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HISTORY OF THE NIKE HERCULES WEAPON SYSTEM

U.S. ARMY MISSILE COMMAND

Redstone Arsenal, Alabama

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HISTORY
OF THE
NIKE HERCULES WEAPON SYSTEM

<u>S E C U R I T Y</u>

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HISTORY OF THE NIKE HERCULES WEAPON SYSTEM

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PREFACE

During the final stages of World War II, a critical need emerged for the development of a radically new air defense system to counter the threat posed by advances in offensive aircraft technology. In February 1945, following a 12-month exploratory study of a surface-to-air guided missile system, the Ordnance Department awarded the Western Electric Company a contract for further research studies and development work leading to an antiaircraft guided missile system that would be capable of engaging high-speed, high-altitude, maneuverable bombers far beyond the effective range of conventional artillery. Code named Project NIKE for the Greek goddess of victory, this work paved the way for development of the renowned family of NIKE weapon systems which have served as the free world's primary air defense for nearly 20 years.

The NIKE AJAX weapon system, which became operational in 1953, was the first land-based air defense guided missile system to be tactically deployed in the United States and other allied countries. The transition from antiaircraft artillery guns to guided missiles began with deployment of the first combat-ready NIKE AJAX battalion in March 1954 and was essentially complete by mid-1958. The NIKE AJAX served the purpose for which designed; however, even before its deployment, feasibility studies were in progress on an improved air defense system to cope with the rapid advancements in aircraft altitudes, speeds, and nuclear payload capabilities. From these studies evolved the second-generation NIKE HERCULES air defense system, which began replacing the NIKE AJAX in June 1958. The NIKE AJAX system was phased out of U. S. Army units in 1964, after a full decade of active air defense service. The NIKE HERCULES system, with updated ground guidance equipment to counter the changing air threat, completed its 14th year as an operational air defense weapon in June 1972.

A historical monograph on the NIKE AJAX guided missile system was published on 30 June 1959. The present volume traces the evolution of the NIKE HERCULES weapon system from its inception in FY 1953 through FY 1972, and deals with significant NIKE AJAX developments not previously recorded.

19 April 1973 Mary T. Cagle

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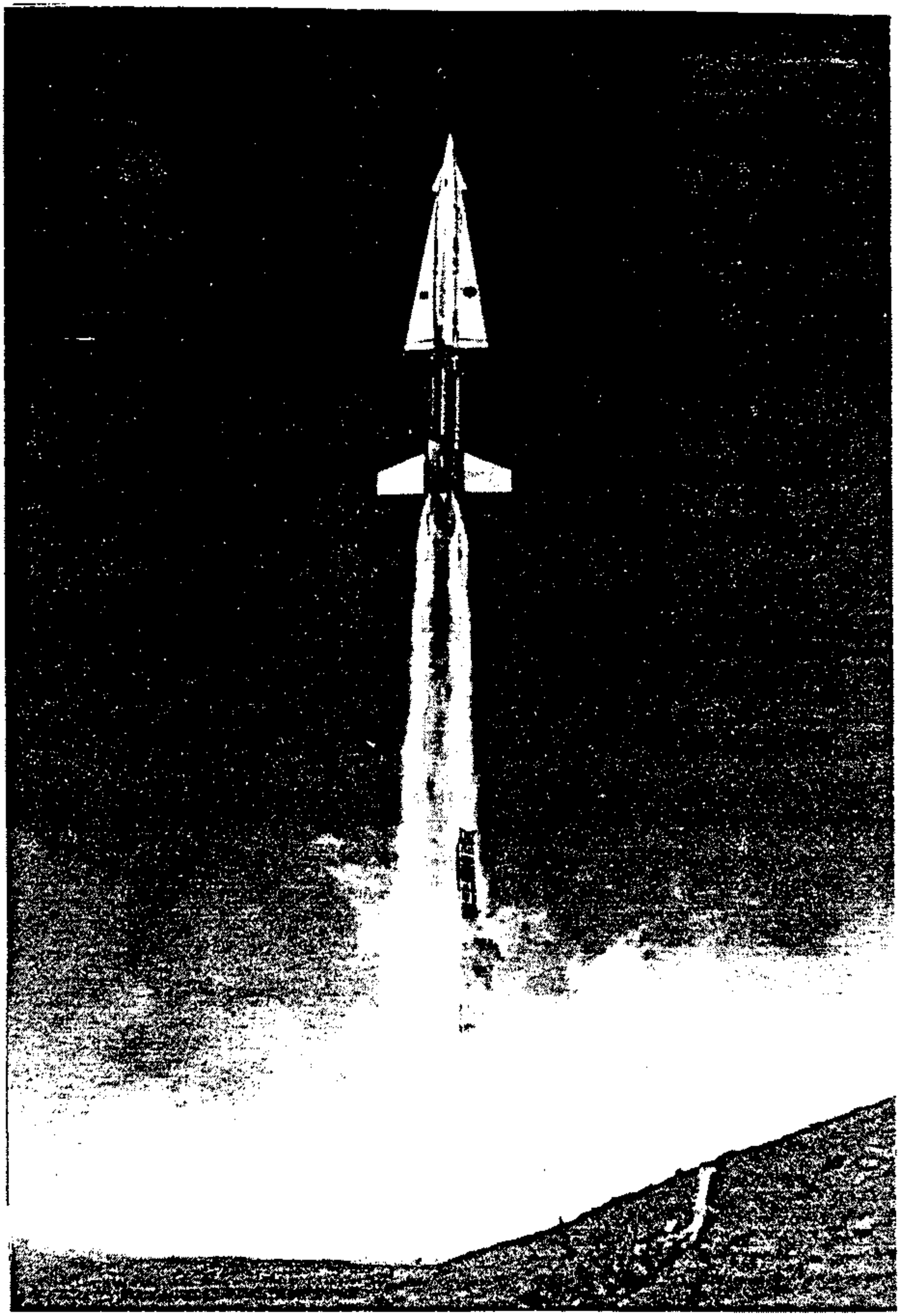

CHAPTER I

(U) ORIGIN AND HISTORY OF ARMY AIR DEFENSE ROLES AND WEAPONS

The Advent of Aerial Warfare

Throughout the countless centuries of warfare the development of weapons has been characterized by an eternal duel between the offensive and the defensive, the latter historically following the former. With the introduction of each new offensive weapon affecting the strategy of warfare, there invariably follows a parallel defensive weapon to counter the potential threat to a nation's security. A historical yet contemporary example of such changes in military tactics and equipment took shape in 1914, when the airplane emerged as a powerful weapon against the Allied powers in France. On 30 August 1914, just 27 days after the war began, a single German plane bombed Paris. German air raids on London followed as early as October, and there were frequent attacks on Allied troops and supply lines in France.

Although the first military use of the airplane had occurred during the Tripolitan War in 1911, the development of antiaircraft artillery did not begin until after the first bombing attacks of World War I. The United States developed and produced some artillery pieces and small arms, but the air defense weapons used by the American Expeditionary Forces were acquired in large part from France and Great Britain. On 10 October 1917, some 6 months after the United States entered the war, the first U. S. Army antiaircraft units began training at Langres, France, and the first tactical batteries moved to the front in April 1918. At the end of World War I, there were about 12,000 men with antiaircraft artillery forces. American units, in action less than a year, destroyed a total of 58 enemy warplanes.[1]

Between the Wars

In the years between the two world wars, antiaircraft artillery grew up as a part of the Coast Artillery Corps, at that time a separate branch of the Army. The War Department had assigned the new antiaircraft mission to the coast artillery rather than the field artillery largely because the coast artillerymen had training in firing on moving objects. Although handicapped by meager appropriations for research and development, Army arsenals and laboratories managed to devise some new items of equipment and to improve old ones. But very little new equipment was forthcoming for the ground combat units until after Army appropriations began to rise in 1936. The successes of Germany's Luftwaffe in the invasions of 1939 and 1940 spurred the rapid expansion of U. S. antiaircraft artillery.

World War II Developments

It was not until 25 years after the formation of the first units that a separate organization for antiaircraft artillery was established in the United States. On 9 March 1942, 3 months after Pearl Harbor, the Antiaircraft Command (AAC) was organized as an element of the Army Ground Forces. The growth of antiaircraft artillery forces surpassed all other arms of the Army during the war. By the end of 1943, the peak year, there were 431,000 men in more than 550 battalions, for an increase of about 1,750 percent over the pre-war strength.[1]

Although some antiaircraft rockets were developed during

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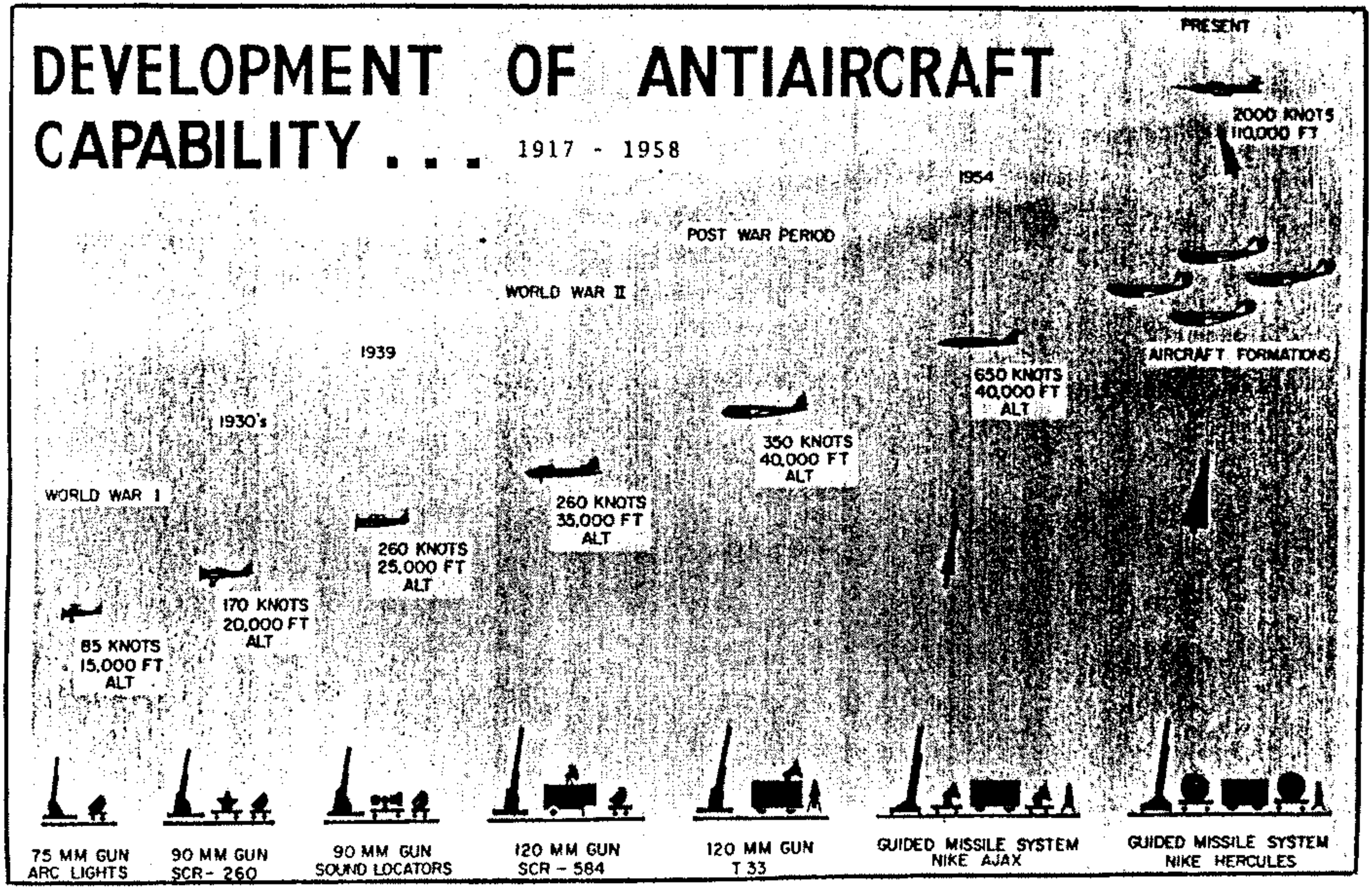
[1](1) *ARADCOM Argus*, Vol. 1, No. 9 (1 Oct 58), p. 3. (2) ROTCM 145-20, Jul 59, pp. 336, 340-41.

[2](1) ROTCM 145-20, Jul 56, pp. 373, 380. (2) *ARADCOM Argus*, *op. cit.*, p. 3.


DEVELOPMENT OF ANTIAIRCRAFT CAPABILITY . . . 1917 - 1958
PRESENT
2000 KNOTS 110,000 FT
1954
POST WAR PERIOD
WORLD WAR II
AIRCRAFT FORMATIONS
1939
650 KNOTS 40,000 FT ALT
1930's
350 KNOTS 40,000 FT ALT
WORLD WAR I
260 KNOTS 35,000 FT ALT
260 KNOTS 25,000 FT ALT
170 KNOTS 20,000 FT ALT
85 KNOTS 15,000 FT ALT
75 MM GUN ARC LIGHTS
90 MM GUN SCR - 260
90 MM GUN SOUND LOCATORS
120 MM GUN SCR - 584
120 MM GUN T 33
GUIDED MISSILE SYSTEM NIKE AJAX
GUIDED MISSILE SYSTEM NIKE HERCULES

World War II, the U. S. Army continued to rely almost entirely on conventional artillery guns as its first line of defense against aerial attack. These antiaircraft weapons ranged from the .50-caliber machine gun and 37- and 40-mm. guns for protection against low-flying, strafing-type planes, to 120-mm. guns for the defense of large areas against bombers. For defense against aircraft at considerable altitudes, the Army's mainstay was the towed 90-mm. gun with a maximum vertical range of 12,000 to 13,000 yards.

A new threat, the German 650-mile-per-hour (mph) jet-propelled airplane, appeared before the end of the war, bringing to obsolescence the antiaircraft artillery fire control systems that had been designed to cope with 450-mph propeller-driven aircraft. This development, together with the advent of the guided missile and the atomic bomb in the closing days of the war, marked the beginning of a new era in the Army's air defense mission.[3]

The Postwar Era and Project NIKE

Soon after the war, it became apparent that antiaircraft targets of the near future would include greatly improved missiles of the V1 and V2 types and partially armored airplanes flying at various speeds up to and including the supersonic and at heights from near the ground to extremely high altitudes. Mindful of these conditions, plus the added threat of nuclear-tipped intercontinental ballistic missiles, the War Department Equipment Board, in May 1946, advocated the development of improved air defense equipment that would be capable of detecting, destroying, or nullifying the effectiveness of all forms of aerial vehicles.

Realizing that a flexible, long-range research program would be necessary to generate new knowledge and achieve

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[3]TIR CD-1, OCO, Jun 60, subj: Dev of AD Wpns, pp. 3-4. RSIC.

the actual design of new equipment, the board recommended that two parallel courses be pursued: the vigorous research and development of new or anticipated types of equipment, and continued improvement of existing equipment as an interim measure. The proposed solutions to the antiaircraft problem embraced the development of conventional artillery weapons having the greatest obtainable effectiveness, improved fire direction and fire control equipment, and guided missiles capable of intercepting and destroying high-speed, high-altitude aircraft and missiles of the V1 and V2 types.[4]

The Bell Telephone Laboratories had begun, for the Army, exploratory studies of a surface-to-air guided missile system as early as February 1944. A year later, following the introduction into combat of the German jet-propelled airplane, the Ordnance Department awarded the Western Electric Company a contract for the Bell Telephone Laboratories to perform further studies and development work leading to a new air defense system that would be capable of engaging high-speed, high-altitude, maneuverable bombers far beyond the range of conventional artillery. The Douglas Aircraft Company accepted a subcontract for design studies of the missile and launching equipment. Code named Project NIKE for the Greek goddess of victory, this work culminated in the establishment of a formal research and development program for an antiaircraft guided missile system later to be known as the NIKE AJAX.[5]

While work on the NIKE was in progress, the Ordnance Department focused its attention on the modernization of existing antiaircraft guns to counter the prevailing aerial threat. The 90-mm. (medium) and 120-mm. (heavy) antiaircraft guns of World War II were modernized by addition of the new M33 radar-directed

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[4] Rept of the War Dept Equipment Board (Stilwell Board), 29 May 46, pp. 4, 8, 12, 25, 49. RSIC.

[5] OTCM 29012, 13 Sep 45. RSIC.

fire control system. The only light-intermediate conventional weapon developed after World War II was the M51 SKYSWEEPER, a towed 75-mm. radar-directed antiaircraft gun. Placed in development in 1948, the SKYSWEEPER was designed to defeat 1,000-mph aircraft flying at altitudes up to 20,000 feet. The improved 90-mm. gun covered the region up to 35,000 feet, and the 120-mm. gun altitudes between 10,000 and 80,000 feet.[6]

As international tensions mounted in 1948, there was a new buildup of antiaircraft artillery forces. In the fall of 1949, antiaircraft artillery battalions were moved to training centers near cities they were ultimately to defend. Several months later they were deployed at their defense sites, and became the first units to establish Army antiaircraft as an integral part of the continental air defense team.[7]

The Korean Emergency

The announcement by President Truman in September 1949 that the Soviet Union had exploded an atomic bomb (several years ahead of prediction), the outbreak of the Korean War in June 1950, and the knowledge that most of the United States was in range of Russian bombers, created an urgency seldom experienced except during all-out war. Faced with the possibility that the Korean conflict might expand into a global war, the Army accelerated preparations for assuming its full share of responsibility for continental air defense.

On 1 July 1950, all artillery units having continental air defense missions were placed under the newly organized Army

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[6](1) TIR CD-1, OCO, Jun 60, pp. 5, 7, 9-10. RSIC. (2) For a history of the Light Antiaircraft Development Program, *see* Mary T. Cagle, *History of the MAULER Weapon System* (MICOM, 19 Dec 68).

[7]*ARADCOM Argus*, *op. cit.*, p. 3.

Antiaircraft Command (ARAACOM), with headquarters at Ent Air Force Base, Colorado Springs, Colorado.[8] At the same time, action was taken to speed the availability of tactical antiaircraft guided missiles to counter the new air threat. After a review of all guided missile projects, Mr. K. T. Keller, the Director of Guided Missiles, Office of the Secretary of Defense, concluded that the NIKE program was the most advanced in the development stage and offered the best defensive capabilities and growth potential. He therefore recommended that the NIKE research and development (R&D) and production processes be overlapped in order to get the missile system out of development and into the tactical weapon stage at the earliest practicable date. Approval of the Keller recommendations came in January 1951, and the Chief of Ordnance placed the NIKE program on a crash basis later the same year.

In a positive effort to expedite delivery of the NIKE I* missile system, the Chief of Ordnance selected the Western Electric Company (WECo) as the prime contractor with full responsibility for the design, development, production, and delivery of the complete tactical weapon system within the limits prescribed by the military characteristics and technical requirements. WECo retained the Bell Telephone Laboratories (BTL) as its prime development subcontractor and the Douglas Aircraft Company (DAC) as subcontractor for the missile and launching equipment. Contractor evaluation tests of the tactical prototype NIKE AJAX system began in January 1953 and continued through 12 May 1953. The first prototype model of battery equipment was turned over to the Ordnance Corps at White

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*In November 1956, the NIKE I was renamed and is hereafter referred to as the NIKE AJAX, the latter name for the warrior in Greek mythology. At the same time, the second-generation NIKE B system was renamed the NIKE HERCULES, the latter name for the Greek hero and strong man. DA Cir 700-22, 15 Nov 56.

[8](1) *Ibid.* (2) DAGO 20, 1 Jul 50. (3) Walter Millis, *Arms and the State* (N. Y., 1958), p. 245.

Sands Proving Ground on 15 May 1953. Service evaluation tests by tactical Army troops began on 28 October 1953, several months after the Korean War ended.[9]

The Transition From Guns to Guided Missiles

During the years immediately following the Korean War, the "ack-ack" of conventional antiaircraft artillery guns gradually gave way to the "ack-track-smack" of the NIKE AJAX, the first land-based air defense guided missile system to be tactically deployed in the United States and allied countries. The conversion from guns to guided missile artillery began on 20 March 1954, when the first combat-ready NIKE AJAX battalion was tactically deployed at Fort Meade, Maryland, in the Washington-Baltimore Defense Area. Although conventional antiaircraft gun units continued to play important roles in augmenting the protection provided by NIKE AJAX battalions, they had already been outnumbered by the NIKE as early as December 1956. By mid-1958, the conversion to missile artillery was essentially complete, with only two gun units (both armed with the 75-mm. SKYSWEEPER) left in the U. S. air defense network.[10]

NIKE AJAX batteries were installed around strategic sites in the Continental United States (CONUS) and overseas. Each battery was an integrated air defense guided missile unit that, with its command guidance system, could engage one aircraft at a time while maintaining continuous surveillance of all targets within the effective range of the system. Its primary mission was the destruction of long-range bombers having speeds of up to 1,100 mph. The maximum practicable range was 45,700 meters against aircraft at

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[9]For a complete history of the AJAX program, *see* Mary T. Cagle, *Development, Production, and Deployment of the NIKE AJAX Guided Missile System, 1945 - 1959* (AOMC/ARGMA, 30 Jun 59).

[10](1) *Ibid.* (2) *ARADCOM Argus, op. cit.*, pp. 2-3.

altitudes of up to 60,000 feet, but targets could be identified as far away as 128,000 meters, and a missile could be launched when its target was 75,000 meters from the battery.

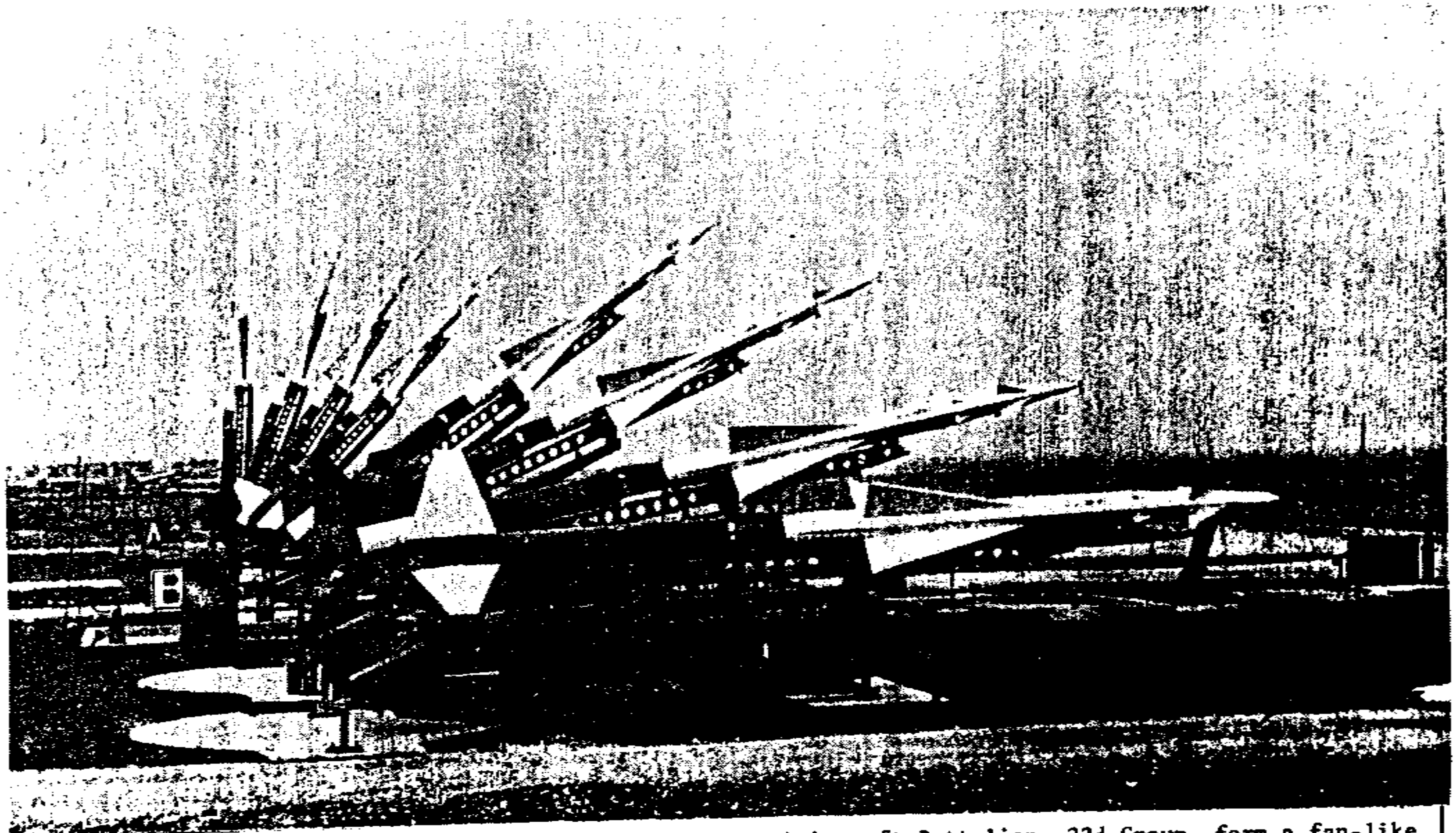
The NIKE AJAX had a command-type guidance system with an acquisition radar on the ground that detected targets and furnished initial data on their positions to a target tracking radar, also on the ground. The latter radar obtained accurate information on the path of the target and transmitted it to the control computer, while at the same time a ground-based missile tracking radar furnished the computer with data on the position of the missile. The computer generated guidance-command signals, which were transmitted to the missile-borne guidance and control system by way of the transmitter of the missile tracking radar. The AJAX missile was first propelled by a booster motor that burned a cast, double-base solid propellant. The booster was jettisoned after burnout, and flight was sustained by a liquid propellant motor with jet engine fuel and red-fuming nitric acid for the oxidizer. The missile carried a conventional high-explosive warhead.[11]

Realignment of the Continental Air Defense Structure

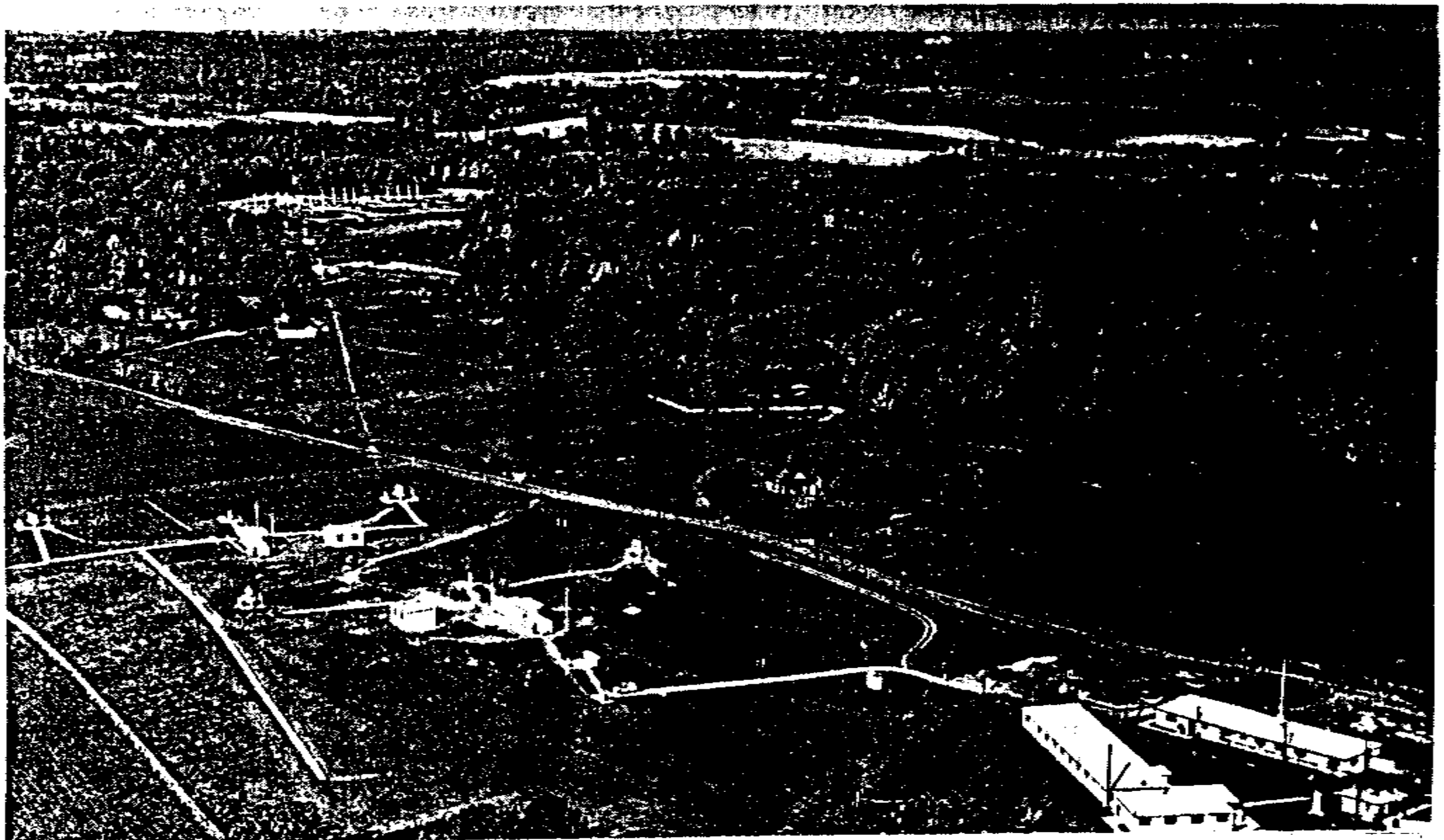
The advent of the world's first land-based antiaircraft guided missile system, coupled with the growing threat of atomic attack by manned enemy bombers, brought significant changes in both the continental air defense structure and the Army's antiair missions and organization. The first came on 1 September 1954, when the Army Antiaircraft Command and its sister elements in the Air Force and Navy were combined into a single organization, the Continental Air Defense Command (CONAD), directed by the Joint Chiefs of Staff and located at Colorado Springs, Colorado.[12]

[11] TIR CD-1, OCO, Jun 60, p. 30. RSIC.

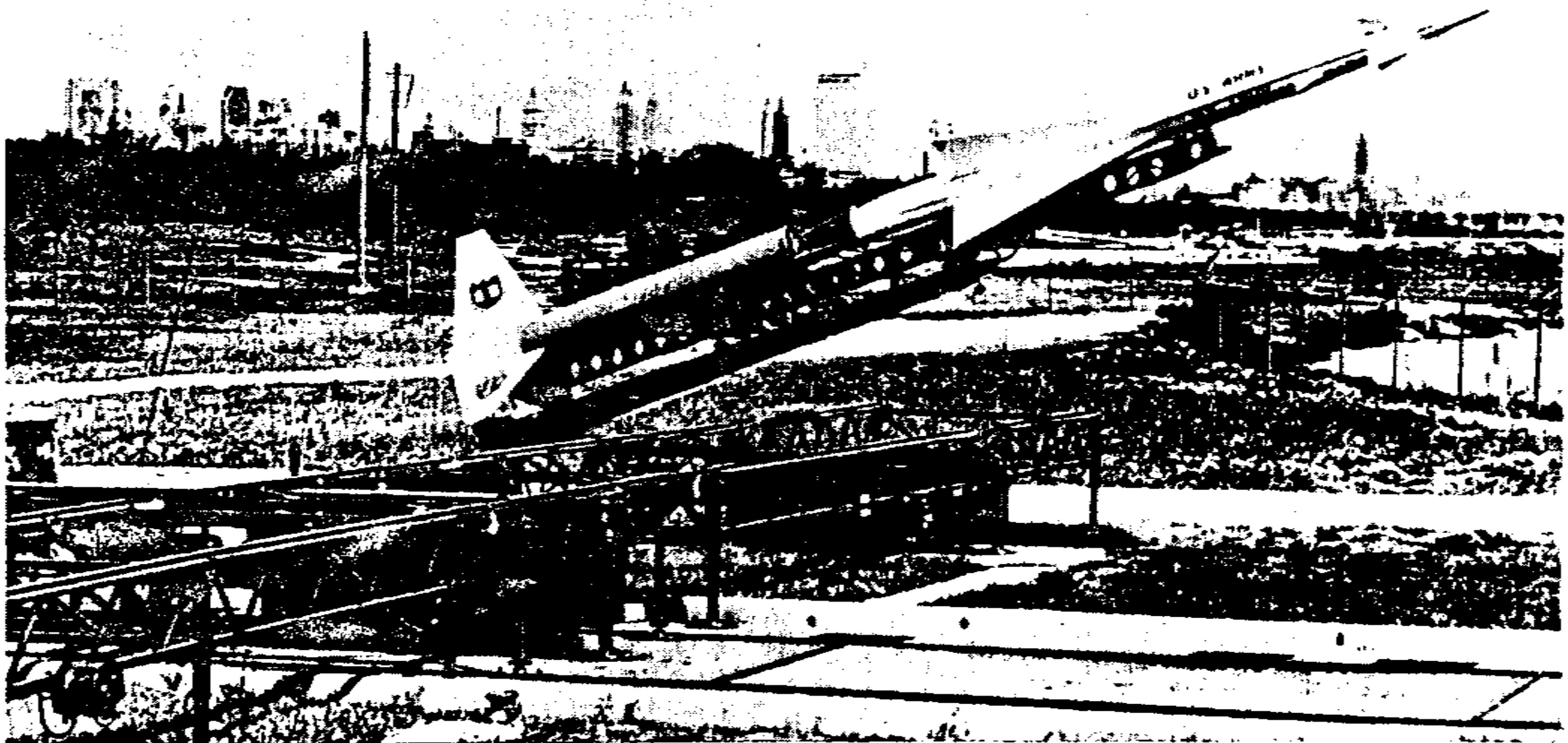
[12] Fact Sheet, The U. S. Army Air Defense Command, Sep 69.



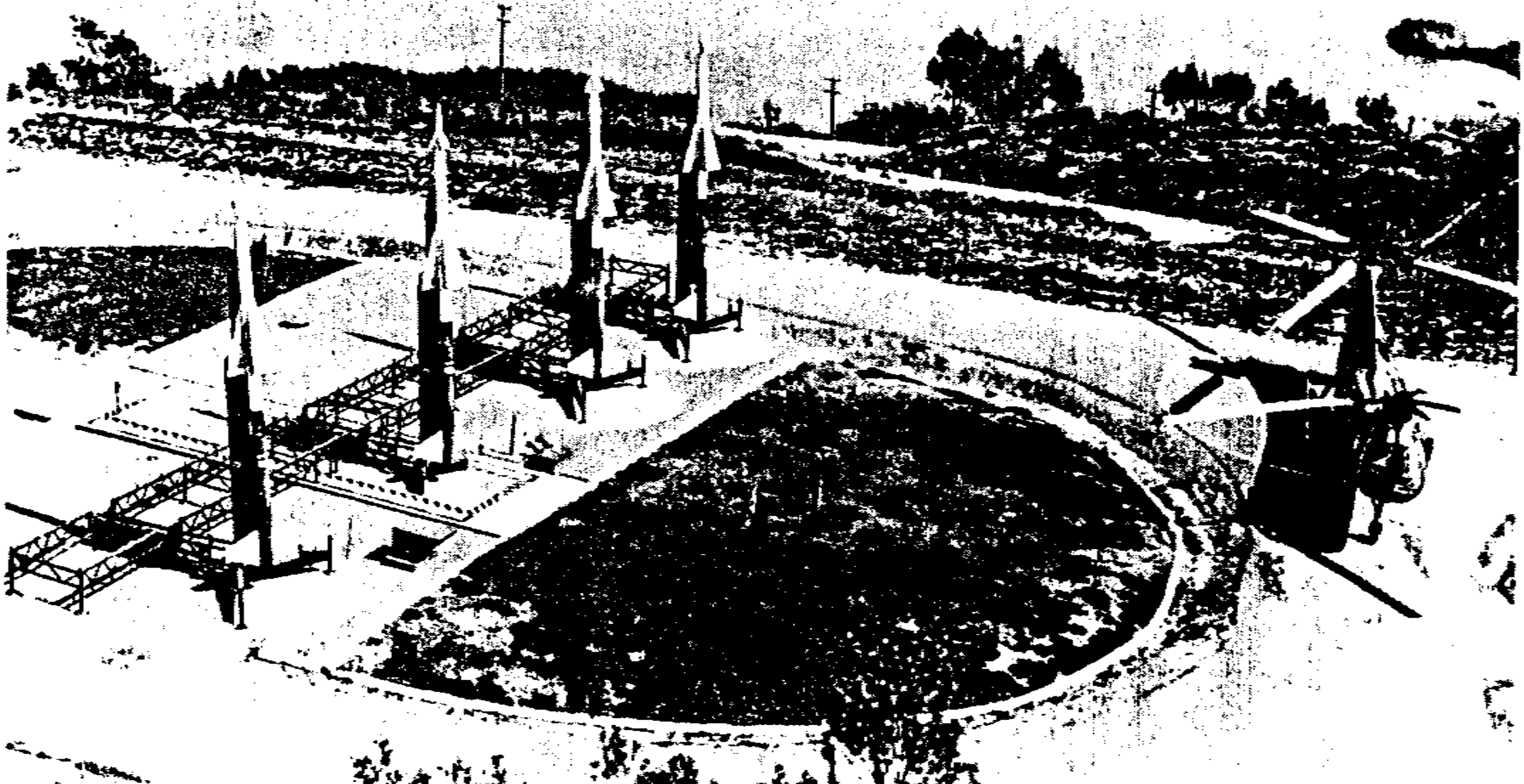
NIKE AJAX guided missiles of Battery B, 485th Army Antiaircraft Battalion, 22d Group, form a fan-like pattern of defense overlooking Lake Michigan. This slow-motion effect exemplifies the raising of the missile to the nearly vertical firing position. (U. S. Army Photograph, 12 Feb 57)



Aerial view of a NIKE AJAX installation west of Baltimore, Maryland. Known as the Granwood NIKE Battery, this defense site was located midway between the communities of Granite and Woodstock, Md. Note distance between the control area (foreground) and launching area (upper left). (U. S. Army Photograph, 29 Apr 59)



NIKE AJAX "B" Battery, 485th Army Antiaircraft Missile Battalion, on site at 26th and Outer Drive, Chicago, Illinois. (U. S. Army Photograph, 6 Nov 57)



NIKE AJAX defense site on Angel Island, San Francisco, California. (U. S. Army Photograph, 12 Apr 58)

This was followed, in 1957, by a realignment of the roles and missions of the three CONAD components. The Army's air defense role was expanded by the assignment of longer ranges and broader coverage for its antiair missiles. Under CONAD, the Army was charged with point air defense by missiles fired from the ground at aerial targets not more than 100 miles away. The Air Force was responsible for manned interceptors, area defense, and missile ranges over 100 miles, and the Navy for sea approaches. Point defense included those geographical areas, cities, and vital installations that could be defended by missile units which received their guidance information from radars located near the launching site. It also included the responsibility of a ground commander for the air protection of his forces.[13] On 21 March 1957, the Army Antiaircraft Command was renamed the U. S. Army Air Defense Command (ARADCOM), a designation that more clearly defined the "all missile" role of the command.[14]

In September 1957, the North American Air Defense Command (NORAD) was formed to combine the air defense capabilities of Canada and the United States under one commander-in-chief, who also headed CONAD. The missile units of ARADCOM and its sister services were placed under NORAD's operational control. In the United States, NORAD reported to the Joint Chiefs of Staff; in Canada, to the Chief of Staff Committee. The unified structure of NORAD gave the continental air defense system true "defense in depth." This strategy combined the dimension of distance with a variety of modern weapons, ready to meet and engage the enemy along the full range of his attack. While the ability to deliver a retaliatory blow remained the principal deterrent against atomic attack, improved air defenses heightened the value of the deterrent

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[13] CAPT Patrick W. Powers, "The Pentomic Army's Missile Power," *Army* Magazine, Jul 57, p. 53.

