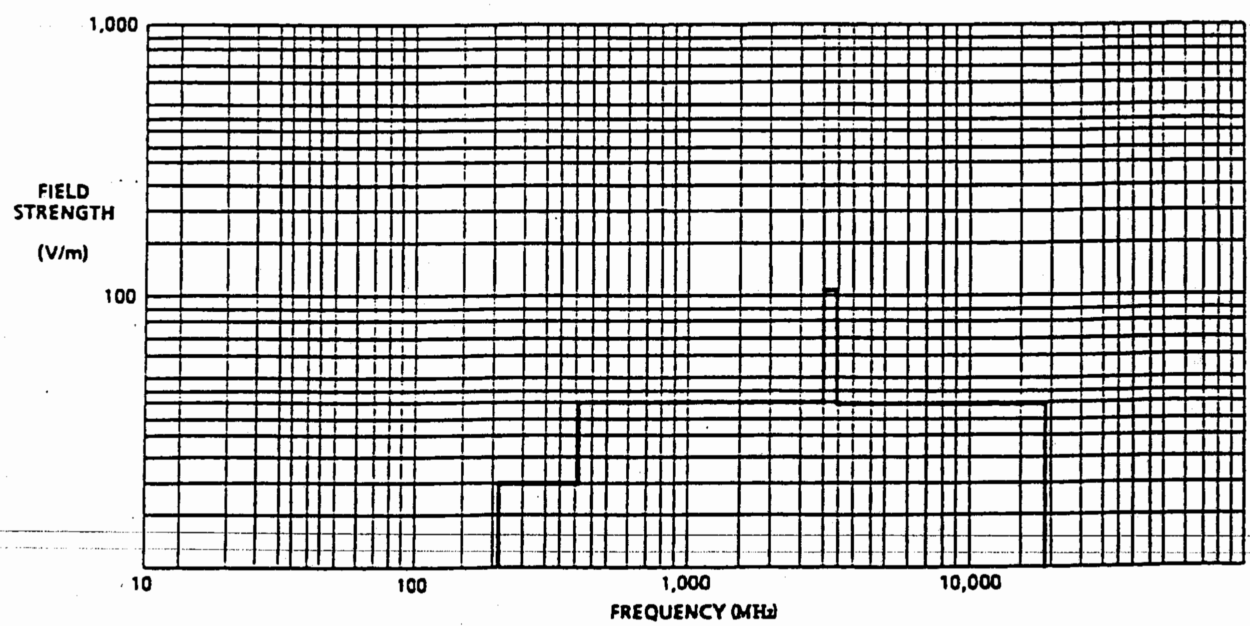

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Figure 3-5 Average EMR Field Strengths in Stages 3 and 4 - ACC Base (Typical) (U) [17]

Stage	Electrical
1 Transportation	A nearby lightning strike is considered a normal environment. The lightning environment associated with a nearby flash is by convention the magnetic field produced by a stroke of either 200-kA peak amplitude at a distance of 100 meters or 20-kA peak at 10 meters. See Figure 3-6. A direct lightning attachment to missile silo is considered a normal environment.
2 Storage	The following parameters define the extreme magnetic field due to a nearby lightning strike. Fields greater than this are likely to be accompanied by the direct attachment of the strike to the warhead, thereby constituting an abnormal environment. The electric field from a nearby lightning strike produces system effects several orders of magnitude smaller than those due to the magnetic field of the same strike. The electric field is, therefore, not specified.
3 Handling & Assembly	Lightning Magnetic Field: Maximum Intensity — 320 amperes per meter Maximum Rate of Change of Intensity — 640 amperes per meter per microsecond
	The waveform of the magnetic field due to a nearby lightning strike can be usefully approximated as
4 Transportation Handling	$H(t) = \dfrac{325}{e^{\frac{-(t-t_0)}{0.113}} + e^{\frac{(t-t_0)}{50}}}$ where t is in μsec and $t_0 = 1.0\ \mu s$.
5 Preflight	Electrostatic Discharge (ESD): The human electrostatic discharge environment is defined as that which results from the discharge of the equivalent electrical model of the human body given in Figure 3-7 due to an initial voltage of like polarity on both capacitors of 25 kilovolts. Other sources of electrostatic discharge are assumed to be less severe than the human model and are enveloped by the human model.
6 Powered Flight	Nearby lightning only - no human ESD.
7 Ballistic Flight	N/A

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Table 3-17 Normal Electrical Environments (U) [24,25]

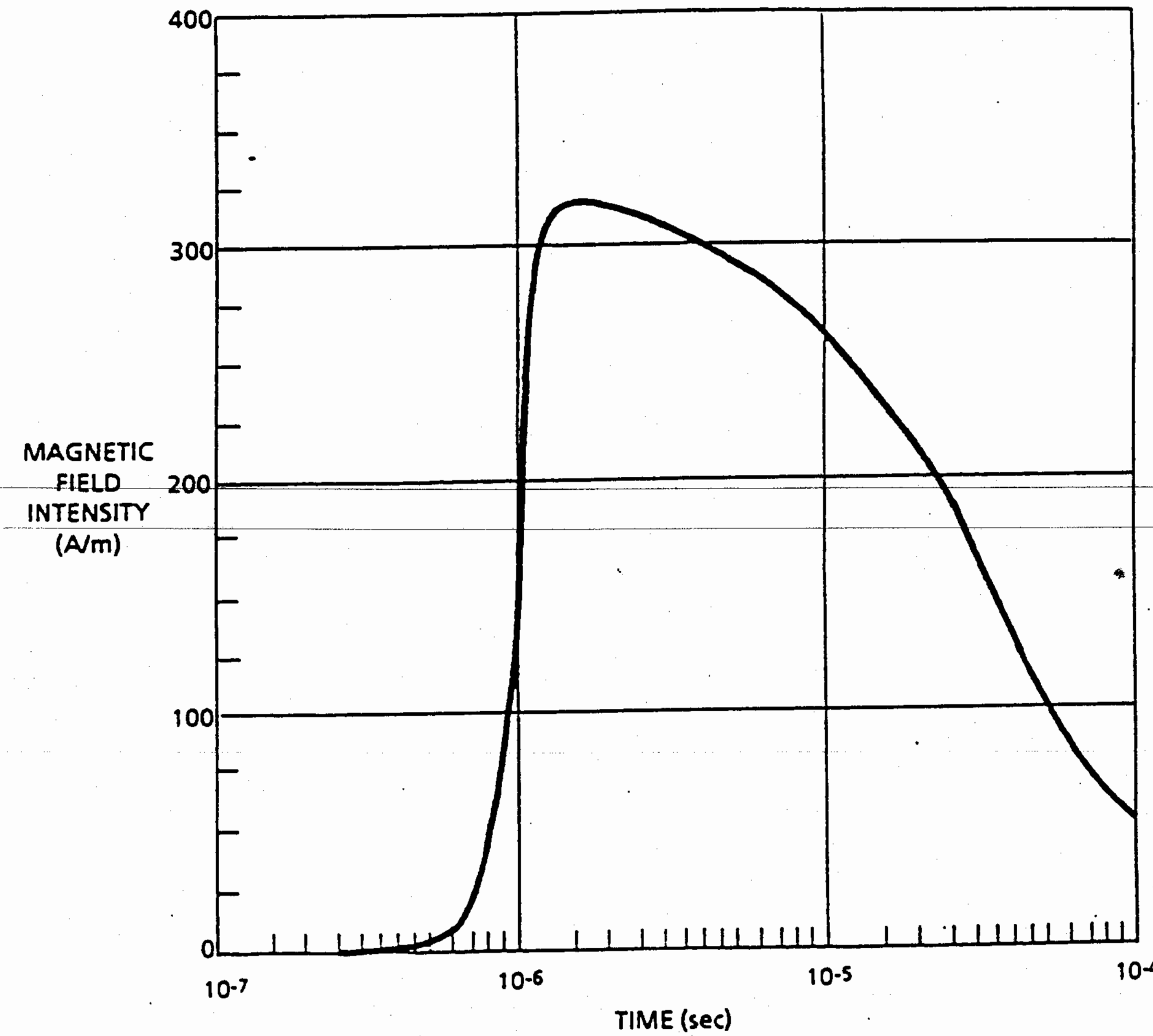

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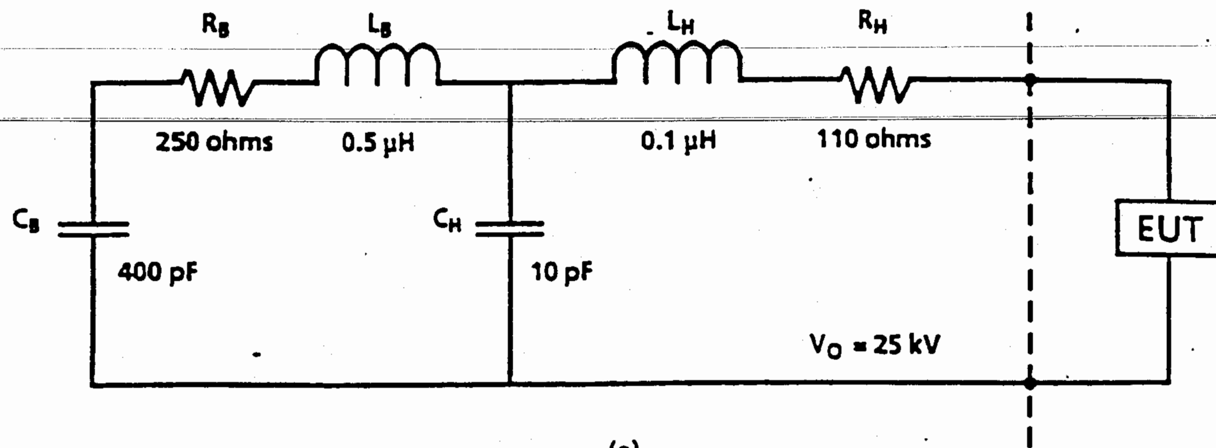
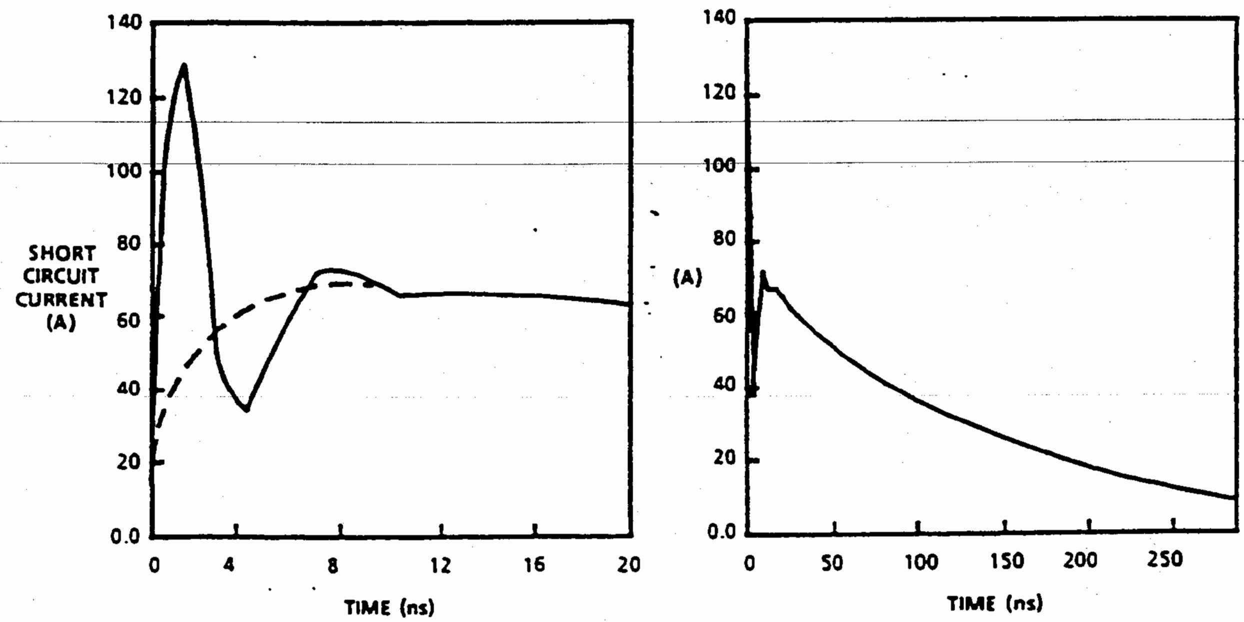
Figure 3-6 Magnetic Field Waveform Resulting from Nearby Lightning (U) [24]



