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ICBM MODERNIZATION

Status, Survivable Basing Issues, and Need to Reestablish a National Consensus

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Comptroller General
of the United States

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President of the Senate and the
Speaker of the House of Representatives

This report discusses major issues concerning the Department of Defense's Intercontinental Ballistic Missile (ICBM) modernization program. This program is comprised of three elements: (1) deploying 50 Peacekeeper missiles in existing Minuteman silos, (2) research to determine a survivable basing mode for 50 additional Peacekeeper missiles or other ICBMs, and (3) developing a small, about 15 ton, single-warhead ICBM.

We are sending copies of this report to the Director, Office of Management and Budget, and the Secretary of Defense.

Charles A. Bowsher
Comptroller General
of the United States

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Executive Summary

Purpose

The primary objective of U.S. strategic nuclear forces is deterrence of nuclear war. The deterrent value of U.S. strategic forces rests on their ability to retaliate with appropriate force after a surprise attack. To counter Soviet nuclear advances, the President has given the highest priority to the modernization of strategic nuclear forces. (See p. 10.)

This report concentrates on the status of land based Intercontinental Ballistic Missile (ICBM) modernization—with emphasis on the development of survivable means of basing for Peacekeeper (also referred to as MX) and Small ICBM (also referred to as Midgetman). Important decisions are to be made in the near future on these systems. GAO prepared this report to assist the Congress in its consideration of these decisions. GAO emphasized survivable basing because it has been and continues to be a key issue. (See p. 13.)

Background

The modernization initiatives are deployment of Peacekeeper missiles, currently limited to 50, in Minuteman silos in Wyoming; development of the congressionally mandated small single warhead missile weighing no more than 33,000 pounds and a hard mobile launcher; and investigations to devise a survivable basing mode for the Peacekeeper or other ICBMs. These initiatives reflect the recommendations made in 1983 by the President's Commission on Strategic Forces, except for the limitation by the Congress on the number of Peacekeepers that can be deployed in Minuteman silos. (See p. 11.)

While GAO's review was in process, the President directed the Department of Defense (DOD) to initiate studies of the cost effectiveness of various size mobile missiles larger than the Small ICBM. Such missiles could replace or complement the Small ICBM program. (See p. 12.)

Results in Brief

The major issue of ICBM modernization has been how to develop ICBM systems with the capability to retaliate with appropriate force after a surprise attack. A mobile missile system is believed to be one such system. Another may be one or more of the eight Peacekeeper basing concepts now being investigated.

Design and development of the Small ICBM system is progressing with three important decisions scheduled for December 1986—a full-scale development decision, selection of basing mode(s), and the selection of deployment area(s). The recently initiated study of larger mobile missiles could have significant effects on these upcoming decisions.

The design of the Peacekeeper missile is complete, and the Air Force expects to have 10 of 50 approved missiles deployed by December 1986. A preliminary basing decision on 50 additional missiles is scheduled for December 1986.

Although the Peacekeeper and Small ICBM systems are achieving technical progress, important obstacles remain to the successful deployment of the systems, and the overall strategy for U.S. land based ICBMs no longer commands a national consensus. Determinations must be made on the most appropriate force mix of missiles which best serves military utility and the goals of stability and arms control. Further, determinations must be made on which basing modes are most appropriate, and what degree of mobility is necessary to achieve strategic goals, feasible within the constraints of land use alternatives, or affordable in the context of other defense priorities.

Principal Findings

Small ICBM

Rationale for Single Warhead Mobile Missile

The missile configuration that has been of primary interest is a single warhead missile weighing about 30,000 pounds. This missile had been recommended by the President's Commission on Strategic Forces because of its survivability potential. Also, since it has a single warhead, it would be a relatively low value target. As such, the Commission considered it to be stabilizing and to enhance the arms control process. (See pp. 11 and 16.)

Based on a need for increased range and payload flexibility, design studies of a single warhead Small ICBM weighing about 37,000 pounds were begun in January 1986. (See p. 16.)

Life Cycle Costs

Missile quantities, basing characteristics, and other factors that influence program costs for the Small ICBM are under study. Preliminary life cycle cost estimates, in 1985 dollars, for deploying a force of 500 Small ICBMs range from \$44.8 billion to \$52.1 billion. (See p. 17.)

Hard Mobile Launcher

To ensure adequate survivability, a launcher must have adequate mobility and be able to withstand nuclear effects. Preliminary mobility test results, using vehicles designed to carry a 30,000-pound missile, are promising. The technology which protects a launcher against the high winds generated by a nuclear explosion has been demonstrated. However, hardening the vehicle's electronics against radiation remains a program challenge. (See p. 19.)

The hard mobile launcher's weight is also important to ensure successful mobile basing, and DOD wants to keep it below 200,000 pounds. Presently, the launcher's weight, together with the 30,000-pound missile, is approaching 200,000 pounds. A 37,000-pound missile and its launcher could exceed 200,000 pounds. (See p. 18.)

Land Availability

There is sufficient suitable land on government installations for operating a force of 500 Small ICBMs on hard mobile launchers in random movement. However, much of the land is in use for other DOD and Department of Energy activities, and securing it for mobile ICBM use will be difficult. The Air Force is addressing the mission conflict and environmental issues and expects them to be sufficiently resolved to allow the selection of Small ICBM deployment areas in December 1986. (See p. 22.)

System Survivability

The level of survivability for the Small ICBM has not been specified, and the level achievable is uncertain. DOD believes that it is not possible to determine a fixed level of survivability for the missile, but plans to build a system that would make a Soviet attack prohibitively costly. However, without defining the survivability requirement, it may be difficult to determine if the system(s) being proposed meets, exceeds, or fails to meet mission needs. (See p. 27.)

To be survivable, Small ICBMs deployed on hard mobile launchers must generate a barrage area large enough to make the number of attacking weapons so great that the Soviets would be unwilling to pay the price of an attack. The Air Force believes that the required barrage areas can be generated. However, current estimates are subject to change based on the selection of deployment locations and more knowledge about terrain features, road conditions, and bridge characteristics.

Peacekeeper

Survivable Basing

In 1985 the Congress reduced the number of Peacekeeper missiles to be deployed in Minuteman silos from 100 to 50. In addition, the Congress stipulated that no additional Peacekeeper missiles were to be procured for deployment unless a basing mode more survivable than Minuteman silos is specifically authorized by legislation.

In response to the congressional action, the Air Force is studying 8 alternative basing concepts to allow deployment of 50 additional Peacekeeper missiles. (See p. 32.)

Life Cycle Costs

The estimated life cycle cost in 1985 dollars for the Peacekeeper program, as currently structured, is about \$21 billion. This estimate provides funding to procure 223 missiles—50 for deployment in Minuteman silos, 50 for deployment in a basing mode to be determined, and 123 for testing. Depending upon the alternative basing mode selected, total life cycle costs for 100 deployed Peacekeepers would range from \$27.6 billion to \$56.5 billion. (See p. 39.)

Combined Force Issues

Costs of Alternative ICBM Forces

The ultimate cost of ICBM modernization is predicated on future decisions on the number and types of ICBMs to be deployed and the basing modes to be used. However, based on preliminary data, the life cycle cost estimates for a combined force of 500 Small ICBMs and 100 Peacekeepers in various basing modes range from \$73 billion to \$109 billion in 1985 dollars.

Costs of other alternatives, such as more or fewer than 500 Small ICBMs or multiple warhead mobile ICBMs instead of Small ICBMs, are not available. (See p. 42.)

Multiple Warhead Mobile Missile Options

The feasibility of developing mobile missiles weighing up to 75,000 pounds, with the capability to carry 2 or 3 warheads, is being studied. Multiple warhead mobile missiles present new sets of ICBM force alternatives, each having potential advantages and disadvantages. The budgetary, land acquisition, and manpower savings could be substantial, depending upon the number of missiles needed and their deployment mode. (See p. 43.)

Peacekeeper and Small ICBM Linkage

The Department of Defense Authorization Act of 1984 linked Peacekeeper deployment beyond 10 missiles to demonstrated progress in developing the Small ICBM system. The law applies to a missile weighing up to 33,000 pounds, however, and a heavier missile could not be developed unless the law is changed. (See p. 45.)

Observations

ICBM modernization continues to be a topic of controversy after several years of debate. In 1983 it appeared that the acceptance of the recommendations of the President's Commission on Strategic Forces, calling for deployment of 100 Peacekeeper missiles in Minuteman silos and development of a single warhead Small ICBM, had calmed the debate. This apparent consensus was, however, short-lived. The number of Peacekeeper missiles to be deployed in Minuteman silos has been reduced from 100 to 50. The search for survivable basing for Peacekeeper missiles has been renewed. The high cost of deploying and maintaining a force of 500 Small ICBMs has led to discussions of its affordability. To reduce costs, consideration is being given to deploying Small ICBMs at Minuteman sites or some combination of this and random movement at government installations. Also, studies of large mobile missiles to accommodate two or three warheads as alternatives to the Small ICBM have recently been initiated.

Important decisions relating to the Small ICBM and Peacekeeper programs are scheduled to occur in December 1986. The recently initiated studies of multiple warhead mobile missiles could have a significant effect on these upcoming decisions.

The President's Commission on Strategic Forces stressed that the two elements of ICBM modernization—the Peacekeeper and Small ICBM—and the approach towards arms control are integrally related. The Commission was unanimous that no one part of their proposal could accomplish this goal alone. (See p. 46.)

Executive Summary

Determinations must be made on the most appropriate force mix of missiles which best serves military utility and the goals of stability and arms control—Peacekeepers, single warhead ICBMs, multiple warhead mobile ICBMs, or some combination thereof. Further, determinations must be made on which basing modes are most appropriate—existing silos; new hardened silos; mobile concepts, such as hard mobile launcher basing; deceptive basing, or some combination thereof.

These and related issues need to be satisfactorily resolved in order that ICBM modernization can proceed in a systematic and coherent manner.

Agency Comments

The Department of Defense reviewed a draft of this report and made suggestions for minor technical changes which have been incorporated, as appropriate.

