ICBM BASING OPTIONS

A SUMMARY OF MAJOR STUDIES TO
DEFINE A SURVIVABLE BASING CONCEPT
FOR ICBMS

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for
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PREFACE

The purpose of this report is to make available to the general public an unclassified summary of the rationale and system evaluation considerations that led the U.S. to decide to deploy the M-X intercontinental ballistic missile (ICBM) in a multiple protective structure (MPS) basing mode.

The search for survivable ICBM basing concepts' beyond our Minuteman basing, started in the mid-1960's when technology pointed to the eventual vulnerability of fixed targets. It received initial emphasis when the Soviets deployed the SS-9 missile aimed at destroying our ICBM launch control centers -- an act clearly indicating their intent to be capable of attacking and destroying our military forces. Further threats developed, centered around Soviet deployment of a new generation of accurate, multiple warhead missiles. In response, we pursued technology advances and system design studies which led to various proposals to start full scale development on a survivable M-X system -- the step involving final design and setting the basis for production and deployment. This step was finally taken in September, 1979.

Much discussion with the Congress and the public has taken place in recent years, both in terms of environmental and public interface matters and in terms of the military adequacy of the M-X/MPS system.

After extensive evaluations and presentations to Congress to fully examine optional courses of action, as called for in the Fiscal Year 1980 Defense Authorization Act (the Stevens Amendment), the Fiscal Year 1981 Defense Authorization Act specifically approved our final system recommendation of a 4600 shelter M-X/MPS system (the Cannon Amendment).

A major environmental impact analysis has been conducted. In public review and process at present is a draft of the third environmental impact statement (EIS) which focuses on basing area selection, public land withdrawal, and/or private land acquisition. Full system basing in Nevada/Utah or Texas/New Mexico and split basing in both areas are addressed. Two previous EISs were issued. For 1976 we issued one concerned with a test site effort in Arizona. In 1978 we issued an EIS which analyzed, in depth, the alternate, reasonable basing modes. By reasonable, it is meant that the concept has to satisfy national policy and military performance objectives.

This report summarizes all the concepts that received serious attention in past studies, but not all of them are reasonable by the above definition. None of the alternatives are without problems of one sort or another, but alternatives that are not reasonable and do not provide adequate capability pose the most serious problem of all -- an increased risk of nuclear war with the Soviets.

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INTRODUCTION

This report addresses the following questions:

1. Why does the U.S. need a new ICBM basing system?
2. What alternatives have been studied?
3. What is the basing system that has emerged from this process?

Fundamental questions have been raised about the need for maintaining a viable ICBM force and about the particular selection of the MPS basing mode. In order to address these questions in the total strategic force context, it is worthwhile to begin with a background discussion on the nature of our strategic forces.

Our strategic nuclear forces consist of three elements - the strategic triad. We have about 1,000 land-based intercontinental ballistic missiles, ICBMs; about 650 submarine-launched ballistic missiles, SLBMs; and about 350 B-52 bombers carrying a variety of weapons and with cruise missiles to be deployed on some of them starting in late 1982.

The three methods of deploying the force – land-based, sea-based, and air-based – derive from concepts originally formulated in the late 1950's. The considerations that went into the selection focused on technical and cost practicality and the need for diversity in technical characteristics. The diversity gives us two major benefits. First, it allows us to have confidence that if one of the Triad's three legs develops technical troubles, the other two can function, since they are independent. Secondly, diversity forces the Soviet Union to spread its countermeasure and defensive efforts over a wide range of threat characteristics, so that no single effort can threaten our total force.

The principal mission for our strategic forces is to deter nuclear war with the Soviet Union. If this deterrence fails, the forces must be capable of attacking and destroying key targets in the Soviet Union in order to end the war quickly and insure the most favorable postwar situation for the United States. To achieve these objectives, it is essential that our forces be unquestionably viewed as being alert, militarily capable, and usable in a counterattack even if the Soviets attack first and destroy an appreciable fraction of them.

Our forces not only protect the United States, but are vital to the interests of our allies and friends. In the Free World, only the United States is able to afford the expense of maintaining adequate strategic forces to hold the Soviets in check. Our friends and allies depend on this protective umbrella. In turn, we depend on them to help pay the price of maintaining an adequate balance of conventional non-nuclear forces to offset those of the Soviets, the Warsaw Pact, and others.

In past years, our force structure and our programs provided for very comfortable margins of superiority over the Soviets. During the last decade, however, the Soviets have spent enormous amounts of money to upgrade their military capability, while we reduced spending and depended on benefits from earlier investments made in the 1960's. For example, during the 1970's the Soviets outspent us by about $250 billion in research, development, and purchase of military equipment. In ICBMs alone, they outspent us by about $45 billion. Projections for the 1980's are that the Soviets will continue this pace and outspend us by, perhaps, $300 billion. As a result, our margins are no longer adequate, and it is necessary to modernize our forces. We are planning to do this across the board. Our bomber fleet will be enhanced by the addition of cruise missiles in 1982. This step will overcome many of the problems we see arising from deployment of new Soviet air defenses. In October 1979, we started deploying new, longer range, and more effective missiles in our current submarines, and our new Trident submarines will soon begin sea trials. These two steps enhance our sea-based forces. But, in addition, we must now start to eliminate a critical and growing deficiency - the vulnerability of our ICBMs.

The most disturbing feature of the continuing Soviet strategic force buildup is that our Minuteman and Titan ICBM forces, which are based in hardened, reinforced concrete silos, will soon lose their ability to survive a nuclear attack. This danger results from the improved accuracy of a newly deployed generation of Soviet ICBMs. The warheads on these missiles are large enough and accurate enough to destroy any fixed target in the United States. They will be deployed in large numbers and could allow the Soviets to shoot two warheads at each of our ICBM silos while still leaving the Soviets with many thousands of large, accurate ICBM warheads to use against other targets in the United States.

However, vulnerability of our ICBMs does not mean the United States is now vulnerable. We will still have our bombers and submarine-launched missiles to retaliate against the Soviets, if they attack. But deterrence depends on what the Soviets think about the matter. The arithmetic of nuclear war depends on what the Soviets believe about our forces and resolve, and what they believe about their own capabilities. The opportunities for miscalculation in this complex problem, and the consequences of miscalculation are both too great to take chances.

So, how should we respond to the threat to one leg of our strategic Triad? Some argue that we should ignore it and avoid paying the price of restoring the survivability of our ICBMs. Instead, they say, why not depend just on our SLBMs and bombers? This approach has two principal flaws:

1. By abandoning our ICBMs we would concede an important advantage in international perceptions to the Soviets. The appearance of unwillingness by the United States to react to a severe threat to its national security would be the wrong signal to send to an adventurous, aggressive competitor such as the Soviet Union. Lack of action might cause us to have to pay a high political price, if the Soviets exploited the situation.

2. By not having a strong ICBM system we would concede a military advantage to the Soviets by easing the problems they face as they pursue military programs which can result in superiority over us. The Soviets might thus achieve superiority simply by our inaction.

Each leg of our strategic Triad has unique characteristics both in terms of military offensive capability to enforce deterrence and invulnerability to various types of attack. The fact that there are no common vulnerabilities in the three legs gives the Soviets a virtually impossible targeting problem, if they try to disable all of our strategic forces. Additionally, the strategic Triad provides us with a hedge against two realistic and serious technical risks. The first is the development of operational or technical problems that can temporarily disable some of our equipment. Such problems have occurred in the past, fortunately not often, but when they did, the existence of the other two legs continued to provide a temporarily adequate level of deterrence while the problem was being repaired. The second risk can occur over a longer time period, when a technological breakthrough or rapid change in the threat erodes the survivability of one of the Triad legs. Having the mix of systems provides the necessary time to eliminate the vulnerability in a rational, deliberate manner.

Right now, we are in this latter position with our present ICBM force. Even though we expect our ICBMs to become vulnerable in the early 1980's, we have high confidence in the capability of our other strategic deterrent forces, allowing us time to restore the survivability of our ICBM force. But, if we do not correct the ICBM deficiency, the Soviets will be able to concentrate their efforts to undermine our SLBM and bomber forces more easily and likely sooner. This situation would increase the risk of the Soviets developing a surprise advantage and lead to a possibly dangerous gap in deterrence. We must, therefore, fix our ICBMs soon enough so that we do not give the Soviets sufficient time to concentrate on developing counters to our other strategic systems.

The M-X program is designed to restore our ICBM capability by deploying a new missile in a survivable basing mode - one which makes attacks by the Soviets highly unprofitable for them. Our design would cause them to lose ground in an attack by having to use more of their warhead inventory in the attack than the number of our warheads they might destroy. By making this outcome obvious to them, we insure that they will not try an attack - this is an essential element of deterrence.

Over the last decade many alternate basing concepts have been evaluated for M-X. This report describes each of these concepts briefly and summarizes their evaluations using common criteria.

EVALUATION

EVALUATION CRITERIA

There are eleven criteria as follows:

(1-3) Survivability, which encompasses the following three factors:

1. Susceptibility to responsive threats – The system should not be so fragile that its survivability could be jeopardized by threats that the Soviets might likely field in response to our deployment of the system.
2. Independent survivability mode from the other two legs of the Triad – No two legs of the Triad should be susceptible to failure from the same vulnerability.
3. Endurance – Prolonged post-attack endurance is very desireable so that U.S. retaliation can be deliberately and carefully measured. Endurance, as used in this report, does not consider the type, size, or tactics of possible responsive threats

(4-6) Operational Feasibility, based on the following three criteria:

4. Public interface – Nuclear weapon systems should be highly isolated from the public.
5. Security – The system should not be vulnerable to terrorist or paramilitary attacks.
6. Operability – The system should be readily operable by the military using accepted practices and organizational methods. It should be capable of meeting military mission objectives derived from national policy objectives.

(7-11) Other Criteria:

7. Technical risk The system should require no technical breakthroughs and should embody no phenomenology that cannot be adequately analyzed or tested.
8. Environmental impact – The system should not absorb undue amounts of land, should not deplete precious resources, cause unacceptable defacing of natural terrain, nor cause harmful public dislocations and burdens.
9. Cost – Cost is judged relative to the baseline M-X MPS system.
10. Schedule – Schedule is judged relative to the baseline M-X MPS system.
11. Arms control treaties – In this document the consistency with, and restrictions of, arms control treaties are noted. Details of verification, per se, are not discussed because of their classified nature.

EVALUATION OF INDIVIDUAL CONCEPTS

Each concept will be briefly described, then evaluated according to the forelisted eleven criteria. The evaluations will be standardized to one of the following four grades:

1. Negative Feature X
2. Major Negative Feature **X**
3. Satisfactory ✓
4. Major Positive Feature **✓**

Major negative features and major positive features are those considered to be the driving factors in evaluating the system. Features that are graded simply negative or satisfactory are those judged to be of lesser importance; i.e., not key in accepting or rejecting the system. In the interest of brevity, only the major negative features and major positive features will be described.

SUMMARY OF RESULTS

Concept descriptions and major positive and negative features are summarized on Table 1. Table 2 (last page of document) summarizes all eleven evaluation criteria for each of the thirty concepts.

Table 1. Summary of Basing Alternatives

System Concept	Description	Evaluation	
		Major Positive Features	Major Negative Features
NO REBASING			
Launch Under Attack (LUA)	• Launch Minuteman force when early warning systems assess attack in progress	• Low cost • Near term • Public interface* • Environmental impact* • Cost* * = no change from present operations	• Vulnerable to attacks on warning and C^3 systems • Requires warning • No endurance • Extremely short decision time • Catastrophic false alarm problem
Orbital Based	• New booster in Minuteman silos • On warning, launch weapons into orbit • On command, deorbit to attack or recover	• Low cost	• Vulnerable to attack in orbit • Requires warning • Accuracy insufficient for hard targets • False alarm means loss of capability • Orbital weapons violate space treaty
WATER-BASED			
Shallow Underwater Missile (SUM)	• Fasten two or more M-X encapsulated missiles to submarines that patrol off U.S. coast	• Minimal public interface • Minimal environmental impact	• Same survivability mode as Trident but probably inferior • Advanced technology subsystems • Early 90's for earliest IOC (with new submarines)
Hydra	• Scatter missiles in the ocean on strategic warning from ships or submarines • Water-proof missiles float unattended until commanded to launch, or recovered	• Minimal environmental impact	• Localization/destruction of missiles by trailing ships or airplanes • Strategic warning required • Capture of unmanned missiles • False alarms, recovery, operating environment problems
Orca	• Anchor encapsulated missiles to offshore sea bed	• Long endurance • Minimal public interface • Minimal environmental impact • Low cost	• Can't check status without revealing location • Violates seabed treaties
Ship – Inland	• Carry canisterized missiles on barges that move continuously along inland and coastal waterways	• Low environmental impact	• Available waterway length insufficient to withstand expanded attack • Interference with commercial traffic
Ship – Ocean	• Carry missiles on special vessels moving randomly on oceans	• Minimal public interface • Minimal environmental impact	• Trailing ships or aircraft can localize and destroy • Accuracy insufficient for hard targets

Table 1. Summary of Basing Alternatives (Continued)

System Concept	Description	Evaluation	
		Major Positive Features	Major Negative Features
AIRCRAFT-BASED			
Sea Sitter	• Large amphibian aircraft carries ICBMs • Plane flies over ocean, landing randomly for extended periods of time	• Minimal public interface • Minimal environmental impact	• Trailing of airplanes, followed by attack while sitting • Low endurance • Weather problems, particularly with high seas • High cost • Accuracy poor
Wide Body Jet (W.B.J.)	• Launch missiles from C-5 or 747 class aircraft • Aircraft operate on ground alert like bombers • Option for continuous airborne operations		• Requires warning • Endurance limited to hours • High cost, particularly for airborne alert
Short Takeoff and Landing (STOL)	• Launch missiles from STOL type aircraft • Can access numerous landing sites with STOL capability • Aircraft operate on ground alert like bombers		• Requires warning • Attack on secondary dispersal sites limits endurance • High cost, particularly for airborne alert
Vertical Takeoff and Landing (VTOL)	• Launch small missile (single R/V) from VTOL aircraft • Aircraft operate on ground alert from numerous sites and have a "land anywhere" capability		• Requires warning • Very high cost • 90's for earliest IOC • Violates interim SALT II
Dirigible	• Carry ICBMs on fleet of dirigibles operating in a continuous airborne mode over oceans • Launch missile from dirigible	• Minimal environmental impact	• Easy to track and attack • Nuclear safety precludes operations over CONUS • Weather limits operations
LAND-BASED, PROLIFERATION			
Midgetman	• Build several thousand small, hardened silos and fill each with a small ICBM	• Maintains essential features of ICBMs • Long endurance	• Excessively costly • Violates interim SALT II
LAND-BASED, SUPERHARD			
Hard Rock Silo	• Build silos in granite outcroppings in western U.S. • Design goal is to achieve highest possible hardness with surface-flush silo launchers	• Distinct survivability mode • Long endurance	• Defeated by evolutionary accuracy improvements
Hard Tunnel	• Store missiles in very deep, superhard tunnels which can withstand direct hits • Automatic digout and launch on command	• Distinct survivability mode • Long endurance • Minimal public interface • Good security • Minimal environmental impact	• Slow reaction after attack • Technical risk of self-contained digout machines • Hardness verification impossible

Table 1. Summary of Basing Alternatives (Continued)

System Concept	Description	Evaluation: Major Positive Features	Evaluation: Major Negative Features
South Side Basing	• Base missiles in horizontal shelters or vertical silos at the foot of south-facing mesa or mountain cliff • Mountain/mesa shields missile from Soviet ICBM attack arriving from north	• Distinct survivability mode • Long endurance • Low cost	• Vulnerable to responsive threats (low β R/Vs, SLBMs, MaRVs) • Limited suitable deployment area • Environmental impact, since sites in national parks
Sandy Silo	• Bury encapsulated missile in ~2000-foot-deep hole and cover with sand • Designed to survive direct hit • On command, pressurized water fluidizes sand and capsule floats to surface for launch	• Distinct survivability mode • Long endurance • Minimal public interface • Excellent security • Low cost	• Missile difficult to retrieve for maintenance • Feasibility of egress after a nuclear attack (untestable)
LAND-BASED, UNSHELTERED			
Commercial Rail	• Special trains move ICBMs over existing commercial railroads • Trains move randomly and park to launch	• Independent survivability mode • Long endurance possible	• Enemy might trail trains • Public interface problems of nuclear weapons on commercial railroads • Poor security
Dedicated Rail	• Build new automated railway for nuclear hardened trains carrying missiles • Trains move randomly and launch on command	• Independent survivability mode • Long endurance possible	• Trains could be trailed by remote sensors • Large public exclusion area (~90,000 square miles) • High cost
Off-Road Mobile	• Scatter fleet of off-road mobile transporter/launchers over large uninhabited areas of southwest U.S.	• Independent survivability mode • Long endurance possible	• Track and attack transporter locations • Large public exclusion area • Severe defacing of terrain
Ground Effect Machine (GEM)	• Scatter fleet of GEM transporter/launchers over large uninhabited areas of southwest U.S.	• Long endurance possible	• Track and attack transporter locations • Requires warning • Operational feasibility (gullies and other obstacles) • Severe dust erosion
Road Mobile (Minuteman)	• Use existing Minuteman on road mobile transporter/launchers • Base at existing Minuteman bases	• Long endurance possible • Low cost • Near term capability	• Track and attack transporter locations • Takes too long to move vehicles on warning (hours) • Requires warning • Questionable feasibility due to jammed roads
Road Mobile (New Missile)	• Parked on military bases, new ICBMs on transporter/launchers wait for attack warning • On command, transporter convoys move out over interstate highways and secondary roads	• Long endurance possible	• Track and attack transporter locations • Low survivability without hours of warning time • Requires warning • Questionable feasibility due to jammed roads

Table 1. Summary of Basing Alternatives (Continued)

System Concept	Description	Evaluation	
		..tive Features	Major Negative Features
LAND-BASED, TRENCH			
Covered Trench	• Unmanned transporter/launcher travels randomly in a trench that is covered with a concealing fabric	• Independent survivability mode • Long endurance • Automated operation	• Removal of cover *plus* vehicle immobilization by light precursor attack • Implanted sensors could localize missiles (decoys not feasible) • Large public exclusion area
Hybrid Trench	• Shallow buried tunnels with M-X missile on unmanned transporter • Transporter randomly moves to locations in tunnel that have been selectively hardened	• Independent survivability mode • Excellent security • Automated operation	• Implanted sensors could localize missiles (decoys not feasible) • Large public exclusion area
LAND-BASED, MULTIPLE PROTECTIVE SHELTERS (MPS)			
Dash to Shelter	• Missiles on transporters at center of radial road or rail network • Dash to hardened horizontal shelters on warning	• Long endurance	• Observation of transporter during transit • Requires warning • High speed movement of heavy transporter
Mobile Front End	• Build thousands of silos with a missile booster in each • Randomly mate a lesser number of expensive front ends (reentry vehicles, guidance system) to missiles • Conceal location of complete missile	• Independent survivability mode • Long endurance	• Cost much higher than comparable M-X/MPS • Probably inconsistent with interim SALT II
Pool	• Shelters are pools of opaque water • Transporter deposits water-tight encapsulated missile in pools • Operational concept similar to M-X/MPS	• Independent survivability mode • Long endurance	• Environmental impact (large water usage)
Minuteman/MPS	• Construct additional vertical silos in existing Minuteman silo fields • Use Minuteman or new missile that is randomly shuffled between silos	• Independent survivability mode • Long endurance	
M-X/MPS	• 200 missiles concealed among 4600 hardened horizontal shelters • Decoys simulate missile/launchers in "empty" shelters	• Independent survivability mode • Long endurance	

TERMS, GLOSSARY, AND ACRONYMS

TERMS

Accuracy

Our missiles can be targeted with great accuracy when they are launched from a point whose precise location is known. In the case of fixed, land-based launch sites, such as the present Minuteman system or the M-X Multiple Protective Shelter system, the location of the launch site has been surveyed and is known to within a few feet relative to the location of the target. No new information is needed at launch time.

In the case of any mobile system, it is essential to determine with great accuracy the precise location of the vehicle at the time launch takes place. Land-based mobile systems can make use of presurveyed bench marks located at close intervals over the area of their operation, especially if the carriers are limited to defined routes (roads, rails, waterways). Off-road systems present a more difficult problem of precise determination of location. Systems for which the ocean serves as the location for launch have a similar but more severe problem.

A possible solution for all mobile systems is to have the missile's trajectory corrected after launch, using precision location information determined by the Global Positioning System (GPS). The GPS is a system of satellites specifically designed to provide very accurate determination of both position and velocity by a triangulation procedure. For systems that are on or near land, it can be supplemented by a system of very accurately located ground beacons that also permit triangulation for precise determination of location.

The primary drawback of using GPS and/or ground beacons is that the satellites or beacons may be the first objects of enemy attack, leaving our ICBMs with severely reduced accuracy. It is preferable to keep the accuracy of the missile independent of any external information.

Warning

The United States has in place a number of effective detection and warning systems that are capable of reporting a variety of activities in the USSR, including the launch of missiles. These systems are intended to provide notice of an impending attack. However, if our first alarm is the actual launch of ICBMs in our direction, we will have, at most, half an hour to respond.

Several ingenious ICBM basing options scatter our ICBMs on warning. However, we would prefer a system that does not depend on warning. Our present ICBM force does not, whereas bombers necessarily do. For one thing, a scatter-on-warning system can be spoofed by a false alarm, scattering our ICBMs, perhaps exposing them to attack. For another, if the early warning system should fail for any reason, these ICBMs would be "sitting ducks" for a small number of warheads.

Hardness

If a component of an ICBM system is to survive an attack, it must be "hard" enough to withstand the effects of a nuclear explosion targeted by the optimum strategy against that given type of target. That is, if the component (say, a commercial-type vehicle or an aircraft) is "soft," an explosion at a considerable distance can damage or destroy it. If it is hard, like a Minuteman silo, the explosion must be very close before it will disable the silo.

