

Introduction

The Minuteman ICBM (Intercontinental Ballistic Missile) is a 3-stage, solid-fueled strategic missile. The L indicates that the missile is silo-launched; the G indicates that it is designed to attack surface targets; and the M indicates that it is a guided missile unit.

History

The Minuteman (MM) concept originated in the late 1950's and early '60's. It was the first solid-fueled missile to enter service, giving it a large margin of improvement over the earlier ICBMs such as the LGM-25C Titan II liquid-fuelled ICBM. The fact that the MM is solid-fuelled gives a much higher reliability rate, easier maintenance and longer storage times. Since the fuel is ready to go, unlike a liquid-fuelled ICBM whose fuel requires extensive preparation before launch, the MM can be launched within seconds of the launch keys being turned. The original Minuteman I, the LGM-30A, entered USAF service in 1962. It carried a single W59 nuclear warhead with a yield of 1MT. The Minuteman II, the LGM-30F, became operational in 1965, and carried one 1.2MT W56 nuclear warhead.

The Minuteman-III is a direct descendant of the world's first solid-fuel ICBM. Design studies of such a weapon began in the mid-fifties and actual development of the Minuteman was underway by the summer of 1957. The program was first announced publicly 27 February 1958. The first version of the Minuteman to be deployed was the Minuteman IA, which achieved IOC (initial operating capability) in December 1962 (20 missiles) and a full squadron on alert on 28 February 1963. A modestly improved version of this missile, the Minuteman IB, was in service by 30 September 1963. The Minuteman I was originally planned for mobile basing which imposed serious limitations on its performance. As a result, larger follow-on versions were soon under development.

The Minuteman II had an improved second stage, a dramatically improved guidance system (CEP was only one-fifth that of Minuteman I), and was equipped with micro-electronic circuitry, rather than discrete electronic components. This was the first missile to make use of microelectronics which, along with the new very high precision guidance system, led to reliability problems that plagued its initial introduction. First launched on 24 September 1964, it achieved IOC on 31 October 1965 at Grand Forks AFB. The 1000th (and last) Minuteman silo was completed (Malmstrom AFB) on 21 April 1967, and the last missile was deployed 2 July 1969 (replacing a Minuteman I that was being retired).

The idea of providing post-boost guidance and propulsion so that multiple targets could be engaged by a single missile emerged in a number of quarters in the early 1960s. In 1964 North American Rockwell Autonetics and Rocketdyne began a joint venture to develop such a system for Minuteman, which became the basis of the Minuteman III, which went into regular development in 1966. The Minuteman III had an enlarged third stage, and an entirely new warhead section called the bus. The bus houses the guidance system, has its own liquid fueled rocket motor, and

mounts three warhead/re-entry vehicles. The three 170 Kt W-62 warheads represented less than half of the gross explosive power over the Minuteman II's single 1.2 megaton W-56, but as measured in equivalent mega tonnage (which adjusts for the area damage two-thirds power scaling law) they provide 82% as much destructive power. Since most targets do not require the power of a 1 megaton blast, the multiple warheads permitted attacking many more targets, effectively multiplying the destructive power of the Minuteman missile even with reduced yield.

The first Minuteman III flight took place on 16 August 1968. The first operational missile was emplaced in its silo on 17 April 1970 at Minot AFB, with the first squadron becoming operational on 29 December 1970. As Minuteman III missiles were deployed, the last Minuteman I missiles were removed from service (the last Minuteman Ib leaving service on 27 September 1974). Deployment of the Minuteman III was completed on 11 July 1976 with the 550th being emplaced at Malmstrom AFB. Production of the Minuteman ended with the completion of the last missile on 14 January 1977.

Even before Minuteman III deployment had been completed, plans were afoot to enhance its capability to attack hardened targets, especially missile silos. This was achieved by hardware and software upgrades to the inertial guidance system (making it the INS-20, and by replacing the W-62/Mk-12 warhead/RV combination with the W-78/M-12a. The W-78/M-12a had both twice the explosive power of the W-62 (335 Kt) and greater accuracy also. In terms of equivalent megatons the three W-78s provided 128% of the destructive power of the W-56. The INS-20 upgrade was tested in July 1976, and it achieved IOC in July 1979. The W-78 development began in July 1974, with the first production units being built in August 1979, and continued through October 1982.

The W-78/Mk-12a deployment came at a price in missile performance. The new warhead/RV combination weighed 16 kg more than the W-62/Mk-12 and reduced the missiles range significantly. This reduction put parts of the southern Soviet Union, including some missile fields, out of range. For this reason, 200 missiles were kept in service with W-62 warhead loadings.

