

GAO

United States General Accounting Office

Report to the Chairman, Committee on
Armed Services, House of
Representatives

September 1990

STRATEGIC FORCES

Minuteman Weapon System Status and Current Issues

AD-A232 102

**National Security and
International Affairs Division**

B-239571

September 28, 1990

The Honorable Les Aspin
Chairman, Committee on Armed Services
House of Representatives

Dear Mr. Chairman:

As requested, we evaluated the Air Force's plans to retain the Minuteman II and III missile force through fiscal year 2008. Specifically, we identified the costs to sustain the Minuteman force and assessed the impacts of aging on the systems, the programs planned to support life extension, and the capability of the Air Force to assess and demonstrate the operational condition of the missiles. In January and March 1990, we briefed your office on the preliminary results of our review. This report summarizes and updates those briefings.

Results in Brief

The Intercontinental Ballistic Missile Systems program office estimated that, as of May 1989, about \$30.4 billion in then-year dollars would be needed to extend the life of the Minuteman force through fiscal year 2008. However, in light of the Secretary of Defense's recent announcement to retire about half of the force (450 Minuteman II missiles) by 1998 if a Strategic Arms Reduction Talks agreement is reached, the estimate will decrease by an amount not yet determined by the program office.

The program office states that to extend the life of the Minuteman weapon system through fiscal year 2008, the force must be maintained in a launch ready state with a high probability of successful launch, flight, and target destruction. The Minuteman III missiles are currently being maintained in accordance with this planning criterion, but the Minuteman II missiles are not.

Confidence that the Minuteman II can meet this criterion is questionable because of (1) limited flight testing, due to a shortage of test missiles and (2) reduced reliability, caused by age-related deterioration of guidance computers and Stage 3 propulsion motors. Additionally, because of the limited number of flight tests, the Department of Energy cannot certify the reliability of the Minuteman II warhead.

Minuteman III missiles, which are not as old as the Minuteman II missiles, have not yet experienced the operational performance problems

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facing Minuteman II missiles. However, on the basis of the Air Force's and the Department of Energy's current testing schedules, the Air Force will not have spare components for flight testing to support reliability assessments of that system's nuclear warhead after 1999.

Under current Air Force plans, confidence in Minuteman II missile performance cannot be restored and sustained. Confidence in Minuteman III warhead performance will begin degrading after 1999.

Background

The current Minuteman force structure consists of 450 single-warhead Minuteman II missiles (fielded in 1965) and 500 three-warhead Minuteman III missiles (fielded in 1970) deployed in underground silos at various Air Force bases in the continental United States. (See app. I for a detailed description of the Minuteman weapon system.) The Minuteman force has far exceeded its initial design life goal of 10 years.

Air Force Headquarters has directed that the Minuteman force be sustained beyond the year 2000. According to Air Force Headquarters officials, this direction was given because progress of intercontinental ballistic missile modernization was slower than planned, which placed increased and extended reliance on the Minuteman force as a nuclear deterrent.

The United States and the Soviet Union have agreed to expedite the Strategic Arms Reduction Talks negotiations with the objective of resolving all substantive issues. These negotiations will substantially reduce both countries' strategic offensive forces and place ceilings on the number of strategic offensive warheads and delivery systems. The United States and the Soviet Union have proposed that the reductions be carried out in a phased manner, achieving equal ceilings by agreed dates.

In January 1990, the Secretary of Defense announced that if a Strategic Arms Reduction Talks agreement were reached, the Minuteman II force would be retired beginning in 1992. About 64 Minuteman II missiles would be retired annually over a 7-year period. At that rate, all 450 Minuteman II missiles would be retired by about 1998. More recently, in authorizing appropriations for the Department of Defense for fiscal year 1991, the Senate Committee on Armed Services identified the Minuteman system as one that should be considered for early retirement.

Minuteman Life Extension Cost Estimate

The program office states that the Minuteman force must be maintained in a launch ready state with a high probability of successful launch, flight, and target destruction. It has developed a long range plan that identifies the life extension programs (modifications, replacements, refurbishment, etc.) and associated costs to sustain the Minuteman force through fiscal year 2008.