Hardness is usually expressed in pounds per square inch of pressure a component can withstand; this pressure is highest at the center of the blast and drops off with distance, as shown in Figure 1. The blast pressure alone may not be the physical cause of the damage, which may be due to other nuclear effects such as heat and radiation, but it is a convenient measure for comparing different systems and for determining the required spacing of targets.

Since soft targets must be spaced farther apart than hard targets, the area they occupy is greater. Figure 2 shows how area increases with decreasing hardness for a given survivability. The large areas required by soft targets is an important factor in evaluating many ICBM deployment schemes.

Attack Strategies

In analyzing ICBM basing modes for survivability, we assume that an enemy will use the optimum strategy in targeting any concept to gain the highest probability of destroying most of the U.S. missiles.

If U.S. targets are moving, they are probably more or less soft. The Soviets could then use a barrage attack, spacing air bursts over the whole deployment area and close enough together so that the blast pressure everywhere is enough to kill the targets, no matter where they are.

Alternatively, if Soviet satellites are watching our mobile ICBMs and Soviet planners know how fast (but not in what direction) they will move, they could bracket the last known location with enough bursts to kill the target regardless of which way it moved. This job is easier if the targets have to stay on a known track (a railroad, river, etc.).

If U.S. targets are fixed, the attack strategy is easy; the Soviets target a warhead on each. Of course, if there are more targets than they can cover with their warhead inventory, the futility of attack or coercion through threat of attack dominates.

If many more of the targets are false than real, but they cannot distinguish which is which, they are faced with assigning a warhead against each (or two against each because they cannot expect all their missiles to hit their targets with certainty).

GLOSSARY

- Air Alert. Operational mode for aircraft where a fraction of the force is airborne at all times to decrease attack vulnerability.

- Airborne Launch Control Center. A force of U.S. aircraft which can communicate and launch Minuteman missiles from their silos and which will be able to launch the M-X missile force.

- Alert. A state of readiness indicating that an aircraft or missile can be launched promptly on command.

- Base. The locality or the installations on which a military force relies for supplies, or from which it initiates operations.

- Booster. The rocket motor, or motors, of a missile providing thrust for the launch and initial part of the flight.

- Canisterized Missile. A missile contained in and launched from a canister (capsule).

- Dash-On-Warning (Scatter-On-Warning). A missile operational mode whereby the missile carrier moves away from its normal station upon warning that an enemy missile attack has either been launched or is imminent.

- Decoy (Simulator). An object which is intended to be indistinguishable from a real missile when monitored by sensing devices.

- Deorbit. To supply sufficient energy to an object in orbit to cause it to descend to the earth.

- Deorbit Engine. The engine supplying deorbiting energy.

- Deploy. To extend and arrange military units to appropriate positions over an area.

- Dispersal Site (Dispersal). The area or locations to which missile carriers move in response to an attack warning.

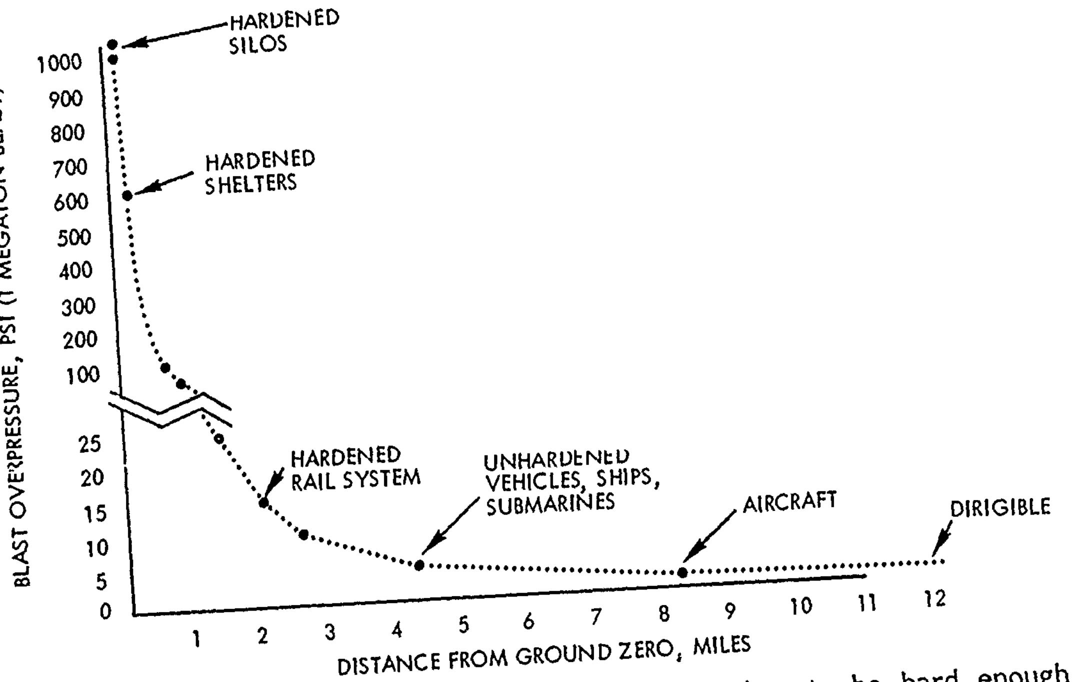


Figure 1. To survive a nuclear explosion, a target has to be hard enough to withstand the overpressure, which drops off rapidly with distance. There is always a choice between hardening the target or giving it a chance of being far enough away, or some of each.

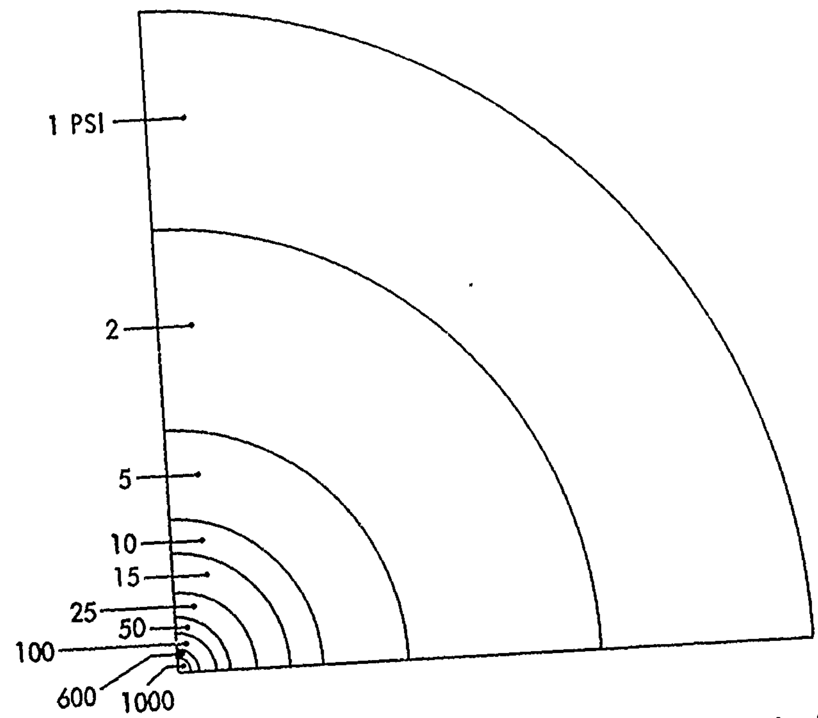


Figure 2. Deployment area required by a survivable system grows as the hardness of the shelters or carriers decreases. With 1-psi targets, a 1-megaton blast can demolish any target in an area of 441 square miles. With targets hardened to 1000 psi, the same blast is effective over only 3/10th of a square mile.

• First Stage Engine. The combination of chemical propellant and oxidizer which supplies energy to the initial stage of a booster (see booster).

• Front End. The combination of guidance device and reentry vehicle or vehicles which constitutes the payload of a ballistic missile (see reentry vehicle).

• Global Positioning System. A constellation of U.S. Air Force satellites which a vehicle on or near the earth can use to determine its position or location with a high degree of accuracy.

• Guidance System. A system which controls the course of a missile, usually by built-in mechanisms.

• Hard Target. An object which can withstand more than a nominal amount of explosive blast pressure. The term usually refers to a facility which has been designed to withstand nuclear detonations in its vicinity but not immediately next to it.

• Land Based Beacon System. A concept similar to the Global Positioning System in which the transmitting and receiving devices are deployed on land. Thus, the beacon system can be used by vehicles within line of sight to precisely locate their positions.

• Launch Control Center. A hardened underground facility from which Minuteman operators can control the launch of from 10 to 50 Minuteman missiles. More generally, the launch control facility for any land-based missile system.

• Launch-Critical. These elements of a missile system whose proper operation is essential to a successful launch.

• Launcher. The integral electronic and mechanical equipment needed to monitor, operate, and assist the missile in its launch.

• Leverage. For example, one ICBM hidden among twenty shelters and defended by one anti-ballistic missile (ABM) has a leverage of twenty compared to one ICBM based in a silo also defended by one ABM. The Soviets would have to attack every shelter while we would defend only the occupied shelter.

• Liquid-Fueled. A type of missile using liquid propellants and oxidizers as a source of energy and thrust.

• M-X. The missile defined for the M-X/MPS system. It is 70 feet long, 92 inches in diameter and weighs 190,000 pounds. It can deliver 10 reentry vehicles to a distance of more than 6,000 miles.

• Maneuvering Reentry Vehicle (R/V). An advanced type of R/V capable of altering its atmospheric reentry trajectory by manipulating its aerodynamic surfaces. Trajectory corrections can be initiated either by built-in sensors or by external means, such as satellite command (see reentry vehicle).

• Megaton. The nuclear explosive power equivalent to one million tons of a chemical high explosive, such as TNT.

• Minuteman (Minuteman II, Minuteman III). A U.S. Air Force intercontinental ballistic missile (ICBM). The missile has three solid propulsion stages which ignite and separate in sequence so as to place a reentry vehicle (R/V) or vehicles in ballistic trajectory above the atmosphere. The R/V reenters the atmosphere and impacts at the target point. Minuteman II has a single R/V. Minuteman III has three R/Vs which are independently aimed at three targets by a liquid-propelled fourth stage. Both types of Minuteman are based in hardened and dispersed facilities (silos) in the U.S. Midwest.

• Minuteman Wing. The largest grouping of Minuteman missiles located in one general area. A wing consists of three or four squadrons, each squadron containing 50 missiles in five flights of 10 missiles. There are six wings, with their headquarters in the states of Montana, South Dakota, North Dakota (two bases), Missouri, and Wyoming.

• Polaris. The first generation U.S. submarine launched ballistic missile (SLBM) system. The missile has two solid propellant stages. The range of Polaris is significantly less than that of an ICBM.

- Poseidon. The second generation U.S. SLBM system. The missile carries a number of reentry vehicles which can be independently aimed. Its range is more than that of Polaris but less than that of an ICBM.

- Precursor Attack. A nuclear missile attack initiated in advance of the main attack. A precursor attack might consist of a relatively small number of nuclear detonations designed to make the main attack more effective. An example would be detonations to disrupt communications.

- Radio Link. Those portions of a missile command or communication system involving radio transmission, or a type of missile guidance system involving radio command to a missile in flight.

- Random Move. An operational procedure for mobile missiles. It may involve instructions to proceed to a randomly selected destination, or instructions to proceed for a randomly selected time in a given direction, followed by a randomly selected change in travel direction.

- Reentry Vehicle (R/V). A vehicle that is propelled above the earth's atmosphere by a ballistic missile and then follows a trajectory that causes it to reenter the atmosphere.

- Reserve Buoyancy. A characteristic of a ship or submarine indicating how much more weight could be taken on before loss of buoyancy.

- Sonar. An apparatus that detects the presence and location of a submerged object by means of sound waves reflected back to it from the object.

- Shelter. In the context of this report, a hardened facility housing a missile, or possibly its decoy or transporter. A shelter can either house the missile in a horizontal or vertical position.

- Silo. A facility used to house missiles, especially the Titan and Minuteman missiles. The Minuteman silos are vertical cylindrical cavities dug into the ground and lined with concrete and steel. Their covers are approximately level with the surface of the ground.

- Spoof. A tactic whereby the U.S. is lured by false indications into expending some of its missile forces. For example, an enemy could simulate missile launches which might cause the U.S. to fire weapons into orbit.

- Strategic Air Command. That part of the U.S. Air Force which operates the nuclear armed inter-continental land-based missile force (Titan and Minuteman), the long-range bomber force (B-52 and FB-111 type aircraft) and certain long-range reconnaissance aircraft such as the SR-71 type.

- Strategic Warning. Some indication that an attack is imminent with the warning being received before the launch of such an attack. Strategic warning can be based on force movements, efforts to bring strategic forces to a high state of alert and by agent reports.

- Tactical Warning. An indication that an attack has been launched and which is received and transmitted to the targeted forces prior to enemy missile impacts. From the definition, tactical warning time cannot be greater than intercontinental missile flight time, usually considered to be 30 minutes. Shorter warning times are possible and likely if the attacking weapons are launched from submarines.

- Triad. The three elements of the U.S. strategic nuclear force – ICBMs, submarine launched ballistic missiles, and bombers.

- Trident. A third generation U.S. submarine launched ballistic missile with three solid stages capable of delivering independently targeted reentry vehicles to intercontinental distances.

• Van Dorn Effect. An effect generated by nuclear detonations in deep water adjacent to a continental shelf. The detonations could generate high velocity motions in the shallow waters above the shelf. Hence, a small number of weapons could cause severe damage to objects on the shelf or traversing the shallow waters of the shelf which adjoins the east coast of the U.S.

• Warhead. In the context of this report, the nuclear explosive device carried by the reentry vehicle of a ballistic missile.

• Warning System. The sensing and communication systems which gather indications of an imminent or actual enemy missile launch and which transmit such information to the National Command Authorities and then to the forces threatened by the attack.

ACRONYMS

ABM	Antiballistic Missile
AIRS	Advanced Inertial Reference Sphere
AMST	Advanced Medium Short Takeoff and Landing Transport
ASW	Anti-Submarine Warfare
EIS	Environmental Impact Statement
FY	Fiscal Year
GEM	Ground Effect Machine
ICBM	Intercontinental Ballistic Missile
IOC	Initial Operational Capability
LUA	Launch Under Attack
MIRV	Multiple Independently Targetable Reentry Vehicle
MLP	Mobile Launch Platform
MM	Minuteman
MM/MPS	Minuteman/Multiple Protective Shelter
MPS	Multiple Protective Shelter
M-X/MPS	M-X/Multiple Protective Shelter
psi	pounds per square inch
R&D	Research and Development
R/V	Reentry Vehicle
SAC	Strategic Air Command
SALT	Strategic Arms Limitation Talks
SLBM	Submarine Launched Ballistic Missile
STOL	Short Takeoff and Landing
SUM	Shallow Underwater Missile
TEL	Transporter Erector Launcher
T/L	Transporter Launcher
VTOL	Vertical Takeoff and Landing
W.B.J.	Wide Body Jet

CONCEPT DESCRIPTION/DISCUSSION AND EVALUATION

A brief summary of the thirty ICBM basing concepts is presented on the following pages. Each begins with an artist's rendition. An assessment of the relative ability of each concept to meet the eleven evaluation criteria leads to the identification of the major negative features and major positive features. An overview of the design and operating characteristics of each concept is also described.

LAUNCH UNDER ATTACK (LUA)

EVALUATION

SURVIVABILITY			OPERATIONAL FEASIBILITY							
RESPONSIVE THREATS	TRIAD INDEPENDENCE	ENDURANCE	PUBLIC INTERFACE	SECURITY	OPERABILITY	TECHNICAL RISK	ENV. IMPACT	COST	SCHEDULE	ARMS CONTROL
MAJOR NEGATIVE FEATURE	MAJOR NEGATIVE FEATURE	MAJOR NEGATIVE FEATURE	MAJOR POSITIVE FEATURE	NEGATIVE FEATURE	MAJOR NEGATIVE FEATURE	SATISFACTORY	MAJOR POSITIVE FEATURE	MAJOR POSITIVE FEATURE	MAJOR POSITIVE FEATURE	SATISFACTORY

X = NEGATIVE FEATURE
X = MAJOR NEGATIVE FEATURE
✓ = SATISFACTORY
✓ = MAJOR POSITIVE FEATURE

MAJOR NEGATIVE FEATURES

- Sensitivity to Responsive Threats
  - Attacks on Warning and C^3 Systems
- Failure to Maintain Independent Triad Survivability Mode
  - Requirement for Warning
- Endurance
  - None
- Operability
  - Extremely Short Decision Timelines
  - Catastrophic False Alarm Potential

MAJOR POSITIVE FEATURES

- Public Interface
  - No Change from Present Operation
- Environmental Impact
  - No Addition to Present Operations
- Cost
  - No Addition to Present Operations
- Schedule
  - Available Now

CONCEPT

A possibility for ICBM survival is to launch under attack (LUA); that is, as soon as our warning systems detect incoming Soviet missiles, we could fire some of our Minuteman missiles. These missiles would have to be pre-aimed at special targets since the limited time available for assessment of the scope of the attack and retargeting of our missiles to respond in kind precludes anything but execution of previously prepared options.

DESCRIPTION/DISCUSSION

Launch of enemy ICBMs can be detected by radar and satellites. The observations of the various sensors are transmitted to sensor processing sites for interpretation. Information such as number and origin of launches, predicted impact points, and missile flight times, can be derived to some extent from the raw sensor data.

Processed sensor information then would be sent to various command centers, such as the National Command Authorities, national military command sites, and the Strategic Air Command. A missile attack emergency conference would be convened using conference-communication networks connecting the various command centers. If launch were authorized, selected Minuteman launch control centers would be directed to execute the agreed-upon retaliation plan.

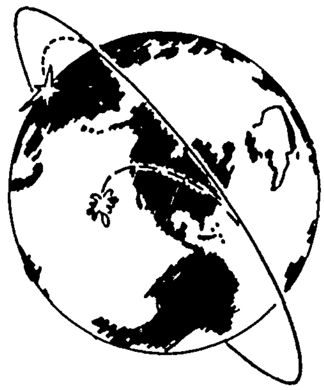
The chief merit of the LUA concept is that it introduces an element of uncertainty into an enemy's planning process. A U.S. capability for LUA, and uncertainty as to whether LUA was or was not a U.S. strategic doctrine, helps deter attack. Maintaining such capability is a U.S. policy.

The overriding problem with LUA is the timeline. It takes only about 30 minutes for Soviet ICBMs to reach the U.S. Subtracting out the time for threat assessment and the launch process, there would only be minutes for the President to make a fatefully important launch decision. For an SLBM attack by the Soviets, the available time for the whole process is only 5 to 10 minutes. Thus execution of launch under SLBM attack is essentially impossible.

Whether or not the Soviets believed that we have an LUA doctrine, they could try to jam and/or attack our early warning systems and communication networks. These systems and networks, located in various parts of the world and in space, are difficult to defend. Accordingly, the President might be forced to make a launch decision on the basis that our warning systems were not working, rather than on positive indications that Soviet ICBMs were in flight toward the U.S.

LUA is a good tactic for us to maintain, but it is a poor strategy to depend on solely. If we did depend on it, the Soviets would surely devise ways to blind our warning systems in a precursor attack, thereby inhibiting our ability and willingness to launch a retaliatory attack with only inconclusive evidence in our hands.

ORBITAL BASED



EVALUATION

SURVIVABILITY						OPERATIONAL FEASIBILITY				
RESPONSIVE THREATS	TRIAD INDEPENDENCE	ENDURANCE	PUBLIC INTERFACE	SECURITY	OPERABILITY	TECHNICAL RISK	ENV. IMPACT	COST	SCHEDULE	ARMS CONTROL
X	**X**	X	X	X	**X**	✓	✓	**✓**	✓	**X**

- X = NEGATIVE FEATURE
- **X** = MAJOR NEGATIVE FEATURE
- ✓ = SATISFACTORY
- **✓** = MAJOR POSITIVE FEATURE

MAJOR NEGATIVE FEATURES

- Sensitivity to Responsive Threats
  - C3 and Sensor System Attack, Attack While in Orbit
- Failure to Maintain Independent Triad Survival Mode
  - Requirement for Warning
- Operability
  - Accuracy Insufficient for Hard Targets
  - Potential Loss Due to False Alarm
  - Recovery from Orbit
- Arms Control
  - Violates Space Treaty

MAJOR POSITIVE FEATURES

- Cost
  - Low

CONCEPT

In this concept, larger, more powerful missiles are emplaced in existing Minuteman silos. The missile has a dual capability; it can fly a fractional orbit (e.g., thus approaching the enemy from the South, a capability the Soviets have had since the late 1960's), or it can inject warheads into space orbit. If the latter case, the warheads are de-orbited by command, onto targets. Or if tension ceases, the payloads can be safely de-orbited into the ocean, then presumably recovered, although this is a difficult and complex problem which has not been satisfactorily worked.

DESCRIPTION/DISCUSSION

For the dual role mission, a missile was sized to place 10,000 pounds into a low (100 mile) orbit or, with minor modifications, 1200 pounds in synchronous orbit (22,000 miles above the earth).

The missile nearly fills the entire available space in an existing Minuteman silo. It has solid-propellant first and second stages. The liquid propellant third stage provides coast and restart capability required for the flexible orbital operation.

The orbital payload consists of the missile guidance system, the radio link, a de-orbiting engine and propellant, and reentry vehicles. About 4000 pounds of total reentry vehicle weight can be carried for a typical low-orbit mission.

In low orbit, each revolution of the earth requires about 90 minutes. During a 15-day orbital life, power is provided by batteries within the payload. (Longer endurance in orbit is practical, but only at high cost measured in terms of weight.) Occasional radio updates to the guidance system are required. However, the accuracy of the deorbiting reentry vehicles would still likely be insufficient to attack hard targets.

