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A Short History of the U.S. Nuclear Stockpile: 1945–1985 (U)

Raymond Pollock*

January 2, 1991

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A Short History of the U.S. Nuclear Stockpile: 1945–1985 (U)

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Raymond Pollock is a consultant on national security policy and strategy, strategic defense, and nuclear-weapons technologies. This follows an earlier career with the Los Alamos National Laboratory, where he specialized in nuclear-weapons design and headed the Theoretical Design Division. His research has focused on weapons physics, fluid dynamics, and computational physics. He served as Director of Defense Programs for the National Security Council (1982–1984). He received a Ph.D. in physics from the University of New Mexico.

The first draft of this report was written in 1988, and the information in the report does not reflect events or research since 1988.

CONTENTS

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PREFACE

This report is one in a CNSS series that surveys the development of nuclear weapons over the past forty-five years. The unifying themes throughout the series are the technical advances and failures associated with new weapon systems, and the creation of the stockpile.

Authors, titles, and report numbers are listed below.

William G. Davey, *Free-Fall Nuclear Bombs in the U.S. Stockpile (U)*, LA-11397

William G. Davey, *Nuclear Tests Related to Stockpiled Weapons Development (U)*, LA-11402

Lawrence S. Germain, *A Brief History of the First Efforts of the Livermore Small-Weapons Program (U)*, LA-11404

Lawrence S. Germain, *The Evolution of U.S. Nuclear Weapons Design: Trinity to King (U)*, LA-11403

Lawrence S. Germain, *A Review of the Development of Los Alamos Gnats and Tsetses before the 1958 Test Moratorium (U)*, LA-11749

Raymond Pollock, *The Evolution of the Early Thermonuclear Stockpile (U)*, LA-11748

Raymond Pollock, *A Short History of the U.S. Nuclear Stockpile 1945–1985 (U)*, LA-11401

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A SHORT HISTORY OF THE U.S. NUCLEAR STOCKPILE: 1945–1985 (U)

Raymond Pollock

ABSTRACT (U)

This report, one in a series concerned with the history of nuclear-weapons research and development, examines the evolution of the U. S. nuclear weapons stockpile. The report distinguishes between weapon requirements resulting from strategic and operational demands and requirements created by technological advances. The acquisition of nuclear weapons through four distinct, evolutionary phases is also reviewed.

INTRODUCTION

The purpose of this report is to identify the possible causes of significant change in the U.S. nuclear-weapons stockpile as it evolved between 1945 and 1985. While we will be concerned with the relationship between stockpile characteristics and national security policy, we concentrate on qualitative changes rather than on inventories. Our principal interest is to distinguish between weapon requirements generated by strategic and operational demands and those resulting primarily from opportunities created by the advance of technology.

As a first step, we examine the diversity of the U.S. nuclear-weapons stockpile, or more particularly, its variation over time. Figure 1 shows the total number of distinct weapon systems (as distinguished by mark number), both strategic and tactical (non-strategic) weapons. The bar charts of Fig. 2 indicate, for the strategic category, system entries and retirements; the net of these determines the data points of Fig. 1. Figure 3 shows entries and retirements for non-strategic systems. Examination of these figures leads to the conclusion that between 1945 and 1985 the U.S. nuclear-weapons acquisition process proceeded in four distinct phases.

In the early postwar phase (1945–1950), the stockpile remained based on the wartime Fat Man and Little Boy designs. Air Force heavy bombers provided the only delivery vehicles, and the "atomic" bomb was clearly seen as solely a strategic weapon of awesome power.

During the second phase (1950–1955), the variety of stockpiled systems grew quite rapidly, as the results of postwar R&D allowed lighter, more efficient fission bombs to be developed. New, heavier bombers made possible the entry into stockpile of the first huge, high-yield, "emergency capability" thermonuclear weapons. And the first weapons developed especially for tactical applications made their appearance.

DOE (b)(3)

Fig. 1. Nuclear weapons stockpile census.

DOE (b)(3)

Fig. 2. **Strategic systems—yearly changes.**

(b)(3)

Fig. 3. Nonstrategic systems—yearly changes.

The third phase, extending from about 1955 to 1965, was characterized by massive growth and turnover. The development of practical thermonuclear weapons coupled with the introduction of ballistic-missile delivery systems led to the entry of 16 new strategic systems into the stockpile, while at the same time, 10 weapon systems were retired. Delivery platforms were developed and deployed that established all three legs of the current Triad, and the strategic planning process was refined into the Single Integrated Operational Plan (SIOP). Equally impressive is the surge experienced in tactical/theater weapon systems—17 introduced and only 3 retired. Toward the end of this period, the stockpile reached its all-time high in terms of total number of weapons deployed and included a number of different weapon systems (33) that has only recently been exceeded.

The fourth phase, extending from 1965 to 1985, appears to be a period of relative stability. The total number of active systems remained relatively constant, with the rate of new introductions matched by an equal rate of retirements and with neither rate approaching anywhere near the hectic pace of 1955–1965. The number of individual weapons stockpiled has declined markedly from the peak, and the total megatonnage dropped even more rapidly as moderate-yield systems replaced earlier thermonuclear weapons for bombers and for the second-generation missile forces.