The most recent program office estimate (May 1989) shows that about \$30.4 billion in then-year dollars will be needed to maintain an effective Minuteman force from fiscal years 1984 through 2008 (see table 1).

Table 1: Cost Estimate for Maintaining the Minuteman Force

Dollars in billions		
	Total cost	Average annual cost
Operations and support	\$19.0	\$0.8
Life extension programs	10.8	0.4
Capability enhancements	0.6	0.02
	\$30.4	\$1.22

Program officials stated that the estimate represents a planning estimate and should not be used to support programmatic decisions or budgetary allocations. They added that the estimate, however, does provide a reasonable representation of past and future costs associated with daily operations and extending the useful life of the Minuteman force through fiscal year 2008.



Flight Testing Issues

Operational flight testing provides the only complete, end-to-end check of weapon system operation from launch command initiation to reentry vehicle impact. Operational test flights also provide the accuracy and reliability data used to develop planning factors for the nuclear war plan.

The Joint Chiefs of Staff has established guidelines that specify minimum statistical confidence levels required for weapon system reliability. The Strategic Air Command has determined that seven Minuteman II and seven Minuteman III flights per year are needed to comply with Joint Chiefs of Staff and Command guidance for maintaining minimum confidence in weapon system performance. Also, as part of the Strategic Air Command's annual flight test program, two Minuteman II and six Minuteman III test flight missiles must be

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equipped with Department of Energy configured test reentry vehicles to demonstrate that the warhead will function as intended.

Minuteman II Flight Testing

A shortage of missiles and missile components is curtailing operational flight testing of the Minuteman II system, and on the basis of current plans, these will continue to curtail this testing. During the 1980s, only 11 of the 70 needed Minuteman II flight tests were conducted (see app. III). Flight testing was suspended in 1987 because of the limited availability of flight test missiles and the planned replacement of guidance system computers and Stage 3 propulsion motors.

Flight testing was scheduled to resume in fiscal year 1993 when replacement guidance system computers and Stage 3 propulsion motors were to become available. However, those replacements have been canceled in anticipation of Minuteman II retirement. Because of the limited test program, the confidence in the operational effectiveness of the Minuteman II system is questionable, and Department of Energy officials at the Albuquerque Operations Office advised us that it cannot certify that the Minuteman II warhead will function as intended.

The Strategic Air Command is assessing the need to resume Minuteman II test flights. However, only 22 Minuteman II missiles remain for flight testing. If flight testing is resumed, according to the program office, all of these missiles will need to be flown during a 3-year period to reestablish a performance baseline. Consequently, missiles will not be available for the flight testing needed to maintain continued confidence in system performance through fiscal year 2008.

The Air Force is considering plans to alleviate the flight test asset shortage. One plan is to procure additional missiles, but, according to program officials, the probability of procuring additional flight test missiles is very low because of their high cost. Another plan being considered is the reduction of the operational force to make Minuteman II missiles available for flight testing. However, the use of operational missiles would require the conversion of an operational reentry vehicle equipped with its warhead into a nonnuclear test reentry vehicle without a warhead. According to Air Force officials, this conversion can be done. However, Department of Energy officials at the Albuquerque Operations Office stated that a feasibility study of such a conversion has not been done and that such a study has not been directed.

Minuteman III Flight Testing

During the 1980s, the needed seven Minuteman III flight tests per year were conducted (see app. IV). These flights have shown that the Minuteman III missile is meeting the specification requirements for accuracy and reliability. The Air Force had plans to continue flight testing Minuteman IIIs at a rate of seven per year until about calendar year 2004. To support these flights, the Air Force is acquiring additional MK 12 and MK 12A reentry vehicle components. After 2004, however, nearly 4 years before the end of the currently planned life of the system, the existing inventory of flight test missiles would have been depleted.

On August 1, 1990, Strategic Air Command officials advised us that it has decided, beginning in fiscal year 1990, to reduce the number of annual Minuteman III flights from seven to four due to fiscal constraints. At a rate of four flight tests per year, there will be sufficient missiles to allow flight testing through fiscal year 2008. The Strategic Air Command believes it can reasonably monitor the performance of the Minuteman III missiles with only four flight tests per year, considering the proven reliability of the system and the existing large base of Minuteman III performance data. Since this decision was made near the conclusion of our review, we have not made a full assessment of the impacts of the decision on the ability to confidently estimate Minuteman III reliability and accuracy.