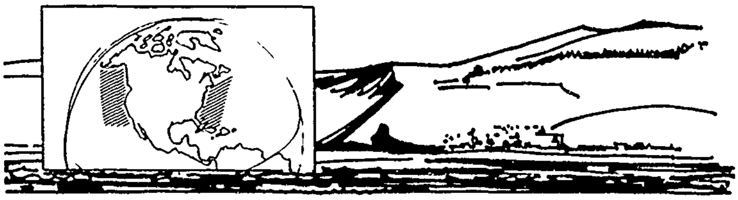
The system can be used to place all or a fraction of the total force into orbit on warning or, conceivably, during a period of high international tension. Later, the missile can be de-orbited onto Soviet targets, when and as commanded. If the situation should change into a peaceful one, then the payloads can be de-orbited into the open sea with the possibility of recovering the warheads.

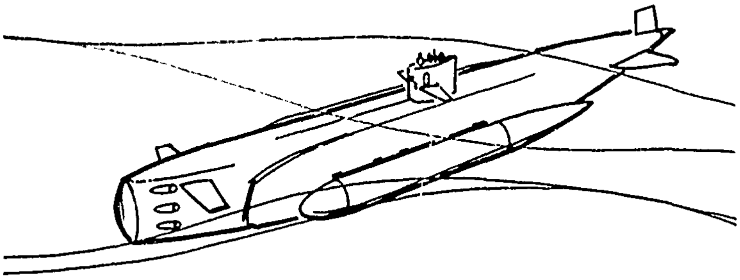
The ability to launch some or all of the warheads into orbit based on early warning could potentially provide decision makers with time to ascertain the real intent of the adversary without actually executing an ICBM strike. If the alarm proves false, the system can be neutralized and the warheads retrieved. Safety issues associated with nuclear warheads orbiting the earth with periodic passes over the U.S. are not clear. Special precautions would be definitely needed.

Survival depends heavily on the adequacy of the warning system. Moreover, placing our bombs in orbit might be misconstrued by the Soviets as an attack. Thus a protective launch into orbit could trigger the Soviets into launching or augmenting their attack on the U.S. A false warning could at best cause us to lose the boosters we had expended, and at worst lead to Soviet retaliation. Further, the false alarm could potentially be produced by malfunctions of the U.S. warning system or by a deliberate Soviet spoof.

Finally, deployment of nuclear weapons in space is prohibited by treaty. (Treaty on Principals Governing Actions of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies, signed 27 January 1967, proclaimed by President Johnson, 10 October 1967.)

SHALLOW UNDERWATER MISSILE (SUM)





EVALUATION

Survivability			Operational Feasibility							
Responsive Threats	Triad Independence	Endurance	Public Interface	Security	Operability	Technical Risk	Env. Impact	Cost	Schedule	Arms Control
X (negative)	X (major negative)	✓ (satisfactory)	✓ (major positive)	✓ (satisfactory)	X (negative)	X (major negative)	✓ (major positive)	✓ (satisfactory)	X (major negative)	✓ (satisfactory)

X = NEGATIVE FEATURE
X = MAJOR NEGATIVE FEATURE
✓ = SATISFACTORY
✓ = MAJOR POSITIVE FEATURE

MAJOR NEGATIVE FEATURES

- Failure to Maintain Independent Triad Survivability Mode
  - Same as Trident, But Probably Inferior
- Technical Risk
  - Advanced Technology Automation and Power Subsystems
- Schedule
  - Very Late (1990's With New Submarine)

MAJOR POSITIVE FEATURES

- Public Interface
  - Coastal Operating Bases
- Environmental Impact
  - Minimal

CONCEPT

Roughly one-third of U.S. strategic nuclear power is in the form of missiles launched from submarines. Our first generation system, Polaris, first deployed in the early 1960s, is currently being phased out. The second-generation Poseidon has been in operation for a number of years, and the new Trident system will soon be entering the fleet. Several years ago it was proposed that we meet the growing threat to Minuteman by an entirely different type of missile-launching submarine which would be very small, would carry its missiles in external canisters attached to the hull, and would operate close in the U.S. coastlines. A simplified examination indicated that this concept might be much cheaper than M-X, might have simpler communications than the Polaris/Poseidon/Trident systems (because of short range) and simpler guidance (by using land-based guidance beacons) than current submarines, and might present problems to the Soviet attack planner very different from those presented by large submarines operating in the broad ocean areas. None of these features, however, proved to be valid in the context proposed.

DESCRIPTION/DISCUSSION

The original SUM idea was to mount two M-X (or four Minuteman) missiles on the outside of a very small (approximately 550-ton) diesel-electric submarine similar to those currently being advertised for export by a West German shipbuilder, HDW. The missiles would be contained in waterproof steel canisters. The M-X missiles would be contained in an 80 x 10-foot steel capsule displacing about 180 tons. Power to the capsule would be transmitted by cable from the submarine. When launched, the capsule would rise vertically. At the surface, part of the capsule would jettison, and the missile would fire. Further technical analysis conducted by the Office of the Secretary of Defense indicated the following:

- All submarines already designed would require extensive structural modification to support missile capsules at or near the surface, particularly for high sea states.
- The German submarine (designated HDW-600) has about 10% reserve buoyancy. With the two M-X capsules, buoyancy would drop to about 4%, which is insufficient for safe operation. Accordingly, the ballast and buoyancy control systems would have to be redesigned, necessitating other major changes to the submarine layout. Also, the submarine structure and control systems would have to be modified to ensure adequate steering, depth, and trim control.
- Because the HDW-600 was not designed for a strategic mission, the existing submarine design lacks space for sonar, missile/control/support, and navigation and communications.

The HDW designers concurred with the above judgments and indicated that it would take years to deliver a partially redesigned submarine. This schedule would still not include all major changes required for SUM nor the possible requirement for the more stringent U.S. quality control procedures.

The study also determined that a new design submarine was feasible and could satisfy the SUM mission. Such a submarine would have a pressure hull displacement of at least 1100 tons, would carry up to four encapsulated M-X missiles external to the pressure hull, and would be manned by a crew of at least 15, assuming a much higher degree of automation than in present submarines (basically unproven concepts). The system would operate within a few hundred to 1000 miles from the coast of the continental United States at an average speed of 3 to 6 knots (10 knot maximum speed) for a four-week patrol. The conclusions of this study effort were:

- A SUM system with a new submarine is probably feasible; however, many major technical problems require resolution.
- No advantage was found relative to present submarine systems such as Trident.
- System acquisition costs might be in the same range as Trident and land-based

M-X; however, development of confidence in this assessment would require further, more detailed analysis.

- System initial operational capability (IOC) might be achieved by the 1990 time period.

In a separate concurrent evaluation of this concept, the U.S. Navy performed detailed studies of a submarine of minimum practical size which could carry external encapsulated M-X missiles. These studies produced a conceptual design for a submarine of about 1600 tons pressure hull displacement that could carry four M-X capsules externally. There would be about 50 such submarines in the force. The IOC of the force is estimated to be 1992 (versus 1986 for the M-X/MPS system).

The new submarine designed by the Navy would have a maximum submerged speed of 10 knots and a nominal patrol cycle of 30 to 60 days. A crew of 45 would be carried. Achievement of missile accuracy approximating that of land-based missiles appeared feasible if survivable land-based radio beacons are provided.

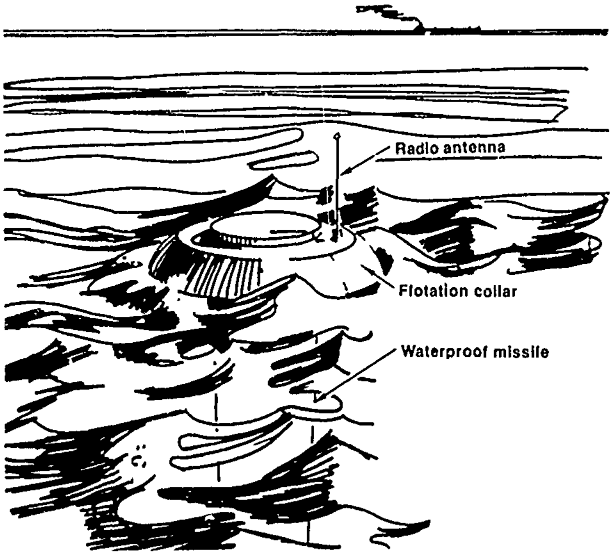
The submarines would patrol off the east and west coasts of the U.S. as well as off the coast of Alaska. Anchorage, Alaska; Narragansett Bay, Rhode Island; and Miller Peninsula, Washington, were suggested as bases. It is possible that the boats could be operated as far as 1000 miles from their bases.

As has been the case with many of the concepts discussed in this report, the initial high hopes for the SUM concept were not sustained when thorough technical analyses were performed and the changes necessary to build a realistic, reliable, and usable military system were evaluated. The small submarines could not confidentially operate on the continental shelf close to the coast because a nuclear explosion phenomenon called the "Van Dorn effect" would allow a few Soviet warheads to wipe out all the submarines. To avoid such vulnerability, the submarine patrol area must be extended further off the coast, whereupon some of the original ideas for simpler communications and guidance no longer apply.

While analyses uncovered no technical problems which would indicate at this time that SUM is technically infeasible, there are certain major areas of risk where extensive development work would have to be carried out. Reliable waterproof canisters for the missiles, miniaturized equipment, and automation of crew functions are areas of particular concern.

The analyses concluded that there is no reason to believe that SUM would be any more survivable than conventional submarines. Since SUM operates in a very small part of the ocean compared to Trident, SUM could become highly vulnerable to Soviet anti-submarine warfare (ASW) forces. At the time SUM could be deployed, the Trident submarines will patrol the Atlantic and Pacific oceans, ranging over 15 to 20 million square miles of patrol zone. With 15 to 20 Tridents on patrol, each one can be said to roam a million square mile patrol area. In the original SUM concept, 30 to 40 subs patrol a one-half million square mile zone consisting of east and west coast segments, or 15,000 square miles per SUM submarine. The ratio of the patrol areas is one measure of the difficulty the Soviets would have in finding a Trident compared to finding a SUM . . . one million to 15,000, or about 70 to 1. Even though this argument is somewhat mitigated by the possibility (although not certainty) that a large submarine may be easier to detect than a small one in certain cases, the overall result favors Trident. The consequences of deploying SUM would thus represent a step backward in U.S. sea based missile system capability. The U.S. coasts would become a fertile hunting ground for Soviet ASW forces. Moreover, there are no existing U.S. Navy forces which could provide a sufficient degree of protection to SUM. Acquiring forces dedicated to SUM defense would cost many billions of dollars in addition.

HYDRA



EVALUATION

SURVIVABILITY			OPERATIONAL FEASIBILITY							
RESPONSIVE THREATS	TRIAD INDEPENDENCE	ENDURANCE	PUBLIC INTERFACE	SECURITY	OPERABILITY	TECHNICAL RISK	ENV. IMPACT	COST	SCHEDULE	ARMS CONTROL
X	**X**	✓	X	**X**	**X**	✓	**✓**	✓	✓	✓

X = NEGATIVE FEATURE
X = MAJOR NEGATIVE FEATURE
✓ = SATISFACTORY
✓ = MAJOR POSITIVE FEATURE

MAJOR NEGATIVE FEATURES

- Sensitivity to Responsive Threats
  - Localization/Destruction of Missiles by Trailing Ships or Airplanes
- Failure to Maintain Independent Triad Survivability Mode
  - Emplaced After Strategic Warning
- Security
  - Capture of Unmanned Missiles
- Operability
  - False Alarms, Recovery, Operating Environment

MAJOR POSITIVE FEATURES

- Environmental Impact
  - Minimal

CONCEPT

The goal of the Hydra concept is to make it difficult for an enemy to locate a water-based missile. Uncertainty of location is achieved by surreptitiously dropping the missiles into the ocean from surface ships or submarines. The missiles are designed to float vertically until they are launched. Only an inconspicuous part of the missile front end is visible above the surface.

An alternative is to stoie the Hydra aboard the ships or submarines until such time as a command to jettison is given. The Hydra missiles, then afloat, remain in alert status until launched or recovered.

DESCRIPTION/DISCUSSION

In addition to ships and/or submarines, the Hydra system consists of waterproof missiles with attached floatation collars. The missile is designed to be launched by remote command while floating in the water. For radio command, the missile is equipped with an antenna. A sonar receiver can be used for underwater sonar command.

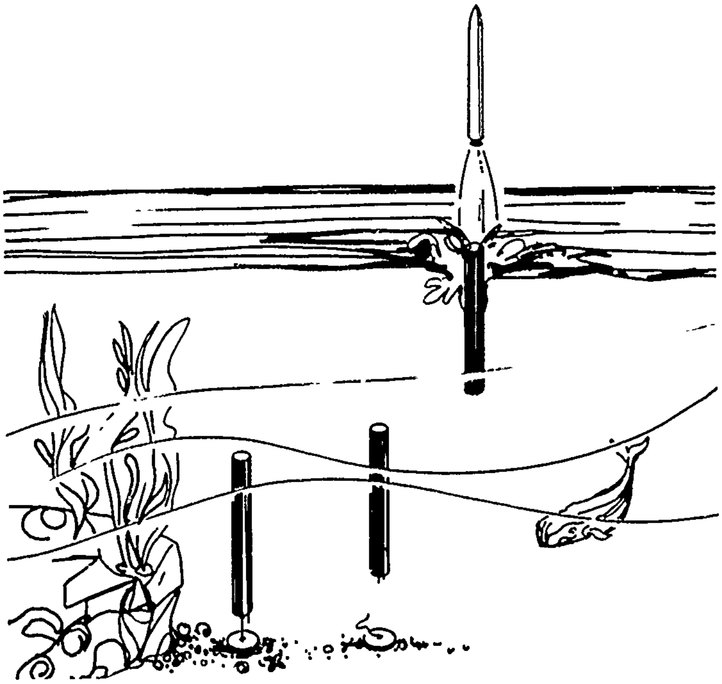
Predispersed missiles may be tethered or not. If tethered, their location is known to the accuracy of the navigation system of the placement ship. If the missile is allowed to float freely, guidance information can be provided by the Global Positioning System of satellites or, less adequately, through the use of an inertial navigation system in the missile. In the case of Hydra missiles jettisoned only on warning (the alternate approach), guidance updates are furnished by the placement ship.

The M-X type missile carries ten warheads and is hardened to 5 psi. For the case in which missiles are dropped into the ocean on warning, the number of ships and missiles required to withstand the nominal ICBM attack follows from an assumption as to the length of strategic warning. Thus, for 8 hours warning, 12 ships carrying 10 missiles each are sufficient. With warning reduced to 2 hours, it is necessary to deploy 40 placement ships and 320 missiles.

For the predispersed concept, remote surveillance of Hydra locations may be possible by sonar or radar sensors. Information on the location could then be conveyed to Soviet naval, merchant, or fishing vessels in the vicinity of the floating missiles. These same vessels would also, presumably, be searching independently for the Hydra missiles. Moreover, it is possible that third-nation, or paramilitary groups, would also be engaged in a hunt for the Hydras. Not under our direct control, any missile can be destroyed or towed away (stolen) at leisure. As to the jettison-on-warning concept, satellite surveillance of ships could make both ships and missiles vulnerable not only to ICBM attack, but also to pursuit and destruction by a variety of enemy weapon systems (submarine, surface ships, aircraft, cruise missiles, etc.). The fleet of placement vessels could also conceivably be tricked into jettisoning their Hydra missiles by a deliberate false alarm, then sunk during or after operations to recover the missiles.

The Hydra concept also presents safety problems of an unprecedented kind. The idea of missiles with nuclear warheads floating unattended in ocean waters introduces an unacceptable hazard to navigation for the world's shipping. This problem is only partly mitigated in the jettision-on-warning approach.

ORCA



EVALUATION

SURVIVABILITY			OPERATIONAL FEASIBILITY							
RESPONSIVE THREATS	TRIAD INDEPENDENCE	ENDURANCE	PUBLIC INTERFACE	SECURITY	OPERABILITY	TECHNICAL RISK	ENV. IMPACT	COST	SCHEDULE	ARMS CONTROL
✓	✓	✓ (major positive)	✓ (major positive)	X	X (major negative)	✓	✓ (major positive)	✓ (major positive)	✓	X (major negative)

X = NEGATIVE FEATURE
X (bold) = MAJOR NEGATIVE FEATURE
✓ = SATISFACTORY
✓ (bold) = MAJOR POSITIVE FEATURE

MAJOR NEGATIVE FEATURES

- Operability
  - Inability to Check Status Without Revealing Missile Location
- Arms Control
  - Use of Ocean Floor Violates Treaties

MAJOR POSITIVE FEATURES

- Endurance
  - Months
- Public Interface
  - Minimal
- Environmental Impact
  - Minimal
- Cost
  - Low

CONCEPT

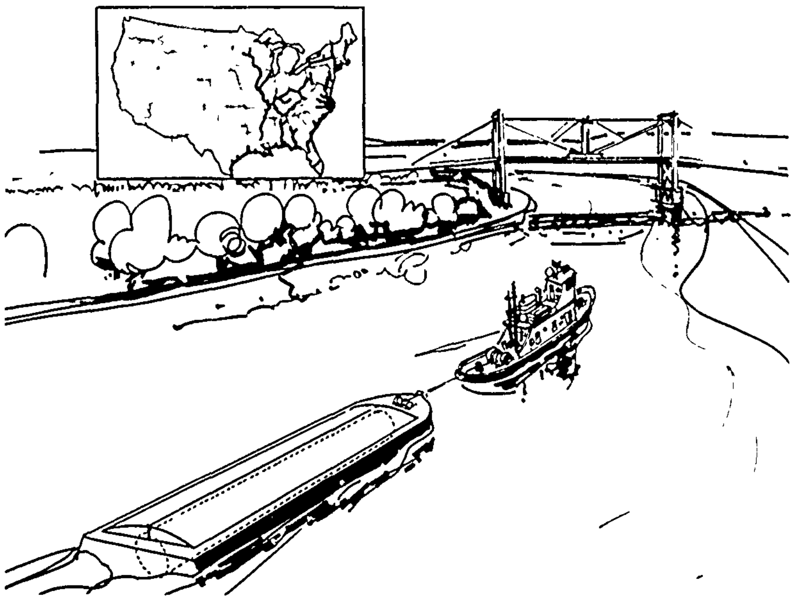
The ORCA concept is similar to Hydra but anchors encapsulated missiles to the coastal seabed. On command, the capsule floats to the surface. The upper part of the capsule is then jettisoned and the missile launched. The missiles remain in a dormant condition until activated by sonar command.

DESCRIPTION/DISCUSSION

A major objection to ORCA is that deployment of nuclear devices on international seabeds is prohibited by an international treaty to which the U.S. is signatory. (Treaty on Prohibition of Employment of Nuclear Weapons and Other Weapons of Mass Destruction on the Seabed and Ocean Floor and in the Subsoil Thereof, signed 11 February 1971, proclaimed by President Nixon, 18 May 1972.)

Another problem is that active sonar search either by enemy surface ships or submarines can reveal the locations of the ORCA missiles on the sea bottom. Additionally, communications, command, and control are seriously deficient. The missile is necessarily dormant . . . i.e., it conceals its location by emitting no signals. Because we would be unable to exercise the missile periodically to verify its readiness, the system is intrinsically unreliable. Conversely, any active communication with the missile risks disclosing its location and making it vulnerable to capture or destruction.

SHIP-INLAND



EVALUATION

SURVIVABILITY			OPERATIONAL FEASIBILITY							
RESPONSIVE THREATS	TRIAD INDEPENDENCE	ENDURANCE	PUBLIC INTERFACE	SECURITY	OPERABILITY	TECHNICAL RISK	ENV. IMPACT	COST	SCHEDULE	ARMS CONTROL
✗ (major)	✓	✓	✗ (major)	✗	✓	✓	✓	✗	✓	✓

X = NEGATIVE FEATURE
X (bold) = MAJOR NEGATIVE FEATURE
✓ = SATISFACTORY
✓ (bold) = MAJOR POSITIVE FEATURE

MAJOR NEGATIVE FEATURES

- Sensitivity to Responsive Threats
  - Insufficient Length of Waterway to Withstand Expanded Attack
- Public Interface
  - Interference with Commercial Traffic and Safety Problems

MAJOR POSITIVE FEATURES

CONCEPT

Barges carrying missiles are towed randomly along inland and coastal waterways totalling 35,000 miles in length.

DESCRIPTION/DISCUSSION

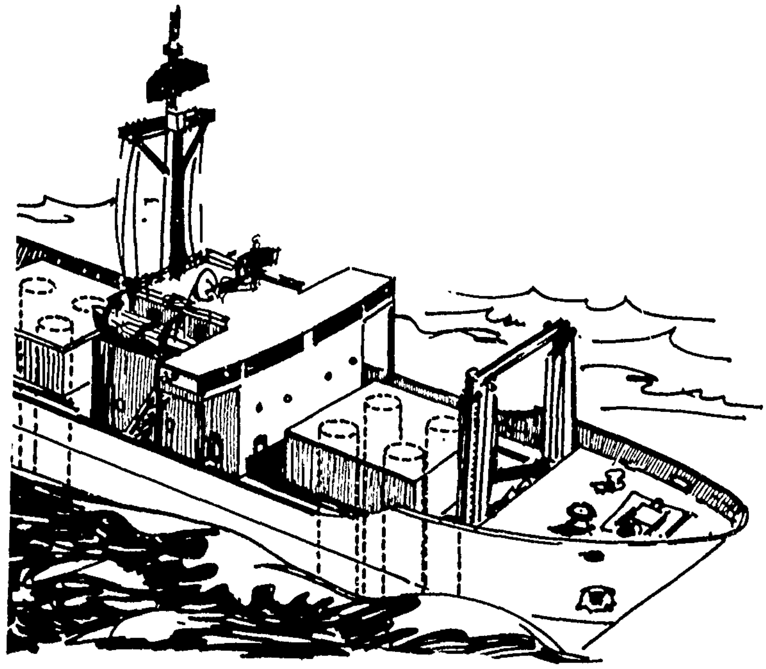
The system of barges moves randomly over 14,000 miles of coastal waters, 12,000 miles in the Mississippi river system and 3000 miles on other inland waterways. Deployment on the Great Lakes would be excluded by the Rush-Bagot Treaty with Canada.