Currently, there are a total of 500 Minuteman III's in the USAF inventory (All MM Is and MM IIs are out of service). They are based Warren AFB in Wyoming; Minot AFB, North Dakota and Malmstrom AFB, Montana. The USAF removed the 150 MM III's at Grand Forks AFB, and transfer them into converted MM II silos at Malmstrom AFB. This reduced the number of Minuteman bases from 4 to 3 in April 1998. In accordance with the START II treaty, the LGM-118A Peacekeeper ICBM will be taken out of service, leaving the Minuteman III as the only land-based ICBM in the Nuclear Triad. This treaty also means that the number of warheads the MM III carries will be reduced from 3 to 1.

A program called Rivet Mile is in progress to repair and slow the effects of aging on the missiles. Also, the REACT (Rapid Execution And Combat Targeting) program was initiated in 1989, modifying the launch control centers, improving communications and weapons status equipment, as well as improving the missile's rapid retargeting characteristics. Also, the possibility of modifying 20 MM IIIs with

defensive kinetic-kill vehicles for anti-missile defense is being evaluated. These and other programs ensure that the Minuteman III will be in service through 2020. The LGM-30G Minuteman III Model 1 was first loaded into a silo assigned to the 741st Strategic Missile Squadron (SMS) at Minot AFB, North Dakota on April 17, 1970. In December the 741st SMS achieved operational status with the LGM-30G. The LGM-30G Minuteman III Model 2 entered service in 1979 and included improved penetration aids such chaff and decoys, to increase the chances of the missile's payloads reaching their targets.

Since the end of the Cold War, and the negotiation of the START II treaty, significant revision has been made in Minuteman III deployment plans. It was decided to reduce the number of deployed Minuteman IIIs by 50 (to 500) and, since the Minuteman II has now been completely retired, the remaining missiles were consolidated at three bases instead of four. Under START II the Minuteman III must be downloaded to one warhead each (de-MIRVing it), and the Peacekeeper (MX) missile must be retired (by 2005). Current plans are to switch the 500 W-87/Mk-21 warhead/RVs now deployed on the Peacekeeper to the Minuteman. The W-87 represents a slight reduction in explosive power compared to the W-78 (300 Kt vs 335 Kt), and is heavier, but has more modern safety features, and is more accurate. It can also be upgraded (in principle) to 475 Kt (it is also about 6 years newer). Since the missile will be carrying only a single warhead, the range limitation issue will disappear.

Between 1998 and 2002, 652 new guidance units (the Peacekeeper's AIRS - Advanced Inertial Reference Sphere) will be purchased and fitted to the existing Minuteman III, giving it accuracy equal to the current Peacekeeper force.

To extend the life of the Minuteman III missile force to 2020, 200 retired Minuteman II missiles are being modified to Minuteman III configuration to provide additional missiles for spares and testing (a number of test missiles are fired each year to ensure reliability). The aging solid fuel first and second stages will also be "repoured" using state-of-the-art propellant and bonding technology, the third stages will be remanufactured. These Minuteman force upgrades and life extension will cost more than \$5 billion. This will result in 608 total units in the inventory. The cost of procuring a Minuteman missile (the "flyaway" cost) was \$4.84 million (FY 77) or \$7.88 million if other program costs are pro-rated (\$2.63 million per deployed warhead, not counting the actual warhead cost).

Description

The MM III has 3 stages. The first stage, which has a diameter of 5 ft 6 in (1.8m), has a Thiokol M55A1 solid-fuel rocket engine delivering 202,600 lb st. (901.21 kN) thrust. The second stage has an Aerojet-General AR19-AJ-1 solid-fuel rocket delivering 60,625 lb st. (269.67kN) thrust, and the third stage has a Thiokol SR73-AJ-1 solid rocket delivering 33,800 lb st. (150.34kN). The Post-Boost Vehicle (PBV) has a Bell Aerospace rocket with 315 lb st (1.40kN). All told this allows the MM III to deliver its warheads up to 8,700 miles (14,400 km).