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Abbreviations

BMD	Ballistic Missile Defense
DOD	Department of Defense
DOE	Department of Energy
GAO	General Accounting Office
HML	Hard Mobile Launcher
ICBM	Intercontinental Ballistic Missile
MX	Missile Experimental
OSD	Office of the Secretary of Defense
SAC	Strategic Air Command

Introduction

The U.S. strategic nuclear forces consist of submarine launched ballistic missiles, manned bombers, and land-based intercontinental ballistic missiles (ICBMs). Since the 1960s, this triad of nuclear forces has contributed to the primary objective of the nation's strategic forces—deterrence of nuclear war. The deterrent value of U.S. strategic forces rests on their ability to survive a surprise attack and be able to retaliate with appropriate force. According to the Department of Defense (DOD), the Soviets are challenging this basic objective by improving critical nuclear force capabilities, such as the accuracy and survivability of their ICBMs. To counter these advances, President Reagan has given the highest priority to the modernization of U.S. strategic nuclear forces. This report concentrates on ICBM modernization—the Small ICBM and Peacekeeper programs—with emphasis on the development of survivable means of basing for these missiles.

ICBM Modernization Initiatives

In 1972 the Air Force's Strategic Air Command (SAC) articulated the requirement for a new ICBM. It determined that the new missile should be able to destroy hardened targets and should be based in a survivable manner. Subsequently, the Air Force validated the requirement for a new ICBM, and the Missile Experimental (MX) program (the name was changed to Peacekeeper in November 1982) was initiated.

Full-scale development of the MX weapon system began in September 1979. The mode of survivable basing selected was referred to as multiple protective shelter basing. Under this concept, survivability would be achieved by moving 200 missiles among 4,600 shelters without revealing the missiles' actual locations.

Upon taking office in January 1981, President Reagan initiated an overall review of the status of U.S. strategic forces and the alternatives for modernizing the forces to meet the deterrent needs of the late 1990s and beyond. In October 1981 the President announced his program to revitalize U.S. strategic forces, including modernization of the ICBM force. The U.S. ICBM force at that time was basically a product of the 1960s technology, consisting of 52 Titan II missiles and 450 Minuteman II missiles fielded in the 1960s and 550 Minuteman III missiles fielded in the early 1970s. None of these U.S. ICBMs could effectively damage hardened Soviet silos.

The President's ICBM modernization program called for

- continued development of the Peacekeeper missile with near term interim deployment in Titan or Minuteman silos, modified to increase silo hardness,
- cancellation of multiple protective structure basing development, and
- deactivation of the Titan II missiles.

The Congress, however, rejected the President's proposal for interim Peacekeeper missile deployment, expressing concern about the feasibility and desirability of such a temporary program from technical, military, arms control, and cost points of view.

On November 22, 1982, the President proposed deploying 100 Peacekeeper missiles in an array of 100 closely spaced, superhardened silos located near F. E. Warren Air Force Base, Wyoming.

The Congress, in December 1982, also rejected this proposal in enacting the fiscal year 1983 continuing resolution. The Congress provided funds for missile development but not for missile procurement, restricted obligation or expenditure of funds for full-scale development of a basing mode, and prohibited flight testing until both Houses of the Congress approve the basing mode.

In 1983, following the actions taken by the Congress, the President appointed a Commission on Strategic Forces to provide advice on ICBM basing options and alternatives to the Peacekeeper. The Commission recommended prompt deployment of 100 Peacekeeper missiles in Minuteman silos; the development of a new, single warhead Small ICBM; and the investigation of concepts for survivable ICBM basing.

The Commission believed that deployment of the Peacekeeper missile in existing silos was needed as a replacement for the Minuteman missiles and the Titan II ICBMs that were being deactivated. It also believed that the Peacekeeper, which had been in full-scale development since 1979, was needed to remove the Soviet advantage in ICBM capability and to encourage the Soviets to seek arms control agreement.

The Commission also believed that developing a Small ICBM would provide more options for survivable basing since it would be compatible with either fixed or mobile deployments. In the Commission's view the Small ICBM would be stabilizing and would enhance the arms control process because the single warhead missile would be a less vulnerable and a relatively low-value target. The Commission's recommendations were endorsed by the President and approved by the Congress in May 1983.

Subsequently, an ICBM modernization program was established to

- deploy 100 Peacekeeper missiles in Minuteman III silos;
- develop a Small ICBM, weighing about 30,000 pounds, and a hard mobile launcher designed to withstand nuclear effects; and
- investigate other survivable basing technologies, such as superhard silos.

In 1985 the Congress reduced the number of Peacekeeper missiles to be deployed in Minuteman silos from the 100 recommended by the Commission to no more than 50. The Congress also stipulated that unless a basing mode other than Minuteman silos was specifically authorized by legislation, no additional Peacekeeper missiles were to be procured except for those needed for testing. To identify a mode for an additional 50 Peacekeeper missiles, DOD has undertaken a study of eight basing options.

In 1986, during our review, the President directed DOD to initiate studies of the cost effectiveness of two and three warhead mobile ICBMs as part of the overall ICBM modernization program. These would replace or complement the Small ICBM.

ICBM Modernization Milestones

Several key ICBM modernization decisions are scheduled in the fourth quarter of calendar year 1986.

- Begin Small ICBM full-scale development.
- Select Small ICBM basing mode(s).
- Select Small ICBM deployment areas.
- Select one Peacekeeper basing alternative for further study.

If a decision is made to continue with the currently approved Small ICBM program, other milestones would include the following:

1989 - First Small ICBM flight test
1989 - Begin Small ICBM production
1990 - Begin Small ICBM facility construction
1992 - Small ICBM Initial Operational Capability

ICBM Modernization Funding

During fiscal years 1983-86, \$14.5 billion has been approved for ICBM modernization. In fiscal year 1987, \$3.7 billion is being requested—\$1.9 billion for the Peacekeeper program, \$1.4 billion for the Small ICBM program, and \$0.4 billion for alternative basing investigations. Small ICBM annual funding requirements beyond fiscal year 1987 are uncertain pending a full-scale development decision. Peacekeeper program funding requirements beyond fiscal year 1987 are also uncertain pending the definition of an acceptable survivable basing mode. ICBM modernization funding by program is shown in table 1.1:

Table 1.1: ICBM Modernization Current
and Prior Years Funding

Dollars in Billions		
	Fiscal years 1983-86	Fiscal year 1987 request
Peacekeeper (a) (b)		
Research and Development	\$6.1	\$4
Procurement	6.4	1.5
Construction	0.2	-(c)
Total	\$12.7	\$1.9
Small ICBM/Hard Mobile Launcher		
Research and Development	1.4	1.4
Alternative Basing Investigations		
Research and Development	.4	.4
Total ICBM Modernization Funding	\$14.5	\$3.7

^aThe Peacekeeper funding for fiscal years 1983 to 1986 was extracted from the Peacekeeper Selected Acquisition Report for the period ending December 31, 1985, and does not reflect subsequent budget reductions of about \$200 million.

^bAs noted in our 1984 report (GAO/NSIAD-84-112) on the Peacekeeper missile, about \$4.6 billion in development and basing costs incurred before 1983 are not included in the Peacekeeper cost estimates.

^cActual request of \$28 million not displayed due to rounding.

Objective, Scope, and Methodology

Our objective was to obtain information on the status and issues associated with ICBM modernization. On the Small ICBM, we focused on hard mobile launcher (HML) development and activities related to identifying available, suitable deployment areas. On Peacekeeper, we focused on the definition of survivable basing concepts. We chose to emphasize survivable basing as opposed to the other aspects of ICBM modernization, such as missile development, because an acceptable mode of survivable basing has been and continues to be a key issue.

ICBM modernization, as currently structured, was previously discussed in our July 8, 1985, report, Status of the Intercontinental Ballistic Missile Modernization Program (GAO/NSIAD-85-78), and our May 9, 1984, report, Status of the Peacekeeper (MX) Weapon System (GAO/NSIAD-84-112).

It should be recognized that the Small ICBM program and Peacekeeper alternative basing program are in varying stages of system definition and development—the Small ICBM program is in pre-full scale development and some Peacekeeper basing alternatives are in concept definition. This report is based on information available as of June 1986.

During our review, we obtained and reviewed pertinent documents, including program directives, financial records, system specifications, test plans and related materials, statements of operational needs, threat reports, descriptions of operational concepts, and materials describing the availability and suitability of land for deployment of the Small ICBM. We held discussions with cognizant officials for the Small ICBM and Peacekeeper programs. These discussions were held at the Air Force's Ballistic Missile Office, Norton Air Force Base, California; SAC Headquarters, Offutt Air Force Base, Nebraska; Air Force Headquarters and the Office of the Secretary of Defense (OSD), Washington, D.C.; and selected Small ICBM contractors. In addition, we visited Minuteman sites in Montana and all the military installations in California and Arizona that are candidate installations for Small ICBM deployment to observe and discuss with base personnel the availability and suitability of land at those locations.

Where possible, information was obtained from the office of primary responsibility. For example, operational needs statements were received from SAC. We also examined reports provided by OSD to the Congress, such as the Peacekeeper Selected Acquisition Report, the ICBM Modernization Program Annual Progress Reports, and the Defense Science Board Report on Small ICBM Modernization.

Our review was performed in accordance with generally accepted government audit standards.

DOD reviewed a draft of this report and made suggestions for minor technical changes which we incorporated as appropriate.

Progress Made but Challenges Remain in Developing and Deploying the Small ICBM

Design and development of the Small ICBM system, with a single warhead missile weighing about 30,000 pounds, is progressing with important decisions scheduled for December 1986.¹ At that time DOD must decide whether to advance the system into full-scale engineering development and must also select deployment sites. Based on preliminary test results and analyses, the Air Force is convinced that a mobile Small ICBM will be survivable against the projected threat. Uncertainty exists, however, in DOD and among some in the Congress as to whether the Small ICBM should be approved or whether multiple warhead mobile missiles would be more appropriate. Recent initiatives to study the feasibility of multiple warhead mobile missiles are discussed in chapter 4.

For the Small ICBM, issues to be resolved include the number of missiles required and their costs, the need to harden the mobile launchers' electronics to protect against nuclear radiation without separate shielding, and the need to secure sufficient suitable land for system operations. Also, pending decisions on missile size and deployment areas could change current survivability estimates.

Small ICBM Program Description and Basing Concepts

The Small ICBM program involves developing a missile and survivable basing options. The missile configuration of primary interest has been a single warhead missile weighing about 30,000 pounds. In response to direction from Air Force Headquarters in January 1986, the program office is conducting design studies of a single warhead missile, weighing about 37,000 pounds, that will have increased range and payload flexibility. The design studies will provide sufficient data on the 37,000-pound missile so that it can be considered for the full-scale development decision. A report issued by a Defense Science Board Task Force in March 1986 recommended deploying a 37,000-pound Small ICBM.

Appendix I provides a description of the Small ICBM concept of operations.