A manned tug tows a shallow draft barge, sized to carry one relatively small canisterized missile (three R/Vs), and its essential command, control, security, and launch equipment. The barge system is hardened to 5 psi. About nine knots is the maximum speed attainable as the tug/barge moves along its patrol route among commercial waterways traffic. Since the Soviet ICBM inventory is sufficient to apply 5 psi along more than half of the available waterway routes, and a portion of the barge fleet is always undergoing maintenance and refurbishment, about 1400 barges are required.

The chief advantage of this concept compared to most other surface mobile systems deployed in or near the U.S. is that it needs neither roads nor rails. However, it cannot tolerate any significant increased Soviet threat; nearly total destruction of all barge-borne missiles bounded within a 29,000 mile long waterways system would be threatened by a nominal Soviet ICBM escalation.

Another objection to the barge system is that barge location can potentially be compromised by satellite sensors or local observers. Also, moving so great a number of nuclear weapons on heavily travelled waterways is potentially a severe threat both to public safety and to missile security.

SHIP–OCEAN



EVALUATION

	SURVIVABILITY			OPERATIONAL FEASIBILITY						
RESPONSIVE THREATS	TRIAD INDEPENDENCE	ENDURANCE	PUBLIC INTERFACE	SECURITY	OPERABILITY	TECHNICAL RISK	ENV. IMPACT	COST	SCHEDULE	ARMS CONTROL
X (major negative)	✓	✓	✓ (major positive)	✓	X (major negative)	✓	✓ (major positive)	✓	✓	✓

X = NEGATIVE FEATURE
X = MAJOR NEGATIVE FEATURE
✓ = SATISFACTORY
✓ = MAJOR POSITIVE FEATURE

MAJOR NEGATIVE FEATURES

- Sensitivity to Responsive Threats
  - Localization/Destruction of Ships by Trailing Ships or Aircraft
- Operability
  - Accuracy Insufficient for Hard Targets

MAJOR POSITIVE FEATURES

- Public Interface
  - Coastal Operating Bases
- Environmental Impact
  - Minimal

CONCEPT

Special surface ships carry M-X type missiles and move randomly over the high seas.

DESCRIPTION/DISCUSSION

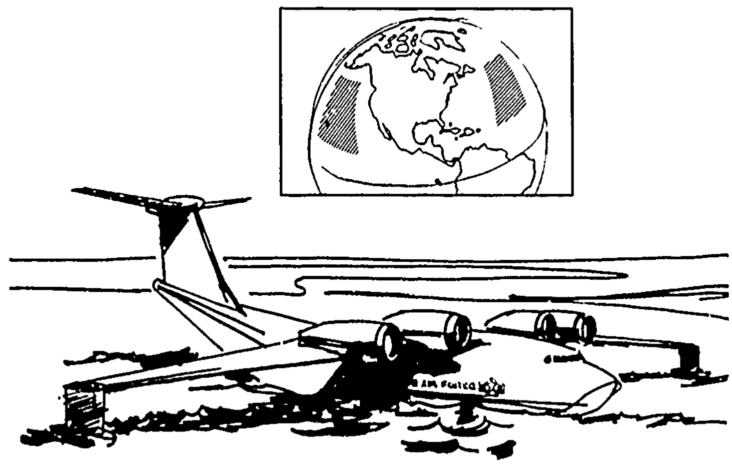
The ships, hardened to nuclear effects, each carry eight canisterized missiles equipped with ten warheads each. About 65 such ships (with 40 at sea at any given time) are needed to cruise over broad ocean areas at about 17.5 knots. The missiles are stowed vertically below deck and launched from that position. Variants include vessels with greater hardness or speed (hydrofoils).

Removing ICBMs from our mainland is the chief feature of this concept. Accordingly, it rates high on environmental impact and public interface. Except for naval bases, it makes use of no land.

Command and control of a force widely dispersed over the open seas presents some difficulties. Very importantly, without external aids, missile accuracy is inadequate against hardened targets.

Since the location of the ships can always be ascertained by surveillance satellites, trailing ships, or submarines, the ships are extremely vulnerable to surprise attack by enemy ships, submarines, tankers, aircraft, and missiles. And while the cost of this system is acceptable, it would soon escalate out of range if it were necessary to protect the ships with naval vessels.

SEA SITTER



EVALUATION

SURVIVABILITY			OPERATIONAL FEASIBILITY							
RESPONSIVE THREATS	TRIAD INDEPENDENCE	ENDURANCE	PUBLIC INTERFACE	SECURITY	OPERABILITY	TECHNICAL RISK	ENV. IMPACT	COST	SCHEDULE	ARMS CONTROL
X	✓	**X**	**✓**	✓	**X**	X	**✓**	**X**	X	✓

X = NEGATIVE FEATURE
X = MAJOR NEGATIVE FEATURE
✓ = SATISFACTORY
✓ = MAJOR POSITIVE FEATURE

MAJOR NEGATIVE FEATURES

- Sensitivity to Responsive Threats
  - Trailing of Airplanes Followed by Attack While Sitting
- Endurance
  - Low
- Operability
  - Weather Problems, Particularly High Seas
  - Accuracy Insufficient For Hard Targets
- Cost
  - High

MAJOR POSITIVE FEATURES

- Public Interface
  - Coastal Operating Bases
- Environmental Impact
  - Minimal

CONCEPT

In this approach to air mobility, large amphibian aircraft are dispersed over large ocean areas. Each plane flies from its base to the open sea, lands, sits for an interval conserving fuel, then flies randomly to the next location, eventually returning to base. Since the plane launches its missiles in flight, it can also fly in a continuous airborne alert mode.

DESCRIPTION/DISCUSSION

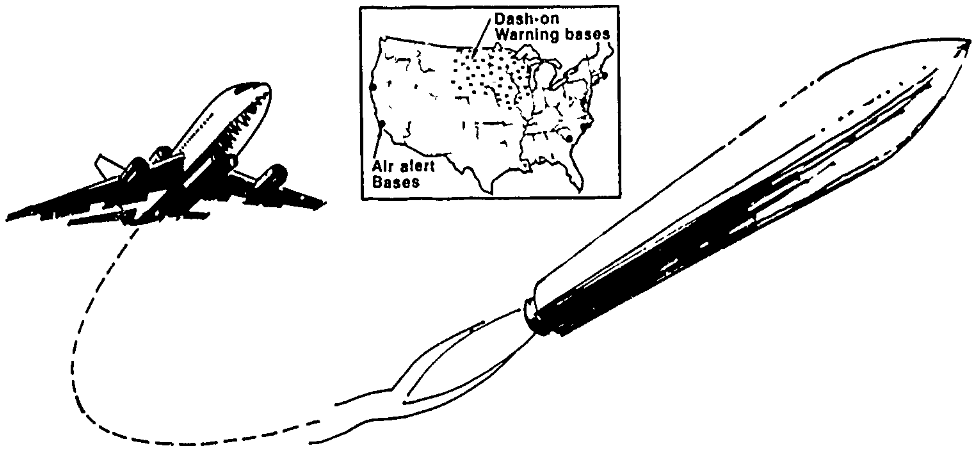
The Sea Sitter is a twin-hull amphibian which carries four 80,000-pound missiles, each bearing five warheads. Gross takeoff weight is 2 million pounds from land and 1.85 million pounds from water. (As a comparison of magnitude, the gross takeoff weight of a Boeing 747 is about 0.75 million pounds). The Sea Sitter has an overall length of 260 feet, a wingspan of 375 feet, and a cruising speed of 425 knots. The turbofan engines are mounted above the wing to minimize ingestion of salt spray.

Each carrier has a patrol radius of up to 4000 nautical miles, depending on the number and duration of sea landings, although the range can be extended by in-flight refueling. The plane flies from its main operating base (of which there are four) to an area in the open sea, lands, sits, and then flies from one sea-sit location to another, finally returning to the main base. The scheduled duration of each sea-sit is shorter than enemy detection time; even shorter durations are possible if local weather conditions force a move.

As a variation, a smaller, single-hull airframe was also studied. Its gross takeoff weight from land was 1.2 million pounds.

A crucial question is survivability. The Soviets may elect to counter Sea Sitter by building special systems to detect and attack it. There are also serious technical concerns with respect to salt-water corrosion and the ability to operate in severe weather.

WIDE BODY JET (W.B.J.)



EVALUATION

SURVIVABILITY			OPERATIONAL FEASIBILITY							
RESPONSIVE THREATS	TRIAD INDEPENDENCE	ENDURANCE	PUBLIC INTERFACE	SECURITY	OPERABILITY	TECHNICAL RISK	ENV. IMPACT	COST	SCHEDULE	ARMS CONTROL
X	X (major)	X (major)	✓	✓	X	✓	✓	X (major)	✓	✓

X = NEGATIVE FEATURE
X (bold) = MAJOR NEGATIVE FEATURE
✓ = SATISFACTORY
✓ (bold) = MAJOR POSITIVE FEATURE

MAJOR NEGATIVE FEATURES

- Failure to Maintain Independent Triad Survivability Mode
  - Requires Warning
- Endurance
  - Limited to Hours
- Cost
  - High

MAJOR POSITIVE FEATURES

CONCEPT

In this approach to air mobility, conventional large wide body jet airplanes disperse the ICBMs, either in dash-on-warning or continuous air alert modes.

In the dash-on-warning mode, the aircraft are predispersed in ground alert status on austere bases in the north central region of the U.S., at least 700 miles from the coast. Rapid takeoff of two airplanes from each base in response to warning may provide survivability against a well-coordinated SLBM-ICBM barrage attack on the bases. The airplanes fly to designated orbit areas to await further commands, either to launch missiles or to land at designated dispersal bases. Short time-of-flight SLBM attacks on the air bases jeopardize this concept.

Alternatively, the force can be placed on air-alert status while operating from four bases, two on each coast. This arrangement permits the aircraft to disperse randomly over large ocean areas. (For public safety reasons, airborne alert over the U.S. proper would not occur in peacetime.)

The likely operating concept, called flexible mode, combines the high survivability of the air-alert mode with the lower cost of ground alert. During periods of low tension, the aircraft are positioned in the north-central region of the country, as in the dash-on-warning mode. In response to strategic warning indicators, such as increasing Soviet submarine operations off our coastlines or loss of functioning of some warning systems, the fleet would fly to coastal bases, and commence continuous air alert operations. Thus, the flexible mode responds sensitively to the nature of the warning to improve survivability at substantially lower cost than that of a continuous airborne alert.

DESCRIPTION/DISCUSSION

The WBJ aircraft are design derivatives of existing aircraft (747, C-5A) modified for the air mobile mission. Major design changes are required to the structure and landing gear to permit higher takeoff and in-flight gross weight and the substitution of advanced turbofan engines to accommodate this higher performance. Additional modifications permit missile loading, handling, and air launch, and provide a secure launch control and command center.

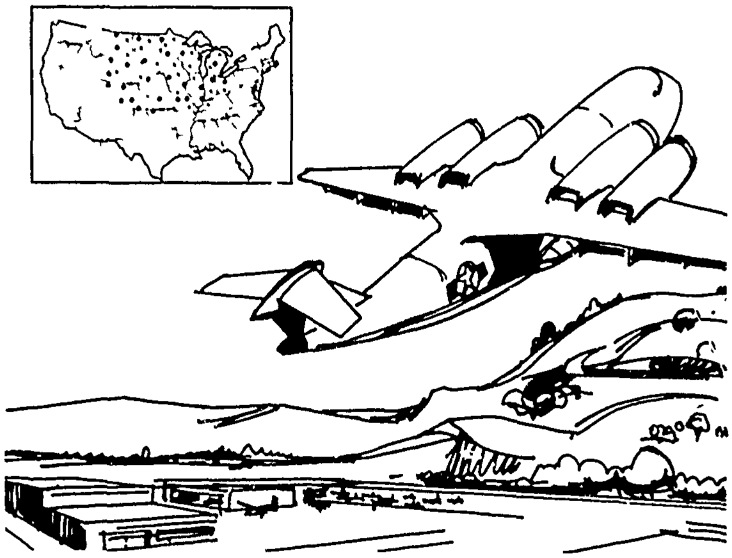
For the dash-on-warning mode, 100 aircraft, each carrying two 150,000-pound missiles with 10 warheads, and 50 bases are needed. In normal peacetime operations, the aircraft are maintained in a 60% alert status, with the missile guidance and navigational systems continuously powered and updated to maintain weapon system accuracy. The aircraft have ground-furnished electric power as well as auxiliary power units for backup, both continuously available for command, control, and communications and for rapid engine start-up.

For the continuous airborne alert mode 129 aircraft and four coastal bases are required. Refueling aircraft stretch the endurance of this ICBM basing system.

The technical feasibility of the concept was adequately demonstrated by air-drop launch demonstration test of the Minuteman from a C-5A aircraft.

A principal difficulty with an air-mobile system using wide-body jets is the limited post-attack endurance of a fleet of heavy aircraft that can disperse only to selected fields that are themselves likely to be bombarded. Also, costs are quite high.

SHORT TAKEOFF AND LANDING (STOL)



EVALUATION

SURVIVABILITY						OPERATIONAL FEASIBILITY				
RESPONSIVE THREATS	TRIAD INDEPENDENCE	ENDURANCE	PUBLIC INTERFACE	SECURITY	OPERABILITY	TECHNICAL RISK	ENV. IMPACT	COST	SCHEDULE	ARMS CONTROL
X	**X**	**X**	X	✓	X	✓	X	**X**	✓	✓

X = NEGATIVE FEATURE
X = MAJOR NEGATIVE FEATURE
✓ = SATISFACTORY
✓ = MAJOR POSITIVE FEATURE

MAJOR NEGATIVE FEATURES

- Failure to Maintain Indpendent Triad Survivability Mode
  - Requires Warning
- Endurance
  - Attack on Secondary Dispersal Sites Whose Locations are Known to an Enemy
- Cost
  - High

MAJOR POSITIVE FEATURES

CONCEPT

With the advent of large-sized STOL aircraft, such as the Advanced Medium Short Takeoff and Landing Transport (AMST), a new air mobile concept became feasible, which involved the use of thousands of potential airfields in contrast to a much smaller number for the wide body jets.

The concept includes a fleet of STOL aircraft based in peacetime at alert bases in the central region of the U.S., removed at least 700 miles from the coast. Each aircraft can launch one ICBM. During periods of international tension, or on strategic warning, the STOLs are redeployed to other airfields, called primary dispersal sites, in the north central region, with one STOL per site. During an extended crisis, the aircraft could scatter to secondary dispersal sites throughout the U.S.

Each STOL has many possible sites at which to land. Upon receipt of a tactical warning or upon loss of the warning system, the aircraft take off to enhance their survivability and, upon command, missiles are launched from the air.

In addition to alert bases and dispersal sites, main operating bases in the north central region provide major maintenance and support.

DESCRIPTION/DISCUSSION

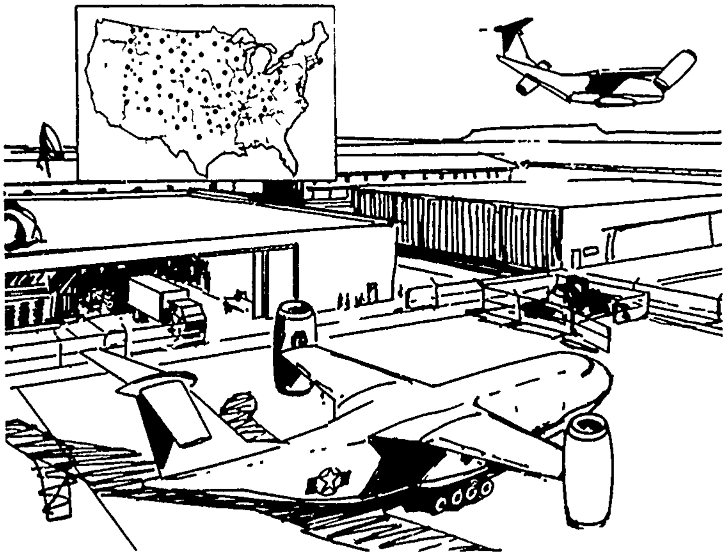
This configuration is designed for rapid escape from alert bases with the planes taking off alternately from each end of a runway.

The STOL carries a single, 10-warhead missile weighing 150,000 pounds, and has a range of about 1000 miles.

A total of 145 STOL on alert, are required, as well as 30 alert bases, and 115 primary dispersal sites. Also, about 2300 secondary dispersal sites are available.

Because of its much higher take-off acceleration profile, this concept has a chance of meeting the short SLBM timelines. However, it is susceptible to attacks on secondary dispersal sites which are limited in number to a few thousand.

VERTICAL TAKEOFF AND LANDING (VTOL)



EVALUATION

SURVIVABILITY			OPERATIONAL FEASIBILITY							
RESPONSIVE THREATS	TRIAD INDEPENDENCE	ENDURANCE	PUBLIC INTERFACE	SECURITY	OPERABILITY	TECHNICAL RISK	ENV. IMPACT	COST	SCHEDULE	ARMS CONTROL
✓	✗ (major)	✓	✓	✓	X	X	✓	✗ (major)	✗ (major)	✗ (major)

X = NEGATIVE FEATURE
✗ = MAJOR NEGATIVE FEATURE
✓ = SATISFACTORY
✔ = MAJOR POSITIVE FEATURE

MAJOR NEGATIVE FEATURES

- Failure to Maintain Independent Triad Survivability Mode
  - Requires Warning
- Cost
  - Very High
- Schedule
  - Very Late (1990's)
- Arms Control
  - Violates Interim SALT II

MAJOR POSITIVE FEATURES

CONCEPT

The goal was to devise an airmobile dash-on-warning system that is less susceptible to SLBM surprise barrage attack than airmobile systems using large aircraft. Essentially, the planes are small, agile, and numerous.

The aircraft are maintained in ground-alert status with a high state of readiness. Upon warning, the VTOLs take off at once. The pilot then has three options:

- Fly to an altitude of 30,000 feet and launch the missile on command. (The combination of aircraft altitude, speed, and angle permits a missile 15 to 20% lighter than a ground-launched missile of the same payload.)
- Fly to a location where fuel and supplies are stored and either loiter there or continue to hop to other fuel supply points.
- Fly back to the original bases.

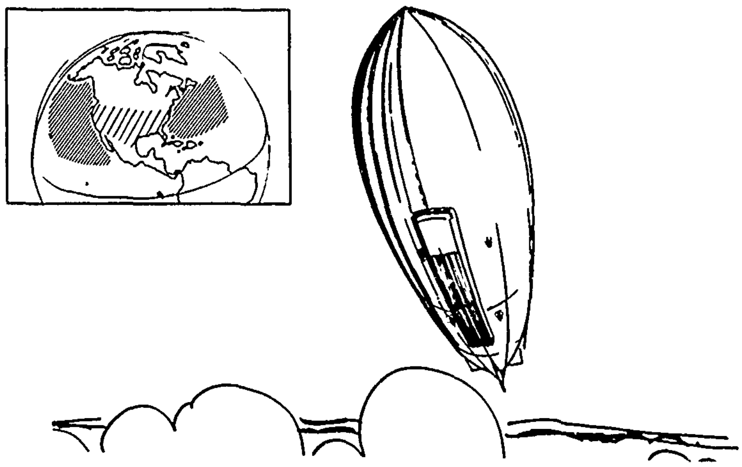
DESCRIPTION/DISCUSSION

The main elements of the system are a small VTOL aircraft, a small, new, lightweight missile (about 25,000 pounds) carrying one warhead, a land-based beacon system to provide accurate guidance updates, and prepositioned fuel supplies.

For the conceptual evaluation, the aircraft was a scaled-up version of the British Harrier and weighing twice as much. About 2100 aircraft (assuming a 60% alert rate) are required.

Military bases of the various services are used. There are about 500 suitable bases at least 400 miles inland from the coast.

DIRIGIBLE



EVALUATION

Survivability			Operational Feasibility							
Responsive Threats	Triad Independence	Endurance	Public Interface	Security	Operability	Technical Risk	Env. Impact	Cost	Schedule	Arms Control
✗ (major negative)	✓	✓	✗ (major negative)	✓	✗ (major negative)	✓	✓ (major positive)	✓	✓	✓

X = NEGATIVE FEATURE
X (bold) = MAJOR NEGATIVE FEATURE
✓ = SATISFACTORY
✓ (bold) = MAJOR POSITIVE FEATURE

MAJOR NEGATIVE FEATURES

- Sensitivity to Responsive Threats
  - Relatively Easy to Track and Attack
- Public Interface
  - Landing and Takeoff with Nuclear Weapons
- Operability
  - All Weather Operations

MAJOR POSITIVE FEATURES

- Environmental Impact
  - Coastal Operating Bases

CONCEPT

Dirigibles are included among various air-mobility basing concepts that have been studied. They can operate in two modes: continuous air alert or random move. In the continuous mode, the dirigibles fly at low speeds from U.S. bases over large ocean patrol areas. Compared to fixed-wing aircraft in a similar operating mode, dirigibles are capable of long-endurance missions. They can cruise over large areas. In the random-move operating mode, the dirigibles move missiles between any number of widely-spaced, fixed launch sites. Both operating modes thus gain survivability by proliferating numerous, scattered aimpoints.

DESCRIPTION/DISCUSSION

Three classes of dirigible-type carriers were examined, with payloads varying from one 47,000-pound canisterized missile (100,000-pound total payload) to three 80,000-pound missiles (300,000-pound total payload). To assess overall system effectiveness and technical feasibility, the small carrier was studied for the random move concept and the larger carrier for continuous air alert operation.

The random move carrier is very soft (½ to 1 psi) and is 730 feet long. It has a volume of 6 million cubic feet, a total gross weight of a third of a million pounds, and a cruising speed of 30 knots, with a maximum speed of 110 knots at altitudes of 10,000 feet. The canisterized missile is contained in a detachable module for ground launch.