From this, one might draw the conclusion that nuclear-weapons technology—or demand—reached essential maturity approximately 20 years ago and has been largely in a state of refinement ever since. An examination in some detail of the actual circumstances dictating the complexion of today's stockpile should reveal the degree to which this is correct. In carrying out this investigation, our major concentration will be on the years following the introduction of thermonuclear weapons and the development of the first SIOP, i.e., the mid-to-late 1950s on. We will deal only lightly with the opening decade of the nuclear era, which is already the subject of an extensive literature. There is little question that in this early phase of nuclear development, technology drove policy almost without exception.

DEVELOPMENTS TO 1965

Phases I and II: The First Decade

The opening of the nuclear age at Alamogordo in July 1945 demonstrated that man now had the ability to release explosive energy on a hitherto inconceivable scale and fundamentally changed perceptions of warfare, probably for all time. With this success, the scientists and engineers of the Manhattan District wrote an indelible finish to the extraordinary surge in technology that characterized World War II. For the foreseeable future, technology would dominate military science, and it appeared that nuclear-weapon technologists would dominate technology. The implosion device tested at Alamogordo was the prototype of the Fat Man weapon used August 9, 1945, to destroy Nagasaki and to end World War II. The gun-type Little Boy dropped over Hiroshima on August 6 had no prior test, so confident were its designers. Thus, by the close of the war the two distinct patterns of fission-weapon that have formed the functional basis for the U. S. nuclear-weapons stockpile ever since were established and demonstrated. But there was room for improvement.

In the immediate postwar years, efforts to better understand the destructive potential of nuclear weapons took priority, leading to the Bikini Able and Baker tests of Operation Crossroads to determine the effects of air and underwater bursts on ships. The major force shaping the U. S. stockpile was scarcity of fissile materials. [redacted]

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[redacted]

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The Mk-IV (or B4) entered the stockpile in early 1949.

To this point, the strategic bomber was the only platform that ever had—or could have—delivered a nuclear weapon. Army B-29s delivered the Hiroshima and Nagasaki bombs and the air-dropped tests in the Pacific. Only specially modified B-29s could carry the heavy, bulky Fat Man; through most of 1948, the Strategic Air Command (SAC) had 30 such airplanes. The nuclear-capable B-50 entered service in 1948, and SAC finished the year with a total of 60 nuclear-capable aircraft.

Planning for nuclear war was similarly limited. World War II experience had shown that attacks on specific functions were more damaging to the enemy's war-making capacity than was the indiscriminate bombing of urban areas. But Russia was a vast and largely undefined target. When serious planning for nuclear strikes began, the small inventory of weapons did not allow for precision destruction of significant military capability: war plan BROILER in 1947 called for 34 weapons to be used on 24 cities. But as the stockpile expanded, so did the target list. Plan TROJAN, approved in December 1948, called for 133 nuclear weapons on 70 cities. In

May 1949, a study headed by Air Force Lt. General H. R. Harmon reported that even if all 133 weapons detonated on target the Soviet leadership would not be critically weakened, Soviet military ability to take selected areas of Western Europe and of the Middle East and Far East would not be seriously impaired, and Soviet industrial capacity would not be sufficiently reduced to prevent recovery. The resulting reassessment of targeting requirements led to a substantial increase in nuclear production. And in the fall of 1949, the Joint Chiefs of Staff (JCS), in conjunction with the North Atlantic Treaty committing the U. S. to European defense, tasked the Strategic Air Command with "retardation of Soviet advances in Western Europe."[1]

With General Curtis LeMay as SAC commander, and freed by the results of Sandstone from the constraints of weapons scarcity, the 60 nuclear-capable aircraft available at the end of 1948 grew to 250 by June 1950. The giant B-36 came on line in 1949, and the all-jet B-47 medium bomber would arrive in 1951. The October 1949 target annex for war plan OFFTACKLE called for attacks on 104 urban targets using 204 weapons, with 72 bombs to be held in reserve.[2] The prime objective was still disruption of the Soviet will to fight, but a number of "retardation" targets were included. By August 1950, concern over growing Soviet nuclear strength led to a further re-prioritization to assign first priority to targets supporting Soviet nuclear-delivery capability. The mission of retarding a Soviet attack in Europe was assigned second priority, and disruption of Soviet war-making capacity by attacks on electric power, atomic energy industries and liquid fuel facilities was assigned third priority. This war-fighting allocation system persisted in U. S. targeting doctrine for the next 10 years.

The move away from simple urban targeting to a more elaborate military targeting doctrine designed to meet specific military objectives was to a large degree made possible by the increasing availability of nuclear weapons, and this move, in turn, stimulated the need for new weapons.

