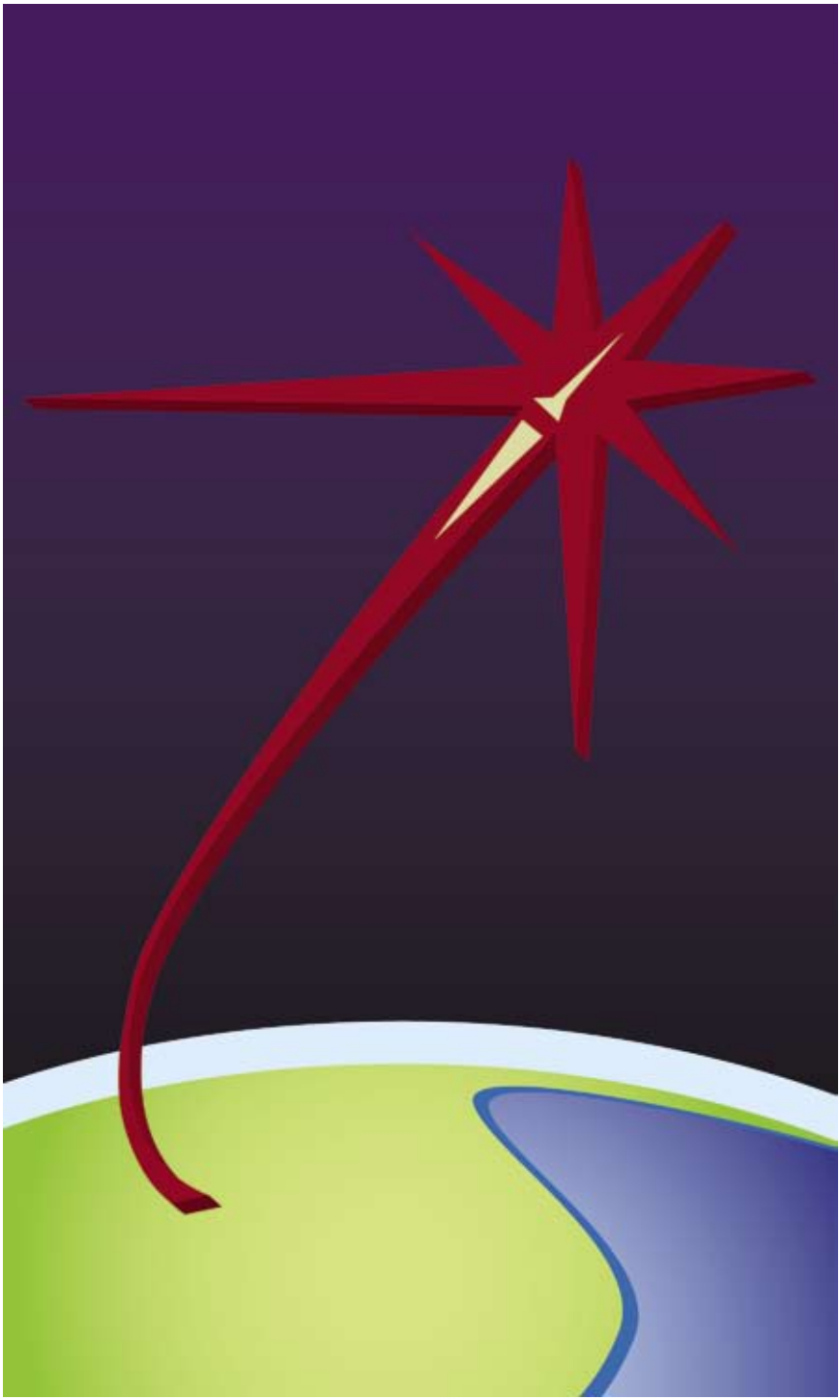
NIKE ZEUS:

THE U.S. ARMY'S FIRST ANTIBALLISTIC MISSILE



Strategic Defense Initiative Organization (SDIO)
1984 – 1994

Ballistic Missile Defense Organization (BMDO)
1994 – 2002

Missile Defense Agency (MDA)
Established January 2, 2002

FOREWORD

The mission of the Missile Defense Agency (MDA) History Office is to document the official history of America's missile defense programs and to provide historical support to the MDA Director and MDA staff.