(a)
Human ESD Equivalent Source Circuit



(b) Early Time

(c) Full Duration

Note: This figure represents the recommended human ESD equivalent source circuit and computed discharge current to ground. (The dotted line in (b) represents the component of current due to the main body capacitance.) Both the definition of the worst case ESD waveform from the literature data base and the derivation of a corresponding simulation circuit ignore possible additional return path inductance. That is, in an actual ESD event to a victim system, significant inductance may be present between the system case and the ground against which the person is charged.

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Figure 3-7 Recommended Human ESD Equivalent Source Circuit and Computed Discharge Current to Ground (U) [25]

Stage	Shock
1 Transportation	Truck: See Figure 3-8. Cargo Aircraft: See Figure 3-9.
2 Storage	N/A
3 Handling & Assembly	Forklift: See Figure 3-10.
4 Transportation Handling	See Figure 3-11 (PT III Van)
5 Preflight	N/A
6 Powered Flight	See Figures 3-12, 3-13 & 3-14
7 Ballistic Flight	TBD

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Table 3-18 Normal Shock Environments (U) [26,27]

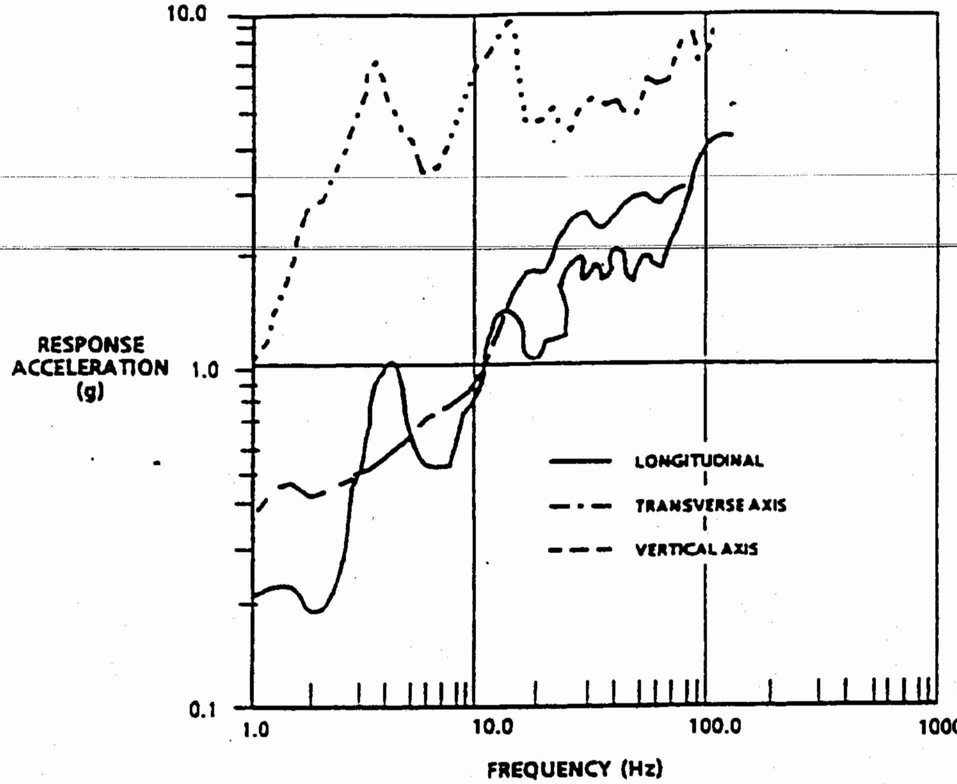

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Figure 3-8 Truck/Tractor-Trailer: Discrete Excitation Model Shock Spectra (3% Damping) (U) [26]

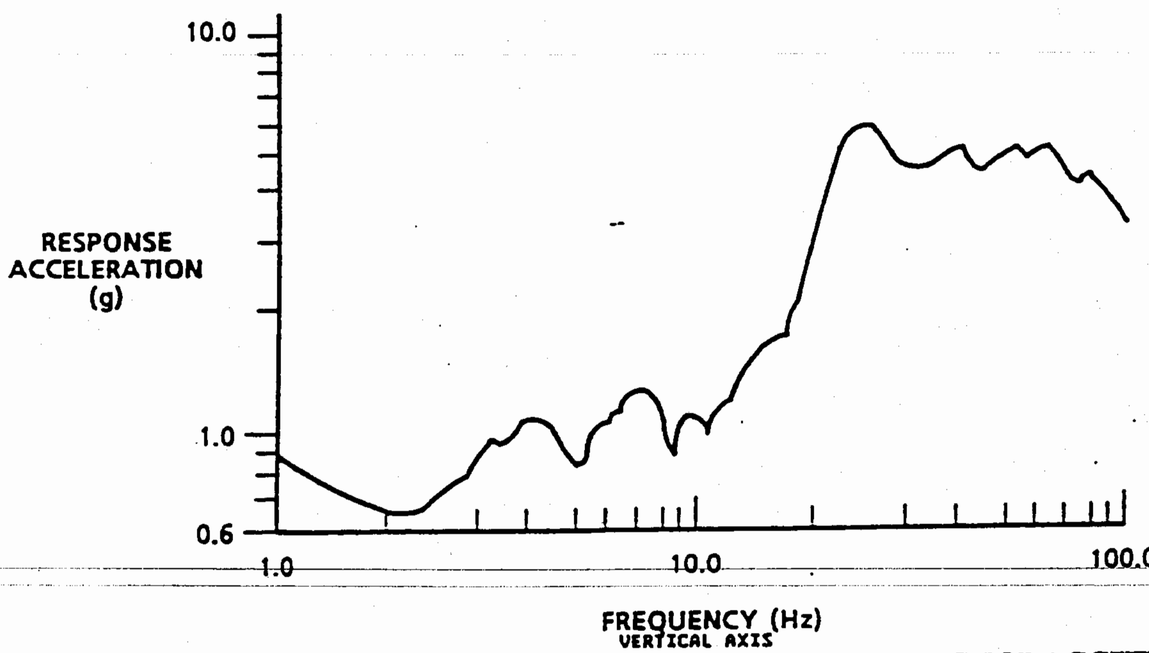

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Figure 3-9 Turbojet: Landing Shock Spectra (Representative) (3% Damping) (U) [26]