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For the European retardation mission, which needed to deal with somewhat transitory targets, the relatively lightweight B5 tactical bomb entered stockpile in 1952. This was followed in short order by a series of new tactical weapons, including development of the Mk-9, 280-mm artillery shell; adaptation of the B5 as the W5 warhead for the Navy's Regulus and Air Force Matador cruise missiles; and development of the W7, as both bomb and warhead for the short-range missiles, and as the first atomic demolition munition (ADM). All of these were implosion weapons, with the exception of the 280-mm artillery-fired atomic projectile (AFAP), which was gun-assembled. Interestingly, the gun-assembled B8 bomb ("Improved Little Boy") also entered stockpile in 1952 and remained for nearly 6 years.

Turning again to the strategic arena, a growing perception that many critical Soviet targets were harder than previously expected, and often covered a large area or were grouped such that "bonus" damage could be achieved with a large enough weapon, drove the quest for higher yields. Boosting was first tested in the Item shot in the 1951 Greenhouse series, and it appeared clear that megaton-yield, boosted fission weapons of reasonable weight and size could be developed. But it was also apparent that the thermonuclear weapon, first considered by Edward Teller and others in a 1942 meeting in Berkeley, would offer an economical route to very high yields if it could be made to work. And the boosted fission explosive offered the possibility of an energy source small and hot enough to provide an ideal primary stage for the practical thermonuclear concept developed by Teller and Stanislaw Ulam.

The controversy surrounding President Harry Truman's decision to go forward with a vigorous effort on the Super is a well-documented story and will not be repeated here. The first thermonuclear device, the liquid-deuterium-fueled Ivy Mike, was tested at a yield of 10 Mt in October 1952 at Eniwetok. [redacted]

By the end of 1955, the total megatonnage in the stockpile began to climb rapidly.

Phase III: 1955 to 1965

At the start of the second Eisenhower administration, the "New Look" strategy of massive retaliation had placed the Strategic Air Command (SAC) in control of U. S. nuclear targeting strategy and had guaranteed the Air Force the lion's share of defense budgets. Between 1955 and 1960, the total megatonnage in stockpile grew enormously as multimegaton warheads were added for the growing SAC bomber fleet, which, with the introduction of the B-52 in June 1955, attained 1,000 nuclear-delivery aircraft. The nuclear stockpile grew in parallel with the growth of nuclear-delivery capability, both in quantity and quality; by the end of 1959, the majority of the weapons intended for SAC delivery would be of the modern, sealed-pit design.

The last years of the 1950s were not focused solely on strategic needs, however. During this same period, a number of new warheads for tactical systems were developed, including the first instances of upgrading existing carriers such as Honest John and Regulus with better nuclear tips. [redacted] This was a clear instance of service needs—safety of the launch platform for close-in engagements—driving technology.

The strategic arena, however, provided the major focus of attention. By 1956 the list of targets for SAC had grown to [redacted] and was still expanding rapidly. Nuclear counterforce targets (including defense suppression targets required to ensure penetration by SAC bombers) continued to receive top priority, and their number grew with every new intelligence assessment. Although the Navy forcefully argued the strategic role of its carrier-based aircraft and targeted these quite independently, the U. S. strategic punch resided almost entirely in the SAC bombers—a "monad." But the situation was changing rapidly. [redacted] To exploit this new capability, the Air Force and Army were developing ballistic missiles—the Air Force the intercontinental Atlas and Titan and intermediate-range Thor, and the Army the intermediate-range

Jupiter. Perhaps even more significant, the feasibility of solid-fueled missiles made the submarine a practical ballistic-missile-delivery platform, and in 1956 the Navy committed to developing Polaris.

But while the strategic forces grew and diversified, SAC doctrine of massive retaliation and emphasis on counterforce targeting, with its apparently unlimited requirements for weapons, came under steady attack within the Joint Chiefs of Staff (JCS). In the spring of 1958, a JCS majority under the leadership of Army Chief of Staff General Maxwell Taylor argued for the need to prepare for limited war. Secretary of State John Foster Dulles agreed that, with the Soviets now a major nuclear power, the doctrine of massive retaliation had outlived its usefulness. President Dwight Eisenhower, however, felt that an increase in conventional forces could be bought only at the cost of increased defense expenditures, which he would not accept, or of weakened strategic (air) forces, which he could not accept without further study. He tasked the National Security Council (NSC) to give high priority to a careful analysis of the minimum requirements for deterrence and retaliation.

In July 1958, Admiral Arleigh Burke weighed in with the Navy's strategy to exploit the flexibility and invulnerability of the coming Polaris force. Burke argued that, while it had once made sense for the U. S. to deploy sufficient force to disarm the Soviet Union, the growing Soviet intercontinental ballistic missile (ICBM) deployment made this "blunting" or disarming mission now unworkable. In addition, the Soviets could now put at risk all U. S. land-based forces; their vulnerability invited surprise attack. The alternative was to secure the U. S. strike force by mobility and concealment, eliminating the pressure to preempt and allowing the U. S. to respond selectively in order to apply political coercion. This strategy of "finite deterrence" would require a small submarine-launched ballistic missile (SLBM) force sized for deterrence alone (i.e., the ability to destroy major urban areas).