[14] DAGO 16, 22 Mar 57.

and promised to exact a high cost in any attack by manned enemy bombers.[15]

The month of October 1958 marked the 41st anniversary of the Army's air defense role—the beginning of the American Antiaircraft School by the American Expeditionary Force at Langres, France, on 10 October 1917. In commemoration of this historic milestone, GEN Maxwell D. Taylor, then the Army Chief of Staff, said:

> *The provision of antiaircraft defense is one of the most important missions assigned to the Army. We have had this job for some 40 years, during which we have conducted our side of the critical duel between the defensive weapon on the ground and the offensive aircraft in the air. Fortunately, we have always been able to keep a little ahead of the airplane as performances have increased. . . .*[16]

The NIKE AJAX fulfilled the mission for which it was designed and for several years served as the free world's primary air defense. However, even before deployment of the AJAX, it was realized that the weapon system possessed certain performance limitations that would prevent it from engaging formations of the faster, higher-flying jet aircraft. Though superior to conventional antiaircraft artillery against single targets at supersonic speeds and high altitudes, the AJAX target tracking radar was limited in the resolution of aircraft in formation and therefore ineffective against mass air attack. This radar had a tendency to wander from plane to plane in the attacking formation, with the result that the missile would pass between two targets and burst where no damage would be done.[17]

In view of the performance limitations inherent in the NIKE AJAX guided missile system and the rapid advancements in aircraft

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[15] (1) Fact Sheet, The U. S. Army Air Defense Command, Sep 69. (2) ROTCM 145-20, Jul 59, p. 523.

[16] *ARADCOM Argus*, *op. cit.*, p. 3.

[17] TIR CD-1, OCO, Jun 60, p. 30. RSIC.

altitudes, speeds, and nuclear payload capabilities, the Ordnance Corps, in 1952, had begun feasibility studies of an improved air defense system that would be capable of countering the new aerial threat. These studies culminated in the second-generation Basic NIKE HERCULES system, which began replacing the NIKE AJAX in 1958; the Improved HERCULES system, which became operational in 1961; and the HERCULES Antitactical Ballistic Missile system, which became available in 1963.

CHAPTER II

(U) PROGRAM ORGANIZATION AND MANAGEMENT

Much of the credit for the successful execution of the NIKE HERCULES program could be attributed to the coordination and spirit of cooperation among elements of the Government-industry team. But the Government deserved far less credit for the success of the program than the WECo-BTL team which managed to meet essentially all of the original schedule dates despite the disruptive influences of short-term, piecemeal funding and pronounced weaknesses in the Army's project management structure. These onerous conditions prevailed throughout the 1950's and left their mark on all of the Ordnance guided missile development programs whose prime contractors lacked the managerial competence to counteract them. Since the Army funding and internal management deficiencies did not seriously hamper the HERCULES program, the present discussion is limited to very broad treatment of the organization and management structure with primary emphasis on the evolution of project management within the Redstone Arsenal complex.[1]

The Government-Industry Team

As the second generation of the NIKE family, the HERCULES was the beneficiary of a ready-made contractor team whose technical and managerial competence was second to none in the military-industrial complex. Before the initiation of the NIKE AJAX program, WECo and BTL had established a very close working relationship in

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[1] For a detailed account of internal weaknesses in Redstone's management structure and their impact on individual programs, see MICOM historical monographs on the SERGEANT, MAULER, LACROSSE, HONEST JOHN, LITTLEJOHN, and PLATO missile systems.

their normal commercial practice. As a result of this rapport, WECo, the prime contractor for the NIKE AJAX, had selected BTL as its prime subcontractor for weapon system design and overall project management. The efficient and speedy execution of both the AJAX and HERCULES programs was aided by numerous subcontractors to the WECo-BTL team. Chief among these were the Douglas Aircraft Company, which had prime responsibility for the missile structure (less electronics), for launching and handling equipment, and for conducting the proving ground firing tests; and the General Electric Company which had the subcontract for development of the high power acquisition radar for the Improved NIKE HERCULES system. Other subcontractors and suppliers of equipment items numbered in the hundreds, each dealing with components or subsystems in his special field.

In keeping with the "system contract" philosophy, the prime contractor was delegated full responsibility for development and production of the complete tactical weapon system pursuant to specified guidelines and technical requirements. Implicit in this responsibility was technical control over the design characteristics of all components and subsystems making up the weapon, including the items of Government-furnished equipment (GFE). In general, the latter items fell in fields familiar to Ordnance and other supporting technical services and governmental agencies.

Among the Government agencies providing actual equipment and/or technical assistance and support were the Atomic Energy Commission (AEC) and Picatinny Arsenal (warheads); Diamond Ordnance Fuze Laboratories (fuzes); Jet Propulsion Laboratory (wind tunnel facilities); White Sands Missile Range (flight test facilities); Corps of Engineers (power generation equipment, air conditioners, heaters, buildings and structures); Signal Corps (missile batteries and communications equipment); Ordnance Tank-Automotive Command (vehicles); Ballistic Research Laboratories and Human Engineering Laboratories, Aberdeen Proving Ground, Maryland (supporting research and consultation services); Redstone Arsenal (basic and supporting research on rocket motors and propellants); and Ordnance Ammunition Command (motor loading). The coordination and direction of the efforts of the Government-industry team was a responsibility of the weapon system manager at Redstone Arsenal, Alabama.[2]

Evolution of the Project Management Structure

The Redstone Arsenal Era—1951-58

From the inception of Project NIKE in 1945 to August 1951, the program was directed, coordinated, and supervised by the Rocket Branch, R&D Division, Office, Chief of Ordnance (OCO). On 16 August 1951, OCO transferred the responsibility for conduct of the R&D program to Redstone Arsenal,* the latter then becoming the sole source of instruction to the contractor. In general, the responsibilities transferred to Redstone embraced the monitoring, coordinating, and conducting of the technical aspects of the project. The Rocket Branch, OCO, retained responsibility and authority for general direction and for rendering decisions on such matters as policy, scope, and objectives of the project and

*A World War II Ordnance installation, Redstone Arsenal had been reactivated from standby status on 1 June 1949. Its primary mission was to conduct basic and applied research, development, and testing of free rockets, solid propellants, jatos, and related items. In 1950, the Arsenal's mission was expanded to include research and development of guided missiles and related items. In 1951, it was assigned national procurement and field service missions in connection with assigned rocket and guided missile projects. For a history of Redstone's mission and organization during and after reactivation, *see* ARGMA Hist Sum, 1 Apr - 30 Jun 58, pp. 1-10.

[2](1) INH Wpn Sys Plan, ARGMA WSP-1, Jul 61, p. IV-1. (2) RSA Tech Rept, Ord GM & Rkt Programs - Vol. II, NIKE, Inception thru 30 Jun 55, pp. 49-50, 78, 91, 198, 205-206. (This document hereafter cited as the NIKE Blue Book.) Both in Hist Div Files.

the original approach and major changes in the design, performance, and operation of the missile. To assist the Arsenal in carrying out its mission responsibilities with respect to the project, OCO transferred its NIKE Project Officer, CAPT John R. Grace. The Resident Ordnance Officer then stationed at the BTL plant in Whippany, New Jersey, was LTC Robert E. LeRoy.[3]

In February 1953, at the beginning of the NIKE HERCULES preliminary design studies, OCO assigned to Redstone Arsenal the additional responsibility of maintaining close technical liaison with other Government field installations and contractors engaged in the development of GFE components for the system. Among these were the Bureau of Ordnance, Department of the Navy (XM-5 booster); Glenn L. Martin Company (self-destroying booster); Picatinny Arsenal (fragmentation warheads); Frankford Arsenal (support, arming device); National Bureau of Standards (T90 safety and arming mechanism); and Signal Corps Engineering Laboratories (countermeasure susceptibility study and missile batteries, chargers, and testers). Since these parts of the project were with installations under control of the R&D Division, OCO, or other agencies of the military, any changes, improvements, cancellations, or accelerations required to maintain proper phasing with the basic project had to be submitted through OCO.[4]

In mid-1955, Redstone Arsenal became the Army Ordnance Commodity Arsenal for rockets and guided missiles, with national

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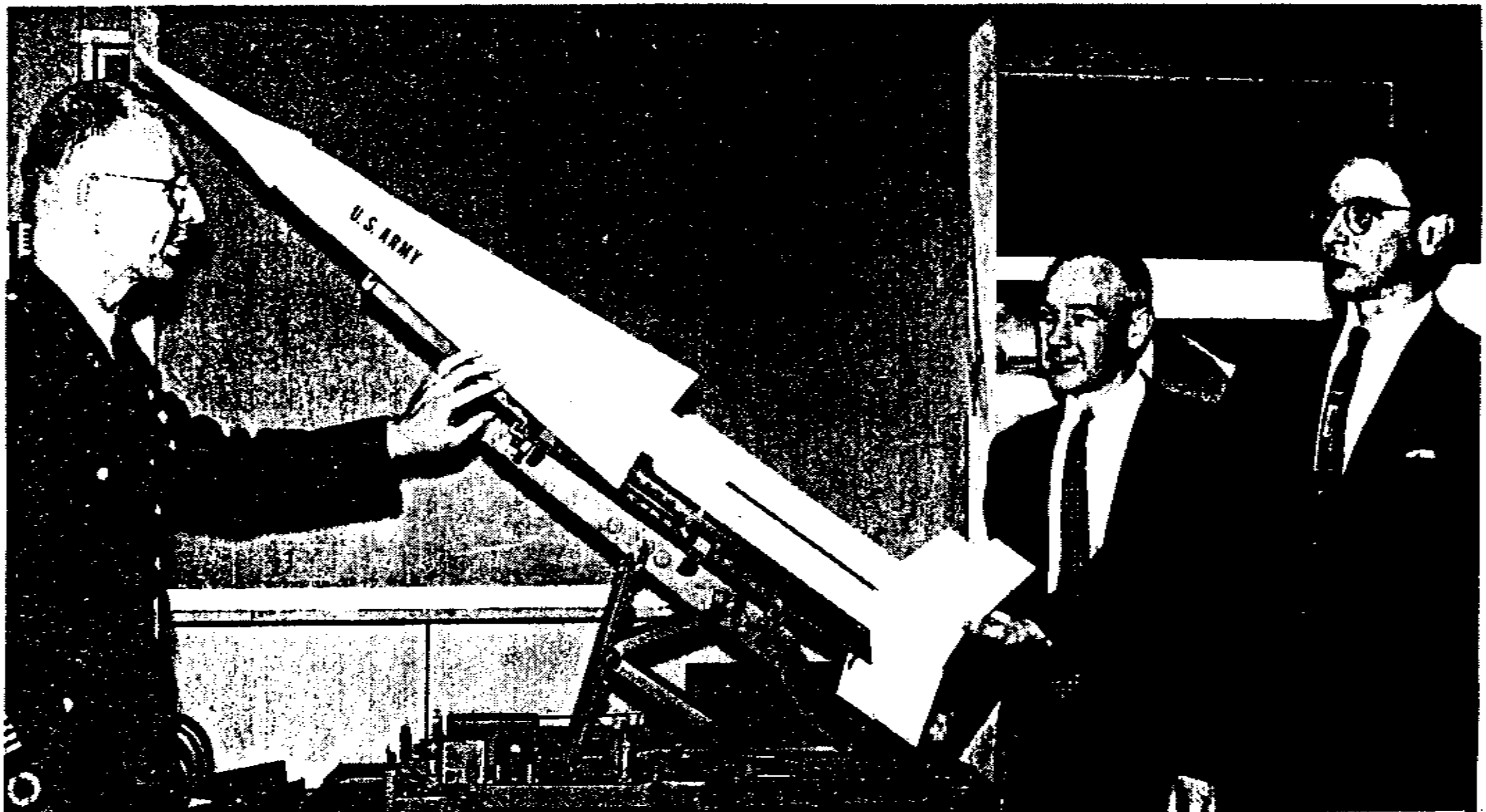
[3](1) Ltr, CofOrd to CO, RSA, 26 Jun 51, subj: Trf of R&D Resp to RSA. Hist Div File. (2) LTC LeRoy continued to serve as Resident Ordnance Officer at BTL until 16 July 1953, when he was succeeded by LTC Glenn Crane. MAJ (later LTC) Richard C. Miles took over the job in August 1955 and stayed with it through the Redstone Arsenal reorganization of 1958. *See* RSA Off Dy Cards & Rosters of Offs. Hist Div File.

[4]Ltr, CofOrd to CG, RSA, 19 Feb 53, subj: Asgmt of Resp for Tech Supvn of Devs Related to the NIKE Proj. Hist Div File.



REDSTONE ENGINEERS WITH NIKE HERCULES MODEL -- Shown above is a model of the NIKE HERCULES, developed under technical control of the Projects Management Staff, R&D Division, Redstone Arsenal, and three of the engineers who were most closely associated with the weapon's development. Left to right are MAJ Rudolph A. Axelson, Deputy Chief, Surface-to-Air Missile Branch; Harry F. Vincent, chief of the branch; and W. J. Millsap, NIKE HERCULES Project Director. (Redstone Arsenal Photograph, March 1957) mission responsibilities for development, procurement, production, industrial engineering, industrial mobilization, maintenance and repair part supply, and stock control.[5] Its major operating elements were the R&D, Industrial, and Field Service Divisions, and the Ordnance Missile Laboratories (OML) consisting of a series of laboratories devoted to in-house research, development, and testing operations.[6]

During the ensuing 3 years, Redstone Arsenal saw the NIKE project through development, test, and initial production of the Basic HERCULES system and early development of the Improved HERCULES system.

The AOMC/ARGMA Era—1958-61

In March 1958, some 3 months before deployment of the first Basic HERCULES battery, Redstone Arsenal was involved in a general reorganization. On 31 March, the Secretary of the Army created the U. S. Army Ordnance Missile Command (AOMC) at Redstone Arsenal and appointed as its head MG John B. Medaris. Placed under General Medaris' direct control were the Army Rocket & Guided Missile Agency (ARGMA), the Army Ballistic Missile Agency (ABMA), the Jet Propulsion Laboratory, the White Sands Proving Ground, and the Redstone Arsenal. Officially established on 1 April 1958, ARGMA assumed responsibility for the NIKE HERCULES program and other technical missions formerly assigned to Redstone Arsenal, leaving the latter with post support functions.[7]

The integration of primary research, development, test, and logistical support installations under single direction, together

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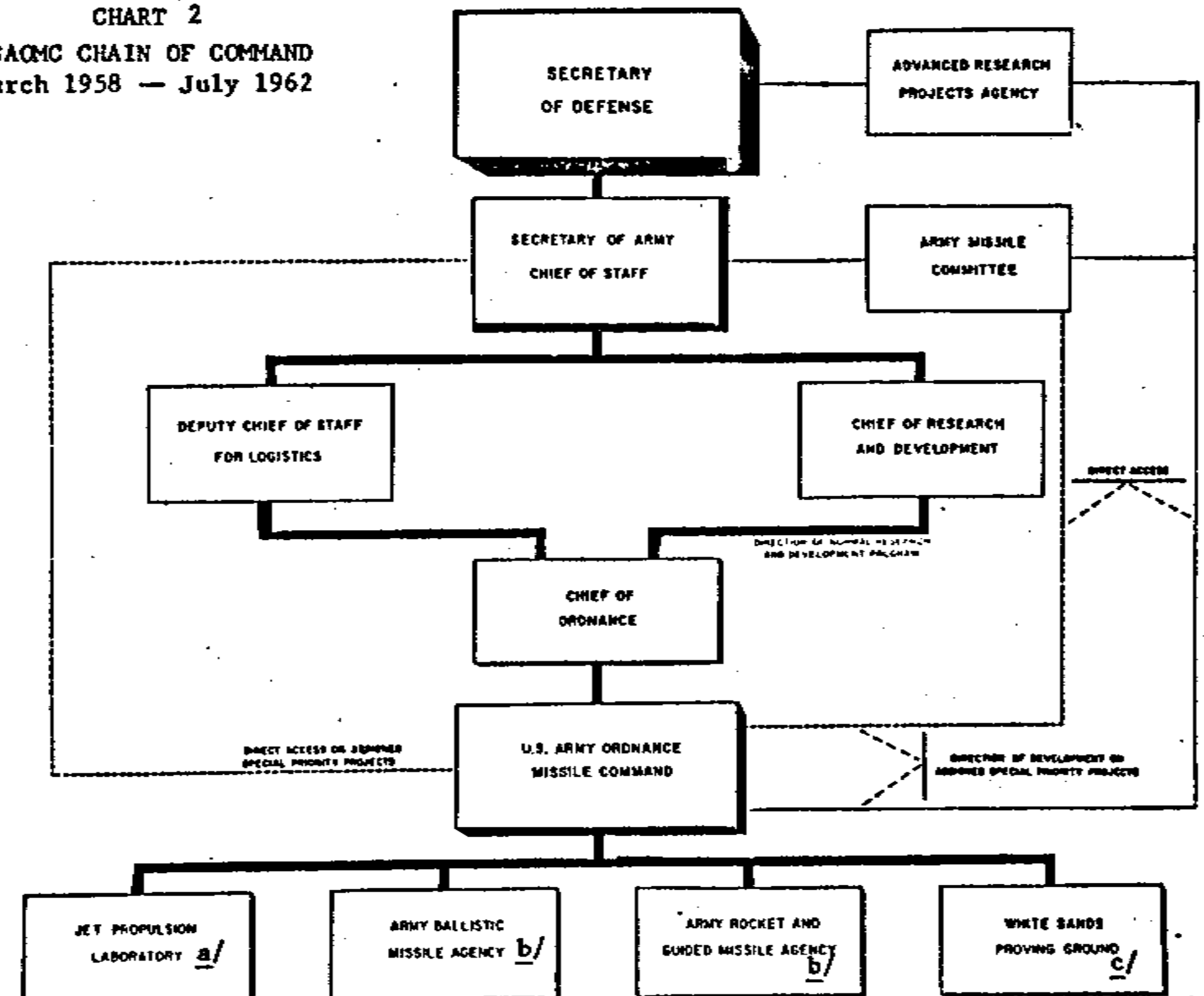
[5] OrdC Orders 15-55 & 19-55, 1 Jun 55.

[6] ARGMA Hist Sum, 1 Apr - 30 Jun 58, pp. 10-11.

[7] (1) DAGO 12, 28 Mar 58. (2) OrdC Order 6-58, 31 Mar 58. (3) AOMC GO 6, 1 Apr 58.

CHART 2
USAOMC CHAIN OF COMMAND
March 1958 — July 1962



a. Reasgd to NASA, 3 Dec 58 (TT, CofOrd to CG, AOMC, 3 Dec 58).

b. Abolished/merged with AOMC Hq 11 Dec 61 (AOMC GO 96, 5 Dec 61; DA GO 47, 26 Dec 61).

c. Renamed WSMR, 1 May 58 (DA GO 14, 19 Apr 58); Reasgd to OCO 1 Jan 62 (Ord Corps Order 16-58, Ch 5, 24 Nov 61).

with the administrative streamlining, provided the means to carry out more effectively the existing and future Army missile programs. Under the executive control of the Chief of Ordnance, AOMC was entirely responsible for the execution of Army rocket and guided missile programs, from the inception of an idea through research, development, production, procurement, and training, to supply, maintenance, and support in the field. Although not directly involved in operational matters, the Commanding General of AOMC, as the weapon system manager, was concerned with whatever pertained to rockets and missiles, regardless of the service within the Army that might be directly interested.[8]

During the 1958-61 period, ARGMA, as the commodity manager under command of AOMC, guided the program through production, type classification, and deployment of the Basic HERCULES system; final development, test, limited production, and delivery of the Improved HERCULES system; initial development of the advanced HERCULES Antitactical Ballistic Missile system; and the final phase of AJAX-HERCULES conversions in CONUS. The HERCULES program activities were directed and coordinated through the Control Office by a staff of Senior ARGMA Representatives (SXR's) at contractor plants and Government installations and designated representatives in the Control Office and the three national mission operations.[9]

LTC Richard C. Miles, who had served as the Redstone Resident Ordnance Officer at BTL since August 1955,[10] became the ARGMA SXR at BTL on 1 April 1958 and remained on the job until December 1959,

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[8] OrdC Order 16-58, 1 Jul 58, subj: Msn of the AOMC.

[9] (1) ARGMA Cir 7 (later renumbered 600-1), 28 Jun 58, subj: ARGMA Ln Pers at Contrs' Plants & Govt Instls, as amended 19 Jun 59. (2) ARGMA Cir 16, 19 Sep 58, subj: Sys Proj Resp (reissued as Cir 1-2, 4 Jun 59, with no change in content). The latter was superseded by Cir 1-2, 12 May 60, subj: Agcy Cmdty Coord. *See* ARGMA Hist Sum, 1 Jan 60 - 30 Jun 60, pp. 15-19.

[10] *See* fn 3, p. 20.

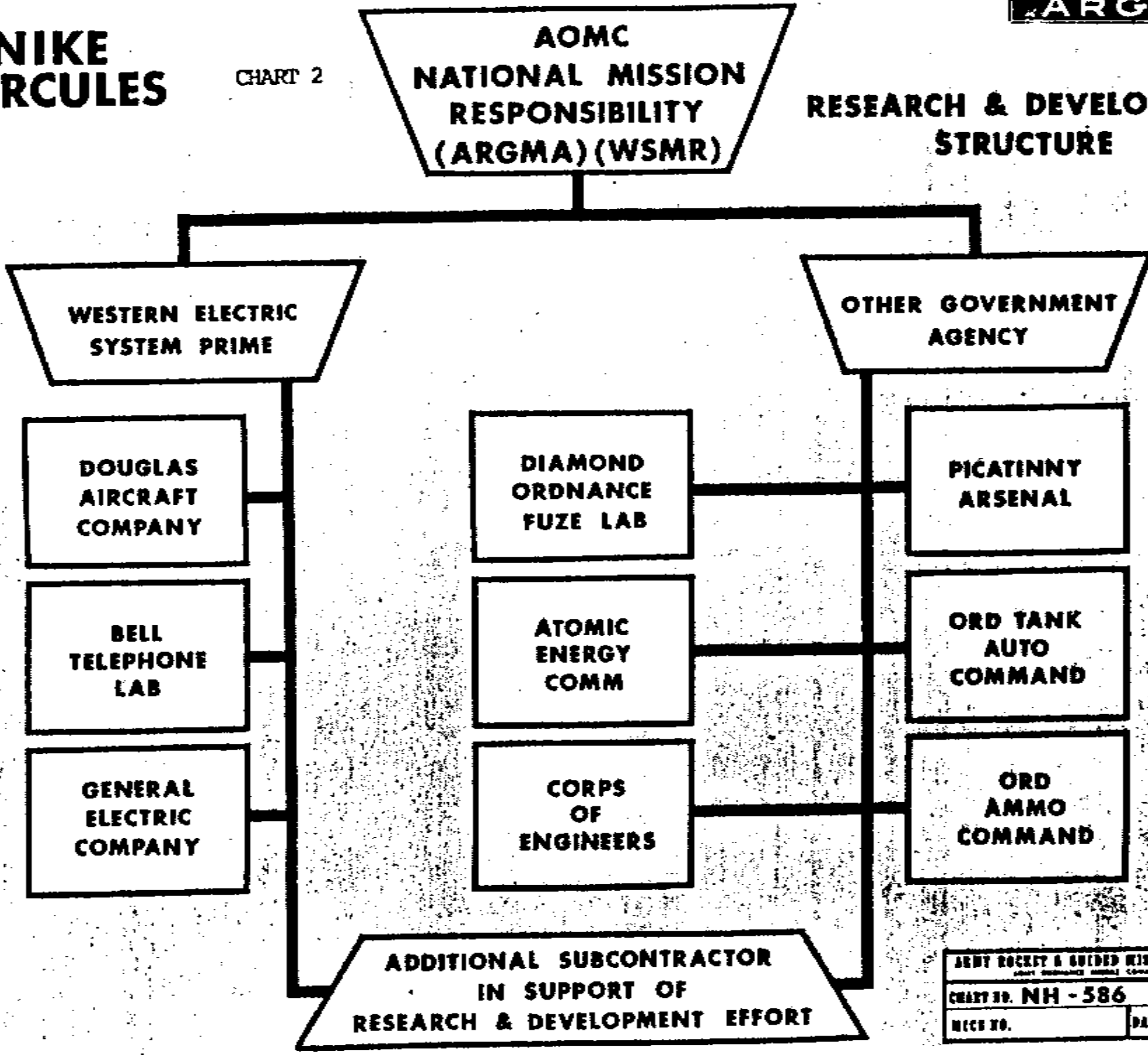
NIKE HERCULES

CHART 2

RCS RMC 5

ARGMA

RESEARCH & DEVELOPMENT STRUCTURE



ARMY ROCKET & GUIDED MISSILE AGENCY

CHART NO. NH - 586	REV A
NEGS NO.	DATE 30 APR 60

when he was replaced by LTC Lee G. Jones.[11] Other SXR's included George W. Haug at WECo's Burlington, North Carolina plant; Louis V. Bilotta at DAC, Santa Monica, California; and Arthur R. Andrews at DAC's Charlotte Division, Charlotte Ordnance Missile Plant.[12] The HERCULES project officers within ARGMA were R. W. Ekis and George Bittenbender, Control Office; W. J. Millsap, MAJ Q. C. Soprano, and M. E. Pederson, R&D Operations; L. F. Chesebro, Industrial Operations; and CWO Clifford A. Van Pelt, Field Service Operations.[13]

In the AOMC reorganization of 11 December 1961, ARGMA and its sister agency, ABMA, were abolished and their functions merged with AOMC headquarters.[14]

The HERCULES/AJAX-Target Missiles-MTE Project Manager

Under the new AOMC organizational structure, which became operational on 1 January 1962,[15] the national and support missions of the former ARGMA and ABMA were consolidated and assigned to the R&D, Industrial, and Field Service Directorates. Established under the Commanding General were Deputy Commanding Generals (DCG) for the two missile system groups: ballistic missiles and guided missiles. There were seven project offices under each DCG, the office of the HERCULES/AJAX-Target Missiles-Multisystem Test Equipment Project Manager being established under the DCG for Guided Missiles (DCG/GM).[16] LTC Joseph C. Baer became the HERCULES/AJAX-Target

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[11] ARGMA SO 15, 1959.

[12] List of ARGMA Fld Rep Ofcs as of 31 Dec 59. Hist Div File.

[13] List of Reps by Wpn Sys Proj, dtd 10 Sep 59, 30 Jun 60, & 1 Aug 60. Hist Div File.

[14] (1) AOMC GO 96, 5 Dec 61. (2) DAGO 47, 26 Dec 61.

[15] Ltr, CG, AOMC, to CofOrd, *et al.*, 29 Dec 61, subj: Reorgn of the USAOMC. Hist Div File.

[16] AOMC GO 96, 5 Dec 61, as amended by AOMC GO 30, 14 Mar 62. (The latter order changed the organizational designation from Project Office to Project Manager.)

Missiles-MTE Project Manager,[17] with responsibility for directing and coordinating the project activities assigned to and performed by the national mission directorates and supporting services. With a small staff of less than 20 people,[18] Colonel Baer could not truly manage his multifaceted program, and was, in reality, little more than a high level staff coordinator. This interim project office, however, did provide essential staff experience for implementing the vertically directed management structure which came into being on 1 August 1962.

The HERCULES Project Manager—1962-70

The AOMC reorganization extended into 1962, overlapping a major Army reorganization which culminated in the creation of the Army Materiel Command (AMC), the abolition of the Office, Chief of Ordnance, the realignment and redesignation of AOMC as the Army Missile Command (MICOM), and selection of the HERCULES system for vertical project management. The new AMC and MICOM organizations existed with skeleton staffs from 23 May to 1 August 1962, when they became operational. AMC absorbed functions of the former OCO and MICOM absorbed functions of the former AOMC.[19]

Effective 31 July 1962, the HERCULES/AJAX-Target Missiles-MTE Project Manager organization was divided in two parts, the latter three programs being grouped under a product manager and the HERCULES joining the project-managed systems. At the same

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[17] AOMC GO 99, 13 Dec 61.

[18] The DCG/GM and his seven project managers had a total assigned strength of only 75 personnel as of 30 June 1962. AOMC Pers Sta Rept, 30 Jun 62. Hist Div File.

[19] (1) DAGO 23, 4 May 62. (2) AMC GO 4, 23 May 62. (3) DAGO 46, 25 Jul 62. (4) MICOM GO 5, 30 Jul 62. (5) DAGO 57, 27 Sep 62. (6) For a detailed history of the reorganization, *see* AOMC Hist Sum, 1 Jan - 30 Jun 62; MICOM Hist Sum, FY 1963; and AMC Hist Sum, FY 1963.

time, the weapon system divisions of the directorates, plus certain quality assurance functions from Industrial and liaison and training from Field Service, were transferred to the HERCULES Project Manager, along with personnel, personnel spaces, records, and equipment. Also transferred from the directorates were management control, direction, planning, programming-budgeting, and review and analysis functions relating to the HERCULES.[20]

The concept of vertical project management recognized the project manager as the single individual responsible for accomplishing the objectives of his assigned program. It stressed maximum integration of the total effort in order to make the best possible use of limited resources, and at the same time attain a high order of stability. It necessarily entailed maximum use of the functional directorates for operational support, but the project manager possessed the authority, resources, and capability within his own office for centralized management, direction, and control of the total effort. This included all phases of research, development, test, procurement and production, distribution, and logistic support for the purpose of maintaining a balanced program to accomplish the stated objectives of AMC. The project manager was charged with exercising full-line authority over all planning, direction, and control of tasks and associated resources involved in furnishing HERCULES missile systems and system support to designated recipients at times and places directed by AMC.[21]

The new project office became operational under the DCG/GM on 1 August 1962, with LTC Joseph C. Baer assigned as the HERCULES Project Manager.[22] The activation plan provided for a total of

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[20]AOMC GO 87, 30 Jul 62.

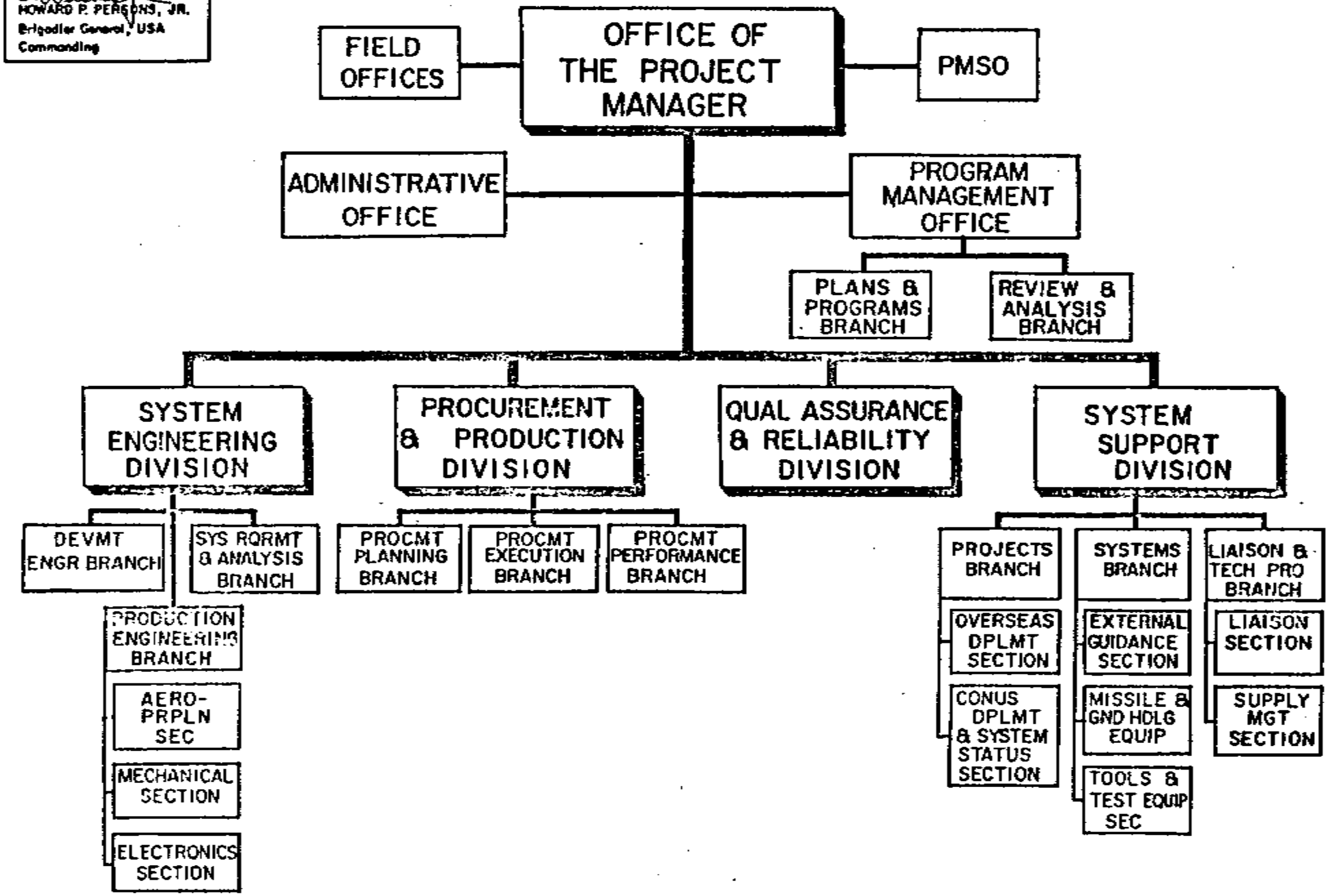
[21](1) MICOM Reg 10-2, Sec 150, 15 Mar 63. (2) Hist Rept, NH PM, 1 Jul - 31 Dec 62, p. 1. Hist Div Files.

[22](1) MICOM GO 5, 30 Jul 62. (2) MICOM GO 15, 7 Aug 62.

APPROVED:
DATE 15 MARCH 1963
HOWARD P. PERSONS, JR.
Brigadier General, USA
Commanding

CHART 3

US ARMY MISSILE COMMAND
HERCULES PROJECT MANAGER



299 (20 military and 279 civilian) personnel to staff the new project manager organization; however, the Table of Distribution (TD) approved by AMC early in December 1962 reduced that number to 266 (20 military, 246 civilian). By the end of December, the project manager's personnel staff had grown to 203 (19 military, 184 civilian).[23] For the next 18 months or so, the assigned personnel strength slowly increased, but all of the TD spaces were never filled and the authorization was gradually reduced.

COL Bernard R. Luczak replaced Colonel Baer as HERCULES Project Manager on 1 February 1963 and remained on the job until 12 February 1964. Mr. Edward L. Smock, the Deputy Project Manager, was acting manager until the assignment of COL Rawlins M. Colquitt, Jr., on 27 May 1964.[24] Meanwhile, the original manpower authorization of 266 had been reduced to 255 by 31 December 1963, and 25 of the spaces were vacant with an actual strength of 230 (19 military, 218 civilian).[25] Six months later, on 30 June 1964, the project manager's authorized strength was further cut to 243, and his assigned strength stood at a peak of 236 (14 military, 222 civilian). In FY 1965, both the authorized and assigned strength declined, the former to 235 and the latter to 229 (19 military, 210 civilian).[26]

Implementation of the refined MICOM project management policy, issued in September 1965, altered the project manager's staffing pattern for 1966 and subsequent years. The revised policy, in effect, sent the major project operations, together with personnel and spaces, back to the functional directorates from whence they had come several years before. It decreed that the project offices

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[23](1) Hist Rept, NH PM, 1 Jul - 31 Dec 62, pp. 1, 24. (2) MICOM Pers Sta Rept, 31 Dec 62. Hist Div Files.

