LA-9866-MS

[redacted]

Nuclear Weapon Data
Sigma 1

This document consists of 127 pages

No. 37 of 105 copies, Series A

Critical Nuclear Weapon
Design Information Per
DoD Directive 5210.2

Issued: September 1983

UNCLASSIFIED

SAB200090150000
DOCUMENT#

DEPARTMENT OF ENERGY DECLASSIFICATION REVIEW
1ST REVIEW-DATE: 3/27/96
AUTHORITY: DA
NAME: [illegible]
2ND REVIEW-DATE: 8/13/98
AUTHORITY: ADD
NAME: [illegible]
DETERMINATION [CIRCLE NUMBER(S)]
1. CLASSIFICATION RETAINED
2. CLASSIFICATION CHANGED TO:
3. CONTAINS NO DOE CLASSIFIED INFO
4. COORDINATE WITH: DOD
5. CLASSIFICATION CANCELLED
6. CLASSIFIED INFO BRACKETED
7. OTHER (SPECIFY): CONTAINS DOE & DOD DELETIONS

DOE HLS

8/28/94

2ND

1ST

Modular Weapon Systems and Insertable Nuclear Components

A Compendium of Requirements, Technology, Applications, and Utility (U)

Joseph S. Howard II
Edward J. Palanek
John L. Richter
Richard R. Sandoval
Frank L. Smith
Richard H. Stolpe
CDR Larkin E. Garcia*
LTC L. Warren**

*Field Command, Defense Nuclear Agency, Military Liaison Office, MS F635, Los Alamos National Laboratory.

**Military Research Associate, US Army Engineering District, Wilmington, Corps of Engineers, P. O. Box 1890, Wilmington, NC 28402.

Los Alamos National Laboratory
Los Alamos, New Mexico 87545

Los Alamos National Laboratory is operated by the University of California for the United States Department of Energy under contract W-7405-ENG-36.

Derivative Classifier
E. M. Sandoval
Classification Analyst

UNCLASSIFIED

[redacted]

T[redacted] as [redacted] in the Atomic Energy Act of 19[redacted]t to A[redacted]s.

[redacted]

95SA20B000325

[redacted]

UNCLASSIFIED

An Affirmative Action/Equal Opportunity Employer

Edited by Wilma J. Bunker, Group S-4
Prepared by Petrita (Pat) Montano, Group S-4

NOTICE: Reproduction of this document requires the written consent of the originator, his successor, or higher authority.

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

[redacted]

UNCLASSIFIED

CONTENTS

GLOSSARY 7

EXECUTIVE SUMMARY 13

ABSTRACT 23

CHAPTER I. INTRODUCTION 24

A. Purpose 24
B. Scope 24
C. Objective 24
D. Definition of Terms 25

CHAPTER II. REVIEW OF PREVIOUS STUDIES AND SERVICE REQUIREMENTS 27

A. General 27
B. Overview of Specific Studies 28
C. Summary of Service Requirements. 40

CHAPTER III. REVIEW OF MODULAR TECHNOLOGY 42

A. General 42
B. Presealed-Pit Weapons 42
C. Benefits of Early IFI and GA Weapons 44
D. Disadvantages of Early IFI and GA Weapons 45
E. Sealed-Pit Technology 46
F. Current Concepts for Modular Weapons 47
G. INC/Convertible Warhead Observations 51

CHAPTER IV. POTENTIAL APPLICATIONS OF MODULAR TECHNOLOGY 54

A. General 54
B. Approach 54
C. Assessment 60

CHAPTER V. UTILITY ANALYSIS 64

A. Introduction 64
B. Weapon Description and Stockpile-to-Launch Sequence (SLS) Differences 66
C. Approach 76
D. Safety 78
E. Security 80
F. Survivability 84
G. Operational Effectiveness 89
H. Logistics 97
I. Costs 105
J. Summary Merit Analyses 111

VI. REVIEW OF PERTINENT REGULATIONS AND DIRECTIVES 113

A. General 113
B. Effect of Present Directives 115
C. Expectation for Change in Handling Procedures 116

VII. CONCLUSIONS AND RECOMMENDATIONS 117

A. Summary 117
B. Findings 117
C. Recommendations 121

REFERENCES 122

[redacted]

UNCLASSIFIED

TABLES

II-I. Trade-off Evaluations 38

V-I. Comparison of Army Baseline and Modular Candidates 71

V-II. Comparison of Navy Baseline and Modular Candidates 74

V-III. Comparison of Air Force Baseline and Modular Candidates 76

FIGURES

III-1. Mk 15 strategic bomb 43

III-2. Mk 33 8-in. projectile 44

III-3. Los Alamos Harpoon Proposal 3A warhead 48

DOD III-4. . . . . 49 DOE

III-5. . . . . 50 (b)(3)

III-6. 51

III-7. LLNL conceptual design for JTACMS/CSWS warhead 52

III-8. Los Alamos conceptual design for AICBM warhead 52

IV-1. Assessment matrix 61

V-1. SLS of Army systems (peacetime) 69

V-2. SLS of Army systems (wartime) 70

V-3. SLS of Navy systems 73

V-4. SLS of Air Force systems 75

UNCLASSIFIED

[redacted]

[redacted]

UNCLASSIFIED

UNCLASSIFIED

[redacted]

GLOSSARY

ABM	antiballistic missile
ACM	advanced cruise missile (a conventional missile to be used by the Navy to attack surface ships from a submerged submarine)
AD/ADA	air defense/air defense artillery
ADM	atomic demolition munition
AEC	Atomic Energy Commission
AF&F	arming, fuzing, and firing
AFAP	artillery-fired atomic projectile
AICBM	advanced intercontinental ballistic missile
ALCM	air-launched cruise missile
ALWT	advanced lightweight torpedo
AMSAA	Army Materiel Systems Analysis Activity
AR	Army regulation
ARRADCOM	Army Armament Research and Development Command
A-Site	nuclear weapons storage site that contains weapons assigned to forward-based ground units
ASM	air-to-surface missile
ASP	ammunition supply point
ASTOR	antisubmarine torpedo ordnance rocket
ASW	antisubmarine warfare
ATSD(AE)	Assistant to Secretary of Defense for Atomic Energy

DOD

DOE b(3)

BN	battalion
BTRY	battery (element of an artillery battalion)
C^2	command and control
CADMUS	controlled atomic demolition munition underground system

CASK	convertible antiship killer (a convertible conventional/nuclear missile to be used by the Navy to attack surface ships from a submerged submarine)
CD/CDS	command disablement/command disablement system
CEP	circular error probable
CFRD	confidential formerly restricted data
CNO	Chief of Naval Operations
CNW	convertible nuclear weapon (an INC weapon that has a nuclear capability when the SNM is emplaced and a valid conventional or chemical capability when the SNM is removed)
CNWDI	Critical Nuclear Weapon Design Information
CNSI	confidential national security information
COB	collocated operating base
COMP	component(s)
CONDOR	Navy air-to-surface missile
CONT	container
CONUS	Continental United States
CRD	confidential restricted data
CSWS	Corps Support Weapon System (recently merged into the Joint Tactical Missile system)
D^3	delay, disrupt, and destroy
D-38	depleted uranium
DEFCON	defense condition
DESTEX	a form of conventional HE
DNA	Defense Nuclear Agency
DoD	Department of Defense
DOE	Department of Energy
DT	deuterium-tritium
ED	emergency destruct
EOD	explosive ordnance disposal

ER	enhanced radiation
ERDA	Energy Research and Development Agency
FA	field artillery
FCDNA	Field Command, Defense Nuclear Agency
FM	field manual
F-Site	nuclear weapon storage site that supports an air defense unit
GA	gun assembled
GBU	guide bomb unit
GGB	guided glide bomb
GLCM	ground-launched cruise missile
GOR	General Officer Review
GP	general purpose
Harpoon	Navy antiship cruise missile that can be launched from aircraft, ships, and submarines
HE	high explosive

DOD DOE b(3)

ICBM	intercontinental ballistic missile
IFI	in-flight insertion
IHE	insensitive high explosive
INC	insertable nuclear component weapon (a nuclear weapon design concept whereby a nuclear-capable warhead can be converted from a nuclear-inert to a live nuclear warhead by inserting a nuclear component. There are two general subclasses of INC warheads--convertible and nuclear-only)
JTACMS	Joint Tactical Missile System (replaces the Corps Support Weapon System (CSWS)
KAFB	Kirtland Air Force Base
LCHR	launcher
LLC/LLCE	limited life component/limited life component exchange
LLNL	Lawrence Livermore National Laboratory

LOADM	low-yield atomic demolition munition
MADM	medium atomic demolition munition
MGGB	modular guided glide bomb
MOB	main operating base
Modularity	general nuclear weapon design concepts that include insertable nuclear components, convertible nuclear weapons, and nuclear-only insertable nuclear components

DOD DOE b(3)

MRBM	medium range ballistic missile
MRR	minimum residual radiation
NATO	North Atlantic Treaty Organization
NCA	National Command Authority
NRC	Nuclear Regulatory Commission
NSC	National Security Council
NSI	national security information
NTS	Nevada Test Site
NUCL	nuclear
Nuclear-only weapon	An INC weapon that has only a nuclear capability. It is not designed to have a valid conventional capability when the SNM is removed.
NWDG	Nuclear Weapon Development Guidance
NWREP	nuclear weapon report
OCONUS	outside the continental United States
OPNAVINST	OPNAV instructions
OPS	operational effectiveness
OSD	Office of the Secretary of Defense
PACOM	Pacific Command
PAL	permissive action link
PBXN	form of plastic-bonded explosive used by the Navy

[redacted]

PRP	Personnel Reliability Program
PWW	planar wing weapon
QRA	quick reaction alert
RADM	radioactivity atomic demolition munition
RD	restricted data
RD&T	research, development, and testing
RV	reentry vehicle
RWC	removable weapon component
SACEUR	Supreme Allied Commander, Europe
SADM	special atomic demolition munition
SAFF	safing, arming, fuzing, and firing
SAM	surface-to-air missile
SLCM	sea-launched cruise missile
SLS	stockpile-to-launch sequence
SNC	separable nuclear component
SNM	special nuclear material
SNW	standard nuclear weapon
SOM	standoff missile
SOP	standard operating procedures
SRD	secret restricted data
S-Site	nuclear weapons storage site that provides storage for specifically assigned unit weapons and initial resupply weapons
SSM	surface-to-surface missile
STF	Special Task Force
S^3	safety, security, and survivability
STS	stockpile-to-target sequence
SWOP	special weapons ordnance publications
TASM	tactical air-to-surface munition

[redacted]

[redacted]

TLAM	Tomahawk land-attack missile
TM	technical manual
TN	thermonuclear
TO	technical orders
TOE	table of organization and equipment
U	utility/worth in merit calculation
^{238}U	uranium-238, most abundant isotope of uranium
	DOD DOE b(3)
VI	value/importance in merit calculation
WHB	warhead body
wr	war reserve
Z-Site	nuclear weapons storage site that provides storage for specifically assigned unit weapons and general resupply weapons

[redacted]

EXECUTIVE SUMMARY

A. Overview

A nuclear weapons stockpile that is totally survivable, secure, safe, and operationally effective with a light logistic burden, all obtainable at a cheap price, represents the ideal world for the military services. This, of course, is an impossibility. As the pendulum of requirements swings in the direction of greater safety and security, survivability necessarily suffers, the nature of the problem being a choice between Scylla and Charybdis.

DOD

We undertook this study to determine if modular weapon technology offers not a panacea, but a means of improving the overall utility of certain types of nuclear weapon systems. It was intended to produce an essential first-reference document useful in determining the feasibility and utility of modular nuclear weapons, including insertable nuclear components (INCs).

For certain tactical applications, safety is enhanced, and more importantly, this enhancement should allow evolutionary modifications to existing stockpile-to-launch sequences (SLSs) and to administrative regulations that can substantially improve nuclear weapon survivability in the European theater and allow for greater flexibility and operational effectiveness in special theaters.

B. Summary

We reviewed the studies that have addressed modularity, identified potenial requirements for modular weapons, examined the technology needed to support modular weapons development, identified potential applications of modular technology, and evaluated the overall utility of developing and deploying these candidate modular weapon systems.

DOD

Although modular requirements have not been formally specified by the services, they have expressed varying degrees of interest in identifying the costs and benefits associated with incorporating modularity in the development of new tactical and strategic nuclear weapons.

DOD

Ironically some of the earliest nuclear weapons in the stockpile incorporated INCs, then called in-flight capsules.

DOE b(3)

The development of the sealed-pit weapons led to the demise of these early modular weapons around 1960. Technological advances plus increasing concerns for the survivability and security of the nuclear weapon stockpile led to a resurgence of interest in modular weapons during the 1970s that has continued to the present.

DOE b(3)

LOL

Potential system applications for modular technology were evaluated in a matrix that compared families of weapon categories with 34 specific weapon system/warhead characteristics. The strongest contenders for modular technology are tactical systems, the most favorable being a land-launched tactical missile/cruise missile, either convertible or nuclear-only; sea-launched tactical missile/cruise missile, again either convertible or nuclear-only; and an air-launched tactical bomb or air-to-surface missile (ASM) with a nuclear-only capability. Other tactical candidates scored very well but were not selected for the utility analysis: artillery fired atomic projectile (AFAP), torpedo, ADM, and air-to-air missile. Within the strategic categories, the mobile ICBM [surface-to-surface reentry vehicle (RV)] appeared to be a reasonable candidate for modularity, but it was viewed as another good follow-on candidate in view of the political and operational problems associated with mobile strategic systems in the continental U.S. (CONUS) at this time.

The utility analysis compared the advantages and disadvantages of modularity with three baseline systems in accomplishing tactical missions for each of the military services. All three candidates are high-value munitions and represent small buys.

- The Army mission analyzed is two-fold:

DOD

and provide conventional and possibly nuclear air-defense (AD) coverage at medium and high altitudes. The baseline systems are Lance, Hawk, and Nike-Hercules. The generic modular candidate is a convertible surface-to-surface missile/surface-to-air missile (SSM/SAM) system.

- The Navy's mission is to defeat enemy ships, submarines, and shore installations using the as the baseline conventional system, and a convertible modular system as the modular candidate.

DOD

- The Air Force's mission parallels the Army's first mission of the family of B57 and B61 gravity bombs make up the baseline. A dedicated force of nuclear-only TASMs is the candidate modular system.

DOD

DOE b

A secure container with permissive action link (PAL) and command disable (CD) features protects the INC before insertion. The warhead body (WHB) contains the electrical interconnects to the missile guidance system and holds the IHE (or DESTEX for the Navy candidate) necessary to implode the pit. It does not contain RD information. The convertible applications also contain the unitary conventional high explosive (HE) or submunition explosives (or chemicals) in its remaining volume.

The major advantages and disadvantages of modularity as shown by the utility analysis are summarized in the section below. One important caveat stands out as discussed in the review of service regulations in Chapter VI. Though it does not appear that the development of modular technology is hindered by present directives or procedures, there are many inhibitors to fielding such systems. If modular systems are designed to be handled exclusively in accordance with presently prescribed methods, the apparent advantages of fielding such systems will not be fully realized. A favorable environment consisting of revised administrative procedures and security

regulations along with a required host of stockpile-to-launch modifications would be necessary to ensure that any of the modular candiates would reap benefits that outweigh the costs as discussed below. This favorable environment, however, could evolve as awareness of the advantages and the technical capabilities of modular weapons to satisfy critical requirements becomes more widespread.

C. Findings

1. Survivability.

DOD

We configured two SLSs for the Army modular candidate, with substantial gains in survivability under the second and preferred sequence--disperse the INCs in peacetime down to the using field artillery (FA) and AD units, storing them in secure unit arms rooms or, if necessary, some type of storage well. The larger the dispersion, the greater the survivability.

DOD

The preferred SLS for the Army modular candidate would continue the deployment of missiles and launchers to survivable field locations during training and alerts. The non-RD WHB would also deploy on the missile with the units. The INCs become more survivable than standard nuclear warheads because of: (1)

DOD

DOD

The advantages and disadvantages are listed below; the service candidate affected is in parentheses.

Pro: (1)

(2)

(3)

DOD

(4)

(5)

Con: (1)

2. Security. Security is a condition that results from the establishment of measures to protect designated information, personnel, systems, components,

and equipment against hostile persons, acts, or influences. Several technical and operational advantages accrue to modular warheads.

DOD

Pro: (1) Command and control requirements are now on components that are individually unable to produce a nuclear yield. (All three candidates)

(2)

(3)

DOD

(4)

Con: (1)

DOE b(3)

(2) Peacetime dispersal to using units (Army) or deployment during crisis/hostilities to collocated air bases or strips (Air Force) for increased survivability means:

a. Exposure to more personnel.

b. Storage at less secure areas than the baseline unless storage wells or shelters are provided.

3. Safety. Safety enhancements are inherent within the INC technologies, regardless of whether or not a favorable administrative and regulatory environment evolves. Two types of safety are analyzed in this report: nuclear detonation safety where an inadvertent detonation gives a nuclear yield in excess of 4 lb HE equivalent, and plutonium-scatter safety where detonation of the HE results in dispersion of plutonium.