Recognizing the Navy threat, SAC in November 1958 proposed that a U. S. Strategic Command embracing all strategic forces, including Polaris, should be formed, with the Air Force in charge. SAC would then be abolished. Burke admired the idea of dismantling SAC, but rejected the notion that anyone but sailors could operate Polaris submarines in conjunction with other naval forces. He also saw no need for any new coordination structure since Polaris would use its missiles against a (Navy-determined) target system that was generally stable.

Despite Admiral Burke's assurances, the problem of controlling and coordinating U. S. nuclear retaliation was growing more serious—even in the absence of Polaris. Thoughtful Air Force leaders believed that an overhaul of "atomic coordination machinery" was overdue. In March 1959, JCS Chairman General Nathan Twining wrote a memo to Secretary of Defense Neil McElroy addressing "Target Coordination and Associated Problems." This memo triggered no immediate action but laid the groundwork for the later formation of the Joint Strategic Target Planning Staff (JSTPS).[3]

In the last year of the Eisenhower administration, the divergence of strategic planning combined with the above considerations to create a situation that demanded resolution. President Eisenhower had grown increasingly dubious about the seemingly endless growth in Soviet targets, but, in the absence of any alternative, had acceded to SAC demands for additional weapon platforms and nuclear-weapons production. In March 1960, the Air Force Intelligence Directorate (AFID) identified [redacted] targets and projected that this total would grow to [redacted] by 1965 as the Soviets added offensive and defensive missiles. Highest priority was assigned to suppressing Soviet air defenses and stopping Soviet nuclear attack on the U. S. and its allies. Halting Soviet land and sea operations (the retardation mission) received a lower priority and was assigned to tactical air forces. The last and smallest group of targets involved the disruption of the war support and recuperation capability of Soviet industry. The explicit emphasis on counterforce targeting fit SAC doctrine but was at odds with Army and Navy positions.[4]

At about the same time, the Hickey Committee proposed an "optimum mix" targeting strategy composed of a combination of counterforce targets, control centers, war-supporting installations, and population centers. The Hickey target list projected for 1962 endorsed basic SAC strategy but included total targets, some 40 percent fewer than the AFID list presented for 1960. With General Twining's support, Eisenhower endorsed the Hickey Committee recommendation as the point of departure for all future JCS planning. At the same time, Eisenhower rejected Air Force pleas for the B-70 aircraft on the grounds that its intended second-strike counterforce mission was not sensible. He also decided that Polaris would be used to clear the way for SAC bombers by knocking out organized defenses and dismissed Navy arguments for Polaris as a vehicle for selective, controlled response.[5]

The festering issue of target planning and nuclear strike coordination came to a head at a stormy White House meeting of the Joint Chiefs and top defense officials on August 11, 1960. This meeting is described in detail by Rosenberg. Secretary of Defense Thomas Gates proposed that the SAC commander-in-chief be designated "Director of Strategic Target Planning" with authority to develop, on behalf of the JCS, a National Strategic Target List (NSTL) and an SIOP. Gates argued that the advent of ballistic missiles, especially SLBMs, created an urgent demand to replace the current system of joint target guidance and separate operational commands. Despite strong Navy objections, Eisenhower, convinced of the need to utilize both the Navy and the Air Force's capabilities simultaneously in any retaliatory strike, endorsed Gate's proposal.[6]

On December 2, 1960, the JCS approved SIOP-62. The NSTL selected targets out of a target data base of 4,100, lumped into designated ground zeroes (DGZs), including urban-industrial targets. With sufficient warning, the U. S. would launch its entire strategic force carrying 3,500 nuclear weapons against this target set. At the very least, an "alert force" of 880 bombers and missiles would attack with some weapons totaling up to The target list developed by JSTPS was 29 percent greater than the Hickey list, and any restraints on target selection had been negated by requirements for overlapping laydowns. Eisenhower left behind an impressive and rapidly expanding nuclear deterrent capability. SAC had 538 B-52s, 1,292 B-47s, 19 B-58s, and 1,094 tanker aircraft.

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Construction of 650 additional Atlas, Titan, and Minuteman missiles was authorized, along with 14 Polaris boats. The first Polaris had gone on station in November.[7]

The nuclear-weapon stockpile had grown even more rapidly. President Eisenhower had steadily endorsed increases in production of all categories of nuclear weapons. Although the strategic questions occupied most of his attention, he was committed to tactical nuclear weapons as an economic means of augmenting conventional strength. Accordingly, tactical weapons and air defense warheads were stockpiled and dispersed in large numbers. By the end of his administration, the stockpile was growing rapidly (Rosenberg claims that it tripled—from 6,000 to nearly 18,000 total weapons—in the 2 years 1958–1960[8]).