The Air Force has identified three mobile basing modes for the Small ICBM which it believes have the potential to satisfy mission requirements and meet the 1992 initial operational capability date.

¹In authorizing the program, the Congress stipulated that the missile should weigh no more than 33,000 pounds. Also, under the law, the Congress must be notified of any weight growth over 30,000 pounds. The Air Force has been designing the missile to weigh no more than 30,000 pounds.

- HML in random movement: This concept has been the basing mode of primary interest since the program's inception. It consists of mobile launchers randomly dispersed on DOD and Department of Energy (DOE) installations. The current operational concept employs a strategy of periodic random movement within a deployment area large enough to complicate enemy planning and targeting. During periods of increased tension, the HMLs would expand their operations to an area approximately twice as large as the day-to-day area while remaining on the installation. Upon tactical warning, the mobile launchers would disperse as far as possible. The Defense Science Board recommended deploying the Small ICBM in this mode on major western government complexes.
- HML at Minuteman facilities: This basing concept is a variant which began to receive equal consideration in October 1985. Unlike random movement basing, the launchers at Minuteman facilities do not employ a strategy of periodic movement. In contrast, during peacetime, all the launchers are parked "on alert" at the facilities. Upon tactical warning, they would disperse off the Minuteman sites. The Defense Science Board recommended against deploying all Small ICBMs in this basing mode because of concerns about dispersing off the sites and the potential public interface problems of dispersing before the United States were attacked.
- HML in random movement and at Minuteman facilities: This concept is a combination of random movement and Minuteman basing. A portion of the force would be deployed at a DOD/DOE installation in random movement, and the remainder would be deployed at Minuteman sites. The program office introduced this concept in November 1985. Program officials believe it combines the best features of both random movement and Minuteman basing. Retaining random movement provides a hedge against a surprise attack. Utilizing existing Minuteman sites reduces operational costs and manpower requirements and minimizes mission conflicts.

Small ICBM Life Cycle Cost Estimates, Manpower Requirements, and Force Size

Missile quantities, basing characteristics, and other factors that influence program cost and manpower requirements are still uncertain for the currently approved 30,000-pound Small ICBM. However, the program office has developed estimates of acquisition and annual operations and support costs. We used these estimates to project life cycle costs as shown in table 2.1.

Table 2.1: Life Cycle Costs^a

Dollars in Billions				
500 Small ICBMs	Total acquisition	Annual operations and support	Total life cycle costs	Total manpower requirements
In random movement	\$38.0	\$1.13	\$52.1 ^b	14,000 to 17,000 ^c
At Minuteman sites	34.0	0.86	44.8	7,000 to 9,000 ^c
In mixed basing	35.0	0.96	47.0	9,600 ^c

^aWe compiled life cycle cost estimates in 1985 dollars, using program office estimates of acquisition costs and annual operations and support costs. Annual operations and support costs were multiplied by 12.5 years—10 years of steady operations plus a build-up-period—to calculate total operations and support cost. Program officials stated that our estimates of life cycle costs may not be meaningful because the operational life of the Small ICBM has yet to be established. We recognize this limitation but feel that representation of potential life cycle costs is useful.

^bBased on program office data, the \$52.1 billion life cycle cost estimate in 1985 dollars is approximately the same as the \$44.0 billion estimate in 1982 dollars included in our July 8, 1985, report.

^cThe program manager stated that these are the worst case manpower estimates which assume no change to, and full compliance with, existing security regulations. Several studies are underway to identify opportunities for manpower reduction.

It is important to note that the above cost and manpower estimates are based on a force of 500 Small ICBMs. The Air Force, however, has yet to determine the Small ICBM force size. Force sizes ranging from 250 to 1,000 missiles are being considered. An initial determination of the force size is expected at the full-scale development decision scheduled for December 1986. The Defense Science Board's March 1986 report identified the following as factors which will influence the number of Small ICBMs needed:

- the threat,
- the size of the Soviet target base,
- the need for a Minuteman II replacement (450 missiles, each with a single warhead),
- the survivability of the remainder of the U.S. Triad, and
- future Peacekeeper deployment decisions.

Small ICBM Launcher Test Results Are Promising, but Challenges Remain

To insure adequate survivability, an HML must combine mobility with the ability to withstand nuclear effects. Preliminary mobility test results are promising. Test results have also demonstrated the technology used in hardening the vehicle against the blast effects of a nuclear explosion. However, hardening the vehicle's electronics against nuclear radiation without shielding remains a program challenge. In addition, the HML's projected weight has increased.

HML Mobility Test Results Are Promising

The overall mobility of a vehicle designed to carry a 30,000-pound missile is exceeding program office expectations. The primary measure of overall mobility was the average speed achieved by mobility test vehicles over four courses at the Yuma Proving Grounds, Arizona.² These courses were designed to measure mobility over the variety of terrain and road conditions that HMLs may encounter in operational situations. Average speed achieved is used as a measure of overall performance and is based on a number of individual performance factors. These factors include the vehicles' ability to accelerate, to maintain speed over different terrain and road conditions, and to transition between on-road and off-road travel. As shown in table 2.2, the speeds obtained were slightly higher than predicted by the program office.

Table 2.2: Test Results

Miles per hour			
Course number	Course length	Average speed	
		Predicted	Actual
1	19.5	19.7	21.4
2	14.9	20.1	25.0
3	11.6	13.1	15.3
4	23.6	42.0	43.0

²To demonstrate and evaluate HML mobility, each of the competing HML contractors—Boeing Aerospace Company and Martin Marietta Corporation—designed and built mobility test vehicles. These vehicles are full-scale HML representations, usable for test purposes only. Photographs of the two vehicles are in figures 2.1 and 2.2.

Figure 2.1: Hard Mobile Launcher Test
Vehicle - Martin Marietta

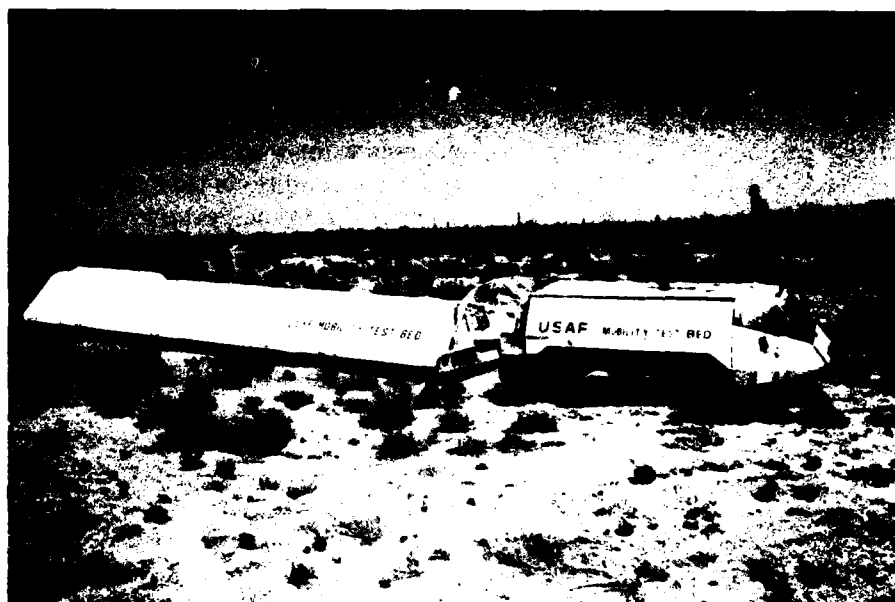
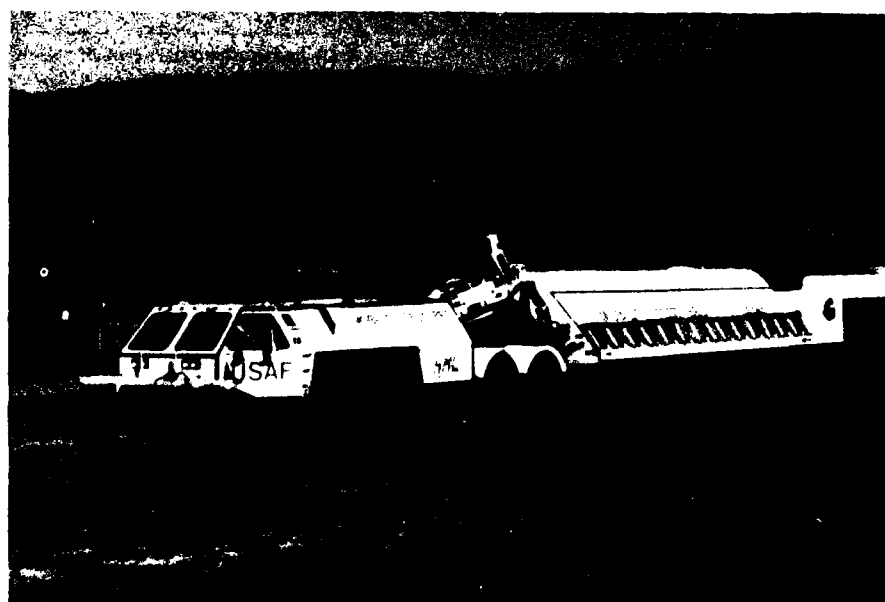


Figure 2.2: Hard Mobile Launcher Test
Vehicle - Boeing Aerospace



While the overall results are promising, the testing identified terrain conditions that present mobility obstacles. These conditions include soils

which do not provide enough traction, slopes which could not be traversed, and intersections and turnarounds which limit HML speed.

Hardening the HML Requires a Major Development Effort

Designing the HML to withstand some of the effects of a nuclear explosion remains a program challenge. The Air Force has demonstrated the technology which protects the HML against the high winds from a nuclear explosion. However, protecting the HML's electronics against radiation without excessive shielding requires a major development effort.

Both nuclear air blasts and radiation can damage the HML severely enough to prevent it from launching its missile. Nuclear air blasts damage the HML by overturning it or causing it to slide from its parking location in a way that damages the equipment launching the missile. Radiation can damage the HML's electronics which receive and execute the launch command.

During 1984 and 1985, numerous tests designed to simulate the air blast effects generated by a nuclear explosion on HMLs were conducted. These tests included using wind tunnels and shock tubes, plus an outdoor explosive test. The tests demonstrated that the HML's shape, vents, and ground sealing system prevent it from either overturning or sliding in a way which damages the launch mechanism. It should be noted, however, that tests using the mobility test vehicles showed that the vehicles' hardening procedures need improvement. The Air Force intends to have these procedures fully validated early in the full-scale development cycle.