The MM III's guidance package consists of an Inertial system from the Autonetics

Division of Rockwell International. The LGM-30G's PBV contains a warhead bus which holds 3 Multiple Independent Re-entry Vehicles (MIRVs) which are deployed from the PBV after the nose shroud has been released. The 3 warheads can either be 170kT W62 warheads contained in General Electric (GE) Mk 12 RVs, which can be delivered with a Circular Error Probability (CEP) of 300 yards (275m); or of 335kT W78 warheads contained in GE Mk 12A RVs, which the MM III can deliver with a CEP of 240 yards (220m). The launch of the missile is controlled by 2 USAF launch officers in a launch control facility approximately 50 ft underground.

LGM-30A/B Minuteman I

In the late 1950s advances in solid-fuel propellants enabled the Air Force to develop its first solid-fuel ICBM, the Minuteman I (LGM-30A/B). Formal development began in September 1958, and after an extraordinarily rapid development program, the Air Force put its first ten Minuteman ICBMs on operational alert at Malmstrom AFB, Montana, in October 1962. Deployment proceeded at an equally furious pace, and within 5 years 1,000 of the solid-fuel missiles stood poised in their silos.

Minuteman is a three-stage, solid-propellant, rocket-powered ICBM with a range of approximately 5,500 nautical miles. Minuteman also possessed an all-inertial guidance system and the capability of being fired from hardened and widely-dispersed underground-silo launchers. A consortium of five contractors produced four distinct models of the Minuteman ICBM weapon system, each model being an improvement over the former: Minuteman I (models "A" and "B"), Minuteman II (model "F"), and Minuteman III (model "G"), the latter capable of carrying multiple independently-targetable reentry vehicles (MIRVs).

The Western Development Division (WDD) was interested in solid-fuel ICBMs in 1954, but at the time found that solid-fuel motors did not produce sufficient thrust and were difficult to control. The Air Force, however, did not abandon the technology, and the WDD and the Wright-Patterson Air Development Center sponsored research in solid fuels throughout the mid-1950s.

By the spring of 1957, Air Force research indicated that a solid-fuel ICBM was possible. That fall the Air Force Ballistic Missile Division's (AFBMD-it changed its name effective June 1, 1957) Col. Edward Hall designed the revolutionary Minuteman ICBM. In marked contrast to the first generation Atlas and Titan I liquid-fuel missiles, Hall proposed building a relatively small, three-stage solid-fuel missile that would be inexpensive to build and maintain. He envisioned basing thousands of the missiles in unmanned, heavily hardened and widely dispersed silos linked electronically to a series of central launch control facilities.

The Air Force was initially cool toward the new concept, but was spurred into action when the Navy proposed modifying its Polaris submarine-launched ballistic missile (SLBM) for use as an ICBM. Anxious to defend its role in solid-fuel development, in February 1958 AFBMD sent Hall to Washington to brief the Secretary of Defense, the Secretary of the Air Force, and the Strategic Air Command's General Curtis LeMay on the Minuteman concept. They were impressed with the program, and quickly allocated the AFBMD \$50 million to begin research and promised the development center another \$100 million if they proved that the Minuteman was indeed feasible.

In July 1958 AFBMD began to develop the components and select the contractors. By the following September the missile development command had made sufficient progress to convince the Air Force to support full Minuteman system development, and the following month the AFBMD chose the Boeing Airplane Company as the missile assembly and test contractor. Shortly thereafter, the AFBMD awarded the guidance contract to the Autonetics Division of North American Aviation (later a Division of Rockwell International) and the reentry vehicle contract to AVCO Corporation. To develop the first-, second-, and third-stage motors AFBMD sponsored a competition between the Thiokol Chemical Corporation, the Aerojet General Corporation, and the Hercules Powder Company. The Air Force awarded the initial contracts with the understanding that the company with the most promising design would win the production contract.

In September 1959 the AFBMD successfully launched a Minuteman first stage motor directly from an underground silo, thus proving that the missile would survive the rigors of a subsurface launch. In February 1961 the AFBMD launched a Minuteman containing all three stages and operational subsystems from the Air Force Missile Test Center in Florida. This was called an "all up" test. The missile performed flawlessly and after a flight of 4,600 miles its reentry vehicle landed within the designated impact zone.

Based on the success of the initial test flight, in March 1961 the Department of Defense formally accelerated the Minuteman program and gave it the same development priority as the Atlas and Titan ICBM programs. In November 1961 the AFBMD launched a complete Minuteman from a silo at the Operational Standardization and Test Facility (OSTF) at Vandenberg AFB, California. The missile recorded a successful flight of 3,000 miles.