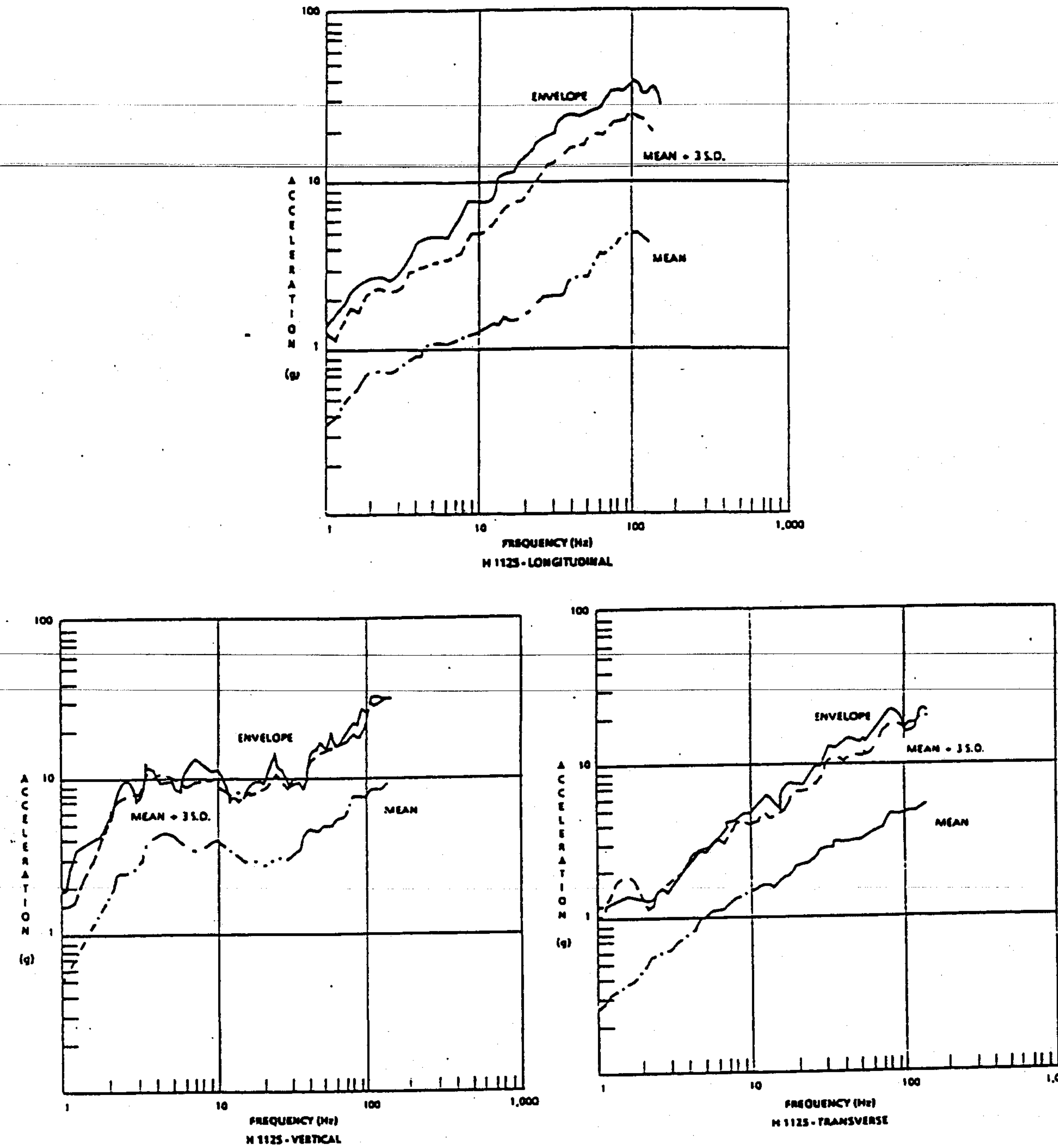

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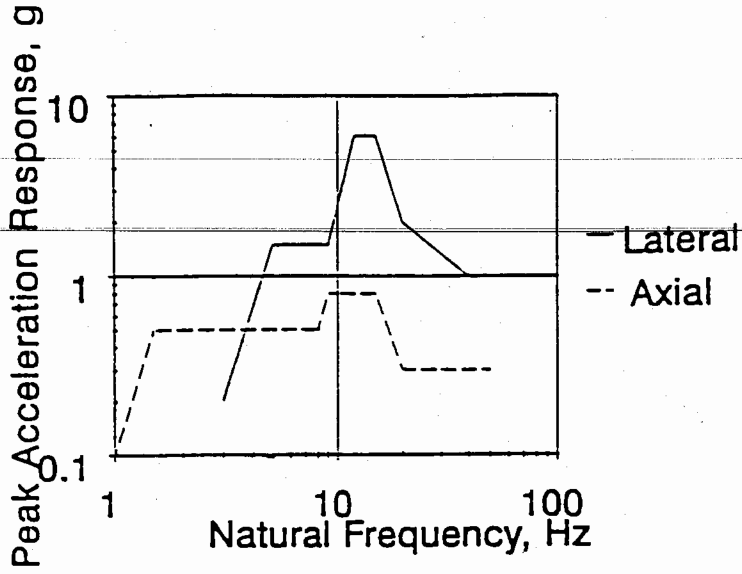
Figure 3-10 Forklift: Summaries of Response Spectra of all Forklift Trucks (U) [27]



Envelopes of RV/PTIII Transport Shock Spectra			
Axial		Lateral	
f,Hz	g	f,Hz	g
1	0.1	3	0.2
1.5	0.5	5	1.5
8	0.5	9	1.5
9	0.8	12	6.0
15	0.8	15	6.0
20	0.3	20	2.0
50	0.3	40	1.0
		50	1.0

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Note: Testing need not be performed below 10 Hz or 70% of lowest resonance, whichever is lowest. If required, shift components of time history which are under lowest frequency of test equipment to above that frequency but under 70% of the RV's, or mounted warhead's, lowest resonance frequency. Lateral peak G of time history=1.0 G, axial peak G of time history=0.3 G.

Figure 3-11 Shock Environment, RS/PTIII Transportation [11]

TBD

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Figure 3-12 [redacted]

DTRA b(1)

TBD

Figure 3-13 [redacted]

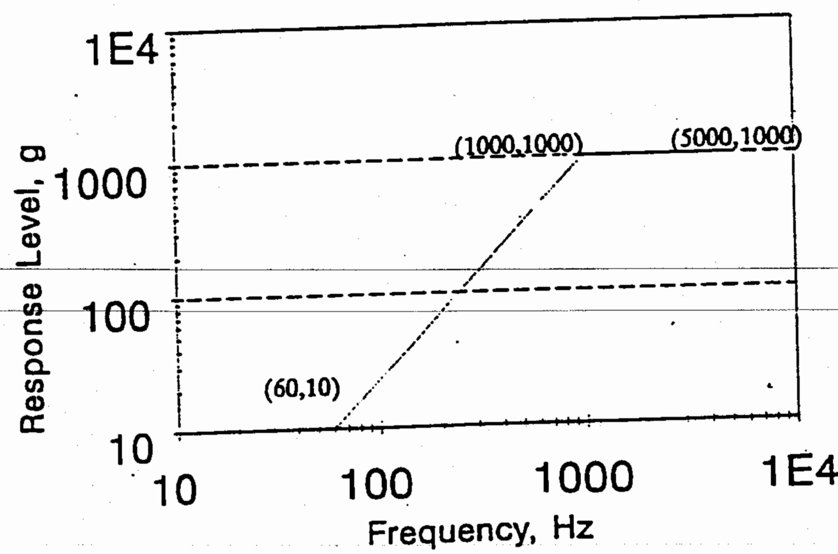

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Figure 3-14 (U) Separation Shock Response Spectrum During Powered Flight (Q=10) [11]

Stage	Vibration
1 Transportation	Truck: See Figure 3-15. Aircraft: See Figures 3-16 through 3-19.
2 Storage	N/A
3 Handling & Assembly	TBD
4 Transportation Handling	WS-133PT: See Table 3-20. PT III Van: See Figure 3-20.
5 Preflight Carriage	N/A
6 Powered Flight	See Table 3-21*
7 Ballistic Flight	See Figures 3-21 & 3-22

* Powered flight vibration environments are from the W78 STS and are provided for information purposes until better information is available.

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Table 3-19 Normal Vibration Environments (U) [26,28,29]

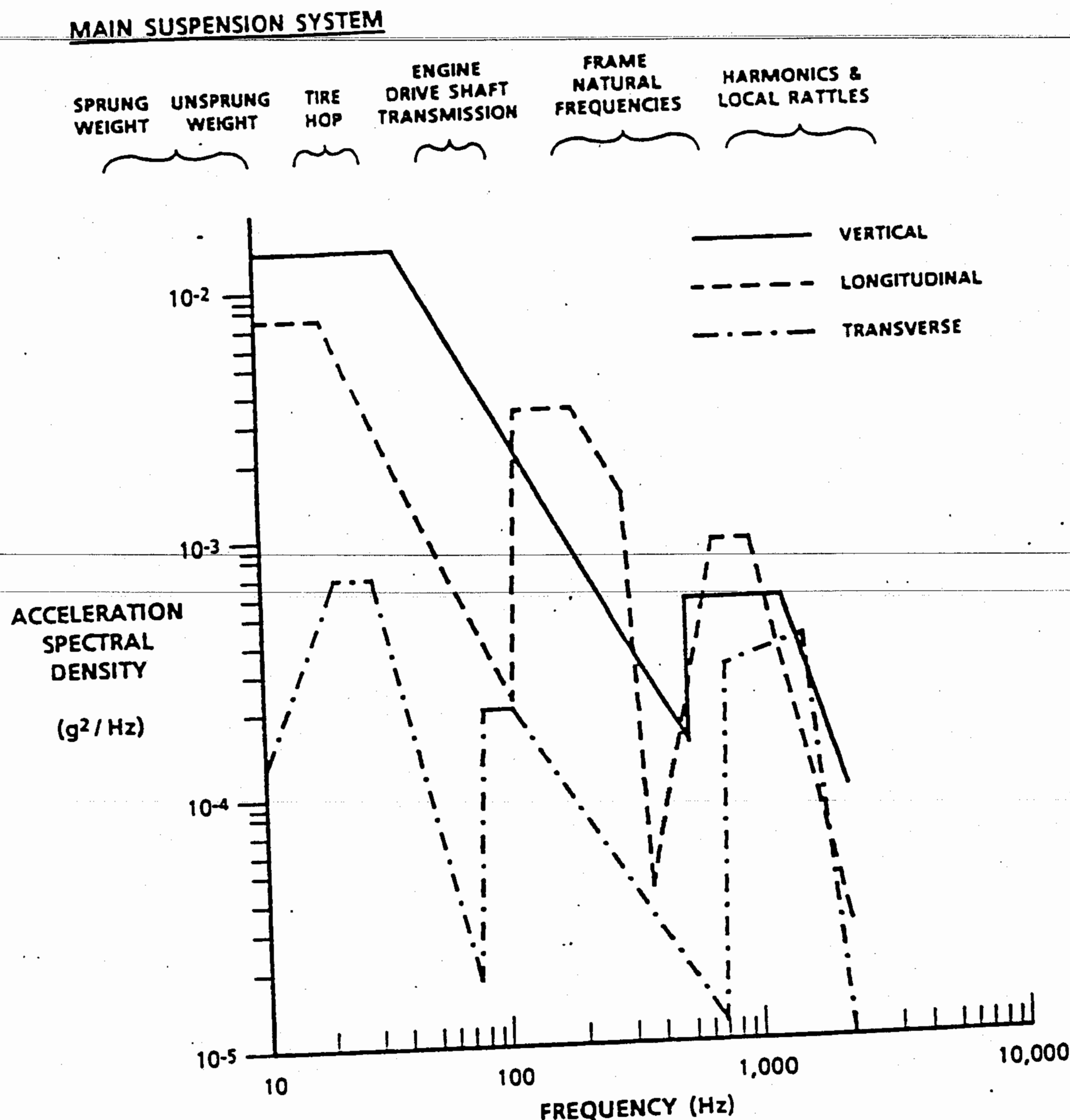

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Figure 3-15 Truck/Trailer Transportation (U) [26]

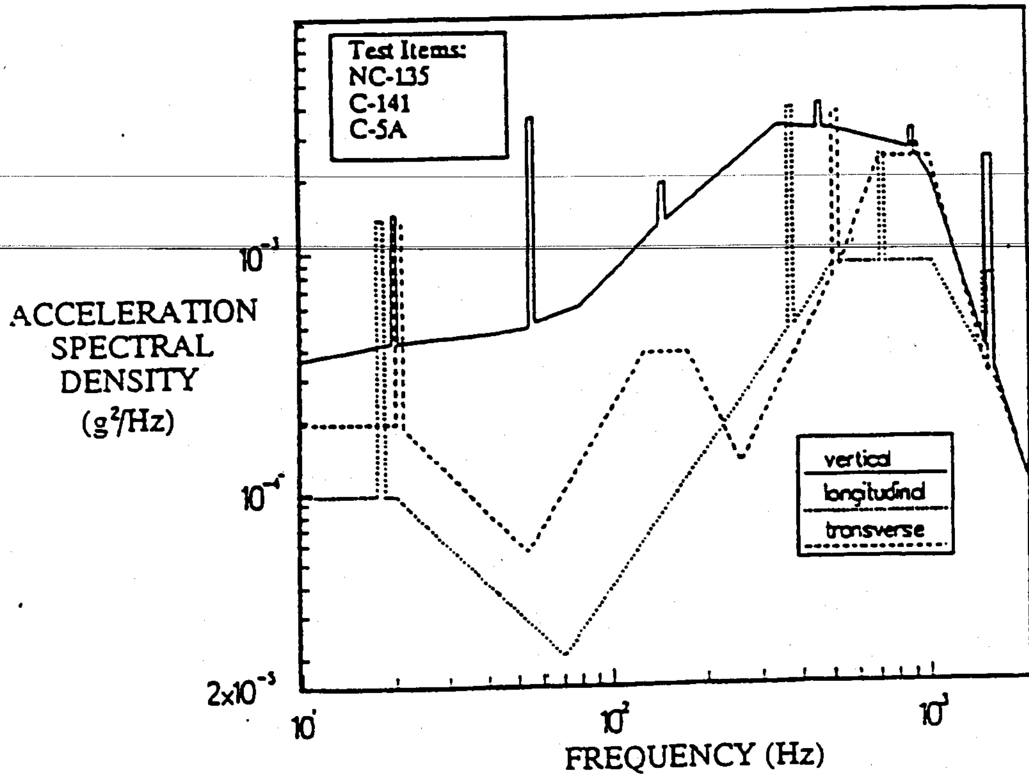

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Figure 3-16 Turbojet Cargo Aircraft (Takeoff/Climb) (U) [26]