At the end of the Eisenhower administration, U. S. nuclear posture had taken the shape it has held ever since. The strategic Triad, though not yet fully implemented, had been designed and was in procurement. Nuclear strike planning, after much strain, had been consolidated into the JSTPS, and the first SIOP was in effect. Nuclear support for the North Atlantic Treaty Organization (NATO) in the theater had been prepared and the weapons to implement NATO MC 14/2 were in procurement. The list of strategic weapons that entered stockpile during the last 5 years of the Eisenhower administration attests to the vigor of the nuclear production complex:

- B28 (thermonuclear bomb)
- B36 (thermonuclear bomb)
- B39 (thermonuclear bomb)
- B41 (thermonuclear bomb)
- W28 (thermonuclear warhead: Hound Dog, Mace)
- W39 (thermonuclear warhead: Bomarc)
- W47 (thermonuclear warhead: Polaris A1, A2)
- W49 (thermonuclear warhead: Thor, Jupiter, Atlas, Titan I).

The list of tactical weapons is equally impressive:

- W25 (fission weapon: Genie air-to-air defense missile)
- W27 (thermonuclear warhead: Regulus II)
- W30 (fission warhead: Navy Talos, TADM missiles)
- W31 (fission weapon: ADM,
- W33 (gun-assembled fission weapon: 8-in. artillery shell)
- W34 (multipurpose fission warhead: Hotpoint).

The momentum built up during the Eisenhower years carried over into the Kennedy Administration, even though Defense Secretary Robert McNamara found SIOP-62 too rigid and apparently lacking in strategic rationale. The new administration initiated a rethinking of strategy and doctrine and introduced flexible options into the SIOP, but did not slow the entry of new weapons into stockpile. As a result, by the end of 1965 the following additional nuclear systems had become operational:

Strategic:

- W38 (thermonuclear warhead: Atlas, Titan I)
- B43 (thermonuclear bomb)
- W53 (thermonuclear warhead: Titan II)
- W56 (thermonuclear warhead: Minuteman II)
- W58 (thermonuclear warhead: Polaris A3)
- W59 (thermonuclear warhead: Minuteman I).

Tactical:

- W44 (fission weapon: ASROC)
- W45 (fission weapon: MADM, Little John, Terrier, Bullpup)
- W48 (fission weapon: 155-mm artillery shell)
- W50 (thermonuclear warhead: Pershing I)
- W52 (thermonuclear warhead: Sergeant)
- W54 (fission weapon: Falcon, Davy Crockett, SADM)
- W55 (thermonuclear warhead: SUBROC)
- B57 (multipurpose fission bomb).

Except for the gun-assembled W33, which required extensive field assembly before firing, all stockpiled weapons were now sealed-pit designs. While there was much innovative detail, and a few really new wrinkles yet to be worked out, the major inventions had been made and heavily exploited, and the basic patterns of nuclear-weapons technology had been firmly established.

DOE (b)(3)

THE STOCKPILE FROM 1965

Since 1965, the growth in the nuclear-weapons stockpile has shown a character entirely different from that of the first two decades. Referring once again to Figs. 1 and 2, we see that only 23 new systems entered stockpile in the 20 years 1966–1985 and that 15 systems were retired during this period. The functional makeup of the stockpile, that is, the proportions dedicated to strategic and nonstrategic missions, remains steady at the pattern established by 1965. This pattern is consistent with a view that little change in fundamental U. S. nuclear strategy has taken place over the last 20 years. Apparently, no nuclear innovation during this period has been sufficiently dramatic to once more induce sea changes like those of the 1940s and 1950s. To a large extent, turnovers in the stockpile appear designed to make more effective use of the technologies first developed in the 1950s in order to match weapon systems to military requirements.

This is not to say that the art and science of nuclear weaponry has not advanced during the modern era. Steady progress in basic weapon technology and a few major technical innovations have substantially enhanced the operational and logistical utility of nuclear weapons. To examine this in detail, we shall in the balance of this report adopt an organization centered on distinguishing weapons by the operational requirements they are designed to fill. Specifically, we shall develop the history of the stockpile in seven different categories:

- Strategic offensive: land-based ballistic missiles
- Strategic offensive: sea-based ballistic missiles
- Gravity bombs
- Air-to-surface missiles
- Tactical missiles
- Defensive weapons
- Miscellaneous tactical weapons.

Before a chronological survey of stockpile development is resumed, the more important advances of the past 20 years will first be described.

Basic Knowledge

While not an identifiable single technology, increased knowledge of basic weapon physics, materials properties and behavior, electronics, and computing technology have resulted in substantial steady improvements in nuclear-weapons design and construction. Weapons designers have been able to use their understanding of the physics of weapon function, plus the marked improvement in their ability to model weapon behavior, to eliminate unnecessary weight and fit a given yield into a smaller envelope. At the same time, miniaturization of weapon electronics and the development of new structural materials have made it possible to use more of the total warhead volume for the nuclear physics package. The result has been a steady improvement over the years in the yield-to-weight ratio, reductions in warhead diameter and size, and the ability to tailor weapons to particular delivery modes.

