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USAF BALLISTIC MISSILE PROGRAMS

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USAF BALLISTIC MISSILE PROGRAMS

1965

by

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USAF Historical Division Liaison Office

March 1967

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FOREWORD

This is the fifth in a series of histories in which the USAF Historical Division Liaison Office has sketched the planning, policies, and evolution of USAF ballistic missile development and deployment programs. The other studies are: Plans and Policies for the Ballistic Missile Initial Operational Capability Program; USAF Ballistic Missiles, 1958-1959; USAF Intercontinental Ballistic Missiles, Fiscal Years 1960-1961; and USAF Ballistic Missiles, Fiscal Years 1962-1964.

The current history deals with the retirement of Atlas and Titan I, describes USAF efforts to modernize and improve Minuteman, and discusses national strategy as reflected in the size and composition of the intercontinental ballistic missile force. One chapter is devoted to programs aimed at insuring the continued effectiveness of Minuteman and Titan II. Other chapters deal with development of reentry systems, the penetrations aids program, and the search for more advanced missile systems.

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I. THE OPERATIONAL FORCE

(U) As fiscal year 1965 began, the operational intercontinental ballistic missile (ICBM) force was undergoing a reformation that both reduced the types of missiles in the USAF inventory and at the same time increased the versatility of those retained. The reduction in kinds resulted from a decision by Secretary of Defense Robert S. McNamara to hasten the phasing out of the Atlas and Titan I. The planned improvement in quality involved acquisition of 200 Improved Minuteman ICBM's and modernization of the remainder of the 1,000 - missile Minuteman force.

The Retirement of Atlas and Titan I

(U) [redacted] Because of the inherent complexity of the Atlas and Titan I missiles, due in part to the use of cantankerous liquid oxygen to help propel them, the Air Force as early as 1963 requested and received approval to retire the older ICBM's as replacements became available. The first missile to leave the operational force was Atlas D, which was phased out during the spring and summer of 1964. While this pioneer weapon system was being retired, Secretary McNamara in May 1964 directed the Air Force to phase out Atlas E and Titan I missiles during fiscal year 1965, rather than retain them into fiscal year 1966 and 1967 as originally planned. Atlas F, he said, would remain operational only into fiscal year 1969, instead of through fiscal year 1970. In November 1964, however, McNamara decided that all the older missiles would be deactivated by the end of fiscal year 1965.[1]

(U) Once the decision had been made to retire these weapons, the Air Force faced the task of removing the missiles from their launchers, closing down launch and support facilities, finding use for the excess missiles and other surplus equipment, and, if possible, discovering some future mission for the abandoned installations themselves. The Air Force Logistics Command (AFLC) assumed responsibility for this undertaking and organized site deactivation task teams at the Strategic Air Command (SAC) bases that had supported this segment of the

[redacted]

missile force. SAC, which manned the missile sites, contributed men to each deactivation task force. After these units completed their work, AFLC was to become caretaker until the Air Force either turned the property over to the General Services Administration (GSA) for disposal or assigned it to another command.[2]

(U) The first steps toward site deactivation were taken by SAC specialists who detached the reentry vehicle and various other system components, removed the missile, and disposed of propellants, gases, and other fuels. AFLC thereupon assumed responsibility and its deactivation crews salvaged communication and electronic gear, generators, and other excess equipment, until all that remained were the permanent structures. The abandoned site could now be transferred to GSA or set aside under AFLC control for future use by the Air Force.[3]

(U) Atlas E, F and Titan I site deactivation took place as follows:[4]

Strategic Missile Squadron	Support Base	Type	First ICBM off Alert	Last ICBM off Alert	Last ICBM Shipped
548 *	Forbes	Atlas E	4 Jan 65	28 Jan 65	8 Feb 65
566 *	Warren	Atlas E	4 Jan 65	30 Jan 65	8 Feb 65
578 *	Dyess	Atlas F	1 Dec 64	3 Feb 65	10 Feb 65
577 *	Altus	Atlas F	30 Dec 64	4 Feb 65	10 Feb 65
579 *	Walker	Atlas F	5 Jan 65	4 Feb 65	10 Feb 65
568 *	Larson	Titan I	4 Jan 65	2 Feb 65	8 Feb 65
850 *	Ellsworth	Titan I	4 Jan 65	1 Feb 65	12 Feb 65
851 *	Beale	Titan I	4 Jan 65	22 Jan 65	10 Feb 65
567 +	Fairchild	Atlas E	17 Feb 65	31 Mar 65	5 Apr 65
550 +	Schilling	Atlas F	1 Feb 65	5 Mar 65	11 Mar 65
556 +	Plattsburgh	Atlas F	12 Mar 65	10 Apr 65	13 Apr 65
551 +	Lincoln	Atlas F	10 Mar 65	12 Apr 65	20 Apr 65
569 +	Mountain Home	Titan I	17 Feb 65	1 Apr 65	8 Apr 65
724+ & 725 +	Lowry	Titan I	17 Feb 65	26 Mar 65	15 Apr 65

* Unit inactivated 25 March 1965
\+ Unit inactivated 25 June 1965

(U) Diesel generators removed from the vacated sites proved of immediate value to the Air Force. Of 196 units, rated at various outputs, that became available by the end of June 1966, 97 were earmarked for Southeast Asia where they would be used to provide power to American military installations. [5]

(U) [redacted] The Air Force anticipated many alternate uses for the surplus missiles. By refurbishing and modifying these discarded weapons to support several current research and development projects, it expected to save, for each launching, about one-third the cost of a new booster. For example, the Atlas missiles were well suited for advanced ballistic missile reentry research and also to support the Army's effort to develop a defense against ballistic missiles. There was, however, no demand for Titan I and, in the spring of 1966, the Aerospace Corporation advised the Air Sfaff against its continued storage. [6]

(U) [redacted] In the meantime, the Air Force was trying to find uses for Minuteman missiles that would become excess because of force modernization. As 1966 drew to a close, the Air Force's plans called for storing 93 missiles. These surplus weapons would support surveillance experiments and various USAF projects. Other plans called for the probable use of an additional 80 missiles to support the Army's anti-missile development work. [7]

(U) [redacted] Besides seeking uses for surplus equipment and missiles, the Air Force studied what to do with the excess launching sites. In December 1964 Secretary of the Air Force Eugene M. Zuckert ordered the retention of those facilities that seemed to have potential worth. Since Atlas E sites were considered too compact to be of value, the Air Force subsequently examined possible uses of the Atlas F and Titan I complexes. The total number considered usable--six Atlas F complexes totaling 72 silos and 18 Titan I complexes with 54 launchers--diminished rapidly. For example, water seepage eliminated all the Atlas F sites around Plattsburg, N.Y. Four other Atlas F sites, which had been damaged by fire, had no further value. Also, the Air Force was reluctant to retain sites near SAC bases scheduled for closing.

[redacted]

(U)[redacted] A total of 15 Titan I complexes, each with three launch sites, and 44 empty Atlas F silos were considered by the Air Staff and major commands. By 30 June 1966, however, new missions had been proposed for only three Titan I sites. When the Office of the Secretary of Defense (OSD) indicated its unwillingness to make new assignments, apparently because of personnel and fund shortages, they were kept under USAF jurisdiction. In addition, one Titan I, two Atlas E, and three Atlas F sites at Vandenberg AFB, Calif., were retained.[8]

Minuteman Modernized and Improved

[redacted] As currently deployed Minuteman consisted of a family of missiles forming two weapon systems with the following characteristics:

		Minuteman I		Minuteman II
	Wing I	Wing II	Wings III-V	Wing VI
Missile	LGM-30A	LGM-30B	LGM-30B	LGM-30F
Range (Nautical Miles)	4,910	5,500	5,500	7,500
CEP* (Nautical Miles)				
Warhead (Megatons)				
Launch Facility Hardness	300 psi	300 psi	300 psi	300 psi
Launch Control Hardness	1000 psi	1000 psi	1000 psi	1000 psi
Launch Control Emergency Generator Hardness	soft	soft	300 psi	1,000 psi
Launch Facility Emergency Generator Hardness	soft	soft	25 psi	300 psi
Survivability	6 hours	6 hours	9 weeks	9 weeks
Targeting	one	two	two	eight

DOE b(3)

*Circular Error Probable

[redacted]

[redacted] A third, more advanced system, Minuteman III, also was scheduled for deployment.

DOE b(3)

If development and deployment proceeded on schedule, 170 Minuteman III's would be incorporated into the 1,000-missile force during fiscal year 1970. By the end of 1974, 600 of the 1,000 launchers would house Minuteman III and the remainder Minuteman II.[10]

(U) [redacted] Pending deployment of Minuteman III, modernization of the Minuteman force remained the principal task facing the Air Force in its continuing effort to maintain the operational arm at peak effectiveness. Modernization involved replacing the Minuteman I missiles with the LGM-30F's. However, installation of the newer and taller model ICBM in silos designed for the LGM-30A and B required several modifications to the steel and concrete structures. Technicians from the Air Force Systems Command (AFSC) and crews provided by civilian contractors had to lower the missile support ring, located near the bottom of the silo, and redesign the mechanism that opened the lid in order to prevent its cables from chaffing against the LGM-30F's reentry vehicle. In the sides of the structure, equipment for aligning the missile's guidance and control unit had to be shifted as did the cooling system for that unit. Finally, the umbilical cables had to be lengthened and their retraction gear modified. Similar changes would be necessary to accomodate LGM-30G since it would be almost three feet longer than the F model.[11]

(U) [redacted] Besides using the LGM-30F, modernized Minuteman also incorporated electronic components redesigned to resemble as closely as possible the equipment in Wing VI. The system used in this newest wing and in a separate squadron--200 sites in all--was developed by Sylvania. The components for modernized Minuteman, to be located in the 800 sites of Wings I through V, were designed by the Boeing Company and the Radio Corporation of America (RCA). Using equipment already installed as their foundation, the two contractors duplicated the major features of the Sylvania system and, in addition, devised equipment that could be expanded to accomodate a subsystem by which combat crews would be able to change by remote control target combinations or similar data stored at the launchers. Although the Air Staff has express confidence in the Sylvania equipment's potential for improvement, its web of cables could not without major change accept this sort of modification. [12]

(U)-[redacted] Except for this difference, the electronic systems were essentially the same. Both incorporated squadron operational status reporting, a system that automatically queried, in code, all 50 of the squadron's missiles and transmitted the latest data, also coded, to all five launch control facilities where it was stored for display. Because the officer in charge of each flight could obtain any of this information in the form of visual displays, printed messages, or recorded announcements, one commander could take over for another in the event a launch control facility became disabled. Besides monitoring the status of all 50 missiles in the squadron, every launch control center could select from among eight targets that reposed in the individual missile computers and also could select any of 100 "war plans"--execution options for the entire squadron. [13]

(U)-[redacted]-Both modernized and improved Minuteman also provided for positive action at the launch control facility in order to prepare and fire the missiles. To do so, each combat crew transmitted to the launch facilities a coded signal designated and authorized by higher headquarters. In the event of a communication failure, the combat crew, after a time had elapsed, could transmit the launch enable code on its own authority, an arrangement designed to cope with the possible destruction of the responsible headquarters by enemy missiles. The act of launching, however, continued to require agreement within a specified interval by two of the squadron's launch control facilities. [14]

(U)-[redacted]-Another feature of both systems was the provision at the launch control facility of a printed record of the time each missile was launched. This was originally intended as the first step toward development of a proposed trajectory accuracy prediction system (TAPS)* in which