In conjunction with the Minuteman development effort, the Army Corps of Engineers Ballistic Missile Construction Office (CEBMCO) built the launch facilities. Construction of the launch facilities and launch control centers at the first Minuteman squadron at Malmstrom AFB, Montana began in March 1961 and was completed late the following September. On October 22, 1962, SAC placed its first flight of ten Minuteman missiles on operational alert.

Deployment of the Minuteman force was accomplished with amazing speed. The Minuteman launch facilities were much smaller and easier to build than the Atlas and Titan launch facilities. Using prefabricated components and standardized construction techniques, CEBMCO built 1,000 silos by 1966.

From its very inception, the Minuteman program was oriented towards mass production of a simple, efficient, and highly survivable ICBM capable of destroying all types of enemy targets with consistent reliability. The Air Force hoped that such a program would reverse the unfavorable trend towards succeeding generations of progressively more costly ICBMs and provide the Strategic Air Command with a weapon system that was inexpensive to operate and maintain.

During the early development phase of Minuteman, the Strategic Air Command favored the concept of deploying at least a portion of the programmed force (from 50 to 150 ICBMs) on railroad cars. SAC submitted a requirement to the Air Staff on 12 February 1959 calling for the first mobile Minuteman unit to be operational no

later than January 1963. To determine the feasibility of deploying Minuteman ICBMs on mobile launchers, SAC ordered a series of tests to be conducted, nicknamed "Operation Big Star." Beginning 20 June 1960, a modified test train, operating out of Hill Air Force Base, Utah, traveled across the western and central United States so technicians could study factors such as the ability of the nation's railroads to support mobile missile trains; problems associated with command, control, and communications; the effect of vibration on sensitive missiles and launch equipment; and human factors involved in the operation of a mobile missile system. Originally, six trial runs were projected, but only four were necessary to realize all test objectives. On 27 August 1960, the last of four Minuteman ICBM test trains arrived back at Hill AFB and the Air Force announced that the test of the Minuteman mobility concept had been completed satisfactorily.

Despite SAC's repeated pleas in favor of mobile Minuteman, the Air Force assigned top priority to the fixed silo-based Minuteman concept. Furthermore, on 28 March 1961, President John F. Kennedy deferred further action on the development of the three mobile Minuteman squadrons in favor of three additional squadrons of silo-based Minuteman units. Secretary of Defense Robert S. McNamara finally settled the issue on 7 December 1961 when he canceled the mobile Minuteman development program.

Minuteman I was deployed in two variants, Minuteman I/A and I/B. Minuteman I/A was an interim weapon because a flawed first stage reduced its range by 2,000 miles. Rather than delay the entire Minuteman program while it corrected the problem, the Air Force elected to go ahead and deploy 150 Minuteman I/As. By July 1963 150 Minuteman missiles were on operational alert; that number increased to 300 in October 1963, 450 by March 1964, and in June 1965 the 800th Minuteman I missile was turned over to its SAC crew at F.E. Warren AFB, Wyoming.

A decision regarding the final size of the silo-based Minuteman ICBM force was not made until December 1964. A new Minuteman system program directive issued on 11 December 1964 established the final Minuteman force at 1,000 missiles. Three years earlier, on 1 December 1961, Headquarters SAC had activated the first Minuteman squadron, the 10th Strategic Missile Squadron (ICBM-Model A Minuteman I) at Malmstrom Air Force Base, Montana. Only two other model "A" ICBM squadrons were activated by Headquarters SAC. These were the 12th Strategic Missile Squadron, activated on 1 March 1962, and the 490th Strategic Missile Squadron, activated on 1 May 1962, also located at Malmstrom. The next thirteen Minuteman squadrons activated by the Strategic Air Command were all model "B" Minuteman I units.

Strategic Air Command housed each Minuteman I, whether a model "A" or "B", in an unmanned, hardened, and widely-dispersed (three-to-seven mile intervals) underground-silo launch facility. A missile combat crew of two officers stationed in a hardened, underground launch control center monitored each flight of 10 launch facilities (five flights per squadron). For purposes of command, control, and communications, hardened underground cables linked all five launch control centers of a Minuteman squadron.

The Minuteman Force Modernization Program initiated in 1966 to replace all

Minuteman I's with either Minuteman II's or Minuteman III's continued through the latter 1960s and into the mid-70s. The last Minuteman I series "A" missiles were removed from their launch facilities at Malmstrom AFB, Montana, on 12 February 1969. These facilities were refurbished and outfitted with Minuteman II series "F" missiles. Boeing Aerospace Company, the contractor responsible for remodeling the launch facilities, completed the nine year modernization effort on 26 January 1975 when it turned over to SAC the last flight of ten Minuteman III missiles at the 90th Strategic Missile Wing, F.E. Warren AFB, Wyoming. The Minuteman I was deactivated in 1972 when the Air Force began its modernization process to the Minuteman III.