[24]MICOM GO 9, 1 Feb 63; GO 14, 11 Feb 64; GO 86, 3 Apr 64.

[25]MICOM Pers Sta Rept, 31 Dec 63. Hist Div File.

[26]MICOM Pers Sta Repts, 30 Jun 64 & 30 Jun 65. Hist Div File.

would consist of small groups of elite management technicians who would rely on the functional directorates to accomplish the "doing" portions of the project work, with the project managers retaining full-line authority for planning, direction, and control of the total effort. To avoid disruption, each directorate would gradually take on the new functions and associated personnel as it demonstrated its ability to perform each function equal to, or better than, the project management organization.[27]

Pursuant to the realignment plan, AMC, in January 1966, reduced the HERCULES Project Manager's manpower authorization from 235 to 111 (10 officers, 101 civilians). The major moves of personnel did not occur until February and March 1966, although some of them confirmed earlier tentative assignments and thus carried an effective date of November 1965. By 30 June 1966, the project manager's assigned strength had dropped to 103 (11 officers, 92 civilians).[28]

With Colonel Colquitt's departure on 1 October 1966, Mr. Edward L. Smock took over as acting project manager and served until the assignment of COL Morris W. Pettit on 26 June 1967.[29] Colonel Pettit steered the HERCULES program through continued system improvement and field modification; the rebuild program for equipment from deactivated defense sites; implementation of the Japanese Co-Production Program; the gradual phasedown of operations preparatory to deprojectization; and finally, the transition to the special items/functional management concept

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[27](1) MICOM Hist Sum, FY 1966, pp. 20-22. (2) Handbook, Project Manager/Directorate Functional Relationships, 15 Sep 65. Hist Div File.

[28](1) Hist Rept, NH PM, FY 1966, pp. 1-2. (2) MICOM Hist Sum, FY 1966, p. 23. (3) MICOM Pers Sta Rept, 30 Jun 66. (4) MICOM GO 19, 1 Mar 66; GO 20, 3 Mar 66; GO 23, 10 Mar 66; GO 33, 11 Apr 66.

[29]MICOM GO 112, 3 Oct 66; SO 155, 18 Jul 67.

under the new standard commodity command structure.

By the end of December 1969, the HERCULES Project Manager's Table of Distribution and Allowances (TDA) had been reduced from 111 to 91 (10 officers, 81 civilians) and his assigned staff had declined from 103 to 83 (10 officers, 73 civilians).[30] The proposed MICOM plan at that time called for the continued phasedown of project office staffing to a level of 42 by 30 June 1971, and conversion to commodity management by 30 September 1971. A concurrent MICOM review of the REDEYE system indicated that it would be ready for deprojectization by 30 June 1970.[31] However, the Secretary of the Army, with concurrence of AMC, officially removed both the HERCULES and REDEYE from project management status effective 27 April 1970, and transition plans for deprojectization of the two systems were forwarded to AMC early in June 1970.

The approved MICOM organization plans called for the establishment of a very small management office, to be known as the Air Defense Special Items Management Office (ADSIMO) and consisting of 15 civilians and 4 officers, to exercise overall management of the HERCULES and REDEYE systems after their deprojectization. The same plans provided for the creation of a new Systems Engineering & Integration Office in the Directorate for Research, Development, & Engineering, which, among other things, would be responsible for all system engineering on weapon systems under technical direction of ADSIMO.

During the transition period (April-December 1970), the HERCULES Project Manager continued to operate under his existing

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[30]MICOM Pers Sta Rept, 31 Dec 69. Hist Div File.

[31](1) SS AMSMI-WM-149-69, Mgt Science & Data Sys Ofc, 24 Oct 69, subj: MFR's on MICOM Bfg to BG Guthrie, AMCRD, 9 Oct 69 [re: Proj Mgt Review on HERC & REDEYE Projs], & incls thereto. (2) Ltr, CG, MICOM, to LTG Henry A. Miley, Jr., DCG, AMC, 14 Jan 70, n.s. Both in Hist Div File.

organizational structure. His operational concepts, however, were modified to follow more closely the concept of commodity management as defined in MICOM Regulation 11-10, and activities, reports, and other instruments or requirements directly connected to project management, as such, were discontinued. Pursuant to the transition plan, the HERCULES TDA was reduced to 3 officers and 39 civilians. The rest of the previously authorized civilian positions were abolished and the personnel were moved to other positions or separated in accordance with their retention rights as a part of the MICOM reduction in force effected on 29 June 1970.[32]

The Air Defense Special Items Management Office—1971-72

The new Air Defense Special Items Management Office was organized effective 4 January 1971. At the same time, the HERCULES Project Office was discontinued and COL Morris W. Pettit was assigned as Air Defense Special Items Manager, with responsibility for overall management of assigned air defense activities and for providing control and coordination to assure full support by all functional directorates. The NIKE HERCULES and REDEYE were the first systems assigned to ADSIMO, with others added later. Personnel of the new Systems Engineering & Integration Office of the restructured Directorate for Research, Development, Engineering, & Missile Systems Laboratory, were collocated with ADSIMO personnel.[33] COL Donald H. Steenburn became chief of ADSIMO on 17 April 1972,[34] following Colonel Pettit's retirement.

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[32] (1) Ltr, SA to CG, AMC, 27 Apr 70, subj: Termn of Proj Mgt for REDEYE & HERC. (2) Ltr, AMCSA-PM to MICOM, 6 May 70, subj: Trns of HERC & REDEYE fr Proj Mgt to Funcl Mgt. (3) Rept of the HERC/REDEYE Deprojectization Study, dtd 19 May 70. (4) Ltr, DCG, MICOM, to HERC PM, 5 Jun 70, subj: Termn of Proj Mgt for HERC. All in Hist Div Files.

[33] MICOM GO's 22, 23, & 24, all dtd 1 Mar 71.

[34] MICOM GO 60, 17 Apr 72.

CHAPTER III

(U) FEASIBILITY STUDY PROGRAM (U)

(U) As stated earlier, the need for an improved air defense weapon became apparent early in 1952, during the final development stage of the NIKE AJAX missile system. The problem stemmed from limitations of the AJAX system in dealing effectively with bomber formations, the units of which were too closely packed for individual resolution by the NIKE radar. These limitations became particularly severe when the spacing between the aircraft was larger than the lethal radius of the NIKE's conventional warhead. In recognition of these shortcomings, the Special Assistant for Mobilization Production, OCO, suggested on 11 March 1952 that a study be made to determine the feasibility of providing the NIKE missile with an atomic warhead. As a result of this suggestion and a series of requests from other Army Staff elements, the Chief of Ordnance, on 9 May 1952, asked BTL to investigate the feasibility of an antiaircraft guided missile carrying an atomic warhead and using the NIKE AJAX ground guidance system.[1]

Early Studies

(U) Personnel of BTL and DAC, assisted in a consulting capacity by the Sandia Corporation and Picatinny Arsenal, completed a brief study of the problem in mid-July 1952 under the existing NIKE AJAX R&D contract (ORD-3182). They concluded that there were two equally feasible solutions to the problem, each possessing both merits and disadvantages. One would involve a rearrangement of the existing XW-9 gun-type warhead. The other solution would entail

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[1] NIKE Blue Book, pp. 161, 178. Hist Div File.

the design of a new and larger diameter (30-inch) missile which would carry the existing XW-7 warhead without modification. Experimental verification of the modified AJAX missile system could be expected 18 months after date of authorization, while for the new missile system this would require 36 months. On the other hand, the warhead of the latter system would be about three times more efficient in its use of fissionable material than that of the modified NIKE AJAX. The use of such a system, however, would involve severe operational problems, and further study of these would be required to demonstrate the ultimate utility of a system of this sort.

(U) The study group therefore recommended that a more thorough engineering study be initiated to fill in the gaps left by the brief preliminary investigation, and to give more detailed attention to the specific design of the new and large diameter missile.[2] The Assistant Chief of Staff, G-4, on 13 August 1952, approved the proposed engineering study and authorized the use of funds available in Contract ORD-3182.[3]

(U) In the process of selecting the optimum air defense weapon system, the Assistant Chief of Staff, G-4, considered many systems and components then under development. The guiding considerations in the analysis were twofold: One was the need for providing an early capability weapon at a minimum cost; the other was the necessity of using a warhead permitting great flexibility of yield and maximum economy in use of fissionable material. At the time of the analysis, the NIKE AJAX guided missile system had reached a

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[2]BTL Rept, 15 Jul 52, subj: Proj NIKE - A Study of the Feas of an AAGM Carrying an Atomic Whd & Utilizing the Pdn NIKE Gnd Sys. RSIC.

[3]DF, G4/F4 51310, ACofS, G-4, to CofOrd, 13 Aug 52, subj: Design Study of NIKE w Atomic Whd. Cited in NIKE Blue Book, p. 162.

fairly advanced and successful stage of development, and locations were being selected for establishment of defense sites throughout the country. It was therefore natural, for every technical, economical, and military reason, to consider primarily the use of a guided missile in conjunction with the NIKE AJAX ground equipment.

(U) Although the NIKE airframe modified to carry the TX-9 gun-type warhead would provide the earliest capability weapon, it was ruled out because of the requirement for extensive missile redesign and the low efficiency in use of fissionable material. Missiles such as the CORPORAL, TALOS, and HERMES, that either were intended or could be made to carry an atomic warhead, could be modified for use with some part of the NIKE ground equipment; however, these would have to be so radically redesigned that any arrangement of that type would result in a completely new system.

(U) The program thus proposed by G-4 and approved by the Deputy Chief of Staff, Plans & Research, in December 1952, called for the development of a new version of the NIKE missile carrying the 30-inch XW-7 warhead and using the AJAX ground equipment. To take full advantage of the latter equipment, the missile would have to be capable of engaging maneuvering targets flying at altitudes up to 60,000 feet. Maximum use of AJAX ground equipment with minimum changes was economically essential in view of the heavy investment to be made in the system by 1955-56. Moreover, it offered the further advantages of proven reliability and minimization of training and maintenance problems. The XW-7 warhead, which was already under development for use with several guided missiles in the national program, not only fulfilled the requirement for flexibility of yield, but also met the criteria for economic use of fissionable material.[4]

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[4] DF, ACofS, G-4, to CSA, 22 Dec 52, subj: Atomic Wpns in Air Def. Quoted in NIKE Blue Book, pp. 162-64.

Preliminary Design Studies

(U) In February 1953, OCO authorized BTL to proceed with preliminary design studies of the two-stage Model 1810 NIKE B* missile under Contract ORD-3182, but on a non-interference basis with the NIKE AJAX tactical prototype, contractor tests of which were just beginning. At the same time, the contractor was requested to study the problems such a missile would pose on the ground equipment and the feasibility of extending the system range beyond the 25-mile limitation of the existing AJAX ground guidance and control system. In keeping with the policy to use as many proven components as possible to reduce the development schedule to an absolute minimum, the preliminary aerodynamic parameters for the missile-booster combination were predicated on the use of a cluster of four AJAX XM-5 solid propellant boosters and a cluster of four AJAX liquid propellant sustainer motors.[5]

(U) In an informal presentation to OCO on 16 March 1953, BTL and DAC representatives outlined three possible systems of ground guidance and control equipment that would permit maximum intercept ranges of 25, 35, and 50 miles, respectively. The 25-mile system would require very few changes to the existing AJAX ground equipment, while the 35-mile system would entail a moderate amount of modification, and the 50-mile system a major redesign effort. Regardless of the range selected for the ground guidance equipment, however, the new version of the NIKE missile would be designed for a 50-mile range. The preliminary proposal for the 3-year development program embraced the construction and test of 30 NIKE HERCULES

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*As stated earlier, the second-generation NIKE system was known as the NIKE B until November 1956, when it was renamed the NIKE HERCULES (DA Cir 700-22, 15 Nov 56). To avoid confusion, the system is hereafter referred to as the NIKE HERCULES.

[5] Army Ord Tech Ln Rept for Feb 53, BTL/Whippany, pp. 8-13. RSIC.

missiles, with system tests and demonstration to be conducted during the period October 1955 to March 1956.[6]

(U) Later in March, the Joint Chiefs of Staff approved the Army's proposed NIKE HERCULES project and requested that development of the two-stage missile be undertaken with 1A priority. Also included in the approved effort was a parallel design study of a single-stage solid propellant missile. A final decision on modification of the NIKE AJAX ground equipment to permit intercept ranges beyond 25 miles was held in abeyance pending more detailed studies and the submission of a firm weapon system proposal in October 1953.[7]

(U) On 30 June 1953, the New York Ordnance District executed a new contract (DA-30-069-ORD-1082) with the Western Electric Company for design and development of the NIKE HERCULES missile system. The basic contract was for $2,261,400 and covered R&D work through December 1953, at which time the planning phase of the program was to be completed. Two weeks later, on 16 July 1953, the Secretary of the Army approved the establishment of the NIKE HERCULES project and the formal statement of military characteristics (MC's).[8]

(U) Briefly, the primary role of the second-generation NIKE system was to attack, with a single atomic warhead, formations of aircraft flying at speeds up to 870 knots (1,000 mph), at altitudes up to 60,000 feet, and at a horizontal range of 50,000 yards (110,000 yards desired) from the launching site. In addition to the primary

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[6] Army Ord Tech Ln Rept for Mar 53, BTL/Whippany, pp. 8-10. RSIC.

[7] (1) DF, ACofS, G-4, to CofOrd, 24 Mar 53, subj: Authzn for the NIKE B Dev Program. Cited in NIKE Blue Book, p. 165. (2) Army Ord Tech Ln Repts for Mar & Jun 53, BTL/Whippany. RSIC.

[8] (1) NIKE Blue Book, p. 178. (2) OTCM 34909, 16 Jul 53, subj: GM, XSAM-A-25 (NIKE B) - Estb of Proj. RSIC.

warhead for engagement of multiple targets, the weapon system was to be supplied with an alternate conventional warhead for use against single aircraft or missiles. It also was desired that the system be provided with the capability of employment against ground targets, but this provision was not to compromise the primary surface-to-air application. Competing characteristics, in the order of priority, were as follows.

1. Antiaircraft effectiveness.

2. Reliability of system.

3. Safety of friendly population and installations from accidental high or low order atomic detonation.

4. Immunity to countermeasures.

5. Ruggedness. (Ability to give trouble-free operation during, or after, exposure to extreme environmental conditions.)

6. Ease of maintenance.

7. Safety of friendly population and installations from any portion of the rocket which may be discarded in flight.

8. Effectiveness in a surface role.

9. Mobility.

10. Standardization of major and minor components.

11. Low maintenance costs.

12. Low silhouette.

13. Small required battle crew.

(U) Both NIKE AJAX and HERCULES missiles were to be capable of being fired from any and all sets of NIKE ground equipment. Hence, any modifications to the AJAX ground guidance equipment necessary to employ the NIKE HERCULES missile could not be such as to prevent firing of the AJAX missile from the same equipment. The guidelines for design of the HERCULES missile gave the development contractor the widest possible latitude in arriving at the final configuration to meet the specified warhead and system performance criteria. In the area of the propulsion system, for example, either liquid or solid propellants could be used, and the missile could be of the two-stage or single-stage design, depending upon the results of the parallel studies then underway. The MC's specified, however, that "boosters, if used, [should] be of the disposable type."[9] For reasons which will be discussed later, this particular requirement was clarified in a subsequent revision of the MC's which added that a "self-destroying type jato is desired for use where safety considerations make use of normal jatos undesirable."[10]

Proposed Weapon System and Schedule

(U) By late October 1953, sufficient design studies and laboratory work had been done to establish the general performance and physical characteristics of the HERCULES missile and to define the problems and costs of fitting this missile into the existing NIKE AJAX ground equipment. Personnel of BTL and DAC outlined the details of the proposed weapon system in a presentation to the Army General Staff on 21 October 1953 and to the Department of Defense (DOD) Committee on Guided Missiles on 26 February 1954.

(U) In selecting the missile configuration for the 30-inch primary warhead, the contractor considered both the two-stage and single-stage designs. The results of the feasibility study by DAC disclosed that a single-stage, solid-propellant missile with probable superior performance to that of the two-stage version could be developed; however, such a missile would require significant technological advancements and would probably lag the contemplated Model 1810 program by as much as 2 years. Since the immediate objective of the HERCULES program was to provide a high energy warhead delivery capability at the earliest possible date,

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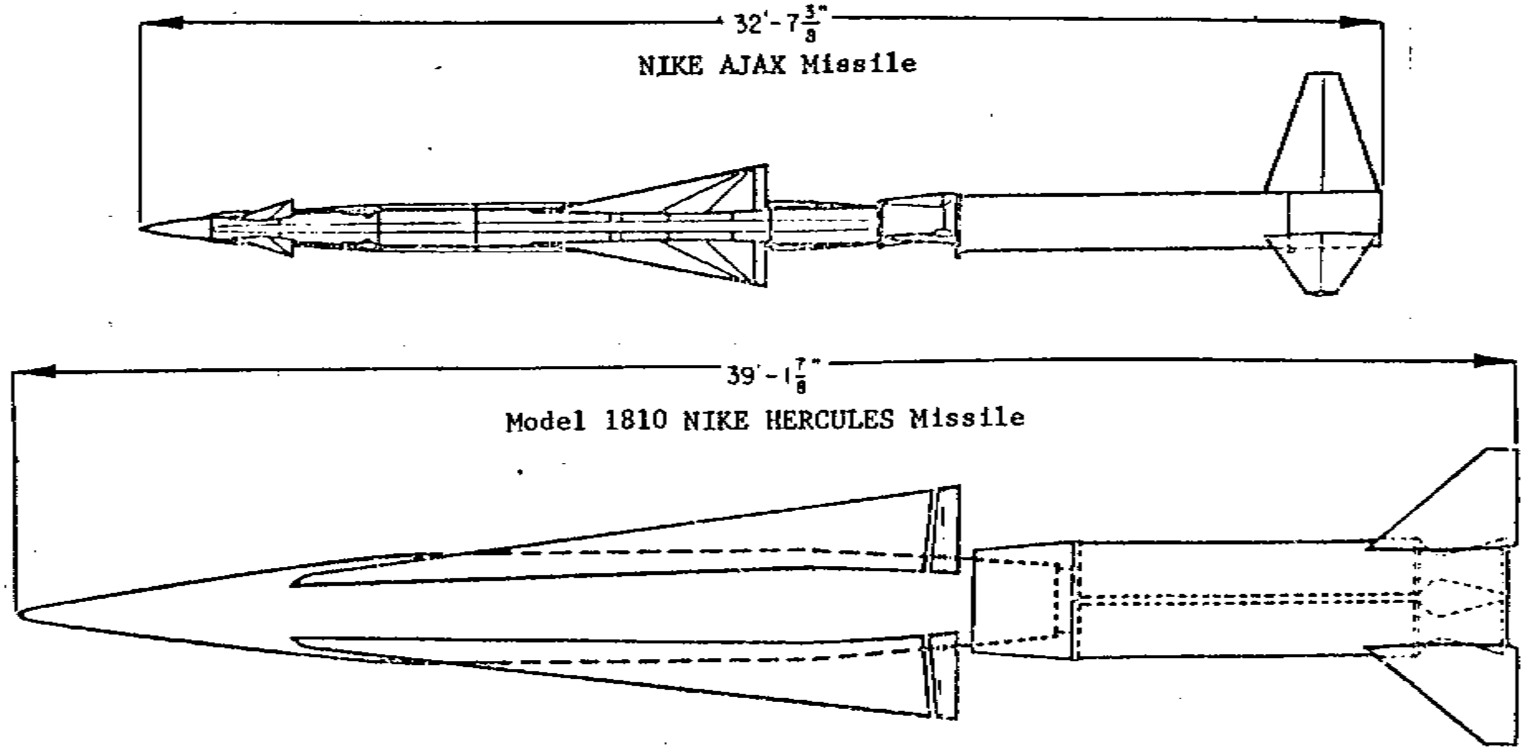
[9] *Ibid.*

[10] (1) OTCM 36581, 11 Jul 57. RSIC. (2) For a complete statement of the MC's, as revised, *see* Appendix A.

BTL recommended that primary effort be focused on development of the larger two-stage (Model 1810) vehicle using proven propulsion techniques and components of the AJAX missile, and that DAC be authorized to conduct a parallel design study of the boosterless solid-propellant missile for possible future use in the HERCULES system.

(U) The proposed two-stage Model 1810 missile used a cluster of four AJAX XM-5 solid propellant boosters and a cluster of four AJAX liquid propellant sustainer motors. As shown in the accompanying size comparison, the HERCULES missile-booster combination was about 7 feet longer than the AJAX. Its maximum diameter was 30 inches, compared with 12 inches for the AJAX missile. The gross launching weight of the complete HERCULES missile (including booster and warhead) was 9,800 pounds, in contrast to 2,500 pounds for the AJAX. The gross weights of the missiles (less booster) were 4,800 pounds and 1,200 pounds, respectively. As an extension of the NIKE AJAX, the HERCULES would retain the command guidance system, thus allowing the more complex guidance functions to be in the ground equipment. The initial HERCULES guidance section would be made up of the same plug-in chassis as employed in the new NIKE AJAX guidance section. Flight instruments, such as gyros and accelerometers, would also be the same for both systems.



(U) Size Comparison - Model 1810 NIKE HERCULES and NIKE AJAX Missiles (21 Oct 53)

(U) The original scope of work had been limited to the modifications necessary to convert NIKE AJAX ground equipment to an integrated HERCULES-AJAX system for the 25-mile range. The study was based on the premise that the NIKE HERCULES would be added one section at a time to a given NIKE AJAX battery, so that both AJAX and HERCULES missiles could be fired from the same ground equipment. During the detailed feasibility study, the BTL engineers found that the missile designed to go to the 25-mile range could be used for a 50-mile system in the surface-to-air role, and further, that this 50-mile missile could also be made to go to a range of about 100 miles in the surface-to-surface role. The cost of adapting the existing AJAX ground guidance and launching equipment to the 25-mile HERCULES missile would amount to 9.5 percent of the original cost of the equipment. In the case of the proposed extended-range (50-mile) HERCULES system, the modification cost was estimated at 23.6 percent* of the original cost of the battery equipment. (*See* Table 1.)

(U) The BTL representatives recommended that work be continued on modifications to convert NIKE AJAX in the field to a HERCULES-AJAX system for the 25-mile range; that they be authorized to conduct concurrent development of additional modifications to extend the HERCULES range in the integrated system to at least 50 miles; and that they be authorized to proceed with the modification of one AJAX guidance system in the field to permit a HERCULES system demonstration at the extended range.

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*The latter cost estimate was originally quoted at 21 percent in October 1953, but was increased to 23.6 percent because of a change in the launcher complement of the battery to one corresponding to the latest decision by the Army General Staff—i.e., provision for four launchers in a section instead of three as previously planned.

TABLE 1—(U) Projected NIKE HERCULES Costs

ITEM	ESTIMATED COST
Development[a]	
25-mile System	$13,000,000
Long-Range System (Additional)	4,000,000
Field Modification (Battery Equipment)[b]	
NIKE AJAX to 25-mile NIKE HERCULES	170,000 Per Btry
NIKE AJAX to Long-Range HERCULES	335,000 Per Btry
25-mile HERCULES to Long-Range HERCULES	165,000 Per Btry
Complete Battery (New Production)[c]	
NIKE AJAX	1,442,000 Per Btry
25-mile NIKE HERCULES	1,500,000 Per Btry
Long-Range HERCULES	1,550,000 Per Btry
Missile[d]	
NIKE AJAX (Inert)	20,000 Per Msl
NIKE HERCULES (Inert)	34,000 Per Msl
Assembly Area[e]	
NIKE AJAX	653,000 Per Bn
NIKE HERCULES (Additional)	150,000 Per Bn

NOTES

a/ Including cost of 40 Model 1810 experimental missiles and system tests through the first quarter of CY 1956.

b/ To modify an AJAX battery to a 25-mile HERCULES would cost $170,000. To modify an AJAX battery to a long-range HERCULES would cost $335,000, while to modify a 25-mile HERCULES to a long-range HERCULES would cost the difference between these two figures, or about $165,000.

c/ The cost of an AJAX battery, consisting of three sections of four launchers each and including ORD 7 spare parts and test equipment, was $1,442,000. The 25-mile HERCULES battery with eight launchers for AJAX and four launchers for HERCULES would cost $1,500,000, while the long-range HERCULES battery with the same launcher complement would cost $1,550,000.

d/ The unit cost for the HERCULES Model 1810 missile considered to be the average cost of the first 2,500 missiles produced. The early missiles would cost more, the later ones less.

e/ The current cost of an AJAX assembly area was $653,000 per battalion. To handle the HERCULES missile, additional equipment costing $150,000 would be required for each assembly area.

SOURCE: BTL Rept, NIKE B (HERCULES) Presn Before the DOD Com on Guided Missiles, 26 Feb 54. RSIC.

(U) Except for the addition of tasks associated with the extended-range system and an increase in the number of R&D test missiles (from 30 to 40), the recommended development schedule essentially duplicated that presented in the preliminary proposal of March 1953. The schedule (Chart 4) called for system design and development, missile design, model construction, and tests culminating in an overall system demonstration at the 25-mile range in the first quarter of 1956. Development of the 25-mile ground guidance and control equipment modifications would be relatively simple and could be completed in a small fraction of the total schedule. With preliminary design work already underway on the extended-range guidance and control equipment (i.e., modification of the acquisition and tracking radars, computer, displays, and other devices), it would be possible to complete development and construction of the R&D prototype in time to have the system tests conducted with the long-range missile during the first quarter of 1956.

(U) The HERCULES production schedule shown in Chart 5 represented BTL's opinion of a reasonable program that could be pursued safely and economically. In addition to detailing the leadtime data reflected in this chart, Mr. R. R. Hough of BTL pointed out that additional test missiles would be required in 1956 for a continued test and evaluation program, and that these missiles should be ordered no later than the third quarter of CY 1954.[11]

(U) Final action on BTL's missile system proposal came in 1954. In early March, the Office, Secretary of Defense approved the Model 1810 liquid propellant NIKE HERCULES system and authorized improvements to the NIKE AJAX ground guidance and

[11](1) BTL Rept, NIKE B Presn, Pentagon Bldg., Washington D. C., 21 Oct 53. (2) BTL Rept, NIKE B Presn Before the DOD Com on Guided Missiles, 26 Feb 54. Both in RSIC.

CHART 4
(U) NIKE HERCULES DEVELOPMENT SCHEDULE
(BTL, 26 FEB 54)

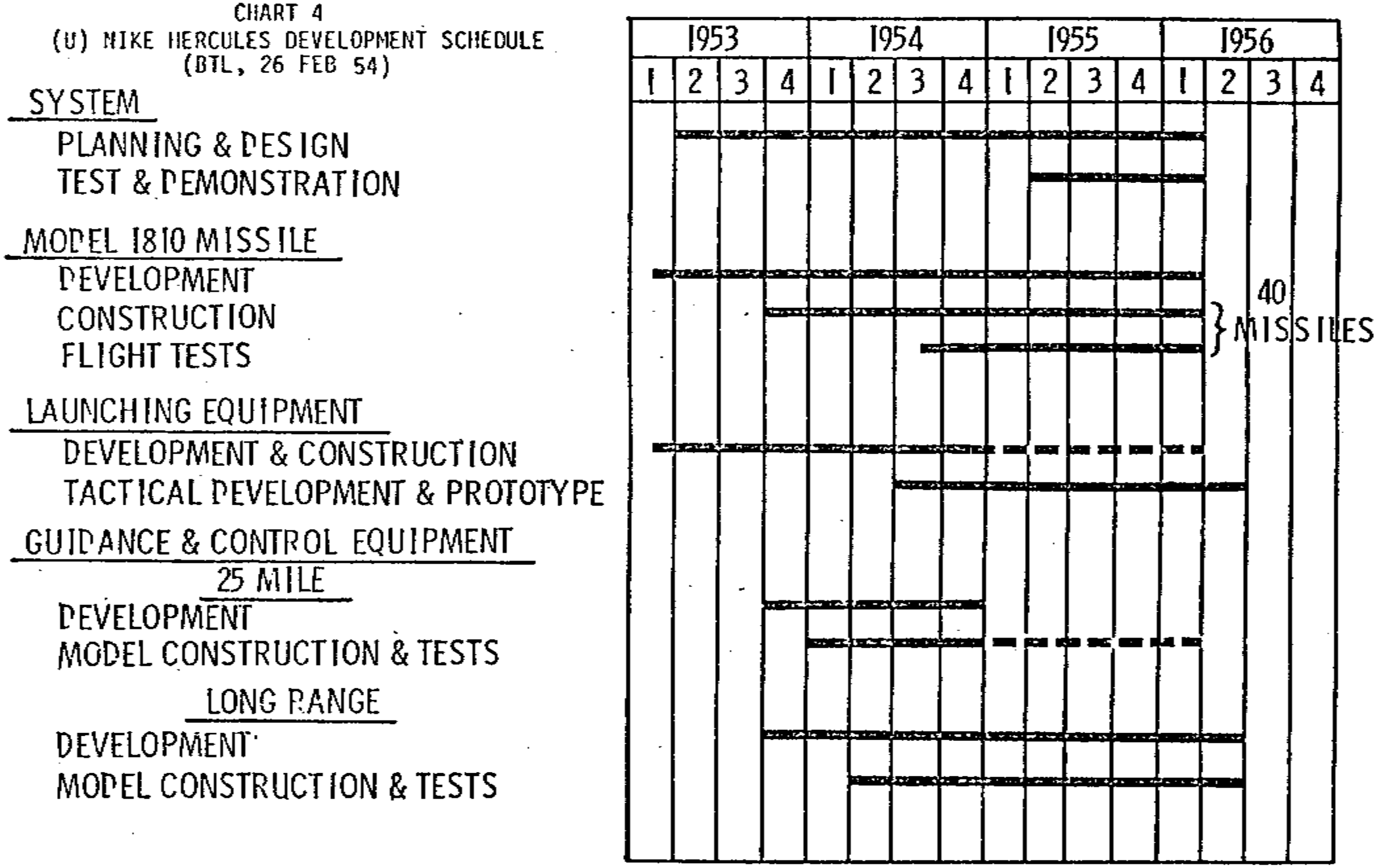


CHART 5
(U) NIKE HERCULES PRODUCTION SCHEDULE
(BTL, 26 FEB 54)

1810 MISSILE

PRODUCTION DESIGN
PRODUCTION

LAUNCHING & HANDING

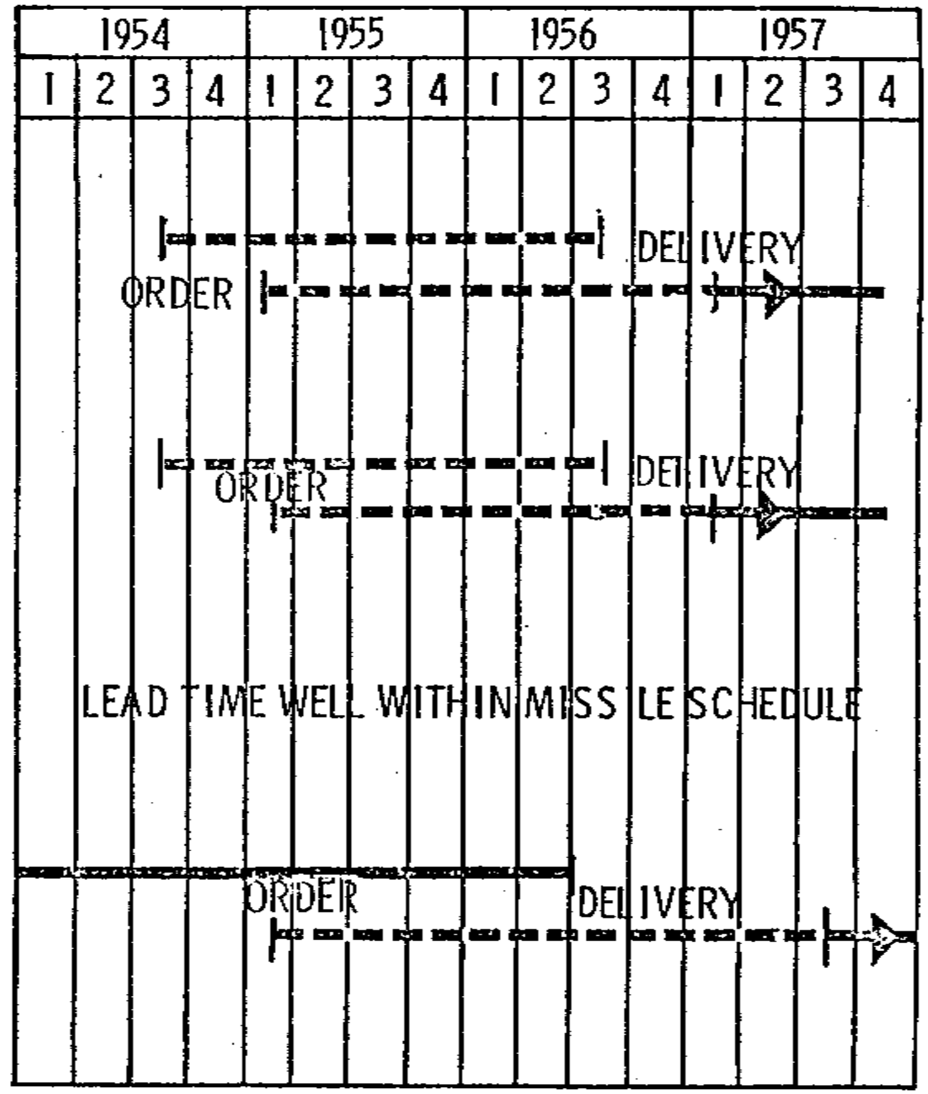
PRODUCTION DESIGN
PRODUCTION

GUIDANCE & CONTROL

25 MILE

LONG RANGE

DESIGN
PRODUCTION



control equipment for the 25-mile HERCULES-AJAX system.[12] On 31 March 1954, WECo's R&D contract (ORD-1082) was supplemented for $7.7 million, extending the time of performance through December 1954 and increasing the amount of the contract from $2,261,400 to $9,961,400.[13] The Army, on 26 May, coordinated its proposed program for demonstration of an extended-range HERCULES system at the eighth meeting of the Coordinating Committee on Guided Missiles.[14] Five months later, in October, G-4 authorized the Chief of Ordnance to demonstrate the HERCULES system at extended range and to manufacture five prototype modification kits and associated equipment for converting AJAX batteries to control HERCULES missiles at the extended range.[15]

(U) The Deputy Chief of Staff for Logistics reiterated that the primary objective of the program was to provide an atomic capability at the earliest practicable date consistent with reasonable nuclear efficiency and maximum use of the large amount of AJAX equipment then on hand and in production. He directed that maximum effort be applied toward completing development and demonstration of a system compatible with the contemplated CONUS NIKE AJAX employment (underground magazines), but also having mobility equivalent to AJAX units in a field army. Priority, however, would be given to the CONUS employment role.[16]

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[12] DF, Cmt #1, G4/F4-12390, ACofS, G-4, to CofOrd, 8 Mar 54, subj: Army's NIKE B Surface-to-Air Program. Cited in NIKE Blue Book, p. 168.

[13] NIKE Blue Book, p. 254.

[14] *Ibid.*, p. 168.

[15] (1) DF, Cmt #2, G-4 to CofOrd, 12 Oct 54, subj: NIKE B Extended Range. Cited in NIKE Blue Book, p. 168. (2) DF, Cmt #2, G-4 to CofOrd, 21 Oct 54, subj: NIKE B Program. Cited in NIKE Blue Book, p. 175.

[16] DF, Cmt #1, DCSLOG to CofOrd, 23 Oct 54, subj: Guidance for Conduct of the NIKE Program. Atchd to OTCM 35654, 30 Dec 54. RSIC.