* See page 25 [redacted]

every missile would signal to a central computer its time of launch, trajectory, and time of arrival in the target area. By comparing these reports with data stored within it, the computer could predict the number of warheads likely to hit their assigned targets. It would not, however, record the effectiveness of defensive countermeasures taken between the transmittal of the last signal and the predicted time of impact. TAPS was subsequently cancelled.[15]

(U)[redacted] Once modernization was finished, all Minuteman crew commanders were to time the launching of their missiles according to Greenwich Mean Time. Use of this standard simplified the execution of plans that called for the simultaneous arrival of several warheads--perhaps from different squadrons--over a target in order to saturate the defenses. Planners now could coordinate the entire missile force without worrying whether local commanders would allow for time zones or daylight saving time.[16]

(U)[redacted] A final feature destined for all Minuteman flights was an ultra high frequency (UHF) receiver to be installed at each launch facility. These sets could pick up commands from an airborne launch control center (ALCC), and thus the destruction of either the launch control facility or the skein of cables through which commands normally traveled would not prevent U.S. retaliation.*[17]

(U)[redacted] Such were the refinements agreed upon for Minuteman. There had been some debate, however, about the manner in which they would be installed in older Minuteman wings, I through V. From the outset, the Air Force urged that one wing be completely modernized before moving on to another. The Office of Secretary of Defense, however, was intrigued by the idea of first modernizing one squadron in each wing so that this unit could back up the less versatile Minuteman I squadrons, then proceeding with the remainder of the program on a squadron-by-squadron basis. The Air Force maintained that the modernization of one squadron would contribute practically nothing toward increasing wing effectiveness and in time the Secretary of Defense agreed. In March 1965 he directed that modernization proceed in line with the USAF proposal. Work began on 25 April 1966 on Wing IV, based at Whiteman AFB,

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* See also pages 27, 29.

Mo. This unit was chosen for the initial modernization because it was assigned the additional mission of providing six Minuteman boosters for SAC's emergency rocket communication system. *[18]

(u) [redacted] At the time modernization started, deployment of improved Minuteman was well underway. Plans called for deploying a wing with 150 missiles, designated as Wing VI, at Grand Forks AFB, N. D. and a 50-missile squadron to be located in the vicinity of Malmstrom AFB, Mont. Work at Grand Forks, begun early in 1964, came to an end in December 1966. The Malmstrom construction started early in 1965; current schedules call for completion of the last site early in May 1967. [19]

Force Levels and Strategic Thinking

(u) [redacted] Secretary McNamara expressed confidence that, for the near future at least, the 1,000 Minutemen and 54 Titan II missiles--plus the Navy's Polaris force--were sufficient to deter large-scale aggression or, if deterrence failed, to inflict mortal damage on the enemy. At the time McNamara pared down successive USAF proposals to arrive at this number, questions arose whether it was adequate to carry out a counterforce strategy and whether counterforce was itself realistic. This strategy, which had found support within the Air Force and received favorable mention from Secretary McNamara, called for the creation of a balanced force of missiles and bombers, backed by adequate defenses, that would be capable first of destroying the enemy's known strategic force and then locating and wiping out other weapons and offensive bases that had not been detected beforehand. According to this plan, by concentrating on the enemy's military power, U.S. strategic forces would reduce to a minimum the violence done to the civilian populace. Moreover, such a strategy, it was believed, would compel the Soviet Union to concentrate in like fashion on the destruction of the U.S. strategic force, with the result that population centers would, insofar as possible, be spared on both sides. However, critics of the counterforce theory asked whether it was possible, or even desirable, to attempt to restrict nuclear blows to predominantly military targets. [20]

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* See: Carl Berger, USAF Strategic Command and Control, 1958-1963, (AFCHO, 1964.)

(U) [redacted] Among those who entertained doubts about counterforce targeting was Gen. Maxwell D. Taylor, who as chairman of the Joint Chiefs of Staff (JCS) directed the Weapons Systems Evaluation Group (WSEG) to determine whether counterforce targeting would be possible if the potential enemy enlarged his fleet of missile-carrying submarines and improved the protection of his inland launching sites. In October 1964, over a year after General Taylor had raised the question, WSEG produced the final version of its study. Instead of offering conclusions on the validity of counterforce, the evaluation group accepted this strategy without comment and went on to discuss the number and total yield of nuclear weapons that should, under varying circumstances, be assigned to counterforce targets. The study failed to provide Gen. Earle G. Wheeler, Taylor's successor, the information originally desired.[21]

(U) Secretary McNamara, in the meantime, was gradually abandoning the counterforce theory, although he continued to acknowledge the probability that strategic forces could help limit damage to the United States in the event of nuclear war. In brief, he assigned to the nation's general war forces two goals: assured destruction and damage limitation. Assured destruction, according to the Defense Secretary's definition, was the ability to "deter deliberate nuclear attack upon the United States and its allies by maintaining . . . a highly reliable ability to inflict an unacceptable degree of damage upon any single aggressor or combination of aggressors, at any time during the course of a strategic nuclear exchange, even after absorbing a surprise first strike." Damage limitation he defined as simply the ability to limit damage to the United States and its allies in the event that deterrence failed.[22]

(U) For assured destruction, Mr. McNamara relied primarily on Minuteman, Titan II, and the Navy's Polaris, supplemented by manned bombers. He displayed confidence that assured destruction "would require only a portion of the ICBM's, submarine-launch missiles (SLBM's) and the manned bombers. . . ." The Secretary of Defense maintained, moreover, that this portion need not be very large, declaring by way of example that "the effective delivery of even one-fifth of the weapons on Soviet cities would destroy one-third of the total population and one-half the total industrial capacity of the Soviet Union."[23]

(U) Those strategic forces not required for assured destruction, if they could strike quickly enough, might to some degree limit damage to the United States by destroying the enemy's offensive bases. Genuine damage limitation, however, would require much more than a small striking force. Among the necessary elements, Mr. McNamara listed fallout shelters, ballistic missile defenses, defenses against submarine-launched ballistic missiles, and improved antiaircraft defenses. Should the United States embark on an elaborate damage limitation effort of this sort, Russia's "technical and economic capability" would, in Secretary McNamara's opinion, "prevent us from achieving a posture that would keep our fatalities below some tens of millions." This number could not be reduced, he explained, because the Soviet Union could increase its first strike capabilities at "substantially less than the extra cost to us of any damage limiting measures we might take." Although he doubted that the Soviet offensive potential could be completely neutralized, at least for the near future, he did acknowledge the feasibility of designing a comparatively cheap defensive system which would have a reasonably high probability of precluding major damage from Communist China in the 1970's.[24]

(U)[redacted] At the end of fiscal year 1966 counterforce seemed dead. The Secretary of Defense no longer talked in terms of maintaining strategic forces large enough to retaliate against exclusively military targets and still provide weapons enough to destroy, if necessary, urban industrial areas. Talk of giving the enemy an alternative to attacking cities gave way to discussions of providing a degree of protection to the urban populace through a combination of defensive weapons and fallout shelters. Several factors contributed to the demise of counterforce. There was, for example, no assurance that the enemy would limit himself to military targets if offered such an option, and, even if he did, it was considered almost impossible to hit essential military installations without endangering nearby cities. The principal objection, however, was that no amount of money could expand the strategic striking force enough to furnish adequate protection. As Secretary McNamara pointed out, "against the forces we expect the Soviet Union to have during the next decade, it will be virtually impossible for us to ensure anything approaching complete protection for our population, no matter how large the general war forces we were to provide . . . ." [25]

[redacted]

II. INSURING THE CONTINUED EFFECTIVENESS OF THE OPERATIONAL FORCE

(U)[redacted] To insure the effectiveness of the missile force, SAC conducted periodic operational readiness inspections and tests of its missiles and crews. During fiscal year 1965 the testing phase included a launch of a modified Minuteman ICBM from an inland operational site near Ellsworth AFB, S.D. The Air Force also investigated several possible innovations to improve the Minuteman system. One potentially serious problem given special attention was the vulnerability of Minuteman facilities to shock waves expected from nuclear detonations. A project was begun to harden the equipment to meet original design specifications of 1,000 psi (pounds per square inch) overpressure for the launch control facilities and 300 psi for the launchers.

Inspection and Testing

(U) Although Minuteman and Titan II were less complex than the recently retired Atlas and Titan I missiles, they nevertheless required highly trained specialists to man and service them. The cycle of training, inspection, and testing continued as before. Following individual training, carried out by the Air Training Command, SAC conducted operational readiness training to fashion technicians into skilled missile teams. Once these units had been formed, they underwent three additional types of training: combat crew upgrade training, which covered skills not normally tested in routine inspections; recurring training to maintain crew efficiency; and corrective training to remedy deficiencies turned up in readiness inspections.[1]

(U)[redacted] Operational readiness inspections were aimed at determining the combat effectiveness of missile units without having them launch their extremely expensive weapons. The inspections were designed for the particular system. For example, Titan II crews conducted a simulated launchings, and the inspectors determined whether the sequence of events would have resulted in a successful launch, a failure, or a delay. If a failure the crew had to demonstrate its ability to deal with the condition that caused it. Minuteman crews faced a thorough test of squadron communications as well as the kind of simulated launch performed with Titan II.[2]

[redacted]

(U) To prepare for these inspections, crews took part in various exercises to familiarize them with their missiles and how to launch them. In addition, missiles and related equipment were subjected to a series of maintenance inspections designed to keep them ready for immediate action.[3]

(u)[redacted] After trying for several years to obtain OSD permission to fire missiles from inland operational sites, the Air Force in November 1964 was authorized by Secretary McNamara to launch three Minuteman missiles, each with a dummy reentry vehicle and inert second and third stages to reduce the weapon's horizontal range to about 7,000 feet. The first of these was launched on 1 March 1965 by a crew of the 68th Strategic Missile Squadron of the 44th Strategic Missile Wing based at Ellsworth AFB, S. C. The test was a complete success. Later that year AFSC received instructions to conduct the remaining tests using two LGM-30F missiles. The first of the two was to have been launched in the fall of 1966 and the other in 1967,[4] but the first LGM-30F test was subsequently postponed until the summer of 1967.