According to DOD's 1986 ICBM modernization program progress report, hardening the HML against radiation dictates a major development effort. Although radiation hardening is not a new technology, its application to an above-ground mobile system is. According to program and contractor officials, the principal trade-offs are the cost of developing "hard" parts and the weight growth associated with separate shielding for "soft" parts. Preliminary analyses and tests indicate radiation hardening requirements can be met.

HML Weight Increases

The projected gross weight of an HML loaded with a missile has increased from between 150,000 to 175,000 pounds to 180,000 to 195,000 pounds. These estimates are still below the less than 200,000-pound weight which DOD, in its 1986 annual ICBM modernization report, specified for

the HML. However, these weight estimates are for a vehicle designed to carry a 30,000-pound missile. An HML designed to carry the larger missiles being discussed may exceed 200,000 pounds.

According to DOD's report, an HML needs to weigh less than 200,000 pounds to ensure successful mobile basing without road and bridge constraints. As a vehicle's weight increases, road widths and bridge load carrying capacity can impair mobility. The precise impact of the HML weight increase is uncertain. Program officials told us the less than 200,000-pound limit was based on general assumptions about road and bridge conditions, not analytical data. They are convinced, however, that the HMLs, at current weight estimates, are sufficiently mobile.

An HML designed to carry missiles large enough to carry penetration aids and/or multiple warheads may weigh more than 200,000 pounds. Program officials estimate that for every one pound the missile's weight increases, there is a corresponding increase of two pounds in HML weight with the missile. For the 37,000-pound missile recommended by the Defense Science Board in its March 1986 report, an HML would need structural reinforcements weighing another 7,000 pounds. This would increase the HML's projected weight range with the missile to between 194,000 and 209,000 pounds.

Obtaining Land for Small ICBM Deployment May Be Difficult

The Air Force has identified sufficient suitable land for Small ICBMs in random movement operations; however, securing it could be difficult. Whether it can be made available for Small ICBM deployment has not been decided. At present, there are 14 sites under consideration, and each has features which make it an attractive or an unattractive site. Some sites have large amounts of land which can support Small ICBM operations, available road networks, and the off-base area the HML can access on warning. Mission conflicts and the environmental impacts associated with Small ICBM deployments and the cost of building roads make some of these sites unattractive. The program office indicated that it is collecting the data necessary to enable decisionmakers to select the deployment installations which would optimize the trade-offs. The Air Force expects the issues to be sufficiently resolved to allow the selection to be made in December 1986.

Land Requirements for Small ICBMs in Random Movement Basing

Land requirements for Small ICBMs on HMLs in random movement basing are predicated on survivability factors including projected threats and HML hardness. Considering these factors, the program office estimates that an average of 8 square miles of suitable land per HML is needed for day-to-day operations—a total of 4,000 square miles for a force of 500 missiles.³ During periods of increased tension a minimum of 16 square miles per HML is needed—a total of 8,000 square miles for a force of 500 missiles.

At the 14 candidate deployment installations, the Air Force identified approximately 16,000 square miles of area suitable for Small ICBM operations. Of this total, 7,000 square miles are being examined for use as day-to-day operations areas. Some of this land may not be available because of conflicts with existing installation activities, environmental concerns or cost considerations. The remaining 9,000 square miles has been removed from further consideration for day-to-day operations areas to minimize conflicts between Small ICBM operations and existing installation activities. Program officials believe, however, the Small ICBM force will be allowed to occupy as much of the deployment installation as needed during periods of increased tension.

The program office has determined that about 600 Small ICBMs on hard mobile launchers could be deployed on the 7,000 square miles being examined for use on a day-to-day basis. In computing that number, the program office reduced the amount of suitable area to reflect its availability on a scheduling basis. About 60 percent of the 7,000 square miles being examined is currently being used to some extent. The remaining 40 percent is not in use. A total of about 850 HMLs could be deployed on the 7,000 square-mile area if conflicting use was not considered.

Mission Conflicts at Candidate Deployment Installations

One of the more difficult tasks facing the Air Force is the resolution of mission conflicts. These mission conflicts interfere with Small ICBM operations and with on going or planned activities at the candidate deployment installations. The on going activities at these installations are also important to national defense. They include weapons research and development and training needed to insure military readiness.

³The land availability issues discussed in this section are based on deploying 500 Small ICBMs. As previously discussed, the number of missiles which will be deployed has yet to be specified. If more than 500 missiles are deployed, the land availability issues will intensify; if less than 500 are deployed, they will be reduced.

Examples of the mission conflict issues which have been identified by the Air Force are as follows:

- Small ICBM command, control, and communications and their effects are potential areas of mission conflict. Operability within an already heavily used radio frequency environment is a major concern at every installation.
- Physical security and the accessibility of the deployed system to vandals and terrorists is a strong issue.
- A major safety concern is the potential overflight of manned HMLs by ordnance-laden, possibly supersonic, low-level aircraft. If any restriction of aircraft overflight of operationally deployed HMLs was imposed, aircrew training and operational/developmental testing would be severely impacted.
- The complexity of the scheduling process at most ranges, caused by a variety of range users and requirements, would be amplified by deployment of the HML on the ranges. Day-to-day scheduling in order to accommodate all missions would be a major effort, requiring flexibility and continuous monitoring of range activities. Additionally, construction activities (roads and facilities) associated with deployment of the Small ICBM could cause extensive scheduling problems, impacting range activities.
- Training missions at some installations require unrestricted freedom to provide a free-play live fire training environment. HMLs operating in these areas could be at risk and could seriously detract from realism in training.

The Air Force updated the program office's Mission Compatibility Report in June 1986 to reflect the position of higher commands on the concerns expressed by subordinate organizations at the candidate deployment locations. Higher commands confirmed the position of subordinate organizations that the Small ICBM deployed on HMLs in random movement basing presents numerous mission incompatibilities which could seriously impact each installation's mission through loss of training and/or testing capability.

The Air Force is continuing to seek resolution of all potential mission conflicts with both the candidate deployment installations and appropriate higher commands. Program officials are confident the mission conflicts can be favorably resolved based on the flexibility of Small ICBMs deployed on HMLs.

Program officials point out the 4,000 square miles that a force of 500 Small ICBMs would use for day-to-day operations need not be a fixed plot of land dedicated exclusively to Small ICBM operations. The mobile launchers can move from one location to another as the circumstances dictate. During periods of increased tension, when 8,000 square miles are needed, program officials believe the HML force will be allowed to occupy as much of the candidate deployment installations as needed. They point out that the HMLs will double their deployment areas only in cases of extreme national emergency when nuclear readiness must be demonstrated. Although the Air Force has not developed a definition of extreme national emergency, program officials believe the 1962 Cuban Missile Crisis is an appropriate example.

Environmental Impacts

DOD has stated that the potential environmental impacts of deploying the Small ICBM system will not be known before November 1986. Environment concerns which the candidate deployment installations have raised range from disturbing archaeologically significant sites to water availability.

The use of special status land at several candidate deployment locations is associated with the Small ICBM system's environmental impact. Special status land is protected by either federal or state law, and its use is jointly managed by the candidate deployment installations and other government agencies.

This land is being considered as available for daily HML operations and during periods of increased tension. The program office wants to use special status lands at these installations to enhance the HML's ability to disperse over a large area on warning. Discussions have been initiated with representatives of both the Departments of the Interior and Agriculture to determine under what conditions these lands could be used. The results of such discussions would influence the final evaluation of the relative attractiveness of each installation for deploying the Small ICBM. The intent of the Air Force is to determine how the land could be used without affecting its environmental value.

To comply with a requirement contained in the fiscal year 1986 DOD Authorization Act and assist in the analysis of the environmental impacts, the Air Force is preparing a legislative environmental impact statement. The statute requires the statement to address the relative environmental consequences of deploying the Small ICBM at each candidate deployment installation and the environmental effects of full-scale

development of the Small ICBM system. This statement is scheduled to be filed with the Environmental Protection Agency and appropriate congressional committees in November 1986.

**Analysis of Road Construction
Costs Not Completed**

Preparing a suitable area for Small ICBM operations includes building new roads, upgrading existing ones, and building off-base defense access roads. The acceptability of some of the land identified on the candidate deployment installations will depend on the cost effectiveness of constructing or upgrading roads.

Some of the on-base roads on which the HMLs and other operational support vehicles will operate may not be usable in their present condition. For example, officials at two large installations stated that many of the roads proposed for use are impassable, even with four-wheel drive vehicles. Officials at another installation stated that developing roads would be a massive undertaking which would entail major civil engineering programs. Program officials are aware of these issues.

On several candidate deployment installations, mountain ranges isolate portions of the random movement area from both the proposed main operating facilities and other parts of the area. Using these isolated areas as deployment locations may require constructing roads either on-base through the mountains or building off-base roads around the mountains. For example, we, along with Air Force officials, used on-base and off-base roads/trails to reach a portion of the random movement area at one of the candidate deployment installations that was isolated by a mountain range. To reach the area, we traveled approximately 4 hours while driving about 75 miles on some roads which, in their present condition, were clearly not traversable by HMLs. Both the Air Force and our officials agreed some type of road construction would be needed to use this isolated area.

The Air Force is aware of the difficulty isolated random movement areas and unusable roads pose and is analyzing the cost effectiveness of making road improvements. It intends to have this analysis completed prior to the full-scale development decision.

Level of Small ICBM Survivability Has Not Been Specified, and Level Achievable Has Not Been Established

The level of survivability for the Small ICBM system has not been specified, and the level achievable in random movement at Minuteman sites or mixed basing is uncertain.

The survivability of the Small ICBM depends upon the hardness of the mobile launcher, the amount of land it could occupy in a crisis or upon warning, and the size and nature of the Soviet threat. The Air Force has yet to establish the system's survivability requirement. The operational requirement, promulgated in an Air Force Program Management Directive, is to develop a system which has adequate survivability against the current and projected threat. The phrase "adequate survivability" has not been defined. Establishing a survivability requirement would better enable decisionmakers to judge the merits of the various options for missile sizing and basing. Without this requirement, it may be difficult to determine if an option exceeds, meets, or fails to meet mission needs.

According to DOD, they cannot know how many weapons the Soviets might be willing to use to attack 500 Small ICBMs. Therefore, it is not possible to determine a fixed level of survivability for the system. Rather, DOD plans to build a system that would make an attack so unprofitable that the Soviets would not be willing to pay the price of an attack. The concept for achieving this goal involves dispersal of the HMLs in a manner that will make the Soviets barrage large land areas to effectively damage the Small ICBM force.