Concerning the Minuteman III warhead, Department of Energy officials at the Albuquerque Operations Office stated that, as part of the Strategic Air Command's flight test program, flight testing of three MK 12 and three MK 12A reentry vehicles equipped with nonnuclear warhead electrical systems is being accomplished and is demonstrating that the warhead will function as intended. Additional MK 12A nonnuclear warhead electrical systems will be needed, however, to allow flight testing after 1999.

Department of Energy officials at the Albuquerque Operations Office stated that it is unlikely that a manufacturing capability for the MK 12A warhead electrical systems still exists. If this capability does not exist, then other actions will need to be taken to ensure extending flight testing through fiscal year 2008. Department of Energy officials stated one such action would be developing and acquiring a new warhead electrical system. These same officials stated that another action could be the reduction of the operational Minuteman III force as nonnuclear electrical systems from operational missiles are expended during flight testing and not replaced.

Reliability Issues

The Air Force has been aware of age-related deterioration of Minuteman weapon system components since the mid-1970s, and it has implemented several programs to correct age-related deterioration of Minuteman II and III missile components in order to maintain weapon system reliability.¹ (See app. II.)

Currently, the program office is reporting that the reliability of the Minuteman III missiles is at an acceptable level, but the reliability of the Minuteman II missiles is substantially reduced because of age-related deterioration of guidance system computers and Stage 3 propulsion motors. The reliability of the Minuteman II force will remain a problem because the Air Force's plans to replace the Stage 3 motors were canceled in anticipation of Minuteman II retirement. Also, the Air Force had planned to implement a guidance computer replacement program in fiscal year 1990 at an estimated cost of \$696 million in then-year dollars. However, the fiscal year 1990 appropriation of \$76 million was transferred for other uses, and the \$110 million requested for fiscal year 1991 was deleted. According to program officials, the replacement of the guidance computer is the key to improving Minuteman II reliability.

Conclusions

The Minuteman missiles have served as a nuclear deterrent for a longer period of time than was contemplated when the first missiles were deployed about 25 years ago. Over the extended lives of the systems, questions have arisen about their continued reliability and operational effectiveness, particularly the Minuteman II system. Confidence in Minuteman II operational performance is reduced because of limited flight testing during the 1980s and deterioration of critical missile components. The Air Force does not currently have a plan that would provide the test assets needed to restore and sustain confidence in the Minuteman II system's operational performance.

These factors, when considered in conjunction with the cost to operate and support the system, suggest that the Minuteman II system could be retired earlier than 1998 as presently contemplated under an assumption of a Strategic Arms Reduction Talks agreement. An alternative would be to reinstate the Air Force's plans to replace deteriorated missile components and acquire the assets needed to resume flight testing at rates necessary to restore and sustain confidence in the system's performance for the remainder of its operational life through fiscal year 2008.

¹Reliability is the probability that a missile will deliver and detonate its warhead in the target area.

Minuteman III missiles are to remain in the force until fiscal year 2008. However, based on current test schedules, by about 1999, components to test the missile's warhead will be depleted. Thus, confidence in the operational effectiveness of the Minuteman III warhead performance will become questionable after 1999.

Recommendations

In view of (1) the Department's decision not to correct the deteriorating condition of the missile and (2) the several hundred million dollars in costs to operate and support the system, we recommend that the Secretary of Defense direct the retirement of the Minuteman II weapon system at a rate that would retire the system earlier than the projected date of 1998, consistent with any Strategic Arms Reduction Talks agreements that are concluded.

We also recommend that the Secretary of Energy, in conjunction with the Secretary of Defense, develop a plan to ensure the availability of Minuteman III MK 12A warhead components for flight testing through fiscal year 2008.

Scope and Methodology

We concentrated on life extension issues related to the Minuteman II and III missiles only, as opposed to all elements of the weapon system such as operational ground equipment, because the impact of aging on system reliability was primarily missile related. However, we did identify and analyze life extension costs related to the entire weapon system.