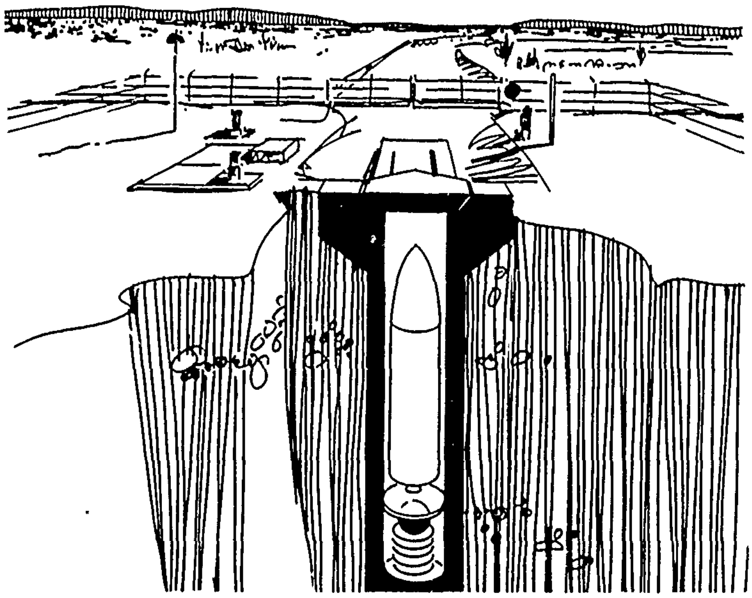
The continuous air alert carrier is 1000 feet long (also ½ to 1 psi hardness), with a volume of 14 million cubic feet, a gross weight of 800,000 pounds, and has similar operating characteristics to the random move carrier. It can sustain 30-knot operation for a period of three weeks. Various means of air-launching the missiles were studied, including parachute-stabilized drop and ejection from launch tubes.

The dirigibles use rigid structures of composite materials with envelopes of dacron and mylar or nylon and mylar. Turboprop engines, mounted inside the gondolas, are accessible for in-flight maintenance.

The favored configuration is the large airship that carries missiles, each with five warheads; 167 such dirigibles are required, assuming a 60% alert rate.

A principal difficulty with dirigibles is that they are potentially easy to track and destroy. Another difficulty is technical risk; there is much controversy concerning the operational feasibility of dirigibles, particularly in regard to safety and reliability in adverse weather conditions and ground handling.

MIDGETMAN



EVALUATION

SURVIVABILITY			OPERATIONAL FEASIBILITY							
RESPONSIVE THREATS	TRIAD INDEPENDENCE	ENDURANCE	PUBLIC INTERFACE	SECURITY	OPERABILITY	TECHNICAL RISK	ENV. IMPACT	COST	SCHEDULE	ARMS CONTROL
✓	✓ (major positive)	✓ (major positive)	✓	✓	✓	✓	✓	X (major negative)	✓	X (major negative)

X = NEGATIVE FEATURE
X (bold) = MAJOR NEGATIVE FEATURE
✓ = SATISFACTORY
✓ (bold) = MAJOR POSITIVE FEATURE

MAJOR NEGATIVE FEATURES

- Cost
  - High Versus Nominal Threat
  - Very High Versus Proliferated Threat
- Arms Control
  - Violates Interim SALT II

MAJOR POSITIVE FEATURES

- Independent Triad Survivability Mode
  - Maintains Essential Features of ICBM's
- Endurance
  - Months

CONCEPT

This concept deploys thousands of small, single-warhead missiles, one per hardened silo, in a manner similar to Minuteman. Purpose is to proliferate targets as a way of diluting the effectiveness of a Soviet ICBM counterforce attack.

DESCRIPTION/DISCUSSION

The Midgetman missile is about 50 feet long and weighs twenty to thirty thousand pounds. Its support equipment is placed in a blast-resistant silo. Sufficient missiles are deployed (3,000 to 4,000) to provide for approximately the same number of surviving RVs as projected for the M-X/MPS force. The range of the missile is about 7,000 miles.

Spaced about a mile apart, the silos are situated in the western U.S. Or they may be located in two or three Minuteman wing areas, thus making use of existing Minuteman bases. A total deployment area of about 4500 square miles is needed, although public use of most of the land is unrestricted, as in the present Minutemen installations.

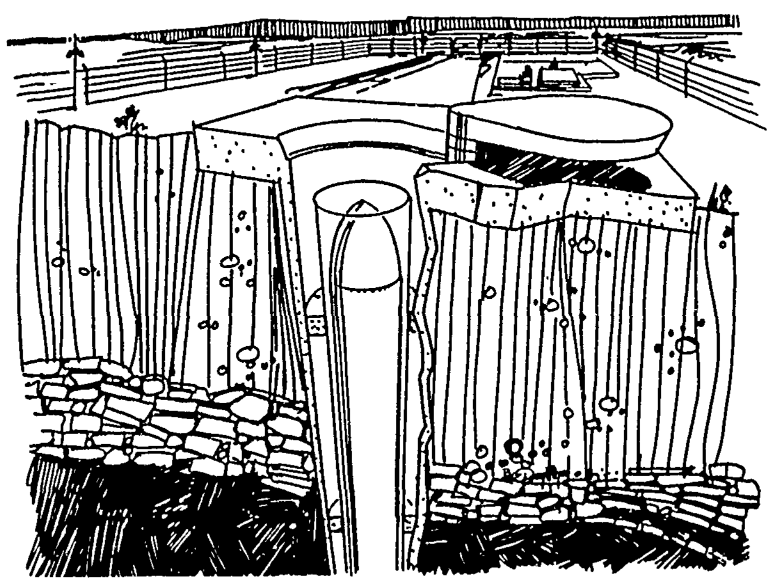
Security provisions are of the Minuteman type whereas command communications are based on the M-X/MPS design approach. The silos are served by buried power and communications cables, and a launch control aircraft overlay provides a redundant communications path.

The transporter that emplaces Midgetman or removes it for maintenance weighs 100,000 pounds (loaded) and so poses no special problems for roads. A single transporter completes a missile emplacement in a working day; hence, one transporter can serve about 200 missiles.

The 1972 Interim SALT agreement and the SALT II negotiating process limits the number of strategic launchers of all kinds to 2,250. For this reason, Midgetman was not considered as a viable alternative to M-X.

Even with a relatively simple single-warhead missile and small vertical shelters, the fact that a missile and its support equipment must be installed in each silo raises total system cost of Midgetman to a level higher than M-X/MPS.

HARD ROCK SILO



EVALUATION

SURVIVABILITY			OPERATIONAL FEASIBILITY							
RESPONSIVE THREATS	TRIAD INDEPENDENCE	ENDURANCE	PUBLIC INTERFACE	SECURITY	OPERABILITY	TECHNICAL RISK	ENV. IMPACT	COST	SCHEDULE	ARMS CONTROL
Major negative feature	Major positive feature	Major positive feature	✓	✓	✓	✓	✓	✓	✓	✓

X = NEGATIVE FEATURE
X (heavy) = MAJOR NEGATIVE FEATURE
✓ = SATISFACTORY
✓ (heavy) = MAJOR POSITIVE FEATURE

MAJOR NEGATIVE FEATURES

- Sensitivity to Responsive Threats
  - Defeated by Evolutionary Accuracy Improvement

MAJOR POSITIVE FEATURES

- Independent Triad Survivability Mode
  - Maintains Essential Features of ICBM's
- Endurance
  - Months

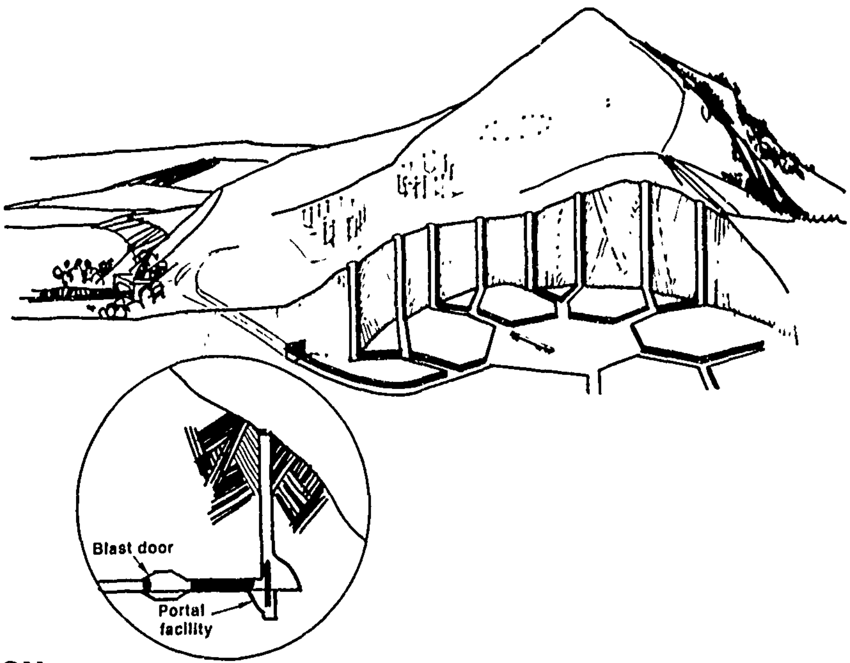
CONCEPT

The Hard Rock Silo was considered as a technique for rebasing Minuteman missiles in the late 1960s. The concept was similar to Minuteman, one missile in one vertical silo, except that the silos were to be located in granite outcroppings in the western United States. This design approach was chosen to achieve the highest possible hardness level for a surface-flush silo launcher.

DESCRIPTION/DISCUSSION

The Hard Rock Silo was to be compatible with the Minuteman III missile or with the next generation ICBM – at that time designated WS 120A – a 10-foot diameter, 70-foot long missile. The facility was to be generally similar to a Minuteman silo with a launch tube and annular equipment room. The launch tube was 16 feet in diameter and 90 feet deep. The approach was to drill the silo cavity in a surface rock outcropping and line the excavation with reinforced concrete. The resulting hardness was estimated to be about 3000 psi. This hardness level is no longer judged to be adequate to cope with the existing Soviet threat, and it is not technically feasible to design them to adequate levels of hardness.

HARD TUNNEL



EVALUATION

SURVIVABILITY			OPERATIONAL FEASIBILITY							
RESPONSIVE THREATS	TRIAD INDEPENDENCE	ENDURANCE	PUBLIC INTERFACE	SECURITY	OPERABILITY	TECHNICAL RISK	ENV. IMPACT	COST	SCHEDULE	ARMS CONTROL
✕	✔	✔	✔	✔	✖	✖	✓	✕	✕	✓

✕ = NEGATIVE FEATURE
✖ = MAJOR NEGATIVE FEATURE
✓ = SATISFACTORY
✔ = MAJOR POSITIVE FEATURE

MAJOR NEGATIVE FEATURES

- Operability
  - Slow Reaction
- Technical Risk
  - Development of Automated Digout Machines
  - Can't Verify Hardness or Egress Without Nuclear Testing

MAJOR POSITIVE FEATURES

- Independent Triad Survivability Mode
  - Maintains Independence
- Endurance
  - Superior to Any Other Concept
- Public Interface
  - Buried in Remote Area
- Security
  - Buried

CONCEPT

The goal was to completely negate an ICBM attack by very deep, superhard, subterranean basing at depths down to 3,000 feet or more.

DESCRIPTION/DISCUSSION

There are several variations of the subterranean tunnel basing scheme, including differences in the geological areas in which they were to be based, the depth of burial, the type of launch technique, and the tunnel design. Hard tunnel systems could vary in hardness from several hundred to several thousand psi, depending upon the siting, depth, and liner design. In general, rock sites and sophisticated liners, which tend to increase the hardness of the complex, also tend to increase tunnel cost.

The basic operation of all of these systems is similar. A transporter/launcher (T/L) carries the missile through the tunnel network until the missile is to be launched. If the tunnel has portals, the missile is brought to one of the portals, erected, and launched. If the tunnel had no portals, some mechanism for digging out is provided.

The particular design called the "citadel" or "central arsenal" uses the following components.

- A missile such as the M-X.
- A central arsenal in the center of the complex, providing protection and life support for all personnel, missiles, and associated launch equipment.
- A tunnel system to accommodate the T/L.
- T/Ls for the missiles.
- Control center facilities providing command and control for the force.
- Missile storage bays for the missiles.
- Launch portals with the capability of launching a number of missiles from one point. The portals consist of lined vertical shafts (15-foot inside diameter) reaching to the surface. Adjoining the shaft bottoms are erection areas to permit rotation of the missiles to a vertical position. The erection area is connected to a portal tunnel, which in turn is accessed by a portal blast door.
- Living quarters for the crews, unless the system is completely automated.

The launch portal hardness is very high; possibly well over 3000 pounds per square inch. In theory, all the missiles can be launched from one portal, thus requiring an enemy to destroy all portals.

The hardest system uses tunnels in hard and sound rock (e.g., granite, igneous rock). Even these tunnels must be lined to prevent cave-ins due to ground shocks transmitted from nuclear detonations. Construction costs are very high. For example, the estimated cost of constructing a 25-foot diameter tunnel in hard rock is from \$20 to \$40 million per mile of tunnel. An extensive excavation technology development program was envisioned as a necessary first step for such a system.

Several versions of the citadel concept were examined, ranging from a single arsenal with the order of 100 vertical exit portals for the entire missile force to ten separate, smaller installations. An investigation was also made of abandoned deep mines in Colorado and Michigan with the aim of reducing hard rock excavation costs.

In all the studies and design arrangements, the weakness of the citadel approach continued to lie in the launch portals. Each launch portal could be attacked individually to seal it off and the very expensive superhard tunnels would have proven useless. Still, if a few launch portals survived – or even one – it would still be possible to launch all the missiles consecutively . . . given enough time and the absence of counter bombardment between launches.

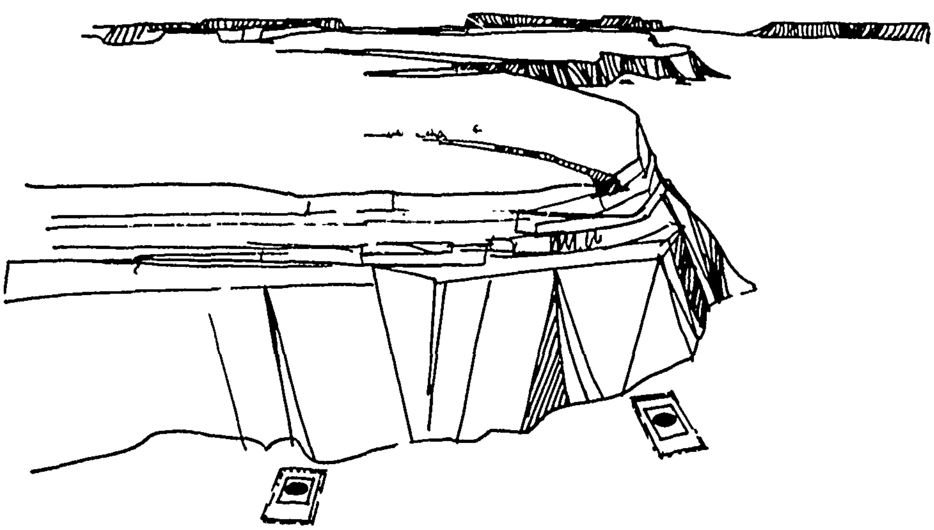
Because the survivability of the exit portals remained questionable, an alternate "dig out" concept was studied for the citadel. Here the arsenal is housed in a network of horizontal tunnels excavated 2000 to 2500 feet below the tops of sandstone mesas in the Southwest. The tunnels run parallel to the cliff of the mesa, a few hundred feet in (measured horizontally) from the cliff face. In this approach, there are no prepared tunnels reaching the surface. Instead, large boring machines would dig out from within after an attack. Perhaps several hundred egress ways could be partially excavated.

Advantages of these superhard concepts include high survivability, excellent post-attack endurance if the egress can be solved, independence of warning, low environmental impact and land use except for the removal from public use of the area in which the system is buried, and a safe separation from the public (per previous remark).

Disadvantages include the great difficulty of assuring survivable communications into the tunnels after attack. Unless there were a very large number of antennas or other communications entry points to the tunnels, the antennas would be very high value targets themselves. Another difficulty is hardness assessment. It may be impossible to specify a survivable design with confidence unless there are atmospheric nuclear tests, which are banned by international treaty (Treaty Banning Nuclear Weapon Tests in the Atmosphere, Outer Space, and Underwater, signed 5 August 1963, proclaimed by President Kennedy, 10 October 1963.)

An additional drawback is the slow reaction time. The missiles cannot be launched quickly, and until a major technology demonstration program is conducted, the egress time cannot be confidently estimated – it could be hours or months. There is also concern about missile vulnerability in the time period between digout and launch.

SOUTH SIDE BASING



EVALUATION

SURVIVABILITY			OPERATIONAL FEASIBILITY							
RESPONSIVE THREATS	TRIAD INDEPENDENCE	ENDURANCE	PUBLIC INTERFACE	SECURITY	OPERABILITY	TECHNICAL RISK	ENV. IMPACT	COST	SCHEDULE	ARMS CONTROL
X	**✓**	**✓**	✓	✓	X	✓	**X**	**✓**	✓	✓

X = NEGATIVE FEATURE
X = MAJOR NEGATIVE FEATURE
✓ = SATISFACTORY
✓ = MAJOR POSITIVE FEATURE

MAJOR NEGATIVE FEATURES

- Sensitivity to Responsive Threats
  - Attackable by SLBM's or Maneuvering R/V's
  - Limited Sites Available
- Environmental Impact
  - Much of Suitable Land in National Parks

MAJOR POSITIVE FEATURES

- Independent Triad Survivability Mode
  - Maintains Essential Features of ICBM's
- Endurance
  - Months
- Cost
  - Low

CONCEPT

In this concept silos are simply dug near the base of south-facing mesas or mountain cliffs so that they are shielded from approaching missiles. Attacking Soviet reentry vehicles would normally be coming from the northerly direction and, for accuracy, would approach their targets at fairly flat angles such that they could not impact targets at the base of south-facing slopes.

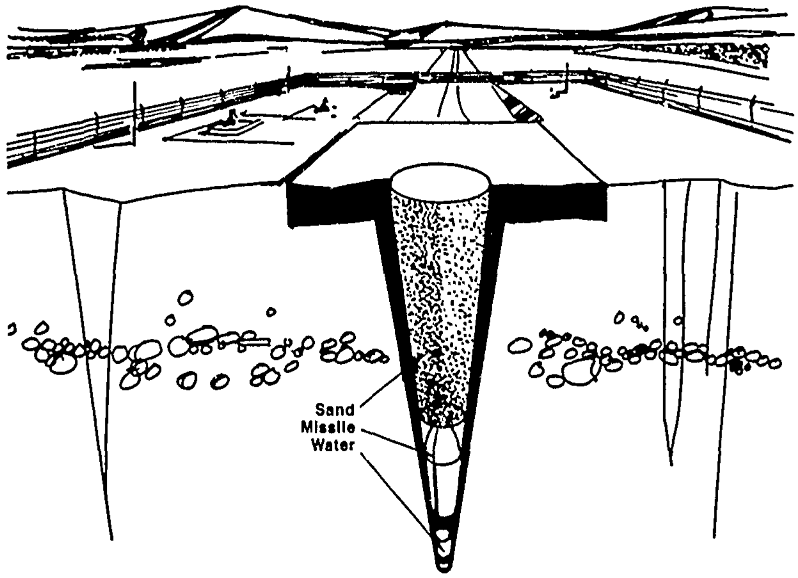
DESCRIPTION/DISCUSSION

Similar to Minuteman silos, these silos each contain a single M-X type missile. Communications antennas at the silo are no less survivable than the silo itself. Also, the silos are unmanned. The silos are supported by two bases and interconnected by roads as necessary.

If it seemed advantageous at a particular site, the silos could be dug horizontally into the face of the cliff.

The chief difficulties with this intuitively attractive concept are its poor survivability against credible advances in Soviet threats and the surprising scarcity of suitable sites. The threats include SLBMs launched from the south, maneuvering reentry vehicles and attacks of the mesas, cliffs, etc., to bury the silos in debris, thereby precluding launch. The concept requires special terrain: cliffs that are both sheer and high, and rock formations that are resistant to landslides. Such sites are hard to find in large numbers.

SANDY SILO



EVALUATION

SURVIVABILITY			OPERATIONAL FEASIBILITY							
RESPONSIVE THREATS	TRIAD INDEPENDENCE	ENDURANCE	PUBLIC INTERFACE	SECURITY	OPERABILITY	TECHNICAL RISK	ENV. IMPACT	COST	SCHEDULE	ARMS CONTROL
X (negative feature)	major positive feature	major positive feature	major positive feature	major positive feature	major negative feature	major negative feature	✓ (satisfactory)	major positive feature	✓ (satisfactory)	✓ (satisfactory)

X = NEGATIVE FEATURE
X (bold) = MAJOR NEGATIVE FEATURE
✓ = SATISFACTORY
✓ (bold) = MAJOR POSITIVE FEATURE

MAJOR NEGATIVE FEATURES

- Operability
  - Missile Difficult to Retrieve for Maintenance
- Technical Risk
  - Can't Verify Egress Without Nuclear Testing

MAJOR POSITIVE FEATURES

- Independent Triad Survivability Mode
  - Maintains Independence
- Endurance
  - Months
- Public Interface
  - Minimal
- Security
  - Buried
- Cost
  - Low

CONCEPT

In the Sandy Silo concept an encapsulated missile is buried in a 2000-foot-deep hole which is filled with sand. On command, pressurized water fluidizes the sand and the capsule floats up. At the surface, the capsule opens and launches the missile.

DESCRIPTION/DISCUSSION

The major system elements are an encapsulated missile and a column, 30 feet in diameter and about 1500 to 2500 feet deep, lined with clay and filled with sand. The encapsulated missile is emplaced at the bottom of the column inside a 900,000-pound steel pressure vessel. So protected, the missile has a high probability of surviving a surface detonation of a 5-megaton nuclear warhead directly above it. Communication is by buried cable.

For missile launch, pressurized water is released from tanks at the bottom of the column to fluidize the sand. The encapsulated missile is released from the pressure vessel and ascends through the fluidized sands to the surface for launch.