LGM-30F Minuteman II

In service since 1965, the Minuteman "F" was a three stage, solid propellant, intercontinental ballistic missile. Because solid propellant is so stable in storage, the missile can be stored almost indefinitely and yet be ready to launch on short notice. This ICBM had a range of over 7,000 nautical miles and carried a single nuclear warhead. 450 missiles were fielded at one time, though the Minuteman II has been decommissioned and the missiles disassembled.

Even as the Minuteman I program raced forward, the Air Force began developing the new Minuteman II. On 2 October 1963, shortly after the first model "A" and "B" Minuteman I squadrons achieved operational status, Headquarters USAF issued Annex A to Specific Operational Requirement 171 which established a requirement for the Minuteman II ICBM (Model "F").

The new missile was a significant improvement over its predecessor. A more advanced missile than either model of the Minuteman I, the "F" model incorporated a new, larger second-stage, improved guidance system, a greater range and payload capacity, and an increased capability to survive the effects of nuclear blast. A new second-stage motor with a single nozzle and a secondary liquid injection for thrust vector control increased the missile's range from 6,300 to 7,000 miles. The new motors also enabled the Minuteman to carry the larger W-56 warhead with a yield of 1.2 megatons. An improved guidance system made the missile more accurate, and it could store a larger number of preprogrammed targets within its internal memory. Moreover, Minuteman II also carried penetration aids to camouflage the reentry vehicle during reentry.

In view of the numerous advantages of the Minuteman II, Secretary of Defense Robert S. McNamara approved the Minuteman Force Modernization Program on 8 November 1963. The project entailed the eventual replacement of the entire force of deployed Minuteman I ICBMs, 150 "A" and 650 "B" models, with Minuteman IIs. The Air Force awarded Boeing the Minuteman II contract in March 1962 and the Seattle-based contractor conducted the first test flight in September 1964. In May 1966 SAC placed its first Minuteman II squadron on operational alert, and by April 1967, accepted its 200th Minuteman II. At that point the Minuteman force stood at 1,000 missiles; 800 Minuteman Is and 200 Minuteman IIs. Continuing its missile modernization effort, throughout the late 1960s the Air Force replaced many of its Minuteman Is with Minuteman IIs, and by May 1969 it had 500 Minuteman Is and an equal number of Minuteman IIs on operational alert.

To prepare for the emplacement of the newer model Minuteman II ICBM, it was necessary to completely retrofit the original Minuteman I launch facilities, launch control facilities, and associated ground equipment. The Minuteman Force Modernization Program began at Whiteman Air Force Base, Missouri, on 7 May 1966 when the first flight of ten model "B" Minuteman missiles were removed from their silos at the 509th Strategic Missile Squadron. On 1 February 1965, Headquarters SAC activated the 447th SMS at Grand Forks AFB, North Dakota, making it the seventeenth Minuteman squadron and the first to be equipped with "F" model missiles. Fourteen months later on 1 April 1966, SAC activated the fourth Minuteman II, and the twentieth and last Minuteman squadron, the 564th SMS, at Malmstrom AFB, Montana. Once the 564th SMS achieved operational status on 21 April 1967, the deployment of the programmed force of 1,000 Minuteman ICBMs was completed.

In FY96, the last Minuteman II booster was dismantled at Hill AFB, UT, and turned over to the Rocket System Launch Program. All Minuteman II silos at Ellsworth AFB, SD, have been destroyed, with the exception of one National Park Service missile site. Approximately 1/3 of the sites at Whiteman AFB, MO, had been destroyed by FY96, with the remainder programmed for FY97.

LGM-30 Minuteman III

Five hundred Minuteman III missiles are deployed at four bases in the north-central United States: Minot AFB and Grand Forks AFB, North Dakota, Malmstrom AFB, Montana, and F. E. Warren AFB, Wyoming. Operational since 1968, the model "G" differs from the "F" in the third stage and reentry system. The third stage is larger and provides more thrust for a heavier payload. The payload, the Mark 12 reentry system, consists of a payload mounting platform, penetration aids, three reentry vehicles (RVs) and an aerodynamic shroud. The shroud protects the RVs during the early phases of flight. The mounting platform is also a "payload bus" and contains a restartable hypergolic rocket engine powered by hydrazine and nitrogen tetroxide. With this configuration, the RVs can be independently aimed at different targets within the missile's overall target area or "footprint". This concept is known as Multiple Independently Targeted Reentry Vehicles (MIRV).