(u)[redacted] While preparations were under way for these tests, the Air Force also drew up plans for long-range flights from operational sites into the Western Test Range (WTR). Secretary McNamara, although he recognized the desirability of such an undertaking, at the end of June 1966 still had not given his permission to carry it out.[5]

(u)[redacted] Since only one test launch had been made from an operational site, and that using a greatly modified Minuteman, tests conducted at Cape Kennedy, Fla. and Vandenberg AFB, Calif., remained the sources of the data upon which judgments of missile reliability were based. The data came from three categories of tests: demonstration and shakedown operations, which improved reliability and made certain that SAC had an operational system; operational tests, which determined reliability and accuracy; and follow-on operational tests (FOOT) that provided assurance of continuing reliability and accuracy.[6]

(u)[redacted] Operational tests began with the random selection of an operational missile at some inland site and its transportation to Vandenberg. There, after certain range safety and telemetry equipment was installed, it was maintained on alert for 10 days and then launched by its crew. In reports issued during 1964 and 1965, the Weapon Systems Evaluation Group questioned whether this procedure was adequate or realistic. On one occasion WSEG objected to keeping the test missiles on alert at Vandenberg for as long as 10 days; on another it warned that the Vandenberg launchings were not yielding information on warhead arming and fuzing. The Joint Chiefs of Staff (JCS) decided, however, that a minimum of 10 days on alert was necessary to insure proper calibration of the guidance system, which was necessary to produce valid data. As to WSEG's other objection, in May 1964 the JCS advised the group that the Air Force was developing and would install instruments for this purpose. [7]

(U) [redacted] The JCS apparently was referring to a program to launch reentry systems from which the fissionable material, but not the arming and fuzing circuits, had been removed. In its place, technicians installed instruments designed by the Atomic Energy Commission (AEC) to provide data on how the warhead, including its arming and fuzing mechanism, would have behaved during reentry. [8]

(U) [redacted] In February 1965 WSEG recommended that the number of alert missiles be reduced so that a higher percentage would be available for testing, inspection, and maintenance. It also advocated greater reliance on tests from operational sites in determining reliability factors. In reply, the JCS endorsed the existing practice of keeping as many weapons as possible on alert and reminded WSEG that SAC was planning tests from operational sites. [9]

(U) [redacted] Although the procedures for conducting operational tests remained unchanged, both follow-on testing and the uniform prediction system were modified. Since its adoption in 1963, the uniform prediction system had served as a means of assigning reliability factors to the various ballistic missile systems, based on the amount of testing successfully completed. These factors, in turn, were used in preparation of the single integrated operations plan (SIOP). Because both Minuteman I and Titan II were nearing completion of operational testing, the automatic assignment of reliability factors based solely on progress in testing seemed no longer adequate. As a result, the system was re-evaluated in the spring of 1965 and greater emphasis placed upon the judgment of those responsible for testing and employing the weapons. [10]

[redacted]

(U)[redacted] In January 1966 Secretary McNamara decreed a further departure from the original system and the conservative planning factors that it produced. He informed the JCS that "the best estimate of WSR [Weapon System Reliability], rather than a deliberate under-estimate should be used for SIOP targeting" so that "fewer weapons could be assigned per target and hence a longer list covered." [11]

(U)[redacted] Besides the radical revision of the uniform prediction system, the Secretary of Defense sought to modify the follow-on operational test programs for both Minuteman and Titan. The JCS in November 1964 had recommended the launching of 50 LGM-30B missiles annually from fiscal year 1966 through fiscal year 1969, and then 25 in 1970, final year of follow-on operational testing for this system. Between fiscal years 1968 and 1972, 25 LGM-30F's would also be launched each year. McNamara, however, felt these numbers were excessive. [12]

(U)[redacted] In September 1965 the Defense Secretary called upon the JCS to reduce the planned expenditure of missiles. The Joint Chiefs after reviewing their 1964 proposal, admitted that fewer follow-on operational tests might be "marginally adequate." For Titan II they recommended 6 launchings annually, for Wing VI Minuteman they recommended 15. They agreed to 16 LGM-30B firings in fiscal 1966, 30 in fiscal 1967, and 20 annually from fiscal 1968 through fiscal 1970. The follow-on operational tests of the force-modernized LGM-30F, they continued, should include 12 launchings in fiscal 1969, the number increasing by 6 each year until 30 were fired in fiscal 1972. [13]

(U)[redacted] Influenced by analyses done by his staff, Secretary McNamara felt the numbers recommended were still excessive and he continued to urge reductions in the follow-on tests. He maintained that "by relating sample size to desired confidence in estimates and by employing past as well as present FOOT failure data, sample size might be reduced to 20 [LGM-30F] missiles per year" for both Wing VI and modernized Minuteman. [14]

(U)[redacted] USAF headquarters expressed doubts that the number of tests could safely be reduced to this level. It insisted that 15 tests per year were necessary to insure the continuing

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reliability of the Wing VI weapons alone and recommended 10-12 tests of modernized Minuteman during fiscal 1969 with the number increasing as the modernized force grew larger. The viewpoint of the Secretary of Defense prevailed, however, and the USAF plan was not adopted.[15]

(U) [redacted] The follow-on operational test program selected by Secretary McNamara limited the LGM-30F launchings to 15 Wing VI models in fiscal 1968 and 20 per year thereafter, fixed at 6 the annual Titan II follow-on tests, and decreed that 16 LGM-30Bs would be expended in fiscal 1966, 30 in fiscal 1967, and 20 per year through fiscal 1970.[16]

(U) [redacted] In a related move to reduce costs, McNamara also decided that the original Titan II operational test program---which began at Vandenberg in March 1965 and called for a total of 25 firings--should be limited to 19 launchings. Secretary of the Air Force Harold Brown, who succeeded Zuckert on 1 October 1965, asked that the six tests be restored if fewer than 70 percent of the 19 were successful. As it turned out, when the scheduled launchings were completed 20 April 1966, 74 per cent had been successful and McNamara saw no need to expand his approved program.[17]

(U) [redacted] In connection with the Minuteman program, the Air Force sought OSD's approval to establish an engineering test facility at Hill AFB, Utah, "to insure operational integrity of the weapons system." In the proposed facility, engineers would be able to assemble and analyze the entire Minuteman system -- missile, launcher, control center, and all related equipment -- and assess the effectiveness of the whole and the impact of proposed changes to any of its components. McNamara was reluctant to approve this missile laboratory but he agreed after Dr. Brown had made a second request for funds. In planning the test center, which would require construction of a new launcher and launch control facility, the Air Force expected to use ground equipment already in stock, thus keeping costs to a minimum. Programmed for the undertaking were $200,000 for fiscal 1966, $13 million for the following year, and $3.5 million for fiscal 1968 for a total of $16.7 million.[18]

Major Problems and Their Solution

(U) During 1964-1965 Titan II underwent scheduled routine modifications to correct flaws that were detected in missile components, launch facilities, and other elements of the system. Two projects, Top Banana and Yard Fence, were established to improve the system to insure it would remain a useful part of the strategic inventory into the 1970's. The former, which was near completion by mid-1965, involved modifications to engines and hydraulic systems as well as alterations to silo doors and to propellant pressure switches. Yard Fence was a distantly related project aimed at increasing the reliability of installed equipment in and around the Titan silos. Neutron shielding and acoustical lining were to be added to protect the launch ducts and blast doors were to be repaired and fitted with new seals.[19]

(U) [redacted] During Yard Fence the worst tragedy in the history of the missile program occurred. On 9 August 1965, 53 employees of a civilian contractor died in a silo fire while working on a launcher of the 373rd Strategic Missile Squadron near Searcy, Ark. The Air Force immediately suspended work on five silos not yet completed and postponed modifications at 28 other sites where Yard Fence had not yet begun. In November, after the Secretary of the Air Force had approved a revised safety program, the work was resumed. Air Staff agencies estimated that the suspension, together with the adoption of time consuming safety procedures, would delay project completion from the fall of 1966 to late 1967.[20]

(U) [redacted] In addition to the above modifications, the Air Staff sought to remedy weaknesses in silo construction and, in general, to improve system survivability. It proposed, among other things, to eliminate "rattle space" within the silos, to add neutron shielding to silo caps in order to protect the missile guidance system, and to safeguard buried cables from another effect of nuclear weapons -- electromagnetic pulse. In September 1965 OSD approved expenditures of $12.2 million for the various improvements, $6 million in fiscal year 1966, and the remainder in the following fiscal year.[21]

(U) [redacted] The most serious ailment affecting the Titan II missile was recurring failure of the optisyn system -- a device in the inertial measurement unit that converted movements of elements of the stable platform into electric impulses for the guidance computer. Tests during 1964 indicated that light bulbs, which provided the illumination that triggered solar cells connected to the computer, were unable to take the punishment they encountered in normal service. To assure the titanium filaments in the bulbs retained their life expectancy, voltage was reduced and provision made for cooling the bulbs.[22]

(U) [redacted] Modifications to Minuteman and its launch complex also proved necessary. Early in 1965 USAF headquarters expressed concern that debris torn loose immediately after first-stage ignition might be swept upward in the geyser of hot gases and strike the missile as it was emerging from the silo. This potential problem was easily avoided. Since the silo tube itself proved resistant to damage, attention turned to components likely to be ripped from their mountings and these were secured more strongly.[23]

(U) [redacted] Tests conducted during the winter of 1964-1965 verified the effectiveness of previous changes made to Minuteman silo doors to prevent their being blocked by snow and ice. The solution, decided on during 1964, was to install a second gas generator unit that roughly doubled the amount of pressure that could be exerted and to provide a scraper to clear away drifts.[24]

(U) [redacted] Another difficulty caused by snow was silo flooding. At sites where drainage was poor, water from melting snow became trapped around the silo top and rose until it reached an exhaust port through which it could enter the launcher. To resolve this problem, the Air Force authorized construction of retaining walls and other changes to improve water drainage at the sites. Sump pumps at the launchers were modified, and this provided at least a partial answer to leakage.[25]

(U) [redacted] Progress also was made in reducing the number of false alarms emanating from the security system used in Wings II through V. Apparent cause of most of these were short circuits in the sensors that guarded against forcible entry to the silo and launch support building. Modifications in Wings IV and V reduced the average number of false alarms per week to between 20 and 30 per wing. A more thorough overhaul of the security systems in Wings II and III reduced the number to seven. By the summer of 1966, false alarms were no longer considered a problem.[26]

(U) [redacted] Another, more difficult security problem was not so easily resolved. As early as the summer of 1962, the Air Staff was made aware that the underground cables which carried reports of the status of individual missiles were accessible to intruders who might interject false signals into the system that would misrepresent the condition of a weapon. Since development of a lightweight system for tapping the cable and reproducing the impulses seemed unlikely at the time, no action was taken to encode status signals. By the end of 1963, however, the Ballistic Systems Division (BSD) had advised that it, and presumably any potential enemy, could produce just such a "spoofing" device. Out of this development and OSD insistence on the tightest possible control of Minuteman came a decision to encode status signals somewhat in the manner of "scrambled" telephone conversations.[27]

(U) [redacted] This decision applied only to modernized and improved Minuteman squadrons. Since modernization could not be accomplished simultaneously in all wings, it was evident that some would continue for a time to operate with the comparatively insecure cable. The National Security Agency (NSA) pointed out that encoding all Minuteman cable transmissions was required under policies promulgated late in 1963, but USAF headquarters could only reply that the situation eventually would be corrected, since a new flight and squadron authentication system was scheduled for installation on a unit-by-unit basis until all wings were modernized and equally secure. NSA, rather than insisting on disruption of the construction schedule, accepted a USAF plan which called for more careful surveillance against attempted penetration of cables in those squadrons not yet modernized.