Modern nuclear weapons are safe from accidental nuclear detonation, especially those containing IHEs--the U.S. has a perfect record. However, modular warheads are safer before insertion because the INC is physically separated from the HE. The probability of an accidental nuclear yield is zero. Though IHE has greatly reduced the probability of future plutonium

dispersal accidents with standard nuclear warheads, an accident involving the movement of a WHB (less INC) cannot disperse plutonium (it has none); an accident involving an INC would have a much lower probability of plutonium dispersal because of substantially reduced HEs.

Pro: (1) Separation of explosives from nuclear material inherently increases nuclear detonation safety. (All three candidates)

a. Before insertion, modular warheads are safer than the baseline nuclear warheads.

b. After insertion, modular warheads are as safe as baseline nuclear warheads.

(2) Accidents involve lower probabilities of plutonium dispersal. (All three candidates)

(3) Intrinsic radiation concerns can be lessened by storing INCs in shielded containers. (Navy)

a. The INC is stored and transported in strong secure containers with only a small amount of IHE.

b. The WHB body is devoid of plutonium.

Con: (1) Intrinsic radiation concerns are increased because of greater amounts of SNM in INCs if shielding is not adequate. (Navy)

4. Operational Effectiveness. Operational effectiveness as used in the analysis includes mobility, targeting flexibility, enduring capability, storage flexibility, nuclear yield, conventional warhead effects, reliability, range, and foreign political acceptability. The three candidates generally offer improvements over the baseline systems in this area.

Pro: (1) Strategic and tactical mobility for European and special theaters are increased because of the small size and weight of INCs and lack of nuclear materials in the WHB. (All three candidates)

(2) Convertible weapons can provide tremendous targeting flexibility. (Army, Navy)

(3) Enduring capability is available through the rapid logistic resupply of INCs. We think that early dispersal of the missiles and the non-RD WHBs to their field locations will substantially increase their survivability. (All three services)

(4) Convertible weapons allow full nuclear or conventional capabilities where storage areas are limited. (Navy)

Con: (1) Hard fixed-target requirements may necessitate a large and heavy two-stage INC. (Army, Air Force)

(2) Convertible weapons may incur reduced conventional effectiveness because of WHB volume devoted to the nuclear application. (Army, Navy)

DOE b(3) (3) [redacted] This can be minimal with high production standards, affordable because of the small weapon system buys, and fully acceptable especially in insertion operations within a clean environment. (All three candidates)

(4) Range for the nuclear mode of convertible weapons may be less. (Army)

Unknown: (1) Foreign political acceptability of storing, docking, or overflying INCs and/or WHBs (without INCs) is unclear in areas currently restricted to nuclear weapons. (All three candidates)

5. Logistics. We examined the following subareas: transportation and handling, maintenance and support, storage requirements, special theater movements, training, limited-life component exchange (LLCE), administrative and security regulations, component classification, security personnel, and personnel reliability and inspections. Throughout we used the SLSs that were defined under a favorable environment where the missiles and WHBs do not require RD protection.

Pro: DOD (1) [redacted] DOE b(3)

(2) Size of storage areas requiring special nuclear protection is decreased. (All three candidates)

(3) Training in unit areas and in the field can improve because of the greater availability of INC mock-up trainers and non-RD WHBs. (All three candidates)

(4) Transportation of INCs into special theaters can be more rapid and secure than that of full-up nuclear munitions. (All three candidates)

(5) Limited-life component exchange is easier. (All three candidates)

(6) Maintenance and support workload and handling equipment are reduced for the INC. (All three candidates)

Con: (1) Administrative and security regulations must be adapted to engender viability of modular weapons in all utility areas (except safety, which is inherently increased). (All three candidates)

(2) The WHB must not carry a classification higher than its delivery missile. (All three candidates).

(3) Numbers of security personnel will generally be unchanged unless current storage sites become INC-only sites. Security personnel requirements and storage sites will increase if unit storage is allowed. (Army, Air Force)

Unchanged: (1) Requirements for personnel reliability programs and inspections will probably remain the same. (All three candidates)

(2) Limited-life component exchange intervals and stockpile life will remain the same. (All three candidates)

6. Costs. Life cycle costs including development, production, and operation and support categories were examined in a relative context. Though absolute cost numbers were not estimated, the merit assessment establishes the broad cost trends.

DOD

The Army and Air Force modular candidates are estimated to cost more, primarily because of increases in production, security, and storage costs. However, transportation costs are singled out as a category where substantial cost savings should be realized.

Pro: (1) Costs of a convertible warhead force are less than the costs of a dedicated nuclear plus dedicated conventional force. (Navy)

Con: (1)

DOD b(3)

(2)

DOD

(3) Production of safe, secure containers and construction of associated storage facilities may be expensive, particularly for the Army system. (All three candidates)

Unknown: (1) Missile system operation and support costs account for about

[redacted]

fifty percent of weapon total life cycle costs. (If delivery unit life-cycle costs are considered, then the costs of INCs become practically negligible in terms of total life-cycle costs.) Costs may rise in certain areas, and fall in others. The overall effect is highly dependent upon INC storage schemes and security regulations, especially for the Army system. (All three candidates)

D. Recommendations

DOD

(1)

(2) Recommend that the Laboratory continue to develop concepts for engineering designs to support modular systems in support of identified or perceived service requirements.

(3) Finally, based upon specific service stated requirements, recommend that the Laboratory be prepared to develop modular warheads for production and deployment.

[redacted]

[redacted]

UNCLASSIFIED

MODULAR WEAPON SYSTEMS AND INSERTABLE NUCLEAR COMPONENTS

A Compendium of Requirements, Technology, Applications, and Utility (U)

by

Joseph S. Howard II, Edward J. Palanek, John L. Richter, Richard R. Sandoval, Frank L. Smith, Richard H. Stolpe, CDR Larkin E. Garcia, LTC L. Warren

ABSTRACT (U)

This document is to serve as an essential first reference in determining the applicability and utility of modular nuclear weapons, including insertable nuclear components. Potential requirements for modular weapons were identified, past studies were reviewed, and warhead technologies needed to support weapons development were examined. The most promising of the potential applications of modular technology were evaluated in a utility analysis that covered survivability, safety, security, operational effectiveness, logistics, and costs. These analyses indicated potential utility of certain tactical modular applications. Recommendations are made that support continued Los Alamos development work.

UNCLASSIFIED

[redacted]

CHAPTER I

INTRODUCTION

A. Purpose

The purpose of this study is to identify potential requirements for modular nuclear weapons, to review the technology needed to support modular weapons development, and to determine the feasibility, advantages, and disadvantages of developing and deploying one or more generic modular weapons in support of identified service missions.

B. Scope

The scope of this study includes:

- Defining modularity and various system configurations that constitute modularity and other pertinent terms required for understanding the subject area and this study (Chapter I and Glossary).
- Reviewing previous and on-going studies that address modularity and identifying the potential sources of requirements for development and deployment of modular weapons (Chapter II).
- Reviewing modular technology to include the advantages and disadvantages of implementation of the technology (Chapter III).
- Identifying potential applications of modular technology in terms of generic systems and applicable missions (Chapter IV).
- Evaluating potential applications in terms of operational effectiveness: safety, security, and survivability (S^3); design limitations; and cost effectiveness (Chapter V).
- Reviewing publications and regulations that affect the development and deployment of modular weapons (Chapter VI).

C. Objective

The objective of this study is to bring together in one comprehensive document the previous and current work that has been accomplished in the area of nuclear weapon modularity, to evaluate modular technology applications to the missions and requirements of the armed services, and to determine the political and regulatory restrictions that apply. It is intended that this document will serve as an essential first reference in determining whether

modular technology for future weapons should be pursued, identifying weapon types and missions that might use modular technology, and postulating the political and regulatory restrictions that must be overcome.

D. Definition of Terms

Many terms have been used to define the concepts associated with weapons that have alternative warheads or require procedures to ready a complete warhead. In this study, we attempt to establish a set of distinct terms that define the entire spectrum of modularity concepts used here. Other terms used in the study are listed in the glossary.

Modularity - A nuclear weapon design concept that includes insertable nuclear components (INCs), convertible nuclear weapons, and nuclear-only INC weapons.

INC Weapon - A nuclear weapon design concept whereby a nuclear capable warhead can be converted from a nuclear-inert to a live nuclear warhead by inserting a nuclear component. There are two general subclasses of INC warheads: convertible warheads and nuclear-only warheads.

Convertible INC Weapon - An INC weapon that has both a nuclear capability when the special nuclear material (SNM) is emplaced, and a valid conventional or chemical capability when the SNM is removed.

Nuclear-Only INC Weapon - An INC weapon that has only a nuclear capability. It is not designed to have a valid conventional capability when the SNM is removed.

From the definitions above we see that there are two subclasses of INC warheads: (1) convertible warheads and (2) nuclear-only warheads. A convertible warhead is basically a conventional high-explosive (HE) warhead modified so a nuclear assembly, generally called an INC, can be inserted to give the weapon an optional nuclear yield. Convertible warheads may thus have either a nuclear yield or a useful conventional HE yield. With this option, the field commander can choose the yield (either nuclear or conventional) best suited to the delivery system, the battlefield conditions, and the target. Convertible INC designs may make many training and operational requirements

cheaper and simpler because the user need concern himself with just one basic weapon system instead of two. The nuclear-only INC design is used only with a nuclear yield. With either type, the nuclear assembly (the INC) is stored away from the basic weapon most of the time. The INC is inserted only after National Command Authority (NCA) release and, ideally, only after a target is at hand. During almost all the stockpile-to-target sequence (STS), the user does not have a nuclear weapon and thus has no nuclear safety problem, thereby avoiding many problems associated with maintaining, handling, transporting, and guarding nuclear weapons.

[redacted]

CHAPTER II

REVIEW OF PREVIOUS STUDIES AND SERVICE REQUIREMENTS

A. General

Over the past decade more than thirty studies have compared some form of modularity with standard nuclear weaponry primarily as a means of achieving greater S^3. Most of the modular designs in the studies reviewed would provide safer weapons that are more versatile and more effective, and therefore of greater deterrent value. This chapter summarizes much of the work done to date, the bulk of which involves some form of INC warhead design.

Although actual modular requirements have not been specified by the services, they have expressed varying degrees of interest in identifying the costs and benefits associated with incorporating modularity in the development of new tactical and strategic nuclear weapons. The 1972 and 1973 Department of Defense (DoD) Nuclear Weapon Development Guidance (NWDG)[1] requested, as a technological goal, that the Department of Energy (DOE) (then Atomic Energy Commission [AEC]) investigate possible convertible warhead concepts using INC techniques and expressed a desire for an early feasibility demonstration of the concept. This goal was not included in the 1974 NWDG because the feasibility of the concept had already been tested at the Nevada Test Site (NTS) in two configurations. Therefore, feasibility of the concept is a reality. The DOE nuclear weapon design laboratories have worked and are continuing to work with the services on INC conceptual studies for various weapon systems.

The services' laboratories have embarked on new modular weapon design programs. The Army has requested that the modular concepts be evaluated for applicability to their version of the Joint Tactical Missile System (JTACMS), formerly the Corps Support Weapon System (CSWS). The Navy's primary interest in modular weapons programs have mostly been directed toward increasing the capabilities of existing weapon systems [redacted] The Air Force is developing a family of precision-guided munitions, under the general title Glide Bomb Unit-15, (CBU-15) which has a variety of interchangeable guidance and propulsion modules, payloads, and aerodynamic surfaces. Also, the Air Force is studying the possibility of using an INC warhead with the AICBM system.

DOD

[redacted]

[redacted]

B. Overview of Specific Studies

DOD

that time, circa 1970, the nuclear-only INC did not meet with general political acceptance, but it did provide a springboard for the convertible INC. As then envisioned, a conventional warhead, preferably a precision-guided munition, could be simply and cheaply modified to give it a low-yield nuclear option.

2. Convertible Antiship Killer (CASK).[3]

DOD

A

CASK warhead was proposed to greatly increase large ship kill probability when operated in the nuclear mode.

DOD

[redacted]

- a simple and rapid field convertibility; and
- a non-RD classification in the conventional model (applicable to only one design proposal).

DOD DOE DOD DOE

3. Torpedo.[4] The DOE design laboratories with Navy participation conducted a Phase 1 study on a convertible INC warhead for the torpedo. The torpedo is the main submarine-launched antisubmarine warfare (ASW) and antiship weapon. It is capable of speeds up to but has a high noise level at all speeds. Because of the high noise level, the target submarine can detect the torpedo and attempt to outrun it.

DOD

DOE b(3)

The DOE design laboratories and the Navy started a Phase 1 study for a nuclear warhead in early 1972 to explore the possibility of increasing the versatility and effectiveness of the torpedo by incorporating a convertible INC warhead.

DOD

The study results indicated that an INC warhead was desirable and technically feasible. Desirability was predicted on the following:

(1) Lethality (target-submarine hull rupture) would increase significantly.

(2) The dual capability of the torpedo would increase operational flexibility aboard the submarine because conventional HE torpedoes would not have to be off-loaded to accommodate nuclear torpedoes.

(3) Advantages of both conventional and nuclear torpedoes would be available, but with greater ease and at lower cost than possible with two separate weapons.

DOD

(4) Security for the nuclear torpedo would be simplified although the degree would depend on the classification of the design.

(5)

DOD

(6) Increased flexibility under wartime conditions would allow a submarine to conduct combat operations in either a 100% conventional or 100% nuclear mode, or a combination of the two.

(7) Personnel would not be exposed to radiation hazards as they are with present nuclear weapons aboard submarines.

(8) Perturbations to the DoD-developed warhead would be minimum, and the consequent reduction in kill radius for the conventional mode, depending on the design selected, would be no more than about 5%.

(9) The entire allowance of INCs could be safely secured in a properly designated vault or safe.

DOD The conventional _____ torpedo was in production when the study was conducted. This was a major disadvantage in considering a nuclear option. Incorporation of an INC option would probably have necessitated a redesign of the arming, fuzing, and firing (AF&F) circuitry, relocation of interior warhead components, and rework of the production facilities. This situation may have been the reason the Navy did not proceed with a convertible _____ DOD
DOD torpedo. However, with the _____ torpedo being completely upgraded, the Navy may again examine convertibility. Hughes Aircraft is retrofitting the total Navy inventory of over 2000 Mk 48s.

4. Field Command, Defense Nuclear Agency (FCDNA) Insertable Nuclear Component (INC) Report.[5] This is the earliest source document that addresses various aspects of the then advanced nuclear-weapon design technology associated with the INC concept, both convertible and nuclear only. By this time the AEC had tested several INC design concepts at NTS and had completed several conceptual (Phase 1) studies _____ ACM, CASK, DOD
DOD CADMUS, and _____ antiship missile).

This report discusses the effects of the convertible and nuclear-only INC concept on: (1) command and control, (2) custody and logistics, (3) operational readiness, (4) safety, (5) security, (6) administrative aspects of the four safety standards (DoD Directive 5030.15 of 10 June 1960), (7) relative costs, and (8) political ramifications.

5. Phase 2 Feasibility Study for Atomic Demolition Munitions (ADMs).[6]

DOE
b(3)

DOD

DOD

Los Alamos proposed an INC munition with an insertable capsule.

DOE b(3)

DOE b(3)

DOD

6. Mk 46 Torpedo. The Navy requested that the DOE design laboratories participate in a joint Phase 1 study to investigate the feasibility of improving the Mk 46 torpedo warhead.

DOD

The specific areas that the DOE was asked to study were, in priority:

(1) improvement of HE warhead effectiveness including an evaluation of proposed concepts,

(2) development of convertible INC warhead that emphasized improved HE effectiveness, and

(3) development of exchangeable nuclear and conventional warheads.

The study, completed in June 1975, strongly recommended that a well-coordinated joint Navy/DOE Phase 2 feasibility study be conducted.

DOD

7. Nuclear By late 1974, six convertible INC weapons had become subjects of formal studies: torpedoes, ACM/CASK, Mk 84 bomb family, Standard Missile-2, and Harpoon antiship missile. By far the most significant of these studies was which went on to a Phase 2 feasibility study in June 1975 (completed June 1976) and became the first weapon system to proceed through Phase 2A (July 1976 through December 1977).

DOD

DOD

This led the DOE design laboratories to respond with a variety of design proposals that appeared feasible. The problems associated with integrating a nuclear option (convertible INC concept) into the warhead and circuitry of the Harpoon were addressed in subsequent studies.

Conclusions resulting from Phase 2 and Phase 2A studies included:[9,10]

- A nuclear-only replacement warhead compatible with the Harpoon weapon system is technically feasible and could be developed with little technical risk while satisfying modern nuclear weapons safety standards.
- [redacted] DOE b(3) DOD
- DOD [redacted] DOE b(3) Therefore, the performance characteristics, safety, and reliability of such a concept have not been fully evaluated. DOE b(3)
- Various containers (shipping, storage, destruct) for the INCs have been identified.

The Phase 2A study[10] covered cost, commonality, and additional technical issues from the Phase 2 and resulted in a study recommendation for a convertible [redacted] nuclear warhead with design considerations for future adaptation to the [redacted] antiship missile. The cost analysis concluded that: (1) excluding cost of special nuclear material, there is no significant cost difference between convertible and nuclear-only designs, and (2) a convertible warhead is more cost effective than a nuclear-only system in terms of operational flexibility. In summary, the convertible nuclear [redacted] benefits clearly outweigh those of the baseline nuclear [redacted] The commonality analysis concluded that a high commonality level could be

DOD DOD DOD DOD

achievable for Navy low-yield warhead applications and would reduce Navy and DOE costs because of common weapon development and production. The two main technical issues were resolved by actual tests; that is, the convertible warhead survived in the conventional mode, and the Navy conventional HE (DESTEX) could be used in the convertible nuclear warhead. Phase 3 development engineering could be initiated immediately for either a nuclear-only or a convertible warhead for the [redacted] weapon system. The technical risks associated with developing either a nuclear-only or convertible warhead were judged low.