The LGM-30 Minuteman missiles are dispersed in hardened silos to protect against attack and connected to an underground launch control center through a system of hardened cables. Launch crews, consisting of two officers, perform around-the-clock alert in the launch control center. A variety of communication systems provide the National Command Authorities with highly reliable, virtually instantaneous direct contact with each launch crew. Should command capability be lost between the launch control center and remote missile launch facilities, specially-configured EC-135 airborne launch control center aircraft automatically assume command and control of the isolated missile or missiles. Fully qualified airborne missile combat crews aboard airborne launch control center aircraft would execute the NCA orders.

The Minuteman weapon system was conceived in the late 1950s and deployed in the early 1960s. Minuteman was a revolutionary concept and an extraordinary technical achievement. Both the missile and basing components incorporated

significant advances beyond the relatively slow-reacting, liquid-fueled, remotely-controlled intercontinental ballistic missiles of the previous generation. From the beginning, Minuteman missiles have provided a quick-reacting, inertially guided, highly survivable component to America's nuclear Triad. Minuteman's maintenance concept capitalizes on high reliability and a "remove and replace" approach to achieve a near 100 percent alert rate.

Development of the last of the series, the Minuteman III, began in December 1964. By the time the last Minuteman IIs of the 564th SMS were placed on strategic alert in the spring of 1967, significant progress had been made on the development of the more advanced Minuteman III ICBM. The Minuteman III, using modernized Minuteman I and Minuteman II ground facilities, provided reentry vehicle and penetration aids deployment flexibility, increased payload, and improved survivability in a nuclear environment. The missile was the first ICBM to be outfitted with MIRVs that enabled a single missile to carry multiple warheads, each programmed to attack a different target. The Minuteman III reentry system could deploy penetration aids and up to three Mark 12 or Mark 12A multiple independently-targetable reentry vehicles. A liquid-fueled post-boost propulsion system maneuvered the missile prior to deployment of the reentry vehicles, while upgraded guidance system electronics enhanced computer memory and accuracy. The new missile contained an improved third-stage motor with a liquid injection altitude control system and a fixed nozzle that increased the range to over 8,000 miles and significantly increased the payload. A liquid-fuel post boost propulsion system maneuvered the missile before deployment of the reentry vehicles. An improved guidance system with an expanded memory also improved the system accuracy; the Minuteman III warheads are said to be accurate to within 800 feet. In February 1968, the fourth Minuteman III test vehicle fired from Vandenberg AFB completed a successful 5,500-mile flight. In January 1971 the first squadron of Minuteman IIs was turned over to the 91st Strategic Missile Wing at Minot AFB, North Dakota. The force modernization effort continued throughout the early 1970s and by July 1975 there were 450 Minuteman IIs and 550 Minuteman IIIs under SAC's control.

Beginning in 1966 the Air Force instituted a comprehensive long-term maintenance program to ensure that the Minuteman force remained a strong and viable deterrent for years to come. In 1966 the Air Force initiated a Minuteman ageing surveillance program and in 1976 began a long-range service life extension analysis for the propulsion system. The latter effort resulted in the remanufacturing of the Minuteman II second-stage motor and an investigation of the condition of the liner in the Minuteman III third stage. Also during the 1970s many of the Minuteman launch facilities were further hardened and the missiles were fitted with new command data buffers that facilitated faster retargeting. In 1985 the Air Force began the comprehensive Rivet MILE (Minuteman Integrated Life Extension) program destined to take the Minuteman force into the twenty-first century. On 17 April 1970, an important Minuteman III milestone was reached when the first missile was placed in a silo assigned to the 741st Strategic Missile Squadron, Minot AFB, North Dakota. At the end of December, the 741st SMS became the first

SAC Minuteman III squadron to achieve operational status.

Strategic Air Command expected Minuteman to play an important role in the command's force structure beyond the year 2000. To ensure the reliability and maintainability of the Minuteman force into the next century, the Air Force initiated a major Minuteman upgrade and modification program. Rivet MILE (Minuteman Integrated Life Extension Program) began 1 April 1985 at the 341st Strategic Missile Wing, Malmstrom AFB, Montana. This joint Strategic Air Command and Air Force Logistics Command effort was the largest single missile logistics program ever undertaken within the ICBM program.

