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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.

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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.

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Fig. 2. Strategic systems—yearly changes.

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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[redacted] 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 [redacted] 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

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) re-

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.

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

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.

[redacted]

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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.

[redacted]

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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.

[redacted]

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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.

[redacted]

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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 Tri-

dent 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 sig-

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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