8. Convertible Concepts for the Mk 84.[11] The Air Force, with the participation of the DOE design laboratories conducted a study on the utility of giving the Mk 84 bomb a convertible INC option, especially when using the guided glide bomb (GGB) derivatives of the Mk 84: GBU-8, GBU-10, GBU-15 (V). The study included six proposals ranging from self-contained nuclear weapon add-ons to small capsule-type nuclear components. The designs were selected to illustrate the possibilities of the convertible INC concept and to show that application is highly system-dependent. Though several distinct benefits were identified, a formal requirement did not materialize.

"Convertible Concepts for the Mk 84" was the forerunner of a large and comprehensive study effort by the Directorate of Aerospace Studies entitled "A Utility Analysis of Convertible Nuclear Weapons."[12,13] The two study efforts overlapped to some degree but the Mk 84 study is narrower in scope. Much of the information furnished by the then ERDA laboratories for this effort was used in "A Utility Analysis of Convertible Nuclear Weapons."

9. A Utility Analysis of Convertible Nuclear Weapons.[12,13] This report investigated the operational feasibility of convertible nuclear weapons (CNWs) and analyzed their utility in comparison with standard nuclear weapons (SNWs). The concept was found feasible for lower-yield ranges. The CNWs also used new protective devices and storage facilities more effectively than SNWs because of their small size and the separability of the nuclear explosive package from the HE of the conventional weapon.

DOD 10. Nuclear Convertibility for the [redacted]--An Analysis.[14] The main conclusions of this FCDNA analysis provide one of the best condensed DOD overviews of convertible nuclear [redacted] advantages, including a matrix checklist of advantages and disadvantages. The general conclusion states: DOD "The total cost for the convertible nuclear [redacted] compared to the baseline

DOD nuclear [redacted] is about equivalent. The convertible nuclear [redacted] benefits DOD clearly outweigh those of baseline nuclear [redacted]."

11. Phase 1 Study for the GBU-15 Planar Wing Weapon (PWW).[15] This study examined the concept of equipping the GBU-15 Planar Wing Weapon (PWW) with a nuclear capability. The nuclear GBU-15 PWW would have great commonality with the conventional PWW. [redacted] One can see the possibility of a wide range of employment configurations for the GBU-15 PWW.

12. The Effectiveness of a Convertible Warhead. The effectiveness of a convertible warhead, when used in the conventional HE mode, compared with that of the original unmodified conventional warhead was addressed by Los Alamos in an outgoing telecommunication message to ATSD(AE) on August 1, 1977.

The blast effectiveness of a conventional HE warhead is proportional to the cube root of the mass of HE. When such a weapon is modified to make it convertible, its yield, and consequently its effectiveness, may or may not be reduced from that of the original unmodified warhead, depending on the convertible design used. [redacted]

It is possible to design INC convertible warheads that are fully equal in effectiveness to the unmodified conventional warhead. [redacted]

13. Insertable Nuclear Component (INC) Weapon Technology Applications Study.[16,17] The first part of this study examined all feasible current and

developmental U.S. tactical weapon systems, both nuclear and conventional, for use as INC systems. From all of these systems, six were selected as candidates for the second part which compared the cost and feasibility of using a convertible INC warhead with a mix of conventional and standard nuclear warheads. The six candidates chosen in Part 1 were: DOD tactical [redacted] sea-launched cruise missile (SLCM), CONDOR, [redacted] torpedo, advanced lightweight torpedo (ALWT), and standoff missile (SOM). Part 1 also identifies other weapons with significant operational advantages if deployed as convertible weapons.

Part 2 concludes that the INC weapon concept offers an attractive alternative for obtaining greater capability within a constrained budget. Additional savings are possible if the same INC can be shared among various convertible weapon systems (INC commonality).

14. Recent Work on Insertable Nuclear Component (INC) Warhead Designs.[18] This report summarizes the Los Alamos design and development work on INCs to the year 1977.

DOE b(3)

DOD

DOE b(3)

DOE b(3)

[redacted]

Some concerns the report mentions are:

(1) [redacted]

(2) Existing ERDA classification rules affecting the nonnuclear portion of the warhead might need revision to accommodate the warhead when the INC is not in place.

(3) [redacted]

(4) Production plans for the weapon might need altering in order to accommodate INC needs.

(5) Cost studies of convertible warheads vs conventional HE/regular warheads and the cost of the SNM must be determined because cost is an important consideration in the overall evaluation of the weapon.

15. Implications for Theater Nuclear Forces of a Design Concept Using Separable Nuclear Components.[19] This study provides an initial but detailed qualitative assessment of a nuclear weapon design concept termed the "separable nuclear component (SNC) concept" and focuses on military rather than technical factors. Advantages and disadvantages of SNC weapons in comparison with standard sealed-pit nuclear weapons are analyzed, and their dependence on policy, posture, and weapon design factors is examined. The value of the SNC concept under four postulated theater nuclear force postures is analyzed. Potential applications of the SNC concept to delivery systems are considered and ranked as to potential merit. Political and other implications of introducing SNC weapons are discussed.

a. Conclusions. The study recommends that SNC weapon programs at the nuclear weapon laboratories should be reviewed to ensure that they are properly oriented and that factors such as military advantages, design feasibility, and costs are evaluated and constantly updated to allow for the latest developments in the field. The report suggests that DOE should continue conceptual design efforts on the SNC while emphasizing warheads for

theater-level ORA mobile missile systems and should try to get an SNC weapon where the RWC would not have a restrictive security classification. Further, the DoD should work closely with the DOE in evaluating the political-military utility of SNC weapons and in evaluating delivery systems which now appear to have high merit--specifically GLCM, MRBM, Pershing II and ADM.

16. Tactical Air-to-Surface Munition (TASM). The Air Force, with the assistance of the DOE laboratories, completed a pre-Phase 1 study of a nuclear air-to-surface SOM during 1976-1977.[20,21] A Phase 1 study was then conducted during the period of 1979-1980.[22] The results indicated substantial payoff when attacking mobile and fixed targets with an SOM as compared with nuclear gravity bombs. Though the study did not address INC systems, prelaunch survivability was a major concern with sealed-pit weaponry because of their constrained storage at main operating bases (MOBs). An INC weapon system may allow a large gain in survivability by deployment to numerous collocated operating bases (COBs) and alternate airstrips during crises.

17. Compendium of Convertible Technology.[23] This report is designed to provide an overview of the convertible concept by extracting from previous Navy studies the perceived advantages and disadvantages of the convertible concept. The Phase 1, 2, and 2A studies are examined because they are the only studies that attempted to quantify the advantages and disadvantages; these studies also recommended that a convertible system proceed to Phase 3, development engineering. The conclusions of the effort are reiterated and those conclusions that are system-independent are highlighted.

DOD

DOD

Table II-I, extracted from the report, provides a trade-off evaluation of convertible versus standard nuclear weapons.

DOE

DOD

DOD

On the other hand, (1) convertible weapons are less costly taken overall than standard nuclear weapons, (2) designs can be modified so that

[redacted]

TABLE II-I

TRADE-OFF EVALUATIONS

Competing Characteristics	Choice	Rationale

DOD

DOE
b(3)

[redacted]

classification remains the same as for conventional weapons, and (3) few changes have to be made in the conventional warhead.

18. Corps Support Weapon System (CSWS) Insertable Nuclear Component (INC) Study.[2] [The CSWS is replaced by the Joint Tactical Missile System (JTACMS)]. This study reports on the Army's need for a tactical, surface-to-surface weapon system to replace Lance. The system needs to support corps battle plans by delivering conventional, nuclear, and chemical munitions against enemy forces. It should perform the battlefield interdiction task by attacking [redacted] It must not only replace Lance, but it must complement cannon and rocket systems in support of division operations.

DOD

The Army's CSWS initiated a Phase 1 study in August 1981 with a projected completion date of June 1983. The study group identified the nuclear warhead technology applicable to the system to be developed as including standard single-stage and two-stage devices, enhanced-radiation devices, and at the request of the Army, INC devices.

With INC identified as a possible option that might have a significant effect on organizational, operational, and logistical concepts, the CSWS Special Task Force (STF) in September 1981 asked DOE to prepare an INC data package. Based on this data package the CSWS STF compiled an extensive list of desirable INC design features relative to potential user benefits. Many of the desired features are competing characteristics in any design. Therefore, tradeoffs will be required between high-priority requirements and those which may only be goals for an INC design.

The document reports that a special INC subgroup working with the Phase I Study Group made a comparative study of three classes of generic INC designs with two standard nuclear warhead designs (one of which was the W70 currently used in the Lance missile). The study of the technical feasibility of a convertible INC continues and areas such as the effectiveness of the nonnuclear portion of the payload, better definition of the actual hardware and its performance requirements, sensitivity studies of payload, and delivery constraints need further investigation.

Besides the areas awaiting further investigation mentioned above, there are special issues such as classification and its effect on dispersion of INCs

and reliability of the weapon after INC insertion in the field that need resolution.

DOE b(3)

[redacted]

19. Advanced Intercontinental Ballistic Missile (AICBM). A weapon concept currently being investigated concerns small intercontinental ballistic missiles (ICBMs) deployed under different basing concepts. The primary concept is a road-mobile system, but air-mobile, air-transportable, and silo basing concepts are under consideration.

DOE b(3)

[redacted] To increase survivability, the system could be deployed as a mobile system over a road network. Because of the proximity of the warhead to the missile propellant, significant safety concerns are raised when using standard sealed-pit warheads. Security concerns are of an equally severe magnitude because a full-up nuclear warhead is away from a fixed site.

DOE b(3)

[redacted] Accidental nuclear detonation would be an impossibility unless the system was properly mated.

C. Summary of Service Requirements

In October 1977, the National Security Council (NSC), in reviewing the underground nuclear test program proposed by DOE/DoD, held approval of two tests in abeyance pending the DoD submission and interagency review of the military utility and arms control implications of INCs.

DOD

[redacted] Several aspects of the NSC request proved so contentious within DoD that no response was provided.

Certain offices in the Office of the Secretary of Defense (OSD) objected to the Navy rationale for a nuclear [redacted] At that time, there was substantial opposition in OSD to any sea-based tactical nuclear weapons. Accordingly, the Navy suspended consideration of a nuclear capability [redacted] and DOE terminated active programs related to INCs pending resolution of the impasse between the DoD and the NSC over the

DOD

DOE

military utility study.[25] The DOE recently rescinded its freeze on testing of INCs and is allowing laboratory development to proceed.[26]

There is growing interest in the potential advantages of INCs within DoD and DOE, evidenced by the Army request for inclusion of INC warheads in the CSWS/JTACMS program. Another indication of interest in INC is the Chief of Naval Operation's (CNO's) memorandum stating the Navy policy to support further research and development of INC technology, to determine its full capabilities, and to consider incorporation of INC technology in development of new weapon systems.[27]

[redacted]

UNCLASSIFIED

CHAPTER III

REVIEW OF MODULAR TECHNOLOGY

A. General

Los Alamos has had extensive experience with modular weapons. It is important to recognize that most of the early nuclear weapons were modular in form beginning with the Mk 3, the Hiroshima bomb, and the Mk 4.

DOE b(3)

DOD

Safety was equally important but may not have been the driving factor for Mk 3 modularity. Thereafter INC warheads were favored as a way to enhance nuclear safety in the earliest nuclear-weapon designs while using SNM most efficiently system-wide through interchangeable capsules.

DOE b(3) DOD

Such weapons were widely deployed until about 1960, after which time the sealed-pit weapon became the predominant design. During the 1970s, there was a renewal of interest in modular weapons, although none have been deployed. An outline of what we know about modular weapon technology follows.

B. Presealed-Pit Weapons

The first nuclear weapons were handcrafted and dropped on Hiroshima and Nagasaki. The urgent consideration then, of course, was to develop and produce these weapons for use to hasten the end of the Second World War. After the war, considerations such as safety, scarcity of SNM, and long-term storage were recognized. The approach adopted was in-flight insertion (IFI); the same thing would now be called INC. Figure III-1 is a sketch of the Mk 15 strategic bomb.

DOE b(3) DOD

UNCLASSIFIED

[redacted]

DOD b(3

DOD

DOE b(3)

DOE b(3)

DOE b(3)

DOE b(3)

DOE b(3

DOE b(3)

DOD

During the same time frame, gun-assembled (GA) weapons were deployed. Figure III-2 shows a cutaway of the Mk 33 8-in. projectile, which is still deployed in large stockpile numbers.

DOD

DOE b(3)

C. Benefits of Early IFI and GA Weapons

The IFI weapon bodies were flown on alert and there were accidents that involved scatter of SNM. Without delving into details, the IFI designs prevented large-scale health hazards or loss of life because of the separation of the INC from the remainder of the bomb body. The results from an air crash involving an IFI weapon were: loss of life and aircraft, intact survival of

DOE b(3)

DOD

the secondary (if there was one), and scattered uranium at barely detectable levels if an HE explosion or fire occurred. The nature of ionizing radiation allows one to conclude that if it is not detectable with modern instruments, then it is not hazardous to life. Uranium has very feeble radioactivity: 4.5×10^9 year half-life for ^{238}U and 0.71×10^9 year half-life for ^{235}U. In order to put into perspective the hazard of uranium scatter, we note that commercial airliners use depleted uranium as a counterweight material for control surfaces; a Boeing 747 uses about 500 lb of ^{238}U. Unfortunately, airliners crash and burn and sometimes scatter ^{238}U. Whether society is aware of it or not, it has accepted the (infinitesimal) peril of uranium scatter.

DOE b(3)

DOE b(3)

D. Disadvantages of Early IFI and GA Weapons

The IFI weapons were fielded with increasingly complex mechanisms for effecting in-flight insertion. During alert flights, the real bomb bodies were mated with the cores, and the Air Force literally wore them out. Many of the IFI bombs required a weapons officer in the bomb bay. As modern aircraft were developed, the presence of a man in the bomb bay became impossible.

The GA weapons were supplied with trainer weapon bodies as well as mock-up oralloy. The still-in-service W33 is assembled from the ground up in the field. A special truck with an officer and two specialists are required to

assemble an 8-in. weapon. Couple this with the need for a cordon of guards and one has an awkward logistical problem. A highly proficient team can assemble an 8-in. weapon in 45 min; then they handcarry the assembled weapon to the nearby 8-in. howitzer.

E. Sealed-Pit Technology

DOE b(3)

DOE b(3)

The convenience of the all-up round without having to assemble the hardware is very attractive to the military.

The first sealed-pit weapons entered service in 1958, causing production of IFI weapons to cease. The safety crisis came in early 1966 with the accident at Palomares, Spain. A B-52 bomber on airborne alert collided with a KC-135 during a routine refueling operation. Four B28 weapons either fell out or were jettisoned from the falling bomber. One of the bombs fell into the Mediterranean Sea and was recovered relatively intact after about two months. Another soft-landed on the ground because the parachute deployed. The HE of one of the other B28s that hit the ground deflagrated, and the HE of the last one detonated. There was no nuclear excursion from either of the last two, but the plutonium was scattered around the area. Plutonium is pyrophoric, and if it is heated in the presence of air, it will burn and form an aerosol of plutonium oxide. Plutonium ingested through breathing or cuts is a very serious health hazard.

DOE b(3)
DOD

Several acres of topsoil were scooped into barrels and buried at the Savannah River site in South Carolina.

About two years later in early 1968, another airborne-alert B-52 caught fire. The pilot dropped the crew by parachute and then rode the airplane down to a burning crash on an ice floe in North Star Bay, Greenland. The contaminated iceberg was cleaned up at greater cost than the contamination at Palomares. As a result of these accidents, the U.S. stopped flying alert bombers. Work to prevent future Palomares- and Thule-type accidents continues. One important result is the introduction of IHEs. [redacted] However, IHE is extremely insensitive and provides much greater safety. A modern, high-performance, nuclear weapon primary with IHE weighs considerably more than similar technology with the HMX-based explosive. Although many new tactical weapons (except the AFAPs) are being designed with IHE, there is no hint that alert bombers will take to the air with IHE bombs on a routine basis.

DOE b(3)

The use of IHE and Cat F PAL (see Cat F PAL in Section F.1.a below) in modern weapons is increasing. These features undeniably increase safety but can result in decreased weapon effectiveness. That is, for a given weight, volume, or SNM usage, the yield may be less. The INC, or modular, weapon can fulfill safety requirements for reduced plutonium scatter without IHE and can protect the separate, vital weapon components without a Cat F PAL built into the weapon. For these reasons, the INC may be a more attractive alternative than the ever more complicated all-up weapon.