(U) Meanwhile, the Douglas Aircraft Company, in July 1954, began preliminary design studies of the tactical prototype launching and handling equipment. Included in this effort was an examination of the best engineering and economic compromises that would assure maximum flexibility of AJAX and HERCULES equipment so that, where practicable, it could be used with either.[17] On 29 November 1954, personnel of BTL and DAC outlined the details of the proposed equipment in a presentation to members of the Army General Staff. Briefly, the assembly and launching operations of the NIKE battery would consist of three different areas: the Assembly and Test Building, the Fueling and Warhead Area, and the Launching Area. Table 2 lists the equipment requirements for each of these areas and identifies those items which would be peculiar to the HERCULES, the new items for AJAX and HERCULES, the AJAX items requiring modification, and the items of existing AJAX equipment that could be used without modification. BTL personnel pointed out that early authorization to begin design and construction of prototype equipment would be essential in order to phase in with ground guidance equipment prototypes scheduled for delivery in the first half of 1957.[18] In November 1954, BTL received authorization to proceed with the design and development of the tactical launching and handling equipment in accordance with concepts recommended in the BTL/DAC presentation, and to begin preparation of manufacturing information as required for these items.[19]

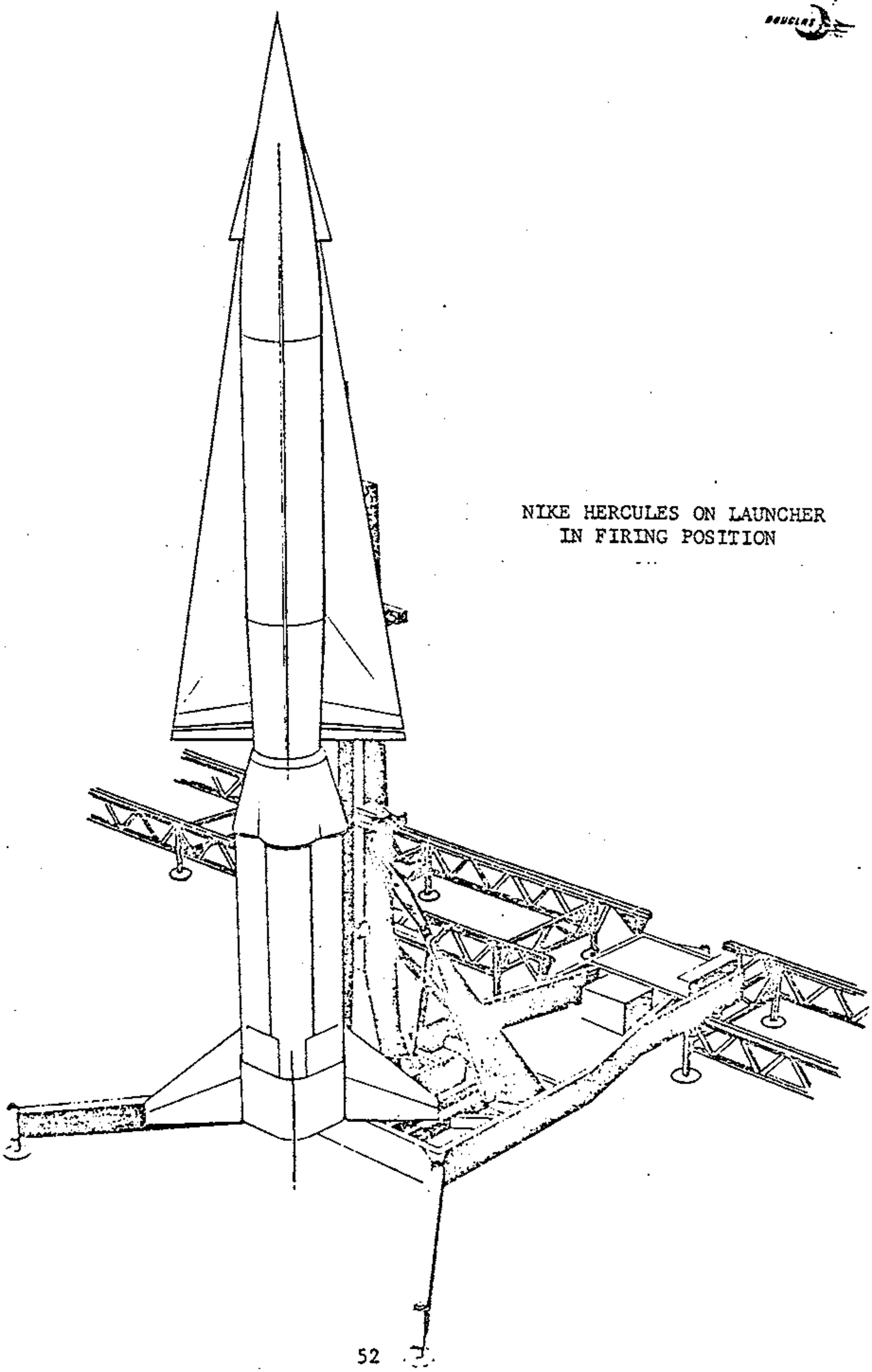
[17] Army Ord Tech Ln Rept for Jul 54, BTL/Whippany, p. 8. RHA Bx 13-595.

[18] BTL/DAC Rept SM-18670, 29 Nov 54, subj: NIKE B Tac Lchg & Hdlg Equip Presn. RSIC.

[19] Army Ord Tech Ln Rept for Dec 54, BTL/Whippany, p. 12. RHA Bx 13-595.

TABLE 2—(U) Proposed Launching & Handling Equipment for NIKE Battery
(BTL/DAC Rept SM-18670, 29 Nov 54)

Equipment	Nr Rqrd For HERC	New For HERC Only	New For AJAX/HERC	Mod. AJAX	Existing AJAX
Assembly and Test Building					
1. Capping Compressor......................	1				XX
2. Propulsion Plumbing System Test Assembly.	1			XX	
3. Missile Dolly...........................	3	XX			
4. Warhead Section Adapter.................	3	XX			
5. Main Body Hoist Beam....................	1	XX			
6. Auxiliary Power Unit Fueling Equipment...	1	XX			
7. Missile Handling Rings..................	5 sets	XX			
8. Hydraulic Test Stand....................	1			XX	
9. Test Assembly Missile Electrical Equip...	1			XX	
10. Servicing Assembly Propellant Draining...	1			XX	
11. Miscellaneous Tools and Equipment........	1			XX	
Fueling and Warhead Area					
1. Fuel Fill Equipment......................	1		XX		
2. Propellant Hoist Assembly................	1		XX		
3. Oxidizer Fill Equipment..................	1		XX		
4. Warhead Section Dolly....................	2	XX			
5. Missile Hoist Beam.......................	1	XX			
6. Warhead Section Hoist Beam...............	1	XX			
7. Booster Cluster Hoist Beam...............	1	XX			
8. Booster Cluster Dolly....................	2	XX			
9. Jato Hoist Beam..........................	1				XX
Launching Area					
1. Launcher.................................	3		XX		
2. Loading Racks............................	17		XX		
3. Loading Frame............................	1		XX		
4. Launching Rail...........................	6	XX			
5. Portable Test Set........................	1	XX			
6. Portable Test Equipment Dolly............	1				XX
7. Launching Section Operation Equipment....	1			XX	
8. Launching Control Trailer................	1			XX	
9. Missile Booster Transporter Trailer......	2				XX
10. Trailer Adapter..........................	2	XX			



NIKE HERCULES ON LAUNCHER
IN FIRING POSITION

CHAPTER IV

(U) DEVELOPMENT OF THE BASIC HERCULES WEAPON SYSTEM (U)

(U) The tactical version of the Basic HERCULES weapon system evolved from the telescoped R&D and industrial programs during the 1955-59 period. Although the preproduction engineering and production contracts were not signed until April 1955, the contractors actually started production engineering on the tactical system in November 1954, 2 months before the first experimental flight of the Model 1810 missile. The system design was established at the end of 1957, but experimental firings and engineering-user tests continued through 1959. The weapon system entered the industrial test phase on 9 January 1960, concurrently with completion of production engineering and the final R&D design release. Minor improvements and design refinements continued through 1960, at which time development and test of the Basic HERCULES system was essentially complete. Meanwhile, the first Basic HERCULES battery was deployed in June 1958, and the weapon system was classified as Standard A in November 1958.

System Design Philosophy

(U) In the design, development, test, and evaluation of the Basic HERCULES, the contractor made maximum use of components, equipment, and techniques already developed and tested as part of the NIKE AJAX system. The basic philosophy of the AJAX—that of a completely integrated battery using command guidance control of the missile—was also maintained. Briefly, the system consisted of an acquisition radar for continuous surveillance of all targets within range, and of means for designation of target location to the target tracking radar. Precise target and missile position information was continuously obtained by the target tracking radar and missile tracking radar, respectively. The computer solved the guidance problem using the position information and issued steering commands required to direct the missile over an efficient trajectory to intercept the target. These orders were coded in a pulse code form and sent via the missile tracking radar to the missile. The orders were received in the missile, decoded by the missile guidance set, and used for positioning hydraulically-operated control surfaces to obtain the desired missile maneuver accelerations. At the proper time before intercept, depending on the warhead used, a burst order signal was sent to the missile. The readiness of the equipment and the progress of the engagement were monitored and controlled at the battery control console.

(U) To reduce the time of flight in dense atmosphere and obtain the maximum specific impulse of the sustainer motor, the dart-shaped missile was launched nearly vertically and propelled to supersonic speed by the booster. The empty booster motor was jettisoned when its propellant burned out, at which time the sustainer motor ignited and propelled the missile to its maximum velocity (about Mach 3.5). Four fixed fins with trailing-edge control surfaces for roll-stabilizing and steering the missile were affixed to the aft section. The control surfaces were inactive until after separation of the booster, when the command guidance system started to control the flight of the missile.[1]

Revision of the Development Schedule

(U) With two exceptions, the WECo-BTL-DAC team accomplished the development and test program essentially according to the planned schedule of February 1954 (*see* Chart 4). Problems with the liquid sustainer motor delayed the initiation of the 40-round

[1](1) BTL/DAC Rept, NH Sys & Adv Design NH Sys Presn at Ft Bliss, 6 Feb 58, pp. 3-4. Hist Div File. (2) TIR CD-1, OCO, Jun 60, p. 32. RSIC.

missile flight test program from November 1954 to mid-January 1955. Although the entire program was geared to a very close timetable, BTL was confident that the time lost in the power plant schedule could be made up, so that the system demonstration could still be completed by 31 March 1956. However, because of the delay in execution of Contract ORD-1447 for preproduction missiles, completion of the system demonstration slipped to October 1956. Warning of the potential program delay, in January 1955, BTL pointed out that construction of the 40 R&D missiles would be completed by October 1955, and that the last of these rounds would be expended during the system demonstration. To provide the necessary leadtime for construction and delivery of preproduction prototypes for continued R&D flight tests, contract authorization for the first 100 rounds was required no later than 1 January 1955. In the absence of such authority, BTL notified Ordnance that the system demonstration would be rescheduled upon completion of contract negotiations for the first lot of preproduction missiles. The contract was finally signed on 29 April 1955, and the target date for completion of the system demonstration was rescheduled for October 1956.[2]

Test Hardware and Equipment

(U) The scope of work under WECo's prime contract (ORD-1082) called for the development and preparation of manufacturing information, research and development in support of the system, an experimental test program, and a training program. Forty R&D missiles and two experimental models of ground equipment were fabricated under the contract for use in development and testing of the system. Since the HERCULES ground guidance and control

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[2](1) Army Ord Tech Ln Repts, BTL/Whippany, for Nov 54, p. 8; for Jan 55, pp. 17-18; for Feb 55, pp. 12-13. RHA Bx 13-595. (2) NIKE Blue Book, p. 286.

equipment was in the early development phase concurrently with the missile experimental flight tests, it was necessary to modify the NIKE AJAX R&D system in use at "C" Station, White Sands Missile Range (WSMR), to permit it to control the new long-range HERCULES missile. The first R&D model of the HERCULES ground guidance equipment was installed at "C" Station during March, April, and May 1956; and demonstration of the complete weapon system using the new command link began on 25 July, following a series of checkout firings using both AJAX and HERCULES missiles. The first R&D model of ground equipment was later returned to Whippany, where it was modified into the second engineering model for use by the contractor in continued system testing and evaluation.[3]

(U) Contract ORD-1447, awarded to WECo on 29 April 1955, called for construction of the first lot of 100 production prototype missiles and for conversion of five AJAX prototype ground equipment sets to HERCULES. Included in the latter were five sets of ground guidance and control equipment, five sets of launching and handling equipment, five sets of assembly area equipment, and three sets of Type IV test equipment, all of which were to be delivered to the Army for use in Ordnance engineering and user tests. The basic contract was later amended to include three additional missile lots, bringing the total number of prototype missiles to 320. Missile deliveries by DAC began in June 1956 and continued into December 1958. The five sets of prototype equipment were delivered between November 1956 and June 1957.[4]

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[3](1) Army Ord Tech Ln Rept for Jan 56, BTL/Whippany, p. 6. RHA Bx 13-595. (2) BTL/DAC Rept, NH Sys & Adv Design NH Sys Presn at Ft Bliss, 6 Feb 58, p. 46. Hist Div File. (3) Stanford Research Institute Tech Rept No. 24, Aug 61, subj: The NH Sys Cost & Aval Expc Factors, pp. 41-42. RHA Bx 13-592. (This document hereafter cited as SRI TR 24.)

[4](1) *Ibid.*, pp. 62, 72-73. (2) For details relating to the preproduction and industrial programs, *see* Chapter V.

Missile and Booster Development

(U) The propulsion, structure, and control system components and the essential aerodynamic characteristics of the HERCULES missile and booster assembly were developed and evaluated in the first 28 test firings at WSMR during the period 13 January 1955 to 29 February 1956. During the "C" Station modification program, four additional HERCULES rounds were fired, with internal programmers in lieu of ground guidance control. Therefore, 32 HERCULES rounds were fired strictly as missile evaluation tests up to the beginning of the system demonstration in July 1956.[5]

(U) The decision to use existing components where practicable created a problem within itself, because components such as the AJAX sustainer motor and XM-5 booster had to be adapted to the HERCULES missile. (As noted earlier, the two-stage Model 1810 missile approved for development used clusters of four AJAX XM-5 solid propellant booster motors and four liquid propellant sustainer motors.[6]) The contractor encountered major problems in the clustering of both power plants, and malfunction of the sustainer motor cluster marred many of the early flight tests.

(U) The first four R&D missiles (Rounds B1 through B4), fired between 13 January and 6 April 1955, were powered by the XM-5 booster cluster and the Bell Aircraft liquid sustainer motor using JPX fuel (a mixture of 40 percent unsymmetrical dimethyl hydrazine and 60 percent JP4 jet fuel, a hydrocarbon between gasoline and kerosene). The remaining 28 R&D test missiles (Rounds B5 through B32), fired between June 1955 and June 1956, were equipped with the XM-5 booster cluster and the redesigned sustainer cluster

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[5](1) BTL/DAC Rept, NH Sys & Adv Design NH Sys Presn at Ft Bliss, 6 Feb 58, p. 46. Hist Div File. (2) NH Dev Test Plan, ARGMA TP-5, Oct 59, p. 6. RHA Bx 13-657.

[6]*See* above, pp. 41-42.

using Aerojet General motors with JP4 jet fuel and inhibited red fuming nitric acid as an oxidizer.

(U) The XM-5 booster cluster exhibited good performance in all but two of the missile evaluation tests. The liquid sustainer motor cluster, however, was a source of constant trouble throughout the missile development test program. Of the first 20 flight tests in 1955, 12 were terminated by malfunction. Two of these failures were attributed to the XM-5 booster cluster, six to the sustainer motor cluster, and the remaining four to other missile equipment.[7]

(U) On 30 September 1955, the program suffered a discouraging setback when an explosion occurred during a routine static test of the liquid propulsion system at White Sands Proving Ground. Explosions had occurred before at this test pit, but never had there been one of such violence. An employee of the White Sands Electro-Mechanical Laboratory was killed, marking the first fatality of the NIKE project, and five DAC employees suffered injuries from flying debris within the control room. The test stand was 6 to 8 feet from the reinforced concrete walls of the control room, where the six personnel were monitoring extra instrumentation equipment provided for the test. The force of the blast caved back the reinforced concrete wall; blew out the narrow safety glass window over the operating console and the larger window on the same wall to the rear of the control room; and snapped the 2 by 10 wooden beams of the control room roof structure. The building, though not demolished, was considered to be nonrepairable.[8]

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[7] (1) NH Dev Test Plan, ARGMA TP-5, Oct 59, p. 21. RHA Bx 13-657. (2) For a detailed description of individual flight test results, *see* DAC/BTL NH R&D Firing Bulletins, RHA Boxes 13-377 and 13-378; & Army Ord Tech Ln Repts, BTL/Whippany, 1955-56, Bx 13-595.

[8] Army Ord Tech Ln Rept for Sep 55, BTL/Whippany, pp. 2-3. RHA Bx 13-595.

XM-30 Solid Propellant Sustainer Motor

(U) As a result of the motor failures in 1955 and recurring malfunctions early in 1956 (four failures in eight trials), BTL and Redstone Arsenal presented OCO a proposed program for parallel development of a solid propellant HERCULES sustainer motor using the T17-type propellant which the Thiokol Chemical Corporation had developed for use in the HERMES and SERGEANT missiles. Under the proposed program, the four liquid motors, their fuel and oxidizer tanks and associated valves, pumps, and plumbing would be replaced with a simple solid motor having no mechanical moving parts. As shown in the accompanying illustrations, the change would necessitate relocation of the airborne guidance package from the aft end to the nose section and redesign of the fuselage. However, the manifold advantages to be derived from such a missile made the redesign effort well worthwhile. The reliability and operability of the system would be significantly improved; production costs would be lower; and field maintenance and service of the missile would be much easier and require less operating personnel and equipment.[9]

(U) The Department of the Army approved the proposed motor development program as a parallel effort in late March 1956.[10] The Redstone Division of the Thiokol Chemical Corporation developed the XM-30 solid propellant sustainer motor for the HERCULES missile in three phases at a total cost of $5,380,247. Contract ORD-4930, awarded on 11 April 1956 for $98,059, covered a 6-month preliminary design and development program. Although work under the initial contract continued until the latter part

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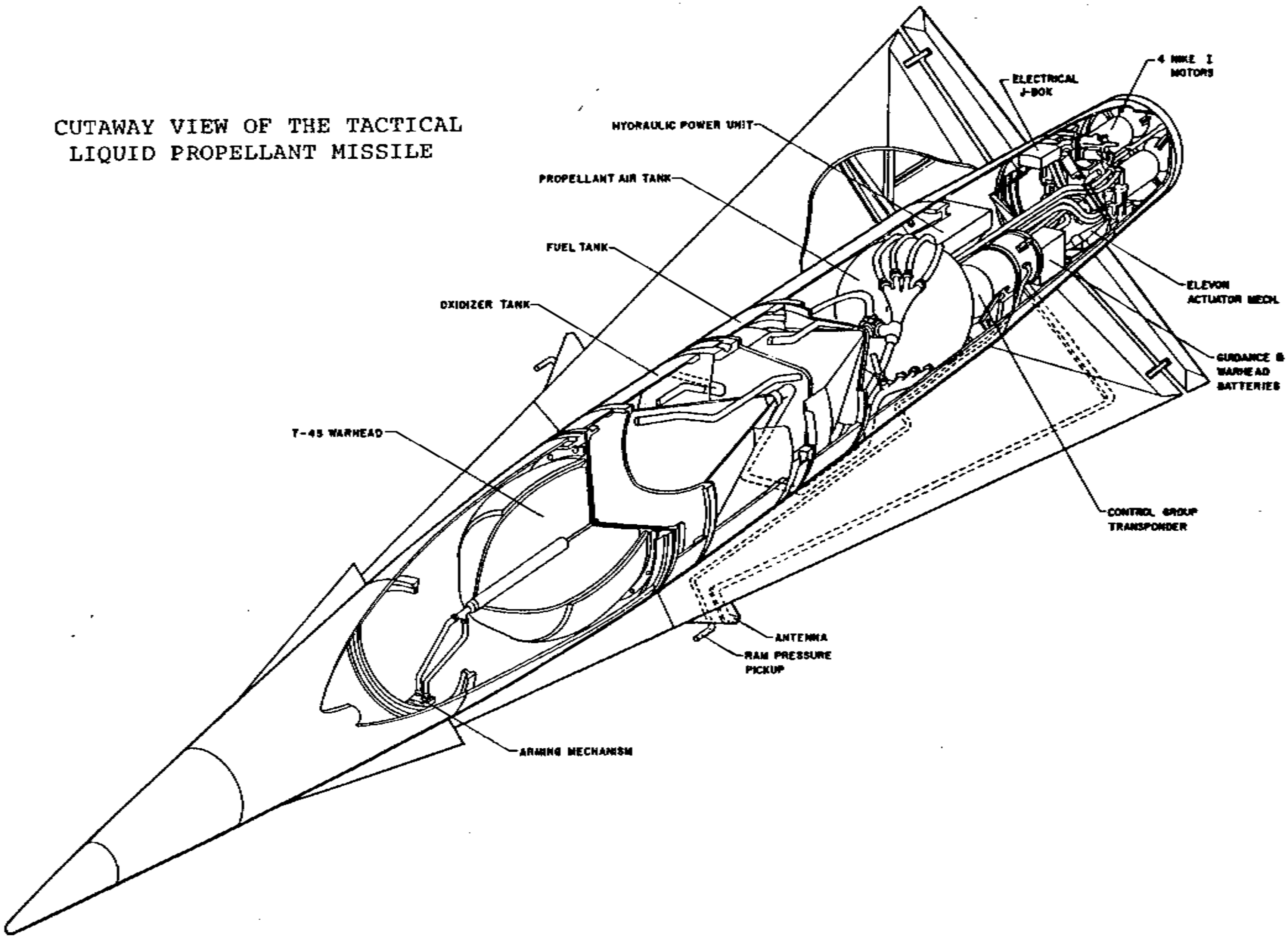
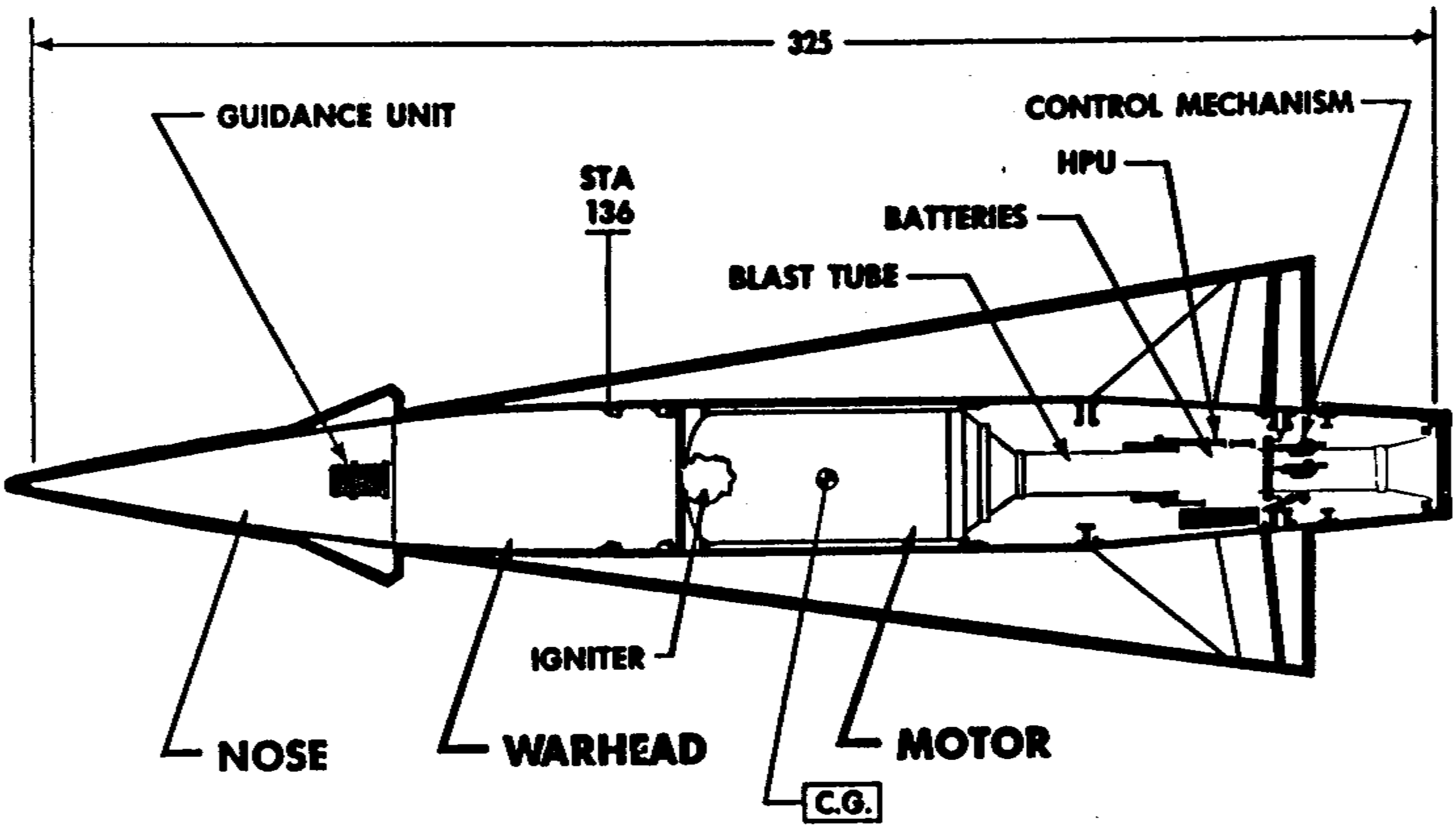
[9] (1) NIKE Blue Book Suppl, 1 Jul 55 - 30 Jun 56, pp. 24-25. Hist Div File. (2) Army Ord Tech Ln Rept for Jan 56, BTL/Whippany, pp. 20-26. RHA Bx 13-595. (3) Ltr, CG, RSA, to CofOrd, 27 Jan 56, subj: Ppsd Dev of Solid Propellant NIKE B. RHA Bx 13-377.

[10] TT, CofOrd, to CG, RSA, 30 Mar 56. RHA Bx 13-377.

CUTAWAY VIEW OF THE TACTICAL
LIQUID PROPELLANT MISSILE



CUTAWAY VIEW OF THE PROPOSED SOLID PROPELLANT MISSILE



of 1956, the full-scale R&D phase commenced with the signing of Contract ORD-4947 on 15 June 1956. The latter contract, for $1,995,498, included $118,542 for necessary modification of existing manufacturing facilities and acquisition of capital equipment. It covered a 12-month development effort which culminated in the flight-type motor design. Contract ORD-5102, awarded on 5 December 1956 for $3,286,690, constituted a continuation and elaboration of work done under the previous contracts.[11]

(U) In addition to numerous small-scale static test motors, Thiokol assembled and loaded 222 XM-30 motors of the flight design during the period June 1956 to March 1958. Of these, 105 were expended in missile flight tests and the remainder in development, pre-flight, and qualification tests.[12] Under a fourth contract, ORD-5028 signed on 28 June 1956 for $85,496, Thiokol supplied six simulated solid propellant motors for safety detonation tests by the Government.[13]

(U) The original schedule for the XM-30 motor development program called for delivery of the first tactical HERCULES missile so equipped in September 1958. However, this schedule was later accelerated to allow the incorporation of solid motors

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[11] (1) TCC Rept 10-58, undated, Final Rept - Contr ORD-4930; TCC Rept 41-58, Jan 59, Final Rept - Contr ORD-4947; & TCC Rept 45-58, Feb 59, Final Rept - Contr ORD-5102. RSIC. (2) NIKE Blue Book Suppl, Jul 55 - Jun 56, pp. 24-25. Hist Div File.

[12] Loading, Testing, & Delivery Summary, XM-30 NH Sustainer Mtr - TRX-110C (T17E3) Propellant, TCC Rst Div, Jan 56 - Mar 58. RHA Bx 13-378.

[13] Work under Contract ORD-5028 was completed in October 1956. A supplemental agreement to the contract, signed on 25 November 1957, authorized use of the unexpended funds ($27,047) for a preliminary design and development study of a solid propellant rocket engine having a self-destroying chamber of Fiberglas-plastic material. (1) Contr ORD-5028, 28 Jun 56, w Suppl Agrmt Agrmt dtd 25 Nov 57. (2) DF, Chf, Rkt Dev Labs, to Contr Administrator, 24 Oct 56, subj: Termn of Contr ORD-5028. Both in RHA Bx 15-224.

into production missiles in the first half of 1958.[14] Aside from some problems and delays in metal parts deliveries, the program proceeded on schedule. Interim design releases of the XM-30 motor and the HERCULES missile with XM-30 motor came on 3 October and 23 October 1956, respectively.[15] In February 1957, the Army adopted the XM-30 solid propellant sustainer motor for the tactical missile and amended WECo's production contracts accordingly. Flight tests of the XM-30 R&D motor began with the firing of Round B57 at White Sands on 13 March 1957. The liquid propulsion system was phased out of the R&D flight test program in 1958.[16]

(U) Meanwhile, the Thiokol Chemical Corporation/Longhorn Ordnance Works* (TCC/LOW) cast the first preproduction motor for static test on 21 January 1957, and began pilot production of the

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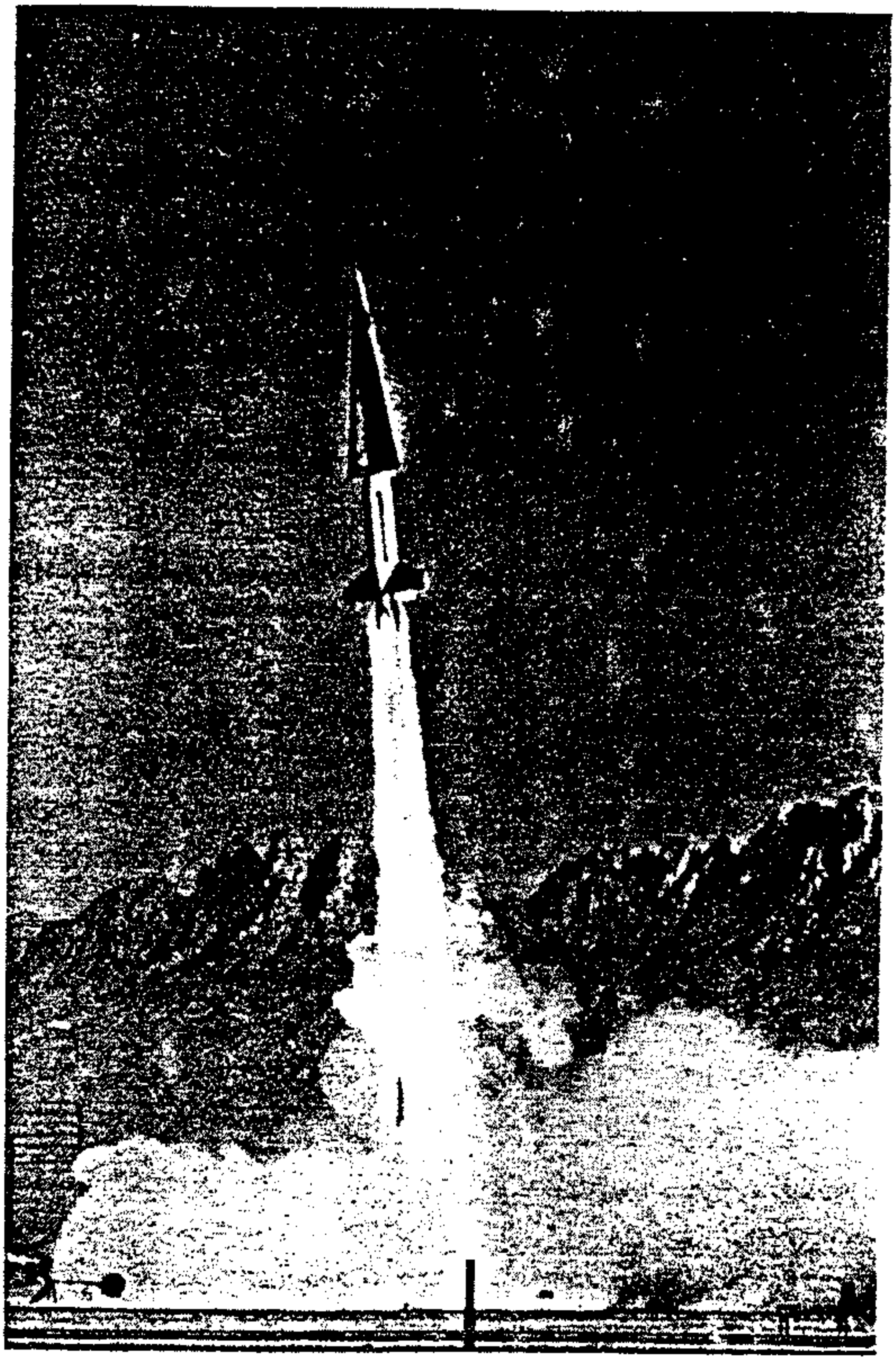
*Located at Marshall, Texas, the Longhorn Ordnance Works was a Government-owned facility operated by the Thiokol Chemical Corporation. This facility was originally a World War II TNT plant. After the war, the Thiokol Corporation, under contract with the Ordnance Ammunition Command, converted a part of the plant into a manufacturing facility for small and medium-sized solid propellant rocket engines, and produced composite propellants for the FALÇON, LACROSSE, and NIKE HERCULES motors. As of January 1959, the Thiokol Longhorn Division had some 1,300 employees at work in the 8,800-acre plant and was in the midst of a $6 million expansion program to provide new facilities for production of large rocket motors for the SERGEANT, PERSHING, and NIKE ZEUS missiles. (Craig Lewis, "Thiokol Stresses R&D on Rocket Motors," *Aviation Week*, Vol. 70, No. 1 [5 Jan 59], p. 42.) In the Army reorganization of 1962, the Longhorn Ordnance Works was redesignated as the Longhorn Army Ammunition Plant (LAAP).

[14] (1) Sum of Conf to Review NH Solid Propellant Sustainer Mtr Dev Program, 13 Jul 56. (2) NH Solid Sustainer Dev Sum, Rkt Dev Labs, Dec 56. Both in RHA Bx 13-377.

[15] (1) Ofc Memo, Chf, PMS, RDD, RSA, to Chf, Indus Div, 3 Oct 56, subj: Interim Design Rel for NIKE B Solid Propellant Sustainer Mtr. (2) Ofc Memo, same to same, 23 Oct 56, subj: Interim Design Rel for NIKE B Msl Incorporating a Solid Propellant Sustainer Mtr. Both in RHA Bx 13-377.

[16] (1) NH Chronology, p. II-3. Hist Div File. (2) DAC/BTL NH Firing Bulletins. RHA Bx 13-378.



First flight test of HERCULES missile with solid propellant sustainer motor at WSPG, 13 March 1957 (Thiokol Photograph)

XM-30 in March. Deliveries of motors for flight test commenced in November 1957,[17] and the first tactical missile of this configuration was completed and shipped from the Charlotte Ordnance Missile Plant in December.[18]

XM-42 Booster Motor

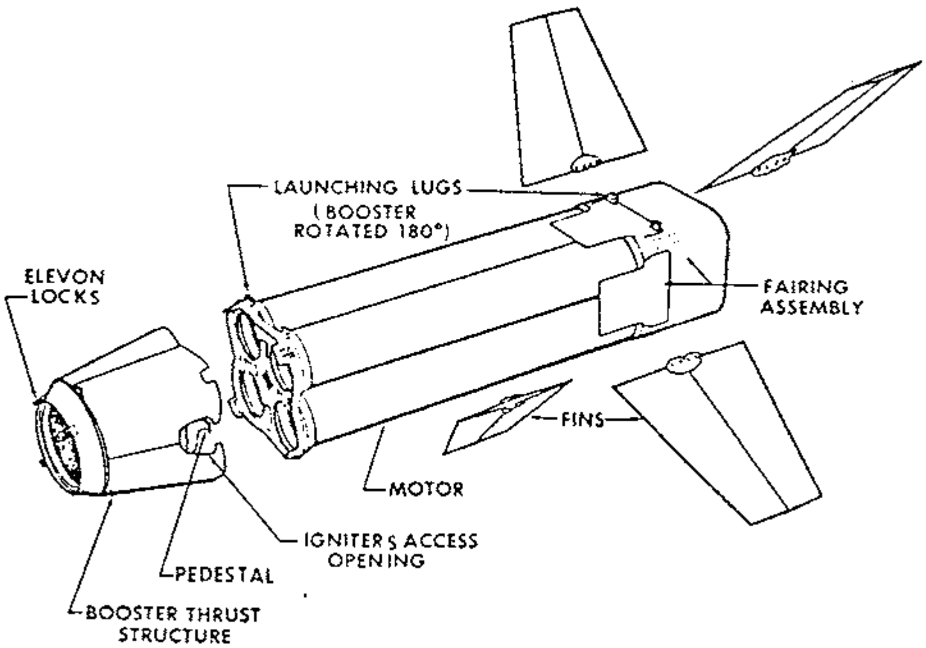
(U) The altered M5 (XM-5) jato adapted for use in the booster

[17] Loading, Testing, & Delivery Summary, XM-30 NH Sustainer Engine, TRX-110C (T17E3) Propellant, TCC/LOW, Jan 57 - Jan 58. RHA Bx 13-378.

[18] BTL/DAC Rept, NH Sys & Adv Design NH Sys Presn at Ft Bliss, 6 Feb 58, p. 27. Hist Div File.

[19] (1) *Ibid.*, p. 27. (2) TCC Rept 45-58, Feb 59, Final Rept - Contr ORD-5102, pp. 2-3, 7-9. RSIC. (3) AMC TIR 2-3-1(4), Aug 63, p. 5. RSIC.

cluster was designated as the M5E1 Jato Unit on 28 July 1955. The M5E1 was identical to the M5 unit except that additional holes were drilled and tapped in the motor body to facilitate mounting the cluster of four motors on the HERCULES missile.[20] The complete booster cluster was officially designated as the XM-42 rocket motor in April 1958.[21]



(U) Exploded View of the XM-42 Rocket Motor

[20](1) OTCM 35906, 28 Jul 55. RSIC. (2) The NIKE AJAX XM-5 jato had been adopted as standard and designated as the M5 Jato Unit on 7 April 1955, early in the HERCULES missile development test program. OTCM 35741, 7 Apr 55. RSIC.

[21]OTCM 36763, 10 Apr 58. RSIC.

The Abortive Frangible Booster Program

(U) The reliability of the M5 booster had been well proven by many NIKE AJAX firings, and its offspring, the XM-42 (M5E1) booster cluster, fulfilled the basic performance requirements of the HERCULES system. Still, the propulsion system failed to meet the HERCULES MC's, established in July 1953, which stated the desire that boosters, if used, be of the disposable type.[23] Underscoring the need for a self-destroying (frangible) booster for the HERCULES missile were problems then being encountered in the acquisition of real estate for construction of NIKE AJAX installations around vital defense areas in the United States. The programmed construction of some 35 AJAX installations in 1953-54 fell behind schedule because of public reluctance to see these pushbutton warfare devices installed in the back yards of the nation. In addition to worry about accidental explosion or misfire of the AJAX missiles, there was great concern about the danger to life and property from the falling steel booster casings.

(U) In large part, the protest by citizens groups in various

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[22] AMC TIR 2-3-1(4), Aug 63, p. 5. RSIC.