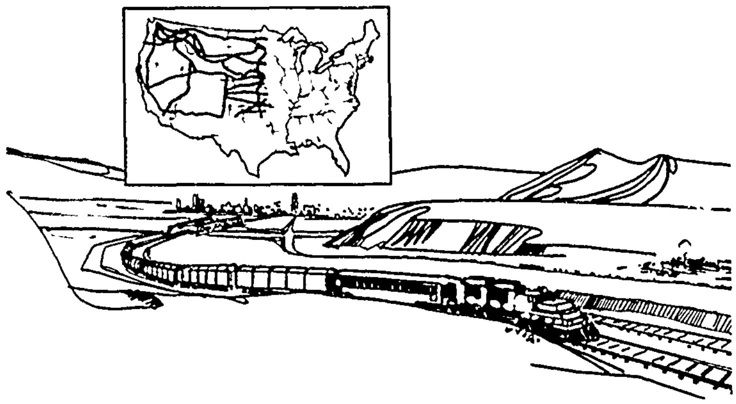
The system consists of about 100 M-X type missiles, each deeply buried in its own impregnable silo. The silos are separated from one another by a few miles and distributed over a 1000-square mile area. The most favorable geology for the silos is unsaturated, porous rock which attenuates ground shock better than other formations. Advantages of this concept are endurance, cost, schedule, and favorable interaction with the public and the environment. Relatively little land would be needed.

Command communications require a number of hardened antennas for each silo, all of which must be interconnected. The vulnerability of the communication nodes is a problem.

The principal disqualifier for the Sandy Silo is however technical uncertainty as to the ability of the system to perform its mission after an attack. Although questions about propagation and attenuation of stress through the sandy column were satisfactorily resolved by a special underground nuclear test project, unresolvable technical questions remain concerning the following:

- Ability of the released water to fluidize compacted sand reliably.
- Ability of the capsule to rise to the surface through the rock-like materials that would be formed at the bottom of bomb craters, especially if the sand column were struck by multiple attacks.

COMMERCIAL RAIL



EVALUATION

SURVIVABILITY			OPERATIONAL FEASIBILITY							
RESPONSIVE THREATS	TRIAD INDEPENDENCE	ENDURANCE	PUBLIC INTERFACE	SECURITY	OPERABILITY	TECHNICAL RISK	ENV. IMPACT	COST	SCHEDULE	ARMS CONTROL
X	✔ (major)	✔ (major)	**X**	**X**	✓	✓	✓	✓	✓	✓

X = NEGATIVE FEATURE
X = MAJOR NEGATIVE FEATURE
✓ = SATISFACTORY
✔ (major) = MAJOR POSITIVE FEATURE

MAJOR NEGATIVE FEATURES

- Sensitivity to Responsive Threats
  - Track and Attack Train Locations
- Public Interface
  - Interference with Commercial Traffic
- Security
  - Terrorist or Paramilitary Attacks

MAJOR POSITIVE FEATURES

- Independent Triad Survivability Mode
  - Not Dependent on Warning of Attack
- Endurance
  - Long, Provided Post-Attack Operations are Unmanned

CONCEPT

In this mobile concept, special trains circulate ICBMs over existing commercial railroads in less populated parts of the northwestern third of the U.S. The missiles are either Minuteman III or M-X. Each train accommodates from one to five missiles. The trains move at random over available trackage or park for random periods at preselected sidings.

Standard railway locomotives, operated by civilian train crews, haul the trains over the rail network.

Military crews launch the missiles from sidings or from designated positions along the main line. Situated within the deployment area are support bases for maintenance, refurbishment, and repair.

DESCRIPTION/DISCUSSION

Such a rail mobile concept was investigated in considerable detail for Minuteman in the early 1960s. Design and development activities for a rail mobile system for Minuteman I included construction of a prototype missile launching car. The train, as then constituted, was made up of a locomotive, a command car, power car, two living cars, and up to five missile cars. The command car serves as a command post and as a maintenance and support unit for the missile train. It contains the communications and launch control equipment required to control and execute launch operations. The power car includes a diesel generator, switch gear, and fuel tanks to support all of the mobile unit power loads. The diner and living cars provide sleeping, sanitary, cooking, dining, recreation, and administrative facilities for the mobile unit crew of 10.

Each missile car is slightly less than 100 feet long and employs air-spring and coil-spring suspension shock absorber devices and other mechanisms to provide a benign shock and vibration environment. The missile is supported by an erector mechanism and mounted on a launch stand. A separate room houses launch support equipment.

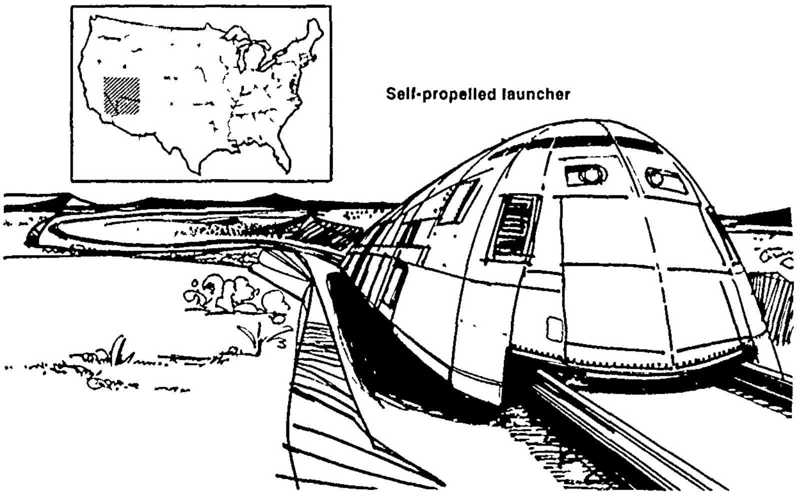
In operation, the trains are deployed and dispersed over as much as 70,000 miles of the existing 80,000 mile rail network in the northwestern region of the U.S. Normally, units are parked at any one of several thousand sidings for random periods or moved continuously along random routes. When parked, the civilian train crew and locomotive are released, the missile cars stabilized and leveled, the missile car roofs opened, and each missile erected to the vertical and aligned. While the train is parked, a few members of the 10-man crew are assigned to security patrols around the mobile unit. If warning is received while a train is in motion, it proceeds to the nearest siding or to a designated launch point along the main line. On command, the missiles are launched.

In the setting of the 1980s, the mobile units would be reconfigured to carry a single more advanced missile with multiple warheads. Increasing the number of warheads from three to ten decreases the required number of missiles, of trains, of miles of track employed, and system costs.

Public safety and safety of the missiles pose insurmountable problems, however. Simultaneous operation of commercial and nuclear missile trains within or near populated areas poses an unacceptable hazard to the civilian population.

System survivability is extremely sensitive to uncertainty of train location. The use of railroad train crews and dispatching personnel for movement and schedule coordination of trains, together with a unique and recognizable train configuration, makes it virtually impossible to conceal train locations from enemy agents. The mobile units would likewise be susceptible to sabotage or paramilitary attack.

DEDICATED RAIL



EVALUATION

SURVIVABILITY			OPERATIONAL FEASIBILITY							
RESPONSIVE THREATS	TRIAD INDEPENDENCE	ENDURANCE	PUBLIC INTERFACE	SECURITY	OPERABILITY	TECHNICAL RISK	ENV. IMPACT	COST	SCHEDULE	ARMS CONTROL
MAJOR NEGATIVE FEATURE	MAJOR POSITIVE FEATURE	MAJOR POSITIVE FEATURE	SATISFACTORY	SATISFACTORY	SATISFACTORY	NEGATIVE FEATURE	MAJOR NEGATIVE FEATURE	MAJOR NEGATIVE FEATURE	SATISFACTORY	SATISFACTORY

X = NEGATIVE FEATURE
X (bold) = MAJOR NEGATIVE FEATURE
✓ = SATISFACTORY
✓ (bold) = MAJOR POSITIVE FEATURE

MAJOR NEGATIVE FEATURES

- Sensitivity to Responsive Threats
  - Track and Attack Train Locations
- Environmental Impact
  - Very Large Exclusion Area
- Cost
  - High

MAJOR POSITIVE FEATURES

- Independent Triad Survivability Mode
  - Not Dependent on Warning of Attack
- Endurance
  - Months

CONCEPT

This concept envisions a new automated rail network for mobile ICBMs. It provides for a blast-resistant installation and a more uniform dispersal of missiles than the commercial rail approach.

The system can operate in three different ways:

- The carriers move continuously at low speed.
- On receipt of tactical warning, each missile leaves its normal parking place and dashes in a direction selected at random.
- Each missile is parked most of the time but moves to new random locations at intervals selected to be shorter than the time needed by the Soviets to locate the missiles and retarget their missiles at them.

DESCRIPTION/DISCUSSION

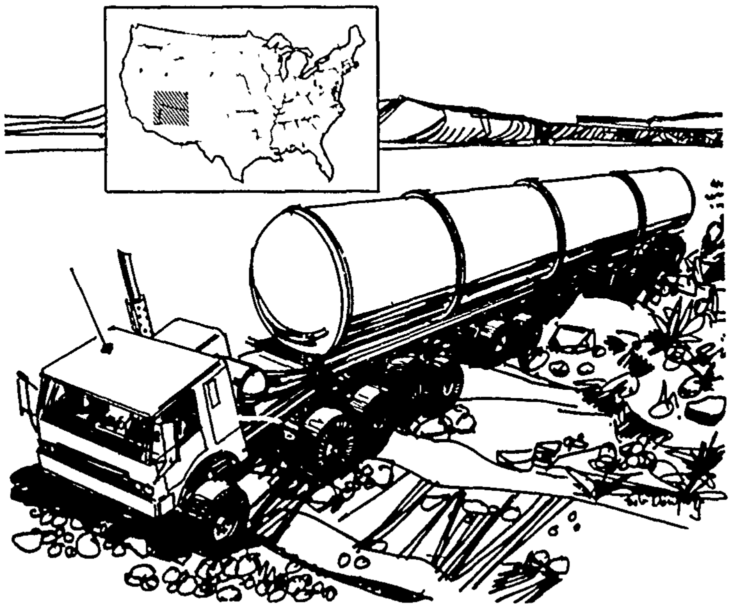
A single M-X type missile is carried on a transporter-launcher-erector (TEL). The unmanned TEL is drawn by a locomotive or is self-propelled. In the latter case, the carrier is 150 feet long, weighs 1 million pounds, travels at 30 mph (maximum) and is hardened to resist a blast of 15 psi.

The 180 TELs operate over a dedicated rail network covering 90,000 square miles. In the western U.S., the total area covered by the system would be at least twice as large because of unusable terrain, e.g., mountains. The tracks are laid in parallel lines four miles apart. Total length of track is 22,000 miles.

In operation, the TELs are dispersed over the entire rail network. A TEL parked at a designated launch point can erect and launch its missile on command without delay. Other TELs proceed to the nearest launch point and commence the erection and launch sequence.

A major concern is the extensive land area that a dedicated rail system must occupy, all of which must be fenced off and closed to public use for reasons of missile security and public safety.

OFF-ROAD MOBILE



EVALUATION

SURVIVABILITY			OPERATIONAL FEASIBILITY							
RESPONSIVE THREATS	TRIAD INDEPENDENCE	ENDURANCE	PUBLIC INTERFACE	SECURITY	OPERABILITY	TECHNICAL RISK	ENV. IMPACT	COST	SCHEDULE	ARMS CONTROL
X	**✓**	**✓**	✓	✓	X	X	**X**	✓	✓	✓

X = NEGATIVE FEATURE
X = MAJOR NEGATIVE FEATURE
✓ = SATISFACTORY
✓ = MAJOR POSITIVE FEATURE

MAJOR NEGATIVE FEATURES

- Sensitivity to Responsive Threats
  - Track and Attack Transporter Locations
- Environmental Impact
  - Very Large Exclusion Area
  - Severe Defacing of Terrain

MAJOR POSITIVE FEATURES

- Independent Triad Survival Mode
  - Not Dependent on Warning of Attack
- Endurance
  - Long, Provided Post-Attack Operations are Unmanned

CONCEPT

A fleet of 220 off-road transporter-launchers is scattered over a large interior land area. Survival depends on dispersal and continuous movement. Each vehicle carries one M-X type missile with ten warheads. The transporters are hardened to 20 psi when tied down.

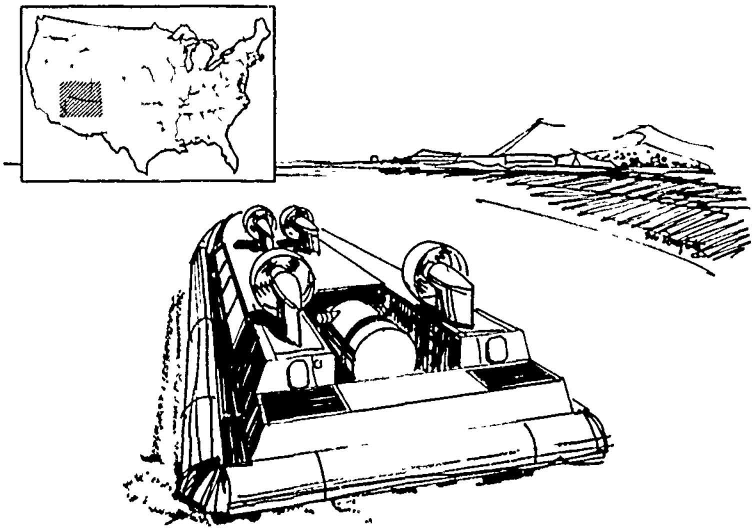
DESCRIPTION/DISCUSSION

As first conceived, the off-road deployment concept made use of relatively standard types of transport vehicles that could withstand overpressures of perhaps up to 5 psi. These vehicles were reasonably adapted to rough terrain (gullies, grades, etc.), but they required huge land areas to attain the desired survivability. Studies revealed a requirement for over 400,000 square miles of operating area, which exceeds the total land area controlled by the Department of Defense and the Bureau of Land Management of the Department of Interior . . . and certainly more than the combined area of military bases in the southwestern U.S.

Equipment hardened to 20 psi requires a deployment area of 90,000 square miles to survive. However, increasing hardness also adds considerably to weight.

The difficulties with this system include severe defacing of the natural environment and the need to exclude the public from 90,000 square miles for missile security and public safety.

GROUND EFFECT MACHINE (GEM)



EVALUATION

SURVIVABILITY			OPERATIONAL FEASIBILITY							
RESPONSIVE THREATS	TRIAD INDEPENDENCE	ENDURANCE	PUBLIC INTERFACE	SECURITY	OPERABILITY	TECHNICAL RISK	ENV. IMPACT	COST	SCHEDULE	ARMS CONTROL
X (major negative)	X (major negative)	✓ (major positive)	✓	✓	X (major negative)	✓	X (major negative)	X	X	✓

X = NEGATIVE FEATURE
X = MAJOR NEGATIVE FEATURE
✓ = SATISFACTORY
✓ = MAJOR POSITIVE FEATURE

MAJOR NEGATIVE FEATURES

- Sensitivity to Responsive Threats
  - Track and Attack Transporter Locations
- Failure to Maintain Independent Triad Survivability Mode
  - Requires Warning
- Operability
  - Movement over Obstacles and Gullies
- Environmental Impact
  - Severe Dust Erosion

MAJOR POSITIVE FEATURES

- Endurance
  - Long, Provided Post-Attack Operations are Unmanned

CONCEPT

This concept rapidly disperses a missile force on warning without making use of public roads. Fast GEM vehicles ride on a cushion of air enclosed by semiflexible skirts. The "Hovercraft" in regular passenger service between Dover, England and Calais, France, is a related example. Operation of air cushion vehicles requires relatively flat surfaces.

The U.S. Navy built and tested a 100-ton air-cushion vessel and, until recently, was designing a scaled-up 3000-ton GEM.

The GEM concept scatters the force from existing military bases in the western and southwestern regions of the U.S. to adjacent government-controlled dispersal areas.

DESCRIPTION/DISCUSSION

As with all dash-on-warning systems, an optimum balance must be struck among the number of vehicles, their hardness, and the size of the dispersal area. Thus, for the nominal survival area, a practical 2-psi GEM carrier requires an excessively large land area (730,000 square miles). Land area is the chief constraint. Greater hardness, of course, requires greater weight.

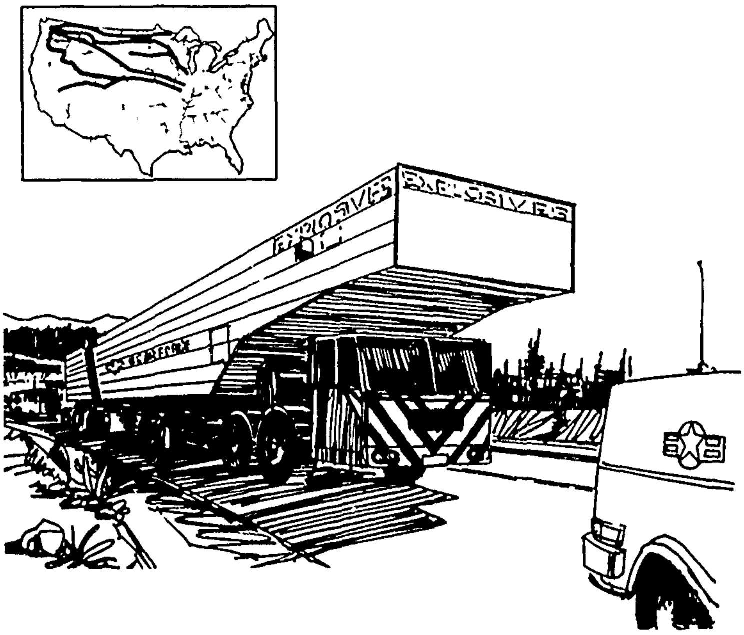
The selected system consists of 600 GEMs scattering from 20 bases into a 90,000 square mile area at a speed of 80 mph. Each 10-psi carrier weighs 260,000 pounds, including a 95,000-pound missile with five warheads. This configuration is able to survive predicted attacks after only 30 minutes of warning. Tiedowns may be necessary to achieve the desired hardness.

About 100 feet long, the GEM rides over uneven terrain on a 2-to-3 foot air bubble and can climb 10% grades.

There are questions concerning environmental impact. A GEM does not disturb a desert surface as much as tracked or wheeled vehicles. On the other hand, it does generate a good deal of dust whenever it is used, as in training maneuvers. Nor is it clear that large deployment areas can be found without modifying the terrain to remove fence posts or gullies, etc., or to level other obstacles that would slow its travel.

Finally, dependence on warning is crucial to survival as in all dash-on-warning concepts. The possibility that our warning systems may be nullified or that a surprise SLBM attack on GEM bases would cut warning time to half the nominal 30 minutes or less, puts survival of the system in doubt.

ROAD MOBILE (MINUTEMAN)



EVALUATION

SURVIVABILITY					OPERATIONAL FEASIBILITY					
RESPONSIVE THREATS	TRIAD INDEPENDENCE	ENDURANCE	PUBLIC INTERFACE	SECURITY	OPERABILITY	TECHNICAL RISK	ENV. IMPACT	COST	SCHEDULE	ARMS CONTROL
Major negative feature	Major negative feature	Major positive feature	Satisfactory	Satisfactory	Major negative feature	Satisfactory	Satisfactory	Major positive feature	Major positive feature	Satisfactory

X = NEGATIVE FEATURE
X (bold) = MAJOR NEGATIVE FEATURE
✓ = SATISFACTORY
✓ (bold) = MAJOR POSITIVE FEATURE

MAJOR NEGATIVE FEATURES

- Sensitivity to Responsive Threats
  - Track and Attack Transporter Locations
  - Low Survival Without Hours of Warning
- Failure to Maintain Independent Triad Survival Mode
  - Requires Warning
- Operability
  - Questionable Due to Jammed Roads

MAJOR POSITIVE FEATURES

- Endurance
  - Long, Provided Post-Attack Operations are Unmanned
- Cost
  - Low
- Schedule
  - Uses Existing Missiles

CONCEPT

A road-mobile basing concept using existing Minuteman missiles was developed. To reduce the acquisition time for such a system, existing Minuteman bases in the north central part of the U.S. were assumed to be operating bases.

Since the primary purpose of this concept was early system acquisition, it was examined principally as an interim solution to the ICBM vulnerability problem.

DESCRIPTION/DISCUSSION

The existing Minuteman missile, after design modifications and tests, is installed in a transporter vehicle weighing about 200,000 pounds and hardened to 5 psi. In view of weight limitations on public roads, it is also necessary to use other vehicles for transportation of security, power, command, control, and communication equipment.

Presurveyed launch pads are established along existing highways to permit satisfactory guidance accuracy. The missile, in its transportation canister, is erected on the launch pad, connected to portable electronic ground control equipment, tested, then placed on alert using airborne launch control aircraft.

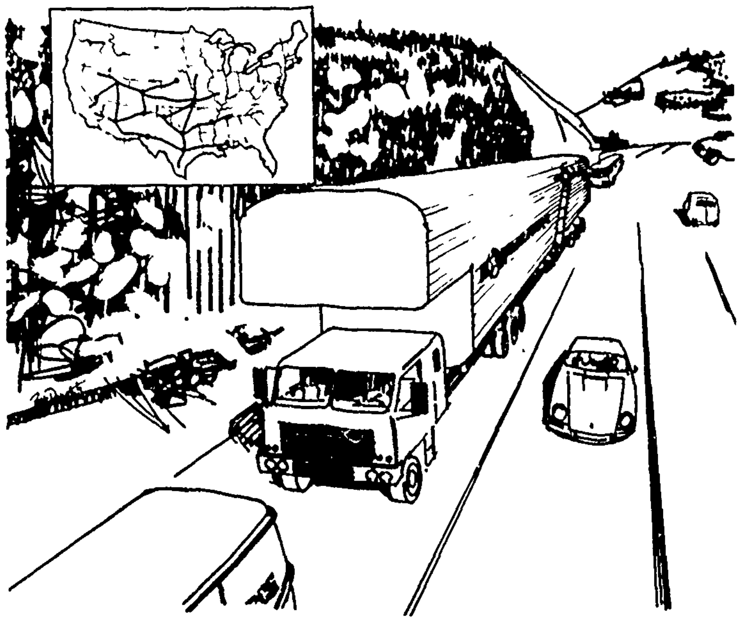
Minuteman III missiles could be scattered on warning over public roads in a five-state region (Idaho, Montana, Nebraska, North Dakota, and South Dakota). This region has a total area of 550,000 square miles. Dispersing from four bases at a convoy speed of 30 mph, the missile force can fan out over an area of 400,000 square miles in six hours.