The Air Force is currently estimating that it can achieve the required barrage area for Small ICBMs on hard mobile launchers in random movement, at Minuteman sites or in a mix of those two deployment options. These estimates are subject to change as the deployment locations are selected and as more becomes known about HML performance characteristics.

Program officials are in the process of gathering and analyzing data on terrain features, road conditions, and bridge conditions to determine (1) the extent these factors could affect HML mobility and (2) the cost of upgrading roads to mitigate these conditions. The results of their analysis will be used to make firmer estimates of barrage area generation capability to support the full-scale development decision.

Program officials believe that the barrage areas, as currently estimated, are more than sufficient to deter any potential attacker if the system is deployed as envisioned. For example, they point out that the Soviets would have to use nearly all their land-based ICBMs to successfully

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Progress Made but Challenges Remain in
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attack the Small ICBM system, leaving few or no remaining systems to attack other U.S. strategic assets.

The Peacekeeper Missile Program and the Search for Survivable Basing

Figure 3.1: Peacekeeper Missile Test Firing



The Peacekeeper weapon system was initiated in 1972 to strengthen the ICBM portion of the nation's triad of strategic forces by providing a prompt response missile in a survivable basing mode and having the ability to destroy hardened targets. The history of the Peacekeeper program has been one of a successful missile design and development and of an inability to identify a basing mode that is technically feasible, affordable, and politically and publicly acceptable. Over 30 different basing modes were previously considered. The search for survivable basing modes continues, however, with eight alternatives currently under consideration, most of which are variants of concepts previously considered. Each of these eight basing modes has positive and negative attributes, and the acceptability of one or more of these concepts awaits future study.

Status of the Peacekeeper Program

The Peacekeeper program, as currently structured, involves the (1) deployment of 50 missiles in Minuteman silos and (2) evaluation of more survivable alternative basing modes for deployment of an additional 50 missiles. As of May 1986 the Air Force had conducted 12 of the 20 planned test flights with successful results. Modification of the Minuteman silos at F. E. Warren Air Force Base is underway, and the Air Force expects to have 10 fully operationally ready missiles deployed there by December 1986. All 50 of the authorized missiles are planned to be deployed by December 1988.

Estimated Acquisition Cost for the Peacekeeper Program

The current estimated acquisition cost for the Peacekeeper program, as reported by DOD in its Peacekeeper Selected Acquisition Report, for the period ending December 31, 1985, is \$16.1 billion in 1982 dollars or \$20.8 billion, with inflation adjustments (referred to as then year dollars). A categorization of the estimate in then year dollars by appropriation is shown in table 3.1.

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Table 3.1: Estimated Peacekeeper Costs (Then Year-Dollars)

Dollars in Billions				
Appropriation	Fiscal year 1983-86 ^a	Fiscal year 1987	To completion	Total ^b
Research and Development	\$6.1	\$0.4	\$0.1	\$6.6
Procurement	6.4	1.5	6.1	14.0
Construction	0.2	0.0 ^c	0.0 ^c	0.2
Total	\$12.7	\$1.9	\$6.2	\$20.8

^aThe Peacekeeper funding for fiscal years 1983 to 1986 was extracted from the Peacekeeper Selected Acquisition Report for the period ending December 31, 1985, and does not reflect subsequent budget reductions of about \$200 million.

^bAs reported in our 1984 report (GAO/NSIAD-84-112) on the Peacekeeper missile, about \$4.6 billion in missile and basing development costs incurred prior to 1983 are not included in the Peacekeeper cost estimates.

^cFunding requests of \$28 million for fiscal year 1987 and an estimated \$21 million to completion are not shown due to rounding.

The \$20.8 billion current cost estimate includes procurement funds for acquiring 223 missiles—50 to be deployed in Minuteman silos, 50 to be deployed in a basing mode to be determined, 108 missiles for operational test and evaluation, and 15 for aging and surveillance. The cost of basing the 50 additional Peacekeepers is not included. (See p. 34.) Under the terms of the 1986 DOD Authorization Act, however, the Air Force cannot procure more than 50 missiles for deployment in existing Minuteman silos, except those needed for testing, without specific legislative approval of an alternative basing mode. Through fiscal year 1986, procurement funds have been appropriated for 54 missiles. The Air Force plans to buy the remaining 169 missiles at a rate of 21 missiles in 1987; 48 in 1988, 1989, and 1990; and 4 in 1991.

Continuing Search for a Peacekeeper Survivable Basing Mode

Survivable basing has been a fundamental program requirement since the need for the Peacekeeper system was first articulated in 1972. Since that time, over 30 basing modes have been studied and rejected for technical, cost, and political and public acceptability reasons. A chronology of selected events illustrating some of the survivable basing concepts considered and rejected is as follows:

- In 1976 when the Peacekeeper weapon system advanced into the validation phase of DOD's acquisition cycle, the basing modes of primary interest involved moving missiles in buried trenches.
- In 1978 the basing mode recommended by the Air Force for advancement into the full-scale development phase of DOD's acquisition cycle was multiple protective vertical shelters.

- In 1979 the basing mode approved by President Carter for advancement into full-scale development involved moving 200 missiles among 4,600 multiple protective horizontal shelters.
- In 1981 development of horizontal shelter basing was terminated by President Reagan, who proposed interim deployment of 40 Peacekeeper missiles in Minuteman and Titan silos while long-term basing options were studied.
- In 1982 silo basing was disapproved by the Congress, and President Reagan proposed placing 100 missiles in closely spaced superhard silos.
- In late 1982 the Congress rejected the closely spaced superhard silo proposal.
- In 1983 the President and the Congress approved deployment of 100 missiles in Minuteman silos.
- In 1985 the Congress directed that the number of missiles in Minuteman silos be reduced from 100 to not more than 50.

As a result of the congressional actions to restrict procurement and deployment of Peacekeeper missiles unless a more survivable basing mode is authorized, DOD and the Air Force began reexamining basing alternatives for further consideration. In September 1985 the Air Force directed the Peacekeeper Program Office to study eight basing modes as alternatives to Minuteman silo basing. In November 1985, OSD directed the Air Force to study four concepts in detail. However, none of the eight has been eliminated from consideration. Plans are to begin full-scale development of one basing mode in fiscal year 1988.

Resource Requirements for the Eight Basing Concepts Under Consideration

The program office, in its December 1985 Peacekeeper Basing Evaluation Report, provided operational characteristics and preliminary estimates of resource requirements for the eight concepts. Listed in table 3.2 are some of the resource requirements for the basing alternatives being considered, revised as of January 1986. The costs are basing-related only. All missile associated costs are excluded.

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Table 3.2: Alternative Basing Resource Requirements

(1985 dollars in billions)

	Acquisition costs	Annual operations and support costs	Personnel required
Hardened Minuteman Silos	\$5.6	\$.08	245
Superhard Silos	6.7	.08	245
Superhard Silos with Concealment	16.3	.11	429
Rail Mobile	16.6	.53	7265
Shallow Tunnel	27.9	.20	1715
Ground Mobile	27.3	.36	3099
Deep Basing	30.4	.27	3087
Carry Hard	31.3	.34	2462

Attributes and Limitations of Eight Basing Modes

The program office, in its Peacekeeper Basing Evaluation Report, also identified the attributes and limitations of the eight basing modes. With the exception of hardened Minuteman silos, all basing modes were designed to provide the same percentage of survivors during the first hours of an attack. The Peacekeeper's survivability for this period is consistent with the mission need for the system, as expressed by SAC, and would provide national leadership time to consider the appropriate response before making the decision to launch the missiles. The program office's assessment of the basing concepts under consideration is shown in table 3.3.

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Table 3.3: Program Office Assessment of Alternative Basing Attributes and Limitations

	Life-Cycle Cost		Personnel	Land	Public interface	Arms control	Congressional concerns
	^a	^b					
Hardened Minuteman Silos	+	+	+	+	+	+	•
Superhard Silos	+	+	+	+	+	•	•
Superhard Silos with Concealment	0	+	+	0	+	+	+
Rail Mobile	0	•	•	+	•	+	+
Shallow Tunnel	•	0	0	•	•	+	+
Ground Mobile	•	•	•	+	+	+	+
Deep Basing	•	0 ^a	•	0	+	+	+
Carry Hard	•	0	0	•	•	+	+

Note:

• Indicates area is a critical limitation.

+

0 Indicates area is not a significant decision factor.

^aAcquisition cost.

^bOperations and support costs.

The attributes and limitations of these concepts, as well as resource requirements, will most likely change as concept definition continues. The Air Force is planning additional study and systems testing, which could result in the resolution of technical concerns and reduction of land, personnel, and funding requirements. In addition, the systems are designed to ensure that a specified percentage of the missiles will survive an enemy attack of a specified capability. As any of these design characteristics change, so too may their resource requirements and relative merits.

Relative Merits of Four Basing Concepts Being Studied in Detail

Although none of the eight basing modes has been eliminated from consideration, OSD directed the Air Force to study four concepts in greater detail. These four concepts—the two superhard silo options, carry hard, and shallow tunnel—are discussed below. The other four basing alternatives not being studied in as great a depth are discussed in appendix II.

Superhard Silos and Superhard Silos With Concealment

The Air Force is considering two basing modes using superhard silos which would be about 30 times harder than the current Minuteman III silos. One option being considered is to place 50 missiles in 50 closely spaced, superhard silos. The other option—superhard with concealment—is to randomly deploy 50 missiles among 300 superhard silos and

periodically relocate the missiles. Because of missile location uncertainty, it would be necessary for the enemy to attack all 300 silos. The silos for both concepts would be about 1,500 feet apart in a patterned array. The first of the 50 missiles for either system would be deployed about 3-1/2 years after authority is given, and the last would be deployed about 5-1/2 years after authority is given.

The ability of closely spaced, superhard silos to survive for a few hours is partly a result of the silo's hardness. Technical advances in the design and construction of silos and successful scale model testing, since about 1980, have enabled the Air Force to demonstrate silo hardness to a level far greater than the current Minuteman III silos. The increased silo hardness makes it possible for a silo to survive numerous attacks. It also allows the silos to be closely spaced, since there is little risk that a single weapon will destroy more than one silo.

Closely spaced basing is important in order to take advantage of the effects of fratricide. Fratricide is the destruction or degradation of attacking weapons by the nuclear effects resulting from preceding attacks. To prevent the nuclear effects of one wave from destroying the next wave of warheads, the enemy must pause between attacking waves. To avoid the effects of fratricide, the attack must be structured over a period of several hours in order to destroy all of the missiles.