This pamphlet is intended to acquaint readers with the history of the Nike Zeus Project, the U.S. Army's first effort to develop an antiballistic missile (ABM) system that could intercept intercontinental ballistic missiles (ICBMs). This pioneering effort was ambitious and controversial. The groundbreaking Nike Zeus Project demonstrated the possibility of intercepting an ICBM, but suffered from technical and operational shortcomings that made it impractical to deploy. Despite these shortcomings, the Nike Zeus Project was instrumental in establishing the foundations for its successor, the Nike-X Project, a more robust ballistic missile defense system.

Constructive comments and suggestions from readers are welcome. Please forward them to Dr. Lawrence M. Kaplan, MDA Historian, at Lawrence.Kaplan@mda.mil, or by telephone at (703) 882-6546.

Nike Zeus: The U.S. Army's First ABM

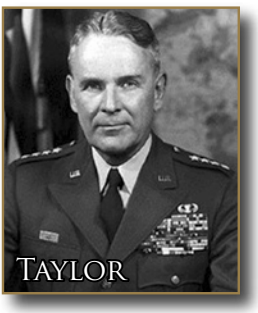
As the Cold War unfolded following World War II, America determined that it faced a hostile and expansionist Soviet Union. The growing threat of Soviet long-range aircraft and long-range missiles posed an unprecedented challenge to defending America against attack. In response, the policies of containment and deterrence became the cornerstones of American strategic doctrine, with a heavy reliance on nuclear weapons and strategic air power to discourage any Soviet or Soviet-supported military aggression. During the Eisenhower administration this policy of striking back decisively against any aggressor was known as "massive retaliation" and evolved into the policy known as "mutual assured destruction" or MAD in the Kennedy administration. By the early 1960s, the advent of long-range Air Force ballistic missiles and Navy submarine-launched ballistic missiles joined manned bombers in completing America's strategic deterrent triad.

Although deterrence relied primarily on offensive measures, strategic missile defense (defending the continental United States) became an increasingly desirable adjunct to American strategic capabilities. Following World War II, the Air Force's Project Wizard began developing a strategic antiballistic missile (ABM) system and in the early 1950s the Army began developing a theater ABM system, Project Plato, to protect deployed military forces against short-range ballistic missiles. During this period, however, the Army was at a significant disadvantage when competing for annual budget money with the other services since it did not have a strategic offensive mission. In 1955, this situation began changing after intelligence reports of an

impending Soviet intercontinental ballistic missile (ICBM) threat spurred the Department of Defense (DoD) to launch several high-priority offensive missile programs among the services. These competing missile programs, which were intended to achieve early operational capabilities, blurred distinctions between the services' roles and missions. In this environment the Army sought to compete with Project Wizard for a role in strategic missile defense.

In March 1955, as part of its air defense research, the Army commissioned Bell Telephone Laboratories, the research and development branch of the Western Electric Company, to examine the prospects for developing a strategic ABM system. Bell Labs had developed the first generation non-nuclear Nike I (Ajax) antiaircraft surface-to-air missile (SAM) and was developing a second generation nuclear-armed Nike B (Hercules) SAM.

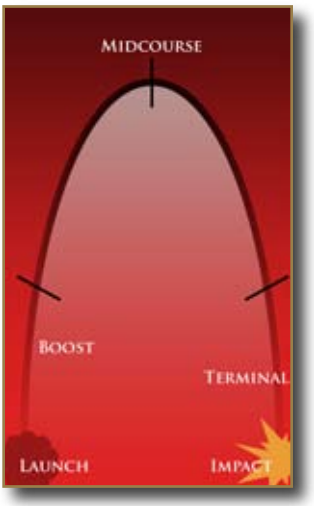
Bell Labs conducted an 18 month Nike II feasibility study that examined continental United States air defense requirements for the 1960s against both high-performance air-breathing threats and long-range ballistic missiles. Initially, the study explored the possibility of a common antiaircraft defense system covering all high-altitude threats, which employed a missile with different warheads, one for use against missiles and one for use against aircraft. In June 1955, as concern increased over the ICBM threat, the Army requested the study shift its focus primarily to missile defense. The shift coincided with General Maxwell D. Taylor's appointment as Army Chief of Staff. He aggressively sought to increase the Army's share of the budget and became a staunch



advocate for expanding the Army's air defense role into strategic missile defense.

The Nike II study assumed that a precisely guided nuclear warhead would be necessary to ensure successful interception of a ballistic missile. By comparison to World War II air defense objectives, where a 10 to 15 percent attrition rate was acceptable against aircraft, the nuclear ballistic missile threat required defense levels of 95 to 100 percent attrition against hard to kill reentry vehicles. Studies showed that using a 50 kiloton nuclear warhead in the interceptor missile required relatively small miss distances to kill an enemy warhead, and the use of a high-yield defensive warhead did not reduce the need for a guidance system of high accuracy.

The first question addressed was where in the attacking missile's trajectory–the boost, midcourse, or terminal phase–an intercept should take place. Given the limited information collection capabilities against hostile missile launches, the study assessed the midcourse intercept option too difficult to be feasible and proposed a terminal-phase interceptor in its place. Technological limitations suggested that a homing system would be unworkable for the interceptor and the most attractive guidance method would be one based on the Nike Ajax/Nike Hercules command systems.



BALLISTIC TRAJECTORY

The study recognized that an extensive communications network, integrating detection, acquisition, tracking and launch control radars, data processing, computation, and tactical control would be necessary to make the system work. All of these disparate parts would have to work together very rapidly as an integrated whole.

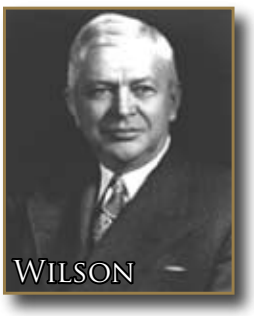
Given limited warning times of 10 to 15 minutes for a missile attack, most actions had to be semiautomated. A human operator would only be able to veto a programmed launch.

The challenge of discriminating real warheads from a debris cloud and other radar countermeasures posed a significant problem. The study recognized that high rates of ICBMs arriving over their targets, coupled with the difficulty of discriminating decoys from real warheads, would require a system capable of engaging up to 20 targets per minute.

In January 1956, Bell Labs advised the Army that a long-range, high-data-rate acquisition radar would be an essential component of any ballistic missile defense system. Bell Labs also advised that if development of this vital radar could begin immediately, an interim ABM defense might be possible with the developmental Nike B (Hercules) missile system.

Bell Labs subsequently completed 50,000 analog computer simulation intercepts of ballistic missile targets. These simulations indicated that it was possible to intercept a target flying through space at 24,000 feet per second. Bell Labs presented their findings to the Army in October 1956.

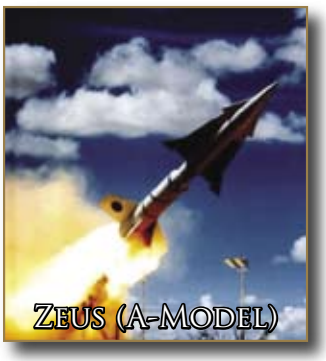
In November 1956, Secretary of Defense Charles E. Wilson attempted to disentangle Army and Air Force air defense responsibilities by distinguishing between "area" and "point" defense. The first, assigned to the Air Force, involved "the concept of locating defense units to intercept enemy attacks remote from and without reference to individual vital installations, industrial complexes or population centers." Point defense, an Army responsibility, was "the defense of specified geographical areas, cities and vital installations." Air defense missiles


WILSON

designed for point defense were to be limited to horizontal ranges of approximately one hundred nautical miles. Even so, it was not easy to draw a clear distinction between area and point defense, and a rivalry grew between the Army and Air Force as they developed competing air defense missiles.

In February 1957, the Army initiated the Nike II development program with Western Electric as the prime contractor, and Bell Labs and the Douglas Aircraft Company as subcontractors, and changed the name to the Nike Zeus Project. The contract laid out a six-year development program for the Nike Zeus antimissile missile system under the supervision of the Army Rocket and Guided Missile Agency, an element of the Army Ordnance Missile Command at Redstone Arsenal, Alabama. Bell Labs served as the technical project director while the Douglas Aircraft Company undertook development of the nuclear-capable Zeus exoatmospheric (outside the atmosphere) interceptor, which represented the third generation in the Nike air defense guided missile family. Zeus was intended to be part of an integrated ABM defense system that included advanced radars for acquisition and tracking, and battle management communications equipment, which the Nike II study indicated would be necessary. The Army also intended to draw upon Project Plato's development in furthering the Nike Zeus Project.

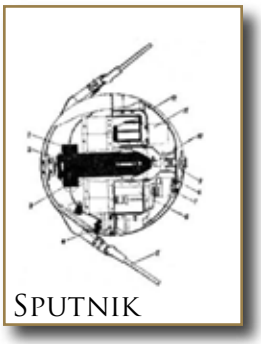
Nike Zeus Project Office Emblem



Technical challenges abounded in the Nike Zeus Project because so much of the developmental work done was groundbreaking. The proposed missile design, the design architecture of the system's radars, the computer and

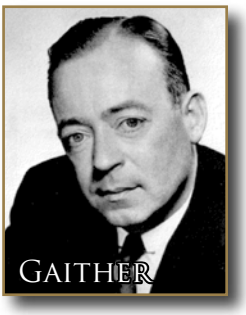
communications integration, and even finding adequate ranges for testing, had to be developed from the ground up. From the outset these technical challenges and projected high costs made Nike Zeus a continuing target of criticism, particularly from the Air Force and the scientific community.

In the midst of this growing controversy, the Soviet Union announced a successful test flight of an SS-16 ICBM in August 1957; and on October 4, 1957, the Soviets launched Sputnik, the world's first artificial satellite. These catalytic events heightened concerns about American vulnerabilities to a Soviet ICBM attack and created a political environment more supportive of developing and fielding an ABM system.


SPUTNIK

A few weeks after the Sputnik launch, the Army stood firm in pressing for Nike Zeus development. General Taylor advised Congress:

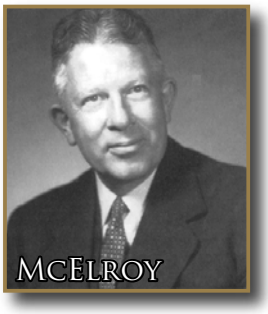
> "We can see no reason why the country cannot have an antimissile defense for a price which is within reach. I am sure many of you have heard the statement that the dollar requirements for this kind of defense are astronomical and that the whole concept is beyond consideration. I can assure you that the studies which I have seen lead me to a different conclusion. We can have an antimissile defense…."


GAITHER

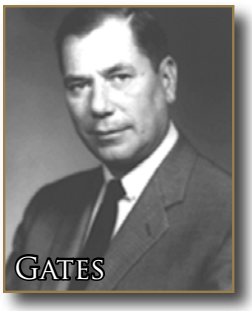
In early November 1957, the presidentially appointed Gaither Panel (named after its chairman, H. Rowan Gaither, Jr., then chairman of the board of directors of the Ford Foundation and a founder of the RAND Corporation), submitted its

report on continental defense, "Deterrence & Survival in the Nuclear Age," to the Eisenhower administration. The report assigned the highest priority to protecting the nation's primary deterrent, Strategic Air Command (SAC) bombers, from a surprise Soviet attack, and recommended having active missile defense at SAC bases. This included developing radars capable of providing early warning of missile attacks, hardening radars against countermeasures, and employing interim antimissile defenses using available weapons such as the Nike Hercules and land-based versions of the Navy's Talos air defense missile. The report also recognized the importance of protecting cities and other key targets:

> "[T]he importance of providing active defense of cities or other critical areas demands the development and installation of the basic elements of a [missile defense] system at an early date. Such a system initially may have only a relatively low-altitude intercept capability, but would provide the framework on which to add improvements brought forth by the research and test programs."

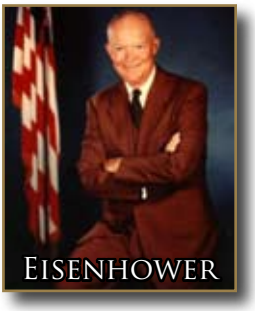


By early 1958, the Army and Air Force rivalry over dominance of the strategic missile defense program prompted Secretary of Defense Neil H. McElroy to settle the dispute. On January 16, 1958, he assigned the active strategic defense mission to the Army. Later that month, the Nike Zeus Project received additional support from a National


GATES

Security Council position paper (NSC 5802) on continental defense that called for "an anti-ICBM weapons system as a matter of the highest national priority."

The Joint Chiefs of Staff argued for an administration commitment to accelerate Nike Zeus development, but President Dwight D. Eisenhower's defense secretaries, Neil H. McElroy (1957-59) and Thomas S. Gates (1959-61), along with many in the scientific community, were not convinced the program was worth the cost and effort to rush to an early deployment. President Eisenhower also was skeptical, questioning whether an effective ABM system could be developed in the 1960s. The same attitude continued into the Kennedy administration (1961-63).

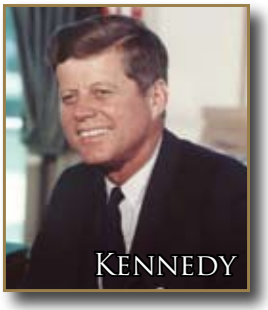

EISENHOWER


ZEUS (B-MODEL)

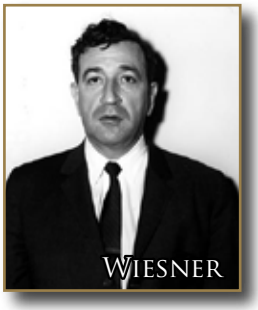
The Army's preliminary deployment studies reportedly estimated that 60 Nike Zeus batteries, each armed with 50 interceptors, would be sufficient to protect major cities and major military installations and would cost approximately $10 billion. The costs rose to approximately $15 billion for 120 Zeus batteries offering expanded coverage to urban centers with populations larger than 100,000 and major industrial targets.

President John F. Kennedy took a keen interest in Nike Zeus development. In pondering why Nike Zeus was so controversial among scientists, he once commented to Dr. Jerome Wiesner, his Science Advisor: "I don't understand. Scientists are supposed to be rational people. How can there be such differences on a technical

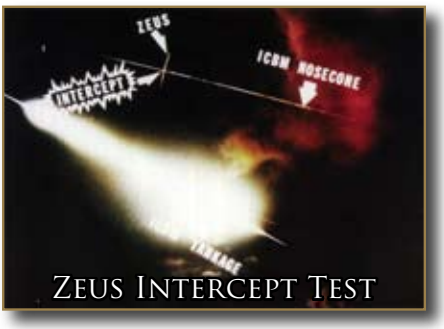
issue?" He was particularly concerned about the system's viability in the face of mounting pressure for its deployment. Dr. Wiesner explained:


KENNEDY

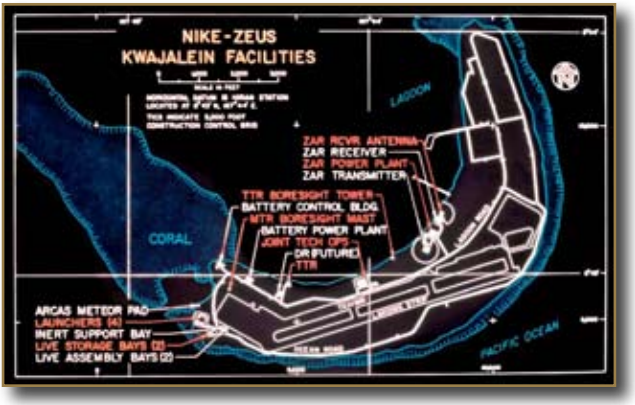
"In 1961, when President Kennedy first began to survey his military problems, his attention was drawn forcefully to an anti-missile system, the Nike-Zeus. He began to get a flood of mail, from friends, from Congress, from people in industry. The press pointedly questioned him about his plans to deploy the Nike-Zeus system. He began to see full pages for it in popular magazines like *Life* and *Saturday Evening Post*, proclaiming how Nike-Zeus would defend America and listing the industrial towns that would profit from the contracts for it…. This pressure built up to the point where President Kennedy came to feel that the only thing anybody in the country was concerned about was the Nike-Zeus. He began to collect Nike-Zeus material. In one corner of a room he had a pile of literature and letters and other materials on the subject. He set out to make himself an expert on the Nike-Zeus and spent hundreds of hours gathering views from the scientific community about it."


WIESNER

As with any groundbreaking system in development, the early Nike Zeus test results were mixed. Though the radar and communications systems progressed reasonably well, many early test firings of the missile failed in part due to



ZEUS INTERCEPT TEST



design flaws. Refinements in the missile design and other system components continued and in late 1961 a Zeus missile supported by all of its associated system components successfully intercepted a Nike Hercules target missile at White Sands Missile Range, New Mexico. In early 1962, the Army transported the entire system to the Kwajalein Missile Range in the Marshall Islands and began conducting a series of Zeus tests against live ICBM targets with the following results:

Mission Number	Date	Target	Remarks
K1	6-26-62	Atlas D	Failure
K2	7-19-62	Atlas D	Partial Success
K6	12-12-62	Atlas D	Success (first missile in salvo)
K7	12-22-62	Atlas D	Success (first missile in salvo)
K8	2-13-63	Atlas D	Partial Success
K10	2-28-63	Atlas D	Partial Success
K17	3-30-63	Titan I	Success
K21	4-13-63	Titan I	Success
K15	6-12-63	Atlas D	Success
K23	7-4-63	Atlas E	Success
K26	8-15-63	Titan I	Success
K28	8-24-63	Atlas E	Success
K24	11-14-63	Titan I	Success

Although the test program showed promise in 1962, DoD decided not to proceed further with Nike Zeus development. Nike Zeus had too many technical and operational shortcomings to warrant continuation. Dr. Wiesner explained:

> "[T]here were several things wrong about the Nike-Zeus that would have made it relatively ineffective in real situations. First, as originally designed, it was supposed to intercept incoming missiles at very high altitudes, out of the atmosphere. This meant that it was easily confused; an enemy could mix real nuclear missiles with lightweight decoys made to look like missiles and send them in against Nike-Zeus, so that it would be totally saturated. To correct this we allowed the incoming devices to come down into the atmosphere; the difference in weights allowed the heavy pieces, the real warheads, to go on, while all this other lightweight decoy junk was slowed down and separated out. This tended to work somewhat better, but even so, the whole system as conceived really wasn't good enough. It could not respond fast enough. Its radars weren't good enough. Its traffic-handling capacity–that is, the number of missiles it could deal with at one time–was not adequate.
>
> "Also, Nike-Zeus was subject… to something called blackout; that is, if a nuclear explosion were set off to destroy an incoming missile, it also upset the gas in the air, 'ionized' it–electrons strip off from the molecules, and for a while the gas acts like a metal rather than a gas so that radar waves cannot go through it and you cannot see what is behind it. Nike-Zeus was open to this in two ways. First, if

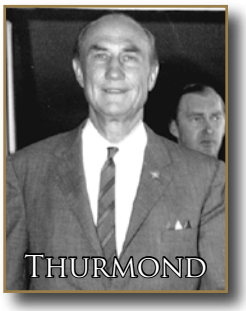
you fired some rockets and they set off their own nuclear weapons, you might generate self-blackout. Second, if the enemy recognized that the defense had this vulnerability, he could design his offensive system to occasionally dump in a rocket with a nuclear warhead, explode it, and generate enough ionization to black out your radars. But, Nike-Zeus had another interesting weakness–by the time it had been brought down to a reasonably low altitude so that the atmosphere would filter incoming devices, no one could be sure that when it set off its nuclear explosion it would not damage itself….

"Still another problem with the Nike-Zeus was that its destruction of the incoming nuclear weapons depended on a phenomenon called neutron heating. When one explodes a nuclear weapon near another nuclear weapon, a flux of neutrons is released; these penetrate into the guts of the second nuclear weapon and heat it enough to melt it. However, this effect does not work over very great distances; so the Nike nuclear explosion could be effective against only a limited number of incoming targets. Although I do not think that cost factors are the most important part of the argument against the ABM, this did create an economic case against it."

The Eisenhower and Kennedy administrations both looked beyond Zeus for a more capable ABM system. What emerged was a layered ABM system called Nike-X. It employed many advanced technologies, including a new family of electronic phased array radars that could detect and track a large

number of objects simultaneously; a new terminal defense interceptor called Sprint, which made possible the use of atmospheric filtering to discriminate between enemy warheads and decoys; and it retained the Zeus missile, subsequently modified and renamed Spartan, for high-altitude targets.

The Kennedy administration announced reorientation of its ABM efforts in the improved and more robust Nike-X Project in January 1963. The following month, Secretary of Defense Robert S. McNamara testified before the Senate Armed Services Committee that the Soviet Union would have "the capability of deploying an antimissile missile system by 1966." After Secretary McNamara added that the Nike-X Project "should be ready by 1970," Senator Strom Thurmond (D-S.C.) began an effort to field the controversial Nike Zeus ABM system as soon as possible as an interim hedge against the possibility of "a period in which there will be a defensive gap" in U.S. strategic security. On April 11, Senator Thurmond led an extraordinary effort in Congress to revitalize and accelerate the Nike Zeus Project. In the first Senate closed session held in twenty years, the Senate assessed the merits of Thurmond's arguments, but determined that the proposed Nike-X Project had more promise than revitalizing the Nike Zeus Project.



Special Collections, Clemson University Libraries

Despite Senator Thurmond's failed effort to revitalize the Nike Zeus ABM, its successful developments were instrumental in establishing

the foundations for its successor, the Nike-X Project, a more capable ballistic missile defense system. In particular, Nike Zeus developers gained vital knowledge of what worked and what failed while advancing discrimination and characterization studies, radar and computer technologies, and high-speed, high-heat missile design. For example, Zeus developers theoretically examined concerns about the effects of high-altitude nuclear detonations on radar signals and subsequently verified their findings in tests at Johnson Island in the North Pacific. Studies showed that radar signal attenuation from nuclear explosion effects could be mitigated by using higher frequency signals. As a result, the Zeus acquisition radar design was modified to double the planned frequency from 500 to 1,000 megahertz. However, these higher frequency radars were never produced or tested. Other successful development examples included the Zeus target intercept computer for guidance of the Zeus ABM and the Zeus missile booster engine. The computer, designed with a modular construction of nearly 175,000 components, was the fastest and most reliable ground computer developed to date in the nation's defense program, and the 450,000 pound-thrust booster engine was the most powerful single solid propellant motor ever successfully fired in the United States up to that time.