We interviewed appropriate officials and examined pertinent documents at the Ogden Air Logistics Center, Hill Air Force Base, Utah; the Strategic Air Command Headquarters, Offutt Air Force Base, Nebraska; the San Antonio Air Logistics Center, Kelly Air Force Base, Texas; the Office of the Secretary of Defense and Air Force Headquarters, Pentagon; and the Albuquerque Operations Office, Department of Energy, Kirkland Air Force Base, New Mexico.

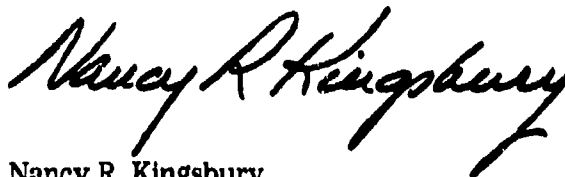
As agreed with your office, we did not obtain agency comments on this report. However, we discussed a draft of this report with officials from the Office of the Secretary of Defense, Air Force Headquarters, Ogden Air Logistics Center, Strategic Air Command, and the Department of Energy's Albuquerque Operations Office and incorporated their comments as appropriate.

We performed our review from July 1989 through June 1990 in accordance with generally accepted government auditing standards.

We plan no further distribution of this report until 30 days from its issue date unless you announce its contents earlier. At that time we will send copies to the Secretaries of Defense, the Air Force, and Energy; the Director, Office of Management and Budget; and appropriate congressional committees. Copies will also be made available to others on request.

Please contact me at (202) 275-4268 if you or your staff have any questions concerning this report. Other major contributors to this report are listed in appendix V.

Sincerely yours,



Nancy R. Kingsbury
Director
Air Force Issues

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Minuteman Weapon System Description

The U.S. strategic nuclear forces consist of submarine-launched ballistic missiles, manned bombers, and land-based intercontinental ballistic missiles. Since the 1960s, this triad of nuclear forces has contributed to the primary objective of the nation's strategic forces—deterrence of nuclear war. The Minuteman weapon system is part of the U.S. land-based intercontinental ballistic missile force, which is comprised of 1,000 silo-based missiles—50 Peacekeeper and 950 Minuteman missiles.

Force Structure Description

The current Minuteman force consists of 450 Minuteman II missiles and 500 Minuteman III missiles. Minuteman II missiles were first deployed in 1965, followed by the first deployment of Minuteman III missiles in 1970.¹ The current Minuteman force is deployed in underground silos located at various Air Force bases, as shown in table II.1.

Table II.1: Location of Minuteman Force

Air Force Base	State	Minuteman	
		II	III
Malmstrom	Montana	150	50
Ellsworth	South Dakota	150	0
Minot	North Dakota	0	150
Whiteman	Missouri	150	0
F.E. Warren	Wyoming	0	150
Grand Forks	North Dakota	0	150
Total force size		450	500

The Minuteman weapon system is comprised of two primary elements: the missile and the operational ground equipment that are required to support the deployed force of Minuteman missiles.

Minuteman II Missile

The Minuteman II missile is 57.6 feet long and 5.5 feet in diameter and weighs 73,000 pounds. It is capable of speeds in excess of 15,000 miles per hour, and it has a range of over 6,300 nautical miles. The missile consists of a three-stage propulsion system, a missile guidance and control system, and a reentry vehicle.

The propulsion system is made up of three solid propellant rocket motors, providing enough thrust to achieve intercontinental ranges. The missile guidance system is an inertial guidance system that directs the

¹The original Minuteman III force of 550 missiles was reduced to 500 by 1988 when 50 Minuteman IIIs were replaced with 50 Peacekeeper missiles in modified Minuteman silos.

flight of the missile to its programmed target,² and the guidance system operates continuously when the missile is on alert status enabling missile launch in less than 1 minute. The reentry vehicle is a Mark 11C and is equipped with the highest yield warhead in the U.S. land-based intercontinental ballistic missile arsenal.

Minuteman III Missile

The Minuteman III missile is 59.9 feet long and 5.5 feet in diameter and weighs 75,000 pounds. The missile consists of a three-stage propulsion system and a post-boost vehicle comprised of a propulsion system rocket engine, a missile guidance system, and a reentry system.