Through state-of-the-art improvements, the Minuteman system has evolved to meet new challenges and assume new missions. Modernization programs have resulted in new versions of the missile, expanded targeting options, significantly improved accuracy and survivability. Today's Minuteman weapon system is the product of almost 35 years of continuous enhancement.

Peacekeeper missile deployment also affected the Minuteman force. As part of the strategic modernization program undertaken in 1982, Strategic Air Command deployed fifty Peacekeeper missiles in modified Minuteman III silos assigned to the 400th Strategic Missile Squadron, 90th Strategic Missile Wing, F.E. Warren AFB, Wyoming. Conversion began on 3 January 1986, when the first Minuteman came off alert, and the phaseout of the 400th SMS's Minuteman III's was completed on 11 April 1988.

The current Minuteman force is structured in a wing squadron, and flight concept. Each missile wing consists of three or four squadrons. Missile wings at F.E. Warren AFB, Grand Forks AFB, and Minot AFB have three MM III squadrons, totaling 150 MM III per wing. Malmstrom AFB had four MM III squadrons totaling 200 missiles once Grand Forks AFB deactivated. Each missile squadron has five flights interconnected by a network of hardened, buried electronic cables. A missile flight consists of an Missile Alert Facility (MAF) electronically tied to 10 Launch Facilities (LFs). The LFs are located 3 to 16 miles from the MAF, with each LF situated 3 to 9 miles apart. These facilities are interconnected by a redundant network of hardened, buried cables, or a single path of hardened, buried cables plus a medium frequency radio (Grand Forks AFB and Squadron IV at Malmstrom AFB). Any MAF within a squadron can monitor status, command tests and launch any of the missiles within its own squadron. Also, the Airborne Launch Control Center (ALCC), under restricted conditions, can launch any missile within the Minuteman Force. Each MAF is staffed 24 hours a day by a missile combat crew of two officers. As a result of U.S. initiatives to cancel development programs for new intercontinental ballistic missiles and retire the Peacekeeper ICBM, Minuteman will become the only land-based ICBM in the Triad. To compensate for termination of the Small ICBM and Peacekeeper Rail Garrison programs, DOD will conduct an extensive life extension program to keep Minuteman viable beyond the turn of the century. These major programs include replacement of the aging guidance system, remanufacture of the solid-propellant rocket motors, replacement of standby power systems, repair of launch facilities, and installation of updated, survivable communications equipment and new command and control consoles to enhance

immediate communications.

The Rapid Execution and Combat Targeting (REACT) equipment modification was installed in a total of 50 Minuteman III Launch Control Centers at F.E. Warren AFB, WY; Malmstrom AFB, MT; and Minot AFB, ND; with a Final Operational Capability date of 31 July 1996. All modified sites are presently on operational alert status. Key features of the modification program include: reduction of retargeting time by 50 percent, integration of Launch Control Center Command & Control and Higher Authority Communications, automation of routine functions to reduce crew workload, increased crew survivability, replacement of obsolete Command & Control and Higher Authority Communications equipment, and implementation of two-level maintenance.

The Minuteman III Guidance Replacement Program (GRP) consisted of a five-year engineering and manufacturing development (EMD) program. The program requirement is to extend the service life of the Missile Guidance Set (MGS) beyond the year 2020 by replacing aging parts/assemblies with current, high reliability technology while maintaining the current accuracy performance. During FY96, the system Preliminary Design Review (PDR) and a number of component critical design reviews were successfully conducted. Engineering Models (EM) of the MGS were built and tested to identify design weaknesses prior to the critical design review, and to lower the risk in the operational models used for qualification testing and initial operational test and evaluation. EM testing was also conducted at the Intercontinental Ballistic Missile (ICBM) Strategic Missile Integration Complex (SMIC) to verify compatibility with the actual missile hardware interfaces. GRP is also upgrading electronics in the Minuteman III MOD 7 telemetry wafer.

On 16 September 1998 the Minuteman III Guidance Replacement Program (GRP) successfully completed a second flight test from Vandenberg AFB. This second and final program development flight test further validated the end-to-end operational capability of the ICBM with the upgraded guidance system. The first flight test was conducted on 24 June 1998, and was found to meet or exceed all operational requirements. Following lift-off from Vandenberg AFB the missile traveled approximately 4,200 miles to the Kwajalein Missile Range. The flight test program followed successful completion of more than two years of rigorous ground testing conducted at government facilities in Albuquerque NM, Ogden UT and Vandenberg AFB and the Boeing facility in Anaheim CA.

