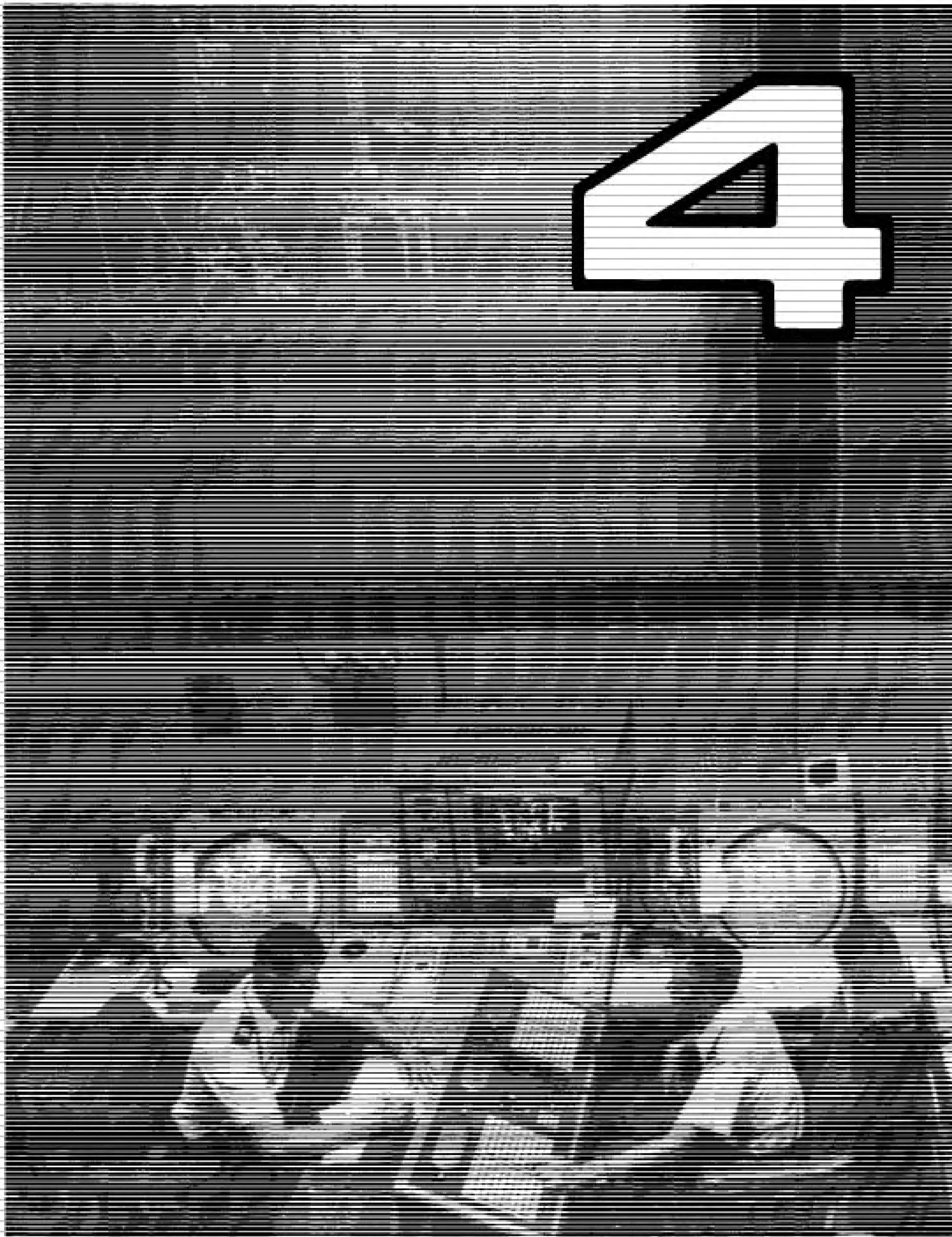
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Chapter Four

The Role of Nuclear Weapons in U.S. and Allied Military Forces

In 1980, 722 military units were "certified" for nuclear warfare.[1] The units comprised 100,000 specially trained and cleared personnel, with properly wired and inspected weapons. These units are to play a contingency role in the nuclear strategy of the United States.[2] The purpose of this chapter is to explain the nature and magnitude of the nuclear weapons support structure—delivery units, maintenance, and storage. This will shed light on a number of reasons for the large number of weapons in the nuclear stockpile and the diversity of weapons types.

U.S. military forces, which are deployed worldwide, continue to follow a practice of widespread "nuclearization" of military equipment and units begun in the 1950s. The Single Integrated Operational Plan (SIOP), the central nuclear war plan for strategic forces, broadly determines the requirements for roughly 10,000 strategic warheads. A variety of tactical/theater plans account

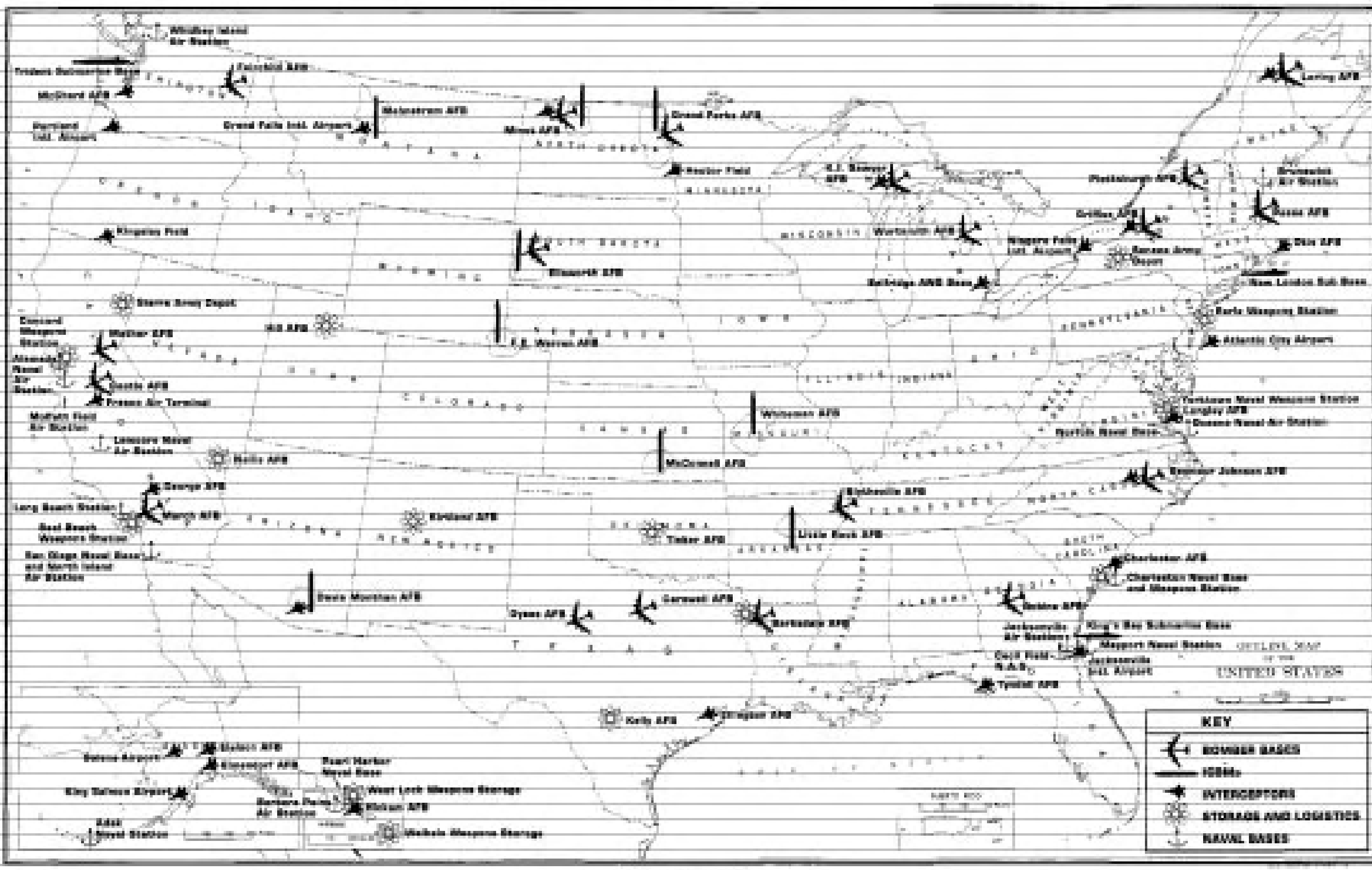

Figure 4.1 Nuclear Weapons Locations in the United States.

1 SAC, FY 1981 DOD, Part 3, p. 730; GAO, "Accountability and Control of Warheads in the Custody of the Department of Defense and the Energy Research and Development Administration," PSAD 77-115, 2 June 1977, p. 5, reported 838 nuclear certified units in October 1976.

2 A nuclear certified unit is "a unit or an activity assigned responsibilities for assembling, maintaining, transporting, or storing war reserve nuclear weapons, their associated components and ancillary equipment"; Defense Nuclear Agency, Department of Defense Nuclear Weapons Technical Inspection System, TP 25-1, 1 January 1974, p. 2.

Table 4.1
Allocation of Nuclear Warheads in the Service Branches (1983)

Warhead	Air Force	Army	Marine Corps	Navy
W25/GENIE	x			
B28 bomb	x			
W31/NIKE-HERCULES/HONEST JOHN		x		
W33/8-inch artillery		x	x	
B43 bomb	x		x	x
W44/ASROC				x
W45/TERRIER				x
W45/MADM		x	x	
W48/155mm artillery		x	x	
W50/PERSHING 1a		x		
B53 bomb	x			
W53/TITAN II	x			
W54/SADM		x	x	x
W55/SUBROC				x
W56/MINUTEMAN II	x			
B57 bomb	x		x	x
B61 bomb	x		x	x
W62/MINUTEMAN III	x			
W68/POSEIDON				x
W69/SRAM	x			
W70/LANCE		x		
W76/TRIDENT I				x
W78/MINUTEMAN III	x			
W79/8-inch artillery		x	x	
W80/ALCM	x			

for approximately 11,500 tactical warheads. Roughly 8000 of the tactical warheads are allocated for NATO/European plans, 1000 for U.S. Pacific Command plans, and 2500 for anti-submarine warfare. A few hundred warheads are for strategic defense of the United States, and the remaining 4000 comprise a strategic and tactical reserve. All four services have a wide variety of nuclear weapons (see Table 4.1, Allocation of Nuclear Warheads in the Service Branches).

However, the large number of warheads far exceeds any level of use or destruction which could be contemplated in the plans. This is due to a variety of factors: the duplicative and competitive nuclear weapons missions of the services, the large number of fixed targets designated to be destroyed by strategic forces, the possibility of the use of thousands of battlefield weapons against mobile and non preplanned targets, and the competitive and aggressive development of new technologies in warheads and delivery systems.

The annual Nuclear Weapons Stockpile Memorandum, approved by the President, determines the number of weapons to be produced and retired. However, the composition of the operational weapons stockpile is primarily influenced by a variety of other plans:

- Annual Unified and Specified Commander-in-Chief[3] requirements as validated by the Joint Chiefs of Staff;
- Annual joint military requirements proposals produced by the Joint Chiefs of Staff, the Joint Strategic Planning Document Nuclear Weapons Annex, Joint Strategic Capabilities Plan, and Joint Planning Assessment Memorandum Nuclear Weapons Annex;
- Annual Secretary of Defense memorandum (Nuclear Weapon Development Guidance) coordinated with the Consolidated Guidance and DOD planning, programming, and budgeting activities; and
- Annual DOD memorandum (Nuclear Weapon Deployment Plan) produced together with the Nuclear Weapons Stockpile Memorandum delineating the allocation of warheads to theater commanders and their storage.

Military units with nuclear capabilities must pass a certification inspection which determines if they are capable of performing their assigned mission. This inspection is called a Technical Proficiency Inspection in the Army, a Nuclear Weapons Acceptance Inspection (NWAI) in the Navy and Marine Corps, and a Capability Inspection in the Air Force. The certification is not only to ensure knowledge of the unique capabilities of nuclear weapons, but also to indoctrinate the unit as to the safety and control procedures accorded these weapons. The control procedures create enormous additional cost over conventional weapons.

One of the most important ways to prevent the inadvertent or accidental use of nuclear weapons is the Personnel Reliability Program (PRP) (see Table 4.2, Personnel with Nuclear Weapons Duties).[4] The PRP insures the reliability and qualifications of people who have cus-

3 The unified commands with nuclear weapons responsibilities include the European Command, Pacific Command, Atlantic Command, Readiness Command, and Central Command (formerly Rapid Deployment Force). The specified commands with nuclear weapons responsibilities are the Strategic Air Command and the North American Aerospace Defense Command.

4 The Personnel Reliability Program is called the Human Reliability Program in the Air Force.

Table 4.2

Personnel with Nuclear Weapons Duties

	1976[1]	1977[1]	1978	1979	1980
United States					
Military	NA	NA	84,923	84,960	82,920
Civilian[2]	NA	NA	2378	2169	2304
Contractor[3]	NA	NA	29	24	30
U.S. TOTAL	87,415	89,473	87,330	87,153	85,254
Pacific					
Military	NA	NA	5829	6427	4577
Civilian	NA	NA	1	13	2
Contractor	NA	NA	-	-	-
PACIFIC TOTAL	5796	4452	5830	6440	4579
Europe					
Military	NA	NA	23,058	25,558	24,140
Civilian	NA	NA	5	17	25
Contractor	NA	NA	30	30	30
EUROPE TOTAL	22,644	25,063	23,093	25,605	24,195
TOTAL					
Military	NA	NA	113,810	116,945	111,637
Civilian	NA	NA	2384	2199	2331
Contractor	NA	NA	59	54	60
	115,855	118,988	116,253	119,198	114,028

Source: DOD, OSD "Annual Status Report, Nuclear Weapon Personnel Reliability Program," RCS DD-POL(A) 1403, Year Ending 31 December 1980; 31 December 1979; 31 December 1978, RCS DD-COMP(A) 1403, 31 December 1977; 31 December 1976.

1 Breakdown for 1977 and 1976 not available.
2 Federal Civilian Personnel.
3 Contractor Personnel.

tody of, control access to, or have access to nuclear weapons. The investigative and administrative procedures of the PRP also create higher expenses in manning nuclear weapons. For example, it is expensive to train personnel in technical nuclear weapons electronics and maintenance skills.[5] The training costs for each nuclear weapons technician (over the first ten years) is approximately \$11,700 for Air Force, \$52,300 for Army, and \$55,200 for Navy personnel. Training over the second ten year career period costs \$22,600 for the Navy and \$26,900 for the Army.

Air Force Nuclear Weapons Roles

The Air Force has the dominant position in U.S. strategic and long-range theater nuclear forces, because it controls land-based intercontinental ballistic missiles, bombers, and tactical nuclear fighter bombers. The missile and bomber force comprises the bulk of the strategic capability. Theater bombers constitute the most important long-range regional strike forces.

The kinds of nuclear weapons employed and the missions undertaken by the Air Force nuclear certified units are governed by the regularly revised USAF Program Nuclear Weapons Capabilities and Equipage Document, deriving from JCS, Secretary of Defense, and Presidential guidelines. In October 1976, Air Force capabilities consisted of 74 nuclear certified units; a similar number is estimated to be active today.[6] Generally, the nuclear certified combat unit in the Air Force is a squadron. A squadron consists of 15-24 aircraft (see Table 4.3, Air Force Nuclear Weapons Units), 18 TITAN missiles, or 50 MINUTEMAN missiles. The squadrons are normally subordinate to a wing or group, where the munitions maintenance unit has custody of the nuclear weapons. An exception is in the case of missiles, where the warheads are present in underground silos.

5 SASC, FY 1980 DOD, Part 1, p. 236.
6 GAO, op. cit.

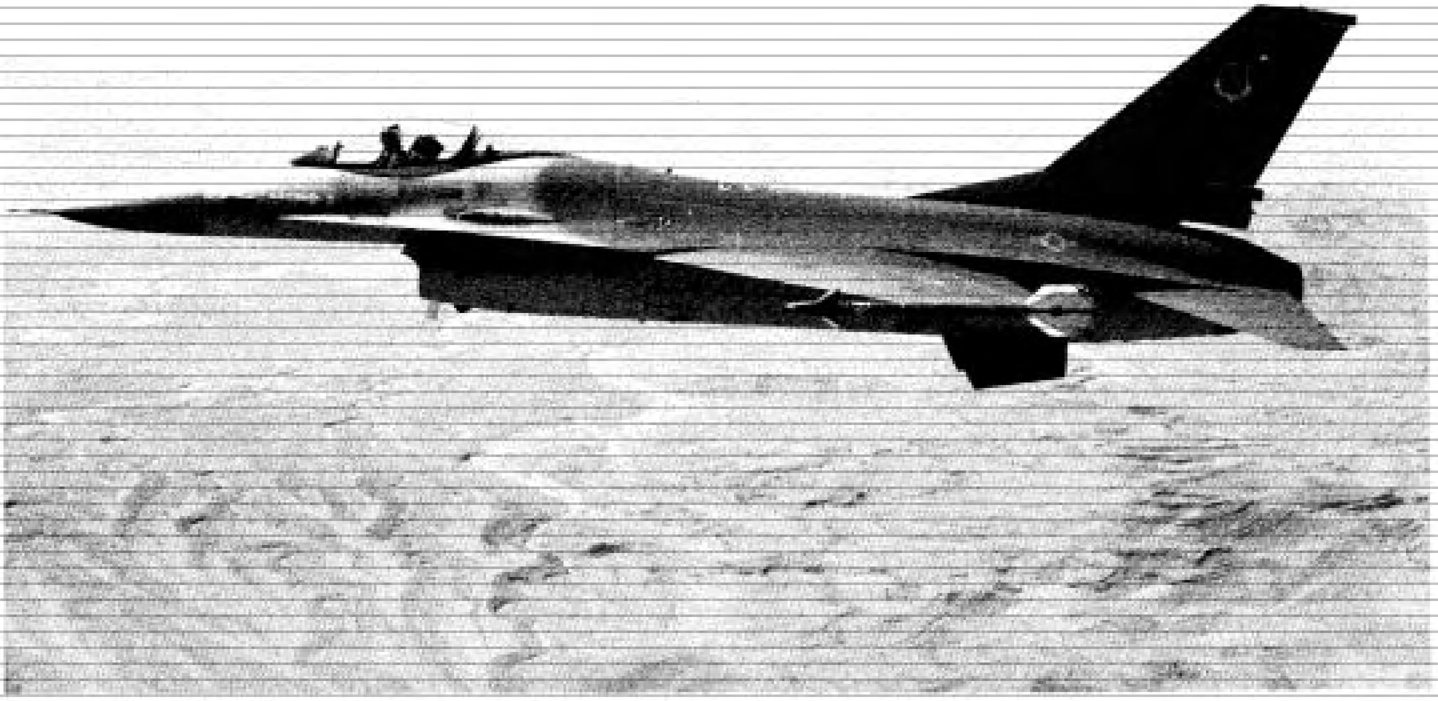

Figure 4.2 F-16 FALCON, the newest nuclear-capable fighter in the Air Force.

The central maintenance and storage of Air Force nuclear weapons takes place at three bases: Barksdale AFB, Louisiana; Nellis AFB, Nevada; and Kirtland AFB, New Mexico. The warheads are shipped to these bases from the Department of Energy's final assembly plant (PANTEX) at Amarillo, Texas and stored and maintained prior to dispersal to other air bases. Three of five Air Force Air Logistic Centers (ALCs) are also involved in supply and repair of nuclear weapons systems: Ogden ALC, Hill AFB, Utah for missiles; Oklahoma ALC, Tinker AFB, Oklahoma for bombers; and San Antonio ALC, Kelly AFB, Texas for nuclear bombs. Air Force nuclear weapons training takes place at six main bases: Chanute AFB, Illinois; Indian Head, Maryland; Kirtland AFB, New Mexico; Lowry AFB, Colorado; Sheppard AFB, Texas; and Vandenburg AFB, California.[7]

As of 31 December 1982, there were 53,144 Air Force personnel in the PRP involved in nuclear weapons work.[8] Including the above number, in FY 1980, 119,802 military and 16,043 civilian personnel were engaged in strategic weapons work within the Air Force. Many of these personnel were obviously not certified for direct contact work with nuclear weapons (PRP) even though assigned to nuclear weapons units.[9] An additional 3460 military and civilian personnel were engaged directly in theater nuclear forces work.[10]

Air Force strategic offensive forces represent about 90 percent of the total megatonnage delivery capability of U.S. strategic forces.[11] The bomber squadrons of the Strategic Air Command (see Table 4.4, Strategic Bomber Force Basing) each have 14-15 B52 or FB111 aircraft assigned and approximately 150 nuclear weapons. The nuclear weapons include B28, B43, B53, B57, and B61 bombs, SRAM missiles, and, increasingly, ALCMs. The ICBM MINUTEMAN strategic missile squadrons (see Table 4.5, ICBM Deployments) each consist of 50 missile

7. AFM 90-5, Volume II.
8. HAC, FY 1983 DOD, Part 3, p. 291; this is a slight reduction from 53,353 as of 31 December 1980.
9. SAC, FY 1980 DOD, Part 3, p. 721.
10. Ibid.
11. SAC, FY 1980 DOD, Part 3, p. 722.

Table 4.3

Air Force Nuclear Weapons Units

Squadron Type	Nuclear Mission / Weapons Type
Aviation Depot	Receipt and Storage / All weapons
Bomber	Launching Unit / B28, B43, B53, B57, B61, SRAM, ALCM
Fighter Interceptor	Storage and Maintenance, Launching / GENIE
Missile Munitions Maintenance	Storage and Maintenance / TITAN, MINUTEMAN
Munitions Maintenance	Storage and Maintenance / Nuclear Bombs, SRAM, ALCM
Munitions Support	Custodial Maintenance and Support / B28, B43, B57, B61
Strategic Missile	Launching Unit / MINUTEMAN II, MINUTEMAN III, TITAN II
Tactical Fighter	Launching Unit / B28, B43, B57, B61

silos, while each full TITAN missile squadron consists of 18 silos. The 1052 active silos (before the beginning of TITAN retirements in October 1982) are located in ten states and spread over approximately 80,000 square miles. Missiles are always prepared to launch within minutes; 30 percent of the bomber force is capable of taking off with nuclear weapons within minutes of any early warning of attack.

Six active and ten Air National Guard fighter interceptor squadrons are also assigned nuclear weapons missions ("strategic defense") with the GENIE air-to-air missile (W25). Four aircraft types (F-106, F-4, F-101, and F-15) are assigned to 28 alert sites (see Table 4.6, Strategic Interception Forces), where at least two armed aircraft are always on 15 minute ground alert. The interceptor force consists of 381 aircraft, 297 operational aircraft, and 84 backup.[12]

In addition to the strategic forces, numerous tactical units of the U.S.-based Tactical Air Command, Pacific Air Force, and United States Air Force Europe (USAFE) are also certified and equipped with nuclear weapons. These tactical fighter wings fly the F-4, F-111, and F-16, and utilize the B28, B43, B57, and B61 bombs. The nuclear equipped units are primarily in Europe. There are thought to be nuclear certified wings in the Pacific area and a large reserve of quickly deployable units in the United States.