F. Current Concepts for Modular Weapons

1. Modern Weapon Systems Architecture. Essentially all nuclear weapons can be considered to be "insertable" in a sense. The B61 is a full-fuzing-option tactical bomb. [redacted] Another example of a weapon that could be considered insertable is the Pershing missile. It has a removable warhead section that is stored separately from the missile. The warhead will not function unless it is mated to the missile and properly launched. Or as a final insertable example, an

DOE b(3)

AFAP will not operate unless it is properly fired from a howitzer. But while these systems are modular in this sense, they are not truly INCs according to the definition in Chapter I.

a. Cat F PAL. A new feature included in many modern nuclear weapons is the Cat F PAL. This is a feature built into the weapon to protect it from unauthorized use. [redacted]

DOE b(3) DOD

b. Emergency Destructs (EDs). The DoD also has developed Standard Operating Procedures (SOPs) for emergency destructs. [redacted]

DOE b(3)

2. Recent Separable Component Concepts.

DOE b(3)

a. [redacted] Figure III-3 shows the convertible concept offered by Los Alamos for the [redacted] With only a trivial reduction in HE

DOE b(3) DOD

[redacted]

DOE b(3) DOD

Fig. III-3. Los Alamos Harpoon Proposal 3A warhead.

DOE b(3)

weight, the weapon body can be used in the conventional role.

DOE b(3)

DOE b(3)

The test device did not include INC attributes because the testing of INC weapons had been banned by Presidential Order in 1977.

DOE b(3)

DOD

DOE b(3)

DOE b(3)

DOD

DOE b(3)

c. Applejack.

DOE b(3)

DOD

DOE b(3)

DOE b(3)

DOE b(3)

DOD

Fig. III-5.

DOE b(3)

[redacted]

DOE b(3)

Fig. III-6. [redacted] DOE b(3)

DOD [redacted] Two problems associated with the concept are reliability and efficient use of SNM. DOE b(3)

e. Two-Component Insertable Nuclear Component (INC). Figure III-7 shows the LLNL concept (Waxwing) for the CSWS/JTACMS. The concept involves a nondescript cavity in the warhead. First, the INC hardware package is installed; then the remaining volume is filled with paste HE. The objective is that the nondescript cavity will be unclassified.

[redacted] DOD

[redacted] The road-mobile missile may eventually use HMX-based propellant, so HMX in the warhead might become acceptable, especially with the separation of the INC. [redacted] DOE b(3) DOE

G. INC/Convertible Warhead Observations

The IFI and GA weapons were of the era when the AEC developed weapons with less consideration for logistics or employment than is now possible, given their experience and knowledge. It is safe to say that the detailed concept

[redacted]

UNCLASSIFIED

DOE
b(3)

DOD

DOE
b(3)

DOD

Fig. III-8. Los Alamos conceptual design for AICBM warhead.

[redacted]

UNCLASSIFIED

formulation guidance was drafted to avoid problems that were evident during the presealed-pit era.

During the 1970's INC convertible warhead studies were done on [redacted] and DOD DOD [redacted] torpedoes, modular guided glide bomb (MGGB) with the Mk 84 2000-lb general-purpose (GP) bomb as the munition, [redacted]. Selective DOD observations can be made concerning each of these INC efforts.

Unwritten nuclear weapon employment doctrine infers that only specified targets will be attacked. [redacted]

DOD

The tritonal was cast into the "low-value" Mk 84 bombs with little concern for product uniformity but with great regard to cost. There were questions about whether a mill run Mk 84 bomb, modified for convertibility, would operate reliably.

The high-value (classified and expensive) weapons are protected much more carefully by the services than low-value weapons. The latter category includes rifles, cartons of Composition C, artillery ammunition, and GP bombs. Since high-value munitions are protected because of cost, classified components such as guidance, and the threat of misuse, it may be that adequate precautions are already in use to protect a convertible or INC.

CHAPTER IV

POTENTIAL APPLICATIONS OF MODULAR TECHNOLOGY

A. General

The objectives of modular technology are to increase the military utility of applicable weapon systems with minimum operational burden and cost to the user. These objectives are achieved through weapon design which is system dependent. Therefore, it was determined that the advantages and disadvantages of modular technology must be analyzed by comparing a set of weapon system/warhead characteristics with weapon categories that group "like" types of weapons into specific strategic and tactical categories.

It has been found in the past that evaluation of generic systems for adaptation of modular technology has not been successful because of the uinique character of each system. To minimize the impact of this problem, the weapon system/warhead characteristics and weapon categories where chosen so as to provide a reasonably definitive weapon "type" without actually selecting a system either deployed or in development.

B. Approach

A single matrix was developed for a generalized list of weapon categories and an assessment was made concerning the impact of modularity on the weapon system/warhead characteristics. The following assessment factors were used:

- Very positive impact
- Some positive impact
- No change
- Netgative impact
- Not applicable

For the assessment, certain assumptions were made and additional factors considered in determining the impact of modularity on systems within the weapon categories developed. The systems were evaluated on the basis of the STS of like-type systems currently deployed. From this evaluation, which is qualitative rather than quantitative, three of the most promising candidates were selected for a more detailed utility analysis.

1. Weapon Categories. The widely-used lists of strategic and tactical weapon systems were grouped into like types of weapons in specific strategic and tactical categories. This was done to develop a workable matrix and to more readily identify categories of systems that might benefit from modular technology. The weapon categories used in the assessment are as follows:

Strategic

Surface-to-Surface Reentry Vehicle

- Fixed
- Mobile

Air-to-Surface

- Bomb
- Cruise Missile

Air-to-Air-Missile

Strategic Antiballestic Missile

Tactical

Surface-to-Surface

- Projectile
- Reentry Vehicle
- Cruise Missile
- Short Range Missile

Air-to-Surface

- Bomb
- Cruise Missile

Antisubmarine Warfare

- Cruise Missile
- Torpedo

Surface-to-Air-Missile

Air-to-Air Missile

Atomic Demolition Munition

2. Weapon System/Warhead Characteristics. The advantages and disadvantages of modular warhead technology were analyzed for each weapon category by comparing their impact on 34 specific weapon system/warhead characteristics. These competing weapon system/warhead characteristics are intended to establish a broad set of measures encompassing a relatively complete range of attributes desirable for nuclear weapons. These weapon system/warhead characteristics, and their definitions, are as follows:

Command and Control (C^2). Those features that limit warhead/warhead section use only to authorized personnel during circumstances specifically designated by proper authority. Features such as PAL and nonviolent disablement are specifically included.

Convertible Weapon (Dual Capability). A type of INC weapon that has both a nuclear capability when the SNM is emplaced and a valid conventional or chemical capability when the SNM is removed. (The fact that an HE plug, specific submunition, or chemical agent must be emplaced in the cavity intended for the INC, to attain a valid conventional/chemical capability in some designs, does not eliminate those designs from the convertible weapon category.) (Technical Publication, TP 4-1)

Cost. Actual or potential expenditure of dollars and SNM required to develop, produce, and support a weapon capability throughout its life.

Design Impact. The impact of nuclear design on the weapon system when considering the following design requirements.

- Primary only
- Primary with boost

DOE b(3) [redacted]

- Classification of WHB
- LLC considerations (the impact of modular technology on LLCs and changeout periods)

DOE (b)(3)

- [redacted] DOE

Desired Yield Range. The capability of modular technology to provide the required yield range.

Destruct (Violent). [redacted] (TP 4-1) DOE b(3)

Disablement Nonviolent. Nuclear weapons disablement which, through the destruction or disassociation of one or more key warhead or warhead section or atomic projectile components, temporarily destroys a weapon's ability to be used in its intended mode or as an ADM. (TP 4-1)

Economy of Nuclear Material. Judicious design of active materials and designated special weapons materials whose possession and use are licensed and controlled by the Nuclear Regulatory Commission (NRC).

Explosive Ordnance Disposal (EOD). Activities involved in render-safe procedures and the safe removal of explosive ordnance.

INC Weapon. A nuclear weapon design concept whereby a nuclear-capable warhead can be converted from a nuclear-inert warhead to a live nuclear warhead by inserting a nuclear component. There are two general subclasses of INC warheads--convertible and nuclear-only.

Intrinsic Radiation. Nuclear radiation intrinsic to a weapon and emitted through the weapon's outer surface.

Maintenance. The actions necessary to maintain material in the desired state of operational readiness throughout its life cycle. Maintenance functions include checkout, servicing, crew augmentation, replacement, modification, and depot maintenance. (U.S.A. TRADOC PAM 71-12)

Mobility. The capability of the system to be easily moved in an operational environment.

Operational Effectiveness (OPS Effect). The capability of a system to perform the missions for which it was designed.

Personnel and Training. The number of personnel required and skills necessary to operate, maintain, and support the material system in its operational environment throughout its life cycle. Training includes the identification of personnel skills, training devices and aids, instructions, training documentation, and manuals required to support a material system. (U.S.A. TRADOC PAM 71-12)

Range. The impact of modular technology on system range.

Regulations and Directives. Official DOE, DoD, and armed services publications that establish or implement policies or procedures governing all phases of the life cycle of a nuclear weapon.

Reliability. The probability (without reference to countermeasures) that a weapon will detonate when it has been delivered to its target. (TP 4-1)

Risk (Technical). The degree of probability that a technical goal will be achievable in the system considered.

Safety (Munitions). The prevention of the initiation of energetic materials by normal or abnormal inputs of energy when initiation is not desired. This should include nuclear, HE, and plutonium-scatter safety.

Security. A condition that results from the establishment of measures which protect designated information, personnel, systems, components, and equipment against hostile persons, acts, or influences. (JCS PUB 1)

Stockpile Life. The period of time a warhead is available for employment by DoD.

Stockpile-to-Target Sequence Environment. The aggregate of all external conditions and influences affecting the weapon throughout the STS, including transportation, maintenance, storage, and launch. Factors included are

temperature, humidity, and contaminants of the surrounding air; physical location and operating characteristics of the surrounding equipment and occupants; operational procedures such as acceleration, shock, vibration, heating effects, and radiation. (TP 4-1)

Support/Maintenance Facilities. Facilities to support the material system. Examples are: physical plant, real estate, portable buildings, concrete pads, revetments, roads, runways, housing, shops, depots, test sites, computers, training facilities, and storage areas.

Survivability. The capability of a system to withstand a manmade hostile environment without suffering abortive impairment of its ability to accomplish its designated mission. (TP 4-1)

Testing. The procedures and equipment required of DoD personnel (at any level) to certify the reliability of the system, or any of its components, in contrast with the more "conventional" nuclear system.

Transportation and Handling. The procedures, equipment, materials, and facilities needed for packing and crating; the use of reusable containers; supplies necessary to support packaging, preservation, storage handling, and/or transportation of prime equipment; support and test equipment needed; repair parts and supply support; personnel; technical data; publications; and facilities. (U.S.A. TRADOC PAM 71-12)

Vulnerability. The characteristics of a system that cause it to suffer a definite degradation as a result of having been subjected to a certain level of effects in an unnatural (manmade) hostile environment. (TP 4-1)

3. Assumptions and Additional Considerations. In development and assessment of the matrix of potential modular applications, certain assumptions and considerations were applied.

(1) Evaluations were made on the basis of providing something better with modular technology than currently exists in a standard nuclear warhead design.

(2) Certain warhead characteristics were weighed more heavily than others in this assessment. These were

design impact

operational effectiveness

safety

security

survivability

transportation and handling

(3) It was assumed that modular design technology would use relatively higher amounts of SNM; therefore, economy of SNM would reflect a "negative" in most generic system considerations.

(4) Generally, a reduction in reliability can be expected in most modular technology designs and was so reflected for all generic system categories.

(5) Deployment of modular systems would necessitate a restructuring of current regulations and directives addressing nuclear weapon storage, transportation, and handling, and therefore reflect a negative impact.

C. Assessment

1. General. Evaluation of the matrix found in Fig. IV-1 indicates that the strongest contenders for modular technology are tactical systems. Those tactical systems that appear to be the most favorable modular candidates but still allow adaptation to other tactical uses include the following:

(1) Land-launched tactical missile/cruise missile (SSM/SAM), either convertible or nuclear-only

(2) Sea-launched tactical missile/cruise missile (SSM), again either convertible or nuclear-only

(3) Air-launched tactical bomb or air-to-surface missile with a nuclear-only capability

These three candidates can cover a wide variation of STS environments and system variations. Other systems identified for future consideration in modular technology applications include the strategic mobile missile system (AICBM), an air-to-air missile (for strategic or tactical use), and several tactical-only systems.

2. Specific Assessment Considerations. A number of observations can be made in reviewing the matrix and resulting evaluation.

DOE b(3)

DOE b(3)

Fig. IV-1. Assessment matrix.

(1) Certain characteristics reflect strong support for modularity technology in all weapon categories. These include

destruct (violent)

disable (nonviolent)

explosive ordnance disposal (EOD)

These three categories encompass security measures designed to ensure against theft or unauthorized use of nuclear weapons. By separation of components, the modular concept provides inherent improvement in security during peacetime and in crisis against the threat of theft

or unintended use. Standard nuclear weapons are not generally amenable to such methods of use denial except through design and operational measures that are relatively cumbersome in comparison to component separation.

(2) Those tactical systems that appeared to be the most favorable candiates for application of modular technology reflecting strong support in the following additional warhead characteristic categories.

command and control

yield range

mobility

safety

security

small volume/lightweight

stockpile-to-target sequence environment

support/maintenance facilities

survivability

transportation and handling

vulnerability

design impact (primary and boost)

DOE b(3)

DOE b(3)

DOD

(3) [redacted]

(4) Some tactical candidates scored very well but were not selected.

DOD

Projectile. [redacted] it was considered improbable that a new projectile would be considered for development in the near term.

Torpedo. A new nuclear torpedo has been under development consideration for several years but is still in question. There is a good possibility that modular technology would have application for

the selected candidate systems, either a new torpedo or in retrofit of [redacted] torpedoes.

DOD

Atomic Demolition Munition. The development of a new ADM is questionable at this time. [redacted]

DOD

Air-to-Air Missile. The requirement here could have Air Force and Navy applications but does not appear to have the urgency that the selected candidates reflect in meeting projected DoD needs. This would be a good follow-on candidate for modularity consideration.

(5) Within the strategic categories, the mobile ICBM [surface-to-surface reentry vehicle (RV)] appeared to be a reasonable candidate for modularity, but in view of the political and operational problems associated with mobile strategic systems in the CONUS at this time, it was viewed as another good follow-on candidate.

CHAPTER V

UTILITY ANALYSIS

A. Introduction

This chapter examines the utility of modular nuclear warheads within the context of three generic candidates, one system for each of the military services. What we have attempted to do is address the advantages and disadvantages offered by these kinds of warheads. We recognize that hardware is only one aspect of the military equation; the conclusions we reach here must be tempered by the existing political and military doctrinal environment and especially by the current administrative framework. Many factors, including the element of political and military strategy, leadership, personnel training, application of the principles of war, and modus operandi of the STS, are major parameters that ultimately drive the real worth of these systems whether in peacetime deterrence or wartime application. Admittedly, the focus is within the European environment where the survivability of our nuclear forces has been and continues to be severely questioned. We see that modular nuclear weapons potentially offer a substantial increase in survivability, particularly for the Army and Air Force candidates. But turning away from our potentially most important war area to those areas of the world where wars may be more likely, a force of Army or Navy convertible systems offers tremendous flexibility to respond conventionally and to deter nuclear responses within special theaters. Several advantages, including the all-important increase in survivability, also accrue to the Air Force candidate modular system that is dedicated to the nuclear role.

Let no one doubt that obstacles must be overcome to field successfully these kinds of warheads. The technical challenges, however, are not high risk. Reliable and safe modular warheads can be built using present design and engineering capabilities. It is their impact upon the well-established administrative, security, and surety community that involves major ramifications. If modular systems are treated as "business as usual," then only safety advantages result from the separation of plutonium from the HE during most of a warhead's life. Instead, the logistic and regulatory community should modify the peacetime logistic system in order to realize a survivable nuclear system, even with the probability of an increase in costs. Increases in survivability should be

the primary reason for developing, producing, and deploying modular nuclear warheads. Though the benefits of having safer warheads are of great importance, we realize that modern standard warheads have an unblemished safety record regarding accidental nuclear detonation;

DOD

The real benefits in safety improvements lie in allowing changes in the transportation and storage of nuclear weapons that, in turn allow greater dispersion and enhanced survivability. Personnel training needs high emphasis, not only in the obvious mechanics of inserting the nuclear component into the WHB or in installing additional submunitions in a field environment, but also in the total tactics of moving from unit kasern to field locations, or in deploying to collocated Air Force bases, or in changing missile capabilities afloat, as the service case may be.

Beyond the scope of this analysis are several important areas that will have an impact on modular warhead deployments. We do not examine the arms control ramifications which are always of concern to military planners when trying to field new hardware. We also do not examine the strategic and tactical doctrine under which the Armed Forces operate. Both of these factors can affect the ultimate utility of modular weapon systems. In this utility analysis, we assume away the arms control problem and accept the major tenets of the present doctrinal framework (such as flexible response) in applying our logic. We do modify some of the underlying tenets to exploit the utility of modular weapons.

Other political and military considerations, more microscopic in nature, do require treatment. In this analysis, we treat these considerations under a generally favorable environment in order to determine the advantages and disadvantages of modular systems.

We initially describe the generic weapon systems, then take the characteristics used in Chapter IV to identify potential modular applications and examine them through a taxonomical structure consisting of sections on safety, security, survivability, operational effectiveness, logistics, and costs. Relative utility numbers are generated for each section and then aggregated to try to quantify the advantages and disadvantages; the reader can accept or reject this tool yet still support the findings in the summary section which ends the chapter. The conclusions and recommendations that emerge from this utility analysis are given in Chapter VII.