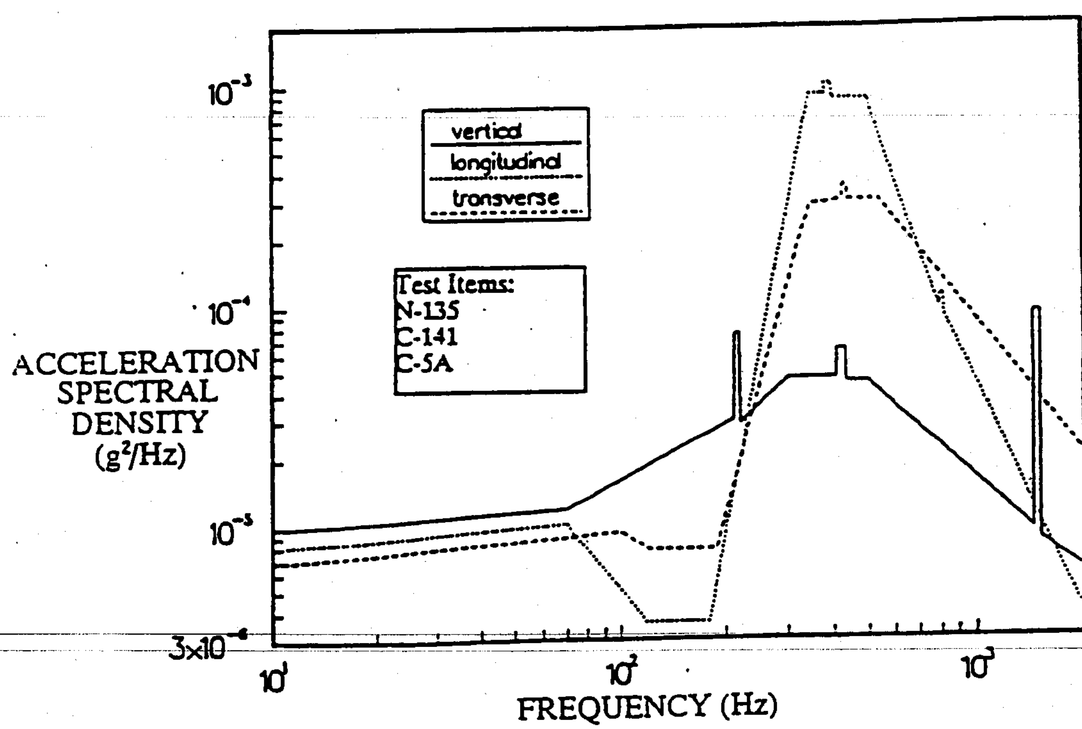

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Figure 3-17 Turbojet Cargo Aircraft (Cruise) (U) [26]

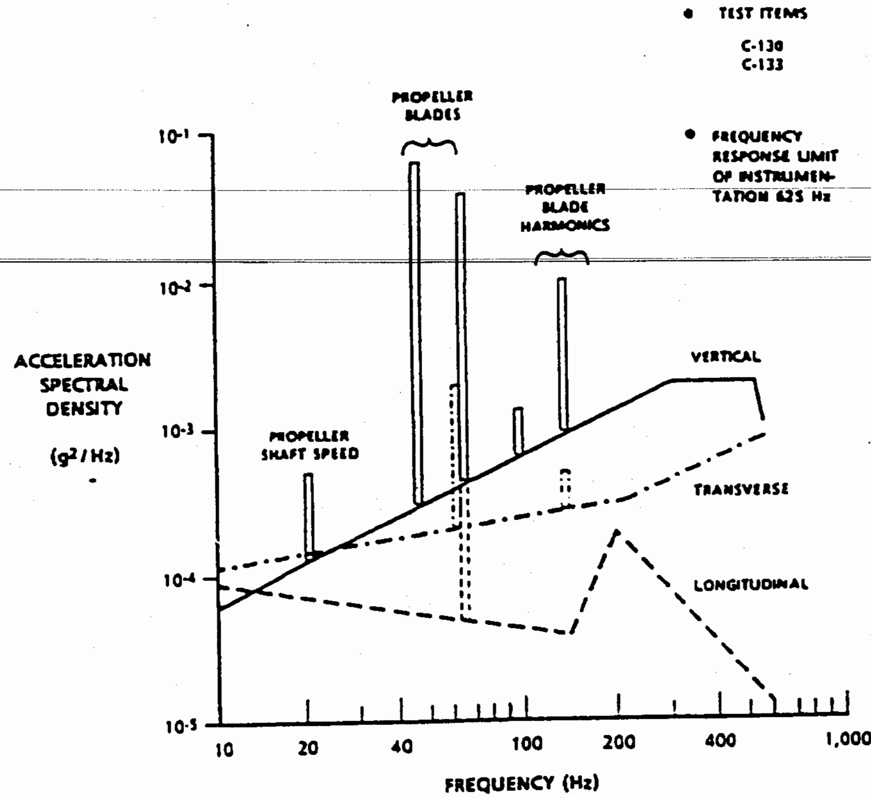

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Figure 3-18 Turboprop Cargo Aircraft (Takeoff) (U) [26]

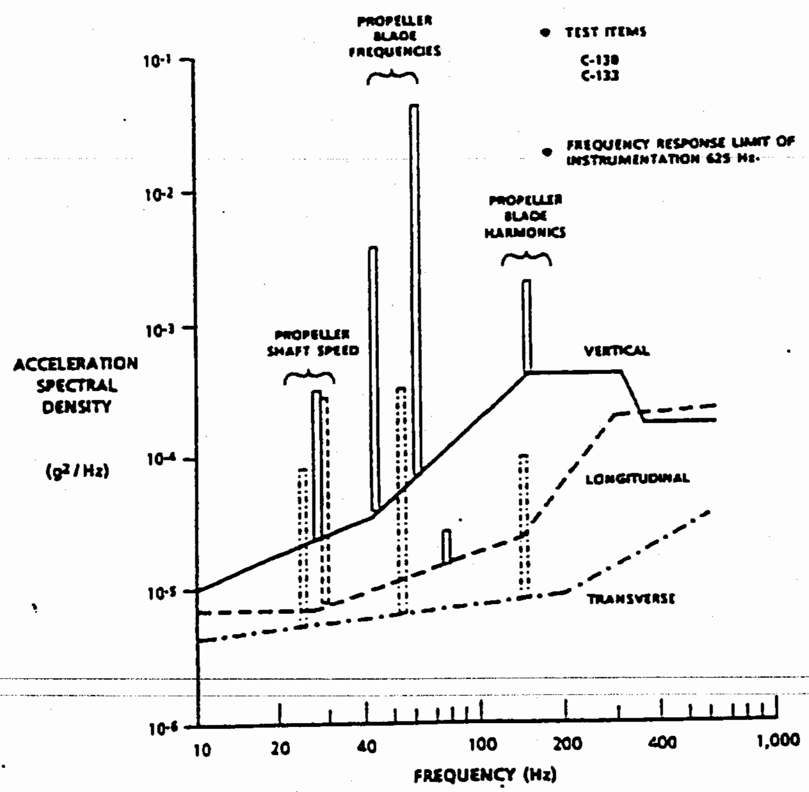

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Figure 3-19 Turboprop Cargo Aircraft (Cruise) (U) [26]

Longitudinal	
Frequency, Hz	**Level, g peak**
< 5	0
5-12	0.5
12-15	Linear decrease in 0.5 to 0.25 (log/log?)
15-300	0.25
>300	0
Transverse	
Frequency, Hz	**Level**
<5	0
5	0.33 inch D.A.
5-7.3	0.33 inch D.A.
7.3-12	0.9 g peak
12-15	Linear decrease in log/log 0.9 to 0.5 g peak
15-30	0.5 g peak
30-35	Linear decrease in log/log 0.5 to 0.25 g peak
35-300	0.25 g peak
>300	0

Note: During Transport of RV by WS-133PT, RV/CG should be limited to 0.8 g in direction of input.

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Table 3-20 Longitudinal and Transverse Axes Vibration Levels at Installation Kit Interface During Stage 4 (U) [28]

Sinusoidal		
Frequency, Hz	Levels, (g) Peak	
	Longitudinal	Lateral
165	0	0
165-350	3.3	1.1
750-900	6.7	2.2
Random (along the longitudinal axis)		
Frequency, Hz	Power Spectral Density, g^2/Hz	
14.4	0.0001	
35-2000	0.0054	

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Table 3-21 Vibration Levels at Installation Kit (Ball Locks) During Stage 6, Powered Flight (U) [28]

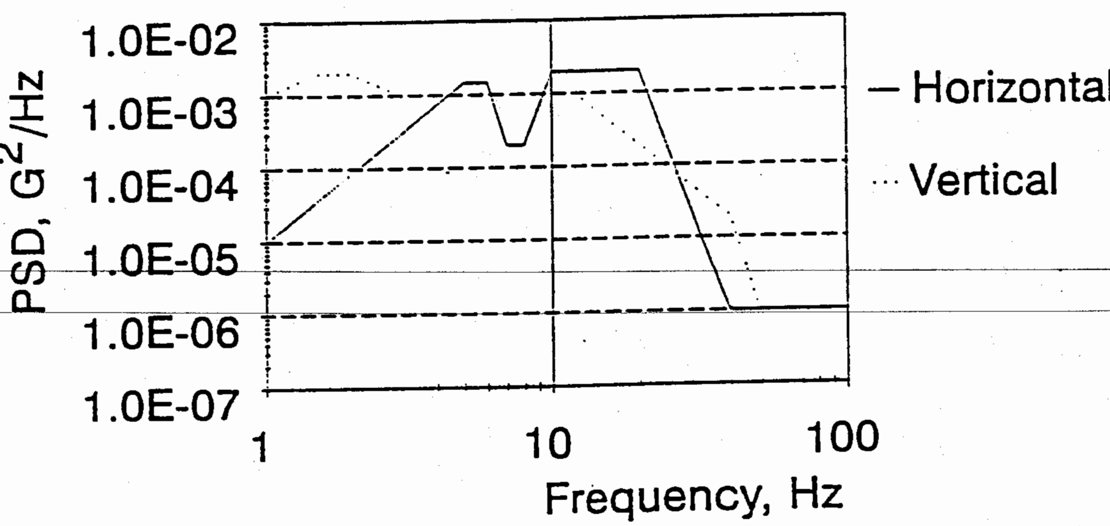

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Figure 3-20 Vibration Environment, RS/PTIII (U) [11]