The superhard silo options were recommended by the program office, in its Basing Evaluation Reports, for basing the second 50 Peacekeeper missiles and have other proponents within DOD. According to the program office, the superhard silo concepts would provide an adequate level of survivors against threats that have been identified through the year 2000. Compared to other Peacekeeper basing alternatives, these concepts are relatively low cost with preliminary life cycle costs, in 1985 dollars, of \$7.7 billion for 50 superhard silos and \$17.7 billion for superhard silos with concealment.

A limitation of the superhard concept, however, is that the length of time that a missile in superhard silos would survive will significantly decrease if the Soviets develop advanced technologies. According to DOD, this action by the Soviets is not considered likely, based on current intelligence estimates. Nevertheless, the Defense Science Board acknowledged this possibility in its report on Small ICBM modernization.

The number of superhard silos could be increased to provide a desired level of survivors against an increased threat. However, because the

cost per silo is relatively high compared to other Peacekeeper concepts, it could become one of the most expensive systems rather than one of the least expensive.

According to the Defense Science Board, the prospects of superhard silo survivability against increased threats could also be improved with the use of Ballistic Missile Defense (BMD). These are defense systems developed to protect the deployed missiles. The Strategic Defense Initiative Organization has been directed by OSD to study the application of BMD to Peacekeeper alternative basing concepts.

Carry Hard

The carry hard operational concept is to disperse 50 missiles in hardened launcher capsules among 3,795 water-filled vertical shelters. The missile would be periodically relocated as maintenance is performed. The Air Force estimates this basing mode would require about 1,150 square miles of area, need about 2,460 personnel, and have a life-cycle cost of about \$35.5 billion in 1985 dollars. The first missile would be deployed about 5-1/4 years after program authorization, and all 50 missiles would be deployed about 8-1/4 years after the decision.

The maintenance of missile location uncertainty among the silos is a concern with the carry hard concept. This basing mode is predicated on creating a large number of inexpensive aimpoints, which would require the attacker to target all of the shelters due to location uncertainty. The number of shelters necessary is based on the number of warheads allocated against the system, their capability, and the number of survivors required. If the missiles can be located through surveillance or other techniques, the number of warheads needed to destroy the system would diminish as the level of knowledge of missile locations increases. Measures to assure missile concealment, such as simulating missile characteristics in empty silos, are being studied.

The program office believes that carry hard land requirements are a critical limitation. Current plans call for private land to be acquired or, as an alternative, the exclusive use of government land. The deployment areas for the shelters require about 40 percent of the total land needs, with the remaining area being used to prevent public access and to assure that missile location can not be determined by ground sensors or other means. Tests and studies on concealment measures are being conducted to determine if the land requirements can be reduced.

The estimated acquisition cost of the carry hard concept is another critical limitation, according to the program office. The cost of this system is primarily a result of the large number of shelters needed and their necessary support facilities. OSD has requested the Air Force to attempt to reduce the cost for a shelter and its associated facilities to about one-half of its current level of about \$3.6 million, in 1985 dollars. The Air Force believes it will be difficult to reduce shelter and facilities costs by this amount.

The primary attribute of the carry hard system is the ability to adapt the system to an increased threat. If the Air Force is successful in reducing the cost per shelter, then as the threat increases, more silos could be added to absorb the increased threat at a relatively low cost, compared to other concepts being considered. According to the Defense Science Board, if silos could be constructed at a cost below what it would cost to build additional attacking warheads, the carry hard concept would become a credible basing mode. The program office estimates that the carry hard system could be adapted to provide an adequate level of survivors against an increased threat at a cost substantially less than the superhard system.

Shallow Tunnel

The shallow tunnel concept is to deploy 50 missiles in 50 shallow tunnels, each about 23 miles long. The entire length of each tunnel would be hardened. Each missile is carried on a transporter-erector-launcher which periodically relocates the missile, and can move within the tunnel on warning to further enhance survivability. Because of the uncertainty of the missile's location within the tunnel, the attacker must target the entire length of each tunnel. This system would require about 1,230 square miles of land acquired from private ownership or, the dedicated use of government land. It would be based in the southwestern United States and cost about \$27.9 billion in 1985 dollars. The first missile would be deployed about 5-1/4 years after authority is given and all missiles would be deployed about 8-1/4 years after the decision.

The program office, in its Peacekeeper Basing Evaluation Report, identified shallow tunnel land requirements and acquisition costs as critical limitations. The majority of the land required for this system is used as a buffer zone to maintain location uncertainty of the missiles within the tunnel. Tests are planned to attempt to reduce the land necessary for operation of the system. Measures are also being examined to reduce the system's acquisition cost.

The shallow tunnel's survival is based on location uncertainty. One advantage that the shallow tunnel has when compared with the carry hard concept is that, if the location of the missiles is identified through the use of sensors or other forms of surveillance, the missiles in the tunnel have the capability to dash on warning, and the attacker must still target the entire length of each tunnel. With the carry hard system, if the missiles are located, they can be individually targeted.

The outstanding feature of the shallow tunnel concept is its resilience to an increase in threat. When the threat is increased, the length of the tunnels can also be increased, which creates more targets for the enemy to attack. The program office estimates that the tunnel concept could be designed to provide an adequate level of survivors against an increased threat at a lower cost than either the superhard or carry hard systems against an increased threat.

Estimated Life Cycle Cost for Deployment of 100 Peacekeeper Missiles

As previously discussed, the Air Force is planning for the deployment of 100 Peacekeeper missiles—deployment of 50 Peacekeeper missiles in Minuteman silos is underway, and 8 alternative basing modes for an additional 50 missiles are being studied. As illustrated in table 3.4, the preliminary estimated life cycle costs for a combined force of 100 Peacekeeper missiles range, for the 8 alternatives, from \$27.6 billion to \$56.5 billion, in 1985 dollars.

Table 3.4: Life Cycle Cost Estimates for Deployment of 100 Peacekeeper Missiles^a (1985 Dollars)

Dollars in Billions

Alternative Basing Concepts	Acquisition			Operations and Support			Life cycle costs
	Current program ^b	Alternative basing ^c	Total	Current program	Alternative basing	Total	
Hardened Minuteman	\$19.1	\$5.6	\$24.7	\$1.9	\$1.0	\$2.9	\$27.6
Superhard silos	19.1	6.7	25.8	1.9	1.0	2.9	28.7
Superhard silos with concealment	19.1	16.3	35.4	1.9	1.4	3.3	38.7
Rail mobile	19.1	16.6	35.7	1.9	6.7	8.6	44.3
Shallow tunnel	19.1	27.9	47.0	1.9	2.5	4.4	51.4
Ground mobile	19.1	27.3	46.4	1.9	4.5	6.4	52.8
Deep basing	19.1	30.4	49.5	1.9	3.4	5.3	54.8
Carry hard	19.1	31.3	50.4	1.9	4.2	6.1	56.5

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^aWe compiled life cycle cost estimates, in 1985 dollars, using program office estimates of acquisition costs and annual operations and support costs. Annual operations and support costs were multiplied by 12.5 years—10 years of steady operations plus a build-up-period—to calculate total operations and support costs. Program officials stated that our estimates of life cycle costs may not be meaningful because the operations life of the Peacekeeper has yet to be established. We recognize this limitation but feel that an indication of life cycle costs is useful.

^b\$19.1 billion in 1985 dollars equals \$16.1 billion in 1982 dollars, as shown on page 31. This estimate includes funding for acquisition of 223 Peacekeeper missiles, including 100 for deployment.

^cThese costs are basing-related only; all missile acquisition costs are excluded.

Combined Force Issues

The Under Secretary of Defense, Research and Engineering, has stated that there is a requirement for at least 1,500 modern land-based warheads. The Congress has authorized deployment of 50 Peacekeeper missiles, with 500 warheads, in Minuteman silos, contingent upon attaining key milestones in Small ICBM development. Several missile configurations, deployable in various basing modes, are being considered, which could carry the remaining 1,000 modernized warheads—10 warhead Peacekeeper missiles, single warhead Small ICBMs, and two or three warhead mobile ICBMs. Affordability and the overall goals of ICBM modernization will be major considerations in determining if 1,500 modernized warheads will be deployed, the types of missile(s) to carry the warheads, and the appropriate basing mode(s) for the missiles.

Costs of Alternative ICBM Forces

Available cost data suggests that affordability/cost effectiveness will be a major issue in determining the number of modernized warheads to be deployed. Table 4.1 shows the life cycle costs of 2 of 24 available options for a combined force of 100 Peacekeeper and 500 Small ICBM missiles. These two options represent the least costly and the most costly combined force options under consideration. Thus, the life cycle cost of 50 Peacekeepers in Minuteman silos, 500 Small ICBMs in one of 3 mobile basing modes, and 50 Peacekeepers deployed in one of 8 alternative basing modes range from \$72.4 billion to \$108.6 billion, in 1985 dollars.

Table 4.1: Examples of Life Cycle Costs for Two Combined Force Options

(1985 dollars in billions)	
50 Peacekeepers in Minuteman Silos, Missiles for Testing, and Acquisition of 50 Additional Peacekeepers for Deployment in Another Basing Mode	\$21.0
500 Small ICBMs Deployed at Minuteman Sites	44.8
50 Peacekeepers Deployed in Hardened Minuteman Silos (Excludes Missile Acquisition Costs)	6.6
Total	\$72.4
50 Peacekeepers in Minuteman Silos, Missiles for Testing and Acquisition of 50 Additional Peacekeepers for Deployment in Another Basing Mode	\$21.0
500 Small ICBMs in Random Movement	52.1
50 Peacekeepers in Carry Hard Basing Mode (Excludes Missile Acquisition Costs)	35.5
Total	\$108.6

Preliminary cost estimates for the full range of various Peacekeeper and Small ICBM alternatives are shown in table 4.2. The estimates represent

the combined costs for 100 Peacekeepers (in the basing modes as displayed on p. 39) and 500 Small ICBMs (as displayed on p. 18). The cost of each of the three Small ICBM alternatives is shown in combination with each of the eight Peacekeeper alternatives. The cost of each Peacekeeper alternative includes the \$21.0 billion estimated life cycle costs for the currently authorized program to deploy 50 Peacekeepers in Minuteman silos.