[23] OTCM 34909, 16 Jul 53. RSIC.

localities stemmed from a lack of public understanding of how the NIKE installations operated. Army officials pointed out that the NIKE missiles had a built-in safeguard against accidental explosion or misfire, and that the batteries would not engage in practice firings but would remain silent and unnoticed unless an actual enemy bomber should get through all other air defenses. In that event, they argued, most cities would rather chance falling missile debris than face the prospect of A-bomb destruction. But to minimize the danger of falling debris, the Army announced that work was going forward on the development of a self-destroying booster that would be harmless to life and property.[24]

(U) The fact that the 2,000-lb. expended HERCULES booster cluster would have a destructive force about four times that of the single AJAX booster dictated that the HERCULES missile also be equipped with a frangible booster. The failure to meet this requirement for either the AJAX or HERCULES was undoubtedly the most disappointing and, for obvious reasons, the least publicized aspect of the entire NIKE project. The Army developed the T48 series frangible booster for the AJAX and the XM-61 single-chamber frangible booster for the HERCULES at a total contract cost of more than $5 million, but neither was ever released for production. Brief summaries of the two overlapping programs follow.

(U) A general requirement for the safe disposition of boosters for all surface-to-air missiles was established in the MC's for those items and duly recorded by the Ordnance Technical Committee on 10 May 1951.[25] The Glenn L. Martin Company of

[24](1) *Time* Magazine, 6 Apr 53, p. 77. (2) *Aviation Week*, 16 Aug 54, p. 388. (3) *Engineering News-Record*, 9 Sep 54, p. 23. (4) *Also see* Mary T. Cagle, *Development, Production, and Deployment of the NIKE AJAX Guided Missile System, 1945-1959* (ARGMA/AOMC, 30 Jun 59), pp. 190-93.

[25]OTCM 33696, 10 May 51, subj: Revised MC's for Surface-to-Air GM's. RSIC.

Baltimore, Maryland, conducted a feasibility study of disposable boosters under an Ordnance Corps contract during the period March 1949 to October 1950. It began formal development of the T48 frangible booster for the NIKE AJAX in January 1951, under Contract ORD-93, with Redstone Arsenal maintaining technical supervision of the program. The Universal Moulded Products Corporation (UMPC) of Bristol, Virginia, fabricated the frangible components of the jato under Contract ORD-3902, and Radford Arsenal manufactured and loaded the standard OIO-type propellant grain.

(U) The motor case and components of the initial T48 series (T48E1 and T48E2) jatos were made of Fiberglas-reinforced plastic. After separation from the missile, high-explosive charges, initiated by delay detonators, reduced the expended booster case to non-lethal dust or very small fragments weighing no more than a few grams each. Tests conducted at WSPG indicated that the T48E2 jato was too heavy and caused too great a degradation in missile performance. Of prime concern were its lower velocity and altitude at burnout than the M5 jato: 1,810 feet per second (fps) and 3,280 feet with reference to the launcher, compared to 2,000 fps and 3,700 feet with reference to the launcher for the M5 jato.[26]

(U) Having determined that the Martin T48E2 jato would not give the required boost velocity, Redstone Arsenal, on 23 December 1954, awarded UMPC a $922,219 contract (ORD-4823) for development of the T48E3 frangible booster. This improved version of the self-destroying jato was constructed of Fiberglas-reinforced epoxy resin laminate. The propellant length was increased by 1 inch (to 103 inches) and the overall weight of inert parts was reduced about 130 pounds, giving a significant increase in flight performance.

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[26] (1) Ofc Memo, Chf, Rkt Dev Div, OML, to Dir, OML, 20 Oct 54, subj: Jato, Self-Destroying, T48E2, Proj TU2-2027. Hist Div File. (2) Army Ord Tech Ln Rept for Nov & Dec 55, BTL/Whippany, pp. 3-5. RHA Bx 13-595.

The T48E3 was capable of boosting the AJAX missile to a velocity of about 1,960 fps and an altitude of 3,600 feet in 3.4 seconds, while delivering a total impulse of about 148,000 pound-seconds. It was about 13 feet long and 18 inches in diameter, and consisted of four major elements: the frangible case, an 808-lb. charge of OIO-type propellant, stabilizing fins, and explosive components to effect self-destruction. Exclusive of its self-destroying features, the T48E3 booster was about 45 pounds lighter than the standard M5 steel unit. Its diameter, however, was larger than that of the M5 jato, and engineering redesign of the standard launcher rail would be required.[27]

(U) Encouraged by the results of developmental tests at Redstone Arsenal and firings at WSPG, OCO, in December 1955, approved the initiation of a 68-round engineering test program to determine the suitability of the T48E3 for release to using units.[28] At about the same time, authority was granted for procurement of 20 service test rounds at a cost of $130,000, and Redstone Arsenal requested WECo/BTL to modify the pertinent AJAX drawings to accommodate the new booster.[29] BTL, in February 1956, authorized DAC to proceed with the necessary engineering redesign effort, but later sided with DAC in a dispute with Redstone Arsenal over the desirability of standardizing the T48E3 booster for use with the AJAX.

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[27](1) *Ibid.*, pp. 5-8. (2) OTCM 35906, 28 Jul 55. RSIC. (3) Notes on Dev Type Mat, 15 May 56, subj: Self-Destroying Booster Rkt Unit, T48E3. RHA Bx 13-377. (4) Rkt Dev Labs Rept, Oct 56, subj: Jato, Self-Destroying, for NIKE I & NIKE B Msls. RHA Bx 13-377. (5) *See also* C. L. Meeter, "Frangible Plastic Case Proven on Nike Booster," *Missiles & Rockets*, Vol. 4, No. 19 (10 Nov 58), pp. 27-28.

[28]Army Ord Tech Ln Rept for Nov & Dec 55, BTL/Whippany, p. 7. RHA Bx 13-595.

[29](1) OTCM 36029, 15 Dec 55. RSIC. (2) Ltr, CG, RSA, thru NYOD, to WECo, 30 Dec 55. Cited in Ltr, BTL to CG, RSA, 26 Apr 56, n.s. Hist Div File.

(U) DAC's objections to the T48E3 jato centered around its marginal end-of-boost velocity and the time and money required for the redesign and field modification of standard launcher rails. Mr. E. P. Wheaton, Chief Missiles Engineer, claimed that the end-of-boost velocity of the T48E3 was about 45 fps less than that of the M5 jato, which was itself barely acceptable in performance. Moreover, 12,000 to 14,000 launcher rails in the field would have to be modified to accommodate the larger-diameter booster. He estimated that this work would cost "well into 7 figures" and require at least 18 months. For these and other reasons, he said, DAC could not recommend the release of the T48E3 into the NIKE system. Instead, he recommended that consideration be given to the immediate development of a new frangible booster with performance equal to the original design intent for the AJAX (i.e., 2,050 fps end-of-boost velocity) and with external dimensions the same as those of the M5 jato.[30] BTL concurred with DAC's recommendations, and advised Redstone Arsenal that the requested engineering redesign work would not be undertaken pending action on those recommendations.[31]

(U) Personnel of the Redstone Arsenal R&D Division argued that the modification cost should be evaluated against the tactical importance of a frangible booster and that the contractor's estimate of 18 months for engineering redesign verged on the ridiculous. They maintained that performance of the AJAX would be equivalent with either the M5 or T48E3 jato, and that the latter's Fiberglas-plastic construction would eliminate the corrosion problems encountered with metal flight components of the M5. Noting that the Army Antiaircraft Command had stated a firm military requirement for a self-destroying jato for the AJAX, Redstone Arsenal insisted that the T48E3 was suitable for

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[30] Ltr, DAC to BTL, 3 Mar 56, n.s. Hist Div File.

[31] Ltr, BTL to CG, RSA, 26 Apr 56, n.s. Hist Div File.

tactical use and recommended its immediate release to production. The Arsenal set up a meeting to discuss these and other differences with the missile contractors, but they refused to send representatives.[32]

(U) In the end, the DAC/BTL position prevailed. The Department of the Army, over the objections of ARAACOM, decided not to produce the T48E3 jato for use with the NIKE AJAX. UMPC, on 25 September 1956, won a 7-month, $61,029 contract (ORD-354) for the design of an improved T48E3 jato with a higher end-of-boost velocity and an outside diameter equal to that of the M5 jato.[33] In April 1957, however, DA turned its attention to design studies of a single-chamber, disposable booster for the NIKE HERCULES missile, which was to begin replacing the NIKE AJAX in 1958.

(U) Pursuant to the HERCULES MC's, which stated a desire that boosters, if used, be of the disposable type, Redstone's Rocket Development Laboratories, in December 1954, had begun a feasibility study of a single-chamber, self-destroying jato to replace the XM-5 booster cluster then being delivered for the initial missile development tests. This study, completed on 1 March 1955, indicated that the development of such a booster was feasible. In late December 1955, following a more detailed system study of jato requirements by the missile contractors, the Laboratories conducted

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[32](1) Ofc Memo, Chf, SAM Br, PMS, RDD, to Dir, OML, 8 May 56, subj: Rel of Jato, Self-Destroying, T48E3. (2) MFR, NIKE AJAX Proj Engr, SAM Br, PMS, 14 Jun 56, subj: Sys Mods to Accom the T48E3. Both in Hist Div File. (3) Ltr, CG, RSA, to CG, ARAACOM, 28 Jun 56, subj: Jato, Self-Destroying, T48E3 for NIKE I, Ord Proj TU2-2027. RHA Bx 13-378.

[33](1) Ltr, CG, RSA, to UMPC, 16 Jul 56, n.s. RHA Bx 13-377. (2) DF, CofOrd to CRD, DA, 1 Aug 56, subj: Rqrmt for Jato, Self-Destroying, T48E3. Hist Div File. (3) Ltr, Pres, UMPC, to MG H. N. Toftoy, CG, RSA, 29 Nov 57, n.s. RHA Bx 13-377. (4) Contr ORD-354, 25 Sep 56, & Mod #3, 15 Jan 57. RHA Bx 15-224. (5) DF, Chf, P&C, to Rkt Dev Labs, 27 Jun 57, subj: Contr ORD-354 UMPC, w Cmt #2, Chf, Rkt Dev Labs, to Chf, P&C, 2 Jul 57. File same.

a design and development study on the proposed booster. The study report, published on 13 March 1956, outlined a project plan and design specifications for a single-chamber, self-destroying jato that would meet all HERCULES performance requirements. The proposed booster, later designated as the XM-61,* would use cast double-base solid propellant with a Fiberglas-plastic case similar to that developed for the T48E3. Its end-of-boost velocity would be about 100 fps higher than that obtainable with the clustered XM-5 jato, and it could be incorporated into the system with no changes in the launcher rail. Moreover, the single frangible booster would permit great flexibility in launching site emplacement; the cost of large booster disposal areas would be saved; handling, shipping, storage, and assembly would be much simpler than for the clustered jato;** and considerable saving would be realized in production costs. It was estimated that development of the flight prototype could be completed in about 18 months at a cost of $2 million. Final R&D flight and engineering tests would require about 15 additional months and cost about $3 million.[34]

(U) In the latter part of 1956, while DA was pondering production release of the T48E3 jato, the Commander of ARAACOM came out in full support of the T48E3 jato for the AJAX and the proposed (XM-61) single-chamber, frangible booster for the HERCULES. A study of critical jato disposal areas in CONUS antiaircraft defenses disclosed that about 80 percent of the areas selected had some form of housing or development located therein. The planned

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*OTCM 37103, 25 Jun 59. RSIC.

**The Army Antiaircraft Command reported that the time required to assemble one clustered jato, using two experienced men, was about 6 hours. 2d Ind, CG, ARAACOM, to CRD, DA, 15 Oct 56, on Ltr, same to same, 17 Jul 56, subj: NIKE B Frangible Boosters. RHA Bx 13-378.

[34] RSA/OML Rept 3J15P, 13 Mar 56, subj: Design & Dev Study on Single Self-Destroying Jato for NIKE B Msl, pp. 2-7. RHA Bx 13-377.

integration of the HERCULES into all active CONUS AJAX sites would create additional disposal problems for those sites already constructed because of the larger booster dispersion distance for the HERCULES. In view of the urgent need for solution of the booster disposal problem in densely populated areas, and the advantages offered by incorporation of the T48E3 and XM-61 frangible jatos into the NIKE systems, ARAACOM recommended (1) that an immediate military requirement be established for these boosters; (2) that production of the M5 (XM-42) cluster jato be terminated except for those necessary for continued test of the HERCULES missile; (3) that production of HERCULES boosters for on-site units be of the frangible, single-chamber type; and (4) that remaining production requirements for the AJAX booster be of the T48E3 type.[35]

(U) Coincident with the above action by ARAACOM, the President of Board No. 4, Fort Bliss, recommended to the Continental Army Command (CONARC) that development of the proposed disposable booster be authorized immediately, and that the HERCULES MC's be changed to read: "It is required that boosters, if used, be of the disposable type."[36] However, since the disposable booster would be needed only at sites in densely populated areas, the revised MC's, issued in July 1957, simply added the statement that a "self-destroying type jato is desired for use where safety considerations make use of normal jatos undesirable."[37]

(U) As noted earlier, DA decided not to produce the T48E3 jato for the NIKE AJAX, and funds for full-scale development of the proposed booster for the HERCULES were not immediately available. Using funds left over from two completed Thiokol

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[35] Ltr, CG, ARAACOM, to CRD, DA, 17 Jul 56, subj: NIKE B Frangible Boosters; & 2d Ind, same to same, 15 Oct 56. RHA Bx 13-378.

[36] Ltr, Pres, Bd No. 4, Ft Bliss, TX, to CG, CONARC, n.d., subj: Disposable Booster for the NIKE B Msl. RHA Bx 13-378.

[37] OTCM 36581, 11 Jul 57. RSIC.

contracts (ORD-4460 and ORD-5028), Redstone Arsenal, in 1957, awarded contracts totaling $46,459 to UMPC and Thiokol for preliminary design studies of a single-chamber jato using a composite-type propellant and having an end-of-boost velocity of 2,050 fps with a growth potential to 2,450 fps.[38]

(U) In August 1957, Redstone Arsenal advised OCO that a unit production cost saving of about $9,000 could be realized on the single self-destroying booster over the XM-42 clustered booster. In view of this long-range saving in PEMA* funds, the Chief of R&D, DA, on 6 December 1957, authorized the immediate initiation of development of the (XM-61) single-barrel, frangible booster.[39] Approval of the proposed contract with the Thiokol Chemical Corporation was not forthcoming from OCO until 16 March 1958, and it took nearly 3 more months to obtain approval of the proposed motor case subcontractors (Zenith Plastics Company and UMPC). The $2,433,728 R&D contract (ORD-5496), signed on 4 June 1958, covered the first 6 months of the 18-month development program, the total cost of which was estimated at $6,634,272.[40]

(U) Two months later, the Army Air Defense Command (formerly the Army Antiaircraft Command) reversed its position on the tactical

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*Procurement of Equipment and Missiles, Army.

[38](1) DF, Cmt #1, Chf, Rkt Dev Labs, to Chf, RDD, 14 Jan 57, subj: Single Self-Destroying Jato for the NH Msl, Proj TU1-3070; & Cmt #2, Chf, SAM Br, PMS, RDD, to Chf, Rkt Dev Labs, 31 Jan 57, same subj. RHA Bx 13-377. (2) CG Rept for Proj TU1-3070J - Single Self-Destroying Jato for NH, Feb 57. Same File. (3) UMPC conducted its study under Contract ORD-479 for $19,412. Thiokol did its study under a modification to Contract ORD-5028. *See* Table 3 and TCC Rept No. RER-231, 2 Jan 58, subj: Prelim Design of 3.28-KS-182,100 Solid Propellant Rkt Engine. RSIC.

[39](1) TT, CG, RSA, to CofOrd, 27 Aug 57. (2) DF, CRD, DA, to CofOrd, 6 Dec 57, subj: Booster for NH. Both cited in SS ORDXR-C-94, 21 Nov 58, subj: Dev of NH Self-Destroying Booster. Hist Div File.

[40](1) ARGMA Hist Sum, 1 Apr - 30 Jun 58, p. 68. (2) Sta Rept, NH Single-Barrel Booster, 15 Nov 58. Hist Div File.

and technical advantages of the single-chamber, self-destroying booster for the HERCULES. In a letter to CONARC, on 12 August 1958, ARADCOM recommended that the improved single-chamber, non-frangible (steel) booster using composite propellant be developed, instead of the (XM-61) frangible jato, as a replacement for the existing XM-42 clustered booster.[41]

(U) A subsequent staff study by ARGMA revealed that the FY 1958 procurement cost of the XM-42 clustered booster was $12,652 per unit, rather than the $21,050 unit cost previously estimated by the contractor, and that a slight reduction in cost of the XM-42 could be expected on the FY 1959 program. In contrast, the production cost of the single-chamber booster was estimated at $12,000 per unit with the frangible case and slightly less with the non-frangible (steel) case. The findings of the staff study also indicated that development of the single-chamber steel jato using a composite propellant, favored by ARADCOM, would further complicate the problem of insufficient production facilities for composite propellant motors.[42]

(U) In view of the findings of the above study and the fact that the authorization for development of the single-chamber, self-destroying booster had been based primarily on the estimated cost savings over the existing XM-42 booster, the ARGMA Commander, on 25 November 1958, recommended that the development program for the single-chamber, self-destroying booster for HERCULES be terminated.[43] In the absence of a reply on 29 January 1959, and in view of a

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[41](1) Ltr, CG, ARADCOM, to CG, CONARC, 12 Aug 58, subj: Self-Destroying Frangible Boosters for SAM's. Cited and summarized in SS ORDXR-C-94, 21 Nov 58, subj: Dev of NH Self-Destroying Booster. Hist Div File.

[42](1) Sta Rept, NH Single-Barrel Booster, 15 Nov 58. (2) SS ORDXR-C-94, 21 Nov 58, subj: Dev of NH Self-Destroying Booster.

[43]Ltr, ARGMA Comdr to CofOrd, 25 Nov 58, subj: Single-Chamber Self-Destroying Booster for NH. Hist Div File.

reduction in PEMA/S* program authority, ARGMA and AOMC again requested permission to terminate the program.[44] A search of the available records failed to reveal the exact date that the program was terminated or the funds expended above the initial contract amount ($2,433,728). It is a fact, however, that the frangible booster program was quietly terminated, and the HERCULES missile assembly was standardized with the M42 cluster booster.

(U) Excluding the in-house feasibility and design and development studies, technical supervision, and development tests by Redstone Arsenal, the cost of which must have run well into six figures,[45] the Army invested $5,049,297 in development contracts for self-destroying boosters for the AJAX and HERCULES missiles during the 1951-58 period. (*See* Table 3.)

(U) The termination of the frangible booster program left unsolved the booster disposal problem for HERCULES batteries used for defense of populated areas. The only solution to this problem was to provide a safe booster disposal area for all the launchers of a given battery; viz., an area the size of a circle a mile in diameter with its center about 0.75-mile from the nearest launching station.[46]

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*Procurement of Equipment & Missiles, Army, in Support of R&D.

[44](1) DF, Chf, Programs Br, ARGMA Con Ofc, to AOMC Con Ofc, 29 Jan 59, subj: Xmitl of Program Auth for CY 59 Wind Tunnel Testing at JPL. (2) NH Prog Rept, Jan 59, p. 1. Both in Hist Div File.

[45]It is known, for example, that the cost of updating the original study (RSA/OML Rept 3J15P, 13 Mar 56) amounted to $25,000 alone. (DF, Cmt #1, Chf, Rkt Dev Labs, to PMS, RDD, OML, 15 Oct 57, subj: Revised Design Study for Single Booster for NH. RHA Bx 13-377.) Note also that Redstone Arsenal had exercised technical supervision of the program since the initiation of T48 booster development in January 1951, and conducted numerous development tests of boosters for both the AJAX and HERCULES.

[46]AMC TIR 2-3-1(4), Aug 63, p. 5. RSIC.

TABLE 3—(U) Contracts for Development of Frangible Boosters for NIKE Systems

Name of Contractor	Contract Number	Date	Item	Contract Value
Glenn L. Martin Co.	DA-36-034-ORD-93	24 Jan 51	Self-Destroying NIKE Jatos, T48, T48E1, T48E2	$ 1,290,171
Univ Moulded Prod Corp.	DA-01-021-ORD-3902	4 Aug 52	Fiberglas-Plastic Jato Cases	252,991
Univ Moulded Prod Corp.	DA-01-021-ORD-4823	23 Dec 54	T48E3 Fiberglas Jato	922,219
Univ Moulded Prod Corp.	DA-01-021-ORD-4824	23 Dec 54	Facilities for Fiberglas Jato	42,700
Univ Moulded Prod Corp.	DA-01-021-ORD-354	25 Sep 56	Improved T48E3 Fiberglas Jato	61,029
Univ Moulded Prod Corp.	DA-01-021-ORD-479	Apr 57	Design Study of Single-Chamber Fiberglas-Plastic Jato Case for NIKE HERCULES	19,412
Thiokol Chemical Corp. Redstone Division	DA-01-021-ORD-5028 Modification #1*	25 Nov 57	Prelim Design & Dev Study of Self-Destroying Booster for NIKE HERCULES	27,047*
Thiokol Chemical Corp. Redstone Division	DA-01-021-ORD-5496	4 Jun 58	Development of Single-Barrel Frangible Booster for HERCULES	2,433,728
				$ 5,049,297

*Basic contract for $85,496 called for delivery of six simulated XM-30 sustainer motors. Unexpended funds ($27,047) authorized under Modification #1 for study indicated. *See* Footnote #13, p. 62.

SOURCE: (1) Mary T. Cagle, *Development, Production, and Deployment of the NIKE AJAX Guided Missile System, 1945-1959* (ARGMA/AOMC, 30 Jun 59), p. 279. (2) Record of FONECON, J. B. Galloway, RSA, & L. J. Casey, ORDTU-OCO, 20 Apr 57, re: Congressional Inves of Work Done on Fiberglas Jatos for AJAX & HERCULES. RHA Bx 15-224. (3) Contr ORD-5028, 28 Jun 56, w/Suppl Agrmt dtd 25 Nov 57. RHA Bx 15-224. (4) Sta Rept, NH Single-Barrel Booster, 15 Nov 58. Hist Div File.

Guidance Section

(U) The major components of the missile-borne guidance equipment included electronic devices that received and decoded radar signals from the missile tracking radar, transmitted steering and detonating commands to the proper components of the missile's guidance system, controlled the electrical energy that operated the missile's hydraulic valves, and retransmitted signals from the missile's beacon to the missile tracking radar. As in the case of the propulsion system, the HERCULES guidance set design was originally based on using as many AJAX circuits and components as possible. In addition, to provide a long-range AJAX, there existed the possibility of modifying AJAX missiles to incorporate the HERCULES guidance section communications system.

(U) The GS-18784 (Stovepipe) guidance set thus developed and produced for the initial tactical model of the HERCULES missile was almost identical to that of the AJAX missile, although it necessarily contained more circuits. The guidance unit was mounted in the nose of the solid propellant missile rather than the aft section, as it was in the early liquid propellant version. The antennas for communication with ground tracking radars were located in the linearizer fins adjacent to the guidance section.

(U) Although the GS-18784 guidance set was expected to provide essentially the same performance and reliability as the AJAX set, a program review in 1957 indicated that it would become the limiting factor in missile producibility and reliability. This review also indicated that it would not be a good risk to commit the HERCULES program to the transistor guidance section, which had been developed in parallel with the vacuum tube type. The reasons were twofold. There was no assurance that an adequate supply of reliable and suitable transistors would be available; and there were yet some unknowns with respect to performance of transistor equipment in nuclear radiation fields. It was decided, therefore, to continue the use of vacuum tubes. It was also concluded that a mechanical redesign of the guidance section would be required in order to achieve a higher missile reliability than obtained in the AJAX. The missile nose location in the solid propellant missile afforded more available volume for improvements in design and layout of electronic guidance components.

(U) The new GS-19672 (Mushroom) guidance unit was about 30 percent larger in volume than the Stovepipe design, its diameter being increased to use the available cross-sectional area and its length being somewhat shortened. In addition to improving the overall missile reliability, the modular construction of the new guidance section provided better immunity to shock and vibration and facilitated mass production and field maintenance. Flight tests of prototype models of the Mushroom guidance set started in August 1958 and development was completed a year later. In July 1959, the Stovepipe guidance section was phased out of production and all new missiles produced were equipped with the new Mushroom guidance set.[47]

Warhead Development

(U) In addition to the primary (nuclear) warhead, the HERCULES MC's called for development of an alternate high-explosive, fragmentation, rod, or other type conventional warhead. The nuclear payloads developed included large- and small-yield heads for use against formations of aircraft and single aircraft, respectively. The T45 fragmentation and T46 series cluster warheads were developed for use against low-altitude targets, but the latter was

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[47] (1) Army Ord Tech Ln Rept for Dec 54, BTL/Whippany, pp. 20-21. RHA Bx 13-595. (2) BTL/DAC Rept, NH Sys & Adv Design NH Sys Presn at Ft Bliss, 6 Feb 58, pp. 27-31. Hist Div File. (3) INH DCR at BTL, 2-4 Jun 59, pp. 6-9 - 6-10. Hist Div File. (4) INH Dev Test Plan, ARGMA TP-5, Oct 59, p. 7. RHA Bx 13-657.

never released for troop use. Because of the security classification involved, this study is limited to a brief summary of the conventional warheads.

(U) In the early phase of the R&D program, primary emphasis was placed on development of the T45 blast-fragmentation warhead as the interim armament for both the AJAX and HERCULES, pending availability of the T46 cluster warhead. The T45 head was generally considered to be more economical and easier to fabricate and to have a shorter development period than the more complex T46 warhead. The latter warhead, however, offered the HERCULES missile system two major advantages. It would provide a greater kill probability than the T45 against targets at all ranges and altitudes, particularly in the low-altitude region; and, in comparison with the primary warhead, it would not contaminate or damage the territory below its bursting point, permitting firings over friendly territory.[48]

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[48] (1) OTCM 35495, 9 Sep 54. RSIC. (2) PA Tech Memo DW-322, Feb 61, subj: Mins of T46E1 Whd Review Mtg for FETP, ET/UT & RI, p. 7. RHA Bx 13-595. (3) Army Ord Tech Ln Rept for Oct 55, BTL/Whippany, pp. 7-8. Same File.

[49] (1) NIKE Blue Book, p. 247. (2) SRI TR 24, Aug 61, p. 51. RHA Bx 13-592.

[redacted]

(U) The fact that the cluster warhead would present many difficult development problems had been recognized by BTL as early as October 1953.[51] Aircraft Armaments, Inc., began design studies of the proposed T46 cluster warhead in early May 1954 under Contract ORD-1620. By July, problems incident to application of the warhead to the HERCULES missile were identified and it was concluded that a new and different type cluster design would be required.[52] In the formal development program that began in September 1954, two approaches to the problem were investigated.

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[50] (1) TIR 2-3-1A1(2), OCO, Feb 59, subj: Dev of GM Whd, M17 (T45). (2) OTCM 36833, 10 Jul 58, & OTCM 36913, 20 Nov 58. (3) TIR CD-1, OCO, Jun 60, p. 32. All in RSIC.

[51] *See* above, pp. 42, 44.

[52] (1) Army Ord Tech Ln Rept for Jul 54, BTL/Whippany, pp. 4, 7-8. RHA Bx 13-595. (2) The technical problems encountered in the subsequent T46 program were very similar to those experienced in the attempted development of the AJAX cluster warhead system. The latter effort was undertaken in the product improvement phase of the AJAX program to provide a more lethal warhead while awaiting delivery of the HERCULES system. The AJAX cluster warhead was originally scheduled for troop delivery by mid-1958; however, inadequate funds and problems associated with the ejection and fuzing systems delayed the program about 18 months. The first and only sled test of the cluster warhead system, conducted on 12 April 1957, was unsuccessful. In the absence of adequate funds to continue the program on a timely basis, the Chief of R&D, DA, on 6 June 1957, directed that development of the cluster warhead for the AJAX be terminated. OTCM 36677, 9 Jan 58. RSIC.

[redacted]

(U) Although a significant improvement over the basic T46 design, the T46E1 warhead system still lacked the desired effectiveness and was expensive to produce. The Chief of R&D, DA, therefore requested that necessary action be taken to complete the development and test effort and to effect an orderly

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[53] (1) Army Ord Tech Ln Rept for Oct 55, BTL/Whippany, p. 9. RHA Bx 13-595. (2) TIR 2-3-1A2(5), OCO, Dec 61, p. 1. RSIC.

[54] (1) *Ibid.*, pp. 1-5. (2) PA Tech Memo DW-322, Feb 61, subj: Minutes of T46E1 Warhead Review Meeting for FETP, ET/UT, & RI, pp. 8, 20, 23. RHA Bx 13-595.

termination of the program. The Secretary of the Army approved the formal termination of the T46 project on 21 September 1961.[55]

(U) The R&D contract cost of conventional warheads for the HERCULES missile totaled $3,679,985. Of this amount, $260,430 went for development of the M17 (T45) fragmentation warhead and the remaining $3,419,555 for development of the T46 cluster warhead.[56]

Ground Guidance Equipment

(U) The ground guidance equipment for the Basic HERCULES consisted of four primary subsystems: the acquisition radar, the target tracking radar, the missile tracking radar, and the computer. This equipment was housed in two van-type trailers, two dropbed trailers carrying the precision track antenna mounts and the acquisition antenna assembly. Since the missile design would permit intercepts beyond 50 nautical miles, the detection range of the acquisition radar on the 650-knot target was extended beyond 80 miles, and the target tracking capability was extended beyond 75 miles. In the redesign of AJAX ground guidance equipment to increase the range performance, BTL effected improvements in overall reliability, operability, and maintainability.

(U) The function of the acquisition radar was to detect aerial targets and provide a display of those targets on a plan position indicator. An electronic reference system facilitated the acquisition of any desired target by the target tracking radar. The maximum presentation range was 250,000 yards, or about 125 nautical miles. The acquisition antenna was mounted on a tripod-supported drive unit capable of rotating (the antenna) at speeds of 5, 10, or 15 revolutions per minute (rpm). A new traveling-

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[55] OTCM 37853, 21 Sep 61. RSIC.

[56] *See* Table 6.

[redacted]

wave tube radio frequency (RF) amplifier improved the receiver noise figure and substantially increased the range performance over that realized with the earlier AJAX acquisition radar. The radar was continuously tunable in the S-band from 3100 to 3500 megacycles (mc) and operated at a peak power level of 1,000 kilowatts (kw). Its pulse width was 1.3 microseconds with a repetition frequency of 500 pulses per second (pps). In the battery control trailer, the acquisition range unit was redesigned to incorporate an aided manual tracking feature, thus easing the acquisition of high velocity targets. The Moving Target Indicator (MTI) was basically the same as in the AJAX, but it was redesigned for improved operation and increased stability.

(U) The changes made in the target and missile tracking radars were more visually obvious than those incorporated in the acquisition radar. A larger, reflector-type antenna of novel design replaced the lens antenna of the AJAX, and resulted in a significant increase in the radar range. Because of the increased loads of the larger antenna, the elevation drive in the HERCULES tracking antennas was redesigned to include four drive motors, two more than in the AJAX. The azimuth drive was changed from a friction drive to a gear drive, but still with the four drive motors of AJAX. To solve the wind loading problems created by the larger antenna and to protect radar components and servicing personnel from adverse weather conditions, both of the tracking radars were equipped with radomes made of silicone rubber-impregnated orlon. Another noteworthy change was the incorporation of a hard tube modulator to replace the AJAX hydrogen thyratron.

[redacted]

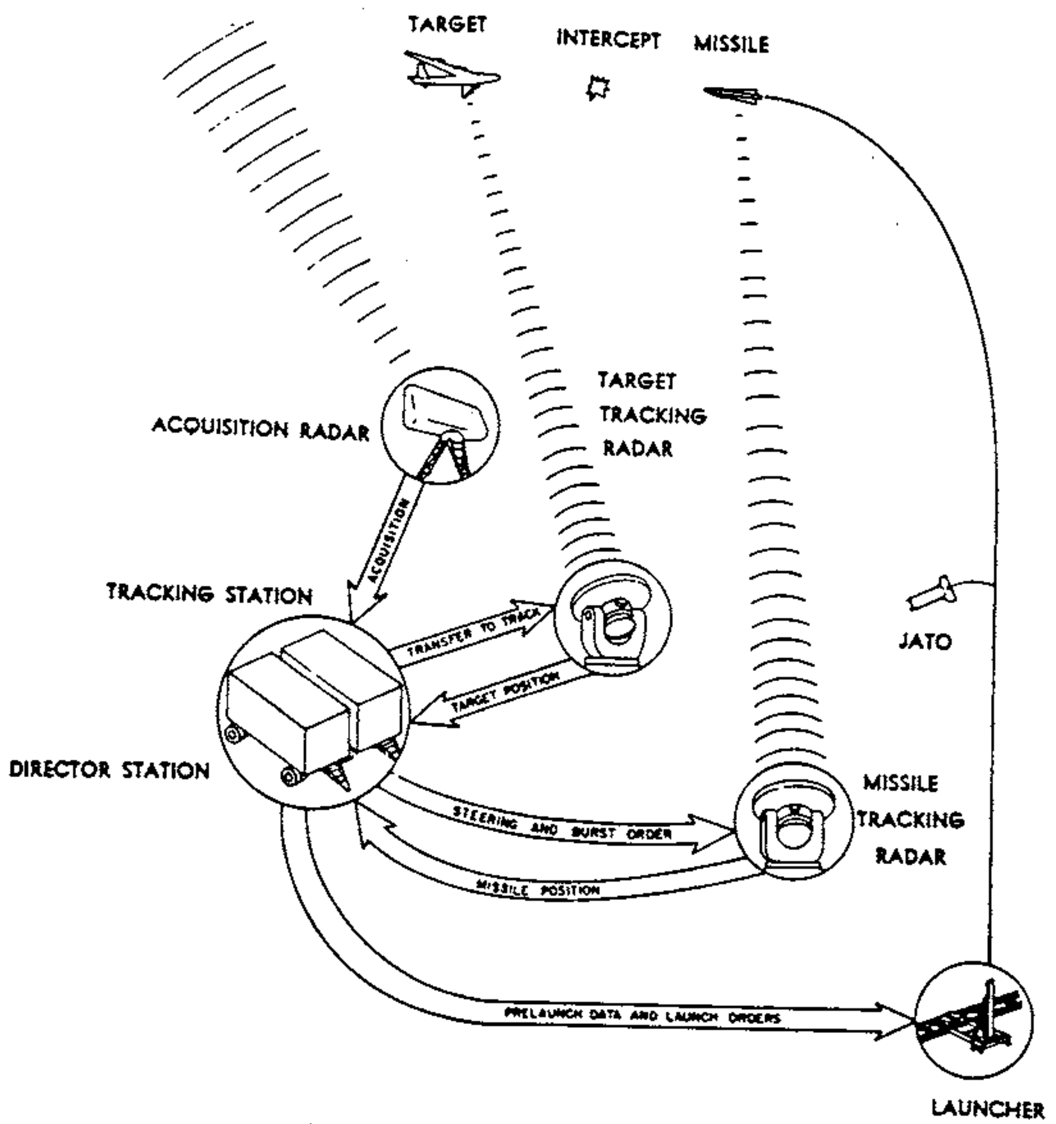
(U) The HERCULES Missile & Target Tracking Radars and Acquisition Radar Emplaced at WSMR.

[redacted]

(U) The Missile Tracking Radar (MTR) was similar in many respects to the TTR. However, in addition to tracking the missile for obtaining position data, it also communicated guidance information and burst signals to the missile by means of coding of the multiple pulse outputs of the transmitter. Pulse coding systems, together with carrier frequency diversity, were used to preclude interbattery interference. These features also provided an added margin against jamming of the missile by enemy aircraft employing electronic countermeasures.

(U) The HERCULES computer was a DC analog device, which, in principle, operated like the AJAX computer but performed many more functions. The added functions were the result of (1) the increased range and flight time of the HERCULES missile; (2) the requirement to fly both AJAX and HERCULES missiles in the same battery; (3) the use of several atomic and conventional warheads with their special safety problems; and (4) the addition of surface-to-surface and low-altitude modes of operation. The HERCULES computer comprised over 100 operational amplifiers, 7 computing servos, 7 plotting-board servos, and almost 200 relays. In the pre-launch phase of an engagement, the computer received continuous target position information from the TTR and continuously predicted the location of possible intercept points. During the flight phase, the computer used position data from both

[redacted]



(U) The NIKE HERCULES Command Guidance System.

the TTR and MTR to compute steering orders and the burst order for the missile and to compute data for the plotting board and other data displays. It was housed in the same number of cabinets of the same size as those used in the AJAX.

(U) An important consideration in insuring the continued tactical readiness of operational ground equipment was the provision for easy maintenance. In the development of this system, the contractor devised a maintenance scheme for routine daily, weekly, and monthly checks and adjustments with built-in test equipment. Normally, maintenance by the user was limited to the replacement of vacuum tubes, removable plug-in panels, and other items carried in the local ORD-7 spare complement. The established procedure for the repair and retest of defective units was a function of Ordnance maintenance personnel using especially designed Type IV test equipment.[57]

Launching & Handling Equipment

(U) Except for the elimination of servicing equipment for the liquid propellant sustainer motor, which was replaced with the solid propellant motor in 1957, the HERCULES launching and handling equipment consisted of those items originally proposed by DAC and approved for development in December 1954.[58] The design philosophy of the equipment was essentially the same for the Basic HERCULES and the AJAX systems. Mobile or transportable equipment of existing AJAX sites could be readily adapted. When practicable, existing equipment and operating procedures could be used. Conversely, HERCULES equipment could be used for AJAX

[57](1) BTL/DAC Rept, NH Sys & Adv Design NH Sys Presn at Ft Bliss, 6 Feb 58, pp. 6-7, 34-40. (2) DCR, INH, 2-4 Jun 59, pp. 6-5 thru 6-7. Both in Hist Div File. (3) Army Ord Tech Ln Rept for Nov & Dec 55, BTL/Whippany, pp. 19-20. RHA Bx 13-595.