B. Weapon Description and Stockpile-to-Launch Sequence (SLS) Differences

1. General. The approach of this section is to describe initially the candidate modular warheads, then to describe the three modular weapon candidates, and finally to compare their SLSs with the baseline systems. All three candidates are low-quantity buy, high-value munitions.

2. Candidate Modular Warheads. Two warhead candidates are chosen to satisfy potential tactical yield requirements. We vastly prefer the first candidate because of its smaller size, lower weight, and simple design.

a. Warhead Candidates #1. [redacted] The second component is the WHB. For the nuclear application, [redacted] Convertible weapons would also contain additional volume in the WHB for conventional munitions, either sub or unitary. Further investigations in the areas of costs, range, safety, and reliability are needed to determine if a conventional HE filler plug for the cavity in the WHB is warranted for conventional missions and if the conventional munitions normally in the WHB should be removed before firing a nuclear mission. The WHB body would not contain RD. [redacted]

DOE b(3)

DOE b(3)

DOD

DOE b(3)

DOE b(3)

DOD

DOD

DOD

DOD [redacted] The INC would contain the nuclear materials, DOE b(
primary, secondary, IHE, and warhead electrical system. Its main disadvantage is in the large size and heavy weight of the INC. [redacted]

DOD [redacted] DOE b(

c. Discussion. These modular warhead designs present some technical development and production difficulties, especially in trying to ensure that the WHB contains no RD. Some low risks face the warhead designers. The biggest challenge is to design and produce a highly reliable system that must undergo field insertion. Probably the major challenge is the successful interconnect of the WHD electrical system with the missile fuzing system. Of course present day Lance and Pershing warheads are field mated to their missiles and they possess high relability. Nevertheless, the INC must undergo, in the field, an operation--the mating of explosives and the pit--that is normally done at a DOE plant. Though reliability may be less, designers are confident of providing a highly reliable system by using proper technology and assuming suitable user training in adverse environments, such as sandy southwest Asia or cold and damp northwest Asia.

3. Army Requirements. The Army missions for the analysis are

- Conventional fires to [redacted] primarily by using submunitions (and perhaps a chemical round) against armored and other tactical vehicles
- Nuclear fires to do the same mission
- Conventional air-defense at medium to high altitude, possibly tactical nuclear ABM defense, and back-up SSM nuclear fires

Current baseline systems are the Lance with conventional warhead for the first mission, the [redacted] nuclear warhead for the second, and the Improved Hawk and Hercules for parts of the last mission. The Lance suffers from several shortcomings: it is manpower inefficient, range-limited, old and increasingly difficult to maintain, and relatively inaccurate and unresponsive because of its time-consuming warhead mating operation. The Improved Hawk, though still one of the best medium-range air-defense systems in the world, is being replaced by the Patriot. The Patriot will also replace the very old Nike-Hercules. The Hawk and the Patriot are not fielded with a nuclear capability.

NL

The AD batteries would generally use a unitary conventional warhead, but these units would also possess a number of missiles that could deliver back-up surface-to-surface nuclear and/or tactical nuclear antiballistic missile (ABM) fires. The field artillery would be dedicated to the ground role, with the capability to deliver nuclear warheads or conventional submunitions (and possibly chemicals). Whether or not these missiles should be convertible in the AD role (unitary conventional or nuclear) and convertible in the field artillery (FA) role (submunition or nuclear) depends upon cost and operational effectiveness trade-offs. We propose a dual-capable missile, however, for two reasons: (1) the greater economics from developing and producing the missile in a joint program and (2) increased survivability through deployment of back-up INCs and SSM missiles to AD units.

Figure V-1 shows the SLSs in peacetime. Fig. V-2 shows these sequences in alert or during wartime.

What are the major differences between the baseline systems and the modular candidate within their SLSs? Table V-I succinctly shows the main differences.

DOD

DOD

Baseline Lance

DOD

Modular convertible SSM/SAM

DOD

Fig. V-1. SLS of Army systems (peacetime).

Baseline Lance
(wartime)

Modular convertible SSM/SAM
(alert/wartime)

Fig. V-2. SLS of Army systems (wartime).

DOD

4. Navy Requirements. The Navy missions are:

- Conventional fires against ships, submarines, and shore installations
- Nuclear fires against the above

DOD The current baseline system is the a conventional system that can be launched from submarines, airplanes, and ships. DOD

DOD (3) The Phase II and IIA studies presented several design approaches with this yield. A number of conventional could be produced with DESTEX, leaving a cavity for insertion of an INC (nuclear application) or a filler component of additional DESTEX (conventional application). Existing ship-board launchers would be used and modified to allow rapid change-out of INCs and conventional filler plugs. A safe secure container would be built and stored away from the crew to DOD For comparative stockpile-to-launch purposes, we configure an expanded baseline consisting of conventional and dedicated DOD standard nuclear DOD. Figure V-3 graphically presents the SLS of the Navy system. Table V-II then depicts the differences between the mixed force of Harpoons and a modular convertible force.

5. Air Force Requirements. The Air Force has identified a tactical DOD mission of with nuclear munitions. The Army and Air Force are currently staffing joint interdiction procedures.

DOD

Modular convertible SSM

Fig. V-3. SLS of Navy systems.

TABLE V-II

COMPARISON OF NAVY BASELINE AND MODULAR CANDIDATES

	Procedure	Baseline Conventional Plus Dedicated Nuclear Harpoon	Convertible Harpoon
1.	Production	All-up canisterized conventional weapon All-up canisterized nuclear weapon	Force of canisterized missiles with HE (WHB) and emplaced conventional plus
2.	Warhead Transportation and Storage	On missile within canister (conventional and nuclear)	Conventional warhead on missile within canister. INC transported and stored in secure storage container away from canisterized missile and shielded away from crew
3.	Missile Storage	Conventional: In canisters with warheads at storage areas or in ship magazines/launchers Nuclear: In special storage areas or in special ship magazines	Missile stored as conventional Harpoon is today
4.	Peacetime Dispersal of WR Warheads	Full-up warheads on missiles in magazines afloat or in special storage	INCs (away from missiles) are in magazines afloat or in special storage areas
5.	Wartime Dispersal of WR Warheads	Onto launchers	Onto launchers; INC inserted into missile
6.	PAL Unlock	Upon message receipt and authentication	Same

An INC TASM could provide a means of increasing weapon survivability if operational procedures and security regulations can be modified (Fig. V-4). An INC separate from the WHB, though still an RD item, is not a nuclear weapon. By dispersing the WHB (less INC) to separate locations in peacetime and storing the INC and its containers in underground storage vaults/wells at both MOBs and COBs, the enemy targeting requirements have risen greatly. Crisis conditions may see the flushing of INCs and exportable shelters to some of the 600 plus airstrips in Europe that can handle F-111 or smaller fighters.

[redacted]

Baseline Gravity Bomb

DOD

Modular TASM

DOD

Fig. V-4. SLS of Air Force systems.

[redacted]

[redacted]

DCD

C. Approach

The summary section at the end of this chapter lists the major advantages, disadvantages, and unknowns that are associated with S^3, operational effectiveness, logistics, and costs.

TABLE V-III

COMPARISON OF AIR FORCE BASELINE AND MODULAR CANDIDATES

DOI

[redacted]

We have stressed the importance of a favorable regulatory and administrative environment upon the potential utility of the modular candidates. Except for the case of safety where modular weapons are inherently more safe than standard nuclear weapons, a favorable environment is necessary to realize fully the advantages of modular weapons and to minimize the potential disadvantages. Environment is used here in the broadest sense of the word and includes major external factors--political, economic, technical, administrative, or military--that may have an impact upon the three modular candidates.

Combining the advantages and disadvantages intuitively into a decision to proceed or not to proceed with development and engineering is difficult. We provide a simple scheme for aggregating the advantages/disadvantages into an overall quantitative merit value. We then use this scheme to present our quantitative numbers as a guide (see tables at the end of each subsection). The steps in the scheme are:

(1) Assign a number from zero to three based upon relative evaluation of the value/importance (VI) of each subarea and major area.

- 0: Unimportant
- 1: Some importance
- 2: Very important
- 3: Extremely important

(2) Evaluate the utility/worth (U) of the modular warhead as compared to that of the the baseline system in meeting the subarea's requirements.

- -1.0: Much inferior to baseline
- -0.5: Inferior to baseline
- 0: Same as baseline
- +0.1: Insignificantly better than baseline
- +0.2: Slightly better than baseline
- +0.4: Somewhat better than baseline
- +0.5: Better than baseline
- +0.7: Substantially better than baseline
- +1.0: Much better than baseline

(3) As a conclusion to each major area (for example Safety) discussion, calculate the average merit for all subareas (N in quantity) within that major area.

(4) Repeat step 3, above, to aggregate all major areas into a final worth.

$$\frac{\sum_{i=1}^{N} \left(VI_i \times U_i\right)}{\sum_{i=1}^{N} VI_i}$$

D. Safety

Safety is the prevention of the initiation of energetic materials by normal or abnormal inputs of energy when initiation is not desired. We distinguish between two types of safety: (1) nuclear detonation safety where an inadvertent detonation gives a nuclear yield in excess of four pounds HE equivalent and (2) plutonium-scatter safety where detonation of the HE results in dispersion of plutonium. Even in an unfavorable regulatory and administrative environment, modular warheads engender increased safety levels.

1. Nuclear Detonation

a. Statement

Separation of explosives from nuclear material inherently increases nuclear detonation safety. (All three candidates)

- Before insertion, modular warheads are safer than the baseline nuclear warheads.
- After insertion, modular warheads are as safe as baseline nuclear warheads.

b. Discussion

Modern nuclear weapons are safe from accidental nuclear detonation, especially those containing IHEs--the U.S. has a perfect record. However, modular warheads are safer before insertion because the INC is physically separated from the HE. The probability of an accidental nuclear yield is zero. After the INC is inserted into the WHB, the modular warhead candidates are as safe as the baseline warheads and can meet the stringent military requirements. INCs would incorporate modern safety features such as weak-link/strong-link circuits and would be stored in safe secure containers. The Army and Air Force candidates would use IHE; the Navy would use DESTEX for their convertible system.

As an example for the first merit estimation and to indicate our logic, we rate the VI of nuclear detonation safety as 3 (extremely important). Compared

to the baseline systems which already afford high nuclear detonation safety, we assign a U of +0.2 (slightly better than baseline).

c. Merit Estimation

Candidate	VI	U	VI x U
A, N, AF	3	+0.2	+0.6

2. Plutonium-Dispersal

a. Statement

Accidents involve lower probabilities of plutonium dispersal. (All three candidates)

b. Discussion.

The two accidents at Thule, Greenland; and Palomares, Spain, in the 1960's required significant cleanup operations and caused much greater political results (such as changes to B-52 alert operations). Future accidents that cause plutonium scatter, especially if in populated areas, could create tremendous problems. The use of IHE for some of our stockpiled weapons has greatly reduced some of these concerns. Nevertheless, the sheer number of nuclear weapon movements leaves the door open for future plutonium dispersal accidents. An accident involving the movement of a WHB (less INC) would not disperse plutonium (it has none) nor should it be called a nuclear weapon accident or incident. An accident involving an INC would have a much lower probability of plutonium dispersal because of substantially reduced HEs. This is because the IHE used in the INC is minimal. Also, the secure container could generally be stronger than the shipping containers and canisters of the baseline systems, meaning less chance for rupture.

c. Merit Estimation

Candidate	VI	U	VI x U
A, N, AF	3	+0.4	+1.2

3. Intrinsic Radiation

a. Statement

Intrinsic radiation concerns can be lessened by storing INCs in shielded containers. (Navy)

Intrinsic radiation concerns are increased because of greater amounts of nuclear materials in the INCs if shielding is not adequate. (Navy)

b. Discussion

The proximity between crew living and working quarters aboard Navy ships and particularly submarines is a real health concern. In some cases aboard submarines, the crews "live" on top of the nuclear weapons. Intrinsic radiation from nuclear warheads might subject crews to levels above that permitted by medical regulations. An all-up nuclear canistered Harpoon is not easily shielded or stored away from crews; a small INC is. Already shielded by its container, additional shielding can be easily provided to the INC because of its small volume. The second concern deals with exposures when handling the INC out of its container. The time intervals are so short that the radiation effect is minimal. Finally, intrinsic radiation concerns are of much smaller magnitude in the Army and Air Force considerations because of personnel separation from the nuclear munition.

c. Merit Estimation

Candidate	VI	U	VI x U
N	2	+1	+2
A, AF	0	+1	0

4. Total and Average Merit Under Safety.

Candidate	Total Merit	Average Merit
A	+1.8	+0.3 (somewhat better than baseline)
N	+3.8	+0.5 (better than baseline)
AF	+1.8	+0.3 (somewhat better than baseline)

E. Security

We define security as a condition that results from the establishment of measures to protect designated information, personnel, systems, components, and equipment against hostile persons, acts, or influences. Several technical and operational advantages accrue to modular warheads.

1. Command and Control

a. Statement

Command and control requirements are now on components that are individually unable to produce a nuclear yield. (All three candidates)

b. Discussion

Command and control is defined as those features that limit warhead use only to authorized personnel during circumstances specifically designated by

proper authority. Baseline systems are protected by PALs and are stored in special nuclear storage areas. One of the reasons for this is the fact that the baseline nuclear round is a full-up nuclear round. An INC in its secure storage container (with PAL, etc.) and the WHB are not full-up rounds by themselves.

c. Merit Estimation

Candidate	VI	U	VI x U
A, N, AF	2	+0.7	+1.4

2. Nonviolent Disablement

a. Statement

Nonviolent disablement measures are more compatible with a secure container than a full-up munition or missile. (All three candidates)

b. Discussion

DOD

DOE b(3)

c. Merit Estimation

Candidate	VI	U	VI x U
A, N, AF	1	+0.2	+0.2

3. Emergency Destruct

a. Statement

Emergency destruct of nuclear capability and design information is more readily conducted within the secure container. (All three candidates)

b. Discussion

DOE

the greater quantities of HE make the probability of plutonium dispersal greater than zero. However, design information may still be inferred. The modular candidates would have their INCs stored in a command-destruct secure container. It would be so designed as to contain the destruction of the INC, maintain its integrity, and yet eliminate design information.

[redacted]

c. Merit Estimation

Candidate	VI	U	VI x U
A, N, AF	2	+0.7	+1.4

4. Safe Secure Container

a. Statement

The safe secure container is virtually secure and reduces concerns for HE protection. (All three candidates)

b. Discussion

DOE b(3)

DOE b(3)

DOE

c. Merit Estimation

Candidate	VI	U	VI x U
A, N, AF	1	+1	+1

5. Vulnerability to Theft

a. Statement

DOE b(3)

DOE

b. Discussion

The INC within its container, while not portable by a single man, is certainly easier to move than a missile, W81 or W70 warhead, or B57 or B61 bomb. This particularly may apply to the Army candidate and to a lesser extent the Air Force and the Navy candidates, according to the number of sites and potential exposure to security threats.

DOE

DOE (b)(3)

This may do wonders for security but it has a negative impact upon operational effectiveness and survivability.

[redacted]

c. Merit Estimation

Candidate	VI	U	VI x U
A	2	-0.4	-0.8
N	1	-0.2	-0.2
AF	2	-0.4	-0.8

6. Peacetime Dispersal

a. Statement

Peacetime dispersal to using units (Army) or deployment during crises/hostilities to collocated air bases or strips (Air Force) for increased survivability means:

- Exposure to more personnel
- Storage at less secure areas than the baseline unless storage wells or exportable shelters are provided

b. Discussion

By personnel, we mean authorized and unauthorized military plus civilians.

Dol

Storage aboard Navy ships and submarines would also be modified to account for shielding of the INC containers and storage away from the crew. The negative impact of dispersal upon Naval security should be very small.

c. Merit Estimation

Candidate	VI	U	VI x U
A	2	-0.4	-0.8
AF	2	-0.4	-0.8
N	1	-0.1	-0.1

7. Total and Average Merit Under Security

Candidate	Total Merit	Average Merit
A	+2.4	+0.2 (slightly better than baseline)
N	+3.7	+0.5 (better than baseline)
AF	+2.4	+0.2 (slightly better than baseline)

F. Survivability

DOD

1. Enemy Targeting

a. Statement

DOD

b. Discussion

DOD

DOD

DOD

c. Merit Estimation

Candidate	VI	U	VI x U
A	3	+1	+3
AF	3	+1	+3
N	3	+0.1	+0.3

2. Nuclear Signature

a. Statement

DOD

b. Discussion

DOD

We do not see differences for the modular Navy system.

c. Merit Estimation

Candidate	VI	U	VI x U
A, AF	3	+1	+3
N	1	0	0

3. Deployability

a. Statement

INCs can be rapidly deployed to alternate locations during wartime. (All three candidates)

b. Discussion

c. Merit Estimation

Candidate	VI	U	VI x U
A	2	+0.5	+1.0
AF	2	+0.5	+1.0
N	1	+0.2	+0.2

4. Concealability

a. Statement

INCs are less visible and more easily concealed. (Army, Air Force)

[redacted]

b. Discussion

DOD

c. Merit Estimation

Candidate	VI	U	VI x U
A	2	+0.5	+1
AF	2	+0.5	+1
N	0	0	0

5. Multiplicity

a. Statement

NCL

b. Discussion

DOD

c. Merit Estimation

Candidate	VI	U	VI x U
A, N	2	+0.5	+1
AF	2	0	0 (not convertible)

[redacted]

[redacted]

6. Insertion Times

a. Statement

Insertion of the INC into the warhead body requires time. (All three candidates)

b. Discussion

DOD

c. Merit Estimation

Candidate	VI	U	VI x U
N, AF	1	-0.4	-0.4
A	1	-1.0	-1.0

7. Total and Average Merit Under Survivability

Candidate	Total Merit	Average Merit
A	+8.0	+0.6 (substantially better than baseline)
N	+1.1	+0.1 (insignificantly better than baseline)
AF	+7.6	+0.6 (substantially better than baseline)

G. Operational Effectiveness

Broadly defined, operational effectiveness means the capability of a system to perform the missions or functions for which it is designed. This definition could then include survivability and security. To limit the scope, we narrow operational effectiveness to include mobility, targeting flexibility, enduring capability, storage flexibility, nuclear yield, conventional warhead effects, reliability, range, and foreign political acceptability. The three candidates generally offer improvements over the baseline systems in this area.