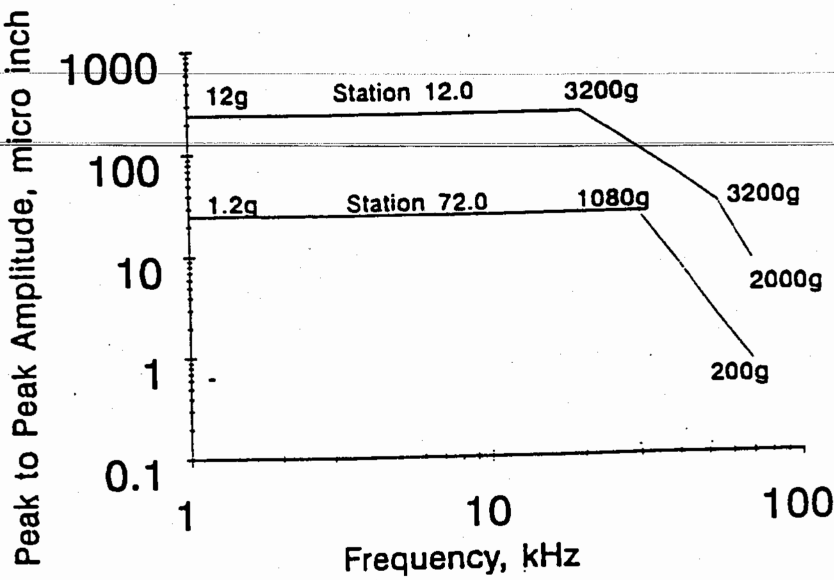

Figure 3-21 (U) Sinusoidal Vibration Spectrum, Stage 7

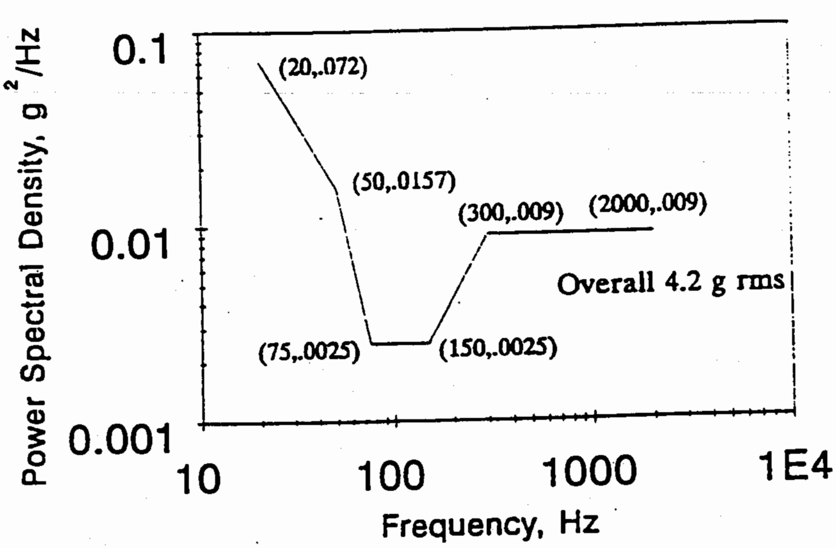

Figure 3-22 (U) Random Vibration along Longitudinal Axis at Installation Kit Interface (Ball Locks), Stage 7 [28]

Stage	Acceleration
1 Transportation	Aircraft: See Table 3-23. Surface: See Shock and Vibration.
2 Storage	N/A
3 Handling & Assembly	Negligible
4 Transportation Handling	
5 Preflight	N/A
6 Powered Flight	Peak acceleration is 12.3g longitudinal combined with 2.4g in any transverse direction [28]*
7 Ballistic Flight	TBD

* Normal acceleration environments are from the W78 STS and are provided for information purposes until better information is available.

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Table 3-22 Normal Acceleration Environments (U) [28,29]

Aircraft	Load Limit (g)	Ultimate Load (g)
C-130	+3.0 -1.0	+4.5 -1.5
C-141	+2.5 -1.0	+3.75 -1.5
C-17	+3.0 -1.0	+4.5 -1.5

Notes:
1. These data refer to the structural capability of the aircraft.
2. Acceleration is normal to the plane of the wing.
3. These are sustained accelerations.
4. The values for the C-17 are preliminary and reflect the capabilities of the C-130.
5. This table represents the maximum g level the warhead will experience.

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Table 3-23 Normal Acceleration Environments: Cargo Aircraft (U) [29]

Stage	Acoustic
1 Transportation	Flight Line: Noise levels vary from 143 dB at 100 ft to 98 dB at 10 kft from fighter aircraft operating with afterburner (re 0.0002 dynes/cm^2). At a fixed distance, the maximum level occurs at about $\pm$140° from aircraft heading. [30] Cargo Aircraft [29]
2 Storage	
3 Handling & Assembly	
4 Transportation Handling	TBD
5 Preflight	
6 Powered Flight	140 dB with no more than 132 dB in any 1/3 octave band up to 10kHz (Reference is 2x10^{-4} dynes/cm^2 [28]
7 Ballistic Flight	TBD

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Table 3-24 Normal Acoustic Environments (U) [28-30]

Stage	Nuclear
1 Transportation	N/A
2 Storage	
3 Handling & Assembly	
4 Transportation Handling	
5 Preflight	Single Burst: See paragraph 3.2.12.1 Multiple Bursts: See paragraph 3.2.12.2 Total Dose: See paragraph 3.2.12.3
6 Powered Flight	Single Burst: See paragraph 3.2.12.4 Multiple Bursts: See paragraph 3.2.12.5 Total Dose: See paragraph 3.2.12.6 See paragraph 3.2.12.10
7 Ballistic Flight	Single Burst: See paragraph 3.2.12.7 Multiple Bursts: See paragraph 3.2.12.8 Total Dose: See paragraph 3.2.12.9 See paragraph 3.2.12.10

Note: The normal nuclear environment from the W78 STS is provided for information purposes.

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Table 3-25 Normal Nuclear Environments (U) [39]

Sections 3.2.12.1 through 3.2.12.10 are TBD. However, information contained within these sections are provided for information purposes acquired from the W78 STS dated November 1994 [11].

CG HPRF-1 (d.a)

3.2.12.1 (U) Preflight Nuclear Threat (Single Burst). This threat will be directed towards the missile during preflight.

USAF
NO

DOE
DTRA
USAF
b(3)

CG HPRF-1 (d.a)

DOE & DTRA & USAF b(3)

CG HPRF-1 (d.a)

[redacted]

3.2.12.1.10 (S) Overpressure. The peak transient pressure pulse is specified in Figure 3-29.

3.2.12.4 (S-RD) Powered Flight (Single Burst). This threat will occur from silo closure opening to RV apogee.

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DOE & DTRA & USAF b(3)

[redacted]

CG HPRF-1

3.2.12.3 (U) Stage 5 - Total Ionization Dose. The total ionization dose is accumulated from exposure to the radiation environments specified in 3.2.12.1.3, 3.2.12.1.4, 3.2.12.1.5 and 3.2.12.2 and exposure to fallout radiation [redacted] Total ionization dose includes the total gamma dose and neutron induced dose in the warhead including inelastic neutron scattering, neutron capture, and charged particle production.

DOE & DTRA & USAF b(3)

CG HPRF-1

3.2.12.4.5 (U) Neutron Induced Ionization. The neutron ionization pulse intensity and time history is consistent with the incident neutron environment of 3.2.12.4.2 and 3.2.12.4.4 and shall include inelastic scattering gamma, capture gamma and charged particle production in both air and within the vehicle.

CG HPRF-1

[redacted]

DOE & DTRA & USAF b(3)

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DTRA

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b(3)

USAF
No

CG HPRF-1

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3.2.12.6 (U) Powered Flight (Total Ionization Dose). The Total ionization dose is specified in 3.2.12.3 added to that accumulated from exposure to the radiation environments specified in 3.2.12.4.1, 3.2.12.4.5, 3.2.12.4.6, 3.2.12.4.7 and 3.2.12.5. The total ionization dose includes Compton effect (photon scattering), photofluorescence, inelastic neutron scattering, neutron capture, and charged particle production.

CG HPRF-1

DOE & DTRA & USAF b(3)

3.2.12.7 (S-RD) Ballistic Flight (Single Burst). This threat will occur during Stage 7 (Flight - from Apogee to Detonation) of the STS.

DOE & DTRA & USAF b(3)

CG HPRF-1

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3.2.12.7.3 (S-RD) **Neutrons.** The total neutron fluence is specified in Figure 3-37 as a function of altitude. [redacted]

DOE & DTRA & USAF b(3)

USAF NO

CG HPRF-1

Intensity and time history shall include pulse time spreading resulting from a range of neutron energies (velocities), and energy spectrum degradation by air scattering (where appropriate). [redacted]

DOE & DTR. & USAF b(3

CG HPRF-1

3.2.12.7.5 (S-RD) **Neutron Induced Ionization.** The neutron induced ionization pulse results from exposure to the neutron environment of 3.2.12.7.3.

[redacted]

DOE & DTRA & USAF b(3)

CG HPRF-1

DOE & DTRA & USAF b(3)

[redacted]

CG HPRF-1

3.2.12.7.8 (U) Electromagnetic Pulse. The electromagnetic pulse environments are of two types with two sets of characteristics: [redacted] For both types, burst direction will be that which produces worst case coupling.

USAF b(1)

CG HPRF-1

DOE & DTRA & USAF b(3)

[redacted]

The air conductivity time history is specified in Figure 3-45.

3.2.12.7.10 (S) Distant Bursts. Distant bursts produce electric and magnetic fields as given in 3.2.12.4.8.

DOE & DTRA & USAF b(3)

[redacted]

CG HPRF-1

DOE & DTRA & USAF b(3)

[redacted]

CG HPRF-1

3.2.12.9 (U) Ballistic Flight (Total Ionization Dose). The total ionization dose is specified in 3.2.12.6 added to that accumulated from exposure to the radiation environments specified in 3.2.12.7.1, 3.2.12.7.5, 3.2.12.7.6, and 1.25 times that specified in 3.2.12.7.7. Total ionization dose includes Compton effect (photon scattering), photofluorescence, inelastic neutron scattering, neutron capture, and charged particle production.

3.2.12.10 (U) Fireball Thermal Radiation. The time history of the environment at the location of the reentry vehicle is specified in Figure 3-48.