[58]*See* above, pp. 50-51.

installations with the added advantage that the capability of the new equipment was retained when firing AJAX missiles.

(U) The decision to employ underground launcher installations at all NIKE sites within CONUS had been made early in 1954. The installation was based upon a design by the Corps of Engineers in conjunction with proposals from the Army Antiaircraft Command. Each site originally included three underground installations per battery, each subsurface magazine consisting of one launcher on an elevator and two above-ground satellite launchers. The original Type C magazines were designed specifically for NIKE AJAX and, because of the size of the structure and elevator, would accept only AJAX missiles and launchers. The Type B magazines were somewhat larger and would accept HERCULES launchers and either AJAX or HERCULES missiles; however, some modifications of the elevator were required to fire HERCULES missiles. The improved Type D magazines, later produced by the Corps of Engineers, incorporated modifications to allow installation of either AJAX or HERCULES equipment and provided increased access to missiles and section equipment.[59]

(U) The Douglas Aircraft Company designed the XM-36 launcher assembly for surface use by the field army and for use in Types B and D subsurface installations at fixed CONUS sites. As shown in the accompanying illustration, each subsurface installation for the HERCULES consisted of one elevator-mounted launcher and three above-ground satellite launchers, with subsurface storage for seven HERCULES missiles.[60] To permit R&D test firings of HERCULES missiles, the AJAX Type B magazine installation was modified in accordance with the specifications adopted as standard for tactical

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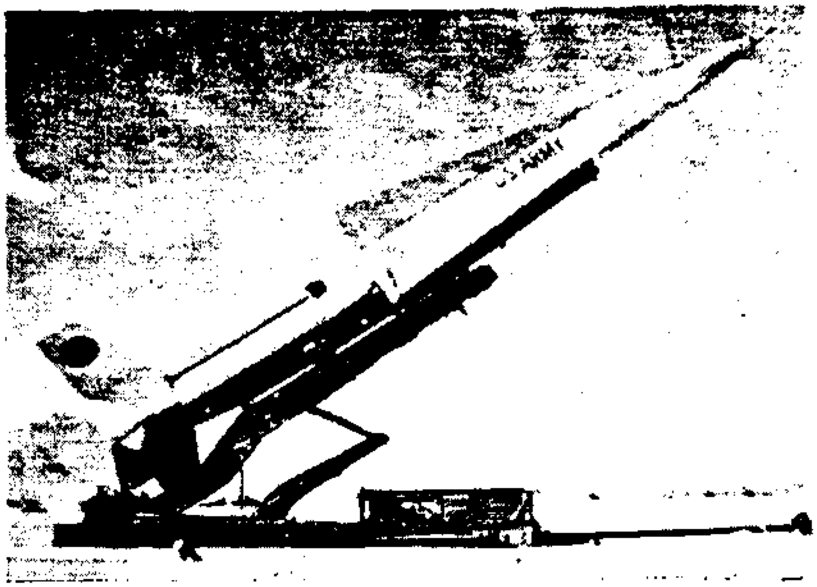
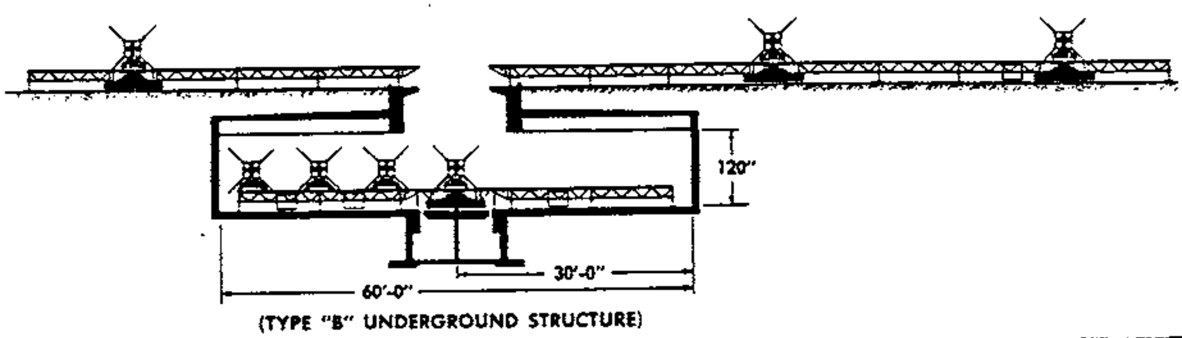
[59] (1) Army Ord Tech Ln Rept for Jan 54, BTL/Whippany, p. 11. RHA Bx 13-595. (2) BTL/DAC Rept, NH Sys & Adv Design NH Sys Presn at Ft Bliss, 6 Feb 58, p. 57. Hist Div File.

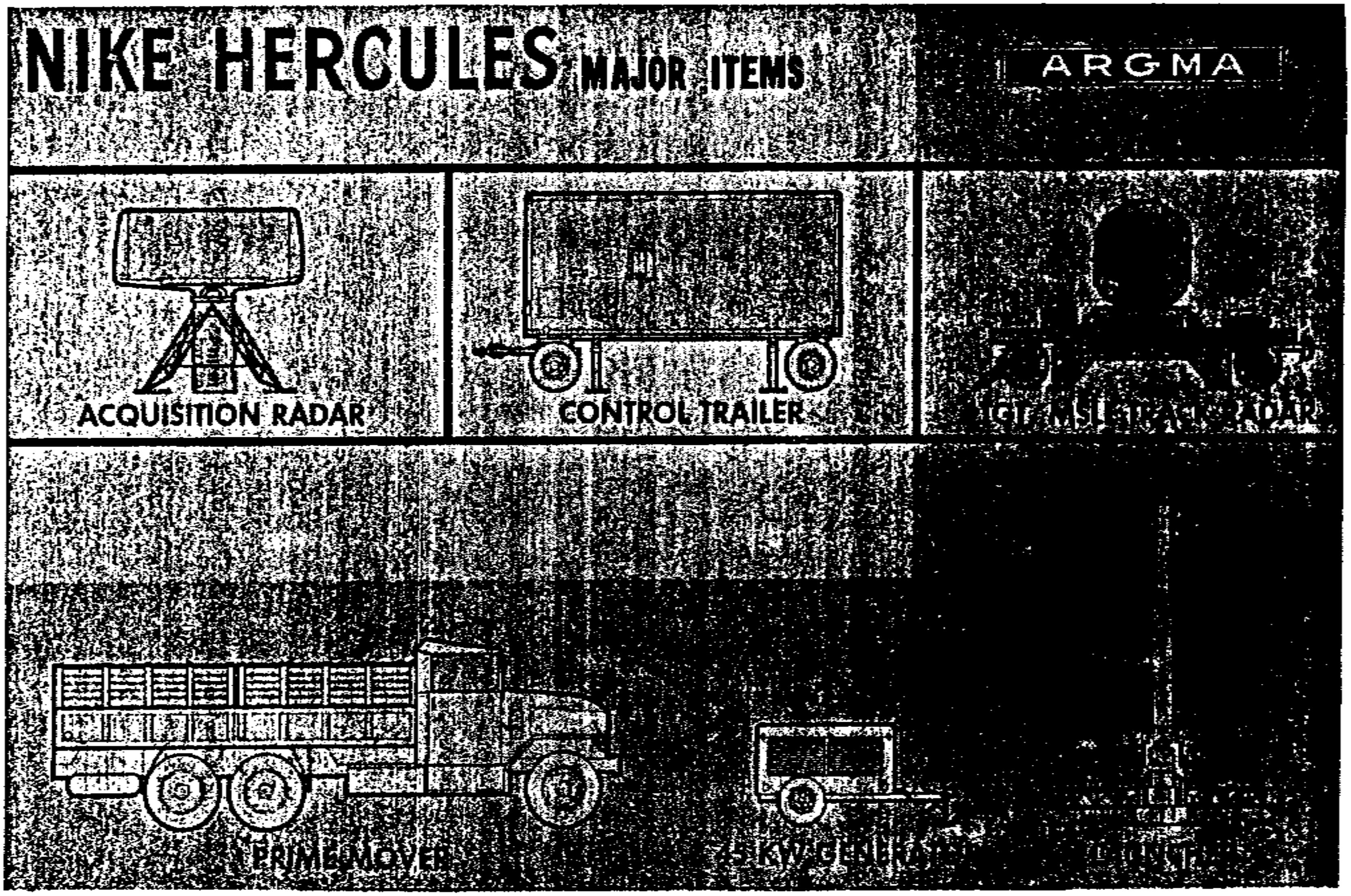
[60] *Ibid.*, pp. 7-8, 57-58.



HERCULES Missile on XM-36 R&D Launcher



Cross Section of NIKE HERCULES Underground Launcher Installation


NIKE HERCULES MAJOR ITEMS
ARGMA
ACQUISITION RADAR
CONTROL TRAILER
PRIME MOVER

site modifications. Detailed load tests of the modified elevator were completed in 1956, and HERCULES missile firings from an early R&D model of the elevator-mounted launcher began in January 1957.[61]

(U) Concurrently with development of the XM-36 launcher, DAC, in 1956, began design work on the cellular launching system for the HERCULES. Similar to the underground storage and servicing magazines adopted for the fixed-site AJAX and HERCULES batteries in CONUS, the cellular facility was designed to reduce operating personnel and land area requirements and to improve system reliability and state of readiness. The cellular launching battery contained 24 reinforced concrete cells in two groups of 12 each, with roll-away overhead doors. Each cell had its own launcher and missile, the latter being loaded by an overhead crane assembly running on a track the full length of the block. The design permitted remote control of all cell doors, launchers, and missiles by a single operator in a central control room. DAC, in conjunction with WSMR and the Corps of Engineers, constructed and tested an interim cellular system at ALA-3 in late 1957. Using the data collected in tests of this interim system, DAC then built the optimum cellular launcher at ALA-1 during the period March 1958 to April 1959. The first HERCULES missile was test fired from the facility on 24 June 1959. Although the cell launching produced no noticeable effects on missile flight, the destructive force of the booster motor blast caused extensive damage to the firing and adjacent

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[61] (1) Army Ord Tech Ln Rept for May 55, BTL/Whippany, pp. 8-9. RHA Bx 13-595. (2) Ltr, Dir, BTL Burlington & Greensboro Labs, to CG, AOMC, 22 Feb 61, n.s., w incl, Memo For File, 11 Jan 61, subj: NH - Destruction of Underground Lchr L-95. RHA Bx 14-241. (3) Firings from the elevator-mounted launcher at WSMR continued until 29 November 1960, when the assembly was damaged beyond economical repair in the firing of HERCULES Round B310. The accident, which occurred with the firing of the 92d round from the launcher assembly, resulted from a freak sequence of events having little probability of recurrence. *Ibid.*

cells. Another HERCULES firing from the cellular launcher, on 19 December 1959, also proved unsuccessful, and the development program was terminated.[62]

(U) The ground launching and handling equipment deployed with the Basic HERCULES system in June 1958 and classified as standard in November of that year met all military characteristics except those relating to mobility for field army use. Although designed with mobility as an original requirement, initial deployment of the Basic HERCULES was restricted to fixed CONUS sites, and certain mobility features were de-emphasized but not wholly discarded.* For example, the trailer undercarriages were removed, but the vans were retained although they were attached to brick and mortar buildings. On the other hand, the design activity relating to launcher mobility was sharply curtailed.

(U) In its report of qualification tests of the semimobile system, conducted in 1958-59, the Air Defense Board noted that extensive site preparation, to include provision of concrete launcher pads and section revetments, was required. A further difficulty experienced with the launcher was its requirement for special handling equipment (M62 wrecker) for emplacement. The Board found the M261 missile transport trailer to be unsatisfactory, chiefly because it could not carry a complete round, and transporting of missiles and boosters separately involved time-consuming joining and dejoining operations.

(U) Among the mobility improvements developed by DAC were a suitable launcher capable of self-emplacement on and firing from

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**See* above, p. 49.

[62] (1) BTL/DAC Rept, NH Sys & Adv Design NH Sys Presn at Ft Bliss, 6 Feb 58, pp. 7, 62. (2) WSPG Hist Rept, Jan-Dec 57, pp. 46-48. (3) Eunice H. Brown, *Development and Testing of Rockets and Missiles at White Sands Missile Range, 1956-1960* (TECOM, Mar 66), pp. 259-63. Hist Div Files. (4) *See also* DAC Rept SM-35959, Nov 59, subj: NH Cellular Sys - Model 1947 Final Rept. RSIC.

dirt, a ready round missile transporter to replace the M261 transporter, trailer mounting of all generators and section equipment, and several accessory items such as cable reel racks and dollies. By early 1960, development and demonstration of the ready round transporter, M94 launcher mobility kit, and other items of the mobility package had been completed, and ARGMA made arrangements for procurement of the new trailers through the Ordnance Tank-Automotive Command. The Army Air Defense Board accepted the HERCULES mobility equipment during a meeting held at Fort Bliss on 17-18 May 1960. Field qualification tests of the Basic HERCULES system, modified to include the mobility package, began in June 1960 and continued through September. The Air Defense Board conducted the tests in cooperation with DAC and Ordnance personnel. In conjunction with this mobility evaluation, air transportability tests were made on certain equipment of the field army system in November 1960 at Biggs Air Force Base.[63] The common and peculiar items required for the semimobile role of the Basic HERCULES system were classified Standard A in May 1962.[64]

R&D Flight Test Summary

(U) During the 1955-59 period, the R&D contractor expended 277 missiles in the development, test, and evaluation of the Basic HERCULES weapon system. Except for additional flight tests associated with T46 warhead development, electronic counter-countermeasure (ECCM) development, and ground equipment mobility improvements, the R&D test phase of the program ended on 1 January 1960. With the final R&D design release on 9 January 1960, the

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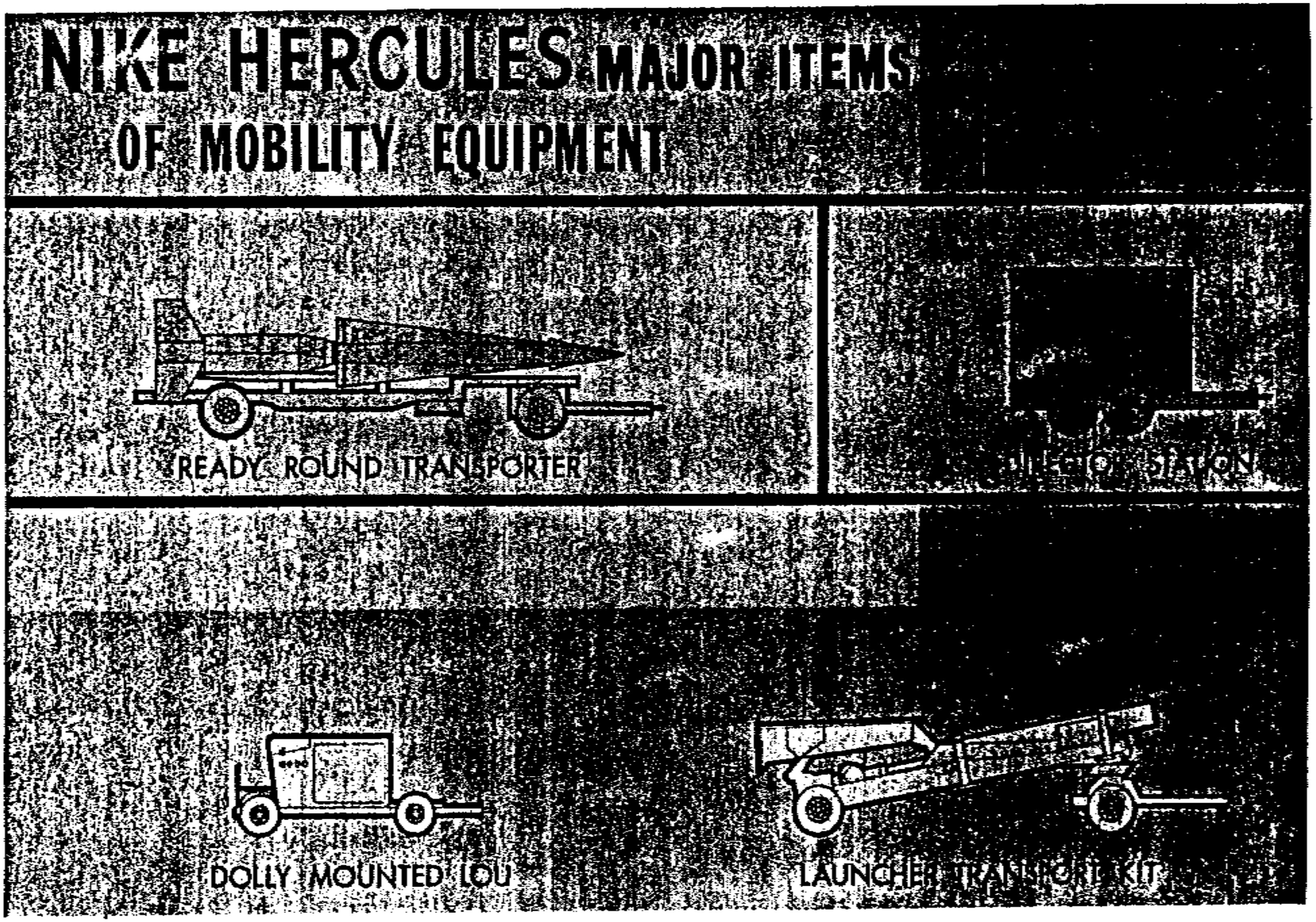
[63](1) BTL/DAC Rept, 1 Mar 61, subj: NH Fld Army Engrg Tests, pp. 1, 3-4. RHA Bx 13-342. (2) Ltr, CG, CONARC, to CRD, DA, 10 Mar 60, subj: Final Rept of Test, Proj Nr GM-556, & incl thereto, ADB Rept of Test--Proj Nr GM-556 - Svc Test of AAGM Sys-NH, dtd 3 Feb 60. RSIC. (3) ARGMA Hist Sum, 1 Jan - 30 Jun 60, pp. 70-72.

[64]OTCM 38048, 10 May 62. RSIC.


NIKE HERCULES MAJOR ITEMS
OF MOBILITY EQUIPMENT
READY ROUND TRANSPORTER
DOLLY MOUNTED LOU
LAUNCHER TRANSPORT KIT

Basic HERCULES missile system passed into the industrial test phase. Firings of the Basic HERCULES were continued in 1960 under the Product Engineering Test Program, overlapping initial test firings of the Improved HERCULES system which began in April 1960.[65]

(U) The contractor fired the first 32 R&D rounds in support of the missile development test and evaluation program during the period January 1955 to July 1956, the first 28 tests being conducted with the AJAX ground guidance equipment and the last four tests for checkout of the new HERCULES ground equipment. Beginning with the system demonstration on 25 July 1956, the R&D test program served the broader purpose of evaluating the complete HERCULES missile and ground equipment. The first HERCULES missile (with ballast warhead) was fired against a QB-17 drone aircraft on 10 September 1956. This was followed by the successful intercept of a drone aircraft by a missile with the special warhead on 31 October 1956, and the first drone kill by a live T45 warhead round on 25 April 1957. The transition, in 1957, from a liquid to a solid propellant sustainer motor resulted in a more reliable propulsion system without degrading missile performance. Of the 277 contractor rounds fired during the 1955-59 period, 72 used the liquid sustainer motor and 205 used the XM-30 solid propellant motor.* Another improvement to missile reliability came with

*These figures were based on a working paper tabulation of all contractor R&D firings during the 1955-59 period, which shows 47 firings of the liquid propellant missile in 1955-56; 20 liquid and 35 solid in 1957; 5 liquid and 76 solid in 1958; and 94 solid in 1959.

65 (1) ARGMA Hist Sum, 1 Jan - 30 Jun 60, p. 72. (2) NH Prog Repts for Jan 60, pp. 1, 4; & Apr 60, p. 5. Hist Div File. (3) Eunice H. Brown, *Development and Testing of Rockets and Missiles at White Sands Missile Range, 1956-1960* (TECOM, Mar 66), p. 319. (4) BTL Prog Rept for Nov 59 - Apr 60, p. 38. RHA Bx 13-592. (5) BTL MFF, 1 Mar 63, subj: Contr NH R&D Firings Jan 55 to Mar 63 - Cases 27362-3 & 27675-2, w incls. RSIC.

the introduction, in August 1958, of the modular (Mushroom) guidance package, which later replaced the less effective Stovepipe guidance section in production missiles.

(U) The contractor began test firings of HERCULES prototype system #1 on 29 March 1957, using AJAX missiles. Tests of this prototype using HERCULES missiles commenced on 7 May and were concluded on 11 October 1957. The first prototype system was then transferred to Post Ordnance at WSMR for use in engineering evaluation firings, which began in April 1958. The other four sets of prototype ground equipment were delivered to the Air Defense Board and other service agencies for use in personnel training and user tests. The accuracy phase of the contractor's R&D flight test program was conducted in 1958-59 (Rounds B103 through B277), concurrently with the engineering-user evaluation and troop training tests. Contractor firings of the Basic HERCULES from "C" Station at WSMR were sharply curtailed in 1960 and succeeding years, with 33 flight tests in 1960, 13 in 1961, 7 in 1962, and 2 during the first quarter of 1963.[66]

Engineering-User Test Program

(U) The BTL/DAC team met virtually all target dates of the weaponization schedule through the prototype tests in 1957; however, the high rate of missile failures during the initial engineering-user tests delayed the type classification of the Basic HERCULES and threatened to disrupt the scheduled system deployments on 30 June 1958. The Ordnance engineering evaluation

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[66](1) BTL MFF, 1 Mar 63, subj: Contr NH R&D Firings Jan 55 to Mar 63 - Cases 27362-3 & 27675-2, w incls. RSIC. (2) ARGMA Hist Sum, Jul-Dec 58, p. 68. (3) BTL/DAC Rept, NH Sys & Adv Design NH Sys Presn at Ft Bliss, 6 Feb 58, pp. 46-49. Hist Div File. (4) INH Dev Test Plan, ARGMA TP-5, Oct 59, pp. 6-7. RHA Bx 13-657. (5) BTL Smanl Prog Rept for Nov 59 - Apr 60, p. 1. RHA Bx 13-592. (6) *Also see* above, pp. 56-57, 62-63, 65, 79-80.

tests began at WSMR on 11 April 1958, followed by the initial package training tests by cadre personnel at McGregor Range on 28 April, and service tests by the Air Defense Board (ADB) on 29 May 1958. By late June 1958, 21 HERCULES firings had been conducted by these agencies, along with 32 R&D accuracy tests by the contractor, with the following results:[67]

	Total Firings	Number Successful	Number Unsuccessful
Ord Engrg Evaluation...	8	2	6
Package Training.......	8*	0	8
Service Tests..........	5	0	5
R&D Accuracy Tests.....	32	11	21
	53	13 (24%)	40 (76%)

*These were practice firings conducted in May and June 1958 under phase one of Operation SNODGRASS.

(U) A WSMR study of the firings conducted through mid-May revealed an overall system inflight reliability of only 25 percent. In a briefing on the reliability study to AOMC officials, COL John G. Redmon, Chief of the Ordnance Mission at WSMR, attributed most of the failures to malfunction of the missile guidance package beacon, auxiliary power supply, and circuitry leading to the W-7 warhead. In view of these and other deficiencies yet to be corrected, Colonel Redmon recommended that the deployment of ground equipment proceed as scheduled, but that deployment of the HERCULES missiles be deferred.[68] When subsequent test firings through mid-June 1958 failed to show any appreciable improvement in missile reliability, MG John B. Medaris, Commander of AOMC, urged the Chief of Ordnance to cancel the scheduled HERCULES

[67](1) WSMR TR 100, Jul 60, subj: Final Rept, Engrg Eval of the Basic NH Sys, pp. 144-45, 151, 154. RSIC. (2) ADB Rept of Test--Proj Nr GM-556, Svc Test of AAGM Sys - NH, 3 Feb 60, atchd to Ltr, CG, CONARC, to CRD, DA, 10 Mar 60, subj: Final Rept of Test, Proj Nr GM-556. RSIC.

[68]Daily Journal, MG John B. Medaris, CG, AOMC, 22 May 58. Hist Div File.

shots in Operation SNODGRASS and to delete the HERCULES system from the press show (Project AMMO) to be held at WSMR on 30 June and 1 July. He also recommended that deployment of missiles to operational sites be deferred pending the correction of deficiencies and delivery of modification kits.[69]

Operation SNODGRASS

(U) Operation SNODGRASS, as originally planned, was a full-scale HERCULES test using special warheads against formations of target drones to study (1) the ability of the HERCULES missile components and circuits to operate in a nuclear environment; (2) the degree and type of damage inflicted upon representative aircraft targets; and (3) the extent of interference imposed by a nuclear environment on the signal propagation of the HERCULES acquisition and tracking radars. The test exercise was to have been conducted in the spring of 1959 at the AEC Nevada test site. In mid-April 1958, however, the original plan was scrapped and Operation SNODGRASS became a crash project to be completed before 1 September at a location other than the Nevada site. This aura of urgency was engendered by the anticipation of an international ban on nuclear testing in the atmosphere.

(U) Under the revised plan, approved on 25 April 1958, Operation SNODGRASS was to be conducted as part of a joint Army-Air Force defense test at Eglin Air Force Base. The Army's portion would be conducted in four phases by a CONARC Task Force headed by BG John T. Snodgrass, with AOMC furnishing coordination and support for Ordnance. In phase one (1 May - 15 June), the task force would be organized and trained at Fort Bliss. The second phase (16 June - 5 July) would entail the movement to

[69] (1) Daily Journal, ACofS, MA&T, 12 Jun 58. (2) DF, CofS, AOMC, to ARGMA Comdr, 14 Jun 58, subj: Cfmn of NH Decns. Both in Hist Div File.

Eglin Air Force Base and the emplacement and checkout of HERCULES equipment and instrumentation. Phase three would consist of final on-site training and six dress rehearsal flight tests (6-31 July), culminating in the (phase four) full-scale nuclear firings (1-31 August 1958).[70]

(U) NIKE HERCULES system number 1009 from the Air Defense Board at Fort Bliss was assigned the role of warhead firing battery, under command of CAPT R. L. Klenik. System number 1060 from C Battery, 738th Guided Missile Battalion, of the Philadelphia defense area, was assigned the role of instrumented missile firing battery, under command of CAPT F. E. Newland. This battery had just completed its package training at Fort Bliss, and, until its assignment to Task Force SNODGRASS, was to have been one of the first four HERCULES batteries to be activated on site. In phase one of the operation (1 May to 15 June), the ADB warhead firing battery fired five practice rounds at WSMR, and the instrumentation missile battery fired two rounds at McGregor Range. All seven of these practice firings were unsuccessful.[71]

(U) On 14 June 1958, DA suspended the (phase two) movement to Eglin for one week and also suspended the shipment of HERCULES missiles and W-7 warheads to operational sites, as AOMC had recommended.[72] CONARC was of the opinion, however, that the move to Eglin should be undertaken as a calculated risk.[73] Moreover, the

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[70](1) Hist of WSMR, Jan-Dec 59, Vol. I, pp. 45-47. (2) DF, CofS, AOMC, to ACofS, MA&T, 6 May 58, subj: Sp NH Tests. (3) Ltr, CG, AOMC, to Mr. F. R. Lack, WECo, 8 May 58, n.s. All in Hist Div File.

[71]BTL MFF, 21 Jul 59, subj: NH - Task Force SNODGRASS - Contr Part Rept - Cases 27675-2 & 27675-7, pp. 3-4, 12-13. RHA Bx 13-592.

[72](1) Daily Journal, ACofS, MA&T, 14 Jun 58. (2) TT, CG, ARADCOM, to CG, OAC, *et al.*, 14 Jun 58. (3) TT, CG, CONARC, to CG, US Army I, *et al.*, 16 Jun 58. All in Hist Div File.

[73]Daily Journal, ACofS, MA&T, 14 Jun 58. Hist Div File.

AEC, which had reluctantly approved the operation, was evidencing more interest in the exercise.[74] In consideration of these factors, the CONARC Commander lifted the suspension on Operation SNODGRASS on 16 June.[75] Since the shipment of missiles to operational sites had already begun, the Chief of Ordnance decided, on 18 June, to stand fast on the initial deployment directive, pending resolution of the warhead pressure-drop problem. The directive was temporarily modified, however, to include only two missiles per site.[76] At the same time, the Commander of the U. S. Army Air Defense Center and the Military Development Engineer for BTL, with the concurrence of OCO, decided to fire the HERCULES in Project AMMO at WSMR.[77]

(U) By late June, a temporary fix had been developed for the warhead problem, 17 modification work orders had been printed and distributed for correction of the other technical deficiencies, and kits were enroute to the launch sites by air freight.[78] These measures were apparently effective, for the HERCULES shot in Project AMMO and the six phase three firings in Operation SNODGRASS at Eglin were all successful.

(U) In its first public launching at Project AMMO on 1 July 1958, the HERCULES successfully intercepted a simulated 650-knot target flying at an altitude of 100,000 feet and a slant range of 50 miles.[79] The six flight tests in Operation SNODGRASS

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[74] Daily Journal, ACofS, MA&T, 16 Jun 58. Hist Div File.

[75] TT ATDEV-4 300776, CG, CONARC, to Comdr, JTF, Eglin AFB, *et al.*, 16 Jun 58. Hist Div File.

[76] (1) TT, CofOrd to CG, AOMC, 18 Jun 58 [re Sta of NH Decns & Actions]. (2) TT, CG, AOMC, to CofOrd, 24 Jun 58, citing OCO msg of 17 Jun 58 on modified dplmt order. Both in Hist Div File.

[77] TT 6-964, CG, WSMR, to CofOrd, 18 Jun 58. (2) TT, CofOrd to CG, AOMC, 18 Jun 58. Both in Hist Div File.

[78] TT, CG, AOMC, to CofOrd, 24 Jun 58 [re Sta of NH Actions]. Hist Div File.

[79] Craig Lewis, "Army Shows Rocket, Missile Capabilities," *Aviation Week*, Vol. 69, No. 1 (7 Jul 58), p. 36.

successfully demonstrated the capability of the HERCULES to single out a specific target among a group of aircraft flying in formation. System 1009, the ADB warhead firing battery, fired three missiles armed with T45 warheads, destroying one QF80 and two Q2A drones. System 1060, the instrumented missile firing battery, also fired its three instrumented missiles successfully.

(U) The first round, an instrumented missile, was flown on 14 July against a single, 350-knot Q2A drone. The second round, armed with a T45 warhead and fired on 17 July, destroyed its 300-knot Q2A target drone in the first firing of a HERCULES missile with a live warhead near a populated area. The next two dress rehearsal rounds, flown in salvo on 24 July, were the first of the dual firings of the two batteries which were tracking the same target—a 300-knot Q2A drone flying at 8,000 feet altitude and 50,000 yards range. The first round, with a T45 warhead, scored a kill on the target; the instrumented round, fired 1 second later, successfully intercepted the same target. In the second dual firing mission, on 29 July, the warhead missile and instrumented missile were fired in salvo 3 seconds apart against a formation of three QF80 drones flying a crossing course at an altitude of 31,000 feet and a range of 81,000 yards. The warhead round picked off and destroyed the lead drone, and the instrumented missile intercepted the second drone which flew 5,000 feet behind the leader. The test results indicated that, with an atomic warhead, the first missile could have destroyed the entire formation.[80]

(U) But the opportunity to demonstrate the nuclear capability of the HERCULES never materialized, as DA quite unexpectedly cancelled the full-scale atomic firings planned for phase four of

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[80] (1) Hist of HQ AOMC, 1 Jul - 31 Dec 58, p. 12. (2) Hist of WSMR, Jan-Dec 59, Vol. I, p. 48. (3) BTL MFF, 21 Jul 59, subj: NH - Task Force SNODGRASS - Contr Part Rept - Cases 27675-2 & 27675-7, pp. 10-11 & App. B. RHA Bx 13-592.

the exercise. Nevertheless, the Task Force Commander and his staff were extremely confident that phase four could have been conducted with maximum safety and efficiency. In his final report on the operation, BG John T. Snodgrass stated:

> *While the cancellation of the August 1958 firings prevented (the) Snodgrass Task Force from accomplishing its primary mission, two major goals were achieved. The firing of six preparatory and rehearsal rounds, all of which were successful, clearly demonstrates that the U. S. Army has in being the ability to:*
>
> *a. Plan, organize, train, move to a remote location, and establish an effective Nike Hercules air defense, all within a relatively short time-frame.*
>
> *b. Plan, fabricate, install, and operate the instrumentation necessary to acquire data on a full-scale Nike Hercules firing.*[81]

Type Classification of the Basic HERCULES System

(U) Meanwhile, the Deputy Chief of Staff for Logistics (DCSLOG), in June 1958, directed the Chief of Ordnance to type classify the Basic HERCULES system as Standard A not later than the July meeting of the Ordnance Technical Committee.[82] The committee took up the question on 10 July; however, the CONARC member blocked the action on the grounds that the capability of the system had not been successfully demonstrated in either user or package training tests,* and that the effectiveness of measures taken to correct major deficiencies was yet to be proved. He recommended that action to standardize the system be deferred for about 90 days, or until a nominal number of successful user flight test firings could be

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*As noted earlier, all 13 of the user and package firings and six of the first eight engineering tests conducted through June 1958 had been unsuccessful. *See* above, pp. 98-99.

[81] Hist of WSMR, Jan-Dec 59, Vol. I, pp. 47-49.

[82] DF, LOG/E3-25000, DCSLOG to CofOrd, 4 Jun 58, subj: TCLAS of Mat (NH). Cited in OTCM 36833, 10 Jul 58. RSIC.

accomplished.[83] In another item taken up on 10 July, the committee reclassified the NIKE AJAX system from Standard A to Standard B.[84]

(U) During the period 1 July to 31 October 1958, 75 missiles were fired in all phases of the HERCULES test program, with significantly improved results over firings conducted during the first 6 months of the year. Forty-one of these rounds were prototype missiles and the remaining 34 were production missiles. As shown in Table 4, 12 of the 34 production missiles were fired by the contractor in a system reliability demonstration, with nine successes and three failures; and 22 were fired by tactical units with 12 successes and 10 failures, for an overall reliability of 62 percent. Of the 41 prototype firings, 32 (78 percent) were successful. The higher reliability for these firings was attributed, in the main, to the introduction of new missile components designed to resolve technical deficiencies noted in earlier tests. For example, of the 24 R&D rounds fired by the contractor, nine were equipped with the new Mushroom guidance set, and all but one of them achieved their test objectives.[85]

(U) In consideration of the successful system reliability demonstration by the contractor and the increased system reliability achieved in the engineering-user test program, DA type classified the Basic HERCULES weapon system as Standard A on 20 November 1958.[86] Service tests, however, continued through July 1959, and the engineering evaluation at WSMR continued up to the

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[83] OTCM 36833, 10 Jul 58 w incl: Memo For: Secy, OTC, fr COL Phillip F. Hoover, CONARC Mbr, 3 Jul 58, subj: OTCM U-813, AD GM Sys - NH - Clas as Std Type. RSIC.

[84] OTCM 36841, 10 Jul 58. RSIC.

[85] BTL MFF, 15 Sep 59, subj: Inflt Reliability - Case 27675-2, w Tables 1 thru 4. RSIC.

[86] (1) OTCM 36913, 20 Nov 58, recording apprl of OTCM 36833, 10 Jul 58. RSIC. (2) For the official nomenclature and function of type-classified items, *see* Appendix B.

TABLE 4
(U) Basic NIKE HERCULES Flight Test Program
July - October 1958

TEST AGENCY & TYPE MISSILE	Total Firings	Nr. Suc.	Nr. Unsuc.
Contractor:			
R&D Msls*..................	24	17	7
Pdn Msls*	12*	9	3
Total Contractor...........	36	26	10
Service:			
Pkg Tng/Pdn Msls...........	22	12	10
Op SNODGRASS/R&D Msls......	6	6	0
Total Service.............	28	18	10
Ord Engrg/R&D Msls..........	11	9	2
Grand Total.................	75	53 (71%)	22 (29%)

*System Reliability Demonstration—3 rounds launched in July 1958 with HERCULES Production Set Nr. 1081 at McGregor Range; remaining 9 rounds launched at WSMR with the HERCULES Model #1 Ground Guidance Set.

SOURCE: BTL MFF, 15 Sep 59, subj: Inflt Reliability - Case 27675-2, w Tables 1 thru 4. RSIC.

final R&D release in early January 1960. Summaries of the service and engineering evaluations follow.

Service Test Program

(U) Since major areas of user responsibility had been explored in special test exercises (such as the Weapon Systems Evaluation Group ECM Tests No. 1 and 3, and the Task Force SNODGRASS test), the Commander of CONARC directed that user tests be terminated by 31 July 1959. Although a number of important tests could not be conducted by the cutoff date, sufficient contractor and Ordnance engineering test data were available to permit analysis from a user viewpoint. One exception was the mobility test which was postponed pending availability of suitable equipment.[87]

(U) Field qualification tests by the Air Defense Board had begun with the receipt of launching area equipment (HERCULES System No. 1009) in the fall of 1957. Following initial checkout at Dona Ana Range, the equipment was moved, in early 1958, to WSMR, where two NIKE AJAX rounds and five HERCULES rounds were fired. It was then transported to Eglin Air Force Base and used to fire three additional HERCULES rounds in Operation SNODGRASS* during July 1958. The equipment was returned to Dona Ana Range in the fall of 1958, subsequently participating in the durability test at that site. Early in 1959, it was again emplaced at WSMR, where nine HERCULES rounds were fired during the period 26 February to 31 July 1959, with an interruption for one firing at McGregor Range on 10 July. During all of these ADB operations, a total of 69 launching area malfunctions were recorded, the most

*The other three SNODGRASS Task Force rounds were fired by System No. 1060. *See* above, pp. 101-103.