1. Mobility

a. Statement

Strategic and tactical mobility for European and special theaters are increased because of the small size and weight of INCs and lack of nuclear materials in the WHB. (All three candidates)

[redacted]

b. Discussion

The baseline nuclear weapons constrain the defense transportation system in its ability to move the weapons rapidly in large numbers. Part of the reason is physical: The baseline nuclear warheads are larger, weigh more than the INCs, and contain significant amounts of SNM next to a large amount of HE. The other part is political: The baseline warheads are full-up nuclear rounds. For example:

(1) Strategic mobility suffers because

- [redacted]

DOE

- [redacted]

(2) Tactical mobility also suffers because

- [redacted]

DOD

- [redacted]

At the risk of overt repetition, [redacted]

c. Merit Estimation

Candidate	VI	U	VI x U
A, N, AF	3	+1	+3

2. Targeting Flexibility

a. Statement

DOE

[redacted]

b. Discussion

c. Merit Estimation

Candidate	VI	U	VI x U
A	2	+0.5	+1
N	3	+1.0	+3
AF	1	0	0 (not convertible)

3. Enduring Capability

a. Statement

Enduring capability is available through the rapid logistical resupply of INCs. (All three candidates)

b. Discussion

DOD

surviving missiles and WHBs than the resupply of a full-up nuclear warhead and missile.

The advantages to the Air Force dedicated TASM are not as large. The number of missiles and WHBs will equal the number of INCs as this is not a convertible candidate. Nevertheless, loss of an INC without concomitant loss of WHBs and missiles will make resupply of INCs stockpiled out of theater easier than resupply of a full-up baseline gravity bomb.

c. Merit Estimation

Candidate	VI	U	VI x U
A, N	2	+0.7	+1.4
AF	2	+0.4	+0.8

4. Storage Flexibility

a. Statement

Convertible weapons allow full nuclear or conventional capabilities where storage areas are limited. (Navy)

b. Discussion

c. Merit Estimation

Candidate	VI	U	VI x U
N	3	+1	+3
A, AF	0	0	0

5. Nuclear Yield

a. Statement

b. Discussion

Secondary missions for the Army SSM and Air Force TASM modular candidates might require destruction of relatively hard fixed targets. This more probably would be the case for the Air Force in its interdiction mission. If these fixed-target requirements are imposed, and other nuclear systems (B61 gravity bomb, GLCM, Pershing IA or II) are not deemed sufficient to cover this target set, then we would strongly recommend the development of a terminal correlation module to be used by some of the SSMs and/or TASMs to get CEPs down to about 30 meters.

DOE b6

DOD

DOD b6

It would be heavy, cumbersome, and difficult to handle. Many of the advantages that we discussed earlier would erode or disappear. To minimize the impact, assign the mission to only one of the services, say the Air Force, and assign only a part of the TASM force (and use a full-up nuclear munition instead of a modular one). Keep the remaining TASM force modular with one-stage INCs.

The merit numbers below assume that the Air Force is assigned the additional fixed-target mission and either builds only part of the TASM force with INCs (the rest are two-stage standard TASMs) or builds additional GLCMs and/or B61s. The yields of the Army candidate would then be sufficient.

c. Merit Estimation

Candidate	VI	U	VI x U
AF	3	-0.5	-1.5
A,N	3	0	0

6. Conventional Warhead Effects

a. Statement

Convertible weapons may incur reduced conventional effectiveness because of WHB body volume devoted to the nuclear application. (Army, Navy)

b. Discussion

DOE b(3)

A conventional filler plug could be developed, but this would require careful study of the trade-offs between increased effectiveness versus the logistic effect of another component upon the STSs.

The Army's problem is more serious with regard to its conventional SSM role (no major implications are seen in the SAM role which uses a unitary HE warhead). This mission of conventionally stopping the enemy second-echelon forces requires the use of submunitions.

DOD

This volume is lost to submunitions and may make the convertible SSM ineffective and too costly. If so, the dual-purpose SSM/SAM should still receive consideration for AD batteries, although the field artillery batteries would then have both full-up conventional SSMs and dedicated modular nuclear SSMs.

c. Merit Estimation

Candidate	VI	U	VI x U
N	2	-0.1	-0.2
A	2	-0.5	-1.0
AF	0	0	0

7. Reliability

a. Statement

A reliability degradation is expected. This can be minimal with the use of high production standards, affordable because of the small weapon system buys, and fully acceptable, especially in insertion operations within a clean environment. (All three candidates)

b. Discussion

DOD

DOE 1.0.

The convertible warheads, when used conventionally, intuitively should have reliabilities almost identical to the conventional baseline systems. This is normally driven by the reliability of the missile. The cavity within the WHB itself can be designed to have a negligible reliability effect.

Reliability of the modular candidates when used in a nuclear mission is of greater concern, particularly when mated to a convertible missile that is produced with reliability levels acceptable just to conventional applications. The cost of building and certifying all the missiles and WHBs to reliability levels necessary for nuclear use will have to be incurred whether the missile system application is nuclear-only or convertible. Since the candidates are all relatively low-buy, high-value munitions, this cost should be relatively small over the total life cycle.

Reliability of the INC built at the DOE production plants, however, should still be very high. A good and simple one-stage design that underwent adequate development, testing, and production, would seem to ensure a very high reliability. In the field, the sealed INC would undergo simple electrical checks to ensure its positive status. The real question is the successful ability to insert the INC, ensure that the proper electrical interfaces have been made, check the overall weapon status, and then be ready to launch a reliable missile, all within about 15 minutes. One can imagine a very difficult environment--dry insertion in rolling seas and pitching decks or on a dark, rainy, dirty, muddy battlefield; or a rather benign environment--a shelter at a collocated Air Force base. One should keep in mind, however, that today the current Lance and Pershing 1A missiles require a physical and electrical mating of the nuclear warhead in field environments.

We think that good operational procedures can result in modular warheads with at best reliability as high as the baseline nuclear warheads, and at worst a slight degradation that is fully acceptable (especially in light of the lower missile reliability). But pending actual reliability testing of mockups and WR warheads, and given the reliability of the missile itself, we conservatively take a pessimistic view in the merit analysis with regard to system reliability.

c. Merit Estimation

Candidate	VI	U	VI x U
A	3	-0.7	-2.1
N	3	-0.5	-1.5
AF	3	-0.2	-0.6

8. Range

a. Statement

Range for the nuclear mode of convertible weapons may be less. (Army)

b. Discussion

The Navy convertible system is not range-affected because the convertible and nuclear applications

DOD

The Army system, however, may or may not carry the submunitions in a nuclear role. Downloading the submunitions would give a full nuclear range, but at a cost of time and affecting survivability, operational effectiveness, and logistics. Again, it may be more cost-effective, as noted above, to have a dedicated modular SSM for the nuclear mission instead of a convertible.

c. Merit Estimation

Candidate	VI	U	VI x U
N	2	0	0
A	2	-0.5	-1.0
AF	2	0	0

9. Deployability

a. Statement

DOD

b. Discussion

DOD

The perception of this rationale by the political leaders and populous of the host nations may be the exact opposite of this study's perception. They may believe instead that "a nuclear weapon is a nuclear weapon..." We have no idea as to the merit of modular warheads as related to these concerns except that there is now a possibility of storing, docking, and overflying modular warheads, while there is not with the baseline systems.

10. Total and Average Merit Under Operational Effectiveness

Candidate	Total Merit	Average Merit
A	+1.3	+0.1 (insignificantly better than baseline)
N	+8.7	+0.4 (somewhat better than baseline)
AF	+1.7	+0.1 (insignificantly better than baseline)

H. Logistics

The broad area of logistics includes transporation and handling, storage requirements, training, special theater movements, LLCE complexity and intervals, administrative and security regulations, component classification, maintenance and support, security personnel and storage sites, and personnel reliability and inspections. We find that in the area of logistics each of the three candidates show potential improvements over the baseline, albeit small in degree in the aggregate.

1. Transportation and Handling

a. Statement

DOE 6C

b. Discussion

Significant advantages accrue in the normal day-to-day logistical transportation and handling of INCs. The INCs can be moved easily by air or ground shipment. Convoy sizes can be reduced in numbers of vehicles and personnel because of the lower physical transportation requirements and the inherent safety of INCs. Likewise, transportation costs for initial deployment and operational and maintenance movements during the warhead's life should fall dramatically.

c. Merit Estimation

Candidate	VI	U	VI x U
A, N, AF	2	+1	+2

2. Storage Requirements

a. Statement

The size of storage areas requiring special protection is decreased. (All three candidates)

b. Discussion

Our premise is that only the INC will contain RD information. Unlike the baseline nuclear munitions that require special nuclear storage of the entire nuclear warhead or an entire nuclear warhead mated to its missile, the nuclear storage requirements of INCs are minimal, whether it be at Army special storage sites or barracks arms rooms, Navy special magazines, or Air Force special storage sites and MOBs/COBs.

c. Merit Estimation

Candidate	VI	U	VI x U
A, N, AF	2	+1	+2

3. Training

a. Statement

Training in unit areas and in the field can improve because of the greater availability of INC mock-up trainers and non-RD warheads. (All three candidates)

b. Discussion

The availability of training devices for the baseline munitions is limited. This limitation, plus the size and weight of the trainers, restricts the quantity and quality of hands-on training.

This problem is particularly acute for the Army baseline system. Though alert exercises train and test the units in their ability to move from the barracks environment to a full field environment, [redacted] The design of the INCs allows for the production of numerous cheap trainers. By having these trainers at the firing unit area, the soldiers during peacetime can receive excellent training in their use by deploying to the field with their missiles, WHBs bodies (drawn from conventional ASPs), and INC trainers. The artillerymen can then train in the insertion of the INCS in the field.

Many of the same benefits accrue to the realistic training for the Navy and Air Force modular candidates. Greater availability of trainers and practice exercises can do much to alleviate the reliability problems and time requirements that we examined previously.

c. Merit Estimation

Candidate	VI	U	VI x U
A, N, AF	2	+1	+2

4. Special Theater Movements

a. Statement

Transportation of INCs into special theaters can be more rapid and secure than full-up nuclear munitions. (All three candidates)

b. Discussion

[redacted]

c. Merit Estimation

Candidate	VI	U	VI x U
A, AF	3	+1	+3
N	2	+1	+2

5. Limited-Life Component Exchange (LLCE) Complexity

a. Statement

Limited-life component exchange is easier. (All three candidates)

b. Discussion

[redacted] This operation has a sizeable impact upon logistic efforts and operational readiness.

The small size and weight of INCs plus their greater accessibility for maintenance is an advantage over the baseline system. The change-out process can be conducted more rapidly and with less maintenance man-hours.

c. Merit Estimation

Candidate	VI	U	VI x U
A, N, AF	1	+1	+1

6. Administrative and Security Regulations

a. Statement

Administrative and security regulations must be adapted to engender viability of modular weapons in all utility areas (except safety, which is inherently increased). (All three candidates)

b. Discussion

The overall utility to be derived from the candidate modular systems largely depends upon modifying current administrative and security regulations. Current restrictions come mainly from the DoD Directive on security criteria.[29] As currently written, this policy means that all components of a modular warhead would inherit the same restrictions as the baseline nuclear systems: two-man rule, large security forces, substantial storage requirements, and concentrated storage at special sites.

We think that our preferred one-stage design approach can satisfy all the safety and security objectives behind current administrative regulations within the SLSs sequences noted previously. We also believe that the intent of the regulations and directives can be fully satisfied by using the modular systems under a newly adapted set of regulations and directives. Nevertheless, we recognize that institutional inertia within the security community (which is common to all large organizations) to keep the same administrative and logistic systems must be overcome. Probably the best way is to provide mock-up point designs (paralleling the DOE Phase 2 and 3 efforts) to the safety, security, and logistic experts who would determine acceptability and work out these modifications. Evolutionary change of these regulations is the only forseeable path that is politically acceptable at this time. Nevertheless, failure to adapt regulations to account for the singular differences of modular weapons from those of standard nuclear weapons would result in disutility greater than that indicated by the merit estimation in this subarea.

c. Merit Estimation

Candidate	VI	U	VI x U
A, N, AF	3	-1	-3

7. Component Classification

a. Statement

The WHB body must not carry a classification higher than its delivery missile. (All three candidates)

b. Discussion

This concern parallels the one above, but needs to be spelled out to allow early field and collocated base deployment of the Army and Air Force candidates.

Current classification is:

DOE DOE b(3)

DOE

DOE b

This is not critical since it will be on a secure container for most of its life.

DOE

DOE b

This is not to say that NCA release and reliable secure communications will no longer be needed to insert the RD INC into the WHB. Sealed authenticators will still be required along with PAL devices on the INC container and even possibly on the complete warhead system after release is granted.

c. Merit Estimation

Candidate	VI	U	VI x U
A, N, AF	3	-1	-3

8. Maintenance and Support

a. Statement

Maintenance and support workload and handling equipment are reduced for the INC. (All three candidates)

b. Discussion

A primary logistic consideration is maintenance. The one-stage design approach should mean that the using unit would only need to make visual inspection and simple electrical checks to ensure that no unauthorized actions had occurred. By keeping the design of the WHB body and INC as simple as possible, maintenance workload should be reduced because of easier access and less sophisticated tests. Normal stockpile maintenance and testing of the interfaces between the explosives and warhead electrical system would be eliminated until mating of the INC occurs during war. Large handling equipment requirements would no longer exist for maintenance of the INC because of its small size. The Navy candidate may also result in some maintenance (and transportation) reduction by not having to send the whole canistered nuclear Harpoon back to depot as the baseline system requires. The dispersal of Army INCs to unit arms rooms (or within security wells, safes, etc.) might require transient maintenance sections to visit the dispersed locations. However, the reduction in workload at the special nuclear sites should offset the personnel requirements for the transient sections. Another alternative is to assign these "go/no-go" checks to the operational crew at the firing units.

Maintenance may rise, however, because additional equipment will be deployed for modular warhead support:

Army INC containers, secure storage at firing batteries (wells, safes, etc.), test equipment

Navy INC containers, test equipment

Air Force INC containers, deployable secure storage assets (transporters, moveable igloos, etc.), test equipment

Additional procedures and administrative guidance would be needed. The modular systems would require their own checklists, repair parts, and special tools.

c. Merit Estimation

Candidate	VI	U	VI x U
A	2	+0.2	+0.4
N, AF	2	+0.4	+0.8

9. Security Personnel and Storage Sites

a. Statement

Numbers of security personnel will generally be unchanged unless current storage sites become INC-only sites. However, security personnel requirements and storage sites will increase if unit storage is allowed. (Army, Air Force)

b. Discussion

As long as the number of storage sites remain constant and include baseline nuclear weapons, then the number of guards will remain unchanged.

The use of the Army modular candidate would cause the dispersion of SSM INCs away from current fixed sites into the arms rooms of the firing units. The fixed sites, however, would still require protection for the AFAPs, ADMs, and Pershings. We see no hope for reductions in guard forces at these sites, unless these sites are consolidated (with a loss of survivability) or some weapons are removed back to CONUS. An argument can be made that security forces may increase, as the quantity and quality of arms rooms guards might be insufficient. Given current FA and AD artillery TOEs, this concern is a valid one.

Security manning for the Navy modular system afloat would remain the same. Peacetime security for the Air Force system would also parallel present requirements; however, crisis deployment to COBs and/or airstrips would have to draw on additional personnel.