(U) [redacted] During the summer of 1963 Minuteman missiles began experiencing the first of several failures of the hydraulic system during launch. The failures, which led to loss of control over the first-stage nozzle unit, appeared to stem from a valve containing a hollow metal pin that failed under the pressure pulse generated during the first few seconds of powered flight. A solid pin was fashioned to replace the defective part. As the exchange of pins was beginning, conclusive evidence emerged that the pins were failing under unexpectedly severe pressures attributable to the design of the suspension system, unique to Wing I. Replacement of the pins continued, but, with the exception of Wing I, as a routine improvement rather than as a vital repair. [29]

(U) [redacted] Of potentially graver consequence than these occasional valve failures was the discovery in July 1964 that certain Minuteman third-state motors were defective. They had been manufactured by a new process that permitted the insulation protecting the motor casing to buckle, so that hot gases from the burning propellant could consume portions of the casing, usually around the base of the nozzles. Of a 179 motors thus affected, 36 were expended in tests and the remainder repaired and returned to inventory. The repairs consisted primarily of using a better glue to secure the insulation to the motor liner. [30]

(U) But even as the old problems were solved, new ones arose, some of them defying quick solution. Among the latter were deficiencies in the Minuteman emergency power system involving a diesel driven generator. When commercial power failed, the generator was supposed to take over the job automatically. Combat crews, however, had no means of monitoring the operating condition of the diesels that turned the generators and these motors frequently failed because they were out of oil. In July 1965 Headquarters USAF authorized AFSC to negotiate a contract to increase oil and fuel capacity and remedy other flaws. [31]

(U) [redacted] Less than a week had passed before the weaknesses of the system were dramatically demonstrated. A temporary reduction in commercial current at a Wing IV silo triggered the emergency system, but the generator continued to operate after outside power had been restored. The resulting overload caused a short circuit that, if followed by a second electrical pulse, could conceivably have ignited the first stage. The guidance and control unit, however, would not have become activated, the second stage would not have ignited, and the missile would have crashed nearby. Experts believed there could not have been a nuclear explosion. [32]

(U) [redacted] The need to improve the emergency system became even more obvious during a blizzard in February 1966. In one wing, 77 unmanned launch facilities lost commercial power; at 30 the diesels failed to start automatically, and at 12 they shut down. In this same organization, 13 of 15 launch control facilities lost outside power, but the combat crews were able to start the diesels manually. These problems led to an intensified effort to improve and standardize emergency power units. [33]

(U) [redacted] The Air Force also ran into difficulties during the deployment of Wing VI. Although the first flight became operational in October 1965 as scheduled, the second flight was a month late. The loss of time could not be made up, and its squadron became operational in April 1966 rather than in March. Bad weather -- climaxed by 35 inches of snow during the week of 28 February -- hampered construction, and the springtime sequence of freeze and thaw disturbed benchmarks sited for the calibration of guidance and control units, making a new survey necessary. [34]

(U) [redacted] Another factor affecting Wing VI was the unexpectedly high failure rate of the N-17 guidance and control units used with the LGM-30F's. Investigation pointed to drastic changes in temperature as the probable cause of the failures. After being exposed to extreme cold while enroute to the operational area, the unit was brought quickly to operating temperature. Once warmed up, a guidance and control coolant was introduced into it to prevent circuits from over-heating. The abrupt application of the coolant, however, appeared to cause a "thermal shock" that distorted the very components the solution was supposed to protect. To correct this condition, the Air Force insisted on greater care in starting the units and directed several modifications to the unit itself, but the remedies were not immediately effective. By August 1966, concern at Headquarters USAF was increasing; BSD stopped installing the units in new missiles and reserved them solely to replace failed components in the 10 flights already deployed. This practice, if continued, would have delayed completion of Wing VI beyond December 1966, but the situation improved during the autumn so that the wing was finished on schedule.

Further Improvements to Minuteman

(U) [redacted] During 1964 Secretary McNamara began urging adoption of a new launch enable system for Minuteman. As originally proposed, this system would link SAC headquarters to the launch control facility thus giving the Commander-in-Chief SAC (CINCSAC) positive control over his missile force. At the control center, it would enable the combat crew commander to select, in accordance with instructions, from among four switches: enable, inhibit, lock and unlock. The first alerted the missiles for launch, the second cancelled the command to enable, the third prevented launch, and the fourth returned positive control to the combat crew. If the crew commander lost contact with higher headquarters, he could throw the lock switch and make SAC headquarters responsible for launching the missile. This portion of McNamara's proposed system came to be called the Launch Encoded Control System (LECS).[36]

(U) [redacted] The other part of the proposed system was the Launch Encoded Enable System (LEES) which would require positive action at the control console to enable the 10 missiles in a flight, in effect to issue them a preparatory command required prior to a launch command. In the original Minuteman design, interruption of a tone generated in the launch control facility alerted the entire flight and, in Secretary McNamara's opinion, opened the way to accidental launch in the event of a disruption of communications between control centers and launchers. With LEES, however, he felt the likelihood of accident would be far more remote since combat crews would have to send an encoded signal to alert the missiles for which they were responsible.[37]

(U) [redacted] The Air Force looked upon the entire proposal as an unnecessary burden to an already complex weapon system. Staff agencies complained that requiring a positive command from the launch control facilities would merely make them prime targets for enemy missiles. Unless some accompanying modification was made, they warned, knocking out the control center would temporarily paralyze the entire flight, thus reducing by nine-tenths (one control center rather than 10 widely separated launchers) the enemy's problem of targeting the Minuteman force.

McNamara nevertheless directed that LEES be incorporated in both improved and modernized Minuteman.[38]

(U) [redacted] Divorced from LECS, LEES was acceptable, if not expecially desirable, but the Air Force continued to oppose adoption of the remainder of the OSD proposal. McNamara himself came to agree that LECS was too complex a method of insuring against unauthorized launch in times of heightened international tensions, and in February 1965 he suggested an alternative. He proposed placing the enabling code in a safe equipped with a time lock. Normally, according to the Secretary's plan, higher headquarters would dispatch the coded signal to the combat crew commander, who could then perform the actions necessary to alert his flight and await order to launch. Should communications fail, possibly because a surprise attack had destroyed the higher headquarters, the time lock would be activated and after a specified delay the crew would be able to open the safe, retrieve the encoded command, and enable the flight.[39] McNamara directed the Air Force to investigate this proposal.

(U) [redacted] After studying this plan, the Air Force concluded it would only make the situation worse. On 15 June 1965 Secretary Zuckert advised OSD that he considered the existing safeguards against unauthorized launch as effective and adequate. The incorporation of either Secretary McNamara's proposed device or an electronic system for the same purpose would, he felt, "provide only marginal increase on insurance against unauthorized launch."[40]

(U) [redacted] The Secretary of Defense did not share this view and in September his deputy, Cyrus R. Vance, directed the Air Force to "design, develop, and install this mechanical time-delay-to-enable feature on one squadron of 50 Minuteman missiles," and authorized for $2.2 million for it.[41]

(U) [redacted] Still skeptical of the OSD plan, members of the Air Staff suggested an alternative electronic system -- dubbed Enable Command Timer (ECT)--which had been devised by BSD. ECT would cost more, its advocates admitted, but they believed it would be more reliable, simpler to operate, less bulky than a safe and better suited to eventual use with an airborne

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launch control center. The Air Force recommended to OSD that ECT be tested in place of the other method, and in March 1966 the Deputy Secretary of Defense agreed. He specified that the $2.2 million originally approved for a prototype mechanical system be used to develop and test an electronic device.[42]

(U) [redacted] The USAF plan called for the ECT to function throughout an entire wing. The command post would decide how long, up to 24 hours, each launch control center (LCC) would have to wait before enabling. Once the decision has been made, the command post would telephone the combat crews, telling them what coded information was to be placed on the ECT panels and what delays, also encoded, were to be inserted in the missile computer. The code thus remained in force until changed at the order of wing headquarters.
If cable communications within the wing should break down, a combat crew would be able to gain access to the code to enable its flight as soon as time had run out. Should communications be restored, an override feature would permit the wing command post to regain control.[43]

(U) [redacted] The override component of the electronic timing device appeared to offer an important advantage from the standpoint of protection against unauthorized launch. Should two LCC's conspire to sever communications, enable, and then "vote" to launch, the remaining launch control facilities in that squadron would be alerted that missiles were being enabled. Upon notifying wing, they would receive a code that would, in effect, cancel the enabling action. No such safeguard had been incorporated in the discarded mechanical system. At the end of June 1966 work on the Enable Command Timer was proceeding.[44]

(U) [redacted] In another area, the Air Force investigated a system which could eliminate the need for authorized personnel to visit each silo in order to change multiple target combinations or other codes. Known as remote secure data change, the system's basic elements included a targeting computer at the control facility and a secure communication link with the launchers. When operative, it would permit the crew to feet data provided by higher headquarters into the computer for transmission to, for example, the guidance and control mechanisms of a selected missile.[45]

[redacted]

[redacted]

(U) [redacted] In October 1965 the Ballistic Systems Division completed a series of studies that confirmed the theoretical value of remote secure data change to the Minuteman force. However, since additional engineering studies were in order, Secretary McNamara withheld permission to go ahead with development until the device had been proved feasible. [46]

(U) [redacted] The Air Force also investigated two possible techniques for acquiring information on whether its warheads had reached their targets. One of these techniques, originally favored by McNamara, involved a missile strike recorder.* This was a device to be carried by the reentry vehicle to signal its arrival in the target area, thus providing data for retargeting the remaining missiles. In its preliminary studies, the Air Force examined the possibility of installing small transmitters in a new multiple reentry system that was under development. Each of the system's independently targeted reentry vehicles would emit a signal capable of being picked up by equipment in the "bus" that had carried them toward their targets and relayed to a ground station in the United States.

(U) [redacted] During 1965, however, doubts arose that such a signal network was technologically possible and in February 1966 the Air Force suspended the program, not only because the proposed transmitter and antenna seemed too heavy for the reentry system with which it was to function, but also because they appeared unable to return sufficient data to the central controller. Meanwhile, the development of new sensors had made it feasible to rely on satellites for strike reporting and the idea of installing a transmitter in reentry vehicles was abandoned. [47]

(U) [redacted] The second technique for acquiring partial targeting informaton involved a trajectory accuracy prediction system, which would help determine whether a missile was on its intended course. System development began in 1964 with plans calling for the installation in each Minuteman of a transmitter designed to send a unique signal if guidance was accurate. These signals, received at each launch control facility in a squadron, would permit combat crews to reassign their remaining weapons to engage targets known to have escaped destruction because of guidance errors or malfunctions during powered flight.

(U) [redacted] Although elements of the Air Staff doubted the value of the device, since

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* Also called missile strike reporting system and warhead survival reporting system.

weapons accurately launched might nevertheless be intercepted and destroyed, OSD was reluctant to abandon it. The estimated cost of research and development tended, however, to discourage the system's supporters, for it rose from about $70 million to some $123 million and promised to go higher if a hardened antenna was incorporated in the design. As a result, the Director of Defense Research and Engineering (DDR&E) deferred the bulk of the fiscal 1967 research and development funds, directed AFSC to continue development "at a minimum rate," and finally, in the fall of 1966, cancelled the program.[48]

(U) [redacted] For a time the Air Force had pursued development of a high altitude fuze for the Mk-11A reentry system as a means of blacking out defensive radar by nuclear detonations outside the atmosphere. The Air Force and OSD believed that if it could be made availabe by December 1967, it would extend the useful life of the Mk-11A and thus provide insurance against delays in reentry development efforts. Unfortunately, work on the high altitude fuze (HAF) proceeded so slowly that OSD during the fall of 1965 became convinced that ground testing of a prototype would still be under way long after the 1967 deadline had passed. DDR&E therefore canceled the undertaking, noting that "future needs for a HAF capability will, of necessity, depend on the Mk-17 R/V program." SAC, however, continued to recommend acquisition of such a fuze in time for use with the Mk-11A.[49]

(U) [redacted] As the Air Force neared success in the development of an advanced reentry system that released three vehicles, each at a different target, it became apparent there also was a requirement to improve Minuteman's "memory," the N-17 guidance system. In December 1965 Headquarters USAF directed AFSC to begin work to increase the number of commands that could be stored in the guidance computer, thus enabling Minuteman to remember what had to be done to direct the warheads to the proper targets. The improvements were to be completed by July 1969, in time to meet the initial operational date of the new reentry system.[50]