Since Minuteman is no longer in production, missiles must be removed from silos and test missiles must be removed from inventory.

Plans for the acquisition of this system provide for an initial operating capability (IOC) date of three years after program go-ahead.

A principal difficulty with this system is the need for many hours of strategic warning even assuming that an average dispersal speed of 30 mph could be maintained.

ROAD MOBILE (NEW MISSILE)



EVALUATION

SURVIVABILITY					OPERATIONAL FEASIBILITY					
RESPONSIVE THREATS	TRIAD INDEPENDENCE	ENDURANCE	PUBLIC INTERFACE	SECURITY	OPERABILITY	TECHNICAL RISK	ENV. IMPACT	COST	SCHEDULE	ARMS CONTROL
X	**X**	**✓**	✓	✓	**X**	✓	✓	✓	✓	✓

X = NEGATIVE FEATURE
X = MAJOR NEGATIVE FEATURE
✓ = SATISFACTORY
✓ = MAJOR POSITIVE FEATURE

MAJOR NEGATIVE FEATURES

- Sensitivity to Responsive Threats
  - Track and Attack Transporter Locations
  - Low Survival Without Hours of Warning
- Failure to Maintain Independent Triad Survival Mode
  - Requires Warning
- Operability
  - Questionable Due to Jammed Roads

MAJOR POSITIVE FEATURES

- Endurance
  - Long, Provided Post-Attack Operations are Unmanned

CONCEPT

A road-mobile concept using existing public roads for missile dispersal seemed an economical basing alternative. Upon strategic warning, the missiles in self-contained mobile transporters dash from existing military bases to presurveyed launch sites along the highways.

The success of this concept depends almost entirely on a reliable strategic warning system that provides hours notice of an impending ICBM or SLBM attack. To reduce dependence on such a warning, an alternate approach of deploying 10% or more of the force in a continuous road patrol was also evaluated.

DESCRIPTION/DISCUSSION

A 95,000-pound missile with five reentry vehicles is transported by a large (250,000-pound class transporter-erector-launcher) on roads throughout the south-central and southwestern U.S. We sought to use the largest missile compatible with the major interstate highway and secondary road systems. The associated security, command, control, and communication equipment follow in a convoy of vans.

To achieve the desired survivability against the nominal ICBM attack, 375 convoys dash outward from 16 bases over 45,000 miles of road at 30 mph until they have dispersed over an area of 300,000 square miles. (At an estimated 90% alert rate, 420 transporters and missiles are needed.)

Unless dispersal onto public roads begins at least two hours before an attack, the system has very little chance of surviving. However, survivability improves rapidly with time. Five hours is satisfactory.

As a way of lightening the gross weight of the missile and transporter while they are in transit, liquid-fueled missiles were considered. By storing fuel and oxidizer at predetermined launch sites, we hoped to reduce the transported weight substantially. However, cost and public safety considerations, together with the time lost in fueling the missiles, argued against this approach.

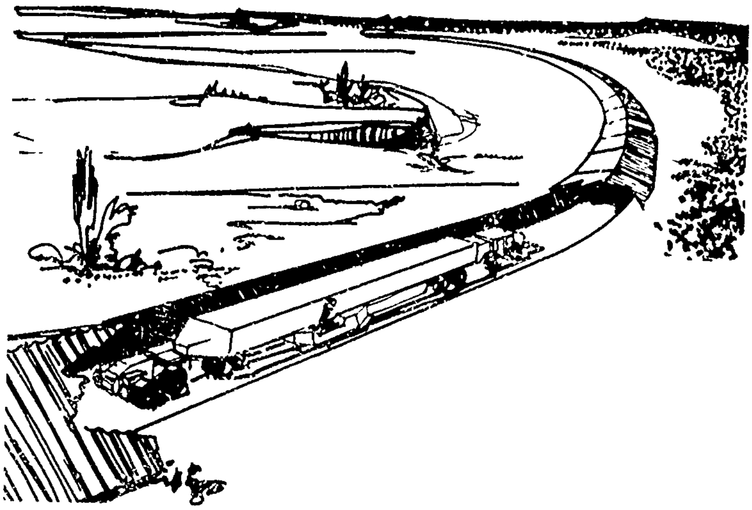
There are two overwhelming objections to this concept

The first is that the system depends on warning, and in so doing, suffers in its ability to survive a surprise attack. And given sufficient warning, there is also the possibility that traffic jams will delay dispersal.

The remedy, at least a partial remedy, is to keep a portion of the convoys in continuous road patrol, i.e., predispersed. But here we expose the population on or near the public highways to heavy nuclear traffic, which poses an unacceptable safety hazard as well as security risk to the missiles. This condition would apply equally to any training exercises on public highways.

Soviet observation of a dispersal, especially in periods of high international tension, could be very destabilizing. It might invite an immediate attack because the Soviets would know that they had one to two hours to launch their missiles after which an attack could not succeed.

COVERED TRENCH



EVALUATION

SURVIVABILITY			OPERATIONAL FEASIBILITY							
RESPONSIVE THREATS	TRIAD INDEPENDENCE	ENDURANCE	PUBLIC INTERFACE	SECURITY	OPERABILITY	TECHNICAL RISK	ENV. IMPACT	COST	SCHEDULE	ARMS CONTROL
X (major negative)	✓ (major positive)	✓ (major positive)	✓	✓	✓ (major positive)	✓	X (major negative)	X	✓	✓

X = NEGATIVE FEATURE
X (bold) = MAJOR NEGATIVE FEATURE
✓ = SATISFACTORY
✓ (bold) = MAJOR POSITIVE FEATURE

MAJOR NEGATIVE FEATURES

- Sensitivity to Responsive Thre...
  - Track and Attack Vehicle After Light Attack on Cover
  - Implanted Sensors Locate Vehicle (Decoys Not Feasible)
- Environmental Impact
  - Large Exclusion Area

MAJOR POSITIVE FEATURES

- Independent Triad Survivability Mode
  - Maintains Independence
- Endurance
  - Months
- Operability
  - Unmanned

CONCEPT

Canisterized M-X type missiles travel intermittently on transporter-erector-launchers (TELs) in long, covered trenches.

The metallized fabric cover over the trench conceals the TEL from optical or radar observation so that the position of the TEL and missile is unknown at any given time. The TEL may ride on guideways or rails, in which case the entire system can be automated. The walls of the trench partially shield the TEL from blast and shock waves, making the system about 50 psi hard, thus requiring less land than unprotected concepts.

DESCRIPTION/DISCUSSION

The system consists of million-pound-class TELs each operating in a trench some 15 to 20 feet deep with sloping concrete walls. Total trench length is about 9100 miles with adjacent parallel sections separated by 2 miles.

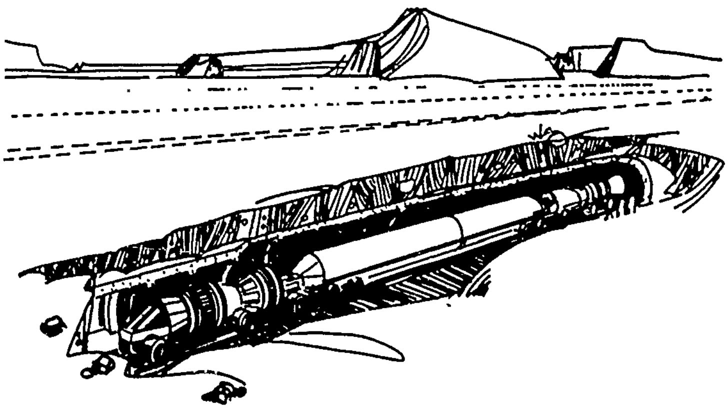
The entire trench is covered to shield the TEL from optical or electromagnetic observation. But overpressure from a nuclear attack would destroy the cover.

The TELs, which are parked most of the time, move at random intervals for random distances at 10 mph. At times of strategic alert, they can travel continuously. Each TEL is self-contained with respect to power and communications.

Survivability of the system depends on uncertainty of missile location. Since there are at least two ways of overcoming concealment, survivability appears questionable.

One way of determing missile location through the trench cover is by local sensors carried by enemy agents on the ground or in overflying aircraft. (There is no practical way to provide decoy TELs.) Security would thus require excluding the public entirely and barring public use of a considerable land area (18,000 square miles). A second way of exposing the TEL's location is by a precursor attack that destroys the cover over each trench and exposes the TELs to satellite surveillance. In this event, continuous movement could be initiated.

HYBRID TRENCH



EVALUATION

SURVIVABILITY			OPERATIONAL FEASIBILITY							
RESPONSIVE THREATS	TRIAD INDEPENDENCE	ENDURANCE	PUBLIC INTERFACE	SECURITY	OPERABILITY	TECHNICAL RISK	ENV. IMPACT	COST	SCHEDULE	ARMS CONTROL
X	**✓**	**✓**	✓	**✓**	**✓**	X	**X**	X	✓	✓

X = NEGATIVE FEATURE
X = MAJOR NEGATIVE FEATURE
✓ = SATISFACTORY
✓ = MAJOR POSITIVE FEATURE

MAJOR NEGATIVE FEATURES

- Sensitivity to Responsive Threats
  - Implanted Sensors Locate Vehicle (Decoys Not Feasible)
- Environmental Impact
  - Large Exclusion Area

MAJOR POSITIVE FEATURES

- Independent Triad Survivability Mode
  - Maintains Independence
- Endurance
  - Months
- Security
  - Buried
- Operability
  - Unmanned

CONCEPT

A variant of the covered trench that uses considerably less land, this concept calls for a series of thin-walled tunnels about 5 feet underground punctuated, at intervals, by thick blast-resistant sections. Within a tunnel, each M-X missile on its transporter-erector-launcher (TEL) moves randomly, pausing for weeks in a hardened section. A pair of massive blast plugs travels with the TEL to seal the missile against airblast. To launch, the TEL breaks through the roof to erect the canisterized missile. The system is unmanned.

DESCRIPTION/DISCUSSION

The 200 tunnels are about 16 miles long and spaced about 4000 feet apart. Each tunnel has about 50 hardened sections spaced 2000 feet apart along the length of the tunnel. The hard sections are 250 feet long and 15 feet in diameter, with a wall of 18-inch reinforced concrete buried under 5 feet of soil. The connecting stretches of tunnel have thinner walls (6 inches). The total subterranean system is laid out beneath a 2500 square mile surface.

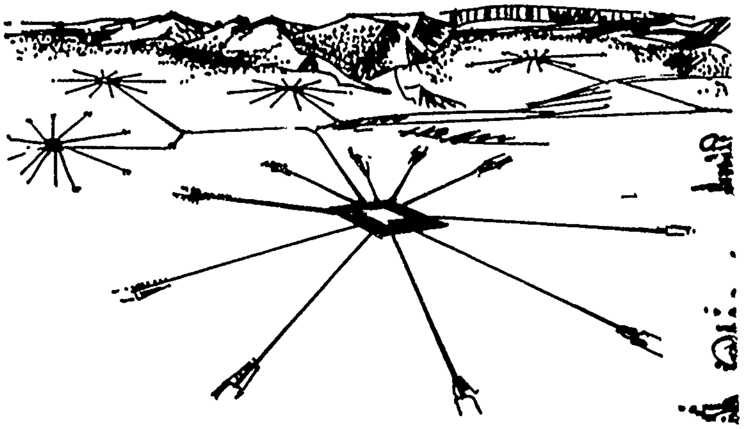
The TEL is a rubber-tired vehicle weighing 650,000 pounds, about 150 feet long by 10 feet wide. Two blast plugs travel in tandem with the TEL. The function of the plugs is to protect the TEL from weapon effects propagating inside the tunnel caused by bombs hitting the tunnel but missing the TEL. The blast plugs weigh 140,000 pounds each. In half-scale tests in July 1978, an experimental blast plug reduced the peak pressure of 4350 psi to less than 3 psi behind the plug, where the TEL would be.

Also, an underground nuclear test conducted specifically to assist in evaluation of this concept indicated that a nuclear blast directly on or in the tunnel could likely be tolerated.

The TEL and blast plugs travel between hardened sections infrequently, perhaps once a month, or as required for maintenance. Motive power is provided by electric rails that run the length of the tunnel, backed up by self-contained motive power. For launch, the TEL erects through the roof of the hard tunnel, breaks rapidly through the over-burden, and tilts the canisterized missile to an elevation angle of 55 degrees. The breakout concept was validated by tests in 1978.

Like the covered trench, its principal shortcoming is its susceptability to loss of concealment of the weapon through the use of special sensors by foreign agents on the ground or in overflying aircraft. The problem is greatly compounded by the fact that decoys cannot be employed in a tunnel system without the great expense of bypass tunnels. Consequently, the public would have to be excluded from the deployment area.

DASH TO SHELTER



EVALUATION

SURVIVABILITY			OPERATIONAL FEASIBILITY							
RESPONSIVE THREATS	TRIAD INDEPENDENCE	ENDURANCE	PUBLIC INTERFACE	SECURITY	OPERABILITY	TECHNICAL RISK	ENV. IMPACT	COST	SCHEDULE	ARMS CONTROL
X (major negative)	X (major negative)	✓ (major positive)	✓	✓	X	X (major negative)	✓	X	✓	✓

X = NEGATIVE FEATURE
X (bold) = MAJOR NEGATIVE FEATURE
✓ = SATISFACTORY
✓ (bold) = MAJOR POSITIVE FEATURE

MAJOR NEGATIVE FEATURES

- Sensitivity to Responsive Threats
  - Track and Attack Transporter in Known Destination Points
- Failure to Maintain Independent Triad Survivability Mode
  - Requires Warning
- Technical Risk
  - High Speed Movement of Heavy Transporter

MAJOR POSITIVE FEATURES

- Endurance
  - Months

CONCEPT

This approach makes it unnecessary to conceal the location of the missile as is done, say for M-X/MPS. Instead the missile is kept on its transporter-launcher in a hardened central facility with roads radiating to a number of hardened shelters. On warning, the crew drives the transporter-launcher to one of the shelters and installs the missile, making it ready to erect and launch on command.

DESCRIPTION/DISCUSSION

The system consists of canisterized M-X missiles on transporter-launchers parked at the center of 200 radial networks of roads, the networks themselves, and 4600 hardened shelters.

Against an ICBM threat, the vehicle must reach the shelter well within the 30 minutes after warning. Although the average distance to the 23 shelters is 2 miles, an extremely powerful tractor is required to accelerate the heavy transporter-launcher (1,600,000 pounds loaded) up to speed (as much as 60 mph) and allow time to enter the shelter, activate the missile, and respond to commands.

Adjacent to the central facility are living quarters for the on-duty transporter crews, who are on alert status at all times. On receiving a warning, a crew drives the transporter to a randomly selected shelter, drives in, and closes the blast door. (The central facility may also be chosen as the launch point, in which case the crew would not move the missile.)

They then connect the transporter-launcher to various shelter subsystems and wait for a launch order.

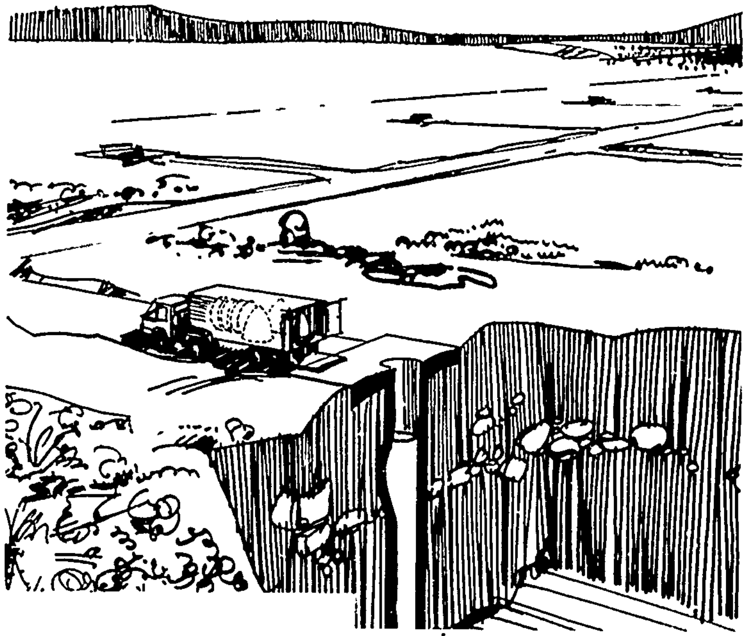
Should they be ordered to launch, the crew opens the shelter door, moves the transporter immediately outside the shelter, and erects the canister containing the missile. Finally, the canister cover is jettisoned and the missile launched.

It would also be possible to launch the missile through the open roof. Another version of this concept uses rails instead of roads.

Cost is considerably higher than M-X/MPS because the shelters must be large enough to house the entire transporter, and operating crews are much larger.

The chief technical problem is in furnishing high dash speed for a 1.5 million pound class transporter. Another difficulty is the critical dependence upon warning.

MOBILE FRONT END



EVALUATION

SURVIVABILITY			OPERATIONAL FEASIBILITY							
RESPONSIVE THREATS	TRIAD INDEPENDENCE	ENDURANCE	PUBLIC INTERFACE	SECURITY	OPERABILITY	TECHNICAL RISK	ENV. IMPACT	COST	SCHEDULE	ARMS CONTROL
✓	**✓**	**✓**	✓	✓	X	X	✓	**X**	✓	**X**

X = NEGATIVE FEATURE
X = MAJOR NEGATIVE FEATURE
✓ = SATISFACTORY
✓ = MAJOR POSITIVE FEATURE

MAJOR NEGATIVE FEATURES

- Cost
  - Much Higher than Comparable M-X/MPS Costs
- Arms Control
  - Probable Violation of Interim SALT II

MAJOR POSITIVE FEATURES

- Independent Triad Survivability Mode
  - Maintains Independence
- Endurance
  - Months

CONCEPT

The goal of this concept is the same as Midgetman, that is, to dilute the effectiveness of an ICBM attack by proliferation of inexpensive aimpoints. However, the novel feature of this approach is an attempt to save cost by moving only the missile front ends (guidance, warhead, and reentry vehicle) from silo to silo. Since front end costs constitute about half the total missile costs, and since only a fraction of the boosters would be equipped with genuine front ends at any given time, substantial savings were expected over a comparable force of fully-equipped missiles. (The cost of moving relatively small front ends from silo to silo is fairly low.)

DESCRIPTION/DISCUSSION

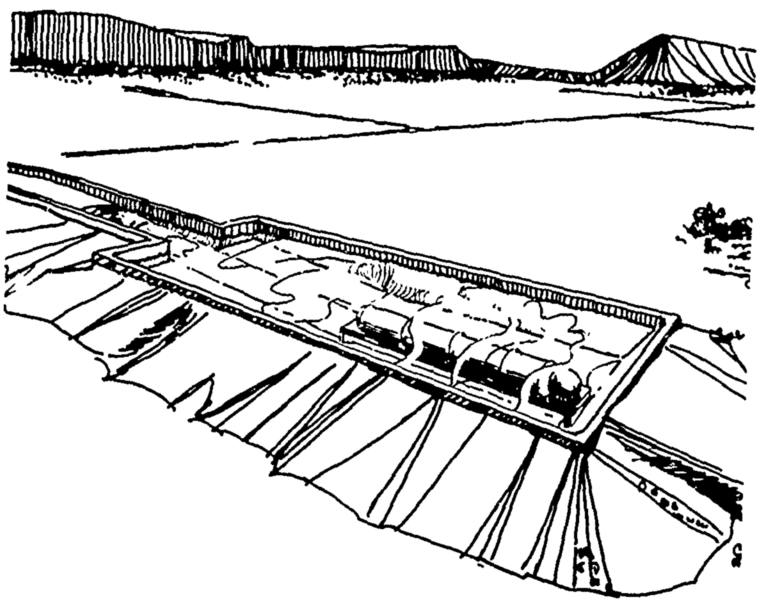
The system elements are the same as for Midgetman. However, some missiles carry real front ends while others are equipped with simulators.

A further saving is obtained by maintaining the front ends in a dormant condition. On the other hand, several hours are needed to warm up the guidance system once a launch order is given.

Front ends and decoys are shifted periodically and randomly, using relatively small transporters over light roads.

Evaluation showed that the extra cost of placing a booster in each hole exceeded the savings incurred from smaller transporters, lighter decoys and simpler roads.

POOL



EVALUATION

Survivability			Operational Feasibility							
RESPONSIVE THREATS	TRIAD INDEPENDENCE	ENDURANCE	PUBLIC INTERFACE	SECURITY	OPERABILITY	TECHNICAL RISK	ENV. IMPACT	COST	SCHEDULE	ARMS CONTROL
✓	**✓**	**✓**	✓	✓	X	✓	**X**	✓	✓	✓

X = NEGATIVE FEATURE
X = MAJOR NEGATIVE FEATURE
✓ = SATISFACTORY
✓ = MAJOR POSITIVE FEATURE

MAJOR NEGATIVE FEATURES

- Environmental Impact
  - Large Water Usage

MAJOR POSITIVE FEATURES

- Independent Triad Survivability Mode
  - Maintains Independence
- Endurance
  - Months

CONCEPT

In this variant of the hide-in-shelters concept, an automated mobile launch platform (MLP) and its support equipment are moved, randomly and infrequently, among numerous pools of water by an amphibian transporter. Dye in the water and a retractable pool cover shield the MLP from infrared, visual, or radar observation. And the water itself protects the MLP against near-miss detonations.

When the transporter enters a pool and deposits an MLP, it takes on an equal weight of water, thus maintaining a constant water level in the pool and a constant transporter weight. Traveling over the interconnecting roads, the transporter moves from pool to pool, picking up or leaving an MLP, or pretending to.