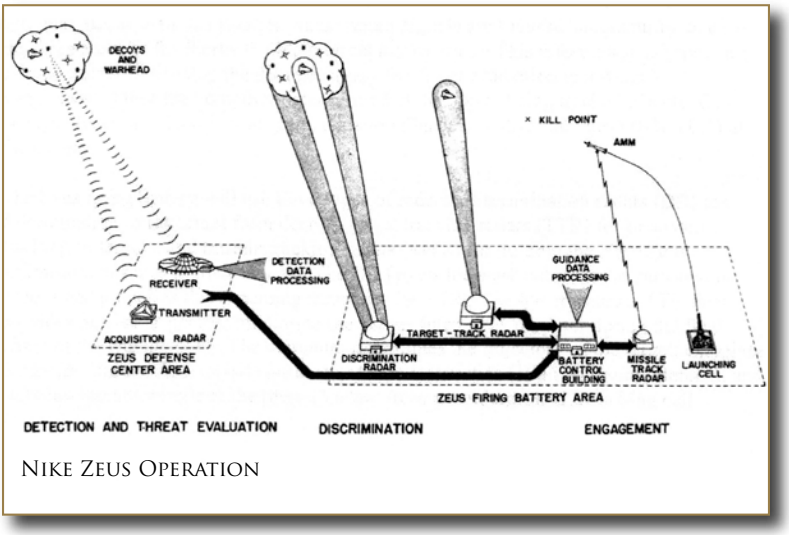

Zeus Acquisition Radar

Following the decision not to deploy Nike Zeus, the Army continued the test program until December 1964 at White Sands Missile Range and May 1966 at Kwajalein Missile Range. During this period Nike Zeus also served briefly as a potential antisatellite weapon. The Army initially proposed employing a modified version of Zeus as an anti-satellite weapon to the Defense Department in 1957, shortly after the Soviets launched Sputnik. The Defense

Department adopted the proposal in early 1962, when Secretary McNamara asked the Army to prepare the Zeus system for possible use in destroying satellites. The new program became known as Project MUDFLAP and used modified Zeus missiles in a variety of antisatellite tests at White Sands and Kwajalein. From 1963 to 1964, the Army maintained Zeus in readiness from Kwajalein to intercept satellites, if required. Testing resumed in 1964 and continued until the Nike Zeus Project's termination in 1966.

In retrospect, the Nike Zeus Project, the U.S. Army's first effort at developing a strategic ballistic missile defense system, was an ambitious and controversial undertaking. The pioneering Nike Zeus Project demonstrated the feasibility of intercepting an ICBM, but the system's technical and operational shortcomings made it impractical to deploy. Despite these shortcomings, the Nike Zeus Project played a pivotal role in preparing the way for its successor, the Nike-X Project, a more capable ballistic missile defense system.

NIKE ZEUS SYSTEM



Nike Zeus Operation

The following Nike Zeus system description is from *Branches of the Army*, ROTC Manual 145-70, Headquarters, Department of the Army, October 18, 1963:

The Nike Zeus system is designed to protect the United States from intercontinental ballistic missile (ICBM) attack. It uses the guidance techniques developed and the experience gained from Nike Ajax and Nike Hercules.

The Zeus system is composed of individual components that can be assembled in a building-block scheme. The "modular" design permits ease of increasing operational capabilities and tailoring of a Zeus defense complex to meet requirements consistent with the size and importance of the area to be defended. A Zeus defense complex might consist of one Zeus defense center (ZDC) and one or more Zeus firing sites.

A typical target for Zeus would be an ICBM warhead streaking toward an area at a speed of about fifteen thousand miles per hour. It may be surrounded by a "cloud" or decoys, which the ICBM has ejected en route in an attempt to confuse the defense. Far out in space the entire cloud is located by the beams of the Zeus acquisition radar (ZAR) which has the sky under constant surveillance.

The ZAR, located at the ZDC, has a very long detection range and uses separate transmitting and receiving antennas. The transmitting antenna is triangular in shape and rotates three hundred sixty degrees in azimuth. The receiving antenna, which is hemispherical in shape provides omnidirectional coverage and rotates in synchronism with the transmitting antenna. Because of this rotation, radar return signals are focused successfully on each of the three racks of feedhorns to obtain target information. This information is processed by a computer to develop the data necessary for threat evaluation and weapon assignment. Once the computer determines that the object being tracked is a cloud of decoys, the entire cloud is brought under surveillance of a discrimination radar (DR) at the battery.

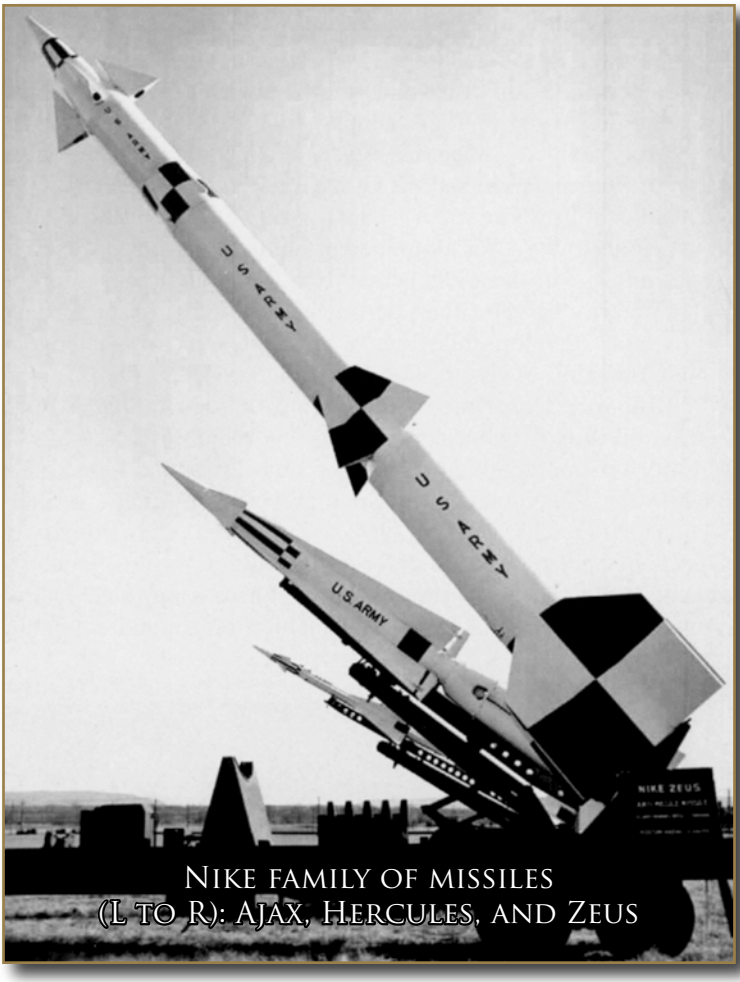
The Zeus firing battery will use three types of radars: discrimination radars (DR) for determination of the target from decoys, target tracking radars (TTR) for precision tracking of targets, and missile tracking radars (MTR) for guiding the Nike Zeus antimissile missiles to their targets. The DR ferrets the warhead from the surrounding decoys and pinpoints this incoming target for the TTR. The hyperaccurate TTR then provides precise target information to the Target Intercept Computer during the final phase of the engagement. The computer determines the trajectory of the target, examines it considering the Zeus missile performance characteristics for an optimum intercept, and launches the antimissile at the proper instant from an underground launching cell.

After launch, the MTR transmits steering orders to guide the Zeus missile to the kill point, which may be inside or outside the earth's atmosphere. At this moment the Zeus warhead detonates, destroying the invader.

Several Zeus missiles can be in the air simultaneously, each on the way to its own intercept and obeying control orders meant for it alone. The Zeus missile is a solid-propellant rocket consisting of three stages—a booster, sustainer, and the jethead stage containing the warhead and onboard guidance.

The Zeus testing program has resulted in successful intercepts of both simulated and real ICBM targets.

The current Army Research and Development Program for ballistic missile defense of the continental United States includes two major tasks. First, the present Zeus test program will be continued. This program has been most valuable in providing information for development in the areas of ballistic missile defense and penetration aids for offensive missile systems. The second task will be to emphasize and accelerate the development of a system presently known as Nike X. Nike X is an advanced antimissile system made possible by the experience and knowledge gained in the development of Zeus. For some time now the Army has been investigating advanced radar antimissile configurations as part of the Zeus program. Nike X will employ an advance radar, the Sprint missile, and a large number of components developed in the Zeus program. Design and hardware developments have been initiated on these items.



Nike family of missiles
(L to R): Ajax, Hercules, and Zeus


MISSILE DEFENSE AGENCY
DEPARTMENT OF DEFENSE