Table 4.2: Life Cycle Cost Estimates for Deployment of a Combined Force of 1,500 Warheads

Peacekeeper Basing Alternatives	Combined Force of 100 Peacekeepers and 500 Small ICBMs on Hard Mobile Launchers		
	At Minuteman sites	Combined MM and random	Random movement
(1) Hardened MM Silos	\$72.4	\$74.6	\$79.7
(2) Superhard silos	73.5	75.7	80.8
(3) Deceptive superhard silos	83.5	85.7	90.8
(4) Rail mobile	89.1	91.3	96.4
(5) Shallow tunnel	96.2	98.4	103.5
(6) Ground mobile	97.6	99.8	104.9
(7) Deep basing	99.6	101.8	106.9
(8) Carry hard launchers	101.3	103.5	108.6

Other Mobile Missile Options

In 1983, the President endorsed, and the Congress approved, the recommendations of the President's Commission on Strategic Forces to develop a single warhead Small ICBM. In making its recommendations, the Commission clearly recognized that if survivability, basing, and other cost considerations are set aside, it would be more costly to deploy a force of single warhead Small ICBMs than an equal number of warheads on a force of multiple warhead mobile missiles. For example, a greater number of expensive guidance systems would be needed. Nevertheless, the Commission believed developing a Small ICBM would provide more options for survivable basing, since it would be compatible with either fixed or mobile deployments. Further, in its view, the Small ICBM would be stabilizing and would enhance the arms control process because the mobile single warhead missile would be less vulnerable and a relatively low value target.

In March 1986, however, the Air Force was directed by OSD to analyze the mobility characteristics of mobile launchers large enough to transport a two- or three-warhead missile. This analysis was begun in

response to concerns about the cost of the single warhead Small ICBM system. The Under Secretary of Defense, Research and Engineering, and some members of the Congress believe the potential cost savings warrant investigating mobile basing of multiple warhead missiles. The budgetary, land acquisition, and manpower savings could be substantial, depending upon the number of missiles needed and their deployment mode.

Table 4.3 shows the options for various mobile missile sizes and payloads. A larger payload requires a larger missile, and a larger missile would require a larger hard mobile launcher.

**Table 4.3: Mobile Missile Weight/
Payload Options**

Weight in pounds				
Missile weight	Payload weight	Missile length (feet)	Missile diameter (inches)	Payload description
30,000-33,000	1,000	46-49	46	one warhead
37,000	1,300	51-53	46	one warhead and penetration aids
45,000-49,000	1,600	51-53	51-53	two warheads
65,000	2,300	56-58	56-58	two warheads and penetration aids or three warheads
75,000	2,800	61-64	61-64	three warheads and penetration aids

The possible development of mobile, multiple warhead missiles raises new concerns. Increasing the size of mobile missiles to carry multiple warheads may be contrary to the basic strategic concept which led to the establishment of the Small ICBM program. This concept is based on the belief that deployment of a more survivable missile force would enhance stability and that movement in this direction would entail reduced dependence on large multiple warhead missiles. The Commission on Strategic Forces proposed the small single warhead missile in order to reduce its value as a target and to allow mobility that would make it more survivable than missiles in fixed silos. Since single warhead missiles can also be less threatening to the other sides' silos, the deployment of single warhead mobile missiles could encourage both sides to move toward more survivable forces without increasing the threat to the other side. On the other hand, placing multiple warheads on mobile missiles is a less costly means of deploying a given number of warheads. However, the increased size of the multiple warhead missile

may also reduce the mobility that made the single warhead missile survivable. The desirability of placing multiple warheads on mobile missiles depends on how mobile the launchers can be made, the potential cost savings, and other issues such as land availability.

Another consideration in the decision to deploy mobile ICBMs is the likelihood of achievements in arms control. Without some limit on the number of both sides' warheads, one side may be able to barrage the other's mobile ICBM deployment area, destroying a large part of the force. Such a limit could ensure the continued survivability of mobile ICBMs.

Peacekeeper Linkage to Small ICBM

In DOD's Authorization Act of 1984, Public Law 98-94, the Congress linked the Peacekeeper deployment schedule to the Small ICBM system. Specifically, no more than 10 Peacekeeper missiles may be deployed until

- demonstration of subsystems and testing of components of the mobile Small ICBM system and
- nuclear effects tests on the components and subsystems of the prototype HML basing system and fixed basing system have been carried out.

No more than 40 Peacekeeper missiles may be deployed until

- the major elements of the mobile Small ICBM have been flight-tested,
- the major elements of the prototype mobile Small ICBM have been designed and functionally integrated and the system has been validated,
- contractors for the full-scale development of a mobile Small ICBM system have been selected and contracts have been awarded to those contractors, and
- full-scale development of such a missile system has begun.

The Air Force has been conducting tests according to the provisions of the law. However, the law requires flight testing of a small missile weighing no more than 33,000 pounds. This restricts the Air Force's options unless the Congress agrees to revise or remove the restrictive language.

Observations

ICBM modernization continues to be a topic of controversy after several years of debate. In the spring of 1983, it appeared that the acceptance of the recommendations of the President's Commission on Strategic Forces, calling for deployment of 100 Peacekeeper missiles in Minuteman silos and development of a single warhead Small ICBM, had calmed the debate. However, this apparent consensus was short-lived. Perceived vulnerability of the Peacekeeper in Minuteman silos led the Congress to take action to reduce the number of Peacekeeper missiles to be deployed in Minuteman silos, from 100 to 50. Since DOD has requirements for 100 Peacekeepers, the search for survivable basing for Peacekeeper missiles was renewed. The perceived high cost of deploying and maintaining a force of 500 Small ICBMs led to discussions of its affordability. Recently, studies of large mobile missiles to accommodate two or three warheads as additions to, or as alternatives to, the single warhead Small ICBM have been initiated.

Important decisions for the ICBM modernization program are scheduled to occur in December 1986. The recently initiated studies of multiple warhead, mobile missiles could have significant effects on these upcoming decisions, which involve (1) a full-scale development decision and the selection of deployment areas for the Small ICBM and (2) a preliminary decision on a basing mode for 50 additional Peacekeeper missiles. The design of the Peacekeeper missile is complete, and the Air Force expects to have 10 of the 50 approved missiles deployed by December 1986.

The President's Commission on Strategic Forces stressed that the two elements of ICBM modernization—the Peacekeeper and Small ICBM—and the approach towards arms control are integrally related. The Commission believed its recommendations would permit the United States, and encourage the Soviets, to move toward more stable ICBM deployments over time and in a way that is consistent with arms control agreements, thus reducing the risk of war. The Commission was unanimous that no one part of its proposal could accomplish this goal alone.

In recommending the development of a single warhead Small ICBM, the Commission believed the system would provide flexibility in terms of basing. In particular, a Small ICBM would provide options for mobile basing and therefore, be potentially more survivable than current systems. As a less vulnerable single warhead missile and a relatively low

value target, the Commission believed the Small ICBM would be stabilizing. The Commission recommended a single warhead Small ICBM, recognizing that an equal force of multiple warhead missiles would be less costly.

In recommending 100 Peacekeepers in Minuteman silos, the Commission believed these missiles were needed to replace the Minuteman and the Titan II ICBMs and to remove the Soviet advantage in ICBM capability.

The national consensus that the Commission's report seemed to achieve in 1983 has eroded. The following actions by both the Congress and the executive branch demonstrate this erosion as well as a move from the Commission report recommendations:

- DOD's Authorization Act of 1984 linked Peacekeeper deployment beyond 10 missiles to demonstrated progress in developing the Small ICBM system. The law restricts missile weight to 33,000 pounds.
- In 1985 the Congress reduced the number of Peacekeeper missiles to be deployed in Minuteman silos from 100 to 50. In addition, the Congress stipulated that no additional Peacekeeper missiles were to be procured for deployment unless a basing mode more survivable than Minuteman silos is specifically authorized by legislation.
- In 1985 the United States proposed, as an arms control position to the Soviet Union, a ban on mobile missiles such as the Small ICBM.
- The President, in 1986, ordered DOD to study the feasibility of mobile, multiple warhead missiles as part of the overall ICBM modernization program.

The successful deployment of the Small ICBM and the Peacekeeper in some survivable basing mode alternatives is dependent upon land being available for operational deployment, the number of missiles required, and their costs. The number of Small ICBMs to be deployed needs to be resolved and permission obtained for the co-location and joint use of the land with existing tenants. The land availability issues discussed in this report are based on deploying 500 Small ICBMs. If more than 500 missiles are needed, the land availability issues will intensify; if less than 500 are needed, the issues will be reduced. Many of the land use issues are outside the control of the Air Force and will require action by DOD and other executive agencies. It is conceivable that special actions by the Congress may be required.

For the Peacekeeper, large areas of land not currently controlled by DOD may be required, depending on the basing mode selected. This has been

identified as a critical limitation by the Air Force in its early assessments of some Peacekeeper survivable basing modes.

The survivable basing mode candidates for the Peacekeeper, likely to provide longer term solutions, are more costly and controversial. Likewise, the affordability/cost effectiveness of a force of single warhead Small ICBMs is a concern. Primarily, as a result of the latter, studies of mobile missiles to accommodate two or three warheads were recently initiated. These studies should deal with the multiple warhead missiles' impact on land and affordability issues, as well as with their survivability compared to the Small ICBM.

Determinations must be made on the most appropriate force mix of missiles which best serves military utility and the goals of stability and arms control—Peacekeepers, single warhead ICBMs, multiple warhead mobile ICBMs, or some combination thereof. Further, determinations must be made on which basing modes are most appropriate—existing silos, new hardened silos, mobile concepts such as hard mobile launcher basing, deceptive basing such as the carry hard concept, or some combination thereof. These and related issues need to be satisfactorily resolved so that ICBM modernization can proceed in a systematic and coherent manner.

Small ICBM Weapon System Description

The Air Force is pursuing research and development of a new single warhead Small ICBM to be based in such a way that an enemy could not be confident of a successful attack on the system. Among the concepts being considered, the Small ICBM could be based in mobile launchers or fixed silos hardened to withstand effects of a nuclear blast or a combination of both. This description deals with mobile deployment of Small ICBMs, which is the focus of this report.

Operational Concepts

The mobile-based Small ICBM could be located on several DOD and DOE installations, existing Minuteman sites, or some combination thereof.