DESCRIPTION/DISCUSSION

The MLP consists of a canisterized missile that is contained and shock-mounted within a hardened, waterproof steel capsule. Beside the cylindrical capsule is a similarly hardened, waterproof sphere containing missile support equipment. Capsule and sphere rest on a palletized frame. The MLP has a 10% negative buoyancy which enables it to withstand near-miss ground motion without tiedowns. There are 200 such MLPs in the system. Each is 100 feet long, 13 feet high, and 14 feet wide; it weighs 680,000 pounds.

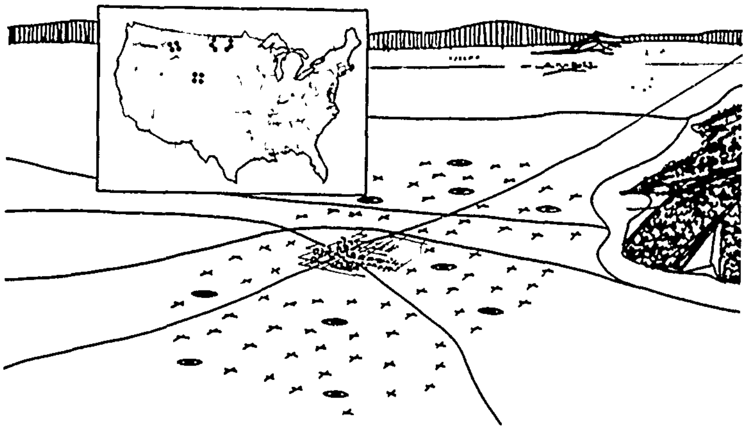
For launch, the capsule is erected to a vertical position by hydraulic rams so that its upper portion clears the water. The top of the capsule now swings open and the missile is fired.

There are ten transporters to move the MLPs from pool to pool. Each weighs 710,000 pounds (1,390,000 pounds loaded). The manned, double-ended amphibian descends the ramp of a pool and stops over an MLP position, raises the MLP to its road-carry position while off-loading an equal weight of water ballast, or reverses these operations, or does nothing. It is driven by gas turbines through 12 large-tired wheels. Length is 153 feet, width is 30 feet (with a 23-foot tread), and height is 23 feet.

The 4600 slope-sided pools are 40 feet deep, 300 feet long and 100 feet wide at the surface, with a 10% grade entry road. Each pool contains about 6.5 million gallons of water. Pools are spaced about 1 mile apart so that an enemy warhead cannot destroy more than one. At least 5000 miles of 28-foot-wide heavy duty pool-connecting roads are constructed. Sixteen hours are required to deceptively emplace or relocate an MLP among 23 pools. Communication, security, and power distribution subsystems are similar to the M-X/MPS concept.

The system has a heavy requirement for water in an arid area; 92,000 acre-feet for initial fill and 26,000 acre-feet annually to replace evaporation loss.

MINUTEMAN/MPS



EVALUATION

SURVIVABILITY			OPERATIONAL FEASIBILITY							
RESPONSIVE THREATS	TRIAD INDEPENDENCE	ENDURANCE	PUBLIC INTERFACE	SECURITY	OPERABILITY	TECHNICAL RISK	ENV. IMPACT	COST	SCHEDULE	ARMS CONTROL
✓	✓ (major positive)	✓ (major positive)	X	✓	X	✓	✓	✓	✓	✓

X = NEGATIVE FEATURE
X = MAJOR NEGATIVE FEATURE
✓ = SATISFACTORY
✓ = MAJOR POSITIVE FEATURE

MAJOR NEGATIVE FEATURES

MAJOR POSITIVE FEATURES

- Independent Triad Survivability Mode
  - Maintains Independence
- Endurance
  - Months

CONCEPT

The goal of this concept was to acquire the survivability benefit of the multiple protective shelter (MPS) approach earlier and cheaper than could be obtained by building the M-X/MPS system. In this approach, the entire force of Minuteman III missiles is periodically shuffled among a large number of vertical shelters (silos), all of which contain either a missile or a simulator. The shelters are dug in the existing Minuteman Wing areas. A new missile, similar in size to Minuteman III, but with higher performance, or M-X missiles could replace the Minuteman in the future.

DESCRIPTION/DISCUSSION

The system makes use of four existing Minuteman bases and 550 silos. About 7800 new silos are constructed. The silos are spaced a mile apart over an 8500 square mile area. An M-X type communications system is installed.

The Minuteman III missile is modified to accommodate the advanced AIRS guidance system for canister launch, for mobile operation, and to extend its useful life so as to justify the cost of rebasing. One change for canister launch is the addition of canister support pads for all three solid propellant stages. For the mobile environment, the post boost vehicle propellant tank and the reentry vehicle attachment mechanism are modified.

Likewise, since Minuteman operational support equipment is no longer manufactured, new or modified equipment compatible with a mobile environment is furnished. Ground and flight software are also changed.

The Minuteman missile in its canister-launcher is carried on a new transporter, 100-feet-long and weighing 225,000 pounds loaded. Forty of these transporters are needed.

About 8 to 10,000 miles of road, capable of bearing the transporter, connects the silos. Part of the route is over public roads currently used for moving the Minuteman missiles.

A crucial issue, however, is how soon the Minuteman/MPS system can be deployed, as compared to the alternative M-X/MPS.

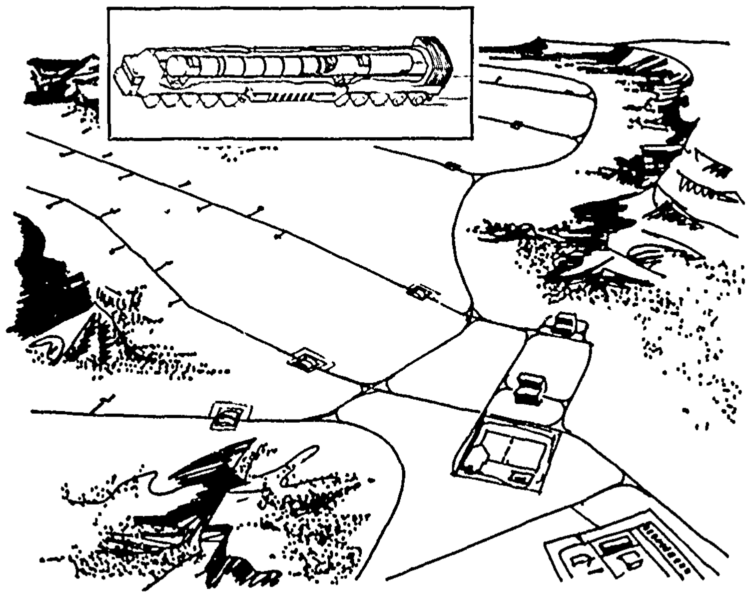
It is estimated that a minimum of 2½ years would be required for development of missile modifications (start of full-scale engineering to first flight test) and an additional 2½ years for production, assembly, and initial deployment.

In a parallel activity, facility design and construction would also take around 5 years, including preparation of an environmental impact statement (EIS), land acquisition, preparation of specifications (about 2 years), and design (about 1½ years) and construction of the first increment of roads, utilities, and shelters (about 1½ years). On the basis of these considerations, a delay of almost one year was estimated for deployment of the first ten Minuteman missiles beyond the current M-X/MPS deployment schedule.

One advantage of this approach is that it makes economical use of existing Minuteman missiles and bases. On the other hand, it imposes a heavy strain on public highways, many of which will have to be upgraded. Highway bridges and other structures will need major rework.

Another disadvantage of this concept is that it requires construction and mobile operations in severe weather. Accordingly, construction, deployment, and operating cost estimates are uncertain, as is the estimate of construction time. In addition, for all the substantial investment required, this system relies on an aging missile with considerably less payload capacity than M-X.

M-X/MPS



EVALUATION

SURVIVABILITY			OPERATIONAL FEASIBILITY							
RESPONSIVE THREATS	TRIAD INDEPENDENCE	ENDURANCE	PUBLIC INTERFACE	SECURITY	OPERABILITY	TECHNICAL RISK	ENV. IMPACT	COST	SCHEDULE	ARMS CONTROL
✓	✔	✔	✓	✓	✓	✓	✓	✓	✓	✓

X = NEGATIVE FEATURE
X = MAJOR NEGATIVE FEATURE
✓ = SATISFACTORY
✔ = MAJOR POSITIVE FEATURE

MAJOR NEGATIVE FEATURES

MAJOR POSITIVE FEATURES

- o Independent Triad Survivability Mode
  - o Maintains Independence
- o Endurance
  - o Months

CONCEPT

Here, 200 M-X missiles and launchers are randomly distributed among 4600 shelters. Periodically, a transporter shifts a missile/launcher from one shelter to another, or pretends to. In this way, the actual location of the missiles is concealed.

Because missile/launcher simulators (decoys) are installed in all vacant shelters, the presence or absence of a real missile cannot be detected by either local or remote sensors. In like manner, the concealed cargo of the transporter can be either a real or a decoy missile/launcher, the difference being undetectable.

The shelters are distributed about a mile apart and so hardened that a direct hit on one will not disable another shelter. Since all the shelters contain either a missile/launcher or a simulator, the enemy would have to destroy all 4600 shelters to be sure that he has struck the 200 missiles.

If there is reason to believe that the true location of the missiles has been compromised, the transporters immediately begin a series of moves to reestablish the uncertainty of missile location.

In concept, the shelter can be either horizontal or vertical. The vertical arrangement offers greater hardness and slightly lower cost. The horizontal geometry offers much more rapid relocation if missile location is compromised and allows for certain SALT verification procedures; these were the two reasons for its selection. In the ensuing writeup, the horizontal version will be described. However, the discussion is essentially equally valid for the vertical version.

DESCRIPTION/DISCUSSION

The system is installed in a total area of about 5500 square miles. The shelters, some support facilities, and portions of two main operating bases are fenced and restricted from public use. The total restricted area occupies about 25 square nautical miles. The remaining land is available to the public as before for grazing, agriculture, mining, recreation, etc.

Partly buried in the ground to resist blast (600 psi) and to blend with the landscape, each 172-foot-long shelter is constructed of 21-inch-thick reinforced concrete. The loading ramp slopes down from the surface to the blastproof door behind which is the cavity for the missile/launcher or simulator decoy. Concrete enclosures for electrical power, communication equipment, and environmental control equipment are buried next to each shelter. Security is provided by a variety of intrusion sensors. A stock fence encloses 2½ acres surrounding the shelter.

The missile is 70 feet long, 90 inches in diameter and weighs 190,000 pounds. It can deliver 10 R/Vs more than 6000 miles away.

Each shelter and each transporter exhibits the same characteristics to external observers whether they contain a missile/launcher or not. The simulator duplicates these characteristics (weight, balance, etc.). One is emplaced in each shelter and carried by each transporter when the real missile/launcher is not present.

The missile/launcher combination consists of a canisterized missile and the integral electronic and mechanical equipment needed to monitor, operate and launch the missile. The missile/launcher assembly weighs 500,000 pounds. When ordered, the launcher partially emerges from the shelter, and the section which contains the missile erects to a vertical position for launch.

At a shelter, the transporter installs a missile/launcher or simulator, or withdraws it. Parked or moving, the transporter conceals its cargo. Only the missile/launcher or simulator is inserted into a shelter. There are 200 transporters. Each is 200 feet long, 16 feet wide (over tires), 25 feet wide (overall) and 31½ feet high. Weight: 1,100,000 pounds empty; 1,600,000 pounds loaded. It travels at 10 mph, or 30 mph in emergencies.

Three types of roads are used. About 6000 miles of 21-foot-wide unpaved roadway interconnects groups of shelters, and are used by the transporter. Approximately 1500 miles of 10-foot-wide gravel roads are used for support vehicle transport. Both road networks are treated with dust suppressant. The third, paved type of road, 24 feet wide and about 1500 miles long is used to transport missile/launchers from the area where they are assembled to the shelter areas.

The command, control, and communications (C^3) system monitors, retargets, and launches the missiles. It links operations, security and maintenance personnel. Under normal conditions, a fiber-optic cable network buried along the interconnecting roads is used for these functions. A medium frequency radio system provides backup if the cable system is inoperative. It uses buried antennas at each shelter to permit control of the M-X system by launch control aircraft.

Electrical power flows via transmission lines to the two operating bases and to 120 distribution centers. From these, underground cable along the roadways provide power to each shelter. Each distribution center has standby diesel generators. As an alternative, the Air Force is investigating renewable energy sources (solar, wind, geothermal, etc.) to reduce or eliminate the need for commercial electric power.

In addition to the intrusion sensors at each shelter, surveillance towers provide radar detection and tracking of vehicles and aircraft in and over the entire shelter deployment region. Sixty to two hundred radar towers (on a ¼-acre fenced area) will be used.

Two operating bases support and maintain the M-X system. Base No. 2 occupies about 6140 acres (3740 fenced), and includes an airfield, operating and maintenance facilities, some housing, and community services. Base No. 1 is about 8180 acres (5990 fenced). In addition to the functions provided by the No. 2 base, it contains the area where the missile/launchers are assembled and a site where weapon system test and evaluation is carried out.

When the system is completed there will be about 12,500 operating and maintenance personnel, most of them working at the main bases. Construction will take over eight years. In the peak year, about 17,000 construction workers and 6,000 assembly and checkout personnel will be employed.

Operation

As the shelters are constructed, a simulator is inserted in each one. After each missile/launcher is assembled (about one per week), it is moved by the transporter to a shelter where it is exchanged for a simulator (or this exchange is simulated). This process is repeated at 23 shelters with the missile/launcher being left at one of them. When all 200 missile/launchers have been placed randomly in the 4600 shelters, there is no activity for months. Eventually (normally for maintenance reasons), the transporter travels to the shelters, removes a missile/launcher or pretends to, and proceeds to other shelters to make an exchange, or pretends to. No observer can tell whether a missile has been moved or not. Most of the time, nothing is happening.

If launch is authorized, the canister portion of the missile/launcher emerges and erects, the missiles are ejected, and the first-stage engine ignites. This sequence occurs automatically and by remote control and takes about one minute.

Survivability

M-X/MPS survival hinges on keeping missile location uncertain. Use of missile/launcher simulators in all unoccupied shelters and transporters and the ability to deceptively relocate launchers are design features intended to foreclose any credible threat to this survival issue in the foreseeable future.

Such a system requires no warning of an ICBM attack, and no other Soviet weapons would be particularly effective against M-X/MPS.

If the Soviets choose to increase their number of warheads, we can build additional shelters more rapidly and at lower cost. Furthermore, we can install an ABM system to defend the M-X missiles. An ABM system is particularly effective when used with multiple protective shelter concepts; it can preferentially defend shelters containing missiles and ignore enemy warheads aimed at other shelters. As we add one interceptor for each of the 200 M-X missiles, the Soviets must double the size of their attacking force to achieve a rebalancing; so, leverage offered by an ABM adjunct is very high. The use of horizontal shelters facilitates placement and movement of the ABM equipment, relative to vertical shelters.

Endurance

Since M-X missile/launchers in their shelters can be remotely monitored and launched, they are not dependent on manned activity in an area which might be contaminated after an attack. Thus, long term post-attack endurance is possible. Power and communication subsystems, as well as dormant operating mode, are designed to extend endurance up to one year after an attack, if we should choose to delay part or all of our retaliatory strike.

Cost

Like all strategic weapon systems, the M-X/MPS is costly. For comparison purposes, the Minuteman – if we were beginning it today – would cost $40 billion. The lifetime cost for the Polaris/Poseidon program is about $50 billion, for the B52 program about $60 billion. Among the alternative basing modes described in this report, the M-X/MPS comes out in mid-range. In constant 1980 dollars, the acquisition cost of M-X/MPS is $33.8 billion. The annual operating cost will be about $440 million. M-X/MPS cost will equal only 1 to 2% of the defense budget during the decade of the 1980's.

Schedule

Detailed scheduling plans have been prepared. The first ten M-X missiles and their associated shelters will be placed in operation during 1986 and the last missile during 1989.

Public/Land Use/
Environmental Impact

The M-X/MPS requires more land than sea- or air-based systems, which need land only for operating bases, maintenance, and communication facilities. With few exceptions, the M-X/MPS approach uses less acreage than other land-based modes. It does so by using hardened shelters to shrink the dispersal field. Base construction and operation environmental impacts are as low as, or lower than any of the concepts studied. Shelter and road construction are not required in some basing options but are more extensive than for M-X/MPS in others.

As previously mentioned, 25 square nautical miles of land will be closed to the public. It should be clear, however, that all remaining land, including the new road network, will be open for public use as before.

The deployment field will not be as isolated and solitary as before, since it is necessary to provide area security surveillance and because there will be operating personnel. Once the system is installed, however, the general level of activity per square mile will be quite low.

As to safety, the M-X missile uses propellants similar to those in the Minuteman missile. It is transported infrequently, under guard, over designated routes in sparsely populated areas in a manner similar to Minuteman. For all but a small fraction of the time, the M-X is housed in a very secure "vault" much like Minuteman. Twenty years experience with Minuteman has clearly demonstrated that the M-X/MPS concept provides a high level of safety (both to the public and to the missile); as high as can be achieved with any candidate concept.

Command, Control, and Communications (C^3)

The M-X/MPS system permits the highest level of reliable, survivable, and enduring control of any of the generic concepts.

This factor is critical. If the command systems cannot be made as robust as the missile it controls, it becomes the weak link which an enemy will seek to overcome.

Technical Issues

M-X/MPS has no major technical difficulties. The missile, shelter, road, transporter, security, communication, test, construction, maintenance, and operation all are similar to well-known Minuteman designs and methods. The principal technical problem is careful design of the system to ensure maintaining position location uncertainty.

Table 2 summarizes all eleven evaluation criteria for each of the thirty concepts. The reason for choosing M-X/MPS is clear. There are no negative features and two major positive features – M-X/MPS provides an independent Triad survivability mode and extended endurance. It is satisfactory on all other counts. Alternative concepts are all judged to be inferior in one or more of the evaluation criteria.

Table 2. Concept Evaluation Summary

X = NEGATIVE FEATURE
X = MAJOR NEGATIVE FEATURE
✓ = SATISFACTORY
✓ = MAJOR POSITIVE FEATURE

	SURVIVABILITY			OPERATIONAL FEASIBILITY							
	RESPONSIVE THREATS	TRIAD INDEPENDENCE	ENDURANCE	PUBLIC INTERFACE	SECURITY	OPERABILITY	TECHNICAL RISK	ENV. IMPACT	COST	SCHEDULE	ARMS CONTROL
Launch Under Attack (LUA)	**X**	**X**	**X**	**✓**	X	**X**	✓	**✓**	**✓**	**✓**	✓
Orbital Based	**X**	**X**	X	X	X	**X**	✓	✓	**✓**	✓	**X**
Shallow Underwater Missile (SUM)	X	**X**	✓	**✓**	✓	X	**X**	**✓**	✓	**X**	✓
Hydra	**X**	**X**	✓	X	**X**	**X**	✓	**✓**	✓	✓	✓
Orca	✓	✓	**✓**	**✓**	X	**X**	✓	**✓**	**✓**	✓	**X**
Ship – Inland	X	✓	✓	**X**	X	✓	✓	✓	X	✓	✓
Ship – Ocean	**X**	✓	✓	**✓**	✓	**X**	✓	**✓**	✓	✓	✓
Sea Sitter	**X**	✓	**X**	**✓**	✓	**X**	X	**✓**	**X**	X	✓
Wide Body Jet (W.B.J.)	X	**X**	**X**	✓	✓	X	✓	✓	**X**	✓	✓
Short Takeoff and Landing (STOL)	X	**X**	**X**	X	✓	X	✓	X	**X**	✓	✓
Vertical Takeoff and Landing (VTOL)	✓	**X**	✓	✓	✓	X	X	✓	**X**	**X**	**X**
Dirigible	**X**	✓	✓	**X**	✓	**X**	✓	**✓**	✓	✓	✓
Midgetman	✓	**✓**	**✓**	✓	✓	✓	✓	✓	**X**	✓	**X**
Hard Rock Silo	**X**	**✓**	**✓**	✓	✓	✓	✓	✓	✓	✓	✓
Hard Tunnel	X	**✓**	**✓**	**✓**	**✓**	**X**	**X**	✓	X	X	✓
South Side Basing	**X**	**✓**	**✓**	✓	✓	X	✓	**X**	**✓**	✓	✓
Sandy Silo	X	**✓**	**✓**	**✓**	**✓**	**X**	**X**	✓	**✓**	✓	✓
Commercial Rail	**X**	**✓**	**✓**	**X**	**X**	✓	✓	✓	✓	✓	✓
Dedicated Rail	**X**	**✓**	**✓**	✓	✓	✓	X	**X**	**X**	✓	✓
Off-Road Mobile	**X**	**✓**	**✓**	✓	✓	X	X	**X**	✓	✓	✓
Ground Effect Machine (GEM)	**X**	**X**	**✓**	✓	✓	**X**	✓	**X**	X	X	✓
Road Mobile (Minuteman)	**X**	**X**	**✓**	✓	✓	**X**	✓	✓	**✓**	**✓**	✓
Road Mobile (New Missile)	**X**	**X**	**✓**	✓	✓	**X**	✓	✓	✓	✓	✓
Covered Trench	**X**	**✓**	**✓**	✓	✓	**✓**	✓	**X**	X	✓	✓
Hybrid Trench	**X**	**✓**	**✓**	✓	✓	**✓**	X	**X**	X	✓	✓
Dash to Shelter	**X**	**X**	**✓**	✓	✓	X	**X**	✓	X	✓	✓
Mobile Front End	✓	**✓**	**✓**	✓	✓	X	X	✓	**X**	✓	**X**
Pool	✓	**✓**	**✓**	✓	✓	X	✓	**X**	✓	✓	✓
Minuteman/MPS	✓	**✓**	**✓**	X	✓	X	✓	✓	✓	✓	✓
M-X/MPS	✓	**✓**	**✓**	✓	✓	✓	✓	✓	✓	✓	✓