Security during normal peacetime transportation movements could be reduced as noted earlier. Convoy security force requirements (infantry units) are substantial and detract from normal training.

c. Merit Estimation

Candidate	VI	U	VI x U
A, AF	2	-0.7	-1.4
N	3	0	0

10. Personnel Reliability and Inspections

a. Statement

Requirements for personnel reliability programs and inspections will probably remain the same. (All three candidates)

b. Discussion

The same high level of personnel competence that currently exists for the baseline warhead systems would apply to the modular candidates. Personnel involved in the authentication system and insertion of the nuclear component would still remain in critical nuclear duty positions. Those involved in the security of the INC would still be in controlled nuclear duty positions. The need for records, operational procedures, and maintenance would have an impact on the three modular candidates to the same degree as it presently does.

c. Merit Estimation

Candidate	VI	U	VI x U
A, N, AF	2	0	0

11. LLCE Intervals

a. Statement

LLCE intervals and stockpile life will remain the same. (All three candidates)

b. Discussion

No differences can be identified between the modular warhead candidates and the baseline nuclear systems in regard to LLCE intervals or stockpile life.

c. Merit Estimation

Candidate	VI	U	VI x U
A, N, AF	1	0	0

12. Total and Average Merit Under Logistics

Candidate	Total Merit	Average Merit
A	+3.0	+0.1 (insignificantly better than baseline)
N	+3.8	+0.2 (slightly better than baseline)
AF	+3.4	+0.2 (slightly better than baseline)

I. Costs

Life-cycle costs including development, production, operation, and support were examined in a relative context. Though absolute cost numbers were not estimated, the merit assessment quantifies the broad cost trends. The Navy's convertible force should cost less than the baseline force if fewer Harpoon missiles are procured for the convertible force. The Army and Air Force modular candidates are thought to cost more, primarily because of increases in production, security, and storage costs. Transportation costs are singled out as a category where substantial cost savings should be realized.

1. Convertible System Cost

a. Statement

Cost of a convertible warhead force is less than the cost of a dedicated nuclear plus dedicated conventional force. (Navy)

b. Discussion

Only one completely detailed cost analysis has been made for a convertible warhead. This analysis was conducted for the [redacted] Phase 2A study in 1977.[10] The major findings are very important as they support not only the total system cost but bear on the other costs elements considered in this analysis.

The [redacted] Phase 2A analysis examined the 25-year life-cycle cost of two baseline nuclear [redacted] and five candidate convertible designs. The cost categories included research, development, and testing; investment and other acquisitions; SNM; and operations, support, and stockpile evaluation. The latter category did not include an analysis of the security costs, which are normally the majority of operation and support costs. Unless a Navy site or magazine contained only modular weapons, one does not expect changes in security manning or costs.

DOE b(3) [redacted] DOD

The cost difference was not large--about 5 to 10% higher over the total 25-year life cycle. In 1977 dollars, the study estimated that it will cost about $60 million more to acquire a modular candidate--the primary differences being the cost of secure logistic containers, command-destruct shipping/storage containers, and greater usage of SNM (discussed below).

So how do we justify our conclusions that the modular candidate is cheaper for the Navy? [redacted] DOD

[redacted]

c. Merit Estimation

Candidate	VI	U	VI x U
N	3	+1	+3
A, AF	N/A		

2. SNM Requirements

a. Statement

Convertible warheads require slightly higher amount of SNMs than non-convertible warheads of the same yields. Nuclear-only INC warheads, however, are about as efficient in the use of SNM as standard nuclear warheads. (All three candidates)

b. Discussion

Previous studies have indicated that INC warheads require more SNM than standard warheads, all other things being equal. [redacted] DOD

DOE b(3)

Two resource considerations also apply to SNM usage--cost and supply/demand. The costs are set by decree and may not reflect SNM's true value. [redacted] DOD

DOE b(3)

DOE [redacted]. One can argue that the cost is not real so long as the weapon is not used or lost--the materials will be recovered at retirement by the DOE. DOE b(3)

A more pressing problem than costs may be the rising demand of reactor products against a supply that is constrained to increase only gradually. The [redacted] Changing requirements and weapon designs have always managed to avoid a real shortfall by the time production occurred. This phenomenon of the "receding bow wave" may occur again. [redacted]

c. Merit Estimation

Candidate	VI	U	VI x U
A, N, AF	2	-0.2	-0.4

3. Development and Production Costs

a. Statement

Given minimal development risks and the use of a simple one-stage design, development and production costs for the modular warhead dedicated to the nuclear role will be higher, but the rise is small in comparison with the total weapon life-cycle cost. (All three candidates)

b. Discussion

DOD [redacted] DOE b(3) Previous Defense Nuclear Agency (DNA) studies[31] have clearly shown that [redacted] These figures indicate that about 20,000 members of the Armed Forces guard our nuclear weapon sites at an average annual cost of almost $15,000 per weapon. By including this cost, the relative importance of the life-cycle cost categories changes to:

[redacted]

UNCLASSIFIED

DOE

Clearly, major changes in RD&T costs have little impact upon life-cycle cost. With a straightforward simple design, nuclear testing can be held to a minimum. We do not foresee much change in RD&T costs as compared to baseline nuclear system costs.

DOD

Production costs for the warheads (DOE and DoD) may show some additional cost expenditures over the baseline systems. This is due to producing a "different" type of warhead. New tooling and facilities will be necessary. Direct unit costs of manpower and material for the warhead will probably be very similar to the costs of baseline systems. Cost savings may be realized through using a simpler and less expensive final assembly at the Pantex Plant.

c. Merit Estimation

Candidate	VI	U	VI x U
A, N, AF	2	-0.2	-0.4

4. Safe Secure Containers and Storage Facilities

a. Statement

Production of safe secure containers and construction of associated storage facilities may be expensive, particularly for the Army system. (All three candidates)

b. Discussion

As noted in the Harpoon studies,[10,30] the real crux of production cost increases lies in the requirements for safe secure containers (all three modular candidates), construction of new storage facilities (wells, igloos, air-transportable shelters), and secure transporters.

DOD

The Navy requirement for this extra equipment is less than the Air Force's or Army's.

UNCLASSIFIED

[redacted]

DOD [redacted] Perhaps C-130 transportable shelters could be procured, or perhaps C-130 transportable versions of safe, secure trailers could be used. (The TASM with WHB less INCs would be carried by the flushed fighter aircraft).

DOD [redacted]

c. Merit Estimation

Candidate	VI	U	VI x U
N	2	-0.2	-0.4
AF	2	-0.4	-0.8
A	2	-0.7	-1.4

5. Missile System Operation and Support Costs

a. Statement

Missile system operation and support costs account for about [redacted] of weapon total life-cycle costs. (If the delivery unit life-cycle cost is considered, then the cost of INCs becomes practically negligible in terms of total life-cycle cost.) The cost may rise in certain areas and fall in others. The overall effect is highly dependent upon INC storage schemes and security regulations, especially for the Army system. (All three candidates) DOD

b. Discussion

Operation and support include the areas of security, maintenance, transportation, reliability testing, and staff support. As noted previously, about DOD [redacted] of the life-cycle cost is for operation and support and [redacted] of operation and support costs are security related. The impact upon operation and support costs by the modular candidates will be a function of the percentage of stockpile that is converted to modular systems, the distribution of them among storage sites, and the type of storage and operational concepts adopted. DOD

DOD [redacted] DOE b(3)

DOE b(3)

DOE

Transportation is one operation and support area where significant savings should be realized. First- and second-destination transportation, operational moves, and transportation to depot for maintenance are expensive in dollars and transportation assets. Convoy sizes and aircraft sortie requirements can fall greatly because of the small INC volume and weight, [redacted] and the inherent safety and security by having the nuclear material separate from the main explosives.

Reliability testing and stockpile support will probably remain the same.

c. Merit Estimation

For the merit analysis, we use the relative importance of each subcategory:

Candidate	VI	U	VI x U
Security			
A	2	-1.0	-2.0
N	2	0	0
AF	2	-0.5	-1.0

Maintenance			
A	1	-0.5	-0.5
N	1	0	0
AF	1	0	0
Transportation			
A, N, AF	1	+1.0	+1.0
Reliability Testing/ Staff Support			
A, N, AF	1	0	0

6. Total and Average Merit Under Costs

Again for the merit analysis, we use the relative importance of each cost category.

Candidate	Total Merit	Average Merit
A	-3.7	-0.3 (somewhat worse than baseline)
*N	+2.8	+0.2 (slightly better than baseline)
AF	-1.6	-0.2 (slightly worse than baseline)

*Fewer modular missiles procured because of convertibility.

J. Summary Merit Analyses

Preceding sections have described the advantages and disadvantages of the three modular weapon candidates. At the end of each section we summarized the quantitative merit based upon the analyzed information. For convenience, the data on average merit are presented below.

Area/Candidate	VI	Army	Navy	Air Force
Safety	2	+0.3	+0.5	+0.3
Security	2	+0.2	+0.5	+0.2
Survivability	3	+0.6	+0.1	+0.6
Operational Effectiveness	1	+0.1	+0.4	+0.1
Logistics	1	+0.1	+0.2	+0.2
Costs	1	-0.3	+0.2	-0.2

By combining the major area average merits, we can arrive at a summary ranking that is useful for comparison between the modular candidates themselves and for comparisons between the baseline weapon systems. First we must

rank the worth of the areas; then we must carry out the simple math. We maintain that the area of survivability is of overriding importance, and we assign a VI of 3, or "extremely important". We rank safety and security next with a VI of 2, or "very important." Operational effectiveness, logistics, and costs are considered to be of "some importance" and are assigned a VI of 1. We arrive at the following figures by multiplying the VI times the average merit for each area, sum the six areas, and divide by the sum of the VIs (10).

Candidate	Average Merit
A	+0.27 (somewhat better than baseline)
N	+0.31 (somewhat better than baseline)
AF	+0.29 (somewhat better than baseline)

There is a striking similarity in average merit between the modular candidates, perhaps because they all have tactical missions and many subareas show utility regardless of the application (for example, plutonium-scatter safety). All three candidates display good potential towards improving the tactical nuclear stockpile; any or all bear continued consideration for addition to the inventory.

[redacted]

CHAPTER VI

REVIEW OF PERTINENT REGULATIONS AND DIRECTIVES

A. General

Providing for safety in handling nuclear weapons is a joint responsibility of the DoD and DOE. The DoD is also responsible for providing secure custody of the nuclear weapons under its control.

DOD

The facilities and procedures prescribed by these directives are accordingly elaborate and require substantial resources. The question raised by the possibility of deploying weapons with INCs is whether the required resources for ensuring safety and security could be thereby materially reduced. That question is discussed in this chapter. A bibliography is shown below:

DOD DIRECTIVES

5210.41	Security Criteria and Standards for Protecting Nuclear Weapons

Miscellaneous Publications

JCS Pub. 6, Vol. II, Part 4	Nuclear Weapons Reports (NWREP)
SB 742-1	Ammunition Surveillance Procedures
ARTEP 9-47	Special Ammunition Unit Operations
CG-W-4	Nuclear Weapon Classification Guide
DOE-DNA TP 0-1	Numerical Index to Joint Nuclear Weapons Publications

Department of the Army Publications

Army Regulations (ARs)

50-5	Nuclear Surety
50-5-1	Nuclear Surety (classified volume to AR 50-5)
50-109	Safety Rules for the Operation of the Lance Nuclear Weapons System
55-203	Movement of Nuclear Weapons, Nuclear Components, and Related Classified Nonnuclear Material

[redacted]

190-11	Physical Security of Weapons, Ammunition, and Explosives
385-64	Ammunition and Explosives Safety Standards
700-65	Nuclear Weapons and Nuclear Weapons Material

Field Manuals (FMs)

9-6	Ammunition Service in the Theater of Operations
9-84	Nuclear Special Ammunition Direct and General Support Unit Operations
19-30	Physical Security
100-50	Operations of Nuclear-Capable Units

Technical Manuals (TMs)

9-1300-206	Ammunition and Explosives Standards
39-0-1A	Numerical Index to Joint Nuclear Weapons Publications (Army supplement)
39-20-7	Nuclear Safety Criteria
39-45-51	Transportation of Nuclear Weapons Material
39-50-8	Emergency Destruction of Nuclear Weapons
39-100-4	Custody, Accountability, and Control of Nuclear Weapons and Nuclear Material
55-1425-485-15-1	Transportability Guidance Lance Missile System

Technical Bulletins (TBs)

9-1100-803-15	Army Nuclear Weapons Equipment Records and Reporting Procedures
9-1100-811-40	Security Classification of Nuclear Weapons Information
742-94-1	Surveillance Inspection Procedures for Nuclear Weapons

Department of the Navy Publications

OPNAV Instructions (OPNAVINSTs)

8023.2A	U.S. Navy Explosive Safety Policies, Requirements and Procedures
8023.19	Safety Criteria and Standards for the Logistical Movement of Nuclear Weapons
8110.18	Navy Nuclear Weapons Safety Program

Special Weapons Ordnance Publications (SWOPs)

20-7	Nuclear Safety Criteria
45-55	Instructions for Tactical Movement of Ground-Delivered Nuclear Weapons

50-1	Nuclear Ordnance, General Information
51-1	Emergency Destruction of Nuclear Weapons Afloat
55-1	Navy Security Classification Guide for Nuclear Weapons

Department of the Air Force Publications

Technical Orders (TOs)

11N-20-7	Nuclear Safety Criteria
11N-20-1012	Transportation and Storage Safety for Nuclear Weapons and Components

B. Effect of Present Directives

The procedures currently applied to the transport, storage, maintenance, and security of U.S. nuclear weapons are strongly influenced by military and civilian safety concerns. These concerns are generated by presently fielded nuclear weapons because fissionable material and chemical HEs are fixed in appropriate configurations for producing a nuclear explosion. The unacceptable consequences of an unauthorized nuclear explosion could follow not only from an incident but also from loss of authorized custody. Accordingly, the procedures that have been established for storing nuclear weapons have resulted in relatively small numbers of storage sites located as remotely as practicable from military and civilian populations. The remoteness has required extensive measures for preserving authorized custody of the weapons.

The introduction of a single new modular nuclear weapon system would obviously not permit dismantling present nuclear weapon storage sites and other handling facilities. Whether handling procedures for the warhead components of such a system would be made significantly different from presently prescribed procedures cannot be determined in the absence of relevant precedents. Since each of the military services provides a different environment for its nuclear weapons, differences exist among the services in established nuclear weapon-handling procedures. It appears that the characteristics of a particular modular system would have to be specified in detail to draw a service decision on whether exceptions to established procedures or new regulations would be allowed for that system. Which specific system characteristics would be more likely to influence that decision would depend on the nature of the system and on the service making the decision. The presumed advantages of fielding a modular system would no doubt be weighed

against the presumed disadvantages of making procedural exceptions. The advantages of modular systems are discussed in earlier chapters of this study. Each service would identify for itself the disadvantages of allowing departures from practices that have long been followed in the care and handling of its nuclear weapons.

C. Expectation for Change in Handling Procedures

It does not seem likely that the military services will change their procedures for handling nuclear weapons before a modular system is fielded. Therefore, the first modular system cannot be designed to accommodate changes that will be made in those procedures after the system is fielded, if any such changes are made. It does not appear that the development of modular technology is hindered by present directives or procedures. If modular systems are designed to be handled exclusively in accordance with presently prescribed methods, however, the presumed advantages of fielding such systems will not be fully realized.

[redacted]

CHAPTER VII

CONCLUSIONS AND RECOMMENDATIONS

A. Summary

This study has identified potential requirements for modular weapons, reviewed the studies that have addressed modularity, examined the technology needed to support modular weapons development, identified potential applications of modular technology, and evaluated the overall utility of developing and deploying three candidate modular weapon systems.

The major advantages and disadvantages of modularity as shown by the utility analysis are found in Chapter V. One important caveat stands out as discussed in Chaper VI in the review of publications and regulations. Although it does not appear that the development of modular technology is hindered by present directives or procedures, if modular systems are designed to be handled exclusively in accordance with presently prescribed methods, the presumed advantages of fielding such systems will not be fully realized. A favorable environment consisting of revised administrative procedures and security regulations along with a host of stockpile-to-launch modifications would be needed to ensure that the modular candidates would reap benefits that outweigh the costs. This favorable environment, however, could evolve as awareness of the logistical advantages and the technical capabilities of modular weapons to satisfy critical requirements becomes more widespread.

B. Findings

1. Survivability.

DOD

[redacted]

The preferred SLS for the Army modular candidate would continue the present practice of deployment of missiles and launchers to survivable field locations during training and alerts. The non-RD WHB would also deploy on the missile with the units.

2. Security. Security is a condition that results from the establishment of measures to protect designated information, personnel, systems, components, and equipment against hostile persons, acts, or influences. Several technical and operational advantages of varying importance accrue to modular warheads. The primary operational advantage lies in the fact that, for most of their life, security requirements are on components that are neither full-up nuclear weapons nor able to produce a nuclear yield.

Security Merit Assessment

Army	= +0.2	Slightly better than baseline
Navy	= +0.5	Better than baseline
Air Force	= +0.2	Slightly better than baseline

3. Safety. Safety enhancements are inherent within the INC technologies, regardless of whether a favorable administrative and regulatory environment comes to pass or not. Two types of safety are analyzed in this report:

DOD

Modern nuclear weapons are safe from accidental nuclear detonation, especially those containing IHEs. The U.S. has a perfect record in this regard. However, modular warheads are safer before INC insertion because the INC is physically separated from the HE. The probability of an accidental nuclear yield is zero.

Although IHE has greatly reduced the probability of future plutonium dispersal accidents involving standard nuclear warheads (an accident involving the movement of a modular WHB without the INC cannot disperse plutonium because the WHB has none,) an accident involving an INC would have a much lower probability of plutonium dispersal because of substantially reduced HEs.

Safety Merit Assessment

Army	= +0.3	Somewhat better than baseline
Navy	= +0.5	Better than baseline
Air Force	= +0.3	Somewhat better than baseline

4. Operational Effectiveness. Operational effectiveness as used in this analysis includes mobility, targeting flexibility, enduring capability, storage flexibility, nuclear yield, conventional warhead effects, reliability, range, and foreign political acceptability. All three candidates generally offer slight improvements over the baseline systems in operational effectiveness.