Basing the Small ICBM at DOD and DOE installations involves the periodic movement of small missiles on mobile launchers at different locations on those installations (called random movement basing). This random movement would add to the survivability of the missiles, as an enemy would not know where the missiles were at any point in time. During times of increased tension, the missiles on their launchers are dispersed over an area approximately twice as large as the day-to-day deployment area (called command dispersal), still within the confines of the DOD/DOE installations. When directed by an appropriate authority, the missiles can disperse off the DOD/DOE land for greater survivability (called attack dispersal).

At the Minuteman sites, the missiles will remain parked on a day-to-day basis and disperse over large land areas only when directed by appropriate authority.

Missile Description

The Small ICBM is a three-stage missile weighing about 30,000 pounds, with a single reentry vehicle and a range of 6,000 miles. Deployed in mobile launchers, the Small ICBM will have capabilities for prompt response, hardened target destruction, rapid retargeting, and post-attack endurance.

The three missile stages will use a high energy solid propellant. The rocket motor cases for each stage will be made of a graphite/epoxy composite and the nozzles will be made of a carbon-carbon composite. Forward of the three rocket stages is a post boost vehicle, which will contain both the guidance system and reentry vehicle, plus several small liquid-propellant thrusters used to precisely deploy the reentry vehicle.

The reentry vehicle and guidance system are adaptations of the Mark 21 reentry vehicle and Advanced Inertial Reference Sphere used on the Peacekeeper missile. The modifications to the guidance and control system are to reduce its weight. This modified system, besides providing missile guidance, could also be used for ground navigation for the mobile launcher.

HML Description

The Small ICBM mobile launcher is a nuclear hardened, separable, tractor-trailer vehicle powered with about a 1,200-horsepower engine and operated by a two-member crew. The vehicle has a gross weight of about 185,000 pounds and is capable of on-road speeds of up to 60 miles per hour. The missile is carried on the trailer (launcher) in a canister, which contains the components necessary to cold launch the weapon.

To achieve its hardened condition, the trailer is lowered to the ground and digs into the surface soil. The digging in of the launcher, combined with its shape, provides blast-hardness in addition to stability for missile launch. The tractor then separates from the launcher and moves away. The missile is now ready for launch. On command, the canister pivots to vertical and launches the missile. Upon clearing the canister, the missile ignites its first stage.

The launcher also contains the equipment necessary to keep the missile on alert, report operational status, and receive and execute launch commands. The two-member crew uses the tractor to move the launcher, as directed, to enlarge the area of deployment and establish launch readiness, but they do not participate in launching the missile.

Command and Control

Operational control of the Small ICBM is provided by communications between the weapon system and higher authorities. During peacetime, fixed launch control centers will direct normal operations. The control centers will be located at main operating bases for a random movement complex and within each wing at the Minuteman sites. Each center will have multiple radio and landline links with higher authorities. The control centers will be capable of receiving or transmitting digital and voice messages through a radio network that also provides intra-wing communications.

Ground mobile launch control centers will be the primary post-attack control centers. They will normally be inactive in peacetime, but could be made active for testing or back-up as necessary. The mobile control

centers will be similar to commercial tractor-trailers, but with hardening against high altitude nuclear blasts. These vehicles will be deployed away from the main operating bases and Small ICBM deployment areas.

Security Concepts

Small ICBM security will be provided by three methods: barriers on the launchers delaying or denying access, armed launcher crews, and security response teams dispersed throughout the bases. The launcher's delay/denial device and the launcher crew are intended to prevent unauthorized access to the warhead until a security response team can arrive at the location.

The launcher crews are to provide the initial response to any attempted intrusions of the mobile launcher or the missile itself, when based at the random movement complex. Launcher crews provide security for each Minuteman launch facility and for launchers based at the Minuteman complexes. The hard mobile launcher will be protected against small arms fire, as will the crew support areas at the Minuteman launch facilities.

Security response force facilities will be in the deployment area, including some co-located at the launcher maintenance facilities. Each facility will have a security response team to respond to alarms.

The hard mobile launcher in random movement mode is deployed in complexes consisting of a main operating base and one or more large DOD/DOE reservations on which the launcher is deployed. Because the deployment area supported by the base is not necessarily contiguous, there will be times (as is the case at the Minuteman sites today) when nuclear assets would have to be moved on public roads. Movement of the hard mobile launcher on public lands will require a security escort. While on public land, within the coverage of the security response force, a "safety" team escorts the launcher. Outside the range of the security response force, escorting the mobile launcher will require a 15-member security team.

Description of Alternative Peacekeeper Basing Concepts

Rail Mobile

The rail mobile basing concept involves deploying 50 Peacekeeper missiles on 50 trains operating on 18,250 miles of commercial rail in the North Central United States. According to the program office, this concept poses an overwhelming public interface dilemma.

The rail mobile system does offer good resilience to an increase in threat. As the capability of the attacking weapons or the number allocated increases, the number of miles of rails could be increased to offset the new threat.

Deep Basing

Deep basing would provide basing for 50 Peacekeeper missiles at a depth of about 4,000 feet, supported by 2 operational control centers. Each control center would support 25 missiles and have tunnels providing egress to about 1,200 feet from the surface. In order to launch, excavation equipment must bore to the surface to complete the tunnel.

Technical uncertainty remains about developing the necessary environmental controls for the personnel within the control centers, and about the ability to excavate the remaining overburden after receiving notice to launch. The program office estimates that it would take between 36 and 60 hours to bore through to the surface after receiving the command. As a result, the concept fails to satisfy the Peacekeeper's requirement for prompt response.

Ground Mobile

The ground mobile basing alternative involves deploying 50 Peacekeeper missiles on 50 HMLs deployed over an area of 3,900 square miles on DOD installations. The vehicles would be 125 feet long, 43 feet wide, and weigh about 1.5 million pounds with the missile. The vehicle would require about 4,700 miles of specially built roads, would periodically relocate to maintain location uncertainty, but is not intended to dash on warning.

The program office stated that this concept has a number of critical limitations which include vehicle size, land requirements, and life cycle cost.

Hardened Minuteman

The hardened Minuteman basing concept involves deploying 50 Peacekeeper missiles in 50 Minuteman silos. The silos would be hardened to the extent their current architecture will allow. The primary attribute for this basing mode is the low life cycle cost, about \$6.6 billion

Appendix II
Description of Alternative Peacekeeper
Basing Concepts

in 1985 dollars. The program office identified as critical limitations the fact that this concept does not adequately add to survivability, nor does it address the concerns of the Congress.

Existing Minuteman

The Air Force is not studying basing the second 50 Peacekeeper missiles in Minuteman silos; however, it still considers this an option. The Air Force estimates that the cost of basing the second 50 Peacekeeper missiles in Minuteman silos would have an acquisition cost of about \$2 billion, which includes the cost of the last 50 missiles, refurbishment of the Minuteman silos, and military construction.

Glossary

Barrage Attack	An attack using nuclear weapons to cover a large area, referred to as barrage area, with a given severity of blast and/or thermal nuclear effects.
Blast Hardness	The resistance of a possible target to the effects of a nuclear blast.
Buried Trench	A Peacekeeper basing mode considered during the mid-1970s.
Cold Launch	The use of a gas generator to build up steam pressure inside a canister housing a ballistic missile which forces the missile out of the canister prior to the ignition of the first stage rocket motor. The temperature of the steam used to eject the missile from the canister is substantially less than the rocket motor exhaust and hence the term "cold launch."
Concept Definition	A weapon system development phase used to assess ideas in sufficient depth to identify best ways to satisfy program objectives.
Dash	A concept in which missiles on vehicles are dispersed rapidly upon receipt of warning that an attack appears underway.
Deployment	The movement of forces to the desired areas of operation.
Deployment Area	Designated location of area of operations.
Dispersal Area	The total land area (expressed in square miles) a force of mobile small ICBMs could occupy after dashing on tactical warning.
Endurance	The ability, over a protracted period of time, to operate as desired and cause the specified damage to the enemy.
Fixed Deployment	Missile deployment in which missiles are based in fixed launchers such as silos.

Glossary

Fratricide	The destruction or degradation of the accuracy and effectiveness of an attacking nuclear weapon by the nearby explosion of another attacking nuclear weapon. This phenomenon would decrease the effectiveness of an attack on closely spaced targets, such as missile silos.
Guidance and Control System	The guidance system evaluates flight information, correlates it with target data, determines the desired flight path of the missile, and communicates the necessary commands to the missile flight control system. The control system serves to maintain attitude stability and to correct deflections.
Hardened Targets	A location that provides protection against the effects of nuclear explosions, such as a hardened missile silo.
Hardness	The resistance of a possible target to the effects of enemy nuclear weapons. The often discussed hardness of missile silos is usually measured in pounds-per-square-inch (psi) of blast pressure.
Hard Parts	Electronic parts designed to withstand the effects of nuclear radiation up to a certain level.
Initial Operational Capability	The date on which a small number of weapon systems is turned over to the commander of a military force for incorporation into the operational forces of the United States.
Mk 21 Reentry Vehicle	An improved reentry vehicle to be used on Peacekeeper and Small ICBM missiles, designed to be more accurate than the MK 12A reentry vehicle used on Minuteman ICBMs.
Mobile Deployment	Missile deployment in which missiles are based in mobile launchers.
Penetration Aids	Equipment, such as decoys, carried on a missile specifically to assist the reentry vehicle(s) to get through ballistic missile defense.

Glossary

Pre-Full Scale Development	A weapon system development effort following concept definition leading to selection of single designs for full-scale development like a single missile or launcher design.
Post Boost Vehicle	That section of a ballistic missile which fits between the main rocket stages and the reentry vehicle(s). It carries the reentry vehicle(s) and directs each toward its target.
Reentry Vehicle	That part of a ballistic missile (warhead and protective shell) designed to reenter the earth's atmosphere in the terminal portion of its trajectory.
Shock Tubes	Long tubes constructed to test scale models simulating the air blast effects of a nuclear explosion.
Soft Parts	Electronic parts not protected against nuclear radiation effects.
Strategic Warning	A notification that enemy initiated hostilities may be imminent. This notification may be received from minutes to hours, to days, or longer, prior to the initiation of hostilities.
Superhard	Strengthening of a silo structure to withstand blast pressures of several thousand pounds per square inch.
Survivability	The capability of a system to withstand an unnatural hostile environment (man-made) and not suffer abortive impairment of its ability to accomplish its designated mission.
Survivable Basing	Ballistic missile system basing mode(s) which denies an enemy confidence of a successful attack.
Tactical Warning	Notification that an enemy has initiated hostilities.

Glossary

Triad

The U.S. strategic nuclear force which consists of land-based ICBMs, submarine-launched ballistic missiles, and manned bombers.