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[redacted]

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[redacted]

[redacted]

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USAF
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CG HPRF-1

3.3 (U) Abnormal Environments. The warhead, RS or RSA may be exposed to any of the single abnormal environments defined in this section. Single abnormal environments are specified in Sections 3.3.1 through 3.3.4. Most accidents, however, involve multiple environments. These environments may occur simultaneously or sequentially. The hazard potential may be increased from synergism between environments. Accident scenarios resulting in combinations of abnormal environments are presented in Section 3.4.

3.3.1 (U) Abnormal Thermal Environments. There are groups of potential accident scenarios that can cause the warhead to be exposed to a fire; transportation accidents, aircraft crashes into weapon storage areas, and missile silo accidents. The main fuel source for transportation and aircraft crash accident fires is liquid hydrocarbon fuels, whereas the main source for missile silo fires is solid rocket propellant. Table 3-29 lists the combustible materials that are of concern in various accident scenarios along with their estimated flame temperatures.

3.3.1.1 (U) Hydrocarbon Fuel Fires. Transportation accidents which lead to the most severe fuel fires involve aircraft. Given that an aircraft accident occurs, there is about a 35% chance that a fire will ensue. Both pool fires and spill fires have been identified, with pool fires resulting in generally hotter temperatures. Flame temperatures in the hot spot of the fire (approximately 2-4 m above the fuel surface) have been reported from below 800°C to temperature spikes as high as 1300°C, with a maximum typical temperature of about 1100°C. Fire durations may vary significantly from as short as a few seconds to as long as many hours; however, the majority reported are less than two hours. Aircraft accident reports also indicate that most major aircraft fires involve other combustibles in addition to aircraft fuel and frequently burn longer than would be expected based on fuel volume alone.[31]

3.3.1.2 (U) Solid Rocket Propellent Fires. In-silo fires may result from the accidental activation of the solid rocket propellent in any of the three missile stages. For in-silo accident scenarios, the resulting fire will likely ignite the remaining stages of the missile Both historical accident data and experimental data on propellant fires under these conditions are nonexistent, however there is some limited information on solid rocket fires under test conditions. As with fuel fires, the duration and temperature of propellant fires can vary significantly. Although propellant temperatures can reach up to 2730°C (adiabatic flame temperature), temperatures typically measured away from the propellant surface are significantly lower. Burn durations for solid rocket propellant is a function of the thickness of propellant and burn sequence. Missile stages may burn simultaneously or sequentially lasting approximately two to eight minutes. Temperatures of up to 1100°C may exist for several hours following a propellant fire. [32]

3.3.1.3 (U) Warhead Heating Characteristics. Anticipated fire conditions can result in either "fast" or "slow" heating environments. "Fast heating" can result from complete warhead engulfment by the fire. "Slow heating" can result from a warhead being a sufficient distance from the fire to avoid engulfment, but sufficiently close to experience a temperature rise which can cause a violent reaction or the operation or failure of any warhead component. Various combinations of fast and slow heating for a given warhead are also possible. In all cases, the fire/thermal heating environment must be assumed to be of sufficient duration to allow all processes to run to completion.

3.3.2 (U) Abnormal Mechanical Environments. These environments include shock, crushing, and puncture.

3.3.2.1 (U) Shock. Events such as aircraft crashes, drops, and ground transportation accidents may cause the warhead to tumble, roll, and impact with various objects including steel, concrete, earth, and water. See Figure 3-49 for Abnormal Shock Environments.

3.3.2.1.1 (U) Aircraft Crashes. Aircraft crash statistics reveal about 75% of crashes involving cargo aircraft and turbojet bombers occurred during landing and takeoff. The main features of the landing and takeoff crashes are that they take place at low speed, at low angle of impact, and without yaw or roll. See Figures 3-50 and 3-51 for impact velocities of representative crashes.

3.3.2.1.2 (U) Drop. Drops comprise the largest percentage of impact environments reported. Weapons dropped during loading or unloading from handling equipment or aircraft make up 37% of all impact occurrences involving nuclear weapons. Weapons dropped during assembly, moving in storage, and other handling constitute another 8%. The warhead may be dropped from heights up to 16 meters. The RS may be dropped from heights up to 30 meters. The RSA may be dropped from heights up to 6 meters. Weapons may be dropped in any orientation. [33]

3.3.2.1.3 (U) Ground Transportation Accidents. Studies indicate that over 50% of all truck-semitrailer accidents are with automobiles and, in most cases, the point of contact is the front of the truck. The distribution of net impact velocities for truck-automobile head-on collisions indicates that closing speeds up to 100 mph can be expected.

Fuel	Flame Temperature	Average Flame Temp
Hydrocarbon (JP series, Diesel, Gasoline)	760-1315°C	1000°C
Solid Rocket Propellant	2400-2700°C [32]	TBD
Magnesium Alloys	625-3600°C	2700°C est*
Aluminum	1000-3600°C	2800°C est*

* Large pieces of aluminum and magnesium are difficult to ignite due to rapid heat conduction away from the ignition source. The flame temperature ranges given are for relatively pure metals in O_2; flame temperatures for alloys should fall within these ranges. Also, fuel rich aircraft fires may not have sufficient oxygen available to support aluminum or magnesium fires.

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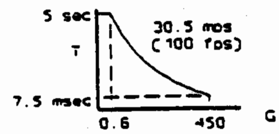
Table 3-29 Abnormal Thermal Environments (U)

Shock: [5]
Ground Transport — as defined by the curve to the right.



Air Transport — as defined by the curves below.

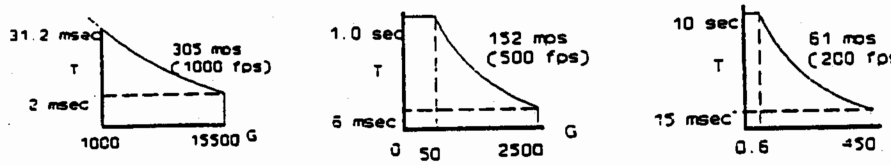


Figure 3-49 Abnormal Shock Environments (U) [11]

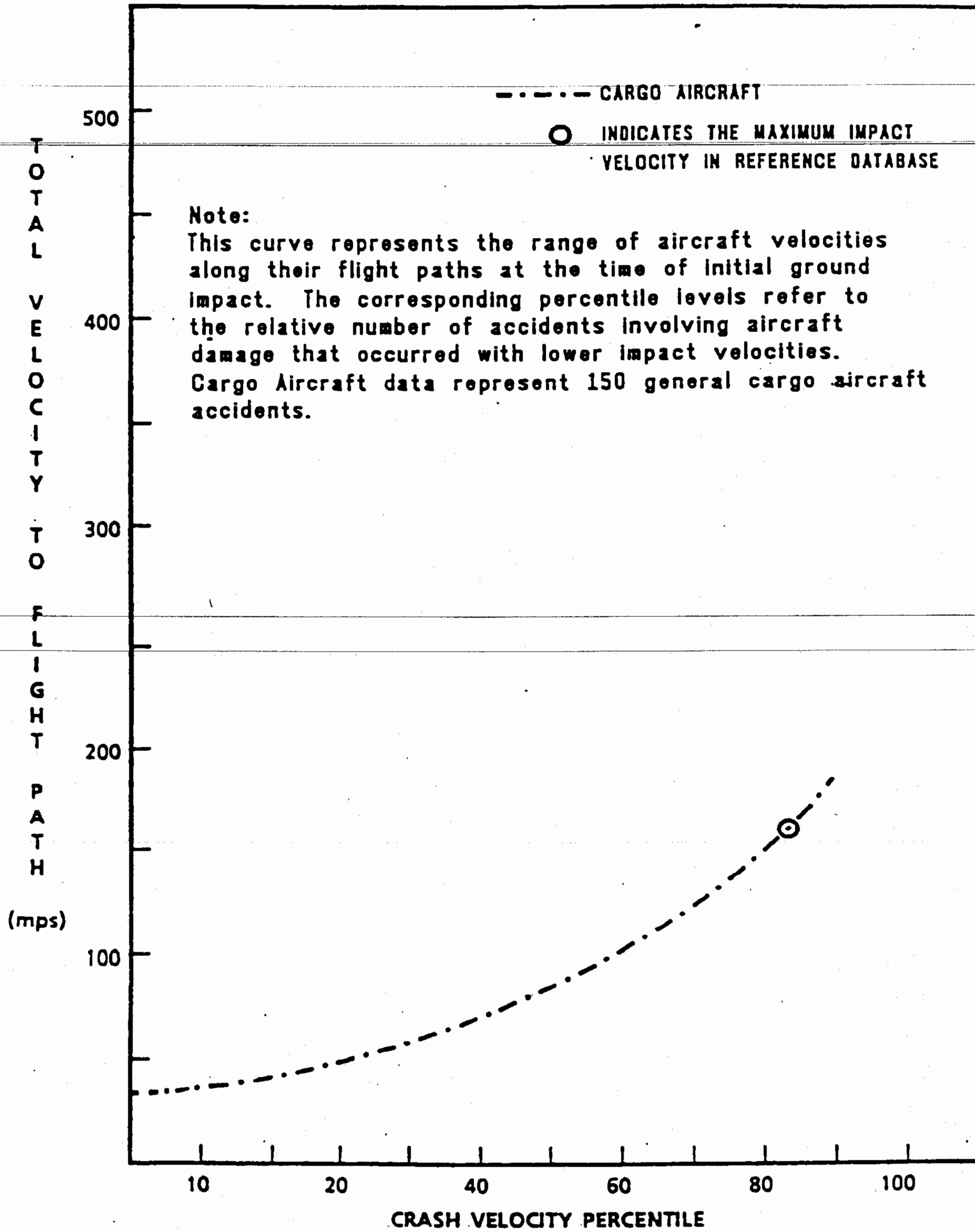


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Figure 3-50 Impact Velocities Along Flight Path (U) [34]