Table 4.4

Strategic Bomber Force Basing (1983)

Base	Number[1] / Bomber-Type[2]	Nuclear Weapons Type
Andersen AFB, Guam[3]	14 B-52D[4]	Bombs, SRAM
Barksdale AFB, LA	14 B-52G	Bombs, SRAM, ALCM[5]
Blytheville, AFB, AR	14 B-52G	Bombs, SRAM, ALCM[5]
Carswell AFB, TX[6]	14 B-52D[4]	Bombs, ALCM[5]
Castle AFB, CA	14 B-52G/H	Bombs, SRAM
Dyess AFB, TX[7]	14 B-52H	Bombs, SRAM[8]
Ellsworth AFB, SD	28 B-52H	Bombs, SRAM, ALCM[5]
Fairchild AFB, WA	14 B-52G	Bombs, SRAM, ALCM[5]
Grand Forks AFB, ND	14 B-52H	Bombs, SRAM, ALCM[5],[8]
Griffiss AFB, NY	14 B-52G	Bombs, SRAM, ALCM[5]
K.I. Sawyer AFB, MI	14 B-52H	Bombs, SRAM
Loring AFB, ME	14 B-52G	Bombs, SRAM
March AFB, CA	14 B-52D[4]	Bombs
Mather AFB, CA	14 B-52G	Bombs, SRAM
Minot AFB, ND	14 B-52H	Bombs, SRAM
Pease AFB, NH	30 FB-111	Bombs, SRAM
Plattsburgh AFB, NY	30 FB-111	Bombs, SRAM
Robins AFB, GA[9]	13 B-52G	Bombs, SRAM
Seymour Johnson AFB, NC	14 B-52G	Bombs, SRAM
Wurtsmith AFB, MI	14 B-52G	Bombs, SRAM, ALCM[5]

1 Number is primary active aircraft (PAA) and does not include spares or extras.
2 SASC, FY 1982 DOD, Part 7, p. 4285; DOD, Memorandum for Correspondents, 31 January 1983.
3 Andersen will replace 14 B-52Ds with 14 B-52Gs in late 1983 and add SRAM.
4 Three squadrons of B-52Ds were retired on 1 October 1982. The last two squadrons at Andersen and Carswell will retire in 1983.
5 Bases scheduled for ALCM deployment starting in late 1981.
6 Starting in late 1983, Carswell will receive 20 B-52Hs replacing B-52Ds.
7 Dyess will receive 26 B-1Bs beginning in late 1985.
8 SRAMs moving from Grand Forks to Dyess due to ALCM deployment at Grand Forks.
9 In late 1983, the B-52Gs from Robins will be relocated.

Army Nuclear Weapons Roles

Nuclear weapons within the Army represent "a tremendous firepower augmentation of conventional

12 SASC, FY 1981 DOD, Part 2, p. 577.

Figure 4.3 Aerial view of **MINUTEMAN** missile launch site.

Table 4.5
ICBM Deployments (1983)

Base	Missiles
Davis-Monthan AFB, Tucson, AZ	15 TITAN II[1]
Ellsworth AFB, Rapid City, SD	150 MINUTEMAN II
F.E. Warren AFB, Cheyenne, WY	200 MINUTEMAN III[2]
Grand Forks AFB, Grand Forks, ND	150 MINUTEMAN III
Little Rock AFB, Little Rock, AR	17 TITAN II
Malmstrom AFB, Great Falls, MT	150 MINUTEMAN II, 50 MINUTEMAN III[3]
McConnell AFB, Witchita, KS	17 TITAN II
Minot AFB, Minot, ND	150 MINUTEMAN III
Whiteman AFB, Knob Noster, MO	150 MINUTEMAN II

1 Beginning in October 1982, one TITAN missile per month from this base is being retired; as of 1 January 1983, there were 15 deployed.
2 The missile silos at F.E. Warren are spread out in three states: Wyoming, Colorado, and Nebraska.
3 Fifty MINUTEMAN II missiles are going to be replaced with MINUTEMAN III missiles at Malmstrom.

weapons" with a more intimate integration than in the Air Force. The Army's nuclear systems are predominantly short-range battlefield weapons, unlike the Air Force's long-range pre-targeted weapons. The basic principles of current land warfare doctrine (codified in Field Manual 100-5, *Operations*) regard nuclear weapons as mere additions to normal combat power whether used to directly "destroy enemy forces, to deny an area to enemy movement or to demonstrate national resolve."[13] Although conflict in Europe remains the primary concern of the Army and the political implications of the effects of nuclear warfare are well recognized. The preponderance of short-range Army nuclear weapons and units are only able to fire within friendly territory.

Contingency planning for the tactical use of Army nuclear weapons consists of division and corps plans compiled to implement theater (e.g., NATO) tactical objectives. The corps develops plans for the use of "packages" (sets) of nuclear weapons after it has consolidated the "subpackages" from its subordinate division plans. Each package is "a discrete number of nuclear weapons by specific yields and weapon systems for employment in a specified area during a short time period to support a specific division tactical contingency."[14] The package is not a target list, rather it is the number of nuclear weapons deemed necessary for a specific purpose, e.g., halt an attack by a division-size force over hilly terrain, by a tactical commander.

The central storage and maintenance of Army nuclear weapons takes place at two United States depots—Sierra Army Depot in Herlong, California, and Seneca Army Depot in Romulus, New York. These depots receive finished warheads from the Department of Energy assembly plant (PANTEX) at Amarillo, Texas. The warheads are then transferred to field depots and storage sites for subsequent use. "Special Ammunition" ordnance units—"general support" and "direct support"

13 Basic sources on Army nuclear weapons doctrine and policy include: U.S. Army, *Operations*, FM 100-5 (20 August 1982); U.S. Army, *Staff Officers Field Manual, Nuclear Weapons Employment Doctrine and Procedures*, FM 101-31-1 (March 1977); U.S. Army, *Tactical Nuclear Operations*, FM 100-30 (Test) (August 1971); U.S. Army, *Operations for Nuclear Capable Units*, FM 100-50 (March 1980); CGSC, "Nuclear and Chemical Operations," *Infantry and Airborne Division and Brigade Operations* (Draft FM) (July 1978), p. 18-1; John P. Rose, *The Evolution of U.S. Army Nuclear Doctrine, 1945-1980* (Boulder, CO: Westview Press, 1981).

14 U.S. Army CGSC, op. cit., p. 18-8.

Table 4.6
Strategic Interception Forces (1983)

Main Bases[1]	Aircraft
*Atlantic City AP, Pleasantville, NJ	F-106
Castle AFB, Merced, CA	F-106
*Ellington AFB, Houston, TX	F-101[2]
Elmendorf AFB, Anchorage, AK	F-4
*Fresno Air Terminal, Fresno, CA	F-106**
*Great Falls IAP, Great Falls, MT	F-106
Griffiss AFB, Rome, NY	F-106
*Hector Field, Fargo, ND	F-4
*Jacksonville IAP, Callahan, FL	F-106***
K.I. Sawyer AFB, Gwinn, MI	F-106***
Langley AFB, Hampton, VA	F-15[3]
McChord AFB, Tacoma, WA	F-106***
Minot AFB, Minot, SD	F-106***
*Niagara Falls IAP, Niagara Falls, NY	F-4
*Otis AFB, Falmouth, MA	F-106
*Portland IAP, Portland, OR	F-4
*Selfridge ANGB, Mt. Clemens, MI	F-4

* Air National Guard units and bases.
** Units scheduled to receive F-4D replacements in late 1983.
*** Units scheduled to receive F-15 replacements starting in late 1984.
1 This list does not include 11 alert satellite sites where aircraft are also on full time alert.
2 The F-101 is completing phase out and is being replaced by the F-4.
3 Langley is the first of six bases/fighter interceptor squadrons to receive the F-15 to replace the F-106 starting in 1982. HAC, FY 1983 DOD, Part 5, p. 548.

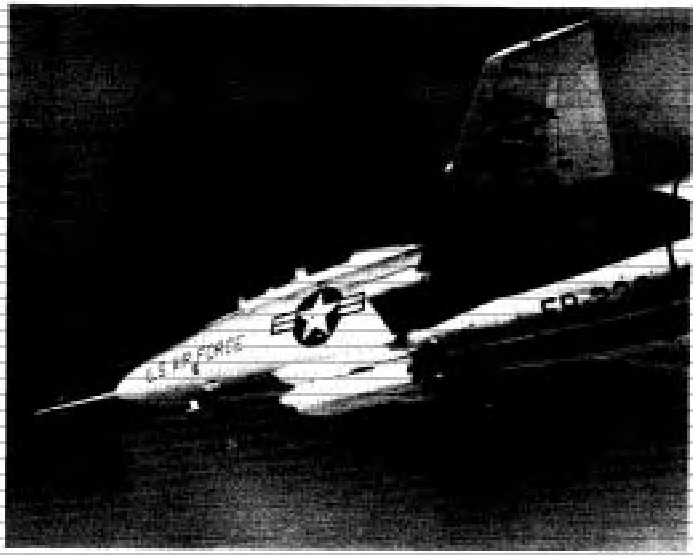

Figure 4.4 Two GENIE (AIR-2A) rockets mounted under Air Force F-101.

(assigned to or in support of a unit)—maintain custody of all warheads until they are transferred to the using delivery units. Nuclear weapons supply and maintenance support—from the Theater Army Area Command, Corps Support Command, or Nuclear Weapons Support Command, to the nuclear capable unit—includes a supply of the basic components, periodic exchange of limited life components (e.g., those containing tritium), and any maintenance which the receiving unit cannot or is not authorized to perform. Army Nuclear weapons training takes place at a number of bases, including Indian Head, Maryland; Kirtland AFB, New Mexico; Fort Sill, Oklahoma; Aberdeen Proving Grounds, Maryland; Fort Bliss, Texas; Fort Belvoir, Virginia; and Redstone Arsenal, Alabama.

In October 1976, 275 units in the Army were nuclear certified,[15] including air defense, artillery, atomic demolitions, and ordnance. Table 4.7 lists the types of units with nuclear missions in the Army. As of 31 December 1982, there were 16,733 Army personnel in the PRP involved in nuclear weapons work.[16] The total number of Army personnel involved in nuclear weapons work is not known. However, with far over 200 certified units and 110 nuclear weapons storage sites worldwide,[17] the number is probably much larger than the number of people involved in the PRP. There are 4780 Army personnel involved in nuclear weapons security, 566 in the United States and 4214 overseas.[18]

The longest-range nuclear weapon system in the Army (750 km) is the PERSHING 1a (W50) missile deployed in West Germany (108 U.S. launchers). These are also the only Army weapons on stand-by alert at all times with nuclear warheads aimed at pre-determined Warsaw Pact targets. The shorter-range LANCE (W70) missile is also deployed with both U.S. corps in West Germany. Six battalions, with six launchers each, provide the general support to U.S. ground forces in Central Europe. Both the PERSHING and LANCE missiles have reloads with nuclear warheads available. Army nuclear capable artillery consists of a variety of 155mm and 8-inch guns (see Chapter Nine) and is widely deployed in Infantry, Armored, or Mechanized divisions and Armored Cavalry regiments (see Table 4.8, Allocation of Nuclear Weapons in Army Units). The use of non-nuclear 105mm and 175mm guns has been virtually eliminated in the past ten years. Almost all Army artillery is now nuclear capable. An Army division has both gun sizes assigned to it, with similar ranges and nuclear capabilites.

15 GAO, op. cit.; the number today is thought to be similar.
16 HAC, FY 1983 DOD, Part 3, p. 291; this is a large reduction from 34,420 personnel as of 31 December 1980.
17 SAC/SASC, FY 1983 Joint Mil Con, pp. 314-315.
18 SAC, FY 1979 DOD, Part 3, pp. 72-73; SAC, FY 1979 DOD, Part 2, pp. 146-148.

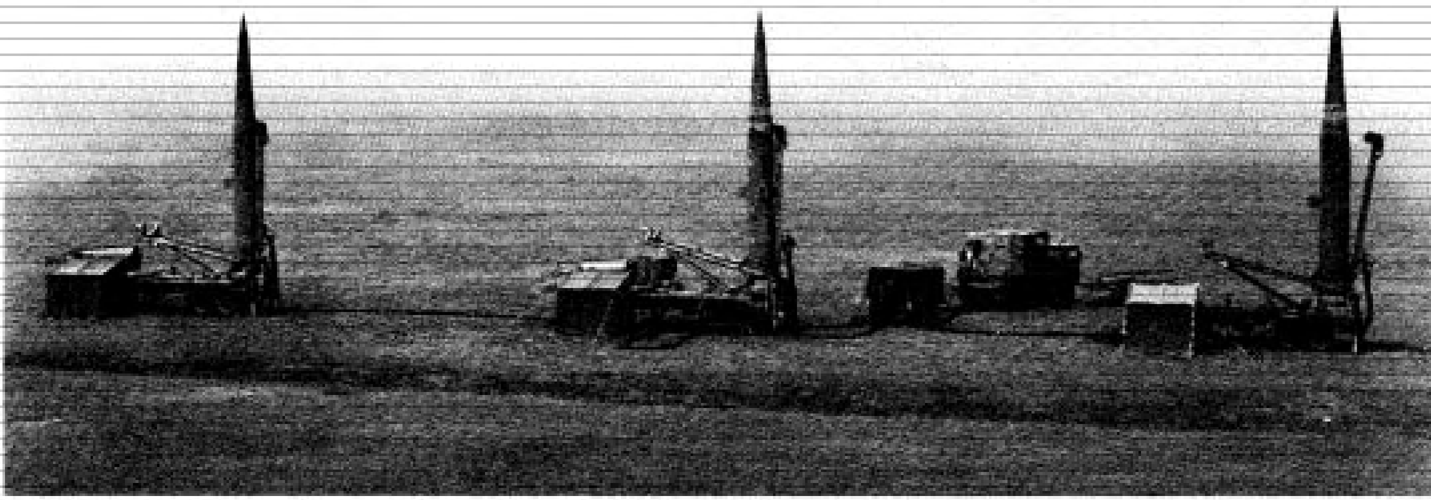

Figure 4.5 PERSHING 1a (MGM-31A/B) platoon in launch position.

"Defensive" nuclear systems used by the Army consist of the NIKE-HERCULES surface-to-air missile system certified for nuclear warheads (W31) and Atomic Demolition Munitions (nuclear land mines) (W54 and W45). A large number of both weapons are deployed, particularly in West Germany.

Marine Corps Nuclear Weapons Roles

The Marine Corps nuclear weapons roles are similar to those of the Army, but because of the high mobility requirements of the Marines, the heavier weapons (LANCE and PERSHING) are not assigned to them.[19] However, the Marines have their own air force which provides 'organic' (internal) nuclear weapons support.

In peacetime, the Marine Corps does not have custody of its own nuclear weapons but would receive them from the Navy during crisis or hostilities.[20] A structure exists for the receipt, supply, and maintenance of these warheads. For air delivered weapons, the Marine Air Wing has a Marine Wing Weapons Unit responsible for nuclear weapons. For Marine ground forces, the Nuclear Ordnance Platoon of the Marine Divisions prepares for the receipt, storage, and assembly of nuclear artillery and atomic demolition munitions. Within the operational structure (combat units), the Marine Amphibious Unit (MAU)—a composite ground and air force combat team—has a weapons shop which is also responsible for nuclear weapons supply and maintenance.

Operationally configured Marine units are carried aboard Navy amphibious ships. The following ships are also certified to carry nuclear weapons for the Marines:

- Amphibious Assault Ships (LPH),
- Amphibious Transport Docks (LPD),
- Dock Landing Ships (LSD), and
- Tank Landing Ships (LST).

19 The basic source of Marine Corps nuclear doctrine is *Staff Officers' Field Manual, Nuclear Weapons Employment Doctrine and Procedures*, FM 11-4, March 1977.

20 Information provided by the Department of Defense.

Figure 4.6 M109 155mm howitzer.

Marine CH-46 and CH-53 helicopters are also authorized to transfer nuclear weapons between ships and land.

The Marine Corps presently flies two nuclear capable aircraft: the A-4 SKYHAWK and the A-6 INTRUDER.[21] They are certified to carry the B43, B57, and B61 bombs, flying from Navy aircraft carriers or land bases. The A-4, a light attack aircraft, will be replaced with the AV-8B HARRIER II, a vertical/short takeoff and landing (V/STOL) aircraft, which, unlike the AV-8A first generation V/STOL, will be nuclear capable. The A-6, the primary long-range bomber, will remain in the inventory through the 1980s. The new F/A-18 under development will more than double the Marine Corps nuclear capable inventory when it enters service during FY 1982-1983. It will replace the current Marine Corps F-4 force which is not nuclear certified.[22]

The ground forces are equipped with dual capable 155mm and 8-inch artillery also used in the Army. Marine Corps policy is to certify all nuclear capable artillery units to fire nuclear weapons.[23] The 155mm howitzers—older towed M-114s, self-propelled M-109s, and newer towed M-198s—fire the W48 and will be compatible with the W82, which is under development and already adopted by the Marines. The only 8-inch gun in use by the Marines, the self-propelled M-110, fires both the W33 and the W79 nuclear projectiles.

In 1975, a reorganization of artillery in the Marine Corps resulted in the shift from 105mm (non nuclear)

Table 4.7

Army Nuclear Weapons Units[1]

U.S. Unit Type		**Nuclear Mission**
Air Defense Artillery:	Battery	NIKE-HERCULES basic firing unit with nine launchers
	Detachment	NIKE-HERCULES custodial unit supporting allied battalion/squadron[2]
	Team	NIKE-HERCULES custodial unit supporting allied firing battery[2]
Atomic Demolitions:[3]	Company	Corps level general support ADM unit
	Platoon	Division/Regiment direct support ADM unit
	Team	ADM basic firing unit providing direct support to maneuver units and allied forces
Field Artillery:	Battalion	Artillery, LANCE, or PERSHING unit
	Battery	Artillery, LANCE, or PERSHING basic firing unit[4]
	Detachment	Artillery, HONEST JOHN, LANCE, or PERSHING custodial unit supporting allied battalions[2]
Ordnance:	Company	Direct and General unit support providing maintenance and/or storage of nuclear weapons[2]

1 Other units with nuclear support missions include security [military police], maintenance [ordnance], storage [ordnance], transportation [organic and external [assigned or in support of]], explosive ordnance disposal, command and control, and planning.
2 Custodial units are subordinate to "U.S. Army Artillery Groups" which provide command and control of custodial units and weapons.
3 Atomic demolitions units are officially designated "engineer [atomic demolition munitions]."
4 Artillery batteries have 6-12 guns; LANCE battery has six launchers; PERSHING battery has nine launchers.

21 JCS, FY 1982, p. 79.
22 JCS, FY 1981, p. 49.
23 Maj. Roger A. Jacobs, "Artillery's Nuclear Mission," Marine Corps Gazette, April 1982, p. 24.

Table 4.8

Allocation of Nuclear Weapons in Army Units

Headquarters Unit	Nuclear Unit / Weapon
Theater Army	Field Artillery Brigade/PERSHING 1a Army Air Defense Command/NIKE-HERCULES
Corps	Corps Artillery/LANCE, 8-inch artillery Engineer Brigade/ADMs
Division	Division Artillery/155mm and 8-inch Artillery Engineer Battalion/ADMs
Armored Cavalry Regiment	Howitzer Battery/155mm Artillery Engineer Company/ADMs
Special Forces Group	Engineer Team/ADM

artillery in the division organization to 155mm artillery. With the beginning of deployment in 1981 of the new nuclear-certified M-198 155mm gun, the number and range of Marine dual-capable artillery will increase by more than 300 and 60 percent, respectively.[24] The new 155mm gun will replace the existing non-nuclear 105mm howitzers as the direct support weapon in two of the three Marine Divisions[25] and will replace all other older towed 155mm guns in Marine Corps artillery. Marine engineers and commandos are also equipped with the Medium and Special Atomic Demolition Munitions (MADM and SADM).[26]

Figure 4.7 The Marine Corps' newest fighter, the **AV-8B HARRIER**, which is nuclear capable.

Navy Nuclear Weapons Roles

The Navy has the greatest diversity of nuclear weapons responsibilities, including: strategic warfare (missile firing submarines), tactical/theater land attack warfare, defensive anti-air warfare, and anti-submarine warfare. Its nuclear capability is assigned to surface ships, submarines, and ship and land based aircraft (see Table 4.9, Navy Nuclear Weapons Units). The strategic weapons of the Navy are on average the newest weapons in the strategic nuclear arsenal. The tactical nuclear weapons, on the other hand, are some of the oldest. The Navy has not introduced a new theater nuclear weapon for 16 years.[27]

Most of the nuclear certified units in the Navy are ships. The number of certified units is counted by the quarterly average. In October 1976, there were 287 certified units in the Navy.[28] That number has probably remained stable, but will rise in the next few years as new nuclear weapons are introduced into the Navy. As of 31 December 1982, there were 34,871 Navy (and

24 JCS, FY 1982, p. 97; JCS, FY 1981, p. 49.
25 SASC, FY 1980 DOD, Part 3, p. 490.
26 U.S. Navy, *Loading and Underway Replenishment of Nuclear Weapons*, NWP 14-1, Rev. A (November 1979) p. 3-25.
27 JCS, FY 1982, p. 33.
28 GAO, op. cit.

Table 4.10

Naval Bases for Nuclear Armed Ships and Submarines (1983)

Base	Supported Unit
Alameda, CA	Aircraft carriers
Apra Harbor, Guam	Strategic and attack submarines, surface ships
Bangor, WA	Strategic and attack submarines
Charleston, SC	Strategic submarines, surface ships
Gaeta/Naples, Italy	Surface ships
Groton, CT	Strategic and attack submarines
Holy Loch, Scotland, UK	Strategic submarines
Kings Bay, GA	Strategic submarines
La Maddalena, Italy	Attack submarines
Long Beach, CA	Surface ships
Mayport, FL	Aircraft carriers, surface ships
Newport, RI	Surface ships
Norfolk, VA	Surface ships, attack submarines
Pearl Harbor, HI	Strategic and attack submarines, surface ships
San Diego, CA	Attack submarines, surface ships
Subic Bay, Philippines	Surface ships

percentage of the Navy aircraft carriers, cruisers, destroyers, frigates, and attack submarines are equipped with nuclear capable weapons systems and are supplied with nuclear warheads during operations (see Chapter Eight). The surface ships either have launchers for the nuclear TERRIER (W45) surface-to-air system or ASROC (W44) anti-submarine rocket; attack submarines have the capability of firing the SUBROC (W55) anti-submarine rocket. However, the preponderance of the tactical nuclear weapons capability is in Naval aviation, both land and aircraft carrier based. Six aircraft types—A-4, A-7, F-4, F/A-18, S-3, and P-3—and one (SH-3) helicopter are certified to carry the B43, B57, and B61 nuclear bombs for land attack and anti-submarine warfare.

Allied Nuclear Weapons Roles

Nuclear warheads for NATO countries are provided by the U.S. under Programs of Cooperation (POC)—bilateral agreements between the U.S. and NATO countries involving the transfer and certification of nuclear capable delivery vehicles or the deployment of nuclear warheads on foreign soil for support of foreign forces.[33] The U.S. unit which maintains control of nuclear weapons for use by allied units is called a custodial unit. All three services have custodial units. The United States maintains POCs with nine nations: Belgium, Canada, Greece, Italy, The Netherlands, South Korea, Turkey, The United Kingdom, and West Germany (see Table 4.11, Allied Nuclear Capabilites) and has nuclear weapons deployed in each of those countries.

There are over 600 allied dual capable tactical fighters and medium bombers available for nuclear duties.[34] Allied aircraft certified for nuclear weapons duty include the F-4 PHANTOM in Greek and Turkish units, the F-100 in Turkey, and the F-104 STARFIGHTER in Belgian, Dutch, Greek, Italian, and West German units. The new F-16 and the multi-national TORNADO now being introduced are planned for nuclear certification in Belgian, Dutch,[35] Italian, and West German units. Other countries are currently seeking suitable replacements capable of nuclear certification for some of their older aircraft. They are also considering the F-18 in addition to the planes already mentioned above.

Nuclear bombs known to be in allied use include the B43, B57, and B61. The B23RE is also thought to be in limited use. Some allied NEPTUNE and P-3 ORION maritime patrol and anti-submarine aircraft are also nuclear certified. British and Dutch forces have both B57 depth bombs stored in the United Kingdom. Canadian CF-101 interceptor aircraft, part of the North American Aerospace Defense Command (NORAD), are also equipped with nuclear armed GENIE (W25) air-to-air rockets at their bases in Canada.

Three Army missile systems (PERSHING, LANCE, and HONEST JOHN) are currently nuclear armed in allied military formations. The PERSHING 1a missile system supplied solely with nuclear warheads (W50), with two "wings" each equipped with 36 launchers and missiles, is utilized by the West German Air Force for medium-range nuclear support. Five allied armies utilize the nuclear armed dual capable short-range LANCE missile system (W70), while Greece and Turkey are still armed with the older and obsolete HONEST JOHN rocket (W31). These battlefield missiles are deployed at

33 SASC, FY 1980 DOD, Part 6, p. 3426.
34 JCS, FY 1982, p. 76, and previous JCS reports stated 400 allied dual capable aircraft; JCS, FY 1984, p. 19, reported 600.
35 The final decision by the Dutch government as to whether the new F-16s will be nuclear certified has not been made.

Table 4.11
Allied Nuclear Capabilities (1983)

	Belgium	Canada	Greece	Italy	Netherlands	South Korea	Turkey	United Kingdom	West Germany
W25		x							
B28[1]				unknown					
W31[HJ]			x			x	x		
W31[NH]	x		x	x	x	x			x
W33	x		x	x	x	x	x	x	x
B43[1]				unknown					
W45[MADM]					x			x	x
W48	x		x	x	x	x	x	x	x
W50									x
B57[Bomb][1]				unknown					
B57[ASW]					x			x	
B61[1]	x		x	x	x		x		x
W70	x			x	x			x	x

1 B28RE, B43, B57, and B61 nuclear bombs are deployed to Europe; AFM 50-5, Volume II, p. 3-87.

the Corps level for general nuclear support of military operations and comprise the most capable and longest-range nuclear delivery means of the NATO ground forces. Seventy LANCE and 26 HONEST JOHN launchers are estimated to be deployed in non-U.S. NATO military formations, supported by approximately 400 warheads. The South Korean Army also uses the HONEST JOHN rocket and it is possible that the United States maintains warheads for those rockets in South Korea.

Five countries currently have nuclear warheads (W31) for their NIKE-HERCULES surface-to-air air defense missile launchers. It is estimated that more than 700 warheads are available for nuclear air defense (including U.S. Army systems in West Germany).[36] Although the nuclear NIKE-HERCULES air defense missile system is obsolescent and is currently being replaced by the conventional Improved HAWK missile (or being reduced in the nuclear role as plans are laid for introduction of the future conventional PATRIOT system), numerous allied batteries remain nuclear armed with nuclear warheads on a high level of alert. The NIKE-HERCULES also has a surface-to-surface capability.

Seven allied armies are supplied with nuclear warheads for their artillery. The warhead supply includes both the current 155mm (W48) and 8-inch (W33) versions. A large number and wide variety of guns are certified for nuclear missions (see Chapter Nine). Nuclear artillery is typically deployed at Corps level, although there are a number of certified units and guns at the division and even brigade level. An estimated 1700 155mm guns and 400 8-inch guns are available for nuclear missions in Europe.[37] The two most common guns are the standard American designs, the self-propelled M-109 (155mm) and M-110 (8-inch). Seven additional 155mm gun types in the armies of allied countries are also certified for nuclear weapons use: the older

36 Although the NIKE-HERCULES is assigned to the Army in the U.S. military, the allied NIKE units all fall under the Air Force.

37 This number includes U.S. Army guns deployed in Europe.

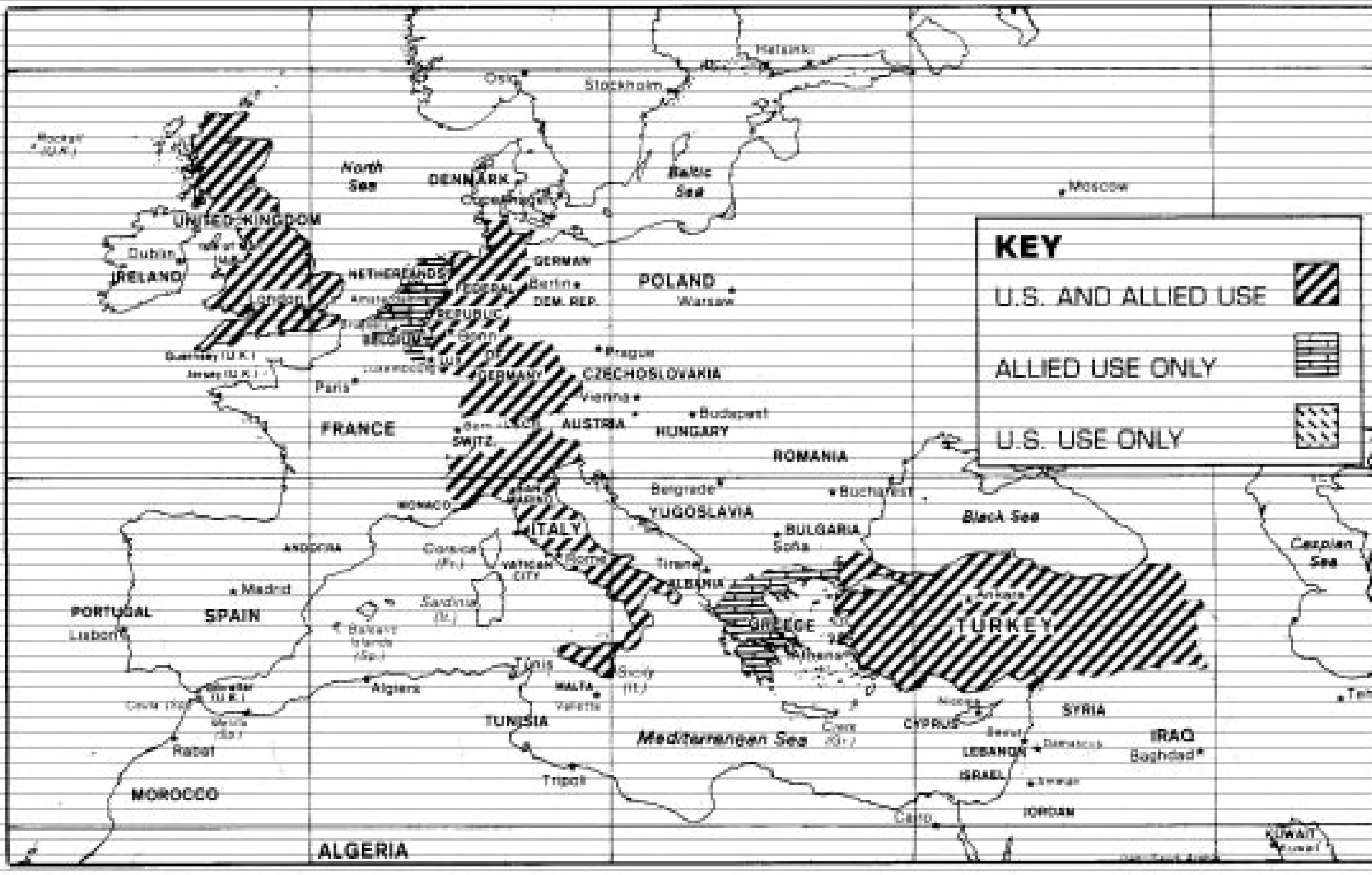

Figure 4.10 Deployment of U.S./NATO nuclear weapons in Europe.

American designed M-44, M-53, and M-114 guns, the newer towed M-198, and two European designed guns, the FH-70 (towed) and the SP-70 (self-propelled). Two older American designed 8-inch gun types are also utilized with nuclear weapons: the M-55 and the M-115. With the current nuclear warheads, the nuclear artillery of both calibers average 17-18 kilometers in range.

Atomic demolitions are also allocated to allied forces. Little is known of the nature of the agreements for the supply of atomic demolition munitions, but it is known that at least West Germany, the Netherlands, and Britain have special engineer units trained and certified for the use of the Medium Atomic Demolition Munition (W54). Since the ADM is a nuclear weapon without a delivery system, per se, the procedures for the sharing of ADM tasks remains unclear.

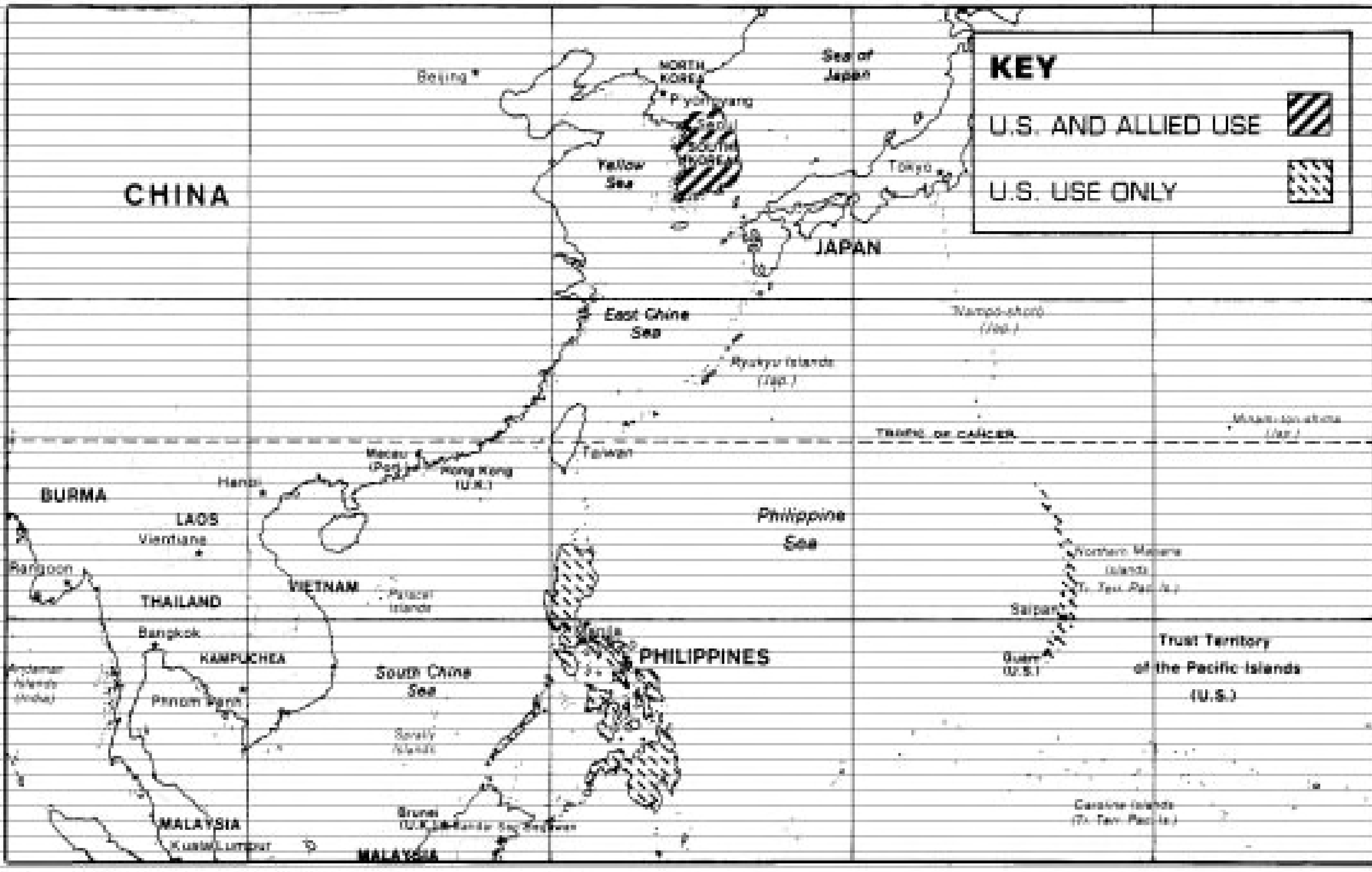

Figure 4.11 Deployment of U.S. nuclear weapons in Asia.

5

Chapter Five
Strategic Forces

U.S. strategic nuclear weapons are delivered by three principal means: land-based intercontinental ballistic missiles (ICBMs), submarine-launched ballistic missiles (SLBMs), and bombers. These three strategic systems are referred to by the Department of Defense as the "Triad."[1] A fourth element—Sea-Launched Cruise Missiles (SLCM)—will be added to strategic forces in 1984 (see Chapter Six) as part of a so-called "Strategic Reserve Force." One "defensive" strategic weapon—the GENIE air-to-air missile (W25)—is also deployed for bomber interception, and development of a nuclear armed anti-ballistic missile system continues. U.S. Strategic Forces in 1983 comprise about 10,000 operational nuclear warheads. Approximately $30 billion per year[2] is spent on these forces and some 140,000 military personnel are involved.[3]

The strategic warheads are either in ballistic missile reentry vehicles, missiles, or bombs. Once outside the earth's atmosphere, ballistic missiles (e.g., ICBMs and SLBMs) continue on a trajectory governed by gravity until reentry through the earth's atmosphere. The term ballistic derives from the reentry vehicle's free-fall trajectory after the rocket's boost phase and separation. There are currently five types of reentry vehicles deployed on ballistic missiles, with warheads ranging in yield from 40 Kt to 9 Mt. The ballistic missiles currently deployed all use reentry vehicles which are themselves ballistic, but future RVs may be maneuverable (and consequently non-ballistic).

Strategic ballistic missiles are multi-staged rockets with intercontinental ranges of well over 5000 miles. The demonstrated accuracy of land-based ICBMs is close to one-tenth of a nautical mile (200 m) and improving. The shape and construction of the RV is chosen to minimize drag upon atmosphere reentry, thus maintaining accuracy under varying weather conditions and rendering the high-speed RV difficult to defend against. The transit time of the missiles over intercontinental range is about 30 minutes.[4]

Each of the elements of the Triad has relative advantages and disadvantages in terms of reliability, accuracy, safety, and responsiveness (see Table 5.1). The land-based ICBM, however, has three characteristics, other than its high accuracy, that make it superior to the other strategic delivery systems: a large percentage of missiles prepared for immediate launch, a high probability of missile survival under nuclear attack, and a more secure communications link with command authorities.

The sea-launched systems (SLBMs and SLCMs) have the advantages of reduced vulnerability as long as the launching submarine is travelling quietly and invisibly under the ocean surface. SLBMs and SLCMs are also very flexible in deployment and movement. The submarine has a more tenuous communication link with the national command authorities, particularly under wartime conditions. The SLBM is also not as accurate as the ICBM because of the uncertainty of the submarine's location, orientation, and velocity, although with the deployment of the TRIDENT II missile starting in 1989 submarine missiles will begin to approach land-based missile accuracy.

Bombers, which carry nuclear warheads in gravity bombs, cruise missiles, or short-range air-to-surface missiles (SRAM), can be recalled after launch and enroute retargeting is possible. They are thus the most responsive to changing political or tactical circumstances. The short-range attack missile (SRAM) and cruise missiles launched from the aircraft also provide bombers with a standoff delivery capability and thus passive survivability. The bomber force is also highly accurate in targeting.

Land-Based Missiles

The land-based missile force currently consists of 1000 MINUTEMAN missiles (450 MINUTEMAN II and 550 MINUTEMAN III) armed with 2100 warheads, and 49 TITAN II missiles[5] armed with 49 warheads. Four

1. Triad is the Latin term for a union or group of three.
2. This is calculated based on the FY 1984 budget request, including Strategic Forces, Research and Development, and Department of Energy warhead expenses.
3. John M. Collins, *U.S.-Soviet Military Balance: Concepts and Capabilities, 1960-1980* (NY: McGraw-Hill, 1980), p. 249.
4. The launch to target time for a missile with a range of 6500 nm is about 36 minutes for a "minimum energy trajectory," neglecting effects of the earth's atmosphere. The launch speed is 14,800 nm/hr, the maximum height is 1300 km (701.5 nm), the speed at the top of the trajectory is 11,400 nm/hr and the angle between the trajectory and ground at impact is 18 degrees. See Abram Chayes and Jerome B. Weisner, eds., *ABM* (New York: New American Library, 1969), p. 278.
5. As of 1 January 1983. TITAN II missiles are being retired at a rate of about one per month; JCS, FY 1984, p. 13.

Table 5.1

Features of "Legs" of the Strategic TRIAD

ICBMs

- full target coverage
- high degree of accuracy (depending on model)
- assured ballistic penetration
- rapid retargeting capability
- constant survivable command and control
- highest degree of reliability (98%)[1]
- highest degree of alert (90%+)
- hardened silos
- post attack survivability
- quickest reaction time
- low operating cost ($330 m/yr)[2]

SLBMs

- highest degree of survivability (60% of forces at sea)
- assured ballistic penetration
- tenuous communications link
- high degree of reliability
- ability to withhold from initial attack
- invulnerable to detection or attack[3]

Bombers

- survivability of forces on alert (30%)[4]
- recallable after takeoff
- flexible targeting to include mobile targets, targets of opportunity, and multiple targets separated by long distances
- highest degree of accuracy
- vulnerable to air defenses
- ability to withhold from initial attack

1 SASC, FY 1981 DOD, Part 2, p. 549.
2 SASC, FY 1982 DOD, Part 7, p. 4002.
3 SASC, FY 1982 DOD, Part 3, p. 183.
4 SASC, FY 1982 DOD, Part 7, p. 3799.

Table 5.2

Strategic Nuclear Forces (1971-1981)[1]

	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
B-52	412	402	422	422	420	419	417	344	343	343	344
FB-111	66	60	71	72	69	68	66	66	65	63	62
MINUTEMAN	990	955	970	999	1010	1094	1162	1180	1170	1167	1164
TITAN II	58	57	57	57	57	58	57	57	57	56	56
SRAM	—	227	651	1149	1451	1431	1415	1406	1396	1383	1374
ALCM	—	—	—	—	—	—	—	—	—	—	14
HOUND DOG	340	338	329	327	308	288	249	—	—	—	—

1 SAC, "The Development of Strategic Air Command 1946-1981," 1 July 1982.

RV/warhead types are deployed on land-based missiles: the Mk-6/W53 on TITAN with 9 Mt yield, the Mk-11C/W56 on MINUTEMAN II with 1.2 Mt yield, the Mk-12/W62 on 250 MINUTEMAN IIIs with 170 Kt yield, and the Mk-12A/W78 on 300 MINUTEMAN IIIs with 335 Kt yield. The MINUTEMAN III missiles have multiple independently-targetable warheads (MIRVs). The remainder of the land-based missile force has single warheads.

The land-based missile force is deployed in hardened underground launching silos, primarily in the western United States (see Chapter Four). The first ICBM, the liquid fuel ATLAS, was deployed in above ground launching sites starting in 1959 and had an accuracy of about one mile. Eight years after the first ATLAS ICBM deployment numerous upgrades of the missile had been deployed, and the new heavy TITAN I and solid fuel MINUTEMAN I were added to the land-based force. Almost as quickly as the new missiles were deployed, however, they were phased out. By 1970, the missile force was stabilized at 1054 ICBMs, already with second generation TITAN and MINUTEMAN missiles. The first third generation missile—the MINUTEMAN III—with the new multiple independently-targeted reentry vehicle began testing in 1968. Between 1970 and 1975, 550 MINUTEMAN IIIs were deployed, replacing the same number of older single warhead MINUTEMANs.

Although the number and type of land-based missiles deployed has not changed for a decade, their military effectiveness has been continuously improved. The original warheads (W62) on a portion of the MINUTEMAN III force (300) missiles were upgraded to a higher yield variant (W78). The accuracy of MINUTEMAN II, MINUTEMAN III, and TITAN II missiles was improved through the deployment of new and more accurate guidance systems, and targeting and retargeting options were improved through the development of newer, faster, and more responsive systems.

Work on a completely new missile design—the MX—was already well underway when MINUTEMAN III was first deployed. Ten years later, the MX missile, now designated "PEACEKEEPER," is still under development and planned for a late-1986 initial deployment. The MX missile will carry 10 warheads, more than three times that of the MIRVed MINUTEMAN III, and it will be twice as accurate. Although deployment has been bogged down in controversy over strategic, environmental, cost, and political issues, a massive investment is still going into the new missile. The deployment plans are to retrofit 100 MX missiles into MINUTEMAN

Table 5.3
Strategic Nuclear Forces (1983)

Delivery System	No.[1]	Warheads/Launcher	Total Warheads	Yield (Mt)	Total Mt
MINUTEMAN II	450	1	450	1.2	540.0
MINUTEMAN III	550	3	1650		
Mk-12	(250)		(750)	.17	127.5
Mk-12A	(300)		(900)	.335	301.5
TITAN II	49	1	49	9.0	441.0
Total ICBMs	1049		2149		1410.0
POSEIDON	304	10	3040	.05	152.0
TRIDENT	240	8	1920	.1	192.0
Total SLBMs	544		4960		344.0
B-52G/H	241		2096		
ALCM	(14)	20[2]	(280)	11.08	155.1
Non-ALCM	(227)	8	(1816)	8.68	1970.3
B-52D	31	4	124	8.00	248.0
FB-111	60	6	360	4.68	280.8
Total Bombers	328		2580		2654.2
GRAND TOTAL	1921		9689		4408.2

1. As of 1 January 1983.
2. Weapons include 12 ALCM, 4 SRAM, 4 bombs.

underground launching silos, in lieu of placing the missiles in one of the previously chosen "survivable" basing modes (see MX Basing). The MX will carry a new reentry vehicle, the Mk-21 (Advanced Ballistic Reentry Vehicle), and a new warhead, the W87. The W87 warhead has an initial yield of 300 Kt, but can accommodate a change in fissile material and provide an upgraded yield of 475 Kt. A single warhead ICBM is also being developed, for an early-1990s IOC, as an eventual MINUTEMAN and MX replacement.

The Air Force is removing and dismantling approximately one TITAN II missile per month as part of a five year retirement program begun in October 1982. During FY 1983-1984, 50 single warhead MINUTEMAN II missiles will also be replaced in their silos with triple warhead MINUTEMAN IIIs. The remainder of the MINUTEMAN II force (400) will then begin retirement in 1986 as the PEACEKEEPER/MX enters the inventory. Six hundred MINUTEMAN IIIs will probably remain deployed through the 1990s.

Sea-Based Systems[6]

The present force of strategic ballistic missile submarines includes two TRIDENT and 31 POSEIDON submarines capable of firing 520 submarine-launched ballistic missiles (SLBMs) and carrying approximately 4960 warheads (see Table 5.4).[7] The POSEIDON submarines, constructed between 1960 and 1967, have 16 launch tubes for either POSEIDON C3 or TRIDENT I C4 ballistic missiles. Twelve submarines carry the TRIDENT I and 19 carry the POSEIDON C3. The new TRIDENT submarine has 24 launch tubes and carries the TRIDENT I C4; it will begin carrying the TRIDENT II D5 in 1989. Numerous improvements have taken place since the original POLARIS submarines and missiles were deployed in 1960. Besides new missiles and newly designed submarines, there have been significant improvements involving the latest communications, computing, quieting, and electronics equipment. The latest class of submarine, the OHIO, commonly referred to as TRIDENT, is now beginning to enter the SLBM force (see Tables 5.19 and 5.6).

The missile inventory consists of 304 POSEIDON C3 launchers in 19 POSEIDON submarines, 192 TRIDENT I C4 launchers in 12 POSEIDON submarines, and 48 TRIDENT I C4 launchers in two TRIDENT submarines.[8] Two RV/warhead types are deployed on the submarine missiles: the Mk-3/W68 on POSEIDON with 40-50 Kt yield, and the Mk-4/W76 on TRIDENT I with 100 Kt yield. Both missiles are MIRVed, with the POSEIDON capable of carrying 14 RVs, but averaging about 10, and the TRIDENT I carrying eight RVs.

There are 20 TRIDENT submarines in the current Five Year Defense Plan (Reagan Administration as of FY 1984). Although still undetermined, estimates are that 20-25 TRIDENT submarines will be built.[9] Ten TRIDENT submarines are authorized for construction through FY 1983. The shipbuilding program proposed by the Department of Defense for Fiscal Year 1983 includes funds for construction of two more TRIDENT submarines and one sub per year thereafter (see Table 5.6).[10]

The TRIDENT program, first called the Undersea Long-Range Missile System (ULMS), began as a follow-on to the POLARIS and POSEIDON fleet in the late 1960s. It was envisioned as a more survivable system capable of launching missiles at intercontinental ranges from quieter submarines. The need for the eventual modernization of POSEIDON was based upon the projected 20-25 year service life for deployed submarines (this has since been extended to 30 years). Development of a new missile (TRIDENT I C4) and submarine (OHIO class) was approved on 14 September 1971 by the Secretary of Defense.

The new TRIDENT submarines, the largest submarines ever built by the U.S., are more than twice the size of the present POSEIDON submarines. They are designed to operate at greater speeds and to emit less noise than the POSEIDONs. A new refit, maintenance and overhaul cycle, and the longer range of the missiles permit basing in the United States and operations off the protected U.S. coast. The increased patrol area still allows targeting throughout the Soviet Union.

Development of the TRIDENT I and TRIDENT II missiles has always been part of the TRIDENT program. The size of the TRIDENT I missile was limited to allow its deployment in smaller POSEIDON submarines. The

Table 5.4
Strategic Missile Submarines (1983)

Type (class)	Active	Building	Missiles
POSEIDON (*Lafayette*, *Madison*)	19	—	16 POSEIDON C3
POSEIDON (*Franklin*)	12	—	16 TRIDENT C4
TRIDENT (*Ohio*)	2	9	24 TRIDENT C4

6 An excellent history is *Fleet Ballistic Missile System: Polaris to Trident* (R.A. Fuhrman, President, Lockheed Missiles and Space Company, Inc., AIAA von Karman Lecture for 1978) (Washington, D.C.: AIAA, February 1978).
7 ACDA, FY 1982 ACIS, p. 78; ACDA, FY 1983 ACIS, p. 33.
8 Ibid.
9 Ibid; HASC, FY 1980 DOD, Part 4, p. 93; SASC, FY 1980 DOD, Part 7, p. 4179, mentions a 20 boat force.
10 ACDA, FY 1982 ACIS, p. 78; ACDA, FY 1983 ACIS, p. 36.

5

Strategic Submarines

Table 5.5
Strategic Submarine Chronology

Sep 1955	Sea basing of ballistic missile system considered in "Killian Report"
Mar 1956	Fleet Ballistic Missile submarine and surface combatant development program authorized
Apr 1956	Lockheed awarded contract to determine feasibility of submarine missile development
Dec 1956	Navy authorized to proceed with development of small, solid propellent POLARIS missile
Jan 1958	First POLARIS test flight; construction begun of first three POLARIS submarines
Apr 1959	First full successful POLARIS vehicle flight test
Dec 1959	U.S.S. *George Washington*, first POLARIS submarine, commissioned
Sep 1960	Development of POLARIS A3 approved
Nov 1960	U.S.S. *George Washington* leaves on first operational patrol with 16 POLARIS A1
Oct 1961	First launch of POLARIS A2 missile
Dec 1961	Last production model of POLARIS A1 delivered
May 1962	U.S.S. *Ethan Allen* successfully fires a POLARIS missile with a nuclear warhead
May 1962	U.S.S. *Lafayette* launched, first of new POSEIDON class
Aug 1962	First flight test of POLARIS A3 missile
Sep 1964	U.S.S. *Daniel Webster* goes on first patrol with POLARIS A3
Oct 1965	Last POLARIS A1 patrol
Oct 1965	Development of POSEIDON missile begins
Dec 1966	Production of POSEIDON C3 approved
Dec 1966	Electric Boat awarded contract for STRAT-X studies
Apr 1967	Last POSEIDON submarine, U.S.S. *Will Rogers*, commissioned
Aug 1967	STRAT-X system designated ULMS (Undersea Long-Range Missile System)
Jul 1968	Last production-line POLARIS A3 missile delivered
Aug 1968	First flight test of POSEIDON C3
Feb 1969	Program begun to convert 31 SSBNs from POLARIS to POSEIDON
Aug 1969	Production of POSEIDON C3 begins
Oct 1969	ULMS program formally established
Jun 1970	Development flight testing of POSEIDON C3 completed
Mar 1971	U.S.S. *James Madison* makes initial POSEIDON operational patrol
Dec 1971	TRIDENT missile advanced development begins
May 1972	ULMS renamed TRIDENT
Feb 1973	Bangor, WA selected as initial TRIDENT base
1973	TRIDENT C4 enters engineering development
Nov 1973	Funds for first TRIDENT submarine authorized
1974	Production of POSEIDON C3 completed
Mar 1974	First test flight of TRIDENT C4
Jun 1974	Last POLARIS A2 patrol
Jul 1974	Electric Boat receives contract for lead TRIDENT submarine
Nov 1975	Final flight test of TRIDENT C4
Apr 1976	Keel laid for *Ohio* (SSBN-726), first TRIDENT submarine
Jan 1977	First full scale production flight of TRIDENT C4, production begins
Feb 1978	Completed conversion of 31 POLARIS to POSEIDON
Apr 1979	Launch of U.S.S. *Ohio*
Jul 1980	UK announces decision to purchase TRIDENT system
Jul 1981	Delivery of U.S.S. *Ohio* by Electric Boat to Navy
Nov 1981	Commissioning of *Ohio*
Jan 1982	First test firing of TRIDENT I C4 from *Ohio*
Apr 1982	Deployment of *Ohio* on operational sea trials
May 1982	UK announces decision to acquire TRIDENT II rather than TRIDENT I
Mar 1983	Retrofit program of 12 POSEIDON SSBNs backfitted with TRIDENT I C4 missiles completed
Apr 1983	Planned deployment of the second TRIDENT, U.S.S. *Michigan*
End 1986	Six TRIDENTs scheduled for deployment
late 1988	First TRIDENT II deployed
1993	First POSEIDON hull scheduled for retirement
1993-1999	POSEIDON submarines scheduled for retirement

Sources: USN, Strategic Systems Project Office, "FBM Facts Polaris, Poseidon, Trident," 1978; General Dynamics Corporation, Electric Boat Division, "General Dynamics Trident Progam Milestones," April 1980; ACDA, FY 1982 ACIS, p. 85; SASC, FY 1983 DOD, Part 7, p. 4516.

Table 5.6
Strategic Submarine Forces (1979-1990)[1]

	FY 79	FY 80	FY 81	FY 82	FY 83	FY 84	FY 85	FY 86	FY 87	FY 88	FY 89	FY 90
TRIDENT SSBNs with TRIDENT I SLBMs	0	0	1	1	2	4	5	7	8	8	8	8
TRIDENT SSBNs with TRIDENT II SLBMs	0	0	0	0	0	0	0	0	0	0	1	2
POSEIDON SSBNs with TRIDENT I SLBMs	0	5	11	12	12	12	12	12	12	12	12	12
POSEIDON SSBNs with POSEIDON SLBMs	31	26	20	19	19	19	19	19	19	19	19	19

Source: ACDA, FY 1983 ACIS, p. 38; SASC, FY 1981 DOD, Part 6, p. 3469.

1 Cumulative Forces of launched (but not operational) submarines.

TRIDENT I missile, first deployed in FY 1979, increased the range over the POSEIDON and doubled the yield (from 50 to 100 Kt), but had similar accuracy. The TRIDENT II, planned for initial deployment on the ninth TRIDENT submarine scheduled for late 1989, will have increased range over the TRIDENT I and employ a much higher yield warhead. However, its most significant feature is its accuracy, which approaches the capability of land-based missiles. The deployment of TRIDENT II missiles (with 10 warheads each) in at least 20 new submarines will cost over $30 billion. The high yield variant of the W87 MX warhead (see MX Warhead), with a yield of 475 Kt, on a modification of the Advanced Ballistic Reentry Vehicle (designated the Mk-5), has been chosen as the developmental baseline for the TRIDENT II. A maneuvering reentry vehicle (designated the Mk-600) is also being considered for the missile.

In 1978, U.S. SSBNs had completed 1723 alert patrols of approximately 104,000 patrol days.[11] By 1981, 2043 patrols had been completed.[12] Approximately 60 percent of the submarine force is on patrol at any one time, and this percentage will increase as more TRIDENTs are deployed.

Strategic Bomber Force

The Srategic Air Command operates over 400 B-52 and FB-111 bombers, of which 272 B-52s and 56 FB-111s are in the active force[13] with the others used for training and backup. Thirty percent of the bomber force is always kept on 15-minute alert.[14] This percentage could be increased to 50% during an emergency.[15] Some bombers could be launched in as little as three minutes.[16] The bomber force carries five different types of nuclear bombs: the B28, B43, B53, B57, and B61. These bombs have various weights, yields, accuracies, and delivery profiles (see Chapters Three and Seven). Two missile systems are also carried: the Short-Range Attack Missile (SRAM) with its W69 warhead in the 170-200 Kt range and the new Air-Launched Cruise Missile (ALCM) with a 200 Kt warhead (W80).

The B-52 heavy bomber was first developed during the Korean War to create an intercontinental capability which was not possible with the B-29 or B-47 bombers it replaced. The B-52's airframe is old. This makes it difficult for the bomber to meet the current requirements of penetrating Soviet defenses or flying to targets at low altitudes. The usefulness and reliability of the B-52 in this role is undeniably decreasing, but the airframe is still reliable as a high altitude cruise missile platform. In fact, recent Air Force studies have confirmed the serviceability of the airframe until the year 2000. As the ability of B-52s to penetrate Soviet defense is diminishing, its role is also changing to the less demanding stand-off role for cruise missile carriage. Beginning in late 1981, B-52Gs were being deployed as cruise missile carriers. By the 1990s, B-52s will no longer have a penetration role.

Shortly after the B-52 was deployed in the 1950s, a modernization program began to evaluate and upgrade the capability and effectiveness of the B-52 force. Numerous modifications to the B-52 over the last 20-25 years have increased aircraft weight and drag.[17] Table 5.22 describes the extensive nature of the modernization program.

11 SASC, FY 1980 DOD, Part 6, p. 2406.
12 SASC, FY 1983 DOD, Part 7, p. 4515.
13 JCS, FY 1984, p. 23.
14 DOD, FY 1979 Annual Report, p. 44.
15 Ibid, p. 57.
16 Military Applications of Nuclear Technology, Part 1, p. 7.
17 SASC, FY 1982 DOD, Part 7, p. 3790.

Table 5.7

Strategic Bomber Force Loadings

Average Weapons Per Plane

Aircraft	Number[1]	ALCM	SRAM	Bombs
B-52G	151	12	4	4
B-52H	90	—	4	4
B-52D	31	—	—	4
FB-111	56	—	4[2]	2[3]

Capable Load

Aircraft	Number	ALCM	SRAM	Bombs
B-52G	151	12	20	12[4]/4
B-52H	90	20[5]	20	12[6]/4
B-52D	31	—	—	4
FB-111	56	—	6	6[7]

1 The number of bombers reduces every year as a result of attrition; these are operational bombers as of 1 January 1983; SASC, FY 1983 DOD, Part 7, p. 4556; JCS, FY 1984, p. 13.
2 SAC, FY 1981 DOD, Part 5, p. 1629.
3 ibid.
4 Maximum number of B61s possible: SASC, FY 1982 DOD, Part 7, p. 4329.
5 Planned.
6 Maximum number of B61s possible: SASC, FY 1982 DOD, Part 7, p. 4329.
7 ibid.

Table 5.8

Bomber Forces Funding (1970-1980)

[$ millions]

Year	RDT&E*	Procurement*	Operations*
1970	131.1	288.2	476.1**
1971	73.7	473.7	435.5**
1972	6.8	724.5	496.1**
1973	50.0	544.1	583.6
1974	14.8	388.0	573.5
1975	67.8	284.6	637.1
1976/7T	70.8	181.1	780.5
1977	154.8	217.0	834.7
1978	395.3	269.2	839.8
1979	537.7	493.8	886.8
1980	266.3	1137.1	709.4
TOTAL	1769.1	5001.3	8654.2

* Then year dollars.
** Includes South East Asia funding.
Source: SASC, FY 1980 DOD, Part 1, p. 398. Table excludes B-1 funding, but includes bomber/bomber weapons funding.

The bomber force is more capable of destroying hardened military targets than MINUTEMAN.[18] This capability will be enhanced with the continued deployment of some 4000 ALCMs (and its Advanced Cruise Missile replacement), the new B83 bomb (planned for the mid-1980s), and a replacement for the SRAM, the Advanced Strategic Air-Launched Missile (see Chapter Six). Although the bombers are capable of carrying 24 nuclear weapons, the location of high priority targets within the Soviet Union makes it unlikely that they could go to 24 different places.[19] The widespread deployment of new long-range ALCMs and SRAM replacements will increase target flexibility and allow for great distances between targets.[20] The new weapons incorporate further technological advances in many areas, including lightweight materials, miniaturized electronics, modern warhead design, and advanced guidance systems. The new bomb can be delivered at low level and at supersonic speeds.

In addition to changes in the weapons load, the bomber force itself is in the midst of significant changes and upgrading. Older B-52Ds, the last of the gravity bomb carriers armed with four high yield nuclear bombs, began retirement in FY 1983 and will be completely withdrawn in FY 1984.[21] The B-52G, which was the first ALCM launcher starting in 1982, will continue to be modified to carry ALCMs on two large external pylons mounted under the wings. Plans to modify these bombers for internal ALCM carriage have been cancelled. The B-52H force will be modified to carry ALCMs both internally and externally, starting deployment in 1985.[22] The B-52Gs will convert entirely to standoff bombers as B-1Bs are deployed starting in 1985-1986. The B-52Gs will begin retirement with deployment of the Advanced Technology Bomber (ATB) ("Stealth") in the early 1990s. The B-52H force will continue as an ALCM carrier well into the 1990s. After a long, difficult development program, a new manned bomber, the B-1B, will be deployed in FY 1985 and will carry cruise missiles and gravity bombs. Deployment of 100 B-1Bs and 100-150 ATBs is planned. The FB-111s will be transferred to the tactical inventory as ATBs are deployed.[23]

Ballistic Missile Reentry Vehicles

The reentry vehicle (RV) on a ballistic missile carries the nuclear warhead. Reentry vehicles are designed to minimize the environmental factors, such as wind and atmospheric density, which accompany the missile's reentry to the earth's atmosphere. Both missile speed and accuracy are only slightly reduced. Assuming perfect ballistic trajectories, aside from reentry effects, RVs

18 SASC, FY 1982 DOD, Part 7, p. 4010; ACDA, FY 1979 ACIS, p. 3.
19 *Military Applications of Nuclear Technology*, Part 1, p. 7.
20 ACDA, FY 1983 ACIS, p. 67.
21 SASC, FY 1983 DOD, Part 7, p. 4880.
22 ACDA, FY 1980 ACIS, p. 67.
23 DOD, FY 1984 Annual Report, pp. 222-224.

Table 5.9
U.S. Ballistic Missile Reentry Vehicles

RV	Warhead	Missile System	RVs/Missile
		Deployed (1983)	
Mk-3	W68	POSEIDON (C3)	up to 14 (MIRV) (avg 10)[1]
Mk-4	W76	TRIDENT I (C4)	up to 10 (MIRV) (avg 8)
Mk-6	W53	TITAN II	1
Mk-11C	W56	MINUTEMAN II	1
Mk-12	W62	MINUTEMAN III	2-3 (MIRV)
Mk-12A	W78	MINUTEMAN III	3 (MIRV)
		Retired	
Mk-1	W38,W49	ATLAS/THOR/JUPITER	1
Mk-2	W38,W49	TITAN I	1
Mk-1 (Navy)	W47	POLARIS (A1/A2)	1
Mk-2 (Navy)	W58	POLARIS (A3)	3 (MRV)[2]
Mk-5	W59	MINUTEMAN I	1
Mk-11	W59	MINUTEMAN I	1
		Cancelled Programs	
Mk-17	—	MINUTEMAN III/ POSEIDON	1
MK-18	—	MINUTEMAN III	multiple unguided RVs
Mk-19	—	MINUTEMAN III	MIRV/MaRV
Mk-20	—	MINUTEMAN III	MIRV/MaRV

1 JCS, FY 1984, p. 16; prior to FY 1984, the average loading was nine; the C3 missile has been tested with 14 warheads. Since there is a tradeoff between throwweight and range, actual loadings are less than the maximum depending on target and submarine locations.

2 Not independently targetable.

can achieve overall theoretical accuracies of better than 250 feet CEP.

All ballistic missile systems may carry one or several reentry vehicles which may be independently targeted. If the missile system carries several RVs that are not independently-targetable, the system is referred to simply as a multiple reentry vehicle (MRV) system. In a multiple independently-targetable reentry vehicle system (or MIRVed system), the separate reentry vehicles are carried on a "bus" which releases the RVs one by one after making preselected changes in speed and orientation so as to direct each RV to separate targets. These RVs will land inside a "footprint" of perhaps 100 miles by 300 miles. Missiles with multiple RVs have less targeting flexibility than single warhead missiles, because the other RVs on the bus are not completely independent in arrival time or location of the RV first released.

The newest RV, the Mk-12A, has been retrofitted on 300 MINUTEMAN III missiles, replacing the Mk-12.[24] The Mk-12A, designed in the mid-sixties, retained approximately the same dimensions, aerodynamic properties, and radar cross section of older RVs, and its weight was only slightly greater than the Mk-12. The Mk-12A incorporated a larger yield warhead, increased accuracy, and an improved arming and fuzing system over the Mk-12.[25] The Air Force justification for this new RV was that it was necessary to compensate for continual Soviet hardening of its strategic targets.

The Mk-12A RV was originally intended to be deployed on all 550 MINUTEMAN IIIs. However, because of additional weight over the Mk-12 and the resultant decrease in range, some Mk-12 equipped MM IIIs were retained in order to reach all targets.[26] Until January 1982, the Mk-12A was also the baseline RV for the PEACEKEEPER/MX missile, but has now been

24 1083 Mk-12A RVs are planned for procurement for MM III forces; SASC, FY 1982 DOD, Part 7, pp. 3986-87.

25 ACDA, FY 1979 ACIS, p. 2.

26 HAC, FY 1980 DOD, Part 2, p. 499.

Table 5.10

RV Developments

Mk-80	MX/TRIDENT II/ MINUTEMAN III	Lightweight oralloy warhead/RV, cancelled
Mk-81	MX/TRIDENT II/ MINUTEMAN III	Plutonium warhead/ RV, cancelled
Mk-500 EVADER	TRIDENT	Maneuvering RV
Mk-5/ Mk-21/ ABRV	MX/TRIDENT II/ Small ICBM	Highly accurate RV
AMaRV	MX/TRIDENT II/ Small ICBM	Highly accurate maneuvering RV
PGRV	MX/TRIDENT II	Highly accurate terminally guided RV
Mk-600	TRIDENT II	Highly accurate, terminal homing maneuvering RV

shelved in favor of the more accurate Mk-21 (formerly ABRV) with a new warhead, the W87.

The U.S. ballistic missile RVs currently deployed are shown in Table 5.9. All currently deployed missile RVs are ballistic. Future RVs, however, including possible reentry vehicles for the PEACEKEEPER/MX and TRIDENT II D5 missile systems, may be nonballistic or Maneuvering Reentry Vehicles (MaRVs). For accuracy or evasion, the MaRV will be able to correct its flight path after reentry.

The Advanced Strategic Missile Systems (ASMS) program is continuing DOD research and development of RVs and subsystems for ICBMs, IRBMs, and SLBMs. The ASMS program (its name was changed from the Advanced Ballistic Reentry Systems (ABRES) program in FY 1982) includes advanced development for ballistic missile systems, subsystems, and reentry and penetration aids for existing and future weapons. These reentry vehicles are discussed later in this section.

The ASMS program, started in 1962, generally focuses on post-ballistic phases of the trajectory. The feasibility of large MaRVs was demonstrated by flight tests in the mid-1960s.[27] In the 1970s, flight tests examined advanced design concepts and more severe maneuvering environments, including:[28]

- Concealment: reduction of radar cross section, new shapes, and materials,
- Countermeasures: radar blackout, saturation, replica decoys, traffic decoys, active ECM,
- Evasion: maneuvering,
- Speed: increased,
- Accuracy: terminal guidance, post maneuver accuracy.

Maneuvering RVs could also have the purpose of attacking mobile targets, such as ships or mobile missiles. It is generally assumed that with a long-range ballistic missile it is difficult to observe continuously and accurately the position of a mobile target. But once launched, a MaRV equipped missile together with an

Table 5.11

RV Chronology[1]

Mar 1963	First ABRES test launch atop ATLAS missile
May 1963	Advanced Ballistic Reentry Systems (ABRES) program started
Feb 1964	First ATHENA rocket launched to test subscale ballistic reentry vehicles
Aug 1966	First Maneuvering Ballistic Reentry Vehicle (MBRV-1) launched
Sep 1973	Advanced Nosetip Test program to develop Multiple Small RVs for MINUTEMAN tested
Dec 1974	Mk-12A development contract signed with GE
Mar 1975	First Mk-500 flight test
May 1975	Second Mk-500 flight test
Aug 1975	Third Mk-500 flight test
Jan 1976	Fifth Mk-500 flight test
Jan 1976	AMaRV concept review conducted
Apr 1976	Mk-12A critical design review conducted
FY 1976	PGRV program initiated
Jan 1977	First Mk-12A flight
Jul 1977	AMaRV prototype construction began
FY 1978	First ABRV flight
FY 1979	Mk-12A completed development
FY 1980	First two AMaRV flight tests conducted
FY 1980	IOC of Mk-12A on MM III
FY 1981	Third and final AMaRV flight test
Mar 1981	93 MM III fitted with Mk-12A[2]
Jan 1982	ABRV chosen for MX
1983	Deployment of Mk-12A on 300 MM III completed

1 ACDA, FY 1979 ACIS, p. 1; information was also received from USAF Space Division.
2 HAC, FY 1982 DOD, Part 2, p. 225.

27 ACDA, FY 1981 ACIS, p. 17; ACDA, FY 1982 ACIS, p. 18.

28 *Ibid.*

Table 5.12
ABRES / ASMS Costs:[1]

FY	Total Appropriation ($ million)
1977 & prior	1757.5[2]
1978 & prior	1855.5[3]
1979 & prior	1961.2
1980	95.4
1981 & prior	2153.3[4]
1981	103.8
1982	99.6[5]
1983	52.3

Mk-12A COSTS:

FY	Total Appropriation ($ million)
1977 & prior	152.7
1980 & prior	402.5[6]
1981 & prior	626.6[7]
1982	56.4[8]

1 ACDA, FY 1981 ACIS, p. 23; and DOD, *Program Acquisition Costs by Weapon System*, FY 1982, 15 January 1981.
2 ACDA, FY 1979 ACIS, p. 48.
3 HAC, FY 1980 DOD, Part 6, p. 677.
4 ACDA, FY 1983 ACIS, p. 12.
5 In FY 1982, Congress appropriated $100 million even though DOD requested $50 million.
6 ACDA, FY 1982 ACIS, p. 24.
7 *Ibid.*, p. 11.
8 *Ibid.*

autonomous sensor could reach the target area and maneuver in order to attack a non-fixed target.

The goal of the current MaRV development program is to establish whether ballistic missiles can reliably fly nonballistic reentry trajectories in order to evade ballistic missile defenses and improve accuracy. The two MaRV efforts under development include the Advanced Maneuvering Reentry Vehicle (AMaRV) program initiated in FY 1976 and the Precision Guided Reentry Vehicle (PGRV). The PGRV is a longer term effort involving technology developed in AMaRV with terminal sensors.[29]

Funding for maneuvering RVs over the past five years has been approximately $100 million per year.[30] Current research emphasis is on nosetip ablation/erosion studies, tests, materials development, maneuvering subsystems, decoys, and other penetration aids.[31] The ASMS program contracts with approximately 40 corporations and consultants and extensively uses government laboratories.[32] A new Air Force study, "Strategic Missile Systems 2000," begun during FY 1982, will determine the most promising ballistic concepts, technologies, and areas of development for the future.[33]

Mk-21/Mk-5 (Advanced Ballistic Reentry Vehicle) (ABRV)

The ABRV program began in 1975 to demonstrate the maximum accuracy achievable with small ballistic reentry vehicles. An ABRV was originally envisioned for the MX and, in January 1982, was chosen as the RV for the MX carrying the 300 Kt W87 warhead.[34] The ABRV has also been selected as the baseline RV for the TRIDENT II (designated Mk-5) and for the Small ICBM.[35] The development program has sought to optimize yield-to-weight ratios, improve packaging, and incorporate a new, improved (interactive) fuze.[36] The choice of the W87 warhead for the Mk-21 results in a number of new characteristics—use of less nuclear material, the ability to increase low yield later by adding more materials, and incorporation of IHE.[37] The weight of the ABRV, however, is reportedly greater than the Mk-12A. This restricts its range.[38]

The current R&D program includes flight testing, data analysis, and development.[39] Flight testing for the ABRV, which began in 1978, has been used to demonstrate the use of shapes, materials, fuzing, heat shielding, cooling, and composite structuring.

The size of the ABRV permits a larger number of warheads to be carried by MX and TRIDENT II, but the increased weight and SALT II adherence would restrict the number.[40] There are three warheads compatible with the ABRV: the current warhead; the versatile 300 Kt light-weight warhead (W87) (which can be upgraded to 475 Kt);[41] the 500-600 Kt CALMENDRO warhead; and the 800+ Kt MUNSTER warhead.[42] The W78 has also been considered for the ABRV.

Advanced Maneuverable Reentry Vehicle (AMaRV)

The AMaRV R&D program, a follow-on to the earlier Mk-500, aims to develop a more accurate maneuvering RV capable of evading enemy terminal offenses with

29 ACDA, FY 1981 ACIS, p. 17.
30 SASC, FY 1982 DOD, Part 7, p. 3995.
31 DOD, *Program Acquisition Costs by Weapon System*, FY 1982, 15 January 1981, p. 135.
32 Ibid.
33 AF, FY 1983 RDTE Statement, 2 March 1982; *Air Force Magazine*, February 1982, p. 21; ACDA, FY 1983 ACIS, p. 8.
34 See MX and W87 warhead.
35 AW&ST, 17 January 1983, p. 26.
36 ACDA, FY 1981 ACIS, p. 16.
37 SASC, FY 1983 DOD, Part 7, p. 4179.
38 AW&ST, 4 May 1981, p. 52.
39 ACDA, FY 1982 ACIS, p. 18.
40 ACDA, FY 1981 ACIS, p. 16.
41 AW&ST, 17 January 1983, p. 26.
42 AW&ST, 9 March 1981, p. 25.

advanced interceptor missiles. The AMaRV program includes the development of a high-altitude maneuver capability, with an inertial measurement system on the reentry vehicle[43] affording accuracy equal to or better than the ballistic RV it replaces.

AMaRV completed a concept review in January 1976 and a contract was awarded in September 1976 for the development and flight testing of two AMaRVs.[44] These two flight tests occurred in FY 1980. A third and final AMaRV test took place in FY 1981.

The AMaRV program has now replaced the Mk-500 EVADER by utilizing advances in technology and by adding new angles of attack, speed, acceleration, and guidance features. The AMaRV program is evaluating a laser gyro, stellar navigation updating, and a new inertial platform.

Mk-500 EVADER Maneuverable RV (MaRV)

The Mk-500 development program began in the late 1960s as an evasive maneuvering endoatmospheric RV for the TRIDENT missile. The program, which enables the U.S. to respond to potential changes in Soviet ABM defenses, is essentially designed to maneuver against terminal defensive missiles. The Mk-500 lacks a terminal maneuvering guidance and thus is less accurate than the current generation SLBM ballistic RVs. This first generation MaRV is essentially ready for deployment on TRIDENT I, even at the price of degraded accuracy, should a rapid change in Soviet ABM capabilities occur.[45]

The program has remained an advanced test program conducted by Lockheed, the prime contractor, and General Electric, the principal sub-contractor.[46] Flight testing on MINUTEMAN boosters began in 1975 and two flight tests on TRIDENT I missiles have been conducted. The DOD goal is to obtain an acquisition readiness during FY 1983. Presently there are no firm plans to produce the RV.[47] The Mk-500 Advanced Development Program has fully demonstrated the feasibility of MaRV and compatability with the TRIDENT I.[48] The Readiness Maintenance Program maintains a capability to deploy a maneuvering RV with little delay and low risk.[49] Included in this program is design and testing of fire control software, parts, and guidance system.

Precision Guided Reentry Vehicle (PGRV)

The Precision Guided Reentry Vehicle (PGRV) program began in FY 1976 with completion of a system design study. Development of PGRVs is a long term effort utilizing AMaRV technology and adding terminal sensors. The terminal sensor would allow for corrections in guidance in the final phase of flight by providing relative position and velocity updates for the RV guidance system as the RV approaches its target.[50]

A maneuvering PGRV is under development which could, given expected technological developments, be accurate enough to significantly increase the U.S. ability to destroy the Soviet ICBM force. Alternatively, a PGRV with a low yield warhead could permit "greater targeting flexibility with lower collateral damage, but without a hard target capability."[51] A PGRV, designated Mk-600, with terminal homing guidance, has been adopted as an alternative warhead for the TRIDENT II. Deployment of the Mk-600 PGRV is thought possible by the 1990s.[52]

43 Currently only ballistic missile boosters, not RVs, have inertial navigation systems.
44 ACDA, FY 1979 ACIS, p. 53.
45 ACDA, FY 1979 ACIS, p. 54.
46 Other sub-contractors include Litton, Rockwell Autonetics, Batelle, Bell, Northrop, and Hamilton Standard.
47 ACDA, FY 1983 ACIS, p. 40.
48 SASC, FY 1981 DOD, Part 2, p. 612.
49 SASC, FY 1981 DOD, Part 2, p. 612; ACDA, FY 1981 ACIS, p. 30.
50 ACDA, FY 1981 ACIS, p. 18.
51 ACDA, FY 1979 ACIS, p. 56.
52 AW&ST, 8 March 1982, p. 27.

Land-Based Missile Systems

TITAN II (LGM-25C)

Figure 5.1 TITAN II (LGM-25C) missile.

DESCRIPTION:	Largest Air Force Intercontinental Ballistic Missile (ICBM), with single high yield warhead, and the only ICBM remaining which is liquid fueled.
CONTRACTORS:	Martin Marietta Corp. Denver, CO (prime) General Electric Philadelphia, PA (RV) Delco Electronics (guidance) Aerojet General Sacramento, CA (propulsion) IBM (guidance)

SPECIFICATIONS:

Length:	103 ft (31.3 m)
Diameter:	120 in (305 cm)
Stages:	2
Weight at Launch:	327,000 lb (149,700 kg)
Fuel:	liquid[1]
Propulsion:	
Stage 1:	two Aerojet LR87-AJ-5s, 98,000 kg thrust each
Stage 2:	Aerojet LR91-AJ-5, 45,500 kg thrust
Speed:	24,000+ km/h at burn-out
Guidance:	inertial gimballed; original guidance system replaced FY 1979-FY 1981[2]
Throwweight/ Payload:	7500 lb;[3] 8275 lb[4]
Range:	6296 nm;[5] 7250 nm;[6] 8100 nm;[7] 4000 km;[8] 15,000 km[9]
Ceiling:	about 700 miles
DUAL CAPABLE:	no
NUCLEAR WARHEADS:	one W53/Mk-6 reentry vehicle with penetration aids; 9 Mt (see W53)

DEPLOYMENT:

Launch Platform:	fixed site underground hardened silo
Silo Hardening:	300 psi[10]
Number Deployed:	49 missiles deployed (Jan 1983); retirement program began October 1982 with one missile per month dismantled.[11] 65 warheads in stockpile prior to start of withdrawal[12]

5

TITAN II

Location:

Wing	Base	Missiles[13]
308 SMW	Little Rock AFB, AR	17
381 SMW	McConneell AFB, KS	17
390 SMW	Davis-Monthan AFB, AZ	15

HISTORY:

IOC:	8 June 1963[14]
Dec 1963	TITAN II achieves full operational capabilities[15]
1980	54 TITAN IIs deployed prior to silo accidents in 1978 and 1980 at Rock, Kansas and Damascus, Arkansas
Oct 1981	Reagan strategic program calls for early retirement of TITAN missile force
Oct 1982	first TITAN missiles at Davis-Monthan AFB, AZ, begin retirement[16]
late 1986	10 TITANs remain on alert at MX IOC[17]
FY 1983-1987	TITAN force deactivated[18]

TARGETING:

Types:	wide area soft military targets, industry and urban areas; "hundreds" of "high-yield aggregate Desired Ground Zeros (DGZs) which contain more than one primary DGZ" (target)[19]
Selection Capability:	two target selection capability
Retargeting:	missile silos are also launch centers
Accuracy/CEP:	0.7-0.8 nm;[20] 0.5 nm[21]

COST:

Annual Operations:	$330 m (FY 1980)[22] $345 m (FY 1982)[23]

FY	Number Procured	Total Appropriation ($ million)
1981 & prior	-	1765.7[24]
1982	-	266.8[25]

COMMENTS: TITAN warhead is the largest in the U.S. land-based inventory and provides the most destructive soft target (population center, industry, etc.) capability in the U.S. strategic forces. Early retirement will result in a FY 1982-1987 savings of $500 million.[26]

1 Fuel is mixture of 50 percent hydrazine (N_2H_4) by weight and unsymmetrical dimethylhydrazine $(2H_2\ (CH_3)_2)$; oxidizer is nitrogen tetroxide (N_2O_4); SAC, Fact Sheet, "TITAN II," August 1981.
2 JCS, FY 1980, p. 97.
3 Military Balance, 1980-1981, p. 88; Heritage Foundation, SALT Handbook, p. 75.
4 John Collins, op. cit.; Paul H. Nitze, Prepared Statement Before Senate Foreign Relations Committee, 12 July 1979, Revised 13 January 1981, Reprinted in Congressional Record, 20 July 1972, p. S10079.
5 Military Balance, 1975-1976, p. 71.
6 John Collins, op. cit., p. 446.
7 Military Balance, 1980-1981.
8 Flight International, 30 May 1981, p. 1637.
9 Jane's Weapons Systems.
10 HAC, FY 1982 Mil Con, Part 6, p. 275.
11 49 missiles were deployed as of 1 January 1983; JCS, FY 1984, p. 13.
12 AF, "Missile Procurement Justification," FY 1981 (January 1980), p. 184.
13 Before the decision to retire the TITAN force, the silo at Damascus, Arkansas (site of the accident in September 1980) was not planned for rebuilding. A second site in Kansas destroyed by an oxidizer leak in 1978 had been reported as being repaired, but it is now likely that the weapons will be retired in lieu of repair. See, for instance, Walter Pincus, Washington Post, 23 May 1981, p. A-11.
14 SASC, FY 1977 DOD, Part 1, p. 393.
15 ACDA, FY 1983 ACIS, p. 2.
16 HASC, FY 1983 DOD, Part 2, p. 103; New York Times, 12 November 1982, p. A19; the first wing will phase out over a two year period; the other two wings will follow over a three year period.
17 SASC, FY 1983 DOD, Part 7, p. 4159.
18 AF RDTE Statement, FY 1983, p. II-3; Walter Pincus, Washington Post, 24 September 1981; DOD, FY 1984 Annual Report, p. 221.
19 SASC, FY 1982 DOD, Part 7, p. 3841.
20 A CEP of 0.7 nm is given by Paul H. Nitze, op. cit., and by UN Secretary General ("General and Complete Disarmament," A/35/392, 12 September 1980). John Collins, op. cit., assumes 0.8 nm. These estimates are probably low since, according to the Joint Chiefs of Staff (FY 1982, p. 69), "A new more accurate guidance system has been installed in the TITAN II missile."
21 Colin S. Gray, "The Future of Land-Based Missile Forces" (London: IISS, Adelphi No. 140), p. 32.
22 Annual MINUTEMAN/TITAN operating costs, including military personnel: SASC, FY 1982 DOD, Part 7, p. 4002.
23 Ibid., p. 4337.
24 Does not include initial procurement costs: ACDA, FY 1983 ACIS, p. 11.
25 System safety, reliability, and maintainability modifications planned: SASC, FY 1982 DOD, Part 7, p. 3829.
26 Ibid., p. 4232.

MINUTEMAN II (LGM-30F)

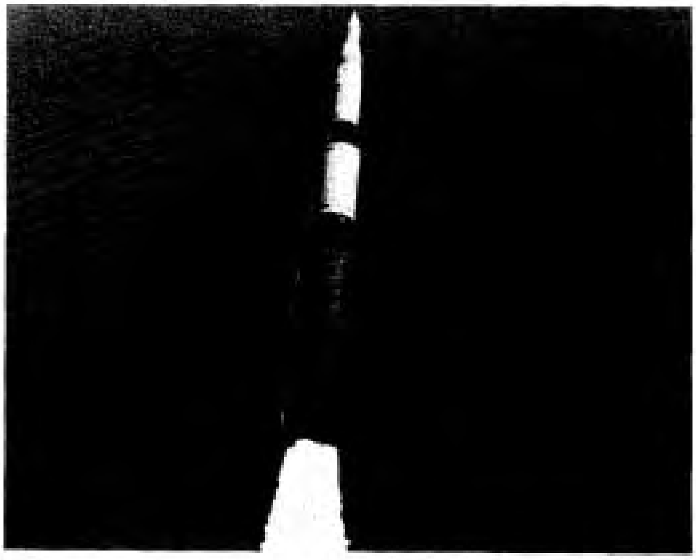

Figure 5.2 *MINUTEMAN II (LGM-30F)* missile.

DESCRIPTION: Air Force three-stage, solid fuel, single warhead ICBM.

CONTRACTORS:
Boeing Aerospace Co.
Seattle, WA
(prime, assembly and test)
AVCO Systems
Wilmington, MA
(reentry vehicle)
GTE Sylvania
Needham Heights, MA
(ground electronics)
Autonetics Division,
Rockwell International
Anaheim, CA
(guidance)
Aerojet General
Sacramento, CA
(propulsion)
Thiokol Chemical Corp.
Brigham City, UT
(propulsion)
Hercules Inc.
Wilmington, DE
(propulsion)
Tracor Inc.
Austin, TX
(penetration aids)
TRW Systems
Redondo Beach, CA
(technical direction)

SPECIFICATIONS: (same as MINUTEMAN III except for top stage)

Length: 57 ft 6 in (691.2 in)[1]

Diameter: 67.2 in; 72 in[2]

Stages: 3

Weight at Launch: 73,000 lb; 70,000 lb[3]

Propulsion: three solid-propellant rocket engines

Speed: 15,000+ mph; 24,000+ km/h at burn-out

Guidance: inertial gimballed NS-17 guidance and control system

Throwweight/Payload: 1000-1500 lb;[4] 2500 lb;[5] 1625 lb[6]

Range: 6080 nm;[7] 8000 nm;[8] 6500 nm;[9] 7000 mi[10]

Ceiling: about 700 miles

DUAL CAPABLE: no

NUCLEAR WARHEADS: one W56 warhead/Mk-11C reentry vehicle;[11] 1.2 Mt (see W56)

DEPLOYMENT:

Launch Platform: fixed 25 m deep underground hardened silo with missile suspension, shock isolated floor, debris collection system and EMP protection

Silo Hardening: 1200-2200 psi

5

MINUTEMAN II

Number Deployed: 450 active (1983).[12] Fifty MM II missiles will be replaced with MM IIIs at Malmstrom AFB, MT, starting in FY 1983.[13]

Location:

Wing	Base	Missiles
I/ 341 SMW	Malmstrom AFB, MT	150
II/ 44 SMW	Ellsworth AFB, SD	150
IV/351 SMW	Whiteman AFB, MO	150[14]

HISTORY:

IOC: 1966[15] (see Table 5.13 for MINUTEMAN chronology)

TARGETING:

Types: moderately hard targets; soft large-area military and industrial installations requiring high yield but less than pinpoint accuracy; isolated targets[16]

Selection Capability: eight target selection in missile computer, one set designated default primary

Retargeting: re-programming of target data in missile computer could take 36 hours. Command Data Buffer System, which permits retargeting in 25 minutes, is not being installed in MINUTEMAN II.[17]

Accuracy/CEP: 0.2-0.34 nm[18]

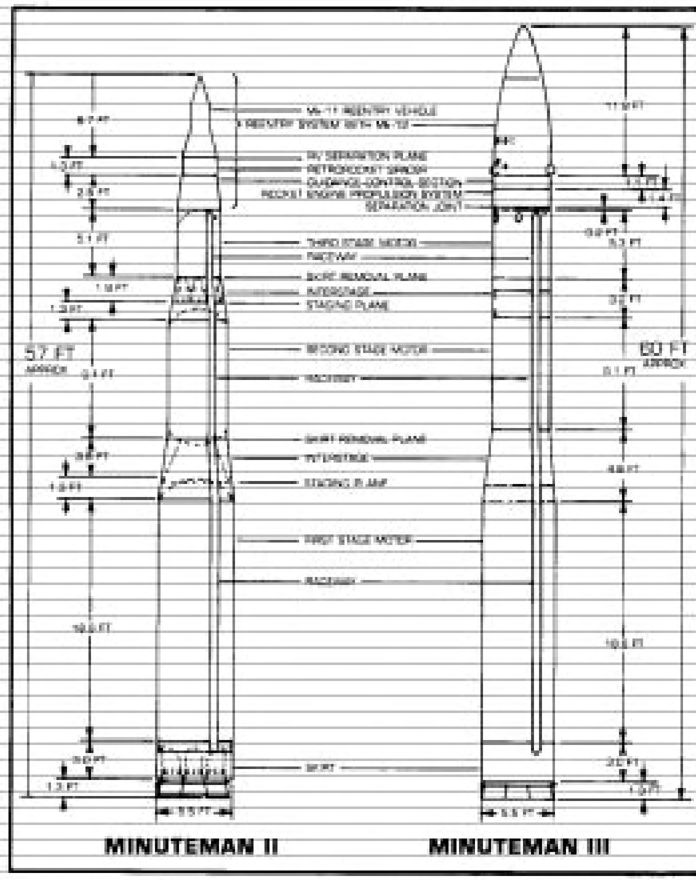

Figure 5.3 Comparison of MINUTEMAN II and MINUTEMAN III.

COST:

Annual operations: $330 m (FY 1980)[19]
$345 m (FY 1982)[20]

FY	Number Procured	Total Appropriation ($ million)
1979 & prior	620[21]	unknown
1980	-	144.5
1981	-	196.0
1982	-	140.7

COMMENTS: MM II has the capability to carry chaff and the Mk-1A penetration aids canister.[22] Missile is showing signs of deterioration and by mid-1980s missiles will have to be replaced or overhauled.[23]

1 The World's Missile Systems, 6th Ed., p. 286.
2 Ibid.
3 Ibid.
4 Military Balance, 1980-1981, p. 88; Heritage Foundation, SALT Handbook, p. 75.
5 William Schneider, Jr. and Francis P. Hoeber, Arms, Men and Military Budgets: Issues for Fiscal Year 1977 (New York: Crane, Russak, 1976), p. 27.
6 John Collins, op. cit.; Paul H. Nitze, op. cit., assumes 1600 lb.
7 The World's Missile Systems, 6th Ed., p. 289.
8 John Collins, op. cit., p. 446.
9 Heritage Foundation, SALT Handbook, p. 75.
10 The World's Missile Systems, 6th Ed., p. 288.
11 Mk-11C is an evolution of the Mk-11 RV originally deployed on MINUTEMAN I. Mk-11 had no penetration aids and two target selection capability. Mk-11A reportedly had a different warhead yield. Mk-11B designed for MM II had an eight target selection capability and incorporated penetration aids. Mk-11C was improved and hardened against nuclear weapons effects.
12 Colin S. Gray, "The Future of Land-Based Missile Forces," op. cit., p. 33.
13 JCS, FY 1983, p. 72.
14 Eight MINUTEMAN II missiles at Whiteman AFB are armed with Emergency Rocket Communications System (ERCS) transmitters rather than warheads.
15 DOD, FY 1981 RDA, p. 13-14.
16 JCS, FY 1984, p. 15.
17 Colin S. Gray, op. cit.
18 The UN Secretary General ("General and Complete Disarmament," A/35/392, 12 September 1980); AW&ST, 16 June 1980, p. 178; Paul H. Nitze, op. cit., assume a CEP of 0.2 nm; John Collins, op. cit., assumes a CEP of 0.34 nm; Colin Gray, op. cit., assumes 0.3 nm.
19 Annual MINUTEMAN/TITAN operations cost, including military personnel: SASC, FY 1982 DOD, Part 7, p. 4092.
20 Ibid., p. 4337.
21 An additional 48 missiles were procured during R&D.
22 SAC, FY 1981 DOD, Part 5, p. 1522.
23 SASC, FY 1981 DOD, Part 2, p. 508.

MINUTEMAN III (LGM-30G)

Figure 5.4 MINUTEMAN III (LGM-30G) missile in silo.

DESCRIPTION: Air Force three-stage, solid fuel MIRVed ICBM with improved rocket motor, new reentry system and new guidance.

CONTRACTORS:
Boeing Aerospace Co.
Seattle, WA; Ogden UT
(prime, assembly and test)
General Electric
Philadelphia, PA
(reentry vehicle)
GTE Sylvania
Needham Heights, MA
(ground electronics)
Autonetics Division,
Rockwell International
Anaheim, CA
(guidance)
Aerojet General
Sacramento, CA
(2 stage propulsion)
Thiokol Chemical Corp.
Brigham City, UT
(1 and 3 stage propulsion)
TRW Systems
Redondo Beach, CA
(technical direction)
Bell Aerospace Textron
Buffalo, NY
(post boost RV control)

SPECIFICATIONS: (same as Minuteman II except for third stage)

Length: 59 ft 11 in (718.8 in)[1]

Diameter:
Stage I: 66 in
Stage II: 52 in
Stage III: 52 in

Stages: 3

Weight at Launch: 77,900 lb; 76,000 lb[2]

Propulsion: three solid propellant rocket engines plus post boost system

Speed: 15,000+mph; 24,000+km/h at burn-out (Mach 19.7)

Guidance: all inertial gimballed, improved NS-20 (INS-20) has been deployed on all 550 MM IIIs.[3]

Throwweight/Payload: 2400 lb,[4] 1500-2000 lb,[5] 1975 lb,[6] 2000 lb;[7] 2300 lb[8]

Range:[9] 8000 nm,[10] 6950 nm[11]

Ceiling: about 700 mi

DUAL CAPABLE: no

NUCLEAR WARHEADS: 2 or 3 MIRV/missile;[12] missile carries W62/Mk-12 warhead with 170 Kt or W78/Mk-12A warhead with 335-350 Kt

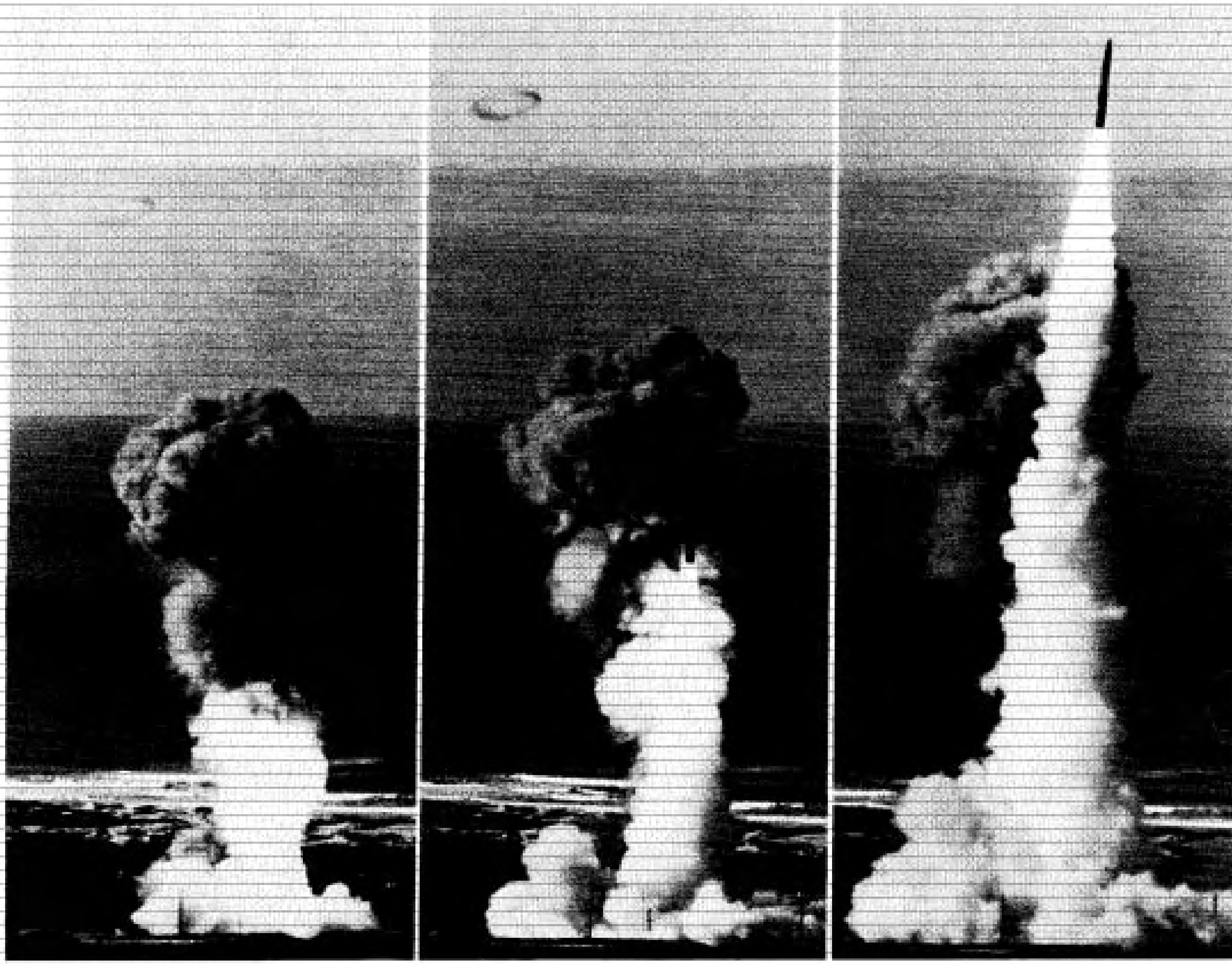

Figure 5.5 MINUTEMAN III launch sequence from Vandenburg Air Force Base, California.

DEPLOYMENT:

Launch Platform: fixed 25+ m underground hardened silo with missile suspension, shock isolated floor, debris collection system and EMP protection; silo upgrade program to protect launch facilities completed in January 1980[13]

Silo Hardening: approximately 2000 psi[14]

Number Deployed: 550 (250 with Mk-12, 300 with Mk-12A) missiles active (1983); 867 missile production deliveries, 152 flight tests[15]

5

MINUTEMAN III

Location:

Wing	Base	Missiles
I/ 341 SMW	Malmstrom AFB, MT	50
III/ 91 SMW	Minot AFB, ND	150
V/ 90 SMW	F.E. Warren AFB, WY	200
VI/321 SMW	Grand Forks AFB, ND	150

A number of silos at Vandenburg AFB, CA can also be used to launch missiles in the event of war.[16]

HISTORY:

IOC: Jun 1970 (see Table 5.13 for MINUTEMAN chronology)

1980-1983: W62/Mk-12 RVs on 300 MM IIIs replaced by W78/Mk-12A[17]

1983-1985: Fifty MM II at Malmstrom replaced with MM III[18]

TARGETING:

Types:

Mk-12A: hardened target system across the entire spectrum

Mk-12: hard targets

Selection Capability: three target selection capability in missile computer, one for each set of MIRVs, one set designated default primary

Retargeting: Command Data Buffer allows infinite retargeting of missiles in 25 minutes and retargeting of the entire force in 10 hours.

Accuracy/CEP: 0.12 nm (Mk-12A);[19] 600 ft;[20] 0.12 nm (Mk-12);[21] 900-1000 ft (INS-20)[22]

Table 5.13
MINUTEMAN Chronology

Oct 1958	Boeing chosen as MINUTEMAN missile contractor
Feb 1961	First MINUTEMAN prototype launch
Apr 1962	First production MM I completed
Oct 1962	First MM I goes on alert
Dec 1962	IOC of MM I (20 missiles)
Feb 1963	First complete operational MM I squadron active at Malmstrom AFB, MT
Sep 1964	First flight test of MM II
Oct 1965	First MM II deployed in underground silos
Feb 1966	First salvo firing of MM from Vandenburg AFB, CA
1966	Development of MM III begins
Apr 1967	450th MM II deployed, and 1000th MM goes on strategic alert
Aug 1968	First flight test of MM III
Dec 1970	First squadron of MM III active at Minot, ND
Mar 1973	MM II completes replacement of MM I
Feb 1975	Command Data Buffer/Upgrade Silo Modification completed at first MM III base
Jul 1975	Last MM III deployed at Malmstrom AFB, MT
Jul 1976	MM III tested with INS-20 guidance
Sep 1976	Guidance improvement/software modification completed at all MM III wings
Nov 1978	Production of MM III completed
Jul 1979	IOC of INS-20 guidance on MM III
Jan 1980	Silo Upgrade Program completed
1983-1984	50 MM III replace 50 MM II at Malmstrom

COST:

Unit Cost:	$4.622 m (FY 1976) (flyaway)
	$7.875 m (program costs)
	$4.842 m (FY 1977) (flyaway)
Annual Operations:	$330 m (FY 1980)[23]
	$345 m (FY 1982)[24]

FY	Number Procured	Total Appropriation ($ million)
1979 & prior	794[25]	12,800.0[26]
1981 & prior	794	12,586.2[27]
1980	-	144.5
1981	-	196.0
1982	-	185.7

COMMENTS: Airborne Launch Control System (ALCS) provides a backup launch control capability to underground launch control centers for 200 of 550 MM IIIs.[28] The Mk-12 reentry vehicle has the capability to carry chaff.[29]

1 The World's *Missile Systems*, 6th Ed., p. 288.
2 *Ibid.*
3 ACDA, FY 1982 ACIS, p. 3; ACDA, FY 1983 ACIS, p. 3. The improved software is "predicted" to improve operational accuracy but more tests are required to confirm estimates.
4 2400 lb for 3 reentry vehicles. General Accounting Office, "The MX Weapon System: Issues and Challenges," 17 February 1981, p. 34.
5 GAO, op. cit., p. 88.
6 John Collins, op. cit., p. 446.
7 Colin S. Gray, op. cit., p. 132.
8 Heritage Foundation, *SALT Handbook*, p. 78.
9 Range is for MM III/Mk-12; missiles with Mk-12A RVs are heavier and thus have a shorter range; HAC, FY 1980 DOD, Part 2, p. 490.
10 John Collins, op. cit., p. 446; The World's Missile Systems, 6th Ed., p. 288.
11 The World's *Missile Systems*, 6th Ed., p. 289.
12 Three RVs per missile is the nominal loading. Some may be deployed with less; DOD, FY 1981 RDA, p. 11-14; SAC, FY 1980 DOD, Part 1, p. 1407; SAC, FY 1981 DOD, Part 5, p. 1522; payload varies for mission; ACDA, FY 1979 ACIS, p. 1; it is technically possible to use seven RVs on MM III, and this has been demonstrated; SASC, FY 1980 DOD, Part 1, p. 389.
13 ACDA, FY 1983 ACIS, p. 3.
14 HAC, FY 1982 DOD, Part 9, p. 112.
15 AW&ST, 19 April 1982, p. 85.
16 *Air Force Times*, 28 July 1980.
17 AW&ST, 9 March 1981, p. 25. Current plans, however, do not call for the Mk-12A to be deployed on the remaining 250 MM III missiles; ACDA, FY 1983 ACIS, p. 3. SAC has asked the USAF to continue production of Mk-12A beyond FY 1982 and to deploy W78/Mk-12A on at least 200 of the remaining 250 MINUTEMAN IIIs.
18 Fifty MM II missiles at Malmstrom AFB, Montana, will be replaced with MM IIIs starting in FY 1983, thus adding 100 warheads; JCS, FY 1983, p. 72; SASC, FY 1983 DOD, Part 7, p. 4159.
19 Paul H. Nitze, op. cit., and AW&ST, 16 June 1980, p. 176. The UN Secretary General, op. cit., assumed a CEP of 300 m for both the MINUTEMAN III Mk-12 (initial deployment-1970) and the MINUTEMAN III Mk-12A (initial deployment-1979); NS-20 guidance estimated to be .15 nm with Mk-12; see also Colin S. Gray, op. cit., p. 59, fn. 6.
20 *Military Balance*, 1980-81, p. 3.
21 Paul H. Nitze, op. cit.
22 AW&ST, 22 March 1982, p. 18.
23 Annual MINUTEMAN/TITAN operating cost including military personnel; SASC, FY 1982 DOD, Part 7, pp. 3992, 4002.
24 SASC, FY 1982 DOD, Part 7, p. 4337.
25 An additional 44 missiles were procured for R&D; *U.S. Missile Data Book*, 1980, 4th Ed., p. 2-52.
26 Prior to FY 1981, $12.8 billion had been appropriated for procurement of MINUTEMAN ICBMs and spares; ACDA, FY 1982 ACIS, p. 4-5.
27 "Minuteman Squadrons"; ACDA, FY 1983 ACIS, p. 11.
28 ACDA, FY 1982 ACIS, pp. 2, 4.
29 SAC, FY 1980 DOD, Part 1, p. 1407.

PEACEKEEPER/MX Missile System

The PEACEKEEPER/MX missile is a completely new weapon system under development incorporating advanced components and technology in its missile booster, guidance control system, post boost vehicle, reentry system, and warhead. The guidance system improvements, larger post boost vehicle (more warheads), new warhead design,[1] and greater range and accuracy make the MX a significant improvement over the present MINUTEMAN III.

The MX program formally began in 1971 and entered advanced development in 1974. Initially, there was considerable study of basing modes, concentrating on "multiple aim point systems" where each missile would have a large number of launching points (see MX Basing). Although a large missile was quickly chosen to maximize payload capability, the program became bogged down in political controversy surrounding the kind of basing mode, environmental concerns, arms control implications, and cost.

The Reagan Strategic Program, announced in October 1981, determined that MX development would continue and that at least 100 operational missiles would be deployed.[2] Forty MX missiles are to be deployed initially in converted MINUTEMAN silos, even though a plan to "superharden" them to 5000 psi strength was cancelled.[3] Full-scale engineering development contracts for all components of the missile were concluded by FY 1982, and MX development is reportedly on schedule. The first flight test is scheduled for 1983, a full scale production decision is projected for mid-1983, and an IOC is planned for late 1986.

The Strategic Program also presented a number of basing options in place of multiple protective structures and other mobile land-based options. On 22 November 1982, the DOD announced selection of a "closely spaced basing" (CSB) or "dense pack" mode, which would involve placing 100 MX missiles in "vertical shelters" so as to avoid a calculated single attack to destroy all the missiles. Congress, however, decided in December 1982 to restrict expenditure of MX funds until a permanent basing mode was approved, and asked the President to submit a report on MX alternatives. The President then established a Commission on Strategic Forces to examine such alternatives. The Commission was guided in part by the DOD's requirement to deploy a missile in a basing mode or combination of modes "resistant to future Soviet threats resulting from further technological advances in missile accuracy and proliferation of missile warheads."[4]

The Presidential Commission on Strategic Forces reported its recommendations in April 1983:[5]

- immediate deployment of 100 MX missiles in existing MINUTEMAN silos, replacing older MINUTEMAN and TITAN II missiles,
- research to resolve uncertainties regarding silo hardness,
- investigation of different types of land-based vehicles and launchers, including hardened vehicles, and
- engineering design of a new single-warhead ICBM.

1 Before the W87 was chosen, the warheads generally thought to be under consideration for MX were of higher yield than the W78/Mk-12A currently on a portion of the MINUTEMAN force. The W87, however, has a yield approximately equal to the W78.
2 AF/RD, "MX Development and Deployment Plan," 8 February 1982; the previous plan had been to deploy a force of 200 operational missiles.
3 HAC, FY 1982 DOD, Part 9, p. 112.
4 AF/RD, op. cit., p. 2.
5 "Report of the President's Commission on Strategic Forces," April 1983.

MX Missile

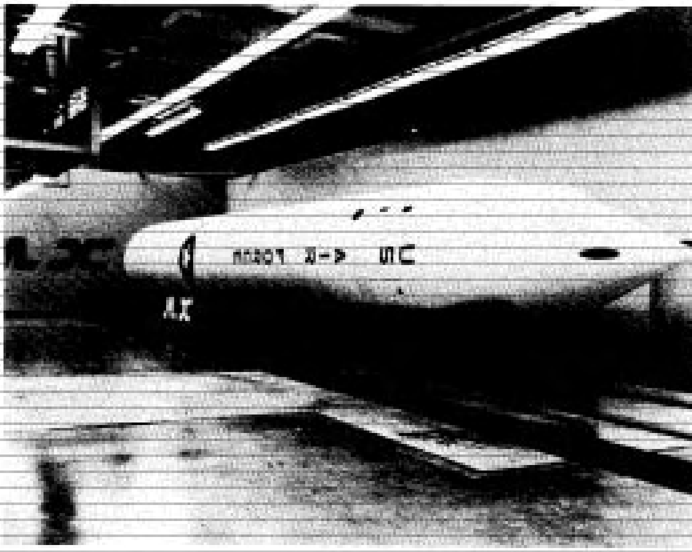

Figure 5.6 Full scale mock-up of **MX** missile.

DESCRIPTION:	Air Force large payload, solid fuel, cold launch,[1] four stage ICBM under development.
PRIME CONTRACTORS:	(see Table 5.15 for list of "associate" prime contractors)
SPECIFICATIONS:	
Length:	71 ft (21.6 m)
Diameter:	92 in (233 cm)
Stages:	4
Weight at Launch:	193,000 lb (87,500 kg)
Fuel:	three solid propellant booster motors, storable liquid hypergolic propellant in the fourth stage, post boost vehicle[2]
Guidance:	inertial floating ball (advanced inertial reference sphere)[3]
Throwweight/ Payload:	7900 lb;[4] 7200 lb[5]
Range:	5800 nm;[6] 7000+ nm (13,000+ km)
DUAL CAPABLE:	No
NUCLEAR WARHEADS:[7]	W87 on the Mk-21 (formerly Advanced Ballistic Reentry Vehicle (ABRV)); 10 MIRV/ missile baseline;[8] there is room for 12 RVs on the MX bus without stacking;[9] 300 Kt range (see W87)
DEPLOYMENT:	(see MX Basing)
Silo Hardening:	circa 2200 psi
Number Planned:	226 missiles for 100 MX system; 339 missiles for 200 MX system[10]
HISTORY:[11]	
IOC:	December 1986[12] (see Table 5.16, MX Chronology)
TARGETING:	
Types:	all hardened targets, including "superhard" control centers; W87 allows targeting of "fourth generation ICBM silos" and "very hard leadership bunkers."[13]
Selection Capability:	five fuzing modes remotely selectable via targeting instructions[14]
Retargeting:	"automatic retargeting" capability including a capability to "reprogram target information to compensate for missiles that malfunction or are destroyed by an enemy attack"[15]
Accuracy/CEP:	less than 400 ft[16]

Table 5.14

MX Missile System Costs

System Costs ($ billion):

Total Acquisition:	**GAO (78)**[1]	**DOD (82) (FY 78 BY)**[2]	**(TY)**[3]	**ACDA (83)**[4]	**DOD (83)**[5] **(FY 82)**
Development:	6.8	6.7	10.6	4.3	9.8
Procurement:	13.0	12.9	26.3	-	8.6
Construction:	9.5[6]	9.0	19.1	.1	.9
Operations (to 2000):	4.9	-	-	-	-
TOTAL:	34.2	28.6	56.0	4.4	19.3

Annual Cost:

FY	**Number Procured**	**Total Appropriation ($ million)**
(1977 & prior)	-	159.4[7]
(1978 & prior)	-	293.8[8]
1980	-	732.4
(1981 & prior)	-	2451.6[9]
1981	-	1605.1
1982	-	1994.1[10]
1983	(5)	4773.6[11]
1984	27	6636.3[12]

Annual Operations Cost: 448.0 million[13]

The Air Force has consistently claimed that the MX system will cost no more than $33-34 billion, including 200 missiles in the MPS basing mode to the year 2000, omitting operations and maintenance costs; a number of other sources, however, estimated MX costs for the same system at $55.6 billion, including operations and maintenance through the year 2000.[14] Some unofficial estimates are more than twice this amount.

New Reagan Administration figures for a 200 MX (100 operational) system are approximately $27 billion.[15] However, since silo basing is itself $19.3 billion, and the additional DOD quoted costs of long term basing is $10-30 billion, system costs appear $30-50 billion. Since most previous estimates have been based upon a particular basing mode, comparison with other estimates is impossible.

1 GAO, "The MX Weapon System: Issues and Challenges," 17 February 1981, p. 4. These costs exclude the DOE costs to develop, acquire, and maintain warheads for MX, and impact assistance funds to the areas where MX will be deployed.
2 SASC, FY 1982 DOD, Part 7, p. 3870.
3 *Ibid.*
4 Sunk Costs; ACDA, FY 1983 ACIS, p. 12.
5 This estimate includes 100 operational missiles and silo basing costs of 40 MX in MINUTEMAN silos.
6 MPS basing mode.
7 ACDA, FY 1979 ACIS, p. 15.
8 SASC, FY 1980 DOD, Part 5, p. 2486.
9 Sunk Costs: ACDA, FY 1983 ACIS, p. 12.
10 *Ibid.*
11 *Ibid.*
12 DOD, FY 1984 Annual Report, p. 221.
13 200 missiles in 4600 MPS system, ACDA, FY 1981 ACIS, p. 15.
14 See Council on Economic Priorities, *Misguided Expenditure: An Analysis of the Proposed MX Missile System* (NY, 1981), pp. 115-126; and GAO, "The MX Weapon System—A Program with Cost and Schedule Uncertainties," 29 February 1980.
15 AW&ST, 12 October 1981, p. 18.

COST: (See Table 5.14)

Missile Costs Only: 226 missiles (FY 1982): $4700 m
339 missiles (FY 1982): $6900 m[17]

1 AF/RD, op. cit.: The missile is initially boosted from its protective storage cannister by pressure created by gas generators. As the missile clears the cannister, the first stage main engines ignite, beginning the powered flight phase.
2 DOD, FY 1981 RDA, p. VI-3; SASC, FY 1982 DOD, Part 7, p. 3945.
3 Floating ball suspended in a fluid, less than a foot in diameter; SASC, FY 1982 DOD, Part 7, p. 3951. AIRS provides the flight computer with information on missile movement during flight.
4 SASC, FY 1981 DOD, Part 2, p. 539; GAO indicates 7000 lb for 10 reentry vehicles (Mk-12A); GAO, "The MX Weapon System: Issues and Challenges," 17 February 1981, pp. 18, 34.
5 Heritage Foundation, *SALT Handbook*, p. 75.
6 SASC, FY 1982 DOD, Part 7, p. 4004.
7 The W78/Mk-12A Warhead/RV was the baseline warhead for the MX until January 1982 when the W87/ABRV was chosen; ACDA, FY 1983 ACIS, p. 6.
8 ACDA, FY 1982 ACIS, p. 16.
9 AF/RD, op. cit., p. 7; SASC, FY 1983 DOD, Part 7, p. 4496, states that 12 ABRV warheads is possible "without significant performance limitations."
10 DOD News Release, 31 December 1981; HAC, FY 1982 DOD, Part 8, p. 264.
11 Air Force Systems Command, "Brief Facts About M-X," Andrews Air Force Base, MD.
12 Original IOC was July 1986. HAC, FY 1982 DOD, Part 2, p. 228; new IOC of Dec 1986 occurred during Reagan Administration.
13 SASC, FY 1983 DOD, Part 7, p. 4173.
14 AVCO Systems Division, "Advanced Ballistic Reentry Vehicle," Fact Sheet, n.d. (circa 1981).
15 AF/RD, op. cit., p. 8.
16 AW&ST, 22 March 1982, p. 18.
17 HAC, FY 1982 DOD, Part 9, p. 284.

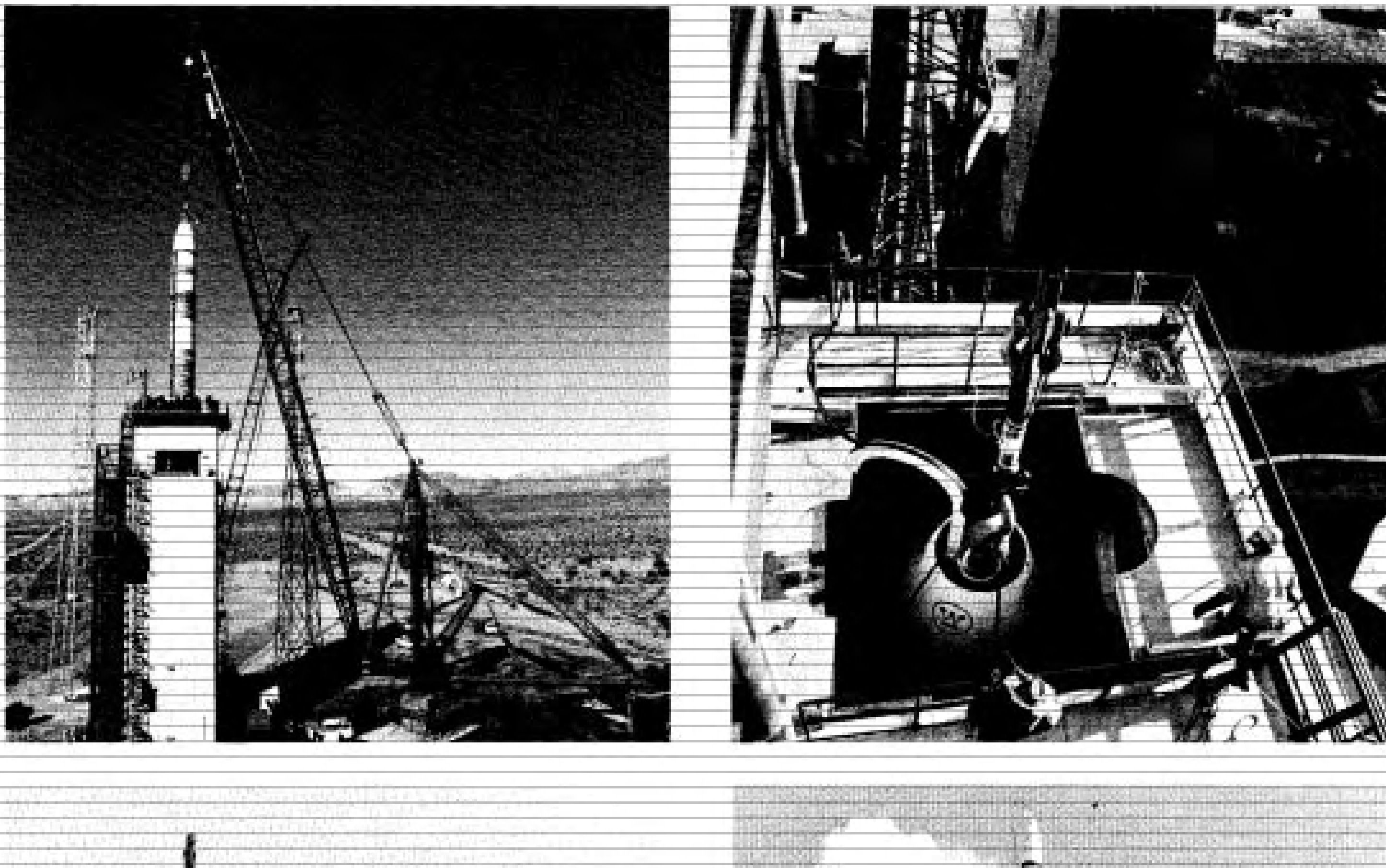

Figure 5.7 MX prototype vehicle launch validation test at Mercury, Nevada, November 1982. MX missile loaded into cannister [top left]; completion of loading phase [top right]; MX ejected from cannister in "cold launch" method [bottom left]; prototype missile clearing cannister in flight [bottom right].

Table 5.15

Major MX Contractors*

Company	Location	Component
Aerojet Strategic Propulsion Co.	Sacramento, CA	propulsion, Stage II
Avco Corp., Systems Division	Wilmington, MA	reentry vehicle
Boeing Aerospace Co.	Seattle, WA; Las Vegas, NV	transporter; basing
Charles Stark Draper Laboratory, Inc.	Cambridge, MA	technical support for guidance and control
Dynamics Research Corp.	Wilmington, MA	inertial measurement study
Economics Technology Assoc.	Los Angeles, CA	system development
Ertech Western	Long Beach, CA	siting studies
Fugro National	Long Beach, CA	siting
General Electric Co.	Philadelphia, PA	reentry vehicle backup
GTE Sylvania, Inc., Strategic Division	Needham Heights, MA; Westboro, MA	command and control
Henningson, Durham and Richardson	Santa Barbara, CA	environmental studies
Hercules, Inc., Aerospace Div.	Magna and Bacchus, UT	stage III
Honeywell, Inc., Avionics Div.	St. Petersburg, FL; Clearwater, FL;	guidance and control
Logicon, Inc.	San Pedro, CA	targeting
Martin Marietta Corp.	Denver, CO	assembly, test and support, cannister
Northrop Corp., Electronics Division	Hawthorne, CA	AIRS, inertial measured unit
Physics International	San Leandro, CA	engineering support
Northrop Corporation Precision Products Division	Norwood, MA	gyro
Ralph M. Parsons Co.	Pasadena, CA	basing
Person, Brinkerhoff, Quade & Douglas	New York, NY	design hardened protective structure
Rockwell International, Autonetics Division	Anaheim, CA	flight computer, guidance
Rocketdyne Division	Canoga Park, CA	stage IV
Sandia Corporation	Albuquerque, NM	arming and fuzing system
Science Applications	San Diego, CA	analysis support, development study
SofTech, Inc.	Waltham, MA	software compiler
Systems Science & Software	San Diego, CA	nuclear hardness
TASC	Reading, MA	guidance/control study
TRW, Inc.	Redondo Beach, CA	integration and targeting
Thiokol Corp., Wasatch & Elkton Divisions	Brigham City, UT; Elkton, MD	stage I and ordnance
UltraSystems, Inc.	Irvine, CA	logistics support
University of Houston	Houston, TX	maintenance/management study
Westinghouse	Sunnyvale, CA	canister

* Prime contractors as of July 1982, information provided by MX Program Office. Adapted from CEP, *Misguided Expenditures*, op. cit., pp. 173–219, and HAC, FY 1980 DOD, Part 2, pp. 455–456.

MX Warhead and Reentry Vehicle

On 29 January 1982, DOD made a final decision on the MX warhead. DOD chose a new warhead, the W87, to be mated with the new Mk-21 Advanced Ballistic Reentry Vehicle (ABRV).[1] The fourth stage of the MX Missile carries the reentry vehicle "bus" and computer systems which release the W87/Mk-21 RVs in their intricate spacing and deployment maneuvers, allowing them to continue accurately to their targets.

The W87 warhead was originally thought to be of higher yield than the original baseline warhead for the MX, the W78.[2] It has since been revealed that the W87's yield is approximately the same as that of the W78.[3] Two new features of the W87 were important to its selection. First, the W87 uses less fissile material than the W78 through a more efficient design. Second, the yield of the W87 can be increased by changing the mix of fissionable materials.

Two other factors went into choosing the W87/Mk-21 rather than the W78/Mk-12A: the DOD believes (1) that each leg of the Triad in the strategic force should "have at least two [types of] warheads," and (2) that the ABRV is more accurate.[4] In distinguishing the Mk-21 from the Mk-12A, the DOD states that the Mk-21 is "a more militarily effective weapon in the context of accuracy, hardness and overall military efficiency."[5]

Two other higher yield nuclear warhead designs were earlier considered for MX, but were rejected: the 500-600 Kt CALMENDRO and the 800 Kt MUNSTER.[6] The CALMENDRO was developed at LANL, was moved to LLNL[7] where it entered Phase 3 (Development Engineering) in FY 1982,[8] and was reportedly favored to replace the W78. However, both of these high yield variants were dropped from consideration and development then focused on the W87/Mk-21. The W87 is expected to be ready in time for a 1986 IOC on the first 10 MX missiles.[9]

Table 5.16

MX Chronology

1963	Air Force begins study of the "Improved Capability Missile" (WS120A)
1967	Air Force introduces concept for a mobile land-based missile to be shifted among silos
Nov 1971	SAC forwards requirement for new ICBM
May 1974	Advanced development of MX missile begins
Feb 1975	Secretary of Defense Schlesinger rejects air-mobile concepts for MX in favor of multiple protective shelter and buried trench.
Mar 1976	DSARC I approves large missile with emphasis on trench
Jun 1979	full-scale development of MX missile in MPS basing mode authorized by President Carter
Sep 1979	Presidential decision on horizontal MPS basing and proceeding with full scale development
Oct 1981	Reagan Strategic Program cancelling MPS basing and restructuring of MX program results in delay from July 1986 to late 1986[1]
Jan 1982	W87/ABRV chosen as warhead/RV for MX
Nov 1982	Closely Spaced Basing announced as latest preferred basing mode
Dec 1982	Congress requests report on MX alternatives
early 1983	First flight tests scheduled
Apr 1983	Report recommends MX in silos, with small missile follow-on
Jul 1983	DSARC III
1984	MPS construction slated to start
Dec 1986	Initial operational capability planned[2]
FY 1990	Full operational capability

1 SASC, FY 1983 DOD, Part 7, p. 4484.
2 AF/RD, "MX Development and Deployment Plan," 8 February 1982, p. 6; previous DOD estimates were "mid-1986," see for instance, JCS, FY 1982, p. 70.

1 ACDA, FY 1983 ACIS, p. 7; DOE, FY 1982 Supplemental Request to the Congress, Atomic Energy Defense Activities, March 1982, p. 5.
2 AW&ST, 9 March 1981, p. 51, identified the yields as 500 Kt for the CALMENDRO and 800 Kt for the MUNSTER. New York Times, 10 October 1981, p. 26, later identified the ABRV yield as 600 Kt, but it has also been referred to as 800 Kt in AW&ST, 4 May 1981, p. 51.
3 AW&ST, 9 March 1981, p. 25; AW&ST, 22 March 1982, p. 18.
4 HAC, FY 1982 EWDA, Part 5, pp. 34, 380.
5 SASC, Strategic Force Modernization Programs, pp. 102-103.
6 AF/RD, "MX Development and Deployment Plan," 8 February 1982, p. 7.
7 AW&ST, 22 March 1982, p. 18.
8 HAC, FY 1983 DOD, Part 4, p. 565.
9 New York Times, 10 October 1981, p. 26.

W87

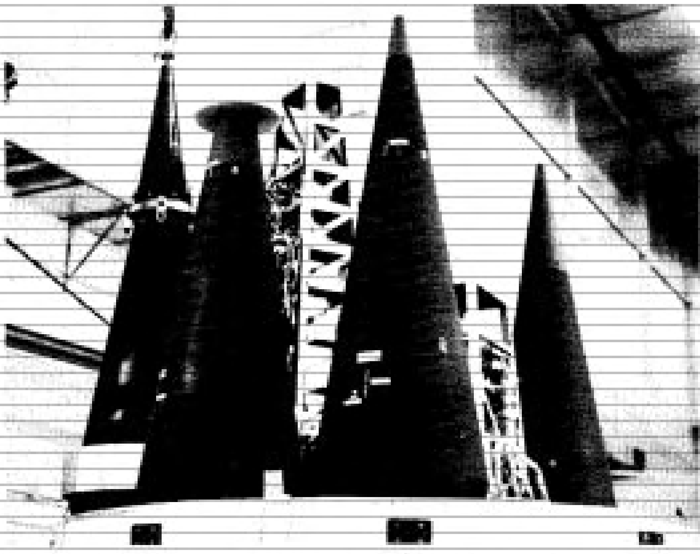

Figure 5.8 MX bus with four Mk-21 reentry vehicles mounted.

FUNCTION: Warhead on the Mk-21 (formerly Advanced Ballistic Reentry Vehicle (ABRV)), for the MX and Mk-5 RV for the TRIDENT II missile.

WARHEAD MODIFICATIONS: none known

SPECIFICATIONS:

Yield: 300 Kt upon deployment for MX,[1] upgradable to 475 Kt[2]

Weight: unknown[3]

Dimensions (Mk-21):

Base Diameter:	21.8 in
Nose Radius:	1.4 in
Overall Length:	68.9 in
Half Angle:	8.2°

Materials: contains oralloy;[5] uses less materials than W78/Mk-12A;[6] has feature to increase yield by adding additional oralloy at later date; contains IHE[7]

SAFEGUARDS AND ARMING FEATURES: primary inertial (interactive) path length fuze with microprocessor immune to jamming;[8] secondary dual mode radar with microprocessor for airburst, surface/proximity fuzing; five modes: high altitude fuze, airburst, low airburst, surface/proximity burst and surfact/contact burst[9]

DEVELOPMENT:

Laboratory: LLNL[10]

History:

IOC:	1986
FY 1983	Lab assignment (Phase 3)
(1986)	initial deployment (Phase 5)

Production Period: 1985-?

DEPLOYMENT:

Number Planned: 1050;[11] 1055[12]

Delivery System: MX missile, possibly TRIDENT II and small missile

Service:	Air Force; possibly Navy
Allied User:	no
Location:	see MX Basing

COMMENTS: Additional program cost of larger warhead over previously planned W78/Mk-12A was estimated at $1.2 billion (in FY 1982 dollars).[13] Given a reduction in cost of fissile materials of some $500 million with the ABRV, the actual additional cost of the ABRV is estimated at $881 million.[14]

1 *AW&ST*, 9 March 1981, p. 29, identified the CALMENDRO, one of the two earlier competing warheads for the ABRV/MX, as having a yield of 600 Kt; *New York Times*, 10 October 1981, p. 36, identified the ABRV yield as 600 Kt; *AW&ST*, 22 March 1982, p. 18, identified the chosen warhead as 300 Kt.
2 *AW&ST*, 17 January 1983, p. 26.
3 The Mk-21/W87 is heavier than the Mk-12A, but the Air Force states that this will not affect its operational requirements: SASC, FY 1983 DOD, Part 7, p. 4174.
4 AVCO Systems Division, "Advanced Ballistic Reentry Vehicle," Fact Sheet, n.d. (circa 1981).
5 *AW&ST*, 22 March 1982, p. 19; HAC, FY 1980 DOD, Part 4, p. 597.
6 SASC, FY 1980 DOD, Part 5, p. 2496.
7 SASC, *Strategic Force Modernization Programs*, p. 100; SASC, FY 1983 DOD, Part 7, p. 4179.
8 SASC, FY 1983 DOD, Part 7, p. 4179.
9 AVCO Systems Division, op. cit.
10 The CALMENDRO warhead was developed at LANL but tested and engineered at LLNL. The MUNSTER warhead was developed at LANL.
11 SASC, FY 1983 DOD, Part 7, p. 4467.
12 SAC, FY 1983 DOD, Part 2, p. 84.
13 SASC, FY 1982 DOD, Part 7, p. 4006.
14 SASC, FY 1983 DOD, Part 7, p. 4467.

MX Basing

Since 1965, the Air Force has studied over forty different options (see Table 5.17) for mobile basing of an advanced ICBM. Options have included trains, trucks, air cushion vehicles, and aircraft, as well as deployment in waterways, in proliferated shelters, or underground buried trenches.

Although basing proposals over the years have varied widely, they have essentially included four major kinds:

- Land Basing: including "multiple protective shelters," either mobile or semi-fixed; silo basing, with and without BMD adjunct; road or off-road mobile,
- Air Mobile,
- Sea Basing: SUM, surface ship or TRIDENT II, and
- Defense: BMD of existing silo, launch under attack, defense of MPS.

The Reagan Administration has found it as difficult as previous Administrations to choose an acceptable basing mode for the new MX missile. In October 1981 it cancelled the Multiple Protective Shelter (MPS) basing scheme chosen by the Carter Administration and announced that initial deployment would be in 40 MIN-

Table 5.17

MX Basing Options[1]

Covered Trench	Unmanned TELs traveling randomly in trench covered with camouflage.	Hard Rock Silo/Deep Underground	Silo launchers built in granite outcroppings in SW United States.
Hybrid Trench	Unmanned TELs in shallow buried tunnels with hardened firing points.	Hard Tunnel	Missile stored in very deep hardened tunnels able to withstand direct hit and then digout on launch command.
Dash to Shelter	TELs at center of radial road or rail network, dashing to hardened shelters on warning.	Launch Under Attack	ICBM force capable of launch from early warning.
Pool	Transporters deposit water-tight encapsulated missiles in opaque water pools, serving as shelters.	Shallow Underwater Missile	Encapsulated missiles fastened to small submarines patrolling off US coast.
Sandy Silo	Buried encapsulated missiles in 2000 ft deep holes covered with sand. Pressurized water would fluidize the sand and capsules would float to surface for launch.	HYDRA	Waterproof missiles anchored to offshore sea bed.
		ORCA	Encapsulated missiles anchored to offshore sea bed.
		Ship Ocean	Missiles on special ships moving in oceans.
Dedicated Rail	Randomly moving unmanned nuclear hardened trains carrying missiles on grid network.	Road Mobile MX/MINUTEMAN	Truck launched missiles dispersed on warning.
Public Railroads	Missiles on special cars randomly moving on public railroads.	MINUTEMAN MPS	Expand MM fields by adding new silos.
Off-Road Mobile	Fleet of off-road mobile TELs scattered over uninhabited areas of SW United States.	BMD	Deploy ABMs in MX or MINUTEMAN fields.
Wide Body Jet	Ground alert missile launching 747 or C-5 class air craft.	Mesa Basing	Horizontal tunnels on south side of mesas.
Short Takeoff and Landing	Ground alert missile launching STOLs, possible with network of new small airfields.	Grasshopper	VTOL aircraft with new small missile.
		Great Lakes	Small submarines or barges in Great Lakes or inland waterways.

1 HAC, FY 1982 DOD, Part 2, pp. 254-255; SASC, FY 1982 DOD, Part 5, pp. 3745-3747; DOD, "ICBM Basing Options: A Summary of Major Studies to Define a Survivable Basing Concept for ICBMs," December 1980.

Figure 5.9 One-eighth scale MX silo test model after being subjected to a large TNT blast.

UTEMAN silos.[1] The silos, however, would not be further hardened although the option of increased hardening remained available.[2] Four alternatives for long-term basing of MX were introduced:

- Deep Basing: deployment in survivable locations deep underground,
- Continuous Patrol Aircraft: deployment aboard long-endurance aircraft that could launch MX,
- Ballistic Missile Defense: active defense of missiles in present ICBM silos, and
- Deceptive Basing: deceptive basing with Ballistic Missile Defenses.

The decision on a long-term basing mode was originally required by 1 December 1982, as directed by Congress.[3]

Following the 22 November 1982 decision by DOD to deploy MX in a Closely Spaced Basing configuration near F.E. Warren AFB, Cheyenne, Wyoming, Congress requested that the Administration reexamine MX deployment and alternatives. The Presidential Commission on Strategic Forces, which was formed in response to Congress, made the following recommendations relevant to MX basing in April 1983:[4]

- Putting the MX missile into production while scaling down, at least initially, the original deployment plan to 100 missiles,
- Deploying 100 MX missiles in underground silos now used for older MINUTEMAN missiles. This option would allow the first MX missiles to be fielded roughly one year earlier than with any mobile basing,
- Accelerating research, development and testing—although not necessarily deployment—of an antiballistic missile (ABM) defense system,
- Beginning engineering design of a missile smaller and lighter than MX that could be produced in large numbers in the early 1990s, be mobile or fixed, and be relatively invulnerable (see Small Missile),
- Accelerating development of the advanced (D5) version of the submarine-based TRIDENT missile, and

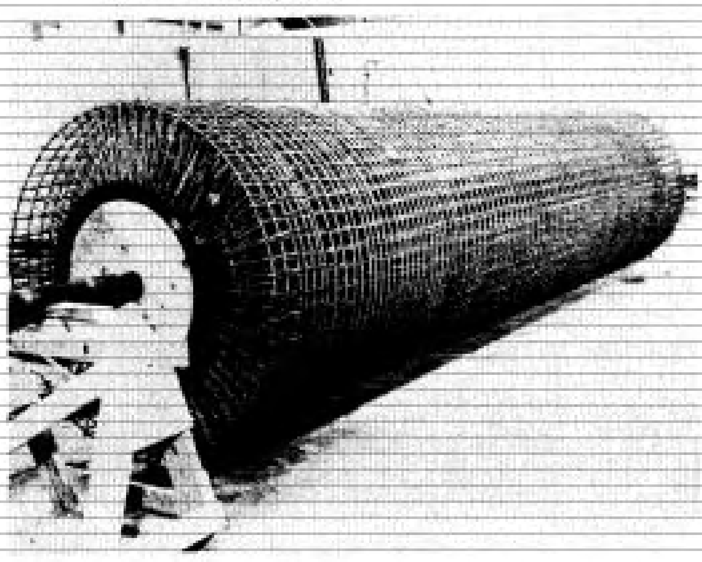

Figure 5.10 Reinforcing steel bar skeleton used in the MX silo model test.

1 The MX, by design, has always been compatible with silo basing but Congress specified in the FY 1977 authorization bill that none of the program's funds be spent on silo basing: ACDA, FY 1979 ACIS, p. 12.
2 AW&ST, 11 January 1982, p. 20; AF/RD, op. cit., p. 9.
3 HAC, FY 1983 DOD, Part 9, p. 723.
4 "Report of the President's Commission on Strategic Forces," April 1983. These were essentially the options discussed much earlier in the Administration: see, for instance, Michael Getler and Lou Cannon, *Washington Post*, 7 June 1981, pp. A1, A16.

- Examining uncertainties regarding silo or shelter hardness and different types of land-based vehicles and launchers, for later possibility of shifting MX or deploying small missiles.

Multiple Protective Structure (MPS) Basing

In August 1979, President Carter announced the selection of a "race track" basing mode, involving 200 tracks of about 25 miles circumference, each equipped with 23 shelters and one MX missile. The missile, its capsule, and a transporter-erector-launcher (TEL) would be docked at one of the horizontal shelters, under cover of a "shield vehicle" which would visit each of the shelters in turn. The shield vehicle would contain either the TEL or a decoy simulator, so that electronic surveillance or observation would not enable one to determine which shelter contained the missile. One option was for the TEL to have the ability to move on warning. Thus, if warned of an ICBM launch against the MX complex, some or all of the 200 TELs would race from the shelters where they had been hidden to other shelters. The shelters would be clustered in valleys in Utah and Nevada. The Air Force favored a variation of this basing mode which called for 200 MX missiles to be shuttled at random among the 4600 shelters spaced out over 5000 square miles. Testimony by U.S. Secretary of Defense Brown and by others emphasized that the capability to move on warning would avoid any vulnerability which might arise if the location of the missiles became known.

Figure 5.11 MINUTEMAN I (LGM-30B) missile launched from a C-5A transport during 1974 test of air-launched ICBM concept.

DOD believed MX could remain survivable against 10,000 RVs.[5]

Critics argue that if the basing mode were limited to 4600 shelters, the Soviet Union, in the absence of SALT II constraints, could have sufficient warheads to defeat this system. Estimates of the required expenditure for this system range from $30-60 billion and more, of which only about $5 billion was for procurement of the missiles themselves.

Deep Basing

Deep Basing (DB) includes several possibilities for deployment, ranging from deep underground silo tunnels for individual missiles to underground "citadels" for several missiles. The greatest asset of this basing mode is that missiles at great depth can survive a nuclear attack.

Although many DB systems have been described, perhaps the best known is the Mesa Concept. This is a system of interconnected deep tunnels 2000 to 3000 feet below the surface of a mesa or similar geological formation that would provide attenuation of weapons effects. Stored within the complex would be the MX missiles and all the necessary equipment, communications, and personnel to operate and maintain them for post-attack "dig-out." Such a system could supposedly provide a secure survivable reserve force.

The primary operational problem seen with deep-based MX was poor reaction time, which would make it available only for launch after an attack. A system with predug portals could provide quick-response capability, but survival of the portals would be difficult to achieve. "Dig-out" capability would increase survivability, but at the sacrifice of quick response. Other significant problems were arms control verification, environmental impact, and cost.

Continuous Patrol Aircraft

The "Continuous Patrol Aircraft" (CPA) concept called for deployment of MX on large, "long-loiter-time," fuel-efficient aircraft. A portion of the MX force would be constantly aloft, with another portion maintained on alert at ground bases. During brief periods of high alert, more aircraft could be kept aloft where they could survive for limited periods of time.

Survivability under this concept would derive from the difficulty in attacking the airborne portion of the MX force. The precise location of CPAs would be kept secret and many would be expected to survive any preemptive

5. AW&ST, 4 May 1981, p. 49.

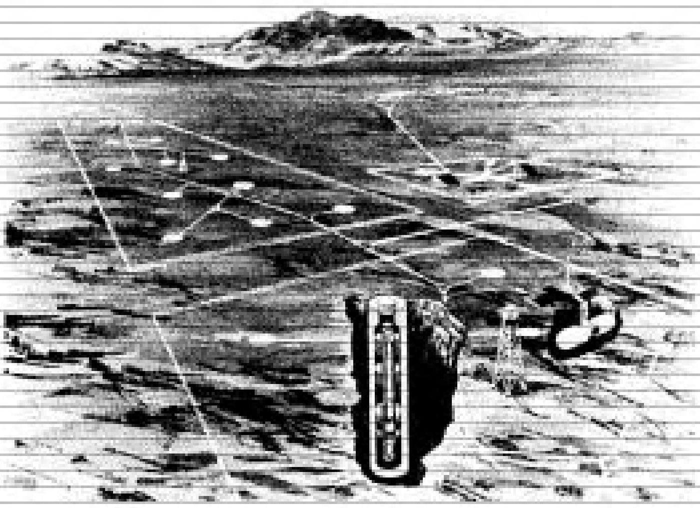

Figure 5.12 Artist's concept of **Closely Spaced Basing** for MX missile.

strike. The primary problem, however, is that CPA would be vulnerable to destruction on the ground by the same means that currently are claimed to threaten U.S. strategic bombers and missile submarines in port.

Ballistic Missile Defense

The feasibility and benefits of a "Ballistic Missile Defense" (BMD)—the concept of actively defending deployed missiles with anti-missile missiles—is being closely examined by DOD. The concept is claimed to be attractive because of technological advances that have been made since deployment of the first ABM system in the early 1970s. Design and development work is presently being focused upon BMD approaches that are compatible with MX basing in silos (the initial 100 plus small missiles and others that could be added in the future), as well as defended deceptive basing of MX or small missiles in some yet to be determined mode. Since silo emplacement is the basing mode for MX, the BMD program is oriented toward plans to increase silo hardness, extend post-attack endurance, and integrate a viable command and control capability concurrent with BMD/silo deployment.

The initial BMD system capability is in the form of a low altitude defense system (LoADs) (called SENTRY) that has for several years been undergoing advanced development for potential use with a variety of MX basing concepts. This system could be used alone or in conjunction with a high-altitude system to enhance the survivability of MX and other ICBMs. The effectiveness of this type of BMD system would be multiplied if deceptive basing of MX missiles would be employed. Then a relatively small number of hardened silo locations would need to be defended by BMD interceptors.

If the BMD option is selected, modifications to the ABM Treaty would be required. The treaty places restrictions on BMD deployments. The possibility of changes in the treaty was anticipated in 1972 when it was agreed that a comprehensive joint review of the treaty would occur every five years. Either side also could unilaterally withdraw from the treaty with six months formal notice.

Closely Spaced Basing/Dense Pack[6]

In November 1982, the last of the formal mobile basing modes for MX—Closely Spaced Basing (CSB)—was recommended as the "permanent" mode. CSB is a new basing mode for land-based ICBMs that would compensate for increasing missile accuracy by using hardness and concentration. CSB involves deploying 100 MX missiles in superhard capsules, spaced 1800 feet apart in a column, which would maximize the phenomenon of "fratricide." Hardness would prevent destruction by an airburst, but at the same time concentration would take advantage of the effects of many incoming ground burst warheads to enhance missile survivability. Fratricide would occur when explosions of incoming warheads attacking closely spaced silos would deflect or destroy other warheads and severely affect their accuracy to destroy hardened silos. The distance between capsules would be small enough to create fratricide but would also be great enough (and capsules hard enough) to ensure that multiple capsules could not be destroyed by one warhead.

The technical claims for CSB were widely disputed. While the Air Force has been reported to believe that 50 to 70 percent of the force could survive an attack in CSB, some analysts believe that only a few missiles would survive.

6 DOD, "MX/CSB System," November 1981; CBO, "Contribution of MX to the Strategic Force Modernization Program," n.d. (1982).

Small Missile

The inability to find an acceptable basing mode for the PEACEKEEPER/MX has directed greater attention to the concept of a small, highly dispersed, single warhead, land-based ICBM. The Presidential Commission on Strategic Forces recommended engineering design of a single warhead ICBM, weighing about 15 tons, deployed in either hardened silos or shelters or hardened mobile launchers. The Air Force is now developing conceptual designs for such a missile, which it plans to deploy in the early 1990s.[1] The deployment of thousands of these small missiles in hardened silos or on mobile launchers, which will disperse the targets and increase survival in a nuclear attack, is now receiving widespread support as a follow-on to the MX and MINUTEMAN programs. The increased penetration potential of such a small missile is also advanced in its favor. There are, however, significant arms control implications in developing a system that violates the 2250 strategic launcher limit in SALT II. At least three small ICBM alternatives have been suggested: MIDGETMAN, SICBM, and long-range PERSHING II (designated PERSHING III). Both fixed and mobile (so-called "ARMADILLO") deployments have beem ,suggested.

The "MIDGETMAN" missile was the original small missile proposal. It is about 50 feet long, has a range of 7000 miles, and weighs twenty to thirty thousand pounds. Three to four thousand missiles would be deployed in blast-resistant silos spaced about a mile apart. With a total deployment area of 4500 square miles, the small vertical shelters would be highly survivable. The major negative features of MIDGETMAN are high cost and potential technological problems with guidance.[2]

The Small ICBM (SICBM),[3] an outgrowth of a study by Boeing Aerospace, was also offered as an alternative to MX. Encapsulated in a canister similar to the MX and dormant for up to one year without servicing, the

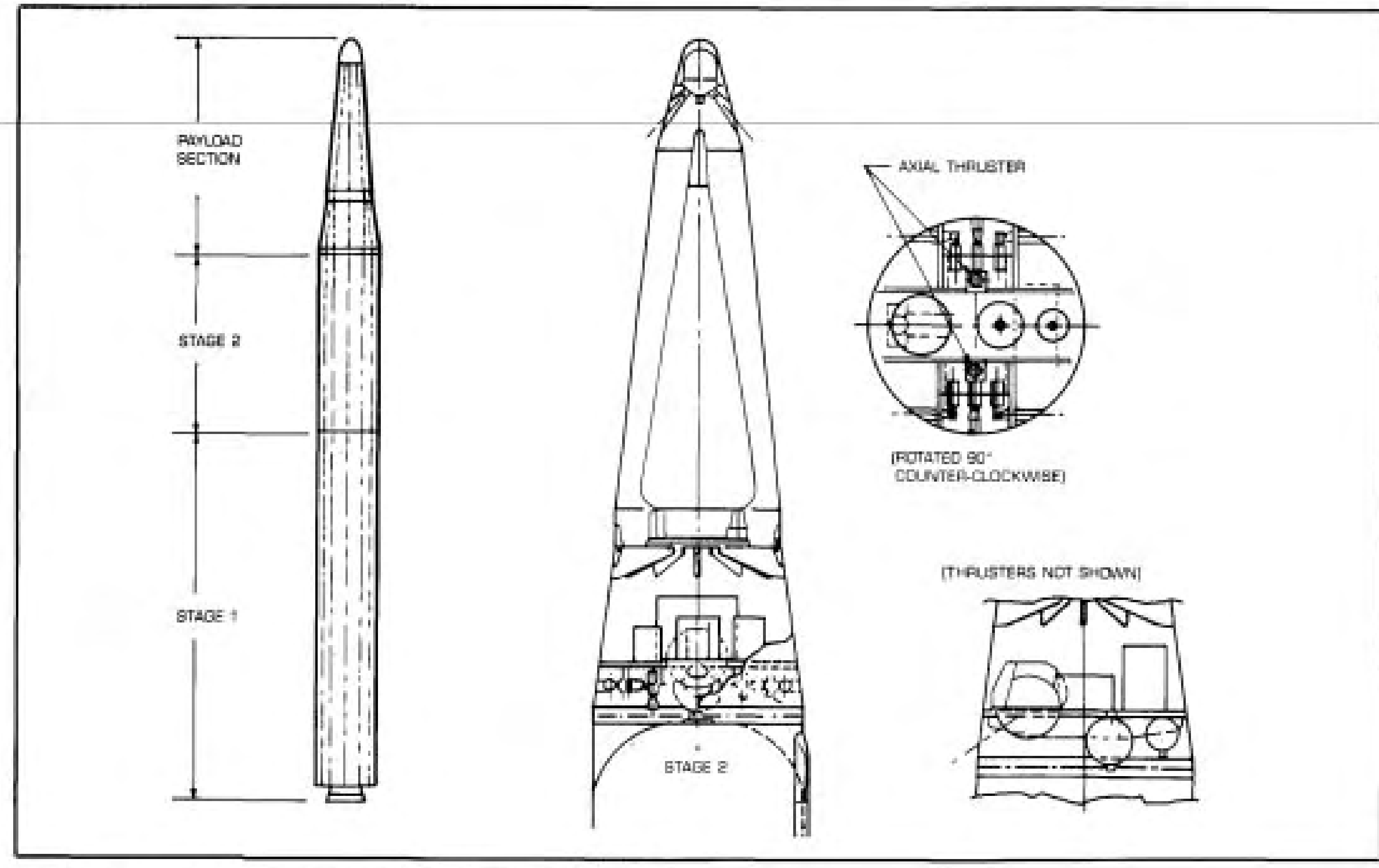

Figure 5.13 Artist's concept of **Small ICBM** prototype.

1. SASC, FY 1983 DOD, Part 7, p. 4500.
2. DOD, "ICBM Basing Options: A Summary of Major Studies to Define a Survivable Basing Concept for ICBMs," December 1980, pp. 42-43.
3. AW&ST, 4 May 1981, pp. 49-51.

SICBM is envisioned as a small, highly survivable, land-based ICBM system. A number of conceptual designs have been suggested, predicated on a 38.2 foot long baseline design weighing 30,410 pounds.[4] These designs include a 37.8 foot missile weighing 28,840 pounds, a 36.6 foot missile weighing 27,280 pounds, and a 35.4 foot missile weighing 23,700 pounds.[5]

The small missile alternative identified in the Presidential Commission report of April 1983 was similar to the SICBM:

- three stage,
- 25,000-35,000 pound (depending on guidance system),
- circa 1000 pound throwweight,
- 38 foot length, 42 inch diameter, and
- CEP 1-1.8 times MX.

The original SICBM proposal was for some 3350 missiles to be deployed in silos on existing military reservations throughout the western U.S. or at MINUTEMAN missile fields. Each canister would be placed initially in a vertical silo hardened to between 7000 and 8000 psi. The silos would be spaced 1500 to 2000 feet apart. Also suggested was road mobile basing, where a SICBM would move on public roads on a TEL. The warheads would either be joined to the missile and be in continuous movement on roads, or the missile would be dispersed from storage prior to launch (Beehive Basing).

A third suggestion for a small missile has been a modification of the PERSHING II missile (designated PERSHING III), with a third (and fourth) stage added for intercontinental range. The Presidential Commission examined an extended range version of the missile with an approximately 8000 mile range.[6] In material submitted with its report, the Presidential Commission identified PERSHING III as follows:

- four stage,
- circa 25,000 pound,
- circa 1000 pound throwweight,
- 43 foot length, 40 inch diameter, and
- CEP 1-1.8 times MX.

Both the PERSHING III and Boeing Small ICBM proposals have been suggested for use in both mobile and fixed deployments. Air and helicopter transportation and launching systems have also been promoted. Two designs have been reported for mobile TEL vehicles for these missiles. Boeing has promoted a tractor and trailer, 60 feet long, 9 feet high, weighing 67,552 pounds, which would carry the missile in its canister on a launch pallet which would be raised into a vertical position for launch.[7] A second concept, reportedly under development by General Dynamics, is "ARMADILLO," a specially armored carrier and launcher for a 38 foot missile. General Dynamics contends that ARMADILLO's thick armored shell, low silhouette, and ability to anchor itself to the ground to strengthen itself against the blast and winds of a nuclear attack will give it a high degree of survivability.[8]

Each of the small missiles would carry one nuclear warhead. Both the W78/Mk-12A and the W87/Mk-21 (ABRV) have been suggested as possibilities. A new 500 Kt warhead, designated the Advanced Mobile ICBM warhead (or possibly the high yield variant of the W87), has also been mentioned.[9] The light weight TRIDENT I C4 W76/Mk-4 has been suggested for the PERSHING III. If the PERSHING II was adapted as a small ICBM, it would need a new warhead because its present warhead (W85) has a low yield. Both small missile alternatives are now given 1992 IOC projections. Boeing claimed in 1981 that its SICBM could begin deployment by the end of 1986 instead of MX,[10] but as of early 1983, it projected a 1989-1990 IOC. Martin Marietta, however, claimed that the use of its PERSHING II would allow deployment by the planned 1986 MX IOC date. The Presidential Commission's support for the concept of a small missile, however, envisioned an "early 1990s" IOC as an augmentation of MX, rather than a replacement.

4 The original SICBM suggested by Boeing in 1981 weighed only 22,000 lb; AW&ST, 4 May 1981, pp. 49-51.
5 Ibid.
6 Walter Pincus and Lou Cannon, Washington Post, 15 February 1983, p. 7.
7 AW&ST, 21 February 1983, p. 14.
8 Leslie H. Gelb, New York Times, 8 February 1983, p. 1.
9 Time, 21 February 1983, p. 18.
10 Walter Pincus, Washington Post, 29 June 1981, pp. A1, A3.

Sea-Based Missile Systems
POSEIDON Submarine

Figure 5.14 U.S.S. *Sam Rayburn* (SSBN-635) with POSEIDON missile hatches open.

DESCRIPTION: New POSEIDON submarine class (616 class), consisting of three classes of converted POLARIS boats, of nuclear powered strategic weapons launchers fitted with 16 tubes for POSEIDON C3 or TRIDENT I C4 submarine-launched ballistic missiles (SLBMs).

CONTRACTORS: Electric Boat Division, General Dynamics Corp.
Groton, CT
(13 submarines)
Mare Island Naval Shipyard
Vallejo, CA
(6 submarines)
Newport News, VA
(10 submarines)
Portsmouth Naval Shipyard
Portsmouth, NH
(2 submarines)
(See Table 5.18 for list of major subcontractors)

SPECIFICATIONS:[1] POLARIS submarines converted to POSEIDON included 3 classes: LAFAYETTE, MADISON and FRANKLIN SSBNs

Length:	425 ft
Diameter:	33 ft
Displacement:	7250 t (surface), 8250 t (submerged)
Draught:	31 ft 6 in
Propulsion:	water-cooled pressurized (S5W) nuclear reactor
Speed:	20 knots (surface), circa 30 knots (submerged)
Crew:	145 personnel (147 berths)
Armament:	4 21-inch forward torpedo tubes

MISSILE SYSTEM: POSEIDON C3 or TRIDENT I C4; gas steam generator launch system

Number:	16 missile tubes, each with POSEIDON C3 or TRIDENT I C4 missiles
Nuclear Warheads:	
POSEIDON:	W68/Mk-3 MIRV, with 10 warheads (average)
TRIDENT:	W76/Mk-4 MIRV, with 8 warheads

Warheads per Submarine:
  POSEIDON: 144-160; current average force loading is 10 warheads per missile
  TRIDENT: 192; current force loading is 8 warheads per missile

Fire Control System: Mk-88[2]

Navigation System: 2 Mk-2 Mod-6 Ships Inertial Navigation System (SINS) and Satellite Receivers[3]

DEPLOYMENT:

Cycle: 55% at-sea availability based on a 32 day refit period, 68 day patrol period, and a 6 year interval between 16 month long overhauls[4]

Homeport: Groton, CT; Charleston, SC, and Kings Bay, GA; submarines operate out of Holyloch, U.K., a forward deployment location. Kings Bay, GA, is being developed as the east coast TRIDENT base and to support 12 POSEIDON submarines.[5]

Patrol Areas: North Atlantic, Mediterranean Sea[6]

HISTORY:

IOC: First LAFAYETTE class sub (USS *Lafayette*) commissioned 1963 (see Table 5.5 for POSEIDON chronology)

COST: The first POSEIDON submarines cost $109 million each.[7] Total POSEIDON program cost (31 submarines and 619 missiles; construction and support equipment) for FY 1966-FY 1980 was $4847 million.[8]

Annual Operations: $1039 m (FY 1980)[9]
$1627 m (FY 1982)[10]

COMMENTS: Originally designed 20 year service life span of POSEIDON SSBNs has been extended to 30 years.[11] First hull is planned for retirement in FY 1993 and last hull in 1999.[12]

1 See various annual issues of Jane's *Fighting Ships*, 1975-76 to present.
2 Fire control system performs target calculations, insertion of data into the guidance system, test and checkout launch order, and sequence control.
3 U.S. Navy, Strategic Systems Project Office, "Polaris & Poseidon FBM Facts," 1970, p. 6; "FBM Facts: Polaris, Poseidon, Trident," 1978, p. 11.
4 SASC, FY 1980 DOD, Part 1, p. 327.
5 ACDA, FY 1982 ACIS, p. 77.
6 ACDA, FY 1981 ACIS, p. 32; SASC, FY 1982 DOD, Part 7, p. 4024.
7 *Ships and Aircraft of the U.S. Fleet*, 11th Ed., p. 20.
8 DOD, Selected Acquisition Report, 30 June 1975.
9 SASC, FY 1982 DOD, Part 7, p. 3992, p. 4002.
10 *Ibid.*, p. 4337.
11 ACDA, FY 1983 ACIS, p. 88.
12 SASC, *Strategic Force Modernization Programs*, p. 169.

POSEIDON C3 Missile System (UGM-73A)

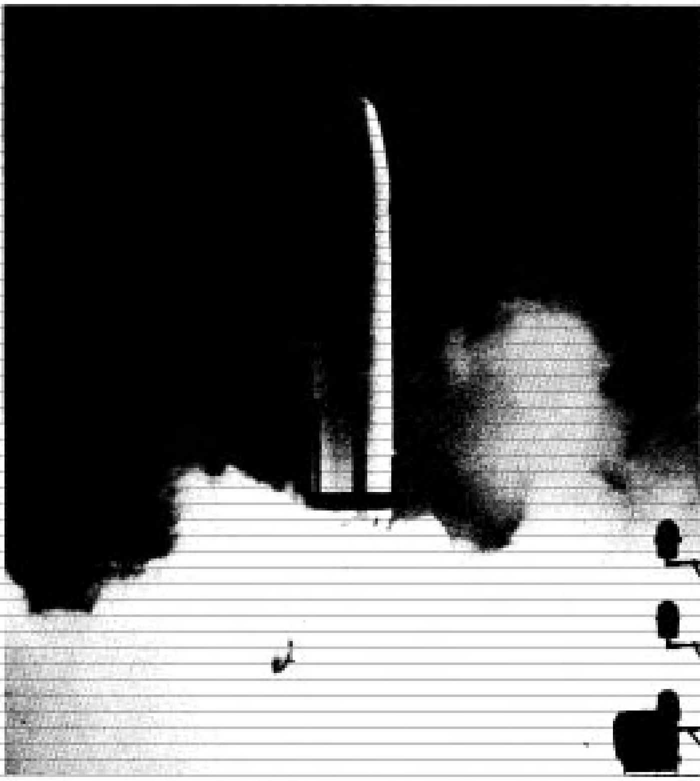

Figure 5.15 POSEIDON C3 (UGM-73A) missile.

DESCRIPTION: Two-stage, solid propellant MIRVed SLBM with improved accuracy and larger payload than POLARIS A3.

CONTRACTORS: Lockheed Missiles and Space Co.
Sunnyvale, CA
(prime)
(See Table 5.18 for list of major subcontractors)

SPECIFICATIONS:[1]

Length:	34 ft 1 in (409 in)
Diameter:	74 in
Stages:	2 (1st and 2nd stages, glass fiber)

Table 5.18
Major POSEIDON Subcontractors

Subcontractor	Work Contracted
Aerojet-General Corp. Sacramento, CA	missile propulsion
Autonetics Div., Rockwell International Anaheim, CA	navigation
Bell Telephone Labs Whippany, NJ	communications
General Electric Co., Ordnance Systems Pittsfield, MA	fire control/ missile guidance
General Electric Corp. Lynn, MA	propulsion
Hercules, Inc. Wilmington, DE	missile propulsion
Honeywell Minneapolis, MN	missile guidance
Hughes Aircraft Co. Culver City, CA	fire control/ missile guidance
Interstate Electronics Corp. Anaheim, CA	instrumentation
ITT Labs Nutley, NJ	communications
MIT Cambridge, MA	missile guidance
Northrop Corp. Anaheim, CA	missile checkout
Raytheon Co. Lexington, MA	missile guidance
RCA, Princeton Labs Princeton, NJ	communications
Sperry Systems Great Neck, NY	navigation
Sylvania Electric Products Co. Buffalo, NY	communications
Thiokol Chemical Brigham City, UT	1st stage propulsion
Vitro Labs Silver Spring, MD	weapons system coordination
Western Electric Corp. Pittsburgh, PA	propulsion
Westinghouse Electric Corp. Sunnyvale, CA	missile launching

Weight at Launch:	64,000+ lb
Propulsion:	solid fuel (1st stage, composite)
Speed:	Mach 10+
Guidance:	all inertial
Throwweight/ Payload:	2000 lb;[2] 3300 lb;[3] 3000 lb[4]
Range:	2500 nm;[5] 3200 mi;[6] 10 RVs: 3230 mi; 14 RVs: 2485 mi
DUAL CAPABLE:	no
NUCLEAR WARHEADS:	6-14 W68/Mk-3 MIRV/ missile;[7] 10 is average;[8] number of RVs was announced as being upgraded from 9 to 14 in October 1980;[9] 40-50 Kt,[10] with penetration aids (see W68)

DEPLOYMENT:

Launch Platform:	LAFAYETTE class, JAMES MADISON class, and BENJAMIN FRANKLIN class SSBNs, designed for launching from submerged submarines
Number Deployed:	619 operational missiles procured;[11] as of 1983, 19 submarines, 304 missiles, and some 3040 warheads were deployed[12]

HISTORY:	(see Table 5.5 for POSEIDON chronology)
IOC:	31 March 1971, in USS *James Madison* (SSBN-627)
1969-1977	31 SSBNs converted from POLARIS to POSEIDON[13] missiles

TARGETING:

Types:	mostly soft targets, military airfields, bases, command and communications installations
Selection Capability:	four target
Retargeting:	unknown
Accuracy/CEP:	0.25 nm; 0.3 nm[14]
COST:	$2.8 m (unit cost) (FY 1975)

FY	Number Procured	Total Appropriation ($ million)
1979 & prior	619[15]	3487.7[16]
1980	-	23.8
1981 & prior	-	2609.1[17]
1981	-	26.2[18]
1982	-	18.7
1983	-	10.5

1 World's Missile Systems, 5th Ed., p. 122; USN, Strategic Systems Project Office, "FBM Facts: Polaris, Poseidon, Trident," 1978.
2 *Military Balance*, 1980-1981, p. 88.
3 Paul H. Nitze, op. cit.
4 U.S. *Missile Data Book*, op. cit.
5 Jane's Weapons Systems.
6 The World's Missile Systems, 6th Ed., p. 328.
7 HAC, FY 1980 DOD, Part 7, p. 830. The C3 missile has been tested with 14 warheads. Since there is a tradeoff between throwweight and range, actual loadings are less than the maximum, depending on target and submarine station locations. For average loading, the 1981 SIPRI Yearbook assumes 10/missile. Paul H. Nitze, op. cit., indicates 8-10 RVs per C3 missile and uses an average of nine.
8 JCS, FY 1984, p. 16; with withdrawal of POLARIS, warheads on POSEIDON missiles were selectively increased; HASC, 4 March 1982, Statement of VADM Walters, p. 5; HAC, FY 1982 DOD, Part 7, p. 844; HASC, FY 1982 DOD, Part 3, p. 156.
9 *New York Times*, 30 October 1980, p. A23.
10 *Military Balance*, 1980-1981, p. 88.
11 U.S. *Missile Data Book*, 1980, 4th Ed., pp. 2-72 – 2-73; DOD, Selected Acquisition Report, 30 June 1975.
12 The first POSEIDON submarine was backfitted with TRIDENT I C4 missiles in October 1979. At time of writing, C4 missiles have been backfitted onto 12 of 31 POSEIDON SSBNs. (The 12th and last was backfitted in FY 1982.) See also C4 missile system.
13 ACDA, FY 1982 ACIS, p. 85.
14 Colin S. Gray, op. cit., p. 32.
15 Ibid.
16 U.S. *Missile Data Book*, op. cit., p. 2-74.
17 Excluding development costs; ACDA, FY 1983 ACIS, p. 48.
18 POSEIDON (C3) missiles are no longer in production. Funding continues to support the weapons system; ACDA, FY1982 ACIS, p. 88.