(U) [redacted] Besides improving the capacity of the N-17 guidance computer and making other refinements, the Air Force sought to devise a more precise method of aligning the guidance and control mechanism at the operational site. To accomplish this, the Air Force requested installation of a portable gyrocompass to replace the optical system currently in use. Although McNamara in December 1965 rejected a request to develop the improved system, he invited further discussion of all factors that affected CEP's (circular errors probable). As a result, Secretary Brown reviewed for him the inadequacies of the optical method which, when used with the proposed Mk-17 reentry vehicle, could increase the CEP-- as influenced by the guidance system alone--from 1,324 feet to as much as 2,260 feet. He therefore recommended in June 1966--and Mr. McNamara later approved--the development and deployment, at an estimated cost of $9.6 million, of 56 portable gyrocompass units suited to Titan II as well as to Minuteman. [51]

(U)[redacted] During 1965 and 1966 work continued on development of the airborne launch control center to provide a backup facility should ground launch control centers be destroyed. Because radioed launch signals tended to follow the line of sight, several ALCC's would be required to cover the entire Minuteman force. The airborne facilities became even more important when it was discovered the Minuteman launch centers were unexpectedly vulnerable to ground shock from nuclear blasts.* In late 1965 Headquarters USAF ordered acceleration of the ALCC development, moving up its initial operational capability date from February 1968 to May 1967. A contract was awarded to the Boeing Company by December 1965. [52]

(U)[redacted] The continuing effort to improve Minuteman resulted in an alarming increase in costs. As early as September 1964, Secretary Zuckert noted that "RDT&E costs for Wing VI Minuteman have already more than doubled." He advised the Chief of Staff, Gen. Curtis E. LeMay, that, even though specific changes might originate with OSD, it was the responsibility of the Air Force "to analyze and evaluate total weapon system program impact and to provide these assessments to the Secretary of Defense including recommendations for alternative approaches where our findings indicate the desirability of such alternatives." Zuckert was apparently concerned that, among other things, the Air Staff was becoming a mere extension of OSD, at least in matters related to Minuteman. [53]

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* See below, p. 28

(u) [redacted] In July 1965, as the program change proposals for fiscal 1965 were being readied, Mr. Zuckert observed to the LeMay's successor, Gen. John P. McConnell, that his earlier call for a careful review of OSD-sponsored modifications had apparently gone unheeded. Minuteman funding for the five-year period beginning with fiscal 1965 had increased by $771 million over earlier projections. "One of my concerns," he told General McConnell, "is that we may price ourselves out of business." Once again he called for careful review. In his response, the Chief of Staff stated that the five-year program had been examined and some $440 million pared from it; the increase, he claimed, was unavoidable. [54]

Minuteman Survivability

(u) [redacted] While considering improvements in Minuteman, Headquarters USAF took steps to correct the unexpected softness of the launch and control facilities. A design review panel, which was organized in 1963, over a period of time identified some 40 "suspect areas" in Wings I through V, and further analysis disclosed that 27 items did not meet design speci-fications. Silo construction seemed basically sound, however; the fault lay in blast valves, pipes, and similar items that could not survive the ground shock produced by nuclear detonations. Instead of being able to survive overpressures up to 1,000 pounds per square inch, launch control facilities could withstand no more than about 125; launcher hardness, designed for 300 pounds per square inch, was rated at approximately 70. [55]

(u) [redacted] Immediately after BSD announced this revised estimate of Minuteman hardness in the summer of 1965, Secretary Zuckert directed a thorough investigation which shortly led to preparation of a plan to restore a satisfactory degree of protection -- 500 pounds per square inch for launch control facilities and 125 for launchers -- by remedying the most serious defects as quickly as possible. The proposed work would cost about $30 million and would concentrate on strengthening control facilities by 1969 and refurbishing the last of the launchers by 1972, which would coincide roughly with the planned completion of force moderni-zation. In August Zuckert approved this plan, together with a $34 million nuclear effects test program, and the two served as starting point for the survivability improvements formulated by his successor, Dr. Harold Brown. [56]

(U) [redacted] Brown wished to start at once to correct critical defects by spending about $30 million for that purpose and embarking on a series of hardness tests costing about $35 million to demonstrate the effectiveness of the planned "fixes." On 18 October he reported to OSD that corrective action would be taken "insofar as available funds permit." [57]

(U) [redacted] Secretary McNamara, however, felt the Air Force approach was too cautious. "It is absolutely essential," he declared, "to correct the hardness deficiencies... as soon as possible." He said the Air Force should spend "whatever funds are required," and he assured Dr. Brown that "if you do not have the authority to obtain the needed funds, please inform me of the additional amounts required and I will supply them." [58]

(U) [redacted] A task force appointed by the Chief of Staff convened late in October 1965 to review the problem in the light of Mr. McNamara's comments. On 5 November it produced a report upon which Dr. Brown based recommendations submitted to OSD on 13 November. The plan, which was accepted by Secretary McNamara, called for completion of essential repairs to silos and control centers by October 1968, achieving an initial operational date of May 1967 rather than February 1968 for the airborne launch control center, and accelerating simulation tests using concentrations of high explosives to produce ground shock comparable to that of nuclear devices. To pay for the "hardness fixes," Secretary McNamara included in the Minuteman program an additional $44.7 million for fiscal 1966 and $24.4 million for fiscal 1967. The amounts added for the hardness tests were $28.6 million in fiscal 1966 and $4.8 million for the following year. [59]

(U) [redacted] In the spring of 1966, however, a problem arose over scheduling the hardening work. To meet the deadline of October 1968, it would be necessary to take 155 missiles off alert for three months during the same quarter of 1967, with the monthly average afterward remaining at 85. The original estimate had been a peak of 100 weapons off alert and a monthly average of 60. The Air Force subsequently managed to avoid so severe a disruption of the force by making minor adjustments in the hardening schedule for three wings and postponing until October 1969 work of installing UHF receivers (for the ALCC) in Wing VI, the newest and most thoroughly hardened unit.[60]

(u) [redacted] Since atmospheric nuclear tests were prohibited by treaty, the Air Force, in order to determine the hardness of Minuteman facilities, resorted to chemical explosives to simulate the rolling ground shock characteristic of nuclear detonations. This technique had been used successfully in scale-model tests and was now applied to silos and control facilities that incorporated modifications called for in the hardness restoration program . A full-scale test, using the high explosive simulation technique (HEST), required that a plywood platform be built directly over the structure being tested. This "roof", covered with a deep layer of dirt, concealed a frame upon which was fitted a grid of primacord. Progressive detonation of the explosive cord produced a rolling shock wave, and the earth covered plywood prevented the pressure from escaping upward. Engineers believed they could in this way produce overpressure as great as 1,000 pounds per square inch that would behave in much the same fashion as a shock wave caused by a nuclear device.[61]

(u) [redacted] The first test, conducted on 1 December 1965 at a launcher near Warren AFB, Wyo. generated overpressures estimated at 300 pounds per square inch but did no serious damage to the silo. This success led to a revision of the HEST schedule. The first test of a launch control facility, originally set for April 1966, was postponed until July, but the overpressure to which the structure would be subjected was increased from 600 to 1,000 pounds per square inch. Preliminary analysis indicated that this detonation, on 22 July, did not disrupt the ability of the control center to receive, process, and transmit commands.[62]

(u) [redacted] In this connection, the Minuteman contractor also made plans for a possible nuclear test of the system's survivability in the event the test ban treaty was lifted. According to the Boeing Company proposal, a missile with only a small amount of propellant would be installed in an especially constructed complex either at the Nevada test site or in some remote part of Alaska. A nuclear device would be detonated nearby, and the launch control center would making minor adjustments in the hardening schedule for three wings and postponing until October 1969 work of installing UHF receivers (for the ALCC) in Wing VI, the newest and most thoroughly hardened unit.[60]

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III. REENTRY SYSTEMS AND PENETRATION AIDS

(U) All USAF research into ballistic reentry was conducted through the Advanced Ballistic Reentry Systems (ABRES) program. While not oriented toward a particular ballistic missile system, it investigated techniques certain to be incorporated in all future ICBM's. Besides conducting this general research, the Air Force worked on several new reentry systems, all of them rooted in the ABRES effort, and pursued developments to perfect penetration aids and nuclear effects shielding for use on ICBM's and other vehicles.

The Advanced Ballistic Reentry Systems Program

(u) [redacted] In 1963 the ABRES program became a national effort to investigate the characteristics of the optical and radar wakes left by reentry vehicles, the forces acting upon those vehicles, and penetration aids including chaff, decoys, and the ability of a reentry vehicle to maneuver. By the early summer of 1965, ABRES had begun producing results both in reentry technology and in the general improvement of vehicle design. This progress heralded a change in financing. As Secretary McNamara pointed out, "many of the early ABRES advanced development activities can now be expected to move into the engineering and operational categories." As a result, ABRES funds could be cut since the cost of further development would be absorbed in individual programs. An example of this sort of change was the transfer of $6 million in fiscal 1966 ABRES funds to the Minuteman account for development of penetration aids for new reentry vehicles to be used with that system. This transaction reduced the amount available for ABRES from $154 million to $148 million.[1]

(u) ABRES [redacted] encompassed several complex technical investigations that gave birth to a host of acronyms. Among the titles in vogue during 1965-1966 were: WAC (wake analysis and control), which was an investigation of the characteristic plume left by reentry vehicles and discernible by both radar and optical instruments; LORV (low observable reentry vehicles), a series of tests designed to show how to reduce radar profiles; and SCOPE (system configuration and performance evaluation), the name of which was self explanatory.

[redacted]

Of particular importance was the combined reentry effort on small systems (CRESS), an undertaking scheduled for completion in 1967 in which some 30,000 possible designs for vehicles weighing less than 300 pounds had already been examined and reduced to 30 basic types. [2]

(U) [redacted] Also noteworthy was a maneuvering reentry technology investigation (MARTI), an attempt to establish the feasibility of a maneuvering reentry vehicle. Flight tests of a prototype maneuvering ballistic reentry vehicle (MBRV) was delayed repeatedly because its guidance computer did not survive vibration tests. A test finally took place in August 1966, only to fail because the booster engine shut down too soon after liftoff. Another maneuverable prototype was the boost-glide reentry vehicle (BGRV) which was to follow a ballistic track part way to the target and then glide through the atmosphere for the remaining distance. A simulated BGRV was being readied during the summer of 1966 for test with an Atlas booster. [3]

(U) [redacted] Activities within the ABRES program changed as new problems arose to take the place of those that had been resolved. Thus, for example, experiments with lightweight vehicles proved their feasibility but also demonstrated their susceptibility to roll resonance, a phenomenon -- believed caused by uneven melting of the ablative shield -- that set up vibrations capable of wrenching the vehicle apart. An inquiry into the causes of roll reconance and the ways it could be prevented became part of the ABRES program. [4]

(U) [redacted] By the end of 1964 two sites were being used for ABRES launchings. The Ballistic Systems Division decided in September of that year to transfer to Vandenberg AFB activities formerly carried out at the Eastern Test Range (ETR). Large boosters, such as surplus Atlas missiles, hurled instrumented reentry vehicles from Vandenberg toward Kwajalein Atoll. [5]

(U) [redacted] The second ABRES site was Green River, Utah, from which four-stage solid-propellant Athena rockets launched scale models of reentry vehicles down a range stretching to White Sands, N.M. The first dozen Athena launchings, beginning with the initial flight on

10 February 1964, were generally unsuccessful, due to various technical and procedural difficulties. However, the rate of launch successes increased dramatically in the second half of calendar year 1965 and by the end of June 1966, about 30 of the 46 launchings had been judged successful.[6]

(U)[redacted] Although it was satisfied with ABRES, in late 1965 Headquarters USAF formed a group of "devil's advocates," headed by Maj. Gen. A. J. Kinney, Assistant Deputy Chief of Staff, Research and Development, to examine every aspect of the program. In January 1966 the group reported it had turned up a number of weaknesses. The general and his colleagues recommended that "a much higher priority... be given to multiwarhead technology" and that increased emphasis be placed on the "development of effective decoys." They also maintained that too much effort was being expended on maneuvering vehicles. In general, however, their verdict was favorable. They found that "the ABRES program provides a broad and probably adequate base of reentry technology for the future." The difficulty lay in "translation of this technology into operational capabilities on a timely basis."[7]

The Development of New Reentry Vehicles

(U)[redacted] Of the new reentry vehicles the Air Force was interested in, three seemed certain to join the operational force. They were: the Mk-12, capable of directing up to three warheads at different targets; the Mk-18, small enough to be employed in clusters; and the Mk-17, a more conventional vehicle designed for the precise delivery of a high-yield warhead.