[87]The HERCULES mobility package was delivered in May 1960 and field qualification tests were completed 4 months later. *See* above, pp. 94-95.

[redacted]

frequently recurring one (43 percent of the total) being associated with the universal launcher and its erecting beam.

[88] (1) BTL MFF, 15 Sep 59, subj: NH - Inflt Reliability - Case 27675-2, pp. 1-2, 7, & Table 4. (2) Army ADB Rept of Test--Proj GM-556, Svc Test of AAGM Sys - NH, atchd to Ltr, CG, CONARC, to CRD, DA, 10 Mar 60, subj: Final Rept of Test, Proj Nr GM-556. Both in RSIC.

(U) The results of air-transportability tests, conducted by the Army Air Defense School and the Army Airborne & Electronics Board, disclosed that all battery equipment, including an 18-round basic load, could be transported without dismantling by 45 C124 or 33 C133 aircraft, but not by helicopter. While the helicopters then in Army service (H21, H34, H37) could not lift all of the battery equipment, missile resupply by the H37 was considered feasible.

(U) In summary, the ADB concluded that the Basic HERCULES was an accurate, maintainable, and reliable system capable of performing its primary mission of antiaircraft defense, and that it met or exceeded the major MC's in all respects except mobility.[89] (The latter requirement was met with delivery of

[89] *Ibid.*

the mobility package in 1960.)

Final Engineering Evaluation

(U) The final Ordnance engineering evaluation of the Basic HERCULES system was predicated on data obtained during the contractor, engineering, and user tests performed during the period January 1958 to January 1960, inclusive. Excluding the 28 service tests mentioned above, 488 HERCULES missiles were fired during that period: 71 in the Ordnance engineering evaluation at WSMR, 175 by the contractor (Rounds B103 through B277), and 242 by tactical air defense units. Of the 242 user rounds, 235 were fired at McGregor Range, 2 in Alaska, and 5 in Okinawa.

(U) In reviewing the firing data recorded by the three test agencies, the Ordnance Mission at WSMR found certain anomalies, particularly in the interpretation of a successful mission. It was therefore necessary to establish a common basis for analyzing and interpreting the test data. In order to arrive at a consistent inflight reliability figure, certain tests conducted by the three agencies were excluded from consideration for one or more of the following reasons:

1. No data on miss distance (even if ruled a success by the test agency).
2. No data on intercept range.
3. Failure due to warhead malfunction.
4. Liquid sustainer motor used.
5. Surface-to-surface mode used (surface-to-air firings only were considered).
6. Low-altitude mode used with non-standard thrust limiter.
7. Special tests where major non-standard or non-tactical elements were employed.
8. Range safety.

Cost Summary

(U) Research, Development, Test, and Evaluation (RDTE) funds were provided for the Basic HERCULES system through FY 1960. Since the Basic and Improved HERCULES development programs overlapped each other by about 4 years and both programs were funded under the same contract, it was impossible to determine the precise development cost of the respective systems. A total of $123.8 million was funded through FY 1960 for RDTE purposes, excluding the nuclear warhead. As of January 1961, a total of $112.7 million was obligated under the prime R&D contract (ORD-1082) with WECo. This contract represented about 91 percent of the total RDTE funding through FY 1960, and about 90.5 percent of the identifiable R&D contracts listed in Table 6.[92]

[91] *Ibid.*, pp. 201-204.

[92] (1) SRI TR 24, Aug 61, pp. 42, 49-51. RHA Bx 13-592. (2) NH Prog Rept, Jun 60, p. "D" (ARGMA Chart MC-NH-2-562, 30 Jun 60). Hist Div File.

Table 6—ORDNANCE CORPS R&D CONTRACTS FOR NIKE HERCULES SYSTEM

Contract	Date	Contractor	Scope of Work	Contract Value As Of Jan 61
ORD-1082	Jun 53	Western Electric Company	NIKE HERCULES Research & Development	$112,688,395
ORD-1620	May 54	Aircraft Armaments, Inc.	Cluster Warhead design, fab, & testing	193,922
ORD-243	Jul 54	Raymond Engineering Labs	R&D on Arming Systems for NIKE Missiles	25,000
ORD-244	Jul 54	Raymond Engineering Labs	Design & Dev of Impvd T90 Arming Mechanism	118,700
ORD-21	Sep 54	Aerojet-General Corp.	Design & Dev of T45 Fragmentation Warhead	206,108
ORD-22	Sep 54	Rheem Manufacturing Co.	Design & Dev of T46 Cluster Warhead	3,225,633
ORD-297	May 55	Stanford Rsch Institute	FS of Fragmentation Warhead for HERCULES	54,322
ORD-4930	Apr 56	Thiokol Chemical Corp.	R&D of XM-30 Sustainer Motor	98,059
ORD-4947	Jun 56	Thiokol Chemical Corp.	R&D of XM-30 Sustainer Motor	1,995,498
ORD-5028	Jun 56	Thiokol Chemical Corp.	R&D of XM-30 Sustainer Motor*	85,496*
ORD-5102	Dec 56	Thiokol Chemical Corp.	R&D of XM-30 Sustainer Motor	3,286,690
ORD-479	Apr 57	Univ Moulded Prod Corp.	Design study of Single-Chamber Fiberglas-Plastic Jato Case for NIKE HERCULES	19,412
ORD-5496	Jun 58	Thiokol Chemical Corp.	R&D of Single-Barrel Frangible Booster for NIKE HERCULES Missile	2,433,728
TOTAL				$124,430,963

*$27,047 of contract amount used for preliminary design and development study of self-destroying Fiberglas-Plastic Booster for the HERCULES Missile; remainder used for fabrication and delivery of six simulated XM-30 sustainer motors. *See* Table 3, p. 78.

SOURCE: (1) NIKE Blue Book, p. 247. (2) SRI TR 24, Aug 61, p. 51. (3) *Also see* above, pp. 59-62, 67-78, 80-84.

CHAPTER V

(U) ~~(C)~~ PRODUCTION AND DEPLOYMENT OF THE BASIC HERCULES SYSTEM (U)

(U) Preproduction and production engineering work on tactical equipment for the Basic HERCULES system began in November 1954, some 2 months before the first R&D missile firing in January 1955. Contracts for production engineering and for fabrication of prototype missiles and ground equipment were signed in April 1955, along with a contract for the first lot of production missiles and concurrent spares. The production contract for the first lot of tactical battery sets was signed 7 months later, in November 1955. The delivery of prototype missiles began in 1956 and continued into December 1958, overlapping initial deliveries of tactical battery sets and missiles, which commenced in June 1957 and December 1957, respectively. The first three batteries were deployed in CONUS on 30 June 1958, followed by deployment of the first overseas unit (Taiwan) in September. In September 1961, Army units finished their package training, and on-site deployment of all programmed CONUS and overseas units was completed at the end of the year.

Preproduction Phase

(U) As a general rule, preproduction activity starts on the date that a definite commitment for production is made to assure delivery of the first tactical units for programmed deployment. Preproduction commitments begin with this production authorization and embrace production tooling, facilities, and production engineering, whichever is earliest. Some subphases of preproduction end with the first production delivery, but other subphases continue. Among these continuing activities are tooling necessary to maintain a certain quantity of production (commonly known as sustaining tooling), expansion of facilities, and additional production engineering. Major time phases for the Basic HERCULES preproduction activities are depicted in Chart 6.

Prototype Missiles and Ground Equipment

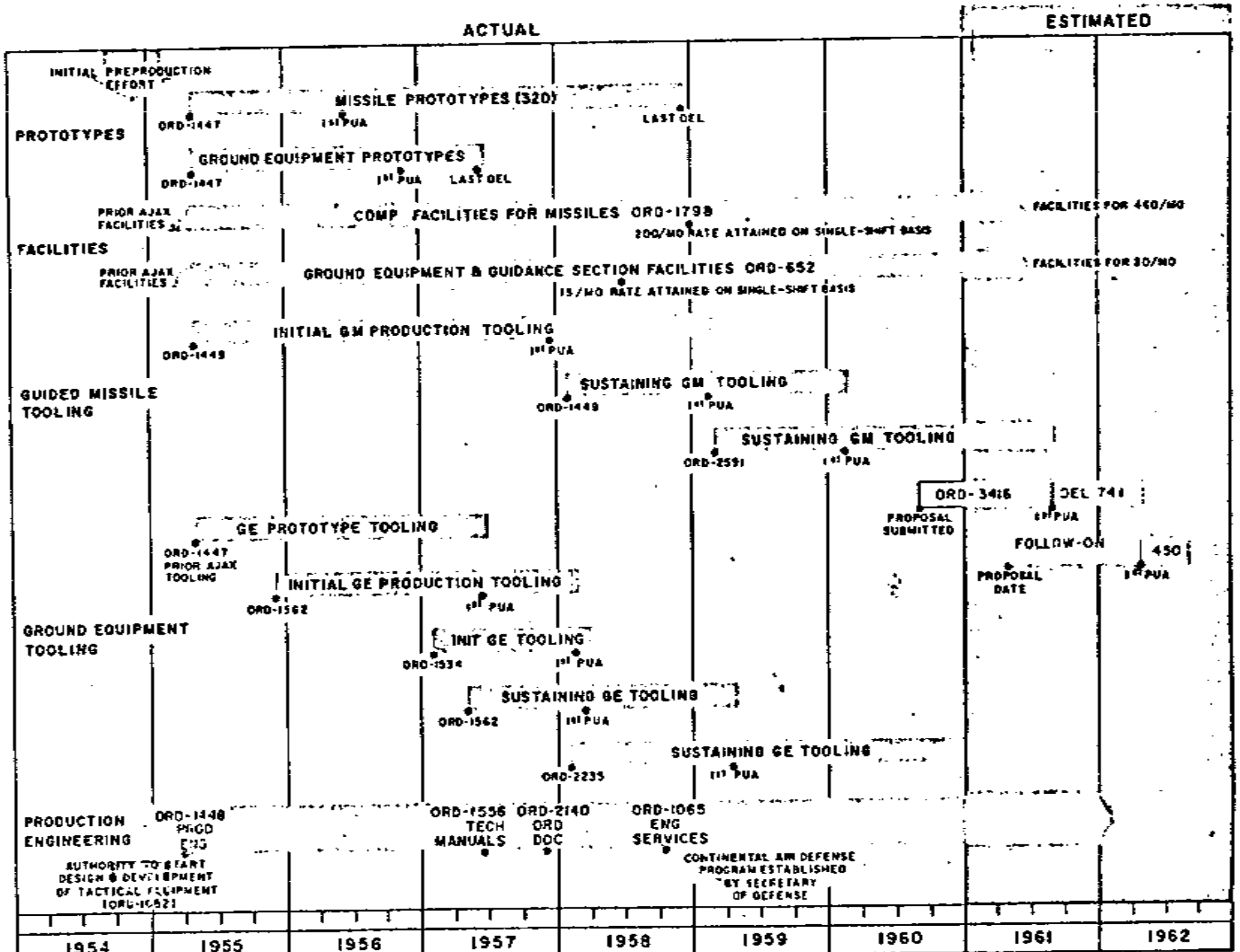
(U) Contract DA-30-069-ORD-1447, which was awarded to WECo on 29 April 1955, covered the fabrication of 100 prototype missiles and the conversion of five AJAX ground equipment sets to HERCULES for use in support of the R&D program. Later in 1955 and in 1957, the contract was supplemented to include three additional lots of missiles, increasing the total number of prototype missiles to 320. In FY 1958, the contract was further supplemented to provide for the construction of one prototype set of Improved HERCULES ground equipment. The major portion of this fixed-price contract, excluding the Improved HERCULES equipment, was redetermined in 1957 and 1959, resulting in a total price of $49,656,000 for the Basic HERCULES prototypes. The price of the Improved HERCULES prototype set was $6,771,500, giving a total contract price of $56,427,500 as of 31 October 1960. Contract prices for prototype missiles and ground equipment, including tooling, are shown in Table 7.

(U) The Douglas Aircraft Company fabricated all 320 missiles at its plant in Santa Monica, California. WECo manufactured the prototype ground equipment sets at its Burlington, North Carolina, plant. Deliveries of the prototype missiles were completed in December 1958, or 3 years and 8 months after date of the contract. WECo completed delivery of the five ground equipment prototypes in June 1957, or 2 years and 2 months from the contract date.[1]

[1] SRI TR 24, Aug 61, pp. 55-57, 59. RHA Bx 13-592.

CHART 6

(U) MAJOR TIME PHASES FOR PREPRODUCTION



NOTE: "PUA" means production unit available. "COMP" refers to Charlotte Ordnance Missile Plant

SOURCE: SRI TR 24, Aug 61, p. 58. RHA Bx 13-592.

TABLE 7—(U) Prices for Prototype Missiles & Ground Equipment Under Contract ORD-1447 (Including Tooling) (Thousands of Dollars)

Item	Quantity	Value as of 31 Oct 1960 Total Price	Unit Price
BASIC HERCULES SYSTEM			
Missiles:			
Lot No. 1			
Missile Body*	100	$ 7,898.5	$ 78.985
Stovepipe Guidance Section	100	1,662.0	16.620
Total Lot No. 1	100	$ 9,560.5	$ 95.605
Lot No. 2			
Missile Body*	100	6,482.0	64.821
Stovepipe Guidance Section	100	1,662.0	16.620
Total Lot No. 2	100	$ 8,144.0	$ 81.441
Lot No. 3			
Missile Body*	50	2,277.2	45.545
Stovepipe Guidance Section	50	823.5	16.470
Total Lot No. 3	50	$ 3,100.7	$ 62.015
Lot No. 4			
Missile Body*	70	3,180.8	45.440
Stovepipe Guidance Section	45	741.1	16.470
Mushroom Guidance Section	25	5,420.9	216.835
Total Lot No. 4	70	$ 9,342.8	$ 133.469
Stovepipe Guidance Section**	9	81.4	9.040
Booster Shipping Containers	1,075	602.0	0.560
Telemetry Set & Installation		371.2	
Miscellaneous Items		586.1	
TOTAL MISSILES	320	$31,788.7	$ 99.340
Ground Equipment (Sets)			
Guidance & Control Equipment	5	7,349.0	1,469.800
Lchg & Hdlg Equipment	5	7,472.3	1,494.465
Assembly Area Equipment	5	792.9	158.579
Type IV Test Equipment	3	1,846.5	615.501
TOTAL GROUND EQUIPMENT (Sets)	5	$17,460.7	$3,492.140
Engineering Support		406.6	
TOTAL BASIC HERCULES SYSTEM		$49,656.0	
IMPROVED HERCULES SYSTEM			
Radar Course Directing Central	1	$ 3,163.9	$3,163.900
High Power Acquisition Radar	1	1,163.0	1,163.000
AJAX Mod Kit & Installation	1	340.3	340.300
Moving Target Indicator	1	110.7	110.700
Maintenance Support		1,993.6	
TOTAL IMPROVED HERCULES SYSTEM		$ 6,771.5	
TOTAL CONTRACT		$56,427.5	

*Including telemetry equipment, booster assembly, and dummy warhead.

**Extra guidance sections for test purposes.

SOURCE: SRI TR 24, Aug 61, p. 73. RHA Bx 13-592.

Production Engineering

(U) Production engineering work on tactical equipment began with the Army's authorization in November 1954. However, much of the preliminary design work on the Basic HERCULES was performed under WECo's R&D contract, ORD-1082, as early as 1953, long before negotiation of the first production engineering contract (ORD-1448) in April 1955.[2] The design and development work done under Contract ORD-1082 was aimed at providing R&D drawings which, with a minimum of effort, could be used for manufacturing, once authorization had been given. Production engineering on the basic system was considered complete on 9 January 1960, when all R&D drawings were released to production.

(U) A total of $95,372,882 was funded for production engineering and allied services on the Basic HERCULES through FY 1960. The first contract (ORD-1448), awarded to WECo on 15 April 1955, provided for production engineering services (including preparation of manufacturing drawings and specifications, spare parts lists, maintenance manuals, and qualification testing) on the Basic HERCULES and the modified portion of existing AJAX ground equipment. Field engineering services were initiated with the signing of Contract ORD-1717 in February 1956, and extended, in 1958-59, under Contracts ORD-1065, ORD-1342, and ORD-2802.[3] These and other identifiable production engineering contracts are listed in Table 8.

Facilities

(U) The principal production sources for the HERCULES system, all carried over from the NIKE AJAX program, were (1) the DAC plant

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[2]For an account of the early design and development work, *see* Chapter III.

[3]SRI TR 24, Aug 61, pp. 59, 63-65. RHA Bx 13-592.

Table 8—(U) ORDNANCE CORPS PRODUCTION ENGINEERING CONTRACTS

Contract	Scope of Work	Contractor	Date	Value as of 30 Jun 60
ORD-1448	Production engineering services	Westerm Electric Co.	Apr 55	$62,797,125
ORD-1717	Field engineering services	Western Electric Co.	Feb 56	119,420
ORD-1752	Training manuals	Western Electric Co.	May 56	187,822
ORD-2140	Ordnance documentation	Western Electric Co.	Nov 57	4,212,594
ORD-1556[1/]	Technical manuals	Western Electric Co.	Jun 57	21,698,365
ORD-1065[2/]	Field engineering services	Western Electric Co.	Jun 58	2,274,977
ORD-1342	Engineering services	Douglas Aircraft Co.	Jun 58	1,727,200
ORD-2802	Engineering services	Western Electric Co.	Jul 59	2,355,379
TOTAL				$95,372,882

[1/] The original contract for NIKE AJAX is dated June 1955. The HERCULES scope of work was added about June 1957. Costs shown are the estimated HERCULES portion only.

[2/] The original contract for NIKE AJAX is dated March 1953. The HERCULES scope of work was added about June 1958. Costs shown are the estimated HERCULES portion only.

SOURCE: SRI TR 24, Aug 61, p. 65. RHA Bx 13-592.

at Santa Monica, California; (2) the Charlotte Ordnance Missile Plant (COMP) at Charlotte, North Carolina, also operated by DAC; and (3) the Western Electric plant at Burlington, North Carolina.

(U) The production facility for missile guidance sections was continued from the NIKE AJAX program at WECo's Winston-Salem, North Carolina, plant until July 1959, when the Stovepipe configuration was phased out of production. A new facility was built at WECo's Greensboro, North Carolina, plant for production of the new Mushroom guidance section.

(U) The Western Electric Company manufactured ground equipment

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[4] *Ibid.*, pp. 59-60, 64, 67.

[5] *Army Navy Air Force Journal*, Vol. 96, 1 Nov 58, p. 274.

for the Basic HERCULES at its Burlington plant. As in the case of missiles, existing AJAX facilities were used for initial production and new ones were added as production expanded. Electronic ground equipment was assembled at the Tarheel Ordnance Plant of WECo* (Burlington) and non-electronic equipment at DAC's Santa Monica plant.

(U) The estimated total cost for both AJAX and HERCULES facilities, under Contracts ORD-652 and ORD-1798, was $27 million; for HERCULES facilities alone, it was about $9 million (*see* Table 9). These Ordnance Corps facility contracts, however, provided for machinery and equipment only. Construction costs (land, buildings, and building rehabilitation) were funded through the Corps of Engineers. The estimated total facility funding for AJAX and HERCULES, including construction, was $56.6 million; for HERCULES alone, it was $15.4 million (*see* Table 10).[6]

Production Program

Missiles

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*The real estate and buildings of the Tarheel Ordnance Plant were Government-owned, but the contractor owned the greater portion of the production equipment. WECo originally leased the plant from the General Services Administration for commercial work. As the AJAX and HERCULES programs evolved, placement of an increasing amount of ground equipment production into the facility resulted in its becoming predominately devoted to military production. Beginning 1 March 1961, all real property and buildings were leased to the contractor. NH Wpn Sys Plan (Indus Op Plan), WSP-1, Annex B, Sep 61, p. 12. Hist Div File.

[6]SRI TR 24, Aug 61, pp. 60, 67-69. RHA Bx 13-592.

TABLE 9
(U) Ordnance Corps Facility Contracts

Contract	Scope of Work	Contractor	Date	Value as of Jun 60	Estimated HERCULES Cost
ORD-652	Facilities for NIKE (ground equipment and missile guidance)	Western Electric Co.	Mar 52	$13,188,728	$2,121,997
ORD-1798	Facilities for NIKE AJAX and HERCULES at Charlotte Ordnance Missile Plant	Douglas Aircraft Co.	Feb 55	13,776,600	6,776,600
TOTAL				$26,965,328	$8,898,597

SOURCE: SRI TR 24, Aug 61, p. 68. RHA Bx 13-592.

TABLE 10
(U) Estimated Funding for Facilities[1/]
NIKE AJAX and NIKE HERCULES
(Millions)

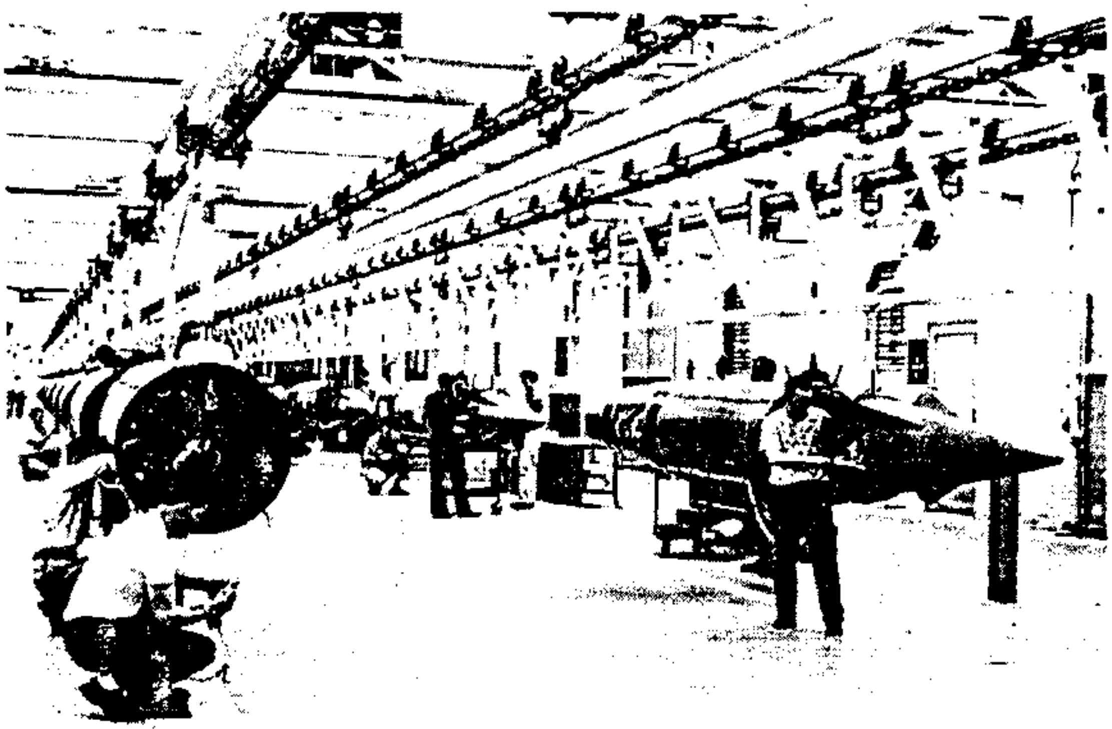
Component and Plant	Total	Estimated HERCULES Portion
Missiles		
Charlotte Ordnance Missile Plant[2/]	$25.5	
Other	4.1	
Total, Missiles	$29.6	$ 9.9
Ground Equipment		
Tarheel Ordnance Plant[3/]	17.6	
Other	9.4	
Total, Ground Equipment	$27.0	$ 5.5
TOTAL	$56.6	$15.4

1/ Including construction.

2/ Douglas Aircraft Co., Charlotte, North Carolina. Maximum capacity: 460 missiles per month on a multishift basis.

3/ Western Electric Co., Burlington, North Carolina. Maximum capacity: 20 ground equipment sets per month on a multishift basis.

SOURCE: SRI TR 24, Aug 61, p. 69. RHA Bx 13-592.



NIKE HERCULES missiles near the end of the final assembly line at the Charlotte Ordnance Missile Plant (October 1958)

(U) The major cost components for the missile consisted of (1) the missile airframe (which included the forward and aft body, main and center fin, booster fin, and booster cluster), the warhead body assembly, and shipping containers, all of which were assembled by DAC at COMP; (2) the guidance section, manufactured

[7] (1) *Ibid.*, pp. 83, 89. (2) NH Wpn Sys Plan (Indus Op Plan), WSP-1, Annex B, Sep 61, p. 29. Hist Div File. (3) NH PM_2P, Ch 8, 30 Jun 65, p. 16g. Hist Div File. (4) Hist Rept, NH PM, FY 1965, p. 20. Hist Div File.

by WECo's plants in North Carolina; (3) the M30 (XM-30) solid sustainer motor metal parts and blast tube assemblies; (4) the solid sustainer motor loading and blast tube lining; and (5) the M42 (XM-42) rocket motor (booster) metal parts and loading. The last three groups of components were supplied by contractors other than WECo.[8]

(U) At the beginning of the program, the two major contractors for XM-30 sustainer motor metal parts and blast tube assemblies were the Borg-Warner Corporation and the Goodyear Aircraft Corporation. With the initiation of competitive procurement, in 1958, the International Manufacturing Company, Inc., became the major supplier of motor metal parts, blast tube assemblies, and gas generators. The Watervliet Arsenal also supplied a small quantity (about 150) of metal parts and blast tube assemblies. These contractors delivered the motor hardware as Government-furnished equipment (GFE) to the Longhorn Ordnance Works (later renamed the Longhorn Army Ammunition Plant—LAAP), a Government-owned plant operated by the Thiokol Chemical Corporation. The Thiokol Longhorn Division loaded the M30 motors under its open-end contract (ORD-200) and shipped them to Ordnance depots for issue to the users. The average unit price for loading the first 5,590 motors was $5,585.[9]

(U) Beginning in FY 1962, the Hicks Corporation became the major supplier of M30 motor metal parts under Contract ORD-13055. The delivery of motor cases under this contract was subject to frequent schedule slippages owing to technical problems with welding procedures. In 1963, for example, serious problems

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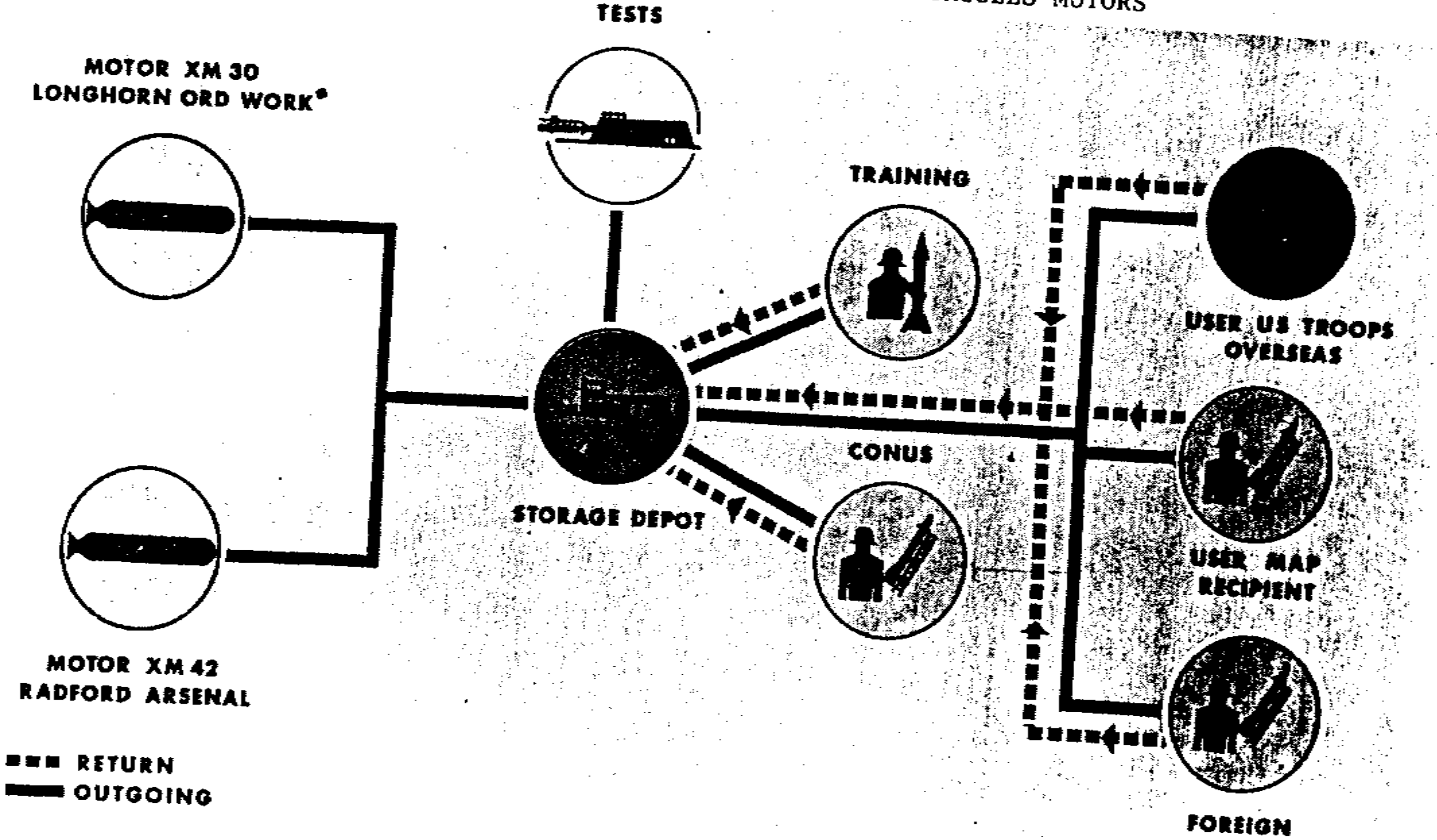
[8] SRI TR 24, Aug 61, p. 89. RHA Bx 13-592.

[9] (1) *Ibid.*, pp. 105, 108, 110-11. (2) NH Wpn Sys Plan (Indus Op Plan), WSP-1, Annex B, Sep 61, pp. 3-4, 6. Hist Div File. (3) Total funding for the first 5,590 units, procured during FY 1956-60, was $31,219,895. In FY 1957, 23 additional motors were loaded for R&D at a total cost of $263,691. SRI TR 24, Aug 61, p. 111.

CHART 7. MATERIEL FLOW CHART - NIKE HERCULES MOTORS



involving cracking on non-pressure area welds were detected after the motors had been loaded and shipped to the depots. Intermittent welding difficulties and schedule slippages continued until May 1964, when the quality problems affecting deliveries were resolved. All delinquent units were delivered by the end of June 1964, and no further schedule delays were reported.[10] The lowest LAAP unit price for loading M30 sustainer motors at a rate of 100 per month in FY 1964 was $4,430.[11]

(U) The M5E1 booster and igniter metal parts for the M42 (XM-42) rocket motor originally were procured from the Borg-Warner Corporation and the Goodyear Aircraft Corporation at a unit cost of about $900 per booster or $3,600 per missile. The Radford Arsenal, a Government-owned plant operated by the Hercules Powder Company, assembled and loaded the XM-42 booster motors under its open-end contract (ORD-37) and shipped them to Ordnance depots for issue to users. Booster loading costs through FY 1958 averaged about $4,300 per missile. Beginning in FY 1959, Radford Arsenal purchased the booster and igniter metal parts from National Electric, a division of the H. K. Porter Company, at reduced costs, and included the booster metal part costs with loading costs. As a result of the change in producers, the unit cost for both booster metal parts and loading was reduced to $7,600 per missile. Another change concerned the cluster hardware cost, which originally was part of the DAC airframe cost. Beginning in FY 1960, this cost was included in the Radford Arsenal loading cost, and cluster hardware procurement was made under an Arsenal contract with DAC/COMP, rather than under a

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[10] *See* Weekly PM Repts to CG, AMC, May 63 - Jun 64. Hist Div File.

[11] Ltr, CG, MICOM, to CG, AMC, 21 Feb 67, subj: FY 67 PEMA 4911 Just - Expansion of Facs to L/A/P [*sic*] NH, M30A2 Sustainer Mtrs - LAAP, Marshall, TX (Proj Rev), atchd to SS AMSMI-I-16-67, 20 Feb 67, same subj. Hist Div File.

WECo subcontract with DAC. This change was effective with the 339-unit missile lot procured under WECo Contract ORD-2591.[12]

(U) The warhead body assemblies produced by DAC/COMP were delivered to the Ramon Engineering Company as GFE for assembly with the loaded warhead. The M17 (T45) warhead metal parts were loaded at the Iowa Ordnance Plant, installed in the warhead body assembly, and shipped to Ordnance depots for issue to the users. The nuclear warheads were assembled at AEC depots and furnished directly to field sites. The Elgin National Watch Company produced the safety and arming devices and shipped them to Ordnance depots for field issue. Missile batteries were requisitioned through Signal Supply Agency channels. Final assembly and check-out of the missile with warhead was accomplished at field sites.[13]

(U) In view of the May 1965 target date for completion of missile end item production at CAMP,* the Assistant Secretary of the Army (Installations & Logistics), in March 1965, directed the initiation of negotiations with DAC for maintenance of the facility in a state of partial layaway. Under this directive, which reflected recommendations of MICOM personnel, DAC would occupy about 20 percent of the plant for non-production activities and the rest of the plant would remain idle with a production capacity of 100 missiles per month to satisfy future HERCULES requirements.[14] On 13 August 1965, however, the Assistant Secretary of the Army (Installations & Logistics) determined that retention of the plant could not be justified under policy guidance issued by the Secretary

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*In the Army reorganization of 1962, the Charlotte Ordnance Missile Plant was redesignated as the Charlotte Army Missile Plant (CAMP).

[12] SRI TR 24, Aug 61, pp. 92, 110, 112-13. RHA Bx 13-592.

[13] NH Wpn Sys Plan (Indus Op Plan), WSP-1, Annex B, Sep 61, pp. 6-7. Hist Div File.

[14] Hist Rept, NH PM, FY 1965, p. 20, & incl thereto: 2d Ind, DCSLOG, DA, to CG, AMC, 2 Apr 65, subj: Dspo of CAMP, w Memo For The CofS, fr ASA (I&L), 25 Mar 65, subj: CAMP. Hist Div File.

of Defense on 11 June 1965, and that the plant should be declared excess. The HERCULES Project Manager promptly prepared a formal objection to the proposed closeout of the plant,[15] but to no avail. Secretary of Defense Robert S. McNamara, on 8 December 1965, announced that the Charlotte Army Missile Plant was one of the excess DOD installations scheduled to be closed and put up for disposition.[16]

(U) Beginning with the conclusion of missile end item production at CAMP in May 1965, and continuing on a phaseout basis until 1 December 1966, the effort at Charlotte was limited to repair parts production, with simultaneous disposition of excess equipment. After 1 December 1966, DAC produced HERCULES spare parts at its California plants. In May 1967, the last HERCULES production equipment left CAMP, and the facility was made available for final sale or disposal on 1 July 1967.[17]

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[15] Ltr, CG, MICOM, to CG, AMC, 25 Aug 65, subj: Ltr of Xmitl, w incls: Memo for CofS, fr ASA (I&L), 13 Aug 65, subj: CAMP, and ppsd Ltr, CG, AMC, to GEN Harold K. Johnson, CSA, n.s. All atchd to SS HE-P-25, HERC PM, 25 Aug 65, subj: CAMP. Hist Div File.

[16] Hist Rept, NH PM, FY 1966, p. 4. Hist Div File.

[17] (1) *Ibid*, p. 4. (2) Ltr, CG, MICOM, to CG, AMC, undated (*circa* 25 Mar 66), subj: Rept of Excess for Real Property (CAMP), atchd to SS AMSMI-OE-21-66, Act Chf, Instl & Svcs Ofc, 22 Mar 66, subj: same. Hist Div File. (3) MICOM Hist Sum, FY 1967, pp. 103-104.

[redacted]

Ground Equipment

(U) The Western Electric Company began production of the

[19] (1) MICOM Hist Sum, FY 1967, pp. 104-105. (2) Hist Repts, NH PM, FY 1967, pp. 1-3; FY 1968, p. 6; & FY 1969, n.p. (3) Ltr, CG, Ammo Proc & Supply Agency (APSA), to CG, MUCOM, 3 Jan 67, subj: FY-67 PEMA 4911 Just - Expansion of Facs to L/A/P [*sic*] NH, M30A2 Sustainer Mtrs - LAAP, Marshall, TX, atchd to SS AMSMI-I-2, 24 Jan 67, subj: same. (4) Ltr, CG, MICOM, to CG, AMC, 21 Feb 67, subj: FY 67 PEMA 4911 Just - Expansion of Facs to L/A/P [*sic*] NH, M30A2 Sustainer Mtrs - LAAP, Marshall, TX (Proj Rev), atchd to SS AMSMI-I-16-67, 20 Feb 67, subj: same. (5) NH PM_2P, 30 Sep 67, p. 28b. All in Hist Div File.

[redacted]

Basic HERCULES ground equipment in November 1955, under Contract ORD-1562. Five months later, in April 1956, DA sought to accelerate production through the conversion of existing NIKE AJAX ground equipment to HERCULES capability. Under this 3-year program, the production of modification kits and the fabrication of new ground equipment sets were to be scheduled simultaneously at a combined maximum rate of 20 per month. Contract ORD-1876 was awarded to WECo on 25 June 1956 for conversion of the first 20 AJAX sets at an estimated cost of $41.2 million. Later in 1956, WECo submitted a proposal for conversion of 37 more sets at a cost of $40.6 million, bringing the total cost of converting 57 sets to $81.8 million. The WECo contract, however, was cancelled in December 1956, when the AJAX conversion program was suspended because of the high cost and complicated scheduling involved. Instead, a lot of 57 new HERCULES battery sets was added to Contract ORD-1562 at an estimated cost of $63.2 million. This was $18.6 million less than the price of the 57 AJAX conversions under Contract ORD-1876, representing a cost saving of about 23 percent. At the same time, 12 NIKE AJAX sets under Contract ORD-1534 were diverted to HERCULES production.