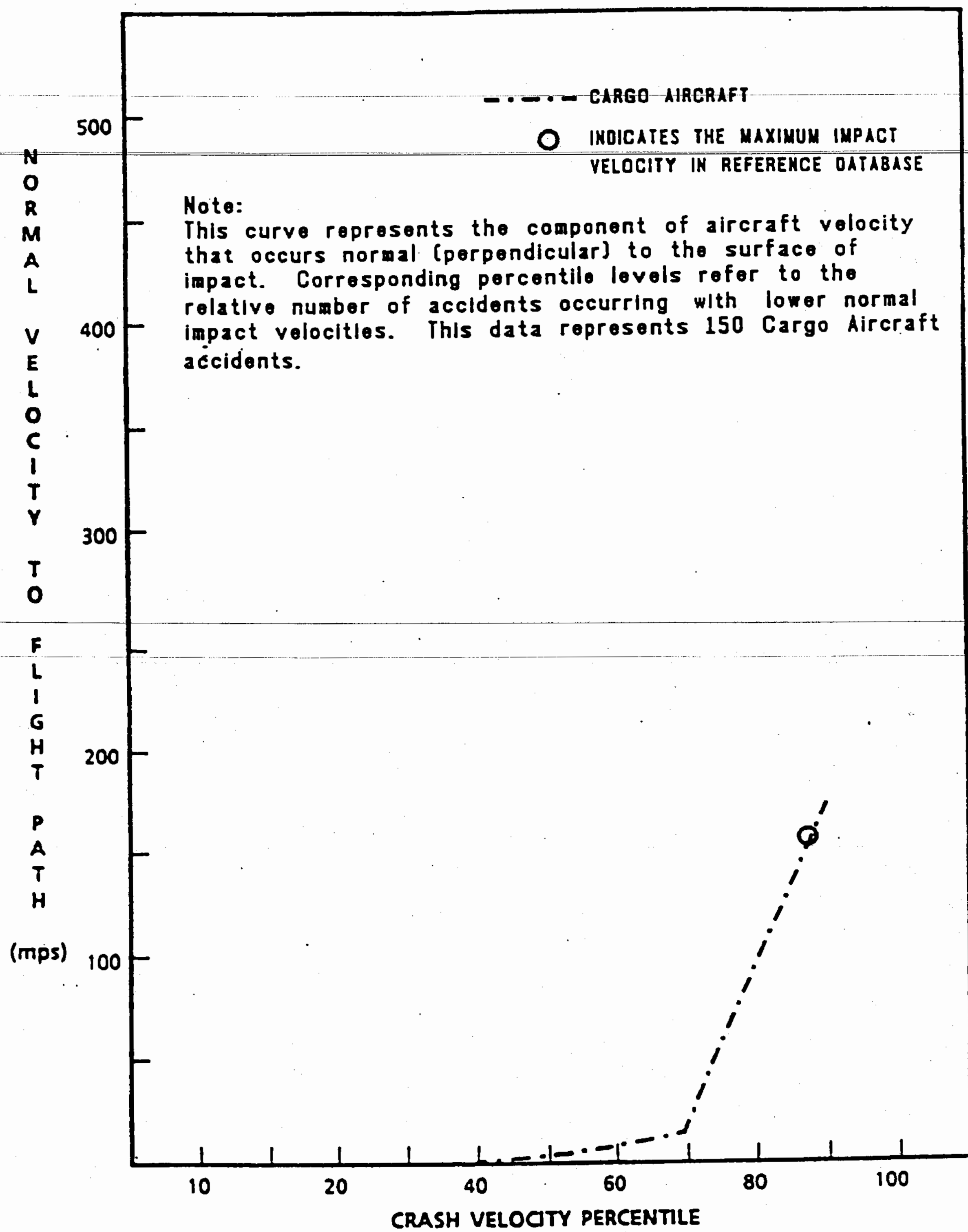

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Figure 3-51 Impact Velocities Normal to Flight Path (U) [34]

3.3.2.2 (U) Crushing. Events such as drops, collisions, crashes, and nearby explosions may cause the warhead to be crushed. Crushing can be divided into two categories:

3.3.2.2.1 (U) Uniform(Hydraulic)Crush. The warhead may be submerged for an indefinite period of time in any body of salt or fresh water in the Continental United States.

3.3.2.2.2 (U) Nonuniform Crush. Massive nonuniform crushing may occur as a result of drops, collisions, and crashes. An example is a warhead being crushed between a crashing aircraft and concrete runway. Gross crushing may occur on any axis of the warhead. The warhead may also be impaled by the aircraft wreckage or may be dropped on blunt objects causing localized crush.

3.3.2.3 (U) Puncture. The weapon may be exposed to the following fragmentation and projectile impacts causing puncture:

- (U) Fragments from explosions during fire, and other sources vary widely in size, shape, and velocity.
- (U) The projectile shape, angle of impact, material composition, and number vary greatly. Table 3-30 shows typical characteristics.

	Projectile Weight	Muzzle Velocity
Projectile	Grams	m/sec
30 mm (M799 HEI)	233	805
20 mm (M53 API)	100 - 120	1045 - 1100
.50 cal/12.7 mm (M20/M8 API)	40 - 43	895
.30 cal/7.62 mm (M80 Ball)	9.7	856
.233 cal/5.56 mm (M193/M856T Ball)	3.6 - 4.0	965 - 991

Note: Adversary ammunition types are very similar.

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Table 3-30 U.S. Projectile Characteristics (U) [35]

3.3.3 (U) **Abnormal Electrical Environments.** These environments include lightning and unintended sources.

3.3.3.1 (U) **Lightning.** Lightning discharge may hit equipment associated with the warhead, RS, RSA or strike the warhead, RS or RSA directly. These discharges can be either a cloud-to-ground or cloud-to-cloud type. For either type discharge, single or multiple pulses are possible. Expected lightning parameters are in Table 3-31 along with the 1% and 50% values. The 1% limits indicate that the probability of the parameter value being above or below the specified spread is 0.01 in each case. The parameter value has an equal chance of being less or greater than the 50% value.

3.3.3.2 (U) **Unintended Sources.** Accidental voltage from associated transportation and handling equipment or the aircraft may be applied to the warhead. The voltages and frequencies may vary from values shown due to the power sources themselves being subjected to abnormal environments. Table 3-32 contains a list of the most common sources of unintended electrical power.

A lightning strike directly to the weapon or to equipment associated with the weapon is considered a credible possibility. The lightning could be of either the cloud-to-ground or cloud flash (intracloud, intercloud, or cloud-to-air) type. Extreme (1% frequency of occurrence) and median (50%) values are given below for those cloud-to-ground flash parameters considered to constitute the most important threats to the weapon. Corresponding cloud flash parameters fall within the envelope defined below and are, therefore, not listed separately.

Return Stroke Parameters[1]	1%	50%
a. Peak Current (kA)	200	30
b. Time to Peak (μs)	.1-15	3
c. Max Rate of Current Rise (kA/μs)	400	150
d. Time to Decay to Half Peak (μs)	10-500	50
e. Amplitude of Continuing Current[2] (A)	30-700	150
f. Duration of Continuing Current (ms)	500	150
Flash Parameters		
a. Number of Strokes	>20	4
b. Interstroke Interval (ms)	10-500	60
c. Total Flash Duration (ms)	30-1000	180
d. Total Charge Transfer (C)	350	15
e. Action ($\int i^2 dt$)($A^2 \cdot s$)	$3x10^6$	$5x10^4$

Notes:

1. The entire cloud-to-ground discharge may be comprised of multiple individual major current pulses. These are known as return strokes or simply strokes.
2. Continuing currents can occur between individual strokes, following the final stroke in a flash or both.

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Table 3-31 Abnormal Lightning Environments (U) [36]

POTENTIAL VOLTS (DC or RMS)	FREQUENCY (Hz)	LOCATION	SOURCE
20-30 VDC	-	WSA	Facility Power
		A/C Auxiliary Power	MD3A
		Cargo Aircraft	Ground Cart Release Systems
	-	Cargo Aircraft	Power Supply
115/200 VRMS	400-3 ϕ	WSA	Facility Power
120 VRMS	60-1 ϕ	WSA/Flight Line	Outlets
220 VRMS	400-3 ϕ	Cargo Aircraft Flight Line	Generators MD3A Ground Cart
120/208 VRMS	60-3 ϕ	Payload Transporter (PT Van)	Auxiliary Power Unit
240 VRMS	400-3 ϕ	WSA	Facility Power
277/480 VRMS	60-3 ϕ	WSA	Power Substation
440 VRMS	60-3 ϕ	WSA	Equipment

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Table 3-32 Common Unintended Power Sources (U) [37]

3.3.4 (U) Abnormal Chemical/Immersion Environments. Events which can subject the warhead to chemicals or immersion fluids include nearby accidents, transportation accidents, and fire fighting procedures.

3.3.4.1 (U) Nearby Accidents/ Incidents. The warhead may be subjected to corrosive gases or vapors from nearby fires or may be partially or completely submerged in liquids as a result of accidents/incidents. Representative liquids are JP-series fuels, gasoline, diesel fuel, and water.

3.3.4.2 (U) Transportation Accidents/ Incidents. Transportation accidents/ incidents may cause the warhead to be immersed in a body of water or in fuels such as JP-series fuels, gasoline, and diesel fuel for an unknown period of time.

3.3.4.3 (U) Fire Fighting Procedures. Fire fighting procedures may result in inundating the warhead with fluids. The primary method of fighting fires involving nuclear weapons is to fog or flood with water to cool the weapon as rapidly as possible. However, other materials may be used. The duration of inundation as a result of fire fighting activities will probably be relatively short (tens of minutes); one possible exception is flooding with water by automatic extinguishing systems. See Table 3-12 for a list of materials that might be used in attempting to extinguish fires.

3.4 (U) Combinations of Abnormal Environments. Table 3-33 shows some possible combinations of abnormal environments. The numbers in the table indicate possible order of occurance. *Example*: in an aircraft crash the combinations could include impact followed by fire. At the minimum every combination on this list should be considered when evaluating abnormal environments.

COMBINATIONS OF ABNORMAL ENVIRONMENTS - EXAMPLES													
ACCIDENT CONFIGURATION			THERMAL		MECHANICAL					ELECTRICAL		CHEMICAL/ IMMERSION	
						Crush		Puncture					
No.	Accident Scenario	STS Stage	Hydro-carbon Fuel	Rocket Fuel	Impact (Shock)	Uniform	Nonuniform	Fragment	Projectile	Lightning	Unintended Sources	Fire Fighting	Immersion
1	Truck Crash	I			1		2						
2	Cargo A/C Crash	I	3		1		2						
3	Aircraft Crash into WSA		2				1					3	
4	Forklift Crash	III			1			2					
5	Facility Fire	III	2				1					3	
6	Drop RS During Hoisting	III			1		2				3		
7	Vehicle Electrically-Induced Fire	IV	2								1	3	
8	Small Arms Fire Strikes RV	IV			1				2				
9	Emplacer Hoist Fails	V		3	1		2					4	
10	Lightning Strike on RS Emplacer Vehicle	V	2							1		3	
11	Sump Pump Fails/Floods	VI									1		2
12	Inadvertent Stage I Ignition	VI		2	3		1					4	

Note: Numbers indicate possible order of occurrence

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Table 3-33 Credible Combinations of Abnormal Environments (U)

3.4.1 (U) Abnormal Environment Scenarios. This section will include

1. Truck Crash

Weapon Configuration:
1) Warhead assembly in its container

STS Phase:
1) Transportation in STS to operational base

Subsequent Events:
1) Truck accelerations to high speed
2) Truck collides with obstruction
3) Warhead assembly container impacts sharp object, rips open, warhead tumbles

Abnormal Environments Applied to Warhead:
1) Slow acceleration
2) Impact shock
3) Tumbling and rolling
4) Crushing