Operational Effectiveness Merit Assessment

Army	= +0.1	Insignificantly better than baseline
Navy	= +0.4	Somewhat better than baseline
Air Force	= +0.1	Insignificantly better than baseline

5. Logistics. We examined the following subareas: transportation and handling, maintenance and support, storage requirements, special theater

movements, training, LLCE, administrative and security regulations, component classification, security personnel, and personnel reliability and inspections. Throughout the study we used the SLSs that were defined under a favorable environment and found slight improvements in the three modular candidates.

Logistics Merit Assessment

Army	= +0.1	Insignificantly better than baseline
Navy	= +0.2	Slightly better than baseline
Air Force	= +0.2	Slightly better than baseline

6. Costs. Life-cycle costs including development, production, operation, and support were examined in a relative context. Though absolute cost numbers were not estimated, the merit assessment qualifies the broad cost trends. The Navy's convertible force should cost less than the baseline if fewer Harpoon missiles are procured for the convertible force. The Army and Air Force modular candidates are thought to cost more, primarily because of increases in production, security, and storage costs.

Costs Merit Assessment

Army	= -0.3	Somewhat worse than baseline
Navy	= +0.2	Slightly better than baseline (fewer modular missiles procured because of convertibility)
Air Force	= -0.2	Slightly worse than baseline

7. Merit Assessment Summary

By combining the major area average merits, we can arrive at a summary ranking that is useful for comparisons between the modular candidates themselves and for comparisons between the individual baseline weapon systems. We maintain that the area of survivability is of overriding importance, followed next by safety and security. Operational effectiveness, logistics, and costs are of lesser relative importance.

There is a striking similarity in merit between the modular candidates; all are deemed to be "somewhat better than baseline." The Navy modular candidate gives a summary merit of +0.31, followed closely by the Air Force and Army modular candidates at +0.29 and +0.27, respectively.

[redacted]

UNCLASSIFIED

C. Recommendations

Increases in survivability should be the primary reason for developing, producing, and deploying modular nuclear warheads. In addition, safety stands out as the single area where INC benefits are unequivocal regardless of the administrative and security environment that evolves for modular warheads. Although the benefits of having safer warheads are of great importance, we realize that modern standard warheads have an unblemished safety record regarding accidental nuclear detonation; however, [redacted] The real benefits in safety improvements lie in allowing changes in the transportation and storage of nuclear weapons that can result in greater dispersion and enhanced survivability.

Several earlier studies and the analyses conducted here indicate the potential utility of a modular system. A careful and logical development process for any of the three modular candidates can lead to exploiting the benefits noted while minimizing the disadvantages. Three specific recommendations are made:

(1) Recommend that the Los Alamos National Laboratory (Los Alamos) develop mockups or point designs for appropriate service generic systems to enable the services to evaluate the operational, logistic, safety, security, survivability, and system cost impacts of INC or convertible systems.

(2) Recommend that Los Alamos continue to develop concepts for engineering designs to support modular systems in support of identified or perceived service requirements.

(3) Finally, based upon specific service stated requirements, recommend that Los Alamos be prepared to develop modular warheads for production and employment.

UNCLASSIFIED

[redacted]

REFERENCES

1. "Nuclear Weapon Development Guidance (NWDG) (U)," Department of Defense (SRD) (1972 and 1973).

2. "Special Nuclear Technology and Analysis Report (U)," Field Command Defense Nuclear Agency report FC/01750080 (SRD) (January 13, 1975).

3. "CASK...A Convertible Anti Ship Killer (U)," Sandia Laboratory at Livermore/Lawrence Livermore Laboratory joint report SCL-SR-720069 (SRD) (November 1972).

4. "Phase 1 Warhead Study for the MK 48 Torpedo (U)," Los Alamos Scientific Laboratory/Lawrence Livermore Laboratory/Sandia Laboratories joint report SC-WD-72 0625 (SRD) (August 1972).

5. LCDR G. F. Nolan, "A New Weapon Concept (U), Insertable-Nuclear Component Concept (CFRD)," Field Command Defense Nuclear Agency (CFRD) (May 1, 1974).

6. "Phase 2 Feasibility Study for Atomic Demolition Munitions (U)," U.S. Army Armament Command report 74-8 (SRD) (June 30, 1974).

7. R. R. Hammond, "Navy/ERDA Phase 1 Study of Lightweight Torpedo Warhead Improvements (U)," Naval Undersea Center report NUC TP 458 (SRD) (February 1975).

8. L. E. Thompson, "Phase 1 Study for a Nuclear Harpoon (U)," Naval Weapons Center report NWC TP 5891 (SRD) (September 1977).

9. "Phase 2 Feasibility Study for a Nuclear Harpoon (U)," Naval Weapons Center report 407/5362/MS 76-145 (SRD) (September 1976).

10. "Joint ERDA/Navy Technical Report of the Nuclear Harpoon Phase 2A Study (U)," prepared by Naval Weapons Center for Naval Air Systems Command, report NWC TM 3303 (SRD) (September 1977).
    Volume 1. "Technical Summary (U)"
    Volume 2. "Warhead/Physics Designs (U)"
    Volume 3. "Safing, Arming, Firing and Fuzing Designs (U)"

11. "Convertible Concepts for the MK 84," Air Force Weapons Laboratory (SRD) (August 1976).

12. H. J. Gevelhoff, M. R. Anderberg, W. M. Boyer, J. A. Higgins, K. Hinkle, H. A. Kuerschner, B. J. Manz, and J. H. Suttle, "A Utility Analysis of Convertible Nuclear Weapons Executive Summary (U)," Directorate of Aerospace Studies report SA-TR-75-4 (SRD) (March 1975).

13. H. J. Gevelhoff, Study Director, "A Utility Analysis of Convertible Nuclear Weapons (U)," Directorate of Aerospace Studies report DAS-TR-76-3 (SRD) (April 1976).

[redacted]

UNCLASSIFIED

14. COL M. B. Sullivan, LtCol C. S. Lee, et al., "Nuclear Convertibility for the Harpoon Missile, An Analysis (U)," Field Command Defense Nuclear Agency report FC/03750148 (SRD) (March 7, 1975).

15. LtCol G. F. Pitstick and Capt S. C. Mauk, "Phase 1 Study for the Modular Guided Glide Bomb (MGGB)," Air Force Weapons Laboratory report 73-SAA-079 (SRD) (August 1973).

16. C. I. Hudson, Jr., and D. E. Warne, "INC Weapon Technology Applications Study-Review of Weapon Systems and Selection of Candidates (U)." prepared by Science Applications Inc., La Jolla, for Defense Nuclear Agency, report DNA 3770F (SRD) (August 31, 1975).

17. "INC Weapon Technology Application Study - Second Part, Detailed Assessment and Economic Analysis (U)," prepared by Science Applications, Inc., La Lolla, for Defense Nuclear Agency, report DNA-4121 F (SRD) (September 1976).

18. L. M. Redman, "LASL Weapons Quarterly (U)," covering January-March 1977, Los Alamos Scientific Laboratory report LA-6830-PR (SRD) (May 1977).

19. E. L. DuBois, "Implications for Theater Nuclear Forces of a Design Concept Using Separable Nuclear Components (U)," prepared by SRI International, Menlo Park, for Lawrence Livermore Laboratory, report UCRL 15244 (SRD) (September 1979).

20. Dr. H. J. Gevelhoff et al., "Utility Evaluation of Stand-Off Missile Candidates, An Annotated Briefing of the Executive Summary," Directorate of Aerospace Studies report DAS-TR-77-16 (SRD) (October 1977).

21. Dr. B. J. Manz, "Utility Evaluation of Stand-Off Missile Candidates, Volume 3 - Military Effectiveness," Directorate of Aerospace Studies report DAS-TR-78-6 (SRD) (August 1978).

22. J. K. Hayes and J. S. Howard II, "Utility Analyses for a Tactical Air-to-Surface Munition (TASM) (U)," Los Alamos National Laboratory report LA-8543-MS (SRD) (April 1981).

23. "Compendium of Convertible Technology (U)," Naval Weapons Center report NWC TM 4646 (SRD) (August 1981).

24. "Corps Support Weapon System (CSWS) Insertable Nuclear Component (INC) Study," U.S. Army Nuclear and Chemical Agency draft report (SRD) (June 30, 1982).

25. R. L. Wagner, "Nuclear Weapons Technology: Insertable Nuclear Components (U)", SRD memorandum from the Assistant to the Secretary of Defense (Atomic Energy) for the Assistant Secretary of Defense (International Security Policy), December 29, 1981.

26. A. R. Cole, "Insertable Nuclear Components (U)," SRD TWX 000383 from DOE/MA to Distribution, June 3, 1982.

UNCLASSIFIED

[redacted]

27. T. B. Hayward, "Insertable Nuclear Component Policy (U)," SFRD memorandum from Admiral, U.S. Navy, Chief of Naval Operations to Distribution, Ser 00/S500207 May 7, 1980.

28. R. L. Anderson and C. H. Blummenfield, "An Analysis--The Suitability of Insertable Nuclear Capsules for an Army Multi-Purpose, Close Support Missile System (U)," Los Alamos National Laboratory internal document WPC-2-78-52 (SFRD) (July 5, 1978).

29. "Security Criteria and Standards for Protecting Nuclear Weapons (U), DoD Dir 5210.41 (U) (September 12, 1978).

30. COL M. B. Sullivan, LtCol C. S Lee et al., "Nuclear Convertibility for the Harpoon Missile, Executive Summary (U)," Field Command Defense Nuclear Agency report FC/03750149 (SRD) (March 7, 1975).

31. Capt T. Alpert, Maj R. Case, LTC D. Fowler, LCDR R. Gordon, LCDR G. Kouba, MAJ T. Mills, LtCol J. Munson, and LTC K. Zahn, "DoD Nuclear Stockpile Operating and Support Costs, Volume I - Executive Summary (U)," Field Command Defense Nuclear Agency report FC/09780326 (SFRD) (September 1, 1978).

[redacted]

UNCLASSIFIED

Standard Distribution

	Copy No.
US DOE, Headquarters Library, Reports Section, Washington, DC	1-3
Manager, ALO, Albuquerque, New Mexico	4
Lawrence Livermore National Laboratory, Livermore, California	5-6
Sandia National Laboratories, Albuquerque, New Mexico	7
Military Liaison Committee, Washington, DC	8
Headquarters, Defense Nuclear Agency, Washington, DC	9-10
Defense Nuclear Agency Field Command, Kirtland AFB, New Mexico	11-12
Commander, Naval Sea Systems Command, Washington, DC	13
Director, Air Force Weapons Laboratory, Kirtland AFB, New Mexico	14
US DOE, Technical Information Center, Oak Ridge, Tennessee Attn: Weapon Data Index	15
Los Alamos National Laboratory Report Library	16-54

Special Distribution

	Copy No.
US DOE, Headquarters Library, Reports Section Washington, DC Attn: COL Charles Steiner, DP-225, GTN	55
Albuquerque Operations Office Department of Energy Albuquerque, New Mexico Attn: Mr. James H. Hines, WDD	56
Lawrence Livermore National Laboratory Livermore, California Attn: Ralph S. Hager, L 7 John Stroud, L 6	57-58
Sandia National Laboratories Albuquerque, New Mexico Attn: Mail Services Station For: James I. Crowther, Org. 0331 Garry S. Brown, Org. 0331 W. J. Patterson, Org. 9331	59-61
Sandia National Laboratory Livermore, California Attn: Document Control For: Robert L. Rinne, Org. 8320 Tim P. Tooman, Org. 8324	62-63
Defense Intelligence Agency Department of Defense Washington, DC Attn: Allan L. Conner	64
Defense Nuclear Agency, Headquarters Department of Defense Washington, DC Attn: MAMR For: LtCOL Gary McIntire	65
Defense Nuclear Agency/Field Command KAFB Department of Defense Kirtland Air Force Base, New Mexico Attn: FCSAC, LTC R. Skarupa	66
Military Liaison Committee Department of Defense Washington, DC Chairman Military Liaison Committee	67
Joint Chiefs of Staff Department of Defense Washington, DC Director, Operations Directorate, J-3, OJCS Attn: Chief, J-3 REC & MSG BR For: J-5	68-69
Secretary of Defense for Program Analysis and Evaluation Department of Defense Washington, DC Office of Assistant Secretary of Defense Program Analysis and Evaluation Attn: Charles Pugh/Michael L. Ioffredo	70
Secretary of Defense (Atomic Energy) Department of Defense Washington, DC Office of the Assistant to the Secretary of Defense (Atomic Energy) For: Eric Schuld MAJ Rich Davis Reynaldo Morales	71-73
Secretary of Defense for Research & Engineering Department of Defense Washington, DC Under Secretary of Defense for Research & Engineering	74
Office of Deputy Under Secretary of Defense (Policy) Department of Defense Washington, DC Office of Deputy Under Secretary of Defense (Policy) Attn: Arthur E. Fajans	75

UNCLASSIFIED

[redacted]

[redacted]

UNCLASSIFIED

Special Distribution (cont)

	Copy No.
Army Corps Support Weapons System Fort Sill, Okalahoma CSWS/STF Attn: MAJ George A. Durham, Jr. For: MAJ D. Medrow	76
Army Armament Research & Development Command Dover, New Jersey Commander Attn: Restricted Data Control Officer and Alternate U.S. Army Armament Research and Development Command For: Mr. Philip Angelotti Mr. Don Miller	77-78
Army Material Systems Analysis Activity Aberdeen Proving Ground, Maryland Director U.S. Army Material Systems Analysis Activity Attn: DRXSY-RE	79
Army Missile Command Redstone Arsenal, Alabama Commander US Army Missile Command Attn: DRSMI-XO For: COL J. Lincoln, PM, JTACMS, DRSMI-XJ Mr. Wilton L. Fowler, DRSMI-XFL	80-81
Army Nuclear & Chemical Agency Springfield, Virginia Deputy Commander, U.S. Army Nuclear & Chemical Agency Attn: Top Secret Control Officer For: COL. E. V. DeBoeser	82
Army TRADOC White Sands Missile Range, New Mexico Director Attn: ATAA-SL or TS Control Office For: Mr. F. Pena	83
Headquarters DARCOM Alexandria, Virginia Attn: Chief, Nuclear Biological Chem. Br., Systems Management, Office of Devel. Engr. & Acq.	84
Headquarters DAMO-NCS Washington, DC Chief, Surety and Management Division Office, Deputy Chief of Staff for Operations and Plans, Headquarters For: LTC J. D. Szwarckop, 3B-540	85
Project Manager for Nuclear Munitions/Dover Dover, New Jersey Commander USA Material Development and Readiness Command Attn: DRCPM-NUC For: LTC J. R. Bobbitt	86
Project Manager for Nuclear Munitions/KAFB Kirtland Air Force Base, New Mexico Project Manager for Nuclear Munitions Albuquerque Field Office Attn: DRCPM-NUC-AFO For: Keith Baird	87
Chief of Naval Operations Washington, DC Director, Systems Analysis Divisin, (OP-96), DNM Office of the Chief of Naval Operations Department of the Navy	88
Naval Sea Systems Command Washington, DC Commander Naval Sea Systems Command Department of the Navy Attn: Nuclear Weapons/Munitions Security Division (SEA-643)	89
Naval Surface Weapons Center Silver Spring, Maryland Commander Naval Surface Weapons Center Attn: Robert E. Eby White Oak	90
Naval Weapons Center China Lake, California Commander Naval Weapons Center (Code 0822) For: Knox, Claude B. (Head M&R Branch)	91
Naval Weapons Evaluation Facility Albuquerque, New Mexico Commanding Officer Naval Weapons Evaluation Facility 120	92
AFCMD/SAE Kirtland Air Force Base, New Mexico Attn: Janet S. Hodges, Technical Information Specialist For: Dr. Hans J. Gevelhoff, DAS Jim H. Suttle	93-94
AF Systems Command Andrews Air Force Base, Maryland HQ AFSC/SDZA Attn: Norman D. Gelfand Nuclear Weapons Program Manager	95

UNCLASSIFIED

[redacted]

[redacted]

UNCLASSIFIED

Special Distribution (cont)

	Copy No.
Air Force Weapons Laboratory Kirtland Air Force Base, New Mexico Attn: SUL, Ms. Georgiana Hillyer For: Report Library Ellsworth A. Rolfs	96-97
Headquarters U. S. Air Force/SAMI Washington, DC Headquarters, U. S. Air Force Chief, Technical Information Service AF/SAMI For: LtCOL Richard A. Harris, XOXFM, 4D-1050 COL Ramelo, RDQ-A, 4D-333 MAJ Nick Hinch, XOXFS, 4D-1018	98-100
Tactical Air Command/LGW Langley Air Force Base, Virginia Commander Tactical Air Command/LGW Attn: David E. McCormick For: XP-ALFA XPBC	101-102
DET 2, USAFFWS Mountain Home Air Force Base, Idaho Attn: Nuclear Weapons Instructor	103
3416th Technical Training Sq/TTV Kirtland Air Force Base, New Mexico Commander 3416th Technical Training SQ Attn: Bernard S. Adams/TTV	104
Headquarters DAMA-AOA-M Washington, DC Chief, ODCSRDA, Mail Room Headquarters DAMA-AOA-M Attn: MAJ Robert Harter	105

UNCLASSIFIED

[redacted]