Full-rate production began in 2000 with a total of 652 units being produced to support 500 operational Minuteman III ICBMs. The upgraded guidance system low rate initial production (LRIP) efforts were initiated in March 1998, with award of the LRIP contract to Boeing. Guidance hardware build efforts commenced at Boeing's El Paso TX manufacturing facility; where all previous GRP engineering and operational model hardware was built. Honeywell, a teammate on the program, conducts program production and test activities at its site in Clearwater FL. The first operational guidance systems were delivered to the Air Force in early 1999, ahead of the contract schedule.

In December 1995, the Minuteman Propulsion Replacement Program (PRP) was declared an Acquisition Category IC program. The program requirement is to

extend the service life of the current Minuteman III rocket motors through 2020. All three stages underwent successful preliminary design reviews which updated the development specifications necessary to achieve the program requirements. Additionally, the Stage 1 rocket motor fabrication processes were demonstrated. The Stage 2 motor was successfully fired with new insulation materials, including environmentally friendly propellant manufacturing processes. The Stage 3 motor demonstrated its first design changes in a static firing at the Arnold Engineering Development Center rocket motor test facility. PRP also experienced a major challenge in FY96. The sole producer of a key propellant ingredient had an event at their facility causing the loss of their manufacturing capability. The program developed several options to find a new source of the material or to demonstrate the feasibility of another material.

The ICBM Team successfully tested a 33.4 year old Minuteman Stage 1 motor at the Utah Test and Training Range on February 24, 1999. LMS and Thiokol personnel in support of the Minuteman Stage 1 aging surveillance program conducted the static test, designated AS-16. Motor performance was very much as expected and even met motor specification requirements designed for Production Quality Assurance (PQA) motors. This 33.4 years old motor was the oldest Stage 1 motor ever tested. This test was the last of a series of 16 aging surveillance tests of Stage 1 motors conducted since 1994. The next aging surveillance test of an operational Stage 1 motor is scheduled for the year 2005.

The Minuteman MEECN Program (MMP) will replace the aging Survivable Low Frequency Communications System (SLFCS) in the Minuteman (MM) Launch Control Centers (LCCs) with an integrated Extremely High Frequency (EHF) and Very Low Frequency/Low Frequency (VLF/LF) communications capability. As the newest link in the Minimum Essential Emergency Communications Network (MEECN), this effort will provide the LCCs with the ability to receive Emergency Action Messages (EAMs) in the EHF and VLF/LF spectrum and send force reportback messages over EHF. For the MM LCCs this will include integration into the Higher Authority Communications/Rapid Message Processing Element (HAC/RMPE) processor. Missile Procedure Trainers (MPTs) and Minuteman Enhanced Procedures (MEPs) trainers as well as the development/maintenance systems will be modified to reflect changes to the ICBM operational system. Performance requirements for this program are specified in the ICBM LCC EHF System (ILES) Operational Requirements Document (ORD), the VLF/LF Communications Capability for the ICBM LCCs ORD, and the MMP ORD Addendum. The ISST and AFSATCOM systems will stay intact until deactivated by AFSPC.

In order to meet warhead levels set by START II, the United States has decided to permanently DEMIRV Minuteman III missiles from their current capability to carry up to three reentry vehicles to a newly configured single reentry vehicle system once the treaty enters into force. "Downloading" Minuteman III missiles from three reentry vehicles to one lowers the military value of each missile; reduces the likelihood of any country expending resources to preemptively attack America's ICBM force; and decreases the probability of future US leaders being force into a

"use or lose" position. For a downsized force of 500 single reentry vehicle Minuteman III to continue to be an effective deterrent force, the guidance replacement program will improve the needed accuracy and supportability that is inherent in a smaller missile force. Peacekeeper missiles will be deactivated by 2003, provided START II is ratified and enters into force. Ultimately, a total of 500 single RV Minuteman III's will be the nation's ICBM deterrent force through 2020. The Safety Enhanced Reentry Vehicle [SERV] program consists of modifications to existing hardware and software to accommodate the MK21/W87 RV on the MMIII weapon system. These modifications consist of the following: changes to weapon system software, changes to the RS to accommodate RV mounting, guidance hardware changes, and changes to support equipment (SE). The program will replace the MK12/W62 and MK12A/W78 (RV's) with a single MK21/W87 RV on 350 missiles. The remaining force will consist of 150 single MK12A's.