The Minuteman III is the latest generation of Minuteman missiles with improved performance characteristics. The Minuteman III uses the same solid propellant rocket motors as the Minuteman II missile for its first and second stages, but the performance of the Minuteman III's Stage 3 motor has been improved, and a post-boost propulsion system has been added to increase the missile's range and capacity to deliver multiple warheads. The Minuteman III's guidance system has been improved. For example, improved electronics within the guidance system have increased the missile's accuracy and reduced its vulnerability to a nuclear environment. Also, the Minuteman III can carry up to three reentry vehicles/warheads that can be independently targeted, providing greater targeting flexibility, whereas the Minuteman II only carries one reentry vehicle/warhead. Furthermore, the Minuteman IIIs are equipped with two different reentry vehicles—200 with the MK 12 reentry vehicle and 300 with the MK 12A reentry vehicle, which has a higher yield warhead than the MK 12.

Operational Ground Equipment

Each Minuteman missile is deployed upright in unmanned silos that have been hardened against blast, shock, radiation, and electromagnetic pulse. These silos are underground about 90 feet deep and 12 feet in diameter.

The silo-based missiles are controlled by underground launch control centers located at remote sites away from the silos. The launch control centers are blast resistant, shock mounted capsules manned by two missile combat crew members who continuously monitor the security and condition of 10 missiles and silos by using displays, alarms, and

²The guidance system cannot be changed or affected from the ground once a missile is launched.

printouts. Each center is equipped with multiple communications systems to receive commands and transmit launch signals to the remotely located silos.

The silo-based Minuteman force also is supported by an airborne launch control center. The airborne launch control center can assume command and control responsibility for the missile force and perform targeting and launch operations if ground-based launch control centers are disabled.

Programs to Replace Deteriorating Missile Components

The Air Force has been aware of age-related deterioration of the Minuteman weapon system components since the mid-1970s but did not fully assess the impact of aging on weapon system reliability until September 1987. As a result of several flight test failures of Minuteman III missiles during 1987, the Chief of Staff of the Air Force directed that a multicommand reliability assessment of the Minuteman III weapon system be initiated to determine the condition of the weapon system and the specific impacts of age degradation on weapon system reliability.

The Minuteman III reliability assessment identified some potential age-related deficiencies with the missile guidance system and Stage 3 propulsion motor but concluded that the impact of these deficiencies on reliability was thought to be low. The assessment concluded that these deficiencies had not directly attributed to any flight test failures. The potential deficiencies are being monitored, and the program office is reporting that the reliability of the Minuteman III missiles is at an acceptable level, as evidenced by recent successful flight test results.

The Minuteman III assessment resulted in a reliability assessment of the Minuteman II missile. The results of the Minuteman II assessment, issued in March 1988, showed that the missile was exhibiting aging effects, particularly within the guidance system computer and the Stage 3 propulsion motor—the two components having the greatest impact on reducing weapon system reliability. Accordingly, the Air Force established programs to replace these two components, but funding was canceled in expectation of Minuteman II retirement. Currently, the program office is reporting that the reliability of Minuteman II missiles is substantially reduced.

To correct the age-related deterioration, the Air Force has implemented several programs and has plans for several others for both the Minuteman II and Minuteman III missiles. Some of these programs are discussed below.

Propulsion Motor Programs

The Minuteman II and Minuteman III missiles' Stage 1 motors are virtually identical. The motors have surpassed their expected lives, and test results indicate statistically significant aging trends. However, no operational problems are expected in the near future. If problems arise, the program office will implement a program to refurbish the entire inventory of 1,140 Stage 1 motors, beginning in fiscal year 1993, at an estimated cost of \$1.6 billion in then-year dollars.

Assessments performed during the mid-1970s on the Stage 2 motors, which are virtually identical for the Minuteman II and Minuteman III missiles, found a gradual deterioration of the liner, and as a result, the program office established a useful motor life of 17 years. Accordingly, a program to replace the liner and propellant in all Stage 2 motors began in February 1979. All Minuteman II motors have been replaced, and replacement of Minuteman III motors will be completed in fiscal year 1993 before the motors exceed their 17-year useful lives. Another liner and propellant replacement program is scheduled to begin in fiscal year 1994 at an estimated cost of \$581 million in then-year dollars.