(U) After Contract ORD-1562, the launchers and associated equipment were contracted for directly with DAC under Contracts ORD-983 and ORD-1592. This eliminated WECo's overhead and profit, resulting in a sizeable cost savings. The equipment quantities and costs for the first 362 battery sets under major WECo and DAC contracts are given in Table 13. The contractor structure and flow of materiel are shown in Chart 9.[20]

Training Devices

(U) Only limited equipment was available for the early training courses on the Basic HERCULES system; however, several training devices were developed and produced for troop use. These varied in complexity from dummy missile handling trainers to intricate electronic equipment capable of exercising a NIKE battery in all tactical modes of operation. They included the XM-74 (18-B-3) warhead section trainer; the Type II missile (aft body) trainer; the XM-29 (3-G-44) booster handling trainer; and the AN/MPQ-36 (15-D-2) radar target simulator.

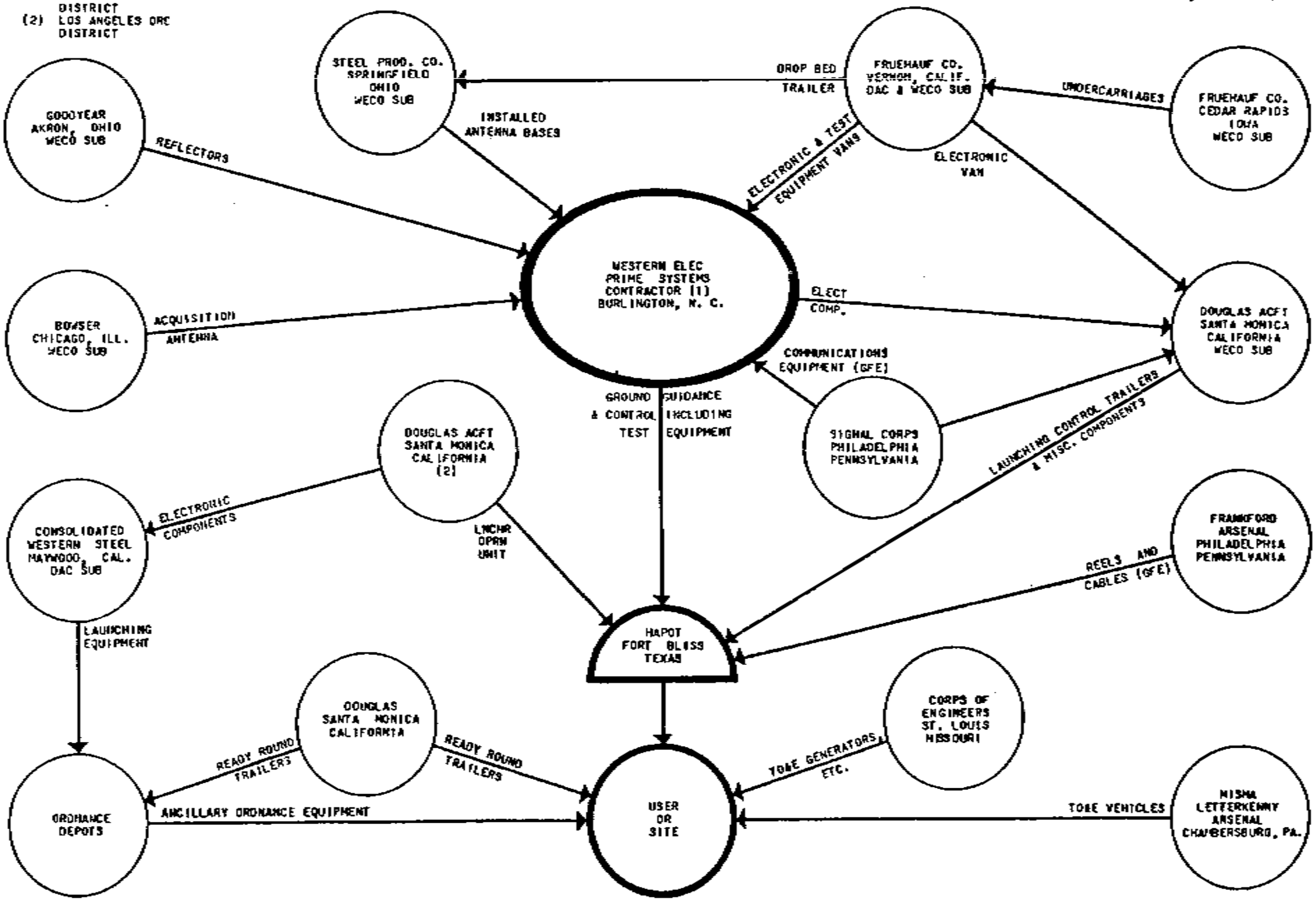
[20](1) AMP FY 1963-70, Vol. III, Mar 64, pp. 125, 129. C&DP Files. (2) SRI TR 24, Aug 61, pp. 79, 84, 114, 117, 130. RHA Bx 13-592. (3) *Also see* Mary T. Cagle, *Development, Production, and Deployment of the NIKE AJAX Guided Missile System, 1945-1959* (ARGMA, 30 Jun 59), p. 179.

COGNIZANT DISTRICTS

(1) NEW YORK ORD DISTRICT
(2) LOS ANGELES ORD DISTRICT

CHART 9. (U) NIKE HERCULES GROUND EQUIPMENT CONTRACTOR STRUCTURE.

9 SEPTEMBER 1960



UNCLASSIFIED

(U) Developed for CONARC by the Naval Training Device Center (NTDC), the XM-74 (Type X) warhead section trainer was designed as a handling and checkout device for use by launcher troops responsible for final assembly, checkout, and launching of the HERCULES missile. NTDC initially procured 225 of the warhead trainers with repair parts from the Bendix Aviation Corporation. CONARC evaluated the trainer and accepted the NTDC technical data package. In FY 1960, ARGMA procured 103 of the trainers with repair parts from Bendix, with the Picatinny Arsenal providing engineering support.

(U) The Type II missile handling trainer, developed for ARGMA by DAC, had the same weight, center of gravity, and exterior configuration as the tactical missile aft body section, and was designed to mate with the Type X warhead section trainer and the XM-29 (3-G-44) booster trainer. Its component parts, however, were not interchangeable with tactical hardware. The total contract price for the design and manufacture of 191 trainers was $718,096.

(U) An inert device which simulated the tactical HERCULES booster assembly, the XM-29 (3-G-44) booster handling trainer was used to train personnel in assembling, handling, and mating procedures. NTDC developed the trainer under direction of CONARC and made the design release to ARGMA in March 1961. Procurement of this item during the FY 1958-61 period totaled 222.[21]

(U) The 15-D-2 radar target simulator was a trailer-mounted device used with tactical missile radar systems in training operating personnel. The original 15-D-2 simulator for the NIKE AJAX operators was developed by Aircraft Armaments, Inc., and produced by the Federal Division of the International Telephone & Telegraph Corporation (ITT), under contract to NTDC (CONARC). NTDC procured 96 of these devices at a unit cost of about $96,000. On 31 March

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[21]NH Wpn Sys Plan (Indus Op), ARGMA WSP-1, Annex B, Sep 61, pp. 8-9, 22-23. Hist Div File.

1961, NTDC transferred the 96 simulators to Ordnance (AOMC/ARGMA), along with the responsibility for logistical support and future procurement. Spare parts to support these devices were provisioned in the amount of approximately $3.5 million, and the parts were distributed to Ordnance field support units. During this phase of the program, the 15-D-2 simulator was renamed the AN/MPQ-36.

(U) Owing to the excessive effort required to connect and disconnect the AN/MPQ-36 when going from a non-tactical to a tactical situation, a requirement was established for a quick-disconnect kit to enable the device to be disconnected from the AJAX in a matter of 2 or 3 seconds. Ninety-six of the NIKE AJAX quick-disconnect kits were procured from ITT, and ARGMA later had a HERCULES quick-disconnect capability incorporated in the kits. However, when the AN/MPQ-36 simulator was connected to the NIKE HERCULES system, it would only train in the AJAX mode of operation. In view of the urgent training requirement for HERCULES operators, ARGMA, in mid-1961, prepared a procurement package for updating the AN/MPQ-36 to handle more advanced targets than those confronted by the short-range AJAX. The contract for updating the simulator for Basic and Improved HERCULES application was awarded to Aircraft Armaments, Inc., on 28 December 1961. As an interim measure, pending completion of the AN/MPQ-36 updating program, a second contract was awarded to ITT to provide Annual Service Practice (ASP) live missile firing capabilities to 10 of the existing simulators.[22] The consummation of these contracts extended into the Improved HERCULES phase of the program and will be discussed in the succeeding chapter.

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[22](1) *Ibid.*, pp. 9-10, 23. (2) NH Prog Repts, Apr 60, p. 33, & Jan 62, p. 7. (3) ARGMA Hist Sum, 1 Jan - 30 Jun 60, pp. 68-69. (4) ARGMA Diary, 1 Jul 61 - 11 Dec 61, p. 234. (4) NH PM_2P, Ch 5, 30 Sep 64, p. 3. All in Hist Div File.

Training and Deployment

(U) The tactical battery sets of Basic HERCULES equipment were distributed between the U. S. Army and countries in the Military Assistance Program (MAP), with the Army receiving about two-thirds of the total. The deployment phase of the Basic HERCULES system was considered to start in November 1956, with the initiation of formal guided missile school courses, though key personnel training began some 9 months earlier. The time required for deployment of authorized U. S. Army batteries, including the necessary training, site construction, and emplacement of equipment, covered a period of about 5 years. The last tactical Army battery became operational in the fourth quarter of CY 1961. The deployment of MAP batteries began in September 1958 and continued into 1962.

Training Program

(U) Key Personnel Training. The key personnel training phase began in February 1956 and continued on an intermittent basis until about the end of 1957, at which time training courses were initiated on the Improved HERCULES system. Training of key personnel, which was conducted at the Ordnance Guided Missile School* at Redstone Arsenal, Alabama, consisted of courses for selected depot and field maintenance personnel and served as a means of training school specialists for the operational training center at Fort Bliss, Texas.

(U) Air Defense School Training. The service school training, which marked the start of the deployment phase, was composed of formal classroom study for military personnel who eventually were to operate and maintain the deployed system. Formal training of specialists began in November 1956, about 16 months before

*Renamed the Army Missile & Munitions Center & School (AMMCS) effective 1 January 1966. DAGO 43, 28 Dec 65.

the start of package training. The leadtime involved in this phase was based on the longest course offered by the Army Air Defense School at Fort Bliss; i.e., maintenance of electronic equipment. This training continued until about August 1961, when the specialists were integrated into the last package unit.

(U) Troop Trained Specialists. The enlisted men who were to operate the equipment (as distinguished from maintenance personnel) were trained in both classroom and on-the-job study at the First Guided Missile Brigade at Fort Bliss. Classes started in late March 1958 for the first package of the conversion program, and continued into the third quarter of CY 1961. The period covered by this phase varied from 4 weeks for conversion packages to 8 weeks for new packages.

(U) Package Training. Package training activities, which included missile firings, required 8 weeks of instruction at the First Guided Missile Brigade at Fort Bliss. At this point in the training cycle, troop trained specialists and school trained personnel were combined into a unit through formal and informal training on their own battery equipment just before deployment to the completed tactical site. Package training for U. S. batteries started in April 1958 and continued until about September 1961, at which time the equivalent of 191 battery packages of active Army units completed courses at the Fort Bliss facility. Package training for MAP batteries commenced in October 1958 and continued into 1962.[23]

The HERCULES-BOMARC Controversy

(U) In September 1958, shortly after initial deployment of

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[23](1) SRI TR 24, Aug 61, pp. 139-42, 227-30, 253. RHA Bx 13-592. (2) For further details on the administration and execution of the training program for the NIKE AJAX and HERCULES systems, *see* NIKE Blue Book, pp. 220-43.

the HERCULES, a feud erupted between the Army and Air Force over the respective merits of the NIKE HERCULES and BOMARC missiles and the role of each in continental air defense.[24] At that time, the first Basic HERCULES batteries had just become operational at converted AJAX sites in the Washington-Baltimore, New York, and Chicago defense areas, and construction was already completed or underway on numerous other sites. The HERCULES-BOMARC dispute, which paralleled the bitter JUPITER-THOR rivalry, came to a head in September 1958, when LTG Charles E. Hart, then Commanding General of the Army Air Defense Command, complained to the Secretary of Defense that wherever the HERCULES was installed, Air Force people leaked false stories about the relative merits of the system as it compared to the BOMARC. He called attention to a number of newspaper articles comparing the two weapons, with the strong implication that the BOMARC would or should eventually replace the HERCULES. Indeed, one such article stated that Air Force officials were calling for replacement of Army NIKE sites

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[24] This HERCULES-BOMARC feud was actually a continuation of the controversy that began some 5 years earlier. It started back in April 1953, when the Army took the wraps off the NIKE AJAX and announced plans to begin its deployment around U. S. cities. The Air Force inadvertently let slip a drawing of its BOMARC missile and the battle in the nation's press began. (*Aviation Week*, 6 Apr 53, p. 15.) In the ensuing years—while the AJAX stood on guard around key U. S. cities and overseas installations and the BOMARC remained in development—the Army was constantly faced with defending the AJAX, as well as the second-generation HERCULES system, against disparaging remarks released to the press by Air Force officials. Secretary of Defense Charles E. Wilson put the whole controversy in proper perspective when he declared: "But one hard, solid fact emerges above them all: No matter what the Nike is or isn't, it's the only land-based operational anti-aircraft missile that the U.S. has." (*Newsweek*, 11 Jun 56, p. 35.) Among other periodicals carrying stories of the controversy were *Aviation Week*, 6 Dec 54, 20 Dec 54, 28 May 56, 4 Jun 56; *Business Week*, 8 May 54; *Life*, 4 Jun 56; and *Popular Science*, Sep 56. *Also see* Hearings Before the Subcommittee of the Committee on Appropriations, House of Representatives, 85th Congress, 1st Session, DOD Appropriations for 1958, Part 2, 28 Feb 57, pp. 1367 - 1372.

surrounding Chicago with BOMARC bases. Convinced that this was a carefully organized campaign aimed at discrediting the military value of the HERCULES, the Department of the Army took up the challenge in a spirited public information program known as Project TRUTH.

(U) Briefly, the Air Force view was that the BOMARC was an area defense weapon, while the HERCULES was a point defense weapon, and that area defense was better than point defense. Top Air Force missilemen argued that the HERCULES was inherently a short-range weapon designed to reach a maximum of 100 miles but was more likely to cover about 85; that it was useless against low-flying aircraft; and that it could not differentiate between friend and foe. On the other hand, the 200-mile BOMARC, they claimed, was an all-altitude weapon that could be stationed in combat readiness by June 1961. Since the radar detection net for the BOMARC, unlike the NIKE, would be linked directly with the early warning system in Canada, they argued that it was much less likely to fire on friendly planes. Moreover, they contended that the 400-mile version of the BOMARC then being tested would have much greater growth potential than the HERCULES.

(U) The Army proponents countered the Air Force claims and arguments with general statements on the capabilities of the NIKE HERCULES and its proven growth potential, emphasizing that the weapon system was already operational and in the hands of our air defense forces. On the other hand, they pointed out, the BOMARC was not yet operational, its reliability was very low (something on the order of 25 percent of the proven reliability of the HERCULES), and its altitude range was distinctly limited because of its air-breathing engines. So far, they said, about $1 billion had been spent on the BOMARC and it was still some 3 years away from an operational status. This was more than twice the amount spent on the entire NIKE family and the land-based TALOS, a Navy weapon which the Army was evaluating. As for the alleged lack of aircraft identification by the HERCULES radar, the Army pointed out that the Army air defense units were to shoot down only those targets picked out for them by the North American Air Defense Command, which was then headed by GEN Earle E. Partridge of the U. S. Air Force. Alluding to the criticism that the HERCULES provided point defense as opposed to area defense, the Army asserted that the area of coverage of the NIKE HERCULES was actually about 20,000 square miles—quite a large point.[25]

(U) In truth, the HERCULES and BOMARC were different systems designed for different air defense tasks; one for long-range area defense, the other for defense of close-in city or metropolitan areas. In recognition of this and the requirements of the defense in depth concept proposed by the Joint Chiefs of Staff and Commander-in-Chief of the Continental Air Defense Command, Secretary of Defense Neil H. McElroy announced that the procurement and deployment of both systems would be continued, and ordered an end to the interservice bickering. The defense in depth concept adopted by the Defense Department involved the use of manned interceptors, pilotless interceptors of the BOMARC type, and shorter range missiles of the NIKE family supplemented by the HAWK low-altitude defense system. Under this concept, invading aircraft would be subjected to continuous attack of increasing severity as they approached critical target areas. Aircraft detected by the early warning system in Canada would first be attacked by manned interceptors, then by BOMARC guided missiles. Enemy aircraft succeeding in penetrating the BOMARC line would come under attack by the HERCULES and HAWK systems, as well as manned interceptors and BOMARC missiles. The HERCULES and BOMARC

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[25] (1) DA Msgs 364169, 9 Sep 58, 364294, 10 Sep 58, 364418, 11 Sep 58, 364417, 12 Sep 58, subj: Proj TRUTH. Hist Div Files. (2) *Army-Navy-Air Force Register*, Vol. 79, No. 4111, 20 Sep 58.

normally would be assigned targets by the Semiautomatic Ground Environment (SAGE) system. The BOMARC was dependent on the SAGE system, while the HERCULES could be operated autonomously; i.e., it had its own control system and could operate with or without SAGE.[26]

Changes in Army Requirements

(U) The DOD decision to deploy both the HERCULES and BOMARC systems ended the interservice fuss over their military value. But it left open the question of how much of the shrinking defense budget should be spent on the two weapons, and the rivalry continued in the annual battle for funds. Congress soon made it clear that it liked neither of the programs and indicated that it would take more of a hand in actual programming of military production if the Secretary of Defense did not take a firmer stand to eliminate interservice rivalries and what it considered duplicate development of equipment. In the end, Congress cut FY 1960-61 appropriations for both programs below the levels requested by DOD, with the Army's HERCULES playing the familiar role of the underdog.[27]

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[26] (1) *U. S. News & World Report*, Vol. XLV, No. 12, 19 Sep 58, p. 10. (2) *Army Navy Air Force Journal*, Vol. 96, 8 Nov 58, p. 287. (3) *Also see* DOD News Release, undated (*circa* mid-Sep 58), subj: Questions & Answers: HERCULES-BOMARC (Appendix C).

[27] (1) Ltr, CG, AOMC, to ARGMA Comdr, *et al.*, 27 May 59, subj: NH Const. Hist Div File. (2) *Missiles and Rockets*, 10 Aug 59, p. 44; 18 Jan 60, pp. 7, 24; & 1 Feb 60, pp. 7, 11.

[redacted]

Site Construction for CONUS Defense Areas

(U) The Basic HERCULES system was employed in fixed or permanent CONUS defense sites and in semimobile sites for the field army air defense role. Most of the CONUS sites used permanent structures and underground launchers, making fewer vehicles necessary. The semimobile site had no permanent facilities and required a greater number of vehicles and trailers. The equipment used in a HERCULES site was located in three distinct areas: the battery control area, the launching area, and

[28] SRI TR 24, Aug 61, pp. 147, 150. RHA Bx 13-592.

[29] (1) *Ibid.*, pp. 144-46. (2) NH Sys Configuration Sta Repts. Maint Engrg Div, Dir for Maint Files.

the assembly area. The minimum space requirement for the battery control area was about 370 by 880 feet. The launching area was the largest of the three main areas, needing a minimum of 130 acres for a semimobile and 43 acres for a permanent CONUS site. A typical launching area for a permanent site contained three underground magazines, each having four launchers, missile assembly and warhead storage areas, and billets for the crew. The siting requirements for the assembly area were not critical to the operation of the unit; however, because of safety factors, the area had to be a minimum of 150 feet from the nearest launcher.[30]

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[30] (1) SRI TR 24, Aug 61, pp. 37-39. RHA Bx 13-592. (2) AMC TIR 2-3-1(4), Aug 63, p. 9. RSIC.

Organization and Deployment of Tactical Units

(U) The organizational unit of HERCULES was the battalion, which generally consisted of four battery sets of three firing sections, each with four launchers. The CONUS missile battalion Table of Organization & Equipment (TOE 44-545T) called for a HERCULES system of 25-percent mobility, with transportation including only the minimum required for administrative purposes. The personnel requirement for a CONUS battalion at full strength (Headquarters & Headquarters Battery and four Missile Batteries)

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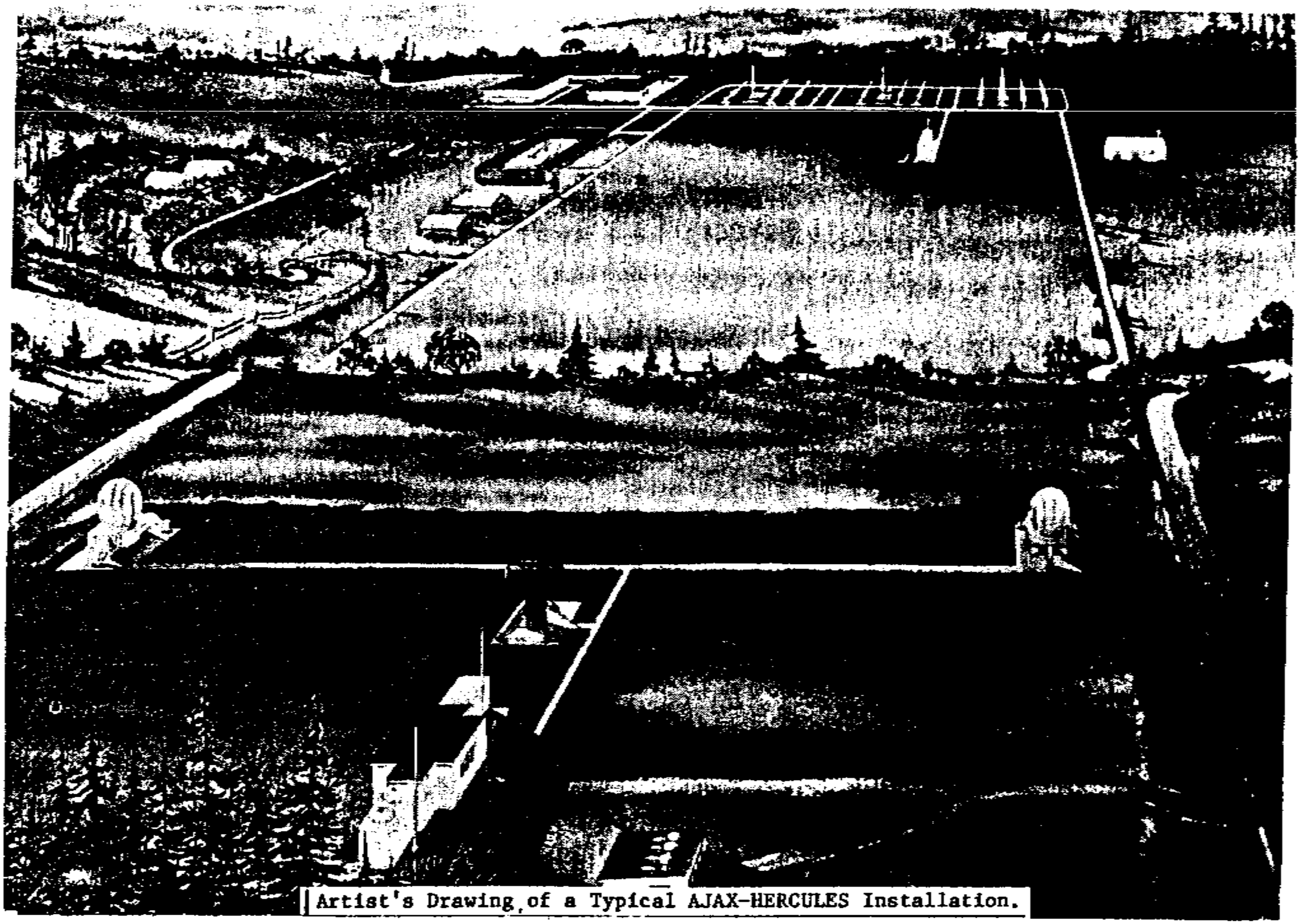
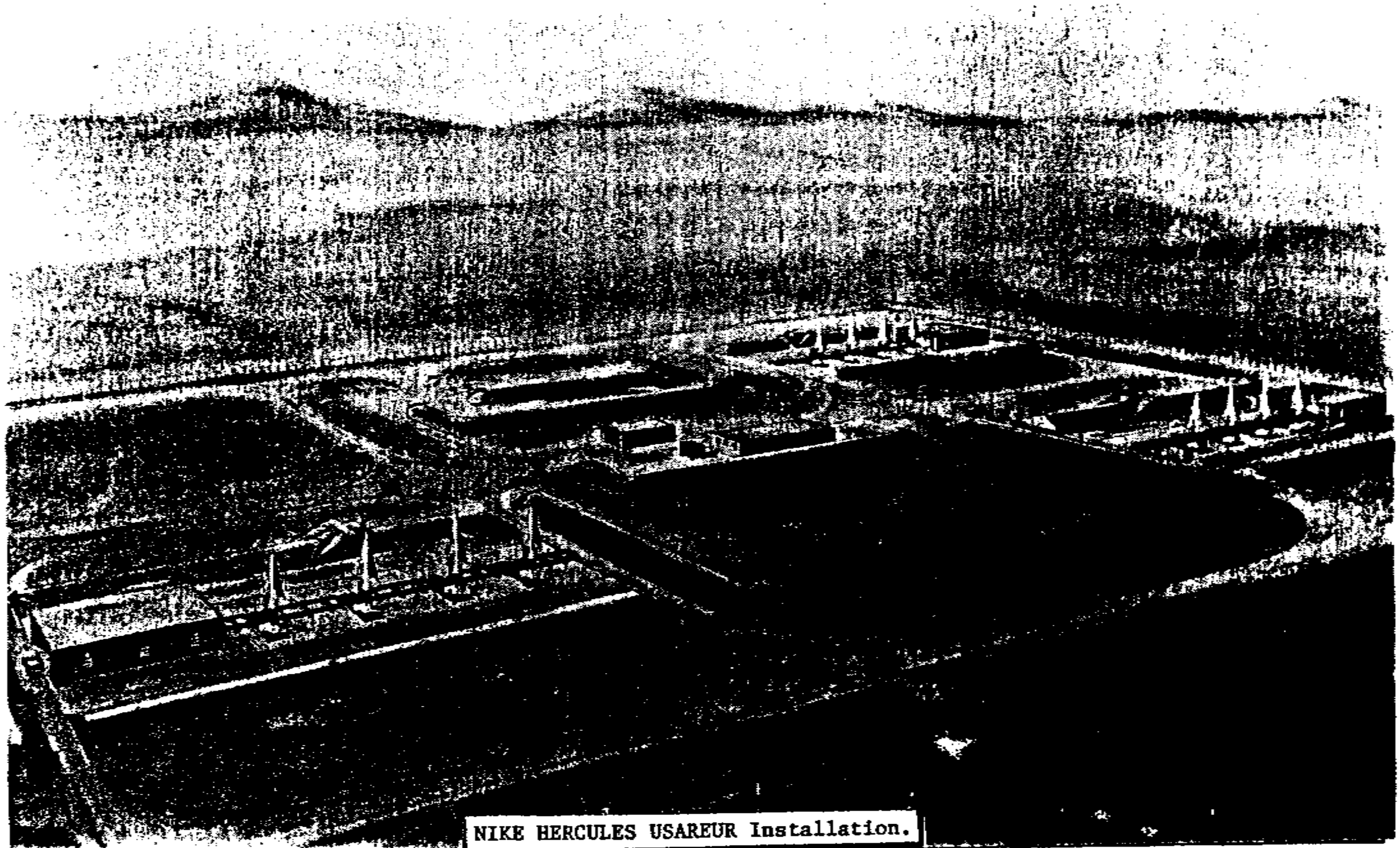
[31] (1) *Ibid.*, p. 9. (2) SRI TR 24, Aug 61, pp. 142, 231-35. RHA Bx 13-592. (3) NIKE-AJAX to NIKE-HERCULES Site Conversions, atchd as Incl 3 to DF, Cmt #2, Dir, Fld Svc Ops, to Chf, ARGMA Con Ofc, 19 May 61, subj: Comd Presn on the NH Program. Hist Div File. (4) *Also see* above, p. 90.

[32] For a complete list of the converted CONUS sites, *see* Appendix D, Table I.

[33] (1) SRI TR 24, Aug 61, pp. 142, 237-38. (2) For a complete list of the new CONUS sites, *see* Appendix D, Table II.



Artist's Drawing of a Typical AJAX-HERCULES Installation.



NIKE HERCULES USAREUR Installation.

[redacted]

totaled 554 (507 enlisted men and 47 officers).

(U) The field army missile battalion (TOE 44-535T) called for a HERCULES system with maximum mobility and transportation allowances. Personnel requirements for a full-strength field army battalion totaled 703 (652 enlisted men and 51 officers).[34]

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[34] SRI TR 24, Aug 61, pp. 37, 39-40. RHA Bx 13-592.

[35] (1) *Ibid.*, pp. 144, 239-42. (2) NH Sys Configuration Sta Repts. Maint Engrg Div, Dir for Maint Files. (3) For specific operational dates, *see* Appendix D, Tables I & II.

[36] NH Sys Configuration Sta Repts. Maint Engrg Div, Dir for Maint Files.

Japanese Co-Production Program

(U) In July 1965, a joint HAWK/HERCULES MICOM team, including contractor personnel, visited the Military Assistance Advisory Group in Tokyo to discuss possible co-production programs for both systems with the Japanese Government. Since 1959, the Douglas Aircraft Company had been actively pursuing co-production of NIKE equipment with Japanese industry, with complete approval of the DOD International Logistics Negotiator. The HAWK contractor had also engaged in such discussions, though in a more recent time-frame. During the July co-production meeting in Japan, it became evident that no clear-cut statement of U. S. policy relating to co-production was available, and that such guidance was essential to the initiation of formal Government-to-Government negotiations. That industry-to-industry talks had progressed far beyond the status of any Government-to-Government agreement became obvious after the July meeting, when representatives of the Mitsubishi Heavy Industries Co., Ltd., visited the United States to discuss co-production with Douglas Aircraft and other contractors.

(U) In a letter recommending the establishment of a DA policy group to formulate U. S. Government policy for co-production programs, the Commanding General of MICOM pointed out the many risks and inherent problems involved in authorizing any government to produce such highly technical and sophisticated weapons as the HAWK and HERCULES. MICOM, he said, had experienced thousands of problems with its breakout program, which was limited to U. S. manufacturers. And, while attempting to obtain alternate sources to eliminate dependence on the system prime contractor, the Command had found that all manufacturing and testing know-how was not transferable. In short, if manufacturing was to be on a co-production basis, "it must be established which government or agency has the responsibility for insuring that the end product is in fact a HERCULES or HAWK Weapon System."[37]

(U) In February 1966, a DOD team, including DA Staff and MICOM members, presented proposals for barter, sale, or co-production of additional HERCULES battalions. Then, in May, a military survey team from the Japan Defense Agency Air Staff Office toured HERCULES production facilities in the United States. A DOD team planned to visit Tokyo for further negotiations in June 1966; however, political considerations in Japan at that time delayed the meeting until May 1967. During talks held on 9 May, a DOD official completed preliminary arrangements with the Japan Defense Agency for co-production of the HERCULES missile and purchase of the required ground equipment from the United States. The missile, to be called the *NIKE J* (*J* for Japan), would be converted to carry only conventional warheads and would be manufactured by the Mitsubishi Heavy Industries Company, Ltd., under a licensing contract with the McDonnell Douglas Corporation.[38]

(U) Final negotiations between the Governments of the United States and Japan began in July and continued until 13 October 1967, when a memorandum of understanding was signed for co-production of HERCULES and HAWK missiles and purchase of related ground equipment.[39]

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[37] SS HE-P-26, HERC Proj Ofc, 8 Sep 65, subj: Co-Pdn Plcy, w Ltr, CG, MICOM, to MG Selwyn D. Smith, Jr., CofS, AMC, 8 Sep 65, n.s. Hist Div File.

[38] (1) Hist Repts, NH PM, FY 1966, p. 5; FY 1967, p. 3. Hist Div File. (2) "Mitsubishi To Build Missiles," *Technology Week*, 5 Jun 67, p. 19. (3) The Douglas Aircraft Company, original producer of the HERCULES, merged with the McDonnell Aircraft Company in 1967.

[39] (1) Hist Rept, NH PM, FY 1968, p. 4. Hist Div File. (2) A Japanese defense official, frustrated and "very much confused" over troubles encountered during the U. S.-Japanese talks, killed himself on 7 October by lying down in front of a speeding passenger train at a busy Tokyo station. Mikio Morita left a note in which he apologized for the difficulties which arose during the negotiations. The *Washington Post*, 8 Oct 67, p. A23.

In November 1967, DOD assigned the Department of the Army as executive agent to implement the program, and designated AMC as the agency responsible for implementation. AMC, in turn, designated the NIKE HERCULES Project Manager as the U. S. project manager for the program and authorized the formation of a liaison office in Japan. A MICOM team, visiting Tokyo in January 1968, concluded a support agreement for a field office.[40] The MICOM Field Office, Japan, was a provisional unit of the Command from 15 February 1968[41] to 15 April 1968, when AMC approved its establishment. Its mission was to represent MICOM and designated project managers in the implementation of the memorandum of understanding relating to Japanese co-production of designated U. S. Army missile systems and related control systems. The office would serve as the in-country point of contact for DOD elements and the Japan Defense Agency in the coordination of matters included in the memorandum of understanding and other instructions.[42]

(U) The MICOM Field Office's coordination actions relating to the initial sales cases for HERCULES equipment were severely hampered by a lack of personnel and by restrictions on temporary duty abroad. DCSLOG approval of the field office, in March 1968, had been contingent upon Japan's agreeing to pay the costs of the office. The Japan Defense Agency, however, refused to bear this cost. The MICOM Project Managers' agreements with the U. S. Army, Japan (USARJ) and the Military Assistance Advisory Group (MAAG), Japan, to furnish administrative and logistics support, office space, and housing, remained in effect through 30 June 1969. On 26 February 1969, DA assigned COL Edward L. Smith as chief (and sole member) of the MICOM Field Office effective 23 May 1969.

[40] Hist Rept, NH PM, FY 1968, p. 4. Hist Div File.

[41] AMC GO 11, 8 Feb 68.

[42] AMC GO 45, 12 Jun 68.

Colonel Smith arrived at his post on 26 August 1969, following a period of orientation in preparation for the assignment.[43]

(U) The Japan Defense Agency, on 28 June 1968, signed the major sales cases for HERCULES ground equipment, totaling $37.9 million, which were included in the 13 October 1967 memorandum of understanding. Japan later accepted a $3,000 sales case for inspection services, which was forwarded from MICOM on 23 August 1968. The aforementioned failure to staff the Field Office in Japan led to a consolidated sales case to cover all MICOM projects (i.e., NIKE HERCULES, HAWK, and related air defense control systems). MICOM forwarded the consolidated sales case to AMC, where it was divided into three cases. A general meeting in Washington, on 15 October 1968, resulted in the decision to send a MICOM team to Japan to survey support requirements. However, when the team departed in November, a DCSLOG representative headed it, and its mission was to sell the sales cases for support of the program. The Japan Defense Agency did not consider reimbursement for all support to be proper, and indicated a willingness to pay only for limited services which they would request.

(U) The HERCULES Project Manager, on 30 September 1968, completed primary contractual action to support the initial sales cases for HERCULES ground equipment. The first shipment of classified hardware left for Japan in March 1969, using a military escort at contractor expense.[44]

(U) Meanwhile, the production of HERCULES missiles in Japan continued on schedule, with resident U. S. contractor personnel providing technical assistance. Fifteen missiles were produced and accepted in FY 1970 and 108 in FY 1971. During October and

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[43](1) Hist Repts, NH PM, FY 1968, p. 4; FY 1969, n.p.; & FY 1970, n.p. Hist Div File. (2) MICOM Hist Sum, FY 1969, p. 69.

[44]Hist Rept, NH PM, FY 1969, n.p. Hist Div File.

November 1970, a Japan Defense Agency team conducted a highly successful flight test program of nine missiles at McGregor Range, New Mexico, with Fort Bliss and the HERCULES Project Office providing support. By 30 June 1971, the resident contractor technical assistance personnel had completed their tours in Japan and returned home.[45] With the initiation of ground systems overhaul in FY 1971, other U. S. contractor personnel rendered the necessary short-term technical assistance. The U. S. Government provided extensive documentation under foreign military sales to support the overhaul. Problems encountered primarily concerned the continued availability of materials and parts from the United States to support both missile production and overhaul.

(U) The first expansion of production in Japan under terms of the 1967 agreement came in FY 1971, when Japan bought depot test equipment and agreed to manufacture other test sets.[46]

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[45]Hist Repts, NH PM, FY 1970, n.p.; & FY 1971, p. 4. Hist Div File.

[46]*Ibid.*, p. 4.

CHAPTER VI

(U) ~~(C)~~ THE NIKE HERCULES IMPROVEMENT PROGRAM (U)

(U) Contrary to the Air Force's claