To Defend and Deter: The Legacy of the United States Cold War Missile Program

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THE LEGACY COLD WAR PROJECT

One of the nine task areas within the Department of Defense Legacy Resource Management Program, the Cold War Project seeks to “inventory, protect, and conserve DoD’s physical and literary property and relics” associated with the Cold War.

Under the direction of Dr. Rebecca Cameron of the Air Force History Support Office, the Cold War Project has commissioned several studies to examine the evolution of the American military during the Cold War. The first of these, To Defend and Deter: The Legacy of the United States Cold War Missile Program, traces the growth of the Army and Air Force missile programs. A similar study, Navy Cold War Guided Missile Context: Resources Associated with the Navy’s Guided Missile Program, 1946–1989, examines the development of the Navy’s missile program.

A second group of Cold War studies takes a wider, more topical approach. Jointly sponsored by the Cold War Project and the United States Air Force Air Combat Command, these are broad studies designed to provide historians and cultural resource managers with a national context for examining the military’s Cold War era programs, structures, and artifacts. The first of the series, Training to Fight: Training and Education During the Cold War, examines the changes in military training brought on by the expansion of the military and the sophistication of its Cold War era weaponry. Additional, two companion pieces were published in 1997, Developing the Weapons of War. Military RDT&E During the Cold War and Forging the Sword: Defense Production During the Cold War.

FOREWORD

The Department of Defense (DoD) Legacy Resource Management Program was established under the Defense Appropriations Act of 1991 to “determine how to better integrate the conservation of irreplaceable biological, cultural, and geophysical resources with the dynamic requirements of military missions.” One of Legacy’s nine task areas is the Cold War Project, which seeks to “inventory, protect, and conserve [DoD’s] physical and literary property and relics” associated with the Cold War.

During the early months of 1993, Dr. Rebecca Hancock Cameron, Cold War Task Area Manager for Legacy, assembled an ad hoc committee of approximately 20 cultural resources experts from throughout the DoD to explore the cultural resources of the Cold War. Their mission was to develop a plan for inventorying and managing these resources. A two-pronged approach, which had been agreed on before the meeting, included site-specific and national studies. The more immediate thrust was to compile site-specific documentation of the most significant Cold War installations and sites. At the time of the ad hoc meeting, studies were already beginning in such places as Vandenberg Air Force Base, Air Combat Command installations, and several important missile sites. Some of these sites are now listed on the National Register of Historic Places.

The second thrust was to develop a series of national theme and context studies, addressing the more prominent military themes during the Cold War era. These studies were designed to provide a tool by which installations and sites of all types and sizes could determine the significance of their Cold War cultural resources. The committee developed an initial list of theme and context topics that ranged from missiles and intelligence to hospitals and day care centers. While all of the topics were important in their own right, a decision was made to focus on only those issues that held a direct relationship to primary Cold War missions.

The initial committee meeting, and the many meetings and telephone conversations that followed, helped to trim the nearly endless list of potential topics down to a short list that DoD would support as national theme and context studies. Those selected included: missiles, radars, research and development, testing and evaluation, and training—To Defend and Deter: The Legacy of the United States Cold War Missile Program—is the first and largest of these studies.

To Defend and Deter is the product of a 2-year effort by personnel from the Tri-Services Cultural Resources Research Center, located at the U.S. Army Construction Engineering Research Laboratories (USACERL), working in cooperation with Dr. Cameron and other members of the military history community. The goal of this effort was to develop a history and reference guide suitable for use in identifying and evaluating the historical significance of missile-related cultural resources. The authors have supplied the information necessary to locate, identify, and understand Army and Air Force guided missile facilities. This, coupled with evaluative guidelines currently being developed within DoD, will help cultural resources personnel make substantive evaluations.
Three members of the USACERL cultural resources staff served as primary contributors to this publication. Dr. John Lomnquest and David Winkler, a doctoral candidate at the American University in Washington, DC, prepared the narrative. Dr. Lomnquest, the lead historian, wrote the sections on the evolution of missile technology and the development and deployment of the long-range deterrent missile systems. He also edited the manuscript, selected the photographs, and compiled the bibliography. Mr. Winkler focused his attention on the development of the defensive missile systems, the social and economic impact of the Cold War missile program, and arms control. Mr. Winkler also prepared the histories of the missile development and deployment sites. Mr. Winkler wrote the weapon system profiles for the defensive missile systems, and Dr. Lomnquest prepared the system profiles for the long-range deterrent missile systems. Mr. James Eaton, a graduate student in architecture at the University of Illinois at Urbana-Champaign, identified and contacted all of the known missile sites within the United States and developed the state-by-state guide to the applicable missile launch facilities in the United States. All three of these gentlemen contributed energetically and selflessly throughout the project. In addition, Ms. Gloria J. Winkler of USACERL served as managing editor for the project. Her input and perseverance during the final stages of this project are greatly appreciated.

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For the course of this project the authors received help from a great many people. First and foremost, we would like to thank Dr. Rebecca Hancock, director of the DoD Legacy Cold War Project. Her guidance and constant encouragement enriched our work. We also want to acknowledge the help we received from Ms. Virge Jenkins Temme, the Cold War series coordinator at the U.S. Army Construction Engineering Research Laboratories. She helped smooth out many of the bureaucratic hurdles we encountered, critiqued our work, and ever-so-gently reminded us of our deadlines. In May 1996, Ms. Julie L. Webster became the principal investigator for this project. Over the following summer and fall, she carefully and patiently shepherded the study through completion. We gratefully acknowledge her help and good humor.

Dr. William Baldwin, of the U.S. Army Corps of Engineers Office of History, and Dr. Alfred Beck, formerly of the Air Force History Office, have been involved with this project since its inception. They reviewed our manuscript as did Dr. Raymond Puffer, formerly the chief historian at the Air Force Ballistic Missile Organization, and Dr. Dill Hunley, historian at the National Aeronautics and Space Administration. Their careful scrutiny and rigorous questioning improved our work.

During the long course of our research Dr. Marttin Gordon and Ms. Lisa Wagner guided us through the Army Corps of Engineers Research Collection. Chief historian Mr. Michael Baker and Mr. Claus Martel of the Army Missile Command supplied many of the administrative and weapon system histories on the Army missile program. Dr. Jim Walker, chief historian at the Army Space and Strategic Defense Command, furnished us with information on antiballistic missile (ABM) development. Dr. David Stumpf of the University of Arizona reviewed the Titan weapon system profile, and Mr. Eric Lemmon of the Thor Association reviewed the Thor section. Ms. Nancy Stillson, librarian at the Redstone Scientific Information Center, provided us with information on early Army missile development as well as the growth of Huntsville during the 1950s and 1960s. Mr. Tony Tuthollow, historian at the Army Engineer District, Los Angeles, supplied us with background information on the formation of the Corps of Engineers Ballistic Missile Construction Office.

Air Force Flight Test Center historian, Ms. Cheryl A. Gumm, helped us identify materials discussing Edwards AFB's role in missile development. Dr. Donald Baucom, historian at the Department of Defense Ballistic Missile Defense Organization, provided us with both documents and advice in our section on ABM development. At the Air Force Historical Research Agency's Archives Branch, Mr. Archbo DiFante helped us track down documents, and in a number of cases, declassified them for us. Another important ally was Ms. Grace Rowe, Chief of the Records Management Branch, Office of the Secretary of the Air Force, who provided the authors with access to the Air Force Chief of Staff for Guided Missiles (AFCGM) records at the Federal Records Center, Suitland, Maryland.

Locating the photographs and illustrations for this study was an arduous task. The authors gratefully acknowledge the help they received from Mr. Bryon Nicholas at the National Air and Space Museum Archives, Mr. David Chomoweth at the Air Force History Office, Mr. Dave Menard of the USAF Museum's Research Division, Dr. Harry Waldron of the Space and Missile Systems Center History Office, Dr. Todd White at the U.S. Strategic Command, and Ms. Ramona Ruhl at the National Park Service's Rocky Mountain System
Support Office. Colonel Milton B. Halsey, Jr., USA (Ret.), the National Park Service’s Nike Site Manager at the Golden Gate National Recreation Area, provided us with illustrations and photographs of various Nike sites and reviewed the air defense sections of the study. Mark Morgan, a ranger with the National Park Service, furnished us with photographs and descriptions of many of the Cold War missile sites he visited.

Archaeologist Martin D. Tagg at Holloman AFB, New Mexico, provided drawings and interpretation for Holloman AFB missile testing sites. At the Titan II Missile Museum at Green Valley, Arizona, Museum Manager Becky Roberts arranged for our researchers to tour the launch facility and discuss our project with the museum staff. At White Sands Missile Range, Public Affairs Officer Deborah S. Bingham supplied us with information on the missile range and set up interviews with Range Archaeologist Robert J. Burton and Diane H. Fulbright of the Range Commander’s Council. Sam Hoyle, Museums Division Chief at Fort Bliss, helped us identify source materials and artifacts at the U.S. Army Air Defense Museum. At the Army Air Defense School Colonel Steve Moeller provided us a copy of his Master’s thesis about the history of the Army’s Air Defense Command, and Patricia Rhodes identified some primary source materials relating to early missile defense. Also, architect John Cullinane provided us with information on the BOMARC missile program and reviewed the BOMARC-related passages of this report.

In preparing this study the authors were fortunate to receive the advice and counsel of many people. While their assistance enhanced our work, the responsibility for any errors or omissions is solely our own.

John Lonnquest and David Winkler, November 1996.
INTRODUCTION: THE COLD WAR AND THE NATION

Between 1945 and 1989 the United States and the Soviet Union were locked in an intense political, military, and economic confrontation that came to be known as the Cold War. The struggle between the two superpowers dominated international affairs, and the conflicts it spawned raged across the globe. The world was seemingly divided into two armed camps: the United States and its allies against the Soviet Union and the communist bloc.

The competition between the two superpowers was played out at many levels, but none was more visible, more consistent, or had a greater impact on the United States than the arms race. It was a race driven by fear and fueled by uncertainty; a contest depicted by both sides as a struggle for national survival. In the United States the arms race became a national obsession. Politicians promoted it, the military exploited it, and the press gave it extensive coverage. But apart from the public debate, the arms race was a battle for technological supremacy; a battle that was waged in laboratories and factories across the country and encompassed the entire spectrum of military technology from conventional arms to nuclear weaponry. As the arms race unfolded, a new class of weapons—guided missiles armed with nuclear warheads—emerged as the defining weapons technology of the Cold War.

In retrospect it is difficult to recapture the sense of fear and anxiety that, for many Americans, characterized the early years of the Cold War. From the United States' perspective the Soviet Union and its communist allies appeared to be on the offensive around the globe, occupying Eastern Europe, taking over China, waging war in Korea, conspiring with Fidel Castro in Cuba, and inciting revolution in Latin America, Africa, and Asia. These were the days of the “Red Menace,” a time when school children crouched under their desks during air raid drills; worried homeowners built fallout shelters; and the government conducted an intrusive campaign to ferret out shadowy “communist sympathizers” suspected of plotting against the nation.

Defense vs. Deterrence

At the end of World War II the United States was confronted by a host of challenges, the most critical of which lay overseas. As the leader of the Western alliance, the United States took the leading role in helping Europe and Japan rebuild their shattered economies, but in doing so found itself increasingly at odds with the Soviet Union. The situation was especially tense in Europe, where the United States faced a strong military challenge from Soviet forces in Eastern Europe. Unable to match the conventional military might of the Red Army, the United States chose to protect the beleaguered nations of Europe by extending its nuclear umbrella overseas.

Between 1945 and 1949, when the United States had a monopoly on nuclear weapons, that remained a viable strategy. But the strategic balance of power changed quickly in 1949 when the Soviet Union acquired nuclear weapons. Suddenly the United States found itself vulnerable to Soviet air attack. To counteract the Soviets’ new offensive capability, the United States hurriedly bolstered its air defense system by deploying additional antiaircraft artillery batteries, and also by accelerating the development of the Nike and BOMARC surface-to-air missiles. Simultaneously the nation expanded its strategic nuclear deterrent, it
increased the production of nuclear weapons, built new long-range bombers, and developed long-range guided missiles.

These strategic and air defense missiles had distinctly different roles, which reflected the divergent concepts of deterrence and defense. The so-called strategic missiles, which included intercontinental ballistic missiles (ICBMs) and air-breathing strategic missiles (the predecessors of today's cruise missiles), were deterrent systems. In conjunction with the bombers of the Air Force's Strategic Air Command (SAC), the deterrent systems were intended to discourage an aggressor from attacking either the United States or its allies for fear of triggering a swift and certain nuclear retaliation. In contrast, the ground-based antiaircraft missile systems, and later antimissile systems, were purely defensive. Defense was a fallback position, a means of minimizing the destruction in the event deterrence failed.

The Evolution of Strategic Doctrine

Although deterrence was relatively simple in concept, the composition of the United States' deterrent and the conditions governing its use were hotly debated. The nation's strategic doctrine underwent numerous revisions during the Cold War. In the mid-1950s the Eisenhower administration, anxious to trim defense expenditures by reducing conventional forces, formulated a new defense policy called the "New Look." Its central tenet was the concept of massive retaliation: the United States would respond to communist aggression anywhere in the free world with atomic strikes on the Soviet Union and China. A number of influential critics found significant flaws in the concept of massive retaliation. First, it was based on the assumption that U.S. strategic forces would survive a Soviet first strike with the ability to retaliate; second, it seemed unlikely that the United States would risk a nuclear war over disputes in Asia or the Middle East.

In 1961 the Kennedy administration implemented a new defense posture called "Flexible Response." Believing that the New Look was overly reliant on nuclear weapons, the administration designed Flexible Response on the premise that the United States needed to maintain a mixture of conventional and nuclear forces to respond to a variety of threats in a proportionate manner. Today, Flexible Response remains the cornerstone of American defense planning.

The Development of the Offensive Missile Force

The primary responsibility for defending the United States against air attack rested with the Air Force. To accomplish this mission, the Air Force developed a defense-in-depth strategy that encompassed early warning radar, fighter aircraft, and long-range antiaircraft missiles positioned to detect and engage the enemy before they entered American airspace. If the enemy penetrated this outer layer, the last line of defense was the Army's antiaircraft missile batteries that defended key urban, industrial, and military targets.

The long-range antiaircraft missile was the Air Force's BOMARC. Development began in 1946 but the first units were not deployed until 1959. BOMARC resembled a long, sleek fighter with sharply swept wings. The 45-foot missile was powered by ramjet engines and traveled at nearly four times the speed of sound. It had an effective range of 440 miles and could carry either a conventional or nuclear warhead.

The 45-foot missile was powered by ramjet engines and traveled at nearly four times the speed of sound. It had an effective range of 440 miles and could carry either a conventional or nuclear warhead. The BOMARC's range was expressed in terms of statute miles. During the 1960s eight BOMARC missile squadrons were deployed along the eastern seaboard and in the midwest.

The Army's contribution to the air defense network was the Nike antiaircraft missile system. Development of the initial model, the Nike Ajax, began in 1945, and the first battery was deployed in early 1946. The liquid-fuel missile was 21 feet long, had a range of 30 miles, and carried a conventional warhead. By 1958, 200 Nike batteries, each site covering 40 acres, had been built across the country.

During the 1950s the Army began to deploy the more capable Nike Hercules. The new missile was 41 feet long and was powered by two solid-fuel motors and boosters that increased its range to 75 miles and operational ceiling to 150,000 feet.

The Nike Hercules was the first antiaircraft missile to be armed with a nuclear warhead. The new missiles replaced the Nike Ajax, and were eventually deployed at 137 sites.

The Development of the Strategic Missile Force

To bolster the nation's strategic deterrent, the Army Air Forces (the predecessor of the Air Force) had been working since 1946 to develop two types of strategic missiles: the winged, air-breathing missile and the futuristic ballistic missile.

The air-breathing missiles looked and performed like aircraft. They had wings to generate aerodynamic lift, used jet engines that required an external oxygen supply, and were powered and guided throughout their flight. In contrast, the ICBM was bullet-shaped, carried an internal oxygen supply, and the majority of its parabolic trajectory was outside the earth's atmosphere. It was called a ballistic missile because once the warhead reached the apogee of its flight path, it followed a ballistic trajectory to its target.

The Air Force's two air-breathing missile programs, the Snark and the Navaho, began in 1945 and 1946, respectively. The 70-foot long Snark had a top speed of nearly 600 miles per hour and carried a 7,000-pound warhead 5,000 miles. The Navaho was a more ambitious project. It was equivalent in size and range to the Snark, but was propelled by two powerful ramjet engines that gave it a top speed of 2,150 miles per hour.

Until 1954 the Air Force favored the air-breathing missiles over ICBMs because it believed the former would be easier to build and was a convenient technological midpoint in the development of an ICBM. Both programs suffered from severe guidance and control problems that were never adequately resolved. After spending hundreds of millions of dollars, the Air Force canceled the Navaho program in 1956. It briefly deployed one squadron of Snark missiles in the early 1960s. While the Air Force was spending huge amounts of money on its air-breathing missiles, the Atlas ICBM program, which began in 1946, languished in obscurity. Many Air Force officers dismissed the ICBM as "Buck Rogers" stuff. The critics charged that the ICBM was not technologically feasible, they also begrudged the money it was diverting from the service's aircraft development programs.

Given the technology of the day, the ICBM was a radically new weapon. The Atlas stood 82 feet tall, was 10 feet in diameter, and powered by three large liquid-fuel rocket boosters. Depending on the propulsion system and payload, Atlas had a range of 5,500 to 6,750 nautical miles and a guidance system accurate enough...
The Changing Face of the U.S. Missile Force

The 1960s and 1970s saw widespread changes in the U.S. defensive missile force. Beginning in the mid-1960s, the Air Force began to close many of its Nike installations, a move prompted in part by improved relations with the Soviet Union and also by the need to pay for America’s rapidly escalating involvement in Southeast Asia.

But important technological changes were also at work. By the mid-1960s it became apparent that the Soviet Union was not going to build a large fleet of long-range bombers. Instead it focused on developing a single-stage ICBM that could pierce the U.S. air defense system obsolete. In an effort to regain the technological initiative, the Army experimented twice with developing an antiballistic missile (ABM) defense system, but the program was canceled short-term because of the cost.

In the late summer of 1957 the Soviet Union boasted it had an operational ICBM, and the following October shocked the West when it launched a Soviet satellite, Sputnik. As the tiny satellite whirled around the earth, Congress demanded to know the status of the American missile program and the phrase “missile gap” entered the political lexicon. Beginning in June 1959 the Air Force, in conjunction with its European allies, deployed seven squadrons of Thor and Jupiter intermediate range ballistic missiles (IRBMs) in Europe. The RBMs, as these missiles were called, had a range of 1,500 miles and were based in Great Britain, Italy, and Turkey. Within the United States the first Atlas ICBMs went on operational alert in September 1959, followed by the first Titan squadron in April 1962, and the first Minuteman missiles in October 1962. The Air Force continued to deploy ICBMs throughout the decade, and by 1969, 1,854 missiles stood poised in their underground silos.

to land the warhead within 2 nautical miles of its target.4 Flying at nearly 16,000 miles per hour, a flight of 6,750 miles would take just 48 minutes. Moreover, once in flight, the ICBM was virtually impossible to intercept.

After considerable foot-dragging, the Air Force accelerated the Atlas program in the spring of 1954; then problems began. First, the Atlas was not as fast as promised. By the end of 1955, only 10 Atlases were deployed, and in 1971 the air Force deployed its first Minuteman III.

The new missiles were the first ICBMs to be fitted with multiple independently targetable reentry vehicles (MIRVs). Each missile carried three warheads, each accurate to within 800 feet.

The Physical Legacy of the Missile Program

The Army and Air Force missile programs left an indelible imprint on the American landscape. Missile launch sites, scattered from California to Maine and from Texas to North Dakota, dotted the country. The Army built 263 Nike batteries in the continental United States and Alaska, and an enormous ABM complex in North Dakota. To house its ICBM force, the Air Force built over 1,200 launch facilities clustered in and around 22 installations in 17 states. But these launch sites represent only the tip of the iceberg, behind them lay a complex infrastructure of research laboratories, test sites, production facilities, training centers, and logistics and maintenance facilities. It was these diverse elements that furnished the United States with a powerful defensive and deterrent missile force.

Today, half a century after the Cold War missile program began, many of these facilities are still in use. Many others, however, have been closed down or abandoned as a result of advancing technology, arms limitation treaties, or the post-Cold War military drawdown. Before these facilities were destroyed, it is necessary that they be examined and cataloged to enable future generations to understand and assess the legacy of the Cold War missile program.

Purpose of This Document

This study was written primarily as a research guide for Department of Defense (DoD) cultural resource managers. Its purpose is three-fold. First, it traces the evolution of the Cold War missile program to enable the readers to evaluate missile facilities and artifacts in their proper historical context. Second, through the comprehensive listing of missile facilities and launch sites, the study establishes the missile program’s scope and its truly national impact on the American landscape. Third, through the combination of the historical narrative, extensive bibliography, and weapon system profiles, the study aims to provide its core DoD audience, plus state historic preservation officers (SHPOs), military facility managers, and scholars with a read- able, informative guide that can serve as a solid foundation for further research.

4 A nautical mile is equal to 1.15 statute miles. The ranges and accuracy requirements for the ICBMs and IRBMs cited in this study are expressed in nautical miles.

This study was published in 2002 as a joint DoD Headquarters, National Park Service, and Department of the Air Force publication. The objectives were to provide a comprehensive listing of missile facilities and launch sites, to describe the environment in which the facilities were located, and to establish the program’s scope and impact on the American landscape. The study was intended primarily for DoD cultural resource managers, but it was also designed to inform other audiences, including state historic preservation officers (SHPOs), state and local government officials, military facility managers, and scholars. The study highlights the historic significance of the Cold War missile program and its lasting impact on the American landscape. It provides a valuable resource for understanding the development and legacy of the missile forces and their associated infrastructure.
Scope of the Study
Considering the sheer number of missiles the United States developed during the Cold War, it became apparent early in the work that this study could not address them all. Some were one-of-a-kind test models, others were more fully developed but never entered production, and still others were operational for only a limited time. To deter some of which missiles should be included in the study, the authors assessed the strategic, economic, and cultural significance of each. That led to two general guidelines. First, the study includes only missiles that entered full-scale production and were deployed at fixed launch sites within the United States. Second, the study does not consider wing-mounted tactical and intermediate-range missiles because they did not exert a decisive strategic impact and had no extensive network of fixed launch sites and support facilities.

Using these selection criteria, the authors focused on missiles with intercontinental range and air-defense missiles deployed at fixed launch sites. The missiles that met these criteria were Atlas, Titan I and II, Minuteman I, II, and III, and Peacekeeper ICBMs and the Snark, an early cruise missile. The defensive systems examined included the Nike family and ROMARC, and the Sentinel and Safeguard antiballistic missile systems.

There were, however, exceptions to the listing criteria. The Thor and Jupiter intermediate-range ballistic missiles were included because, despite being deployed exclusively abroad, they were (during the late 1950s and early 1960s) a critical component of the nation’s long-range ballistic missile force.

Organizing the Report
In assembling this report the authors sought to strike a comfortable balance between historical scholarship and the more concrete requirements of the cultural resource manager. Fortunately the two disciplines proved to be complementary and the needs of one invariably strengthened the other.

The study contains three parts, each one being progressively more specific. Part I is an introductory essay that examines the evolution of the U.S. missile program and its impact on the American military and society. Part II contains profiles of the weapon systems. Part III is a state-by-state listing of missile sites and related facilities.

By design, the three parts are closely intertwined. For example, because Part I is an overview of the entire missile program, it does not include detailed descriptions of the missiles or the facilities. That information is contained in Part II, which is a series of illustrated technical descriptions of each major weapon system included in the study. Each profile includes a developmental history, technical specifications, a description of the launch facilities, and an operational history. Part III contains information on missile sites and facilities. The state-by-state list includes launch sites, research, development, test, and evaluation (RDT&E) facilities, and logistic support, training, and government production facilities.

Each part includes bibliographic information. The bibliography for Part I is the most extensive because it covers the entire missile program. In Part II the bibliographies that accompany the weapon system profiles address the individual weapon systems, and in Part III the bibliography includes citations for each military reservation. Appendix B lists the current status of the sites listed in Part III. Note, however, that the information in the Appendix is subject to change. It was current as of mid-1995.

Photographs
This study contains many photographs and illustrations that provide vibrant images of the people, places, and weapons systems that shaped the Cold War missile program.
PART I

A HISTORY OF THE UNITED STATES COLD WAR MISSILE PROGRAM
The U.S. Cold War missile program left a very rich and diverse legacy of artifacts, both large and small. They range from the mighty intercontinental ballistic missiles (ICBMs) to sleek Nike surface-to-air missiles, from Nike missile bases located on the outskirts of major U.S. cities to the unmanned Minuteman ICBM silos buried under the desolate plains of North Dakota; from the laboratories at the California Institute of Technology to the huge rocket engine test stands at the Redstone Arsenal, Huntsville, Alabama.

Taken individually, these artifacts might appear as nothing more than a jumble of weapons technology and abandoned launch sites, all of which were once supported by a complex infrastructure of test sites and support facilities. But in a larger context, the physical legacy of the Cold War missile program mirrors the broad historic themes of the period. The growth of the U.S. missile program reflected the exigencies of the Cold War, the maturation of aerospace technology, and basic changes in the nation’s strategic posture.

Early Rocketry

Although the exact origin of the rocket is unclear, the Chinese are credited with inventing rockets and were known to use them in combat, primarily as incendiary weapons, in the 13th century. The missiles were relatively crude, consisting of little more than a hollow bamboo tube stuffed with black powder and affixed to a long bamboo pole for stabilization. But these weapons had all the distinguishing characteristics of modern rockets: the black powder supplied both fuel and an oxidizer to support combustion independent of an external air supply, and they were not actively guided in flight. One simply pointed the rocket at the enemy, lit the fuse, and then watched it go.

The Mongols and Arabs soon transferred rocket technology to Europe, and by 1379 the Italians were calling them *rocchetta*, from which the term “rocket” is derived. Between the 15th and 18th centuries the French, Dutch, and Germans all developed rockets, and some were used in combat. The Europeans used rockets as direct-fire weapons. Rockets were an appealing alternative to artillery; they were easier to transport, required less training to use, and could deliver explosive shells, grapeshot, or fire-bombs.

The British started experimenting with rockets at the beginning of the 19th century. In 1807, Colonel William Congreve of the Royal Laboratory of Woolwich Arsenal began developing a series of barrage rockets weighing between 18 and 300 pounds. The most popular of Congreve’s rockets was the 32-pounder, which had a cast-iron warhead, was affixed to a 15-foot wooden shaft, and had a range of 4,000 yards.
Rocket design remained relatively static during the remainder of the 19th century. The British used Congreve rockets with moderate success against American forces during the War of 1812. The rockets were ineffective in the famous bombardment of Baltimore’s Fort McHenry, but the memory of the “rockets’ red glare” is preserved in the U.S. national anthem. American forces, armed with spin-stabilized rockets, fought in the Mexican War, but the military’s interest in the technology waned after midcentury. Rockets were not little used during the American Civil War as the increased range and accuracy of rifle artillery reduced the rockets’ utility as direct fire weapons, and parallel improvements in communications reduced their usefulness as signaling devices.1

The decline of military rocketry continued in the early 20th century with the widespread use of radio and rifled breech-loading artillery. However, during World War I inventors in the United States and Great Britain took the first halting steps toward the development of guided missiles when they outfitted small air-craft with automatic guidance systems to create “flying bombs” or “aerial torpedoes.”2 Although these fragile craft proved to be of little practical value, they established the idea that the difference between a rocket and a missile was a matter of guidance. Rockets are not guided in flight; missiles are.

During the early 20th century a small group of civilian scientists and inventors began exploring the feasibility of using rockets for space travel. One of the most notable was an American, Dr. Robert Goddard. In 1909 Goddard, a physicist at Clark University in Worcester, Massachusetts, began detailed studies of the physical properties of liquid- and solid-fuel rocket motors. By 1914 his work had progressed to a point where the U.S. government awarded him patents for seminal innovations in the areas of combustion chambers, propellant feed systems, and multistage rockets.3

In 1926 Goddard launched the world’s first successful liquid-fuel rocket from a farm pasture near Auburn, Massachusetts, and in 1930 he established a research facility near Roswell, New Mexico. During the following decade, Goddard and his two assistants experimented with a wide range of rockets, the largest of which was 22 feet long, 18 inches in diameter, and weighed almost 500 pounds. In the most successful test, one of his rockets soared to a record altitude of 9,000 feet.4

World War II

While Goddard and his assistants were developing missiles in the arid Southwest, a very different type of missile program was taking shape in Germany. In 1929 the German Army, anxious to escape the prohibitions on heavy artillery contained in the Versailles Treaty, began to secretly explore the possibility of delivering explosives with long-range rockets. In 1931 the German Army Board of Ordnance established a rocket development group and in 1937 built a test station at Peenemünde on the Baltic Coast. On this isolated stretch of coastline the Germans developed the V-2, the world’s first long-range ballistic missile.5

While the German Army was experimenting with long-range ballistic missiles, in 1935 the Luftwaffe began developing a “flying bomb,” later known as the V-1.6 Designed for mass production from inexpensive and readily available materials, the V-1 was 25 feet long with a wingspan of 16 feet. Lift was provided by the two stubby wings bolted to the midsection of the fuselage. The noisy pulsejet engine that powered the V-1’s nickname “buzz bomb” was mounted on the top of the fuselage behind the wings.

Most V-1s were catapulted off long inclined ramps, although a few were air-launched from bombers. The missiles had a cruising speed of 340 miles per hour, a range of approximately 150 miles, and were armed with a 1,800-pound conventional warhead. The guidance system, which consisted of an onboard gyroscope autopilot and an altimeter, was inaccurate. German tests showed that at a range of 110 miles, only 31 per-
term, the V-2 followed a parabolic flight path that carried it 50 to 60 miles above the earth’s surface. After reaching the apogee of its trajectory, the V-2 plowed back to earth at several times the speed of sound, offering no warning before its deafening explosion at impact. The V-2 was classified as a long-range ballistic missile because of its range and flight characteristics. By today’s standards, the missile’s 200-mile range would make it a tactical weapon, but in the mid-1940s the V-2 was considered a long-range weapon. The V-2 also had the flight characteristics of a ballistic missile. The V-2 did not use aerodynamic surfaces to produce lift; it was actively guided during the first half of its flight; and after thrust from the engines ceased, the missile followed a purely ballistic trajectory down toward its target. In other words, after the V-2 reached the apogee of its parabolic flight path, the only forces that controlled its descent were gravity and drag. The V-2 was a technological milestone in missile development. Although its effectiveness was compromised by an inaccurate guidance system and ineffective fuse mechanism, the V-2 lent a new and more ominous meaning to the concept of air power. Once launched, the V-2 could not be stopped. It was a terror weapon in the truest sense of the word. The Allies’ reaction to the V-2 attacks was swift and predictable. First they bombed the launch sites. Next, in late 1944, the United States Army Ordnance Department launched a research program to study long-range ballistic missiles. Finally, the Army began searching for a way to intercept the V-2s in flight using antiaircraft artillery. Independent of the stimulus that came from the German missile program, the United States was without experience in rocket development at the end of the war. In 1936 a small group of graduate students at the Guggenheim Aeronautical Laboratory (GALCIT) at the California Institute of Technology (Caltech) began experimenting with rockets. Their goal was to develop a high-altitude sounding rocket that would enable scientists to conduct experiments in the earth’s upper atmosphere. Over the next two years, the GALCIT group, led by graduate student Frank Malina, conducted numerous experiments and engine tests. By 1938 they had accumulated a substantial body of test data. In 1939 Malina’s work caught the attention of the U.S. Army Air Corps, which hoped to use the rockets as supplemental power sources to help heavily-laden aircraft take off. Later that year the Army hired the GALCIT group to develop jet-assisted takeoff (JATO) apparatus, and between 1939 and 1942 the GALCIT scientists produced a series of progressively more powerful solid- and liquid-fuel JATO boosters. In the summer of 1943 Dr. Theodore von Kármán, director of the Guggenheim Aeronautical Laboratory, asked the members of the GALCIT project to evaluate several startling British intelligence reports on the German rocket program. The GALCIT group, which in 1944 began calling itself the Jet Propulsion Laboratory (JPL), considered the reports alarming and proposed initiating research to produce a long-range jet-propelled missile. The Army Ordnance Department accepted JPL’s proposal, and in January 1944 awarded the laboratory a contract to develop a missile capable of carrying a 1,000-pound warhead between 75 and 100 miles at a speed sufficient to avoid interception by fighter aircraft. Reflecting the identity of the new sponsor, the new effort was called the ORD-CIT project. In December 1944 JPL fired its first 24-pound solid-fuel Private A missile from a temporary test range set up at Camp Irwin, California. The 92-inch long missile had a range of about 11 miles. JPL continued to develop missiles after the war, and in December 1945 it launched its first liquid-fuel missile, the WAC Corporal. Powered by an Aerojet engine that generated 1,000 pounds of thrust, the missile rose to a then-record altitude of 235,000 feet. In retrospect, Caltech’s World War II research and development (R&D) programs made two important contributions to the post-war missile program. First, the Corporal evolved into the Army’s first tactical-range surface-to-surface missile. Second, and more important, the Caltech laboratories were the training ground for many of the scientists and engineers who later played pivotal roles in the Cold War missile program. In November 1944, in an effort parallel with JPL’s, the Ordnance Department hired General Electric (GE) to study the development of long-range rockets and related equipment. The study, called the Hermes Project, had three phases: collecting and analyzing technical data on rockets and guided missiles; assembling and launching captured V-2s; and designing a family of new antiaircraft and intermediate-range surface-to-surface missiles. In another 1944 development, the U.S. Army Ground Forces asked the Ordnance Department to explore the feasibility of developing a “direction-controlled, major caliber antiaircraft rocket torpedo.” The search for a new antiaircraft weapon was prompted by the introduction of new aircraft such as the German jets and the Army’s own high-flying B-29 bomber, both of which revealed the limitations of conventional antiaircraft artillery. Moreover, the Army wanted to determine if an antiaircraft missile would be a viable form of defense against the V-2.
In February 1945 the Ordnance Department contracted with Western Electric to study the feasibility of developing a surface-to-air missile capable of shooting down a bomber such as a B-29. When the Army chose Western Electric and its research affiliate, the Bell Telephone Laboratories, to design the new system, it sent aircraft manufacturers a clear message: building missiles required expertise never before used in building aircraft. The key components of the new anti-aircraft missile system were radar and high-speed computers, and Western Electric and Bell Labs had ample experience in both. To compete in missile development, the airframe industry would have to develop expertise in a number of new areas, particularly solid state electronics. The World War II-era research performed by JPL, GE, Western Electric, and Bell Labs formed a firm foundation for later missile development. Equally important, the working relationships forged between the military, the academic community, and industry served as a template for later Cold War partnerships. Finally, many of the military’s premier missile-testing facilities were established during World War II. In November 1943 the Navy established a missile research and development complex at China Lake, California, and in July 1945 the Army established its White Sands Proving Ground in New Mexico. A week later, on land that would eventually become part of White Sands, another technological achievement occurred that would greatly affect the future of missile development, the detonation of the first atomic bomb.

TO DEFEND AND DETER: THE LEGACY OF THE UNITED STATES COLD WAR MISSILE PROGRAM

Endnotes


3. During his lifetime Goddard was awarded 214 patents and made pioneering breakthroughs in the fields of liquid-fuel rocket engines, gyro-stabilization, steering, and staged engines. The scientist, however, was a secretive man and reluctant to share his findings. As a result, much of his work went unnoticed.


7. Ibid., pp. 50, 60, 62.


THE IMMEDIATE POST-WAR ERA 1945–1950: OPPORTUNITIES AND CONSTRAINTS

For the U.S. missile program, the immediate post-war period was one of both tremendous opportunity and frustrating constraints. The opportunities were the product of the new technologies developed during World War II, technologies such as atomic weapons and jet aircraft that had the potential to revolutionize warfare. In contrast, the constraints were mainly a product of the immediate post-war period. Following the end of World War II the U.S. military underwent sweeping changes: the nation demobilized, defense spending plummeted, and in 1947, the National Security Act resulted in a wholesale reorganization of the military establishment.a

The factor that had the greatest impact on the missile program in the post-war period was the shrinking defense budget. Defense spending had peaked at $81.5 billion in 1945. In 1946 it fell to $44.7 billion, and in 1947 it further declined to $13.1 billion. The Army Air Forces’ (AAF) missile program was hard-hit by the budget cutbacks. In April 1946 the AAF’s comprehensive missile development program consisted of twenty-eight projects that included surface-to-surface, surface-to-air, air-to-surface, and air-to-air missiles. In December 1946 the War Department reduced the AAF’s budget for missile research and development (R&D) by more than 50 percent, from $29 million to $13 million. As a result, by July 1947, the AAF was forced to cancel fourteen of its development projects.1

The drastic military spending cutbacks may seem paradoxical in retrospect. As the euphoria of victory subsided, the United States found itself in an international landscape changed forever by the upheavals of World War II. America’s role in the international community had permanently changed: at war’s end the United States was one of the world’s two predominant military powers, and also the leader of the Western alliance. In that capacity the United States was confronted not only with the challenges of converting its economy back to a peacetime basis, but also with helping the war-ravaged nations of Europe and Asia rebuild their economies and stand up to challenges from an increasingly bellicose Soviet Union.

a The Act subordinated the military services under the new National Military Establishment [later to become the Department of Defense], made the Secretary of Defense the principal advisor to the President in all matters of national security, and established the Air Force as a separate service. Public Law 253, 61 Stat., Chap. 343, 80th Congress, 1st session, “The National Security Act of 1947” 26 July 1947.

(opposite) The Snark’s long-range and heavy payload made it an attractive alternative to ballistic missiles.
TO DEFEND AND DETER: THE LEGACY OF THE UNITED STATES COLD WAR MISSILE PROGRAM

and funding allocated. Service zealously guarded the integrity of its role because it was on that basis that missions were assigned much the same for the Navy. Each service saw long-range missiles as an opportunity to expand its scope of operations in the air.”2

More important, to a nation anxious to forget about the war in Europe, the United States seemed to be a distant enemy. In the late 1940s the Soviets did not have the means to strike directly at the continental United States. The Soviet Union’s small fleet of long-range bombers lacked the forward air bases necessary to attack the United States, and its navy was configured primarily for coastal defense. Furthermore, American analysts predicted that the Soviets would not obtain an atomic capability until the 1950s.

The Impact of Emerging Technologies

World War II produced a revolution in weapons technology that included atomic weapons, jet aircraft, solid-state and miniaturized electronics, and long-range missiles. After the war, U.S. military planners started to assess the impact of those technologies and also began to debate which services would develop and control the new weapons. Apart from the dispute over the Air Force’s self-proclaimed monopoly on delivering nuclear weapons, no issue would be more hotly contested than the struggle for control of the military’s budgeting guided missile program.

The bitter interservice rivalry that eventually arose over long-range missile development illustrates the impact of new technology in blurring the distinction between the services’ established roles and missions. Traditionally, a service’s roles and missions were determined by its primary operational environment: the Army conducted combat operations on land, the Navy at sea, and the newly independent Air Force, in “all operations in the air.”3

Although the services’ areas of operation had never been completely separate, long-range missiles promised to further blur the distinctions by enabling each service to encroach on the operational environment of the others. For example, the Army could use long-range missiles to attack targets far behind the lines of battle, thus undermining the Air Force’s exclusive role in conducting strategic air warfare. The situation was much the same for the Navy. Each service saw long-range missiles as an opportunity to expand its scope of operations at the expense of a rival. This competition produced an inevitable succession of conflicts. Each service zealously guarded the integrity of its role because it was on that basis that missions were assigned and funding allocated.

Moreover, because neither the Army nor Navy was equipped to deliver nuclear weapons in the late 1940s, each saw missile programs as a means to acquire a nuclear capability.

Relations between the United States and the Soviet Union deteriorated rapidly after the war. Soviet delays in withdrawing from northern Iran drew protests from Washington, as did the Soviet handling of occupied Eastern Europe. At the Yalta conference in February 1945 Stalin promised Roosevelt and Churchill that the Soviet Union would allow the nations of Eastern Europe to hold free and fair elections to choose their own governments. However, soon reneged on their promise and over the next 3 years installed a success of satellite governments in the once-sovereign nations of Eastern Europe.

Yet despite these worsening relations, the United States did not perceive the Soviet Union to be an immediate military threat. U.S. leaders generally viewed the Soviet Union as a tired and battered nation at the end of World War II. Four years of fighting had taken the lives of 22 million of its people, and great expanses of its cities and countryside lay in ruins. Although the mighty Red Army posed a constant threat to Western Europe, the United States, then the sole possessor of the atomic bomb, was confident that it could deter Soviet aggression through the threat of nuclear retaliation.

More important, to a nation anxious to forget about the war in Europe, the United States seemed to be a distant enemy. In the late 1940s the Soviets did not have the means to strike directly at the continental United States. The Soviet Union’s small fleet of long-range bombers lacked the forward air bases necessary to attack the United States, and its navy was configured primarily for coastal defense. Furthermore, American analysts predicted that the Soviets would not obtain an atomic capability until the 1950s.

**Long-Range Missile Development**

The jurisdictional dispute over guided missiles between the Air Force and Army began during World War II. At that time both the AAF (the Air Force’s predecessor) and Army Service Forces (ASF) began developing missiles. The AAF saw missiles as an extension of aircraft technology that should be placed under its control. The ASF, which included the Army Ordnance Department, argued in response that missiles were merely an extension of artillery. In 1944, to settle the dispute, Lt. Gen. Joseph T. McNamara, the Army Deputy Chief of Staff, issued a directive assigning the AAF responsibility for missiles launched from aircraft as well as surface-to-surface missiles equipped with wings that provided aerodynamic lift. The ASF would be responsible for developing surface-launched missiles that depended exclusively on momentum for sustaining flight.4

Initially the McNamry Directive appeared to favor the ASF, especially considering the German missile technology the Army acquired at the end of the war. During the closing months of the war a team from the U.S. Army Ordnance Department raced into Germany just ahead of the onrushing Soviets and retrieved huge quantities of valuable technical data plus enough V-2 components to assemble 100 missiles. In an even greater coup, the United States secured the services of Germany’s top missle experts when Wernher von Braun, technical director of the German Army Ordnance rocket development program, surrendered to U.S. forces with approximately 120 members of his staff.5

Under the codename “Operation PAPERCLIP,” the Ordnance Department transferred von Braun and his missile development team to Fort Bliss, Texas, to continue work on the V-2. These Germans brought to the United States extensive experience in the development and testing of airframes, liquid fuel rocket engines, and guidance systems. They also had first-hand experience in the production and deployment of a complex missile system.

Beginning in April 1946 GE personnel, working under Project Hermes, began collaborating with von Braun’s team to assemble operational V-2s from the mountain of parts brought back from Germany. Over the next 5 years they launched 67 of the refurbished missiles from the White Sands Proving Ground. With this practical, hands-on training, the American engineers gained valuable insight into designing, testing, and handling large ballistic missiles.6 The experience gained through Project Hermes was later applied to a number of successful Army missiles.

Immediatley after the war both the ASF and AAF charged ahead according to their own interpretations of the McNamra Directive. In 1946, at the direction of General Henry H. (Hap) Arnold, Commanding General of the Army Air Forces, the AAF greatly expanded its missile research and development program. A key element in that program was a December 1945 study entitled “Toward New Horizons,” prepared at Arnold’s direction and led by Caltech’s Dr. Theodore von Kármán, who was also the chairman of the AAF Scientific Advisory Group.

Von Kármán recommended that over the next 10 years the AAF engage in the “systematic and vigorous development” of new technologies including long-range guided missiles, which at that time the Air Force called “pilotless bombers.”7 The ultimate goal of the long-range missile program, von Kármán wrote, was to create an intercontinental missile, and he recommended that the Air Force develop two types. The first should be an air-breathing “high-altitude, pilotless, jet-propelled bomber” with a speed of Mach 2 and a range of up to 3,000 miles. These “pilotless, jet-propelled bombers” were the predecessors of today’s cruise missiles. They derived aerodynamic lift from wings, required an external air supply, and were internally guided and powered throughout flight.
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Von Kármán also suggested that the Air Force develop a missile of the “ultrahypersonic” type, powered by the “rocket principle” and not intended for level flight. What von Kármán envisioned was a ballistic “glide missile” with wings, which was one of the conceptual predecessors of the intercontinental ballistic missile (ICBM). The wings were intended to increase the trajectory of the missile and also provide it with additional stability during unpowered flight.

In April 1946 the AAF missile program included eleven surface-to-surface missile-development projects, of which all but one were air-breathing. The exception was a study project by the Consolidated Vultee Aircraft Corporation (Convair) of Downey, California. Convair first became involved in the missile program in October 1945 when, in response to an AAF Technical Service Command solicitation, the aircraft manufacturer submitted a proposal to study the feasibility of building a ballistic missile capable of carrying a 5,000-pound payload up to 5,000 miles. The AAF liked Convair’s approach, and in April 1946 awarded the aircraft manufacturer project MX-774, a $1.4 million effort to study long-range ballistic missiles.

The missile that the Convair team designed was based on the proven V-2 but included three pioneering innovations. To reduce weight, Convair abandoned the V-2’s conventional fuselage composed of rings and stringers, instead the MX-774 would derive its structural rigidity from pressurized, integral fuel tanks. Second, to stabilize the missile in flight and reduce drag, Convair abandoned the carbon steering vanes, which worked much like the rudder of a boat, mounted in the engine exhaust. As an alternative it mounted the engines on gimbals, enabling them to swivel and supply directional thrust. Third, to save weight, improve post-boost flight characteristics, and reduce friction during reentry, Convair pioneered the use of a separable warhead.

The Convair project, however, would soon fall victim to post-war budgetary constraints. In July 1947 Convair had been working on the MX-774 for just over a year when sweeping defense cutbacks prompted the AAF to cancel the program. The AAF decided that the program was too expensive, estimating that completing RAND would cost an additional $50 million. The AAF also forecast that the missiles would be prohibitively expensive—about $500,000 each. Rather than investing more money in the long-range ballistic missile program, the AAF felt it would be more prudent to build air-breathing “glide type” missiles, which studies indicated would have a longer range, larger payload, and would be easier to develop.

Along with fiscal constraints, interservice rivalry and bureaucratic prejudices worked against the Convair program. Maj. Gen. Donald Putt, Commander of the Air Force’s Air Research and Development Command (ARDC) and later Deputy Chief of Staff, Development (DCSD), thought that the Air Force’s ongoing dispute with the Army over the future of long range missiles weighed against the MX-774. Citing the McNarney Directive, throughout the late 1940s and early 1950s the Army claimed that all surface-launched missiles were merely extensions of artillery, and thus should be under its control. Putt felt that by making its missiles air-breathing and giving them wings the Air Force was consciously trying to distance itself from the Army’s interpretation that missiles were extensions of artillery. “We were afraid that if we developed them [missiles] to look like rockets or a big artillery shell,” Putt said, “that eventually the Department of Defense would give the mission to the Army.”

Despite its decision to cancel the MX-774, the AAF allowed Convair to use its remaining funds to build three small missiles to test the feasibility of the swiveling motors, guidance system, and the separable warhead. The missiles, which Convair referred to as the Heroe (High altitude Rocket) series, or RTV-A-2, looked much like a much smaller version of the V-2. They were 32 feet high, 30 inches in diameter, and, when fully loaded, weighed slightly over 2 tons. Propulsion came from four alcohol and oxygen motors that together generated 8,000 pounds of thrust.

Between 1947 and 1948 Convair tested the RTV-A-2s at White Sands. Missile performance improved with every flight, and the last missile soared to an altitude of over 80 miles. Although the test results were not spectacular, they were encouraging and confirmed the desirability of using swiveling engines for flight stabilization and control. Yet despite the promising results, the Air Force (it had become a separate service in September 1947) refused to allocate additional funding for the ballistic missile program. Unwilling to abandon the project and lose its lead in a potentially lucrative market, Convair decided to support the ICBM program until it could find a new government sponsor to fund it.

When it canceled the MX-774, the nation’s only ICBM development program, the AAF continued to develop two strategic air-breathing missile programs: the Starfish [SM-62] built by Northrop Aircraft and the Navaho [XM-64] built by North American Aviation. From the AAF’s perspective, air-breathing missiles had two distinct advantages. First, the AAF thought that air-breathing missiles could be developed quickly and easily, and second, at that time, their 5,000-mile range and 7,000-pound payload far exceeded the capabilities of ballistic missiles. The payload was the key factor, the Air Force based the payload requirement on the
size of its smallest atomic warhead. General Purt also noted that these missile programs benefited from the Air Force’s institutional bias in favor of aircraft. “The air-breathing missiles looked like aircraft,” Purt said, and psychologically that made them easier to accept than the bullet-shaped ICBMs. The Air Force even reclassified its air-breathing missiles as “strategic pilotless bombers” to reinforce its claim that the missiles were an offset of aircraft.

Long-Range Air-Breathing Missile Development

The Skylark program began in March 1946 in response to an AAF requirement for a missile capable of carrying an atomic warhead 5,000 miles at a speed of 600 miles per hour. The Skylark looked much like an aircraft. The swept-wing missile was 67 feet long and had a wingspan of almost 43 feet. Initially the primary contractor, Northrop Corporation, promised the Air Force that it could develop the missile within 2½ years at an average cost of $80,000 for each missile. Development of both the airframe and the guidance system proved much more difficult than Northrop expected, and the first successful flight was not launched until April 1951.13

To complement the Skylark, the AAF began work in April 1946 on another long-range air-breathing missile, the supersonic Navaho. This new missile would have the same range and payload as the Skylark, but was designed to travel at supersonic speed. In its final form the delta-wing Navaho was 70 feet long and powered by two powerful ramjet engines that gave it a cruising speed of 2,150 miles per hour. Launched vertically, the missile sat atop a 76-foot rocket booster that carried it up to its operating altitude and then fell away. The Air Force’s decision to abandon the ICBM in favor of the Skylark and Navaho would have far-reaching consequences. Initially, air-breathing missiles offered superior performance, but in the early 1950s, improvements in ballistic missile technology erased that early advantage. Perhaps the Air Force assumed that air-breathing missiles would be a technological midpoint in the development of the ICBM, but the assumption proved to be incorrect.14 The Skylark and Navaho programs turned out to be far more difficult than expected, and with the exception of the Navaho booster, the technology was not readily adaptable to the ICBM program. Both the Skylark and Navaho missiles were plagued with severe guidance and control problems. So many Snarks crashed during testing that the waters around Cape Canaveral, Florida, were said to be unfit for swimming because they were “Snark infested.” Navaho’s persistent technical problems gave the missile the moniker “never go-Navaho.” That name proved to be prophetic: after spending $700 million the Air Force canceled the Navaho program in late 1958. The Snark, on the other hand, saw brief duty. The Air Force deployed a single squadron at Presque Isle, Maine, in February 1961, then deactivated it less than 6 months later.15

Surface-to-Air Missiles

A debate over surface-to-air missiles eventually would mar relations between the Army and Air Force in the 1950s. The Army Ordnance Department’s surface-to-air missile program began in late 1945 when it hired Western Electric to develop what later became the very successful Nike system. At the same time the Army was developing Nike, the AAF was also supporting three surface-to-air missile projects: Thumper, Wizard, and GAPA. The Air Force envisioned that GAPA, conceived late in World War II, would be a ramjet-powered missile launched by a solid-propellant booster capable of reaching an altitude of 60,000 feet at a range of 85 miles. Conceptually, under the provisions of the October 1944 McNary Directive, GAPA should have been under the jurisdiction of the Army Ordnance Department. However, the AAF took considerable pains to explain that guidance for GAPA obviously would be determined by aerodynamic forces, thus placing the program within the “sphere of responsibility of the Army Air Force.”16

GAPA showed promise. After a year of successful prototype testing from Wendover Air Force Base in Utah, the Air Force assured the President’s Air Policy Commission in October 1947 that GAPA should be operational by the mid-1950s. But in 1948 budget cuts prompted the Air Materiel Command (AMC) to reduce funding for the program from $5.5 million to $3 million, hardly enough to sustain Boeing’s R&D organization. The final blow to GAPA came in late 1949 when the Joint Chiefs of Staff (JCS) decided that the three services were developing too many short-range surface-to-air missiles. GAPA was canceled.17

The debate between the Army and Air Force over surface-to-air missiles was typical of the type of disagreements that kept appearing as the services attempted to define their respective roles and missions. Unable to agree on service functions from the JCS, Secretary of Defense James Forrestal in March 1948 held a meeting with the JCS at the naval station at Key West, Florida. Before the Key West Conference, negotiations between the services had founded on determining what role the Navy should have in strategic air warfare, and whether the Army or the Air Force would have responsibility for land-based air defense. After the meetings, the service chiefs agreed that the Air Force would have sole responsibility for strategic air warfare as well as the lead role in protecting the nation against air attack. The Army, however, still held a role in continental air defense because it retained responsibility to “organize, train, and equip” antiaircraft artillery units. At first glance it appeared that the Army and Air Force air defense roles overlapped, but in practice the roles were quite different. Continental air defense was a huge undertaking that required a complex infrastructure of early-warning radars, fighter aircraft, and command and control facilities. In contrast, the Army’s antiaircraft artillery (AAA) batteries were intended for point defense to protect targets such as a bridges, airfields, or troop concentrations. Although the Key West Conference assigned a role for Army AAA within continental air defense, the Army refused to place its antiaircraft batteries under Air Force command.
Force and the Air Force. The Army argued that if it diverted a portion of its limited antiaircraft capability to continental air defense, troops in the field would be left without an adequate air defense capability. In a sense this was true, at the time, most of the Army's AAA units were in reserve status, attached administratively to the six continental armies. The great majority of the Army's active A-4 units were deployed abroad because the Army considered a Soviet attack on U.S. forces overseas much more likely than an assault on the American mainland.

The bickering between the Army and the Air Force abated in September 1949 when a somber President Truman told the nation that the Soviet Union had developed an atomic bomb. Suddenly, continental air defense, previously a low priority, became a pressing concern. Faced with this new threat, in the fall of 1949 the Air Force began formulating an integrated air defense system, and called upon the Army and the Navy for support. In the spring of 1950 the Army deployed the 518th AAA Battalion at Hanford, Washington, to protect the atomic weapons production facilities. It was the first of many AAA units to deploy around the nation's vital military and industrial areas. In July 1950 the Army established the Anti-Aircraft Command (ARAACOM) and a month later, in a spirit of cooperation brought on by a sense of urgency, agreed to place its AAA units under operational command of the Air Force's Continental Air Command.

Despite the fiscal constraints and rivalries that at times appeared to hobble the three services, between 1945 and 1950 the guided missile program made some progress. The Army's Nike program continued to make steady progress, air-breathing missile development was somewhat erratic, and the Air Force contemplated the fate of its ballistic missile program.

One notable achievement during this period was the founding or expansion of many missile development and test facilities. These facilities would later play crucial roles in the Cold War missile program. The Army's White Sands Proving Ground rapidly evolved from a few Quonset huts into a premier research, development, test, and evaluation facility used by all three services. The Air Force's Edwards Air Force Base and NASA's Marshall Space Flight Center, and the Navy's Naval Air Station on the east coast of Florida, 210 miles north of Miami. The Air Force renamed the installation Patrick Air Force Base and designated it home of the Air Force Missile Test Center. Among the Army's White Sands Proving Ground, Public Affairs Office, n.d.), pp. 65–66, 97. 11. This information was drawn from the preliminary flight reports of the MX-774 launches 1, 2, and 3. The reports, prepared between October 1948 and February 1949, are available at the National Air and Space Museum, Washington, DC, Library and Archives Division, file OM–990774–02, folder, “MX-774.”

12. Putt interview, p. 150.


15. The bickering between the Army and the Air Force continued to escalate. In late 1949 the Army and Navy, in a spirit of cooperation brought on by a sense of urgency, agreed to place their AAA units under operational command of the Air Force's Continental Air Command. Despite the fiscal constraints and rivalries that at times appeared to hobble the three services, between 1945 and 1950 the guided missile program made some progress. The Army's Nike program continued to make steady progress, air-breathing missile development was somewhat erratic, and the Air Force contemplated the fate of its ballistic missile program.

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Endnotes


4. For the story of von Braun's work on the German missile program and his decision to surrender to the Americans, see Frederick I. Ordway and Mitchell R. Sharpe, The Rocket Team (New York, Thomas Y. Crowell, 1979).


12. Putt interview, p. 150.


18. Ibid., pp. 10–14.


Upon learning that the Soviets had developed an atomic bomb, President Truman acted with characteristic dispatch. He immediately ordered the Atomic Energy Commission to launch the full-scale development of the hydrogen bomb. Soon after, he created an interdepartmental task force led by the State Department’s Paul Nitze to conduct a general review of U.S. national security policy.

The study, called NSC-68, was completed in the spring of 1950. It warned that if the United States was to deter Soviet aggression, it needed to spend considerably more on national defense. Indicative of the dangers ahead, the study estimated that by 1954 the Soviets would have enough long-range bombers and atomic weapons to launch a devastating attack on the United States. To meet the Soviet threat, defense planners estimated that by fiscal year 1952 defense spending would need to rise to $40 billion, almost a 300 percent increase over the Pentagon’s 1950 budget.

As if to confirm the dire warnings in NSC-68, in June 1950 North Korea launched a surprise attack on South Korea and the United States suddenly found itself embroiled in a conflict in Asia. As the military recalled reservists and mobilized to meet the challenge in Korea, a massive U.S. rearmament campaign began. In 1950 the Army and Air Force missile programs were at different stages. The Army was making substantial progress on its Nike surface-to-air missile system and also beginning work on a 500-mile tactical-range ballistic missile. While the Army was diversifying its missile program the Air Force used Secretary of Defense Louis Johnson’s March 21, 1950 directive on guided missiles to claim sole responsibility for developing all long-range missiles. During the early 1950s the Air Force directed most of its attention to coaxing along its slow-moving Snark and Navaho air-breathing missile programs. At the same time the Air Force’s other long-range missile program, the ballistic MX-774, was in limbo. Officially canceled since 1947, the MX-774 led a curious unofficial existence, financed mainly by Convair and quietly supported by missile advocates within the Air Force.

The rapid evolution of missile technology after World War II made missiles suitable for an increasingly wide range of missions. Whereas the V-2 was considered “long-range” in the mid-1940s, by the early 1950s the United States was developing three distinct classes of ballistic missiles: (1) tactical missiles with ranges under 500 miles; (2) intermediate-range missiles with ranges of approximately 1,500 miles; and (3) strategic or intercontinental-range missiles with ranges in excess of 1,500 miles.
TO DEFEND AND DETER: THE LEGACY OF THE UNITED STATES COLD WAR MISSILE PROGRAM

The 1949 revelation that the Soviets had an atomic bomb stoked new interest in air defense, particularly the Army's Nike program, which had made great strides since its inception in 1945. The Air Force air-defense missile programs had not fared as well. The Air Force lost its first surface-to-air missile program, the ground-to-air pilotless aircraft (GAPN) project, in 1949. However, the Air Force was unwilling to allow the Army to exercise complete control over ground-based air defense. The United States was diversifying its nuclear deterrent, and defense spending was on the rise. Even more promising, in late 1950 a study by the Rand Corporation indicated that recent advances in engines and guidance systems made the ICBM technologically feasible.2

In October 1950 K.T. Keller, the Secretary of Defense's newly appointed Director of Guided Missiles, recommended that the Army's Nike program be accelerated. At the same time Keller also pushed to accelerate the development of the Air Force's BOMARC. In November 1951 a Nike successfully intercepted a target drone in the skies over White Sands, and in 1952 Douglas Aircraft opened its first Nike production facility in Santa Monica, California. In a related development, in April 1950 the Army began to consolidate its missile programs at the new Ordnance Department. By the end of 1950 the Ordnance Department had been transferred to Huntsville, Alabama. One of the organizations transferred there was the Ordnance Research and Development Division Suboffice (Rocket) formerly based at Fort Bliss, Texas, and home to Wernher von Braun and the "Operation PAPERCLIP" team. Since 1946 the Suboffice had administered Project Hermes, in September 1950 the Ordnance Department ordered the Guided Missile Center to make a preliminary study of a 500-mile tactical-range ballistic missile. Under the direction of von Braun, that study ultimately led to the Army's successful Redstone and Jupiter missiles.

Early ICBM Development

While the Army consolidated its missile development program at Huntsville, the Air Force allowed its ICBM program to languish. With a skepticism bred from extensive operational experience, few in the Air Staff felt that the ICBM could reliably and effectively attack targets at intercontinental range. Instead, the Air Force chose to invest in new bombers and, to a lesser extent, long-range air-breathing missiles. Several ICBM advocates composed of Air Force officers and their allies in industry lobbied for the Air Force to resume its support of the ICBM program. Recent events at home and abroad prompted the Air Staff to look at the ICBM program in a new light, and in January 1951 the Air Force ordered Convair to study the feasibility of developing a ballistic missile capable of carrying an 8,000-pound warhead 5,000 miles and striking within a circular error probable (CEP) of 3,500 feet.3

This combination of events at home and abroad prompted the Air Staff to look at the ICBM program in a new light, and in January 1951 the Air Force directed Convair to study the feasibility of developing a ballistic missile capable of carrying an 8,000-pound warhead 5,000 miles and striking within a circular error probable (CEP) of 3,500 feet.4

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Convair completed the missile study in July 1951. The airframe manufacturer concluded that its long-range ballistic missile, which it now called Atlas, was technologically feasible, and it urged the Air Force to begin development without delay. Convair then submitted the study to the newly independent Air Research and Development Command (ARDC). During a series of meetings, the ARDC Deputy for Development, strongly urged the Air Staff to begin development of a long-range ballistic missile immediately, and requested additional funding to support the effort.6

The Air Staff did not share ARDC's enthusiasm for the ICBM. It refused to fund a full-scale development effort and ordered ARDC to limit its activities to a preliminary test program.7 ARDC protested the Air Staff's decision and continued to press for a full-scale development program. In December 1951 ARDC recommended that the Air Staff should begin development of a long-range ballistic missile without delay.8

The sparring between ARDC and the Air Staff continued for the next two years, ARDC wanting to plunge into an ambitious development plan while the Air Staff preferred a slower approach to begin with additional research. In 1953 the two sides finally reached a compromise that yielded a development plan. No definitive date was set for completing the ICBM phase, instead planners estimated it would be "sometime" after 1964. The development plan provided for an operational capability in 1965, but noted that this date could be moved ahead by two or three years with additional support.9

ICBM Technology

As ballistic missile technology continued to improve throughout the early 1950s, the Air Staff's resistance to the ICBM program became increasingly untenable. For example, when the Air Materiel Command canceled Convair's MX-774 program in 1947, one reason given was that the Army's Nike program had made great strides since its inception in 1945. The Air Force and NASA jointly sponsored a new project, MX-1593, which was given a new name: MX-1593. Under the terms of the contract, the Air Force directed Convair to study the feasibility of developing a ballistic missile capable of carrying an 8,000-pound warhead 5,000 miles and striking within a circular error probable (CEP) of 3,500 feet.10

Before 1951 R&D was controlled by the Air Materiel Command (AMC). Critics of the arrangement complained that AMC was not structured to support far-reaching research programs like the ICBM, and urged that a separate R&D command be created.12

12 Radio-inertial guidance used a series of ground-based tracking radars to determine the missile's position. The information was then relayed to ground-based computers that compared the missile's position against the programmed flight path and relayed course corrections to the missile's flight control system. In contrast, the all-inertial guidance system was completely self-contained. Before launch the missile was programmed to follow a specific flight path. Using a system of gyroscopes and accelerometers, the guidance system constantly monitored the missile's position relative to its designated flight path. If the missile strayed from its programmed course, the guidance system sent course corrections to the flight control system. Unlike radio-inertial guidance, the all-inertial system was not susceptible to radio jamming.

5.5 The CEP is the radius of a circle whose half width of the circle is equal to the CEP. Within half the width of the circle the missile can be expected to land.
These new weapons were several orders of magnitude lighter and more powerful than the fission warheads they replaced. For example, the fission bomb dropped on Hiroshima weighed approximately 10,000 pounds and had an explosive yield of 13 kilotons. In contrast, by mid-1953 scientists working for the Air Force estimated that by the end of the decade the United States would be able to build a 1,500-pound thermonuclear warhead with a yield of one megaton. Only 15 percent the weight of the Hiroshima weapon, the thermonuclear weapon would be approximately 70 times more powerful.

The advent of thermonuclear weapons enabled the Atlas design team to overcome two of its most intractable problems, both related to the missile’s originally specified 3,000-pound fission warhead. First, by reducing the weight of the warhead from 3,000 pounds to 1,500 pounds, they could reduce the size of the missile by half. Second, because the thermonuclear warhead was approximately 50 times more powerful than the proposed fission warhead, and also had a much larger destructive radius, the missile’s CEP, a measure of error in delivery accuracy, could be expanded from 1,500 feet to several miles. Expanding the CEP made designing the guidance system much less complicated.

The Air Staff, however, failed to grasp the implications of these developments. These men, who had spent much of their careers in the cockpit, seriously questioned whether the ICBM could function as a reliable component of the nation’s strategic nuclear deterrent. Other Air Force officers resisted the ICBM simply because they were unable to appreciate its tremendous potential. Many pilots were hostile to the ICBM because they feared its effect on their profession. In the early 1950s the Air Force was a tightly knit professional community dominated by pilots and centered on aircraft. Aircraft were the cornerstone of the Air Force’s professional and social order, and any change threatening to disrupt that paradigm was perceived by most of the officer corps with apprehension.

ICBM Advocates

Before 1953, ICBM advocates at ARDC had made little headway against their entrenched opposition. That changed in the spring of 1953 when the ICBM program gained two new advocates: Trevor Gardner and Bernard Schriever. Gardner arrived on the scene first. In February 1953 he was appointed Special Assistant to the Secretary of the Air Force for Research and Development. Gardner, 38 years old at the time, was an engineer and businessman who left his job as president of Hycon Manufacturing in Pasadena, California, to join the government.

Gardner was short and stocky, with closely cropped hair and wire-rimmed glasses. Those who liked him called him blunt, outspoken, and a gifted manager. Herbert York, the Director of the Atomic Energy Commission’s Livermore Laboratories, described Gardner as “intelligent, vigorous, somewhat volatile, and shroud that encased the warhead, which was considered by many experts to be the most difficult hurdle of the entire development effort.” In June 1952 H. Julian Allen, a scientist at the National Advisory Committee for Aeronautics, Ames Research Laboratory, pioneered the concept of the blunt-body reentry vehicle that later became a central feature of the ICBM program.

In the years that followed, the Air Force experimented with two types of reentry vehicles: heat sink and ablative. The heat sink vehicle contained a large, blunt copper core that absorbed heat to keep it away from the sensitive warhead. The ablative type was more streamlined and dissipated heat as the outer layers burned away.

During the early 1950s a revolution in thermonuclear weapons technology also hastened the birth of the ICBM. The United States began earnestly developing thermonuclear weapons in 1949, and by November 1952 successfully tested an experimental device at Eniwetok Atoll in the Marshall Islands. Further improvements followed rapidly, and by early 1953 the United States had perfected an operational thermonuclear weapon. These new weapons were several orders of magnitude lighter and more powerful than the fission warheads they replaced. For example, the fission bomb dropped on Hiroshima weighed approximately 10,000 pounds and had an explosive yield of 13 kilotons. In contrast, by mid-1953 scientists working for the Air Force estimated that by the end of the decade the United States would be able to build a 1,500-pound thermonuclear warhead with a yield of one megaton. Only 15 percent the weight of the Hiroshima weapon, the thermonuclear weapon would be approximately 70 times more powerful.

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impatient to make changes quickly."11 Gardner's opponents were not charitable in their descriptions—they called him "sharp, abrupt, irascible, cold, and a bastard."12

James Killian, President Eisenhower's respected science advisor, described Gardner as "technologically evangelical," and the new special assistant wasted little time in making his mark on the Air Force. Soon after taking office Gardner embarked on an aggressive campaign to develop promising new technologies, which led him to the ICBM. Gardner became a zealous proponent of the ICBM because he believed that if the long-range missiles were developed quickly, they could be destroyed on the ground by a Soviet surprise attack, leaving the United States open to nuclear extortion. A 1953 study by Rand mathematician Albert Wohlstetter found that as many as 85 percent of SAC's bombers could be destroyed on the ground by a Soviet surprise attack, leaving the United States open to nuclear extortion.13

Gardner was an ardent proponent of new technology, and within several months he and Gardner had joined forces to promote a stronger role for R&D within Air Force war planning. Together they formed an effective alliance. Schriever was the inside man, familiar with the Air Force's ongoing programs as well as the politics of the R&D process. Gardner made his contribution at the secretarial level. His intuitive grasp of R&D, coupled with his aggressive approach and the strong support he received from his mentor, Secretary of the Air Force Harold Talbott, made him an unusually effective advocate. Gardner also understood the practical limits of his authority, and he was not afraid to go outside of the Air Force to win support for his programs. The Atlas ICBM was a case in point.

Although both Gardner and Schriever recognized that the ICBM had tremendous potential, they also pragmatists. They understood that their support alone was insufficient to overcome the Air Force's resistance to the missile program. Facing widespread opposition, they realized that to accelerate the Atlas program they needed two things: a convincing justification and a cadre of influential scientists and engineers who would support their actions.

The justification Gardner and Schriever seized upon was thermonuclear weapons. In the spring of 1953 the Air Force Scientific Advisory Board (SAB) estimated that by the end of the decade the United States would develop a 1,500-pound thermonuclear warhead with yield of 1 megaton. It is important to note that thermonuclear weapons were not the single missing ingredient that made ICBMs possible, the warheads were only one of several new technologies to be incorporated in the missile. But on a broader scale thermonuclear weapons served as a badly needed catalyst to accelerate the ICBM program. First, the new warheads furnished Gardner and Schriever with an ideal pretext to lobby for a fresh look at the ICBM program. Second, because thermonuclear weapons weighed far less and were tremendously more powerful than fission weapons, they made the ICBM campaign an ICBM much less demanding and much less expensive, which in turn made the project politically feasible. To exploit the thermonuclear technology breakthrough, Gardner and Schriever's first task was to get official confirmation of the SAB's earlier nuclear estimates. They did this through a subcommittee of the SAB's Nuclear Weapons Panel, chaired by the distinguished mathematician John von Neumann.14

Von Neumann's group completed its study in October 1953. To no one's surprise, the Nuclear Weapons Panel confirmed that in the next 6 to 8 years the United States would be able to develop a thermonuclear warhead weighing 1,500 pounds and generating an explosive yield of 1 megaton. The panel also observed that the size, shape, and yield of thermonuclear weapons made it perfectly suited for the ICBM. Equally important, the von Neumann group noted that the new weapons would have a significant impact on the current Atlas program. One of the most notable examples, the subcommittee found, was in the area of guidance accuracy. In light of the then prevailing nuclear warheads greatly enhanced yield, von Neumann reasoned that the Atlas guidance requirements should be eased considerably.15 He recommended expanding the CEP to a range of 3.2 to 4.5 miles, almost 16 times larger than the original 1,500-foot specification.

The Teapot Committee

The Nuclear Weapons Panel's findings enabled Gardner to convince Secretary of the Air Force Harold Talbott that the Air Force's long-range missile program needed to be evaluated "by a special group of the nation's leading scientists." With Talbott's approval Gardner began assembling his "blue ribbon" scientific advisory committee in October 1953. Officially entitled the "Strategic Missiles Evaluation Committee," everyone referred to the group by its code name: the Teapot Committee. To lead the committee, Gardner once again called on the man Time magazine called "the smartest man in earth," the brilliant and affable Dr. John von Neumann.16

Gardner gave the Teapot Committee a broad mandate, study the Air Force longrange missile program and make recommendations for improving it.17 The committee began meeting in October 1953, and over the course of the next several months it made a detailed study of the SNAKE, Navaho, and Atlas programs. The committee completed its succinct 10-page report in February 1954. The committee's report stated that the Atlas program was beset by a number of serious technological and managerial problems. The committee found that many elements of Convair's design were outdated and they recommended that the entire Atlas program be reviewed in light of the recent advances in thermonuclear weapons. Design deficiencies, however, were only the beginning of the problem. The Atlas program's most press-