Safety

It is noteworthy that, over the span of more than 40 years, there has never been an accidental detonation of a nuclear weapon that produced a nuclear yield. However, there have been accidents with nuclear weapons, and there have been accidental detonations of high explosive (HE) in nuclear weapons. Requirements for one-point safety adopted and enforced many years ago have ensured that, even in the event of an accident sufficiently severe to detonate the HE of a nuclear weapon, no significant nuclear yield will result. However, explosion and fire can still result in the dispersal of weapons materials—most notably plutonium—that still present a significant hazard to indigenous populations and cleanup personnel. The most noteworthy such event occurred in 1966 near Palomares, Spain, when a B-52 carrying four bombs collided with a tanker during aerial refueling and dropped its bombs. Although three were recovered at sea, the HE of one detonated over the Spanish countryside, resulting in a massive effort to scrape up and dispose of contaminated soil.

To avoid further such incidents, the weapons laboratories have introduced several techniques for mitigating the results of any accidental fire or explosion. Some of these involve mechanically isolating the plutonium pit from the HE until the time comes to arm the weapon—a modern version of the original Fat Man. The most widely used method, however, employs insensitive high explosive (IHE, commonly a formulation designated as PBX9502), which combines energetic explosive material with an inert binder in such a way as to make accidental detonation virtually impossible. Only a precision detonator designed to produce an extraordinarily strong shock can explode IHE.

Weapons designed with IHE tend to be somewhat larger and heavier than they would have to be if a more sensitive explosive (PBX9404) were used. For this reason, the use of IHE has become routine in weapons subject to handling, such as air-carried weapons and tactical systems, but it has not become routine until recently in strategic missile warheads. However, with mobile basing of ICBMs now on the horizon, the W87 MX warhead will incorporate IHE, and it is likely that most future weapon designs will do so.

Selectable Yields

[redacted]

This logistic advantage has continued to drive interest in selectable yields for many, if not most, nuclear warheads. [redacted] from time to time, interest in precision strategic warfare surfaces and leads to arguments about the need for low-yield missile options, but so far this complication has not crept into the SIOP.

[redacted]

Enhanced Radiation

[redacted]

As a tactical antipersonnel warhead, the "neutron bomb" ignited much controversy when it was originally proposed for NATO nuclear artillery in the 1970s—controversy that now has somewhat subsided but has not disappeared. [redacted]

A FUNCTIONAL CHRONOLOGY OF THE MODERN STOCKPILE

Land-Based Strategic Ballistic Missiles

As recounted earlier, by the end of 1965 the single-warhead Titan II, Minuteman I, and Minuteman II ICBMs were all operational. Growing concern over the possible need to cope with Soviet missile defenses, an increasing list of hardened Soviet targets, and continued decrease in warhead size and weight came together to spark interest in MIRV technology. Development of the first multiple integrated reentry vehicle (MIRV) warhead for land-based U. S. missiles began formally with the entry of the W62 into Phase 3 in June 1964. By mid-1967, the 1,000th single-warhead Minuteman missile had gone on strategic alert, with 550 Minuteman I and 450 Minuteman II missiles deployed. The first flight test of Minuteman III took place in August 1968, and the three-warhead MIRVed missile became operational in December 1970.

[redacted] result was a MIRV system with high accuracy that could place at risk a growing number of Soviet missile silos and other hard targets. [redacted]

Even before deployment of Minuteman III was completed, however, efforts were under way to improve the hard-target capability of U. S. ICBMs. In 1974, a contract was issued to develop the improved-accuracy Mk-12A reentry vehicle, and the W78 warhead to be carried by this vehicle entered Phase 3. The Advanced Ballistic Reentry Vehicle (ABRV) program, dedicated to maximizing accuracy achievable with small reentry vehicles, was begun in 1975. In July 1976, Minuteman III was flight-tested with the more accurate INS-20 inertial guidance set.

The original specifications for the W78 Mk-12A illuminate the progress made in strategic warhead technology in the decade since the predecessor W62 entered Phase 3.

[redacted] The military justification for this was the need to compensate for continual hardening of Soviet strategic targets.

[redacted]

As it turned out, the W78 Mk-12A almost met all specifications, but was slightly overweight. By 1988, deployment of 300 Minuteman IIIs carrying the Mk-12A was completed.

[redacted] work on the latest U. S. ICBM—the MX Peacekeeper—began formally in 1971 and entered advanced development in 1974. As a completely new weapon system rather than a derivative of Minuteman or any other earlier missile, the MX incorporates advanced technology in all components, including the Mk-21 reentry vehicle (out of the ABRV program).

While controversy over MX basing has clouded the program almost from its beginning—and is not yet completely settled—the process of choosing a warhead for MX was also not serene.

DoE (b)(3)

Segments of the Air Force strongly opposed this, however, arguing that Soviet construction of a new generation of "superhard" missile silos, control centers, and leadership bunkers made it imperative that the MX be used to improve U. S. hard-target kill capability. The March 1976 imposition of a 150-kt limit on nuclear test yields by the Limited Test Ban Treaty (LTBT) complicated the decision process. This meant that a new high-yield warhead for MX would have to be fielded without ever undergoing tests in its complete design configuration. Advocates of hard-target kill won the day fairly early on, but the specifics of the warhead remained uncertain for some time; for an extended period the W78 Mk-12A was carried as the baseline MX warhead. However, in early 1982 the Department of Defense (DoD) chose a new warhead, the W87, to be mated with the new Mk-21 reentry vehicle.