[redacted] During 1962 the Air Force had considered developing both a heavy and light version of the Mk-12.

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Such a weapon, he pointed out, might be used by several missile systems, including a mobile mid-range weapon then under study, or in clusters by the powerful Titan II. The heavy Mk-12, after being redesignated as Mk-16, was eventually dropped.[8]

(u) [redacted] In March 1964 Dr. Alexander Flax, Assistant Secretary of the Air Force (Research and Development) called upon the Air Staff to evaluate the use of clustered Mk-12's as a penetration aid. * The resulting study indicated that decoys, chaff, or "precursor bursts"--the detonation of missile warheads to disrupt defensive radar and other electronics -- were more effective than clusters of Mk-12's. Dr. Flax, however, retained an interest in the use of multiple warheads. [9]

(u) [redacted] Other USAF investigations, meanwhile, led to consideration of a Mk-12 carrying several warheads, each of which could be directed at a different target. At first, the idea was to employ a multiple independently targeted reentry vehicle (MIRV) against hardened targets such as separate sites within a missile complex, but it was apparent that to destroy these would require either unattainable accuracy or a larger warhead than Mk-12 could accomodate. Enlarging the warhead would result in a heavier reentry vehicle and carrier, and these in turn would require a missile more powerful than Minuteman. Although the future of the Mk-12 for a time looked bleak, further study disclosed that almost two-thirds of the so-called "time urgent" targets were soft. This discovery, according to the Scientific Advisory Board's Nuclear Panel, changed the picture drastically; the Minuteman became acceptable, and it was not deemed necessary to improve accuracy "beyond that expected with Minuteman II." [10]

[redacted] In July 1964 DDR&E requested that the Air Force furnish him information on a Mk-12 design that would permit the independent targeting of three warheads carried by a single Minuteman.

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The decision was made to accept some sacrifice in yield in order to meet weight specifications. [11]

(u) [redacted] This compromise cleared the way for development of the Mk-12 MIRV. According to this concept, Minuteman II would propel, on a ballistic track, a "bus" equipped with its own guidance and control and housing three Mk-12 warheads. Once the bus had separated from the third stage, a so-called post boost control system would position the Mk-12 carrier so that it

* See discussion of penetration aids, page 38.

could eject in succession, the three warheads. In this fashion, one Minuteman could engage three separate targets within an eliptical area 50 miles across and extending 200 miles down range.[12]

(u) [redacted] The Mk-12 research and development effort by January 1965 had produced a satisfactory post boost control system. Low thrust, liquid fueled rockets proved adequate to the task of adjusting the position of the carrier for the release of each reentry vehicle. AFSC favored perfecting this design, but at the same time it wanted to develop a solid fueled system which offered improved reliability, although it posed a greater technological challenge.[13] Secretary McNamara when he approved Mk-12 development had called for an initial operational capability of January 1969. In March 1966, however, he approved postponement of the operational date to July 1969, at which time the new Minuteman III also would become available.[14]

(u) [redacted] Mk-12 testing got off to a disappointing start. On 17 March 1966 the first Mk-12 was launched from Vandenberg AFB aboard a Minuteman II missile. Unfortunately it broke up as it was plunging toward the designated impact area. Instrument readings indicated that tumble rockets, designed to propel the reentry vehicle clear of the third stage, failed to fire so that exhaust from a third-stage retro rocket struck the Mk-12, causing it to tumble, reenter the atmosphere at the wrong angle, and generate heat intense enough to cause the ablative shield to peel rather than melt evenly. At about 26,000 feet, the nose cap collapsed, and the vehicle disintegrated. Other test launchings were planned.[15]

(u) [redacted] Approval in April 1966 of the Navy's development of Mk-3 for the Poseidon, successor to Polaris missile, raised the question whether the AEC could provide all the necessary fissionable materials for the various systems being developed. For a time the Air Force hoped that Mk-18 could become the subject of a joint effort with the Navy that would produce a vehicle suited to both Minuteman and Poseidon. The Navy, however, intended from the outset to incorporate in its system a beryllium heat shield that could not cope with the heat and stress imposed on it by the more powerful ICBM. As a result, Secretary Brown on 28 June 1966 approved development of a Mk-18 independently of the Navy's Mk-3 but proposed that Lockheed, the Mk-3 contractor, be invited to compete for the Mk-18 contract. He noted that roll resonance might complicate the Mk-18 effort, since this effect seemed to grow more critical as vehicle size decreased.[18]

[redacted] The third reentry vehicle, the Mk-17, was an attempt to provide Minuteman with a means of destroying hardened targets. This system replaced the heavy Mk-12 which had been redesignated Mk-16, studied, and dropped.

(The weight was later reduced to 900 pounds.) In December 1964 McNamara earmarked $1 million to begin work on the system. The following March he approved, subject to the results of project definition, the development of a Mk-17 suited to both Poseidon and Minuteman and released funds already authorized.[19]

[redacted] Final OSD approval for Mk-17 development came in March 1966. Specifications had changed very little since the beginning of project definition.

Initial plans called for the deployment of 700 Mk-17 reentry systems with the major portion of the operational Minuteman force; the remaining 300 missiles would be equipped with Mk-12's.[20]

[redacted] To permit precision guidance through reentry maneuvers of 100 g's, and thus avoid interception at no cost in weapon system accuracy, the Air Force in late 1963 began development of a new guidance system called SABRE (self-aligning boost and reentry). By January 1966 the Instrumentation Laboratory, Massachusetts Institute of Technology (M. I. T.), had completed work on the first of three prototype inertial measurement units (IMU's) which was integrated with a Univac 1824 computer.

[redacted] On 3 January, the Air Force invited contractors to submit bids for various IMU design and engineering studies as well as for fabrication of two ground-test units. In April competitive contracts were awarded to A. C. Electronics and the Autonetics Division of North

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American Aviation. Funding for system development, originally set at $15 million for fiscal year 1967, was cut back in early 1966 to $13 million, and this was expected to slow the pace of the work. [21]

Penetration Aids

(u) [redacted] By mid-1965 elements of the operational force were being equipped with rudimentary penetration aids. Titan II had mid-course and terminal decoys that simulated the radar image of its Mk-6 reentry vehicle. Some Minuteman I missiles in Wings II through IV were fitted with retro and tumble rockets to insure separation of the final stage from the Mk-11 reentry vehicle and prevent the former from being used by enemy radar as an offset aiming point. [22]

(u) [redacted] Although these aids were crude, they were considered adequate for the time being. Efforts to acquire more advanced aids were pursued as part of ABRES but progress was so slow that Dr. Brown, then DDR&E, in May 1965 and again in June expressed concern about the leisurely pace. He finally directed the Air Force to submit a program for the production of penetration aids suited to both Mk-11A and, if possible, the new Mk-17. A program package was submitted to OSD in September. [23]

(u) [redacted] Subsequently, on the basis of analyses of possible defenses against USAF ballistic missiles, Secretary McNamara directed the Air Force to initiate "an urgent, orderly [penetration aids] development program including an option to produce and [leading to] a production decision early in FY 67." Out of the Secretary's instructions came a plan to develop two penetration systems, both for Minuteman. A USAF proposal to add chaff and dispensers to the Titan fleet was rejected because of the inherent vulnerability of the Mk-6 reentry vehicle to defensive weapons. [21]

(u) [redacted] The two systems placed under development for Minuteman were Mk-1 and Mk-12. Mk-1, which met the requirements of both the Mk-11A and Mk-17 reentry vehicles, would emit nine large clouds of light chaff at intervals of 50 nautical miles during descent prior to reentry. The clouds would be dense enough to conceal both the vehicle and its booster from defensive radar. The initial operational capability for Mk-1 was scheduled for January 1968. The penetration aid planned for the Mk-12 reentry vehicle would deploy heavy chaff at intervals of 15 nautical miles down to 200,000 feet. Decoys also were being developed to confuse terminal defenses. Initial operational capability for Mk-12 was July 1969. [25]

(U) [redacted] The penetration aids program came under frequent review. In March 1966 Dr. John S. Foster, Jr., Dr. Brown's successor as DDR&E, called upon the Air Force to investigate interim measures for countering a Soviet ballistic missile defense that might be deployed around key targets, such as Moscow and Leningrad, as early as 1968. Dr. Foster had in mind modifications that would lower the altitude at which the Mk-11A could be picked up by enemy radar. Proposed changes included nuclear blackout of the radar--which actually belonged under tactics rather than equipment--together with the use of heavier chaff, decoys, or electronic countermeasures. [26]

(U) [redacted] his response Secretary Brown pointed out that the Soviet threat, though it might be effective against Mk-11A, would be of no value against Mk-12. The problem, therefore, would be eliminated when the newer reentry system became operational in 1969. For the interim, Dr. Brown favored tactical innovations -- such as precursor bursts or saturation fo enemy defenses -- rather than development of new equipment for the Mk-11A. [27]

Warhead Survivability

(U) [redacted] In order to survive defensive detonations and destroy their intended targets, USAF reentry systems had to have protection against four nuclear effects: prompt gamma rays, neutrons, electromagnetic pulse, and "soft" and "hot" x-rays. Prompt gamma rays emanating from nuclear blasts introduced currents that caused false guidance signals, while neutrons could damage the components of electronic subsystems. Electromagnetic pulse burned out wires and transistors by causing violent surges of electrical current that might also confuse the guidance system. Soft x-rays could cause the peeling or buckling of heat shields. Hot x-rays could vaporize a heat shield, erase memory drums that carried arming information, or

[redacted]

burn out circuits within the vehicle and thus cause false guidance commands. During 1965-1966 the Air Force was most concerned with protection against hot x-rays which, when caused by nuclear bursts outside the atmosphere, were believed effective for hundreds of kilometers.[28]

[redacted] Early in May 1964 the Air Force proposed that the Minuteman N-17 guidance and control system be given adequate protection against x-rays from nuclear detonations. The Secretary of Defense replied that he did not consider this sort of hardening necessary as yet. He requested further studies of the likelihood of Russia successfully developing and deploying a defensive system using enhanced high energy x-rays, however, and these studies caused him to change his mind. In October 1964 an AFSC study of this subject was submitted to DDR&E, and it led to OSD approval of steps to protect Minuteman reentry systems against x-rays.

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(U) [redacted] To finance this effort, the Assistant Secretary of the Air Force (Research and Development) requested $3.5 million from OSD to begin work during fiscal 1965. However, DDR&E, rather than draw from the department's emergency funds, directed the Air Force to use some of the $9.5 million previously programmed for the N-17 guidance and control system.[30]

(U) [redacted] The question of the survivability and vulnerability of USAF missile system continued to trouble top USAF and OSD officials, who felt that the response to the problem had been sporadic. In October 1965 Headquarters USAF established a focal point within the Directorate of Operational Requirements and Development Planning for monitoring these survivability efforts. AFSC was directed to undertake additional studies. On 5 November 1965 General Schriever advised General McConnell that he would establish an Assistant for Survivability within his headquarters to begin intensive investigations.[31]

(U) [redacted] Subsequently, AFSC's Ballistic Systems Division prepared a comprehensive study on Minuteman and Titan II system survivability. As a result of this study and its evaluation in

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Headquarters USAF in April 1966, BSD revised hardness criteria, increased the recommended hardness of the advanced ICBM, and changed shielding materials on Minuteman II. On 11 February 1966 AFSC also submitted a five-volume study on the effects of hot x-ray weapons on current and future weapon systems which became the basis for planning future hardening activities.[32]

[redacted] In late 1965 Secretary McNamara released funds for an underground test of Mk-11A survivability and also approved further hardening of the new Mk-12 and Mk-17.

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Although data were not immediately available on how the N-17 guidance unit had fared, preliminary indications were that the blast had been as powerful as planned and that the measuring instruments had worked properly.[33]

IV. MISSILE DEVELOPMENT PROGRAMS

(U) Even as it supervised the modernization and improvement of Minuteman and development of advanced reentry vehicles, the Air Force engaged in a search for new missiles to complement the existing force or, possibly, to replace it. Among the proposals considered during fiscal years 1965 and 1966 was an air transportable missile and a mobile mid-range missile, but neither was pursued beyond preliminary studies. The major research and development efforts that gained approval were Minuteman III, an advanced ICBM sometimes called the improved capability missile (ICM), and a short-range attack missile (SRAM).

The Proposed Flexible Theater Missile

(u)[redacted] During the first half of fiscal year 1965 AFSC sponsored a study of a transportable mid-range ballistic missile that could be deployed by air, moved into firing position by road, and quickly made ready for action. The purpose of the study, undertaken at the request of DDR&E, was to determine if a transportable weapon, consisting of Minuteman second and third stages, was the equal of the recently proposed mobile mid-range ballistic missile.* The study concluded that the transportable missile offered no unique advantage, the several reviewing agencies and commands agreed, and DDR&E concurred that such a system would be of no use to the Air Force.[1]

(u)[redacted] The war in Vietnam and China's detonation of a nuclear device revived interest in the mobile mid-range ballistic missile. Originally this weapon had been considered primarily for use by the North Atlantic Treaty Organization (NATO) and discarded largely because member nations showed so little interest. Early in 1965, however, Secretary McNamara raised the question of deploying this kind of system to the Far East. The Air Force reacted by examining several existing or potential weapon systems, stressing their suitability for operations in the Orient.[2]

(u)[redacted] The resulting study concluded that, although Polaris A-1 could serve for the time

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* See Nalty, USAF Ballistic Missiles, 1962-1964, pp 59-67.

being, the flexible theater missile should be developed for deployment to the Far East. The preliminary technical development plan for this weapon proposed a two-stage, solid-fueled booster capable of delivering either nuclear or high explosive warheads at a maximum range of 2,000 nautical miles. The missile system described in the plan would be mounted on a transporter-launcher able to negotiate primary or secondary roads. [3]

(U) [redacted] Despite an endorsement by General Schriever, the Air Force Council decided to shelve the proposed flexible theater missile. The AFSC commander urged development of the weapon for its military value and also in order to forestall an Army attempt to reserve the Far East for its Pershing missile, but his colleagues on the council decided against recommending development lest the project bleed funds from more important work. AFSC continued, nevertheless, to study the general topic of mid-range missiles. [4]

Minuteman III

(U) [redacted] Minuteman III was the result of several improvements to the basic Minuteman design. In November 1965 Secretary McNamara first suggested that adoption of the Mk-12 reentry vehicle justified treating the weapon system as something unique. In a memorandum to Secretary Brown, he said the "Minuteman missile equipped with the multiple reentry vehicle and other changes associated with that warhead is so much more effective and carries much more destructive power that I believe we should give serious consideration to giving it a new name." Brown replied that, though he saw no real need for a new name, Minuteman III would give an accurate description of the combination of missile and reentry vehicle. On the basis of this agreement the term Minuteman III was adopted in December 1965 to apply to those missiles that would be equipped with the Mk-12, while those equipped with either the Mk-11A or the proposed Mk-17 continued to be called Minuteman II. [5]

(U) [redacted] The Air Staff, meanwhile, had been considering an AFSC recommendation, first submitted in June 1965, to develop a more powerful third stage for Minuteman. AFSC said the motor was needed because of weight increases brought on by additions to the system, such as adoption of Mk-12, the emphasis on penetration aids, and the need to provide shielding against the effects of nuclear detonations. The AFSC proposal encountered opposition with the Air Staff. The Director of Production and Programming, Maj. Gen. Harry E. Goldsworthy, suggested in November 1965 that "at this juncture a more pronounced attitude in opposition to further Minuteman change should be adopted." He urged his superior, Lt. Gen. Thomas P. Gerrity, Deputy Chief of Staff, Systems and Logistics, to examine carefully each proposed modification in order to determine its probable impact on the development of an advanced ICBM (discussed below). "We feel," General Goldsworthy declared, "that our resources should be conserved in the interest of protecting the advanced ICBM effort." General Gerrity shared this view. The Air Staff Board subsequently recommended against this further modification of Minuteman and Secretary Brown on 26 February 1966 advised OSD against developing the new third stage.[6]

(u) [redacted] During the discussion that led to Secretary Brown's recommendation, General Schriever had favored requesting funds for both development of the new third stage and for preliminary work on the advanced ICBM. He said he was not convinced that the advanced weapon had to be purchased at the expense of Minuteman. His position, supported by a minority of the Air Staff, coincided with OSD's determination to exploit Minuteman to the fullest before replacing it with a new missile. After further discussions of the subject between representatives of the Air Force and OSD, Secretary Brown on 19 March recommended OSD waive contract definition so that production of an improved third stage could begin as quickly as possible. In his memorandum to OSD, Brown also endorsed the importance of developing an advanced missile and stated that modification of Minuteman should not jeopardize this undertaking.[7]

(U) [redacted] Dr. Foster, the defense research director, agreed that enough preliminary work had been done in connection with advanced ICBM technology to permit waiving contract definition. On 26 March Deputy Secretary Vance approved development of an improved third stage. Plans called for attainment of an initial operational capability in July 1969.[8]

(U) [redacted] Following the decision to add the improved third stage, the term Minuteman III had to be redefined. In May 1966 OSD agreed that Minuteman III consisted of the LGM-30G missile (the first and second stages of Minuteman F and the improved third stage), a post-boost vehicle, and either the Mk-12, Mk-17, or Mk-18 reentry vehicle. The post-boost vehicle consisted of a control system (containing guidance and propulsion subsystems) and a universal reentry system suitable for housing various reentry vehicles and their penetration aids. The Air Force also was to make provision for the possible future incorporation of the trajectory accuracy prediction system, since that program had not yet been halted. [9]

An Advanced ICBM

(U) [redacted] For several years up until late 1961, the Air Force had worked on developing a mobile Minuteman to be launched from railroad trains deployed at reinforced sidings in the western United States. For various reasons -- problems of weight and safety among them -- OSD canceled this program on 14 December 1961. The decision made available $10 million in fiscal year 1963 funds for USAF research that would contribute to an advanced type of ICBM. The new undertaking emphasized technology that could be incorporated in a successor to Minuteman. Among the subjects selected for study were: "cold launch," a means of ejecting a missile from its silo before first-stage ignition using compressed gases -- the so-called "air elevator"; high energy propellants; and improved guidance, including a system capable of remaining dormant for a long period of time with no appreciable sacrifice in accuracy. [10]

(U) [redacted] Subsequent financing for these advanced ICBM studies proved somewhat erratic. Although OSD approved the expenditure of $15.5 million for fiscal year 1964 and $15 million for fiscal year 1965, the amounts actually released were $8 million and $3 million, respectively. Fiscal year 1966 allocations were reduced from $10 million to $5 million despite objections by the Dr. Flox. Although the Air Force wanted $10 million for fiscal year 1967, the $5 million ceiling appeared likely to remain in effect. [11]

(U) [redacted] Despite the uncertain funding and comparatively small amounts actually invested, the advanced technology program produced notable dividends. It resulted, for example, in a successful demonstration of cold launch on 25 June 1965, when a tethered 300,000 pound dummy missile was ejected from a modified Minuteman silo at Edwards AFB, Calif. By adopting this technique, the missile could occupy almost all the space within the silo; without it, room had to be left to accomodate the gases generated by the burning propellant of the first stage. Also progress was made toward acquiring an inertial guidance system that could be activated almost instantly after remaining untended for a long time, and toward increasing the efficiency of solid motors by mixing metal additives with the propellant. In addition, scientists devised a technique which used a framework of propellant-coated wire to support a missile fiberglass casing, thus increasing the ratio of propellant weight to total motor weight.[12]

(U) [redacted] During the summer of 1965 the Air Force Systems Command, which had been sponsoring the advanced technology effort, surveyed the possible Soviet threat during 1970-1975 and concluded that a powerful ICBM capable of propelling 5,000 pounds or more of payload should be developed and deployed with mobile launchers or at sites hardened against nuclear attack. The use of mobile launchers would lessen the danger from multiple reentry vehicles, and the greater lifting power would permit the use of elaborate penetration aids and multiple warheads, either independently targeted or in clusters. Headquarters USAF studies that addressed the future Russian threat also concluded that Minuteman would have to be replaced by a more powerful missile, a mobile system that would become available in fiscal year 1973.[13]

(U) [redacted] Early in 1966 Secretary Brown directed the Air Staff to waste no time in formulating a concept for this advanced system. He expressed concern that delay might result in missing the fiscal year 1968 budget deadline, a failure that would jeopardize the proposed operational date. Dr. Brown also reminded the Air Staff that "1,000 psi was not a magic figure" for system hardness and he asked for a comparison of the advantages of that degree of protection against those afforded by 300 pounds per square inch.[14]

(u)[redacted] The time in which the new system had to be developed was further compressed on 22 March 1966, when DDR&E gave informal notice that contract definition, for which the Air Force wanted $4.5 million in fiscal 1967, would not be approved. Regardless of how thoroughly the Air Force set forth its ideas, the only advanced ICBM funds released by OSD would be for studies and technical development. If the Air Force was to attain an initial operational capability in 1973, which Secretary Brown desired, a preliminary technical development plan would have to be completed during the summer of 1966, so that there would be ample time to request funds for contract definition in the fiscal year 1968 budget submission.[15]

(u)[redacted] In April 1966 the Air Force set about defining the desired characteristics of the new missile. By June analysts had compared the various degrees of hardness and decided that protection against overpressures of 1,000 pounds per square inch was worth the additional cost. Further protection might be provided by the Army's anti-missile batteries, a possibility suggested by Secretary McNamara. Although the preliminary USAF plan called for deploying the Advanced ICBM in silos, it also provided for mounting the weapon on a transporter-launcher for mobile land operations. The Air Force visualized a missile capable of propelling 7,000 pounds a distance of 5,500 nautical miles and achieving a CEP of .2 nautical miles. At the end of June 1966, the Ballistic Systems Division was preparing a system package plan.[16]

The Short Range Attack Missile

(u)[redacted] Early in 1963 the Air Force closed its books on Skybolt, an air-launched, medium range (about 1,150 miles) ballistic missile intended for use by B-52 bombers. Secretary McNamara's cancellation of this development on 31 December 1962 marked the end of a USAF effort of several years' duration. Beginning in 1963 the Air Force turned its attention to development of a short range attack missile that could be adapted to the B-52 as well as to the proposed advanced manned strategic aircraft (AMSA). After an intensive study by Project Forecast of future USAF requirements, conducted in the spring and summer of 1963, General Schriever, the project

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director, in early 1964 recommended to Secretary Zuckert that the Air Force begin development of both the advanced bomber and the SRAM.