The Minuteman III Stage 3 propulsion motor uses the same liner and propellant used in the Stage 2 propulsion motor. The liner and propellant in the Stage 3 motor were also found to be deteriorating. A program to replace the liner and propellant began in fiscal year 1983, and it is scheduled for completion in fiscal year 1993. Another liner and propellant program is planned to begin in fiscal year 1998 at an estimated cost of \$571 million in then-year dollars.

Seven age-related potential failure modes have been identified in the Minuteman II Stage 3 propulsion motor. However, because of limited test assets, only one failure mode—premature thrust termination port actuation¹—has been assessed and is known to be reducing weapon system reliability. The Air Force had planned to implement a program to replace some older Stage 3 motors with new motors. The older motors could then be used to assess the reliability impact of the other six potential failure modes. However, the program was canceled in anticipation of Minuteman II retirement.

The Air Force is refurbishing the thrust termination ports in all Stage 3 motors. According to a program official, as of December 1989, 375 of the 450 deployed Minuteman II missiles had refurbished thrust termination ports, and the remaining 75 missiles will be refurbished by the end of fiscal year 1993. In the interim, the force will have Stage 3 motors with questionable performance. Compounding this condition is that the expected service life of Stage 3 motors is 162 months, and almost all the unrefurbished motors are at least 209 months old.

¹Premature thrust termination port actuation is caused by aging and the resulting leakage of O-rings and seals and degradation of the potting material in the thrust termination ports.

Guidance System Programs

Age degradation of electrical components and faulty technology were identified in some Minuteman II guidance system components during a missile guidance set and flight control degradation assessment study dated August 1984. As a result, in 1985, the Air Force implemented an accuracy, reliability, and supportability improvement program that is scheduled for completion at the end of fiscal year 1992 at an estimated cost of \$237 million in then-year dollars. This program upgrades and replaces degraded and faulty electronics with current technology electronics in addition to providing software changes to enhance accuracy.

The Minuteman II reliability assessment study also determined that age degradation in the Minuteman II missile guidance computer was occurring, and subsequent ground testing showed a substantial reduction in Minuteman II reliability. This degradation is separate and distinct from the electronics degradation being corrected by the accuracy, reliability, and supportability program. The study indicated an increasing failure rate of the guidance computer. Of particular concern was the abnormal number of guidance computers rejected less than 30 days after installation. The Air Force had planned to implement a guidance computer replacement program in fiscal year 1990 at an estimated cost of \$696 million in then-year dollars. However, the fiscal year 1990 appropriation of \$76 million was transferred for other uses, and the \$110 million requested for fiscal year 1991 was deleted. According to program officials, the replacement of the guidance computer is the key to improving Minuteman II reliability.

Similarly, the Minuteman III reliability assessment study indicated concern about age degradation of some missile guidance system components. Given the similarities with the Minuteman II guidance system, the Minuteman III guidance system is also expected to require upgrades and modifications, and engineering evaluation, test, and analyses are being conducted to assess the need for a complete upgrade. If necessary, a program designed to upgrade the Minuteman III guidance system could be implemented in the mid- to late-1990s.

Number of Minuteman II Test Flights Conducted During the 1980s

Calendar year	Number of flights	Number successful
1980	1	1
1981	0	0
1982	3	2
1983	2	2
1984	1	1
1985	0	0
1986	0	0
1987	4	2
1988	0	0
1989	0	0
Total	11	8

Note: According to Strategic Air Command guidelines, 70 test flights were needed during this 10-year period.

Number of Minuteman III Test Flights Conducted During the 1980s

Calendar year	Number of flights			Number with MK 12A
	Total	Number successful	Number with MK 12	
1980	8	7	6	2
1981	8	8	3	5
1982	6	4	3	3
1983	7	5	3	4
1984	7	6	2	5
1985	6	3	3	3
1986	7	6	3	4
1987	7	4	4	3
1988	5	5	3	2
1989	7	7	4	3
Total	68	55	34	34

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