The W87 began the modern era of treaty-constrained development of high-yield warheads.

DoE (b)(3)

Sea-Based Strategic Ballistic Missiles

October 1965 saw the last ballistic-missile nuclear submarine (SSBN) patrol of the Polaris A1 missile and the start of development of the Poseidon C3 missile for the new Poseidon boats. Only 5 years after the first Polaris SSBN had gone on station, the Navy was retiring the earliest elements of its first-generation SLBM force and was entering development of a second, MIRVed generation.

DoE (b)(3)

Neither of the Polaris versions offered very good delivery accuracy, nor would this be a requirement on the yet-to-be-developed Poseidon C3. The primary mission of the SLBM force seemed to be to provide a secure retaliatory force, either to meet the requirements for finite deterrence, spelled out 10 years earlier by Arleigh Burke, or to pave the way for SAC bombers by knocking out defenses, as stipulated by President Eisenhower. In any case, the SLBM force was clearly designed for soft targets.

DoE (b)(3)

The Trident program began as ULMS—Undersea Long-Range Missile System—in 1969 as a result of the STRAT-X studies. As a follow-on to Polaris/Poseidon, Trident was envisioned as a quieter submarine, carrying missiles that could be launched at intercontinental range. The need for Trident was driven by two primary considerations: a replacement for Poseidon would be needed before the end of its projected service life of 20 to 25 years, and the replacement submarines should operate over a wider range of ocean in order to ensure survivability against a growing Soviet surveillance and ASW capability. Development of the Trident I C4 missile and the Ohio-class Trident boat was approved by the Secretary of Defense in September 1971.

The Trident I missile was sized to allow retrofit into the smaller Poseidon SSBNs—a later Trident II missile will fit only the larger Trident boats. By the time the W76 warhead for the C4 was selected in 1973, the Navy had become more interested in missile range than in any further fractionation of payloads.

[redacted] liver its full load of eight W76 warheads to ranges greater than those attainable by an off-loaded Poseidon C3. Although the accuracy of the [redacted]

The W76 is the latest SLBM warhead to enter stockpile. [redacted] complete the Navy's conversion from concentration solely on soft targets.

[redacted]

Gravity Bombs

The story of gravity bombs since 1965 is to a large extent the story of the B61 bomb in all its variants. The B61, which entered Phase 3 development in January 1963, is a multipurpose modern tactical bomb, weighing approximately 700 lb, which now exists in eight models designed for air delivery by both strategic and tactical forces. Because the B61 is a truly multipurpose weapon, carried by a wide variety of U. S. and Allied aircraft dispersed all over the world, the development and refinement of B61 mods has been heavily influenced by requirements for safety and security. All B61 variants but one carry Permissive Action Link (PAL) arming systems, and some of the earlier mods that predated the introduction of IHE are now being replaced by versions employing an IHE primary and more elaborate safety and security systems.

[redacted] The Mod 0 employs a Category B PAL, requiring entry of a four-digit code to arm the weapon. The Mod 1 does not have the PAL (it is intended for Navy use); otherwise, it is identical to the Mod 0. Both of these early versions use PBX9404 HE. [redacted] his version also incorporates command disable, which will destroy critical components of the warhead on coded command. The B61 Mod 5 is the last of the non-IHE versions.

[redacted]

Beginning with the Mod 3, IHE has become standard equipment for B61s, along with weak link/strong link and unique signal generator systems. [redacted]

DOE (b)(3)

[redacted] The Mod 7 is a retrofit of Mod 0 and Mod 1 models to incorporate IHE and Category D PALs.

The history of the B61 program presents a clear case of technical innovation's creating military opportunities, which, as they are exploited, go on to generate further elaborations as military requirements. [redacted]

DOE (b)(3)

Redacted

Only one other gravity bomb has entered stockpile since 1965. [redacted]

DOE (b)(3)

Air-to-Surface Missiles

Modern (i.e., post-Snark) interest in air-to-surface missiles originates from concerns over the ability of aging SAC-Air Force B52s to penetrate Soviet air space with sufficiently low attrition to allow delivery of gravity bombs on target. Two air-to-surface missiles—the AGM-69 SRAM (Short-Range Attack Missile) and the AGM-86B ALCM (Air-Launched Cruise Missile)—are now in the stockpile.

The W69 warhead for the SRAM entered Phase 3 development in 1967 and full production in 1972. The SRAM is a supersonic missile with a range of about 200 km and an accurate inertial guidance system, carried on B-52G/H and FB-111 aircraft. [redacted]

DOE (b)(3)

[redacted] There are now plans to retire the SRAM in favor of a more advanced missile in the early 1990s.

The AGM-86B ALCM, initially deployed in 1982, carries the W80 Mod 1 warhead. [redacted]

DOE (b)(3)

[redacted] The W80 is of conventional thermonuclear pattern, designed to fit the physical envelope and operational environment presented by the small cruise missile airframe and external stowage for extended periods on high-altitude B-52G/H weapon platforms. In other words, military requirements drove the W80.

Tactical Missiles

Five warheads for tactical missile systems have entered the stockpile since 1965:

the W70-1/2 for the MGM-52 Lance short-range Army ballistic missile; the W70-3 enhanced radiation version for Lance; the W80 warhead for the Tomahawk Sea-Launched Cruise Missile (SLCM); the W84 warhead for the Ground-Launched Cruise Missile (GLCM); and the W85 warhead for the Pershing II intermediate-range ballistic missile.

The W70 Lance warhead entered Phase 3 development in 1969 and full production in June 1973. [redacted] In April 1976, as a consequence of successes in demonstrating the tactical value of enhanced radiation (ER) warheads, a Phase 3 program was initiated to develop an ER version of the W70, which entered stockpile in 1981 as the W70-3. [redacted]

Phase 3 for the W84 GLCM warhead was initiated in September 1978, and the warhead entered full production in September 1983. [redacted] Other design features include those becoming common for all weapons requiring ready access by operational crews: IHE, command disable, and Category F PAL systems. [redacted]

[redacted] To comply with the 1987 INF treaty, the W84 and W85 are no longer part of the deployed stockpile.

Defensive Weapons

The surge in demand for defensive air-to-air and surface-to-air weapons experienced in the 1955–1960 period has not been sustained. In fact, the only two defensive warheads to enter stockpile since 1965 were for the defunct Safeguard/Spartan ABM system; one of these warheads has now been put in special reserve and the other has been retired and dismantled. Both warheads were technically very innovative, yet both appear to have led to dead ends.

The W66 warhead for the Sprint terminal interceptor entered Phase 3 in January 1968 and full production in late 1974. The ABM terminal defense mission presented conflicting requirements—a nuclear warhead to kill the incoming weapon at a range of 100 m or more, limited by defensive missile guidance and agility constraints, and the need to minimize the radar blackout produced by nuclear fireballs. [redacted]

DOE (b)(3)

[redacted] The small number of W71s eventually built are now in reserve and may soon be dismantled.

Miscellaneous Tactical Weapons

Only two weapon systems have entered or have been scheduled to enter stockpile since 1965. [redacted]

The W79 replacement for the ancient W33 8-in. shell entered Phase 3 in January 1975 and full production in 1981. It is a modern, one-point-safe implosion design incorporating a Category D PAL in the warhead and command disable in the shipping container. Unlike the W33, the W79 requires no field assembly and is a ballistic match to the conventional HE round. [redacted] The ER feature provided the source for controversy in Europe in 1977 and led to President Jimmy Carter's 1979 decision to rescind his earlier approval for production and deployment. Currently, the W79 is being stockpiled only in the United States, without the ER component.

DOE (b)(3)

[redacted] It is this feature that has produced the controversy that has kept the warhead out of production.

SUMMARY

The evolution of the U. S. nuclear stockpile over some 40 years has been shaped by the interplay of technical, military-operational, and political forces. Our examination of the stockpile history indicates that the development and acquisition of U. S. nuclear forces has occurred in four distinct phases.

In the first phase, ending about 1950, the stockpile remained based on the wartime Fat Man and Little Boy designs, while weapons research concentrated on nuclear effects and on means to mitigate shortages of fissile material. During the second phase, from 1950 to 1955, the variety of stockpiled systems grew rapidly as lighter, more efficient fission weapons were developed and the first thermonuclear weapons were introduced. There can be little doubt that, throughout this first decade, the composition and capabilities of U. S. nuclear forces were determined virtually entirely by the rapidly changing state of nuclear-weapons technology.

The third phase, covering roughly the years 1955–1965, was in many ways the most interesting. Revolutionary innovations in delivery vehicles were coupled with the rapid advance of nuclear-weapon technology to underwrite massive growth in the strategic stockpile. Simultaneously, the intensified Soviet threat to Europe and the consolidation of U. S. nuclear strategy led to the introduction of large numbers of weapons designed for tactical/theater applications. During this period, the three legs of the strategic triad were established and the first SIOP was developed. While progress in nuclear-weapon technology continued to play a major role, technical advance across a broader front, including electronics and ballistic-missile technology, became very important. This era, perhaps more than any other, displays the symbiosis of nuclear and nonnuclear technologies in both prodding and responding to military requirements.

The fourth phase, extending from about 1965 to 1985, might be characterized as largely a period of refinement. While the total number of stockpiled weapons has varied over these years, the number of distinct types—mark numbers—has stayed relatively constant until the recent Reagan administration buildup. Second- or even third-generation warheads have replaced earlier systems, offering quantitative improvements in performance and operational characteristics. Technical advance in the state of the art in nuclear weaponry has continued, but military requirements have become the dominant force in determining the shape of the stockpile.

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