[redacted] In May 1964, on the basis of additional studies by AFSC, Zuckert submitted a program change proposal to OSD calling for development of a "short range air-to-surface missile which can outrange enemy surface-to-air low altitude defenses and which will be effective against either soft or medium hard targets or against the defense when improved penetration capability is required." Desired range was 40 to 60 miles, enough to insure that the missile, when launched at low altitude, would arrive before the plane that carried it came within radar range of the target.

A high explosive warhead also was under consideration, primarily for attacking radar sites.[17]

[redacted] On 31 October 1964 Secretary McNamara responded by requesting the Air Force to undertake further studies of the proposed missile's survivability against likely enemy defenses and of cost effectiveness. He also cautioned the Air Force against possible duplication of the Navy's effort to develop a low altitude attack missile. After doing additional work, in January 1965 1965 the Air Force submitted a new request to begin project definition which triggered a lengthy discussion that clarified SRAM's characteristics. The Air Force maintained that the missile should be capable of three trajectories: low level, with a range of about 20 miles; skip, in which the missile followed a ballistic track that terminated just short of the target, restarted its motor, and continued at low altitude; and ballistic which, like skip, gave a range of about 45 miles. The skip trajectory was designed to meet objections that a ballistic path would be vulnerable to antimissile systems deployed against ICBM's. On 23 March Secretary McNamara accepted the idea of three trajectories which, in his opinion, helped SRAM "present the defender a threat that is significantly different from the ballistic re-entry threat."

[redacted] During this discussion DDR&E questioned the feasibility of using a radar homing device on SRAM. He thought that the homing system would be unable to distinguish among

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various sources of radar waves and that the weapon was likely either to destroy the first radar it chanced upon rather than the one -- perhaps several miles distant -- at which it was aimed, or become so confused in the maelstrom of radar waves that it would crash out of control. Whereupon, Secretary McNamara deleted the requirement for radar homing; however, he directed that space be left within the weapon to accomodate such a system if a suitable one should become available.[19]

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The ability to select by remote control would enable the crew to employ the amount of destructive force better suited to the appropriate target. The requirement for a high explosive warhead was dropped, presumably because no suitable radiation homing device was available, as well as because shorter range, high explosive, anti-radar weapons already were in the arsenal.[20]

(U)[redacted] Subsequently, OSD asked the Air Force to submit its proposed deployment of the missile. On 18 June 1965 Secretary Zuckert submitted a program change proposal calling for procurement of 1,913 SRAM's to equip 17 B-52 squadrons (100 missiles per squadron) plus 213 to support a long-range combat evaluation launch program. On 3 September McNamara advised there would be no immediate decision on SRAM procurement or deployment. The Deputy Secretary of Defense later explained that it appeared "unwise and unnecessary to enter a commitment to purchase SRAM at the time of starting engineering development." The Air Force was authorized to begin development, with procurement to be considered six months to a year after engineering development began. OSD directed the Air Force to prepare alternate proposals for contract definition and to consider use of the SRAM either with the proposed new FB-111 or the B-52.* On 15 November the Air Force awarded contracts to the Martin-Marietta Corporation and the Boeing Company to undertake the Phase I contract definition studies.[21]

(U)[redacted] In December 1965 Secretary McNamara decided to equip the FB-111 with the SRAM. He called for an operational FB-111 force of 15 aircraft in fiscal year 1969, 105 the following

* See Bernard C. Nalty, The Quest for an Advanced Manned Strategic Bomber, USAF Plans and Policies, 1961-1966 (AFCHO, 1966).

year, and a maximum of 210 in 1971. The SRAM force would total 150 in fiscal year 1970, 450 in fiscal year 1971, and reach a planned maximum of 525 by the end of fiscal year 1972. Although McNamara did not approve deployment of SRAM with the B-52, OSD later provided $8.9 million in fiscal year 1967 funds for study of B-52/SRAM compatibility. [22]

[redacted] On 15 March 1966 Martin-Marietta and Boeing submitted their project definition proposals to the Air Force, which immediately began an evaluation that would culminate in the awarding of an engineering development contract some time in August.

These recommendations were being studied by OSD at the close of the period. [23]

Notes

CHAPTER I

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2. Hist (TS-RD), DAC, Jan-Jun 65, 126-127.

3. Ibid, Wilbur K. Clemmer, Phase-Out of Atlas E and F and Titan I Weapon Systems (AFLC No. 350, Oct 66).

4. Hist (TS-RD), SAC, Jan-Jun 65, I, p 127; Clemmer, exhibit 2.

5. Clemmer, p 43.

6. Ltr (U) less atchs, CCSAF for SAF, Jan 65, subj: Disposition of Atlas and Titan I Resources; Memo (S-Gp 4), Under SAF for VCS, 11 Jan 65, same subj, in Missile and Space Sys Div; Ltr (S-Gp 4), Ivan A. Getting to DCS/S&L, 17 Mar 66, no subj, in Msl and Space Sys Div, Dir/Prod and Progr 3. 25).

7. Msg (C), C/S USAF to AFLC, 7 Jun 66, subj: Prog fro Excess Minuteman Msls, in Dir/PP Msl and Space Sys Div 3. 5; Comments by Col Rundell, Dir/PP Msl and Space Sys Div. on Draft of AFCHO Study, Draft dtd 30 Jan 67, in AFCHO.

8. Hist (S), Dir/PP, Jul-Dec 64, p 40; Daily Staff Digest (C), No. 103, 27 May 66; Telecon (U), author with Mr. William Weidenhamer, Dir/Civil Engring, 28 Jun 66; Ltr (U), DCS/S&L for DCS/R&D, 12 Jan 65, subj: Possible AF Uses for Atlas and Titan I Launch Facs; Ltr (U), Asst VCS for SAF, 19 Apr 65, subj: Plans for a Msl Phase Down; Rprt (S) of Strategic Panel Mtg 66-1, in Dir/Dev Msl and Space Sys Div 5. 1.

9. Ltr (TS-RD-Gp 1) Asst Chief Force Planning Div, Dir/Plans, to AFCHO, 14 Feb 67, subj: Draft of AFCHO Historical Study in AFCHO.

10. Ibid.

11. Boeing Minuteman Prog Summary (S), in OSAF 5-64; Daily Staff Digest (C), No. 97, 19 May 66.

12. Memo (S-Gp 3), Asst SAF (R&D) for DDR&E, 7 Aug 65, subj: WS-133A Unmodernized and Force Modernized Minuteman Conformance to Rqmts of DOD Dir S-5200. 16, 18 Dec 65, in Dir/PP Msl and Space Sys Div 3. 16; Minuteman Sys Prog Package (S-RD-Noforn), 15 Jun 66, sec 13 para 7, Dir/Dev in Msl and Space Sys Div 4. 2; Daily Staff Digest (C), No. 97, 19 May 66; OSAF Mgt Summary (S-NOFORN), 14 Jun 66; Msg (S), SAC to Hq USAF, AF IN 55248, 17 Apr 64, subj: Minuteman Force Structure, in Dir/Dev Msl and Space Sys Div 12. 0.

13. Boeing Prog Summary (S), in OSAF 5-64.

14. Hist Rprt (S-RD), BSD, Jan-Jun 65, I, Pt. 2, pp 465-467; Ltr (S), Asst VCS to Dep Under SAF, 11 May 66, subj: Minuteman Crew Side Arm Rqmts, in OSAF 255-66.

15. Boeing Minuteman Prog Summary (S), in OSAF 5-64.

16. Ibid.

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GLOSSARY

ABRES . . . . Advanced Ballistic Reentry Systems

AEC . . . . Atomic Energy Commission

AFB . . . . Air Force Base

AFCHO . . . . USAF Historical Division Liaison Office

AFLC . . . . Air Force Logistics Command

AFSC . . . . Air Force Systems Command

AGM . . . . Air to surface attack guided missile

ALCC . . . . Airborne launch control center

App . . . . Appendix

ASB . . . . Air Staff Board

Asst . . . . Assistant

Atch . . . . Attachment

Br . . . . Branch

BSD . . . . Ballistic Systems Division

C . . . . Confidential

CEP . . . . Circular Error Probable

CJCS . . . . Chairman, Joint Chiefs of Staff

Cmd . . . . Command

Comdr . . . . Commander

Cong . . . . Congress

CRESS . . . . Combined Reentry Efforts on Small Systems

CSAF . . . . Chief of Staff, US Air Force

DASA . . . . Defense Atomic Support Agency

DCS . . . . Deputy Chief of Staff

DDR&E	Director of Defense Research and Engineering
Dep	Deputy
Dept	Department
Dev	Development
Dir/PP	Directorate of Production and Programming
Dir	Director, Directorate
Div	Division
DOD	Department of Defense
DSMG	Designated Systems Management Group
ECT	Enable Command Timer
Engring	Engineering
et al	and others
Exec	Executive
Facs	Facilities
FOT	Follow-on Operational Tests
FY	Fiscal Year
Gp	Group
GSA	General Services Administration
HAF	High Altitude Fuze
HEST	High Explosive Simulation Test
Hist	History
HQ	Headquarters
ICBM	Intercontinental Ballistic Missile
ICM	Improved Capability Missile
IELES	Improved Encoded Launch Enable System
Incl	Inclosure
Info	Information

JCS	Joint Chiefs of Staff
JCSM	Joint Chief of Staff Memorandum
Lab	Laboratory
LECS	Launch Encoded Control System
LEES	Launch Encoded Enable System
LGM	Silo launched, surface attack
Ltr	Letter
MARTI	Maneuvering Reentry Technology Investigation
Memo	Memorandum
Mgt	Management
MIRV	Multiple Independently Targeted Reentry Vehicle
MMRBM	Mobile Mid-Range Ballistic Missile
Msg	Message
Msl	Missile
n. d.	no date
No.	Number
NOFORN	Not Releasable to Foreign Nationals
NSA	National Security Agency
Ofc	Office
Op	Operation, Operational
OSAF	Office of Secretary of the Air Force
OSD	Office of Secretary of Defense
OUO	Official Use Only
PCP	Program Change Proposal
PDP	Project Definition Phase
Prog	Program
P&P	Production and Programming
Pt	Part

RCA	Radio Corporation of America
RD	Restricted Data (Atomic Energy Act, 1954)
R&D	Research and Development
RDT&E	Research, Development, Test, and Evaluation
Rprt	Report
Rqmt	Requirement
S	Secret, Sensitive
SAB	Scientific Advisory Board
SABRE	Self Aligning Boost and Reentry
SAC	Strategic Air Command
SAF	Strategic Air Command
SECDEF	Secretary of Defense
SIOP	Single Integrated Operations Plan
SLBM	Submarine-launched ballistic missile
S&L	Systems and Logistics
SPO	System Program Office
SRAM	Short Range Attack Missile
Subcomte	Subcommittee
Subj	Subject
TAPS	Trajectory Accuracy Prediction System
Telecon	Telephone Conversation
TS	Top Secret
U	Unclassified
UHF	Ultra High Frequency
Under SAF	Under Secretary of the Air Force
USAF	U.S. Air Force

VCS	Vice Chief of Staff
Vol	Volume
WSEG	Weapons Systems Evaluation Group
WSR	Weapon System Reliability

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