2. Cargo Aircraft Crash

Weapon Configuration:
1) Warhead assembly in its container

STS Phase:
1) Transportation by Air Force Cargo Aircraft

Initiating Events:
1) Aircraft crashes into ground during takeoff or landing

Subsequent Events:
1) Container fails structurally, exposing warhead assembly
2) Aircraft wreckage crushes and impales warhead
3) Fuel fire engulfs aircraft

Abnormal Environments Applied to Warhead:
1) Violent impact into ground
2) Violent rotational acceleration
3) Crushing
4) Immersión in jet fuel
5) High temperatures

3. Aircraft Crashes into WSA

Weapon Configuration:
1) All configurations possible

STS Phase:
1) Storage
2) Handling and assembly

Initiating Event
1) Aircraft crashes into igloo or AS&I building

Subsequent Events
1) Warhead is crushed in aircraft and building wreckage
2) Warhead punctured in wreckage
3) Aircraft fuel fire engulfs warhead

Abnormal Environments
1) Nonuniform crush
2) Fuel fire

4. Forklift Crash

Weapon Configuration:
1) Warhead assembly in its container

STS Phase:
1) Transportation by forklift

Initiating Event:
1) Forklift crashes while loading/ unloading warhead assembly in container

Subsequent Events:
1) Warhead assembly in container drops to concrete floor
2) Warhead assembly container punctured by sharp object

Abnormal Environments Applied to Warhead:
1) Impact into ground
2) Fragment puncture

5. Facility Fire

Weapon Configuration:
1) Warhead assembly

STS Phase:
1) Storage of warhead assembly in the OSS/WSA

Initiating Event:
1) OSS or WSA facility fire

Subsequent Events:
1) Fire engulfs combustible materials
2) Part of building collapses onto warhead
3) Fire engulfs warhead
4) Fire fighting chemicals applied to warhead

Abnormal Environments Applied to Warhead:
1) Crushing forces
2) High temperatures
3) Fire fighting chemicals

6. Drop RS During Hoisting

Weapon Configuration:
1) RSA

STS Phase:
1) Handling and assembly operations in the AS&I building

Initiating Events:
1) Drop RSA onto electrical cord during hoisting

Subsequent Events:
1) RS crashes onto heavy electrical cord

Abnormal Environments Applied to Warhead:
1) Impact shock
2) Localized Crush
3) Unintended Electrical Sources

7. Small Arms Fire Strikes RS

Weapon Configuration:
1) RS

STS Phase:
1) Transportation of RS on storage pallet

Initiating Events:
1) Small Arms Fire

Subsequent Events:
1) Small Arms Fire strikes RS
2) Causes Punture in RS

Abnormal Environments Applied to Warhead:
1) Impact shock
2) Projectile punture

8. Emplacer Hoist Fails

Weapon Configuration:
1) RSA

STS Phase:
1) Installation of RSA in silo

Initiating Events:
1) Emplacer hoist fails after RSA is centered over silo opening

Subsequent Events:
1) RSA strikes stage IV
2) RSA punctures stage IV fuel tank
3) Stage IV propellant fire
4) Other stages ignite

Abnormal Environments Applied to Warhead:
1) Violent impact onto concrete
2) Crushing
3) Propellant fire

9. Lightning Strike on RSA Emplacer Vehicle

Weapon Configuration:
1) RSA

STS Phase:
1) Transportation of RSA on emplacer vehicle

Initiating Events:
1) Lightning Strike on RSA emplacer vehicle

Subsequent Events:
1) Hydrocarbon fuel catches fire
2) Fire fighting chemicals applied to vehicle and RSA

Abnormal Environments Applied to Warhead:
1) Lightning strike
2) High Temperatures
3) Fire fighting chemicals

10. Sump Pump Fails/Floods

Weapon Configuration:
1) Missile fully emplaced

STS Phase:
1) Missile fully emplaced and on-alert, no human activity

Initiating Events:
1) Sump Pump fails

Subsequent Events:
1) Flooding of silo and launch equipment room
2) Electrical sources short out
3) Immersion caused by flooding

Abnormal Environments Applied to Warhead:
1) Electrical sources
2) Immersion

11. Inadvertent Stage I Ignition

Weapon Configuration:
1) Missile fully emplaced

STS Phase:
1) On-Site maintenance (silo closure closed)

Initiating Events:
1) Inadvertent Stage I Ignition

Subsequent Events:
1) Missile rams muzzle closure/silo closure
2) Propellants ignite
3) Pressure-vessel explosion
4) Fire fighting chemicals applied to missile

Abnormal Environments Applied to Warhead:
1) Severe crushing of missile
2) High temperatures from missile propellants
3) Impact from explosion
4) Fire fighting chemicals

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APPENDIX F - PRELIMINARY MAJOR IMPACT REPORT FOR JOINT DOD/DOE PHASE 2 FEASIBILITY STUDY OF HPRF WEAPON

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UNCLASSIFIED

PRELIMINARY MAJOR IMPACT REPORT

FOR

JOINT DOD/DOE PHASE 2 FEASIBILITY STUDY OF A HIGH POWER RADIO FREQUENCY (HPRF) WEAPON

SEPTEMBER 1995

UNCLASSIFIED

[redacted]

[redacted]

(U)--I. SCOPE

(U)--This Preliminary Major Impact Report (PMIR) was prepared in conjunction with the Joint DOD/DOE Phase 2 Feasibility Study of a High Power Radio Frequency (HPRF) Weapon. The request for the Department of Energy Albuquerque Operations Office (AL) participation in the Phase 2 Study and request to prepare a Major Impact Report (MIR) is documented in a September 14, 1992 memorandum from RADM W. G. Ellis, Deputy Assistant Secretary for Military Application and Stockpile Support. That memorandum also had attached to it Phase 2 tasking guidance dated September 4, 1992.

(CRD)--The recommendation of the HPRF Phase 2 Study is to conduct further studies on the effectiveness of an HPRF weapon on identified military targets. Because an HPRF weapon is not recommended to go forward to a Phase 2A Study at this time, a PMIR was prepared. A final MIR can be prepared if further studies are undertaken and recommend that an HPRF weapon proceed to Phase 2A. The PMIR identifies those aspects of warhead design proposals which may influence the meeting of program objectives.

(U)--II. PROPOSED WARHEAD DESIGNS

(CRD)--Table I summarizes the major characteristics of the proposed warhead designs as presented in the joint DOD/DOE HPRF Phase 2 Study Report.

CG HPRF-1 (d, a)

DOE & DTRA & USAF b(3)

(U)--III. ANALYSES

(U)--A MIR meeting was held after the HPRF Executive Working Group (EWG) meeting May 31, 1995 at the Nuclear Weapons Integration Division, Air Force Material Command, Albuquerque, New Mexico. The development of a MIR was discussed, and subsequently, a draft of the PMIR was sent to appropriate DOE and National Laboratory EWG members for review.

[redacted]

TABLE I--MAJOR CHARACTERISTICS OF HPRF WARHEAD CANDIDATES

CG HPRF-1

[redacted]

TABLE I--MAJOR CHARACTERISTICS OF HPRE WARHEAD CANDIDATES

CG HPRF-1

UNCLASSIFIED

[redacted]

(CRD)--AL then revised the PMIR and transmitted it to DOE headquarters for review, revision, and transmittal to DoD. Because an HPRF weapon is not recommended to go forward to a Phase 2A Study, no attempt was made to solicit the input of the production plants at this time.

(U)--IV. CONCLUSIONS

(U)--A. Initial Operational Capability (IOC) Support

(U)--No IOC was proposed by the DoD for an HPRF weapon.

(U)--B. Technical Challenge

[redacted]

CG HPRF-1 (d, a, b, c)

DOE & DTRA & USAF b(3)

(U)--C. Early Funding Requirements

(U)--Because there is no IOC, early funding requirements cannot be discussed at this time.

(U)--D. Production Workload

(U)--Because there is no IOC, production workload cannot be discussed at this time.

[redacted]

CG HPRF-1 (d, a, b)

DOE & DTRA & USAF b(3)

USAF

CG HPRF-1 (d.a, b)

[redacted]

DOE & DTRA b(3)

(U)--V. SPECIAL NUCLEAR MATERIALS

[redacted]

CG HPRF (d.a)

DOE & DTRA & USAF b(3)

(CRD)--The United States has not produced tritium for nuclear weapons since 1988. Present needs for the enduring stockpile are being met by the recycling of existing tritium supplies. Until a decision is made dictating stockpile levels, two different start dates for a new tritium source are possible. [redacted]

CG HPRF-1 (d.a)

USAF b(1)

(U)--A draft Programmatic Environmental Impact Statement (PEIS) for Tritium Supply and Recycling was published in February, 1995. Four tritium production technologies were proposed. In August of 1995 the comment period was reopened on the PEIS as DOE evaluates the use of a commercial reactor for the future supply of tritium for nuclear weapons. The final PEIS is scheduled to be published in the fall of 1995.

[redacted]

CG HPRF-1 (d.a)

DOE & DTRA & USAF b(3)

DOE & DTRA & USAF b(3)

CG HPRF-1

(U)--VI. GENERAL CONSIDERATIONS

(U)--A. Reconfiguration

(U)--In September of 1993, DOE finalized plans to consolidate its nonnuclear operations. Three donor sites, Pinellas, Mound, and Rocky Flats are in the process of transferring personnel, equipment, and records to other sites within the nuclear weapons complex. The reconfiguration of nuclear operations and additional reconfiguration of nonnuclear operations in the DOE weapons complex is currently being studied. Options under consideration will be published in late 1995 in a Draft PEIS for Stockpile Stewardship and Management and in a final PEIS in late 1996.

(U)--B. Warhead Certification

(U)--The following discussion of warhead certification is excerpted from a June 1995 draft of the Replacement Warhead Assessment Final Report. The technical basis for the certification of warheads in the current stockpile has been vigorous experimental and analytical programs that included the ability to conduct nuclear tests as required. The basis for a future warhead certification will consist of several elements: data from above-ground experiments; data from previous nuclear tests that incorporated the same or related designs or technologies; numerical simulation of experiments and of warhead performance; and peer review.

(U)--While each of these played a role in previous certifications, the key element was nuclear testing. Without the ability to conduct nuclear tests, the relative importance of the other elements increases. The final balance among them will depend on certain factors that will be characteristic of the particular nuclear design, including: the availability of relevant nuclear test data, the applicability of above-ground experiments to key design issues, and the applicability of available calculational techniques.

(U)--The consequences of the inability to conduct nuclear tests will be manifested in two ways. First, the uncertainties associated with the estimates of expected performance will be greater. Secondly, the degree of confidence that warhead performance will be unaffected by a previously unrecognized factor will be diminished.

(U)--VII. SUMMARY

CG HPRF-1

DOE & DTRA & USAF b(3)

Production facilities to manufacture both nuclear and nonnuclear components should be available to support the production of such a weapon considering the time it would take a design team to produce a warhead design chosen for final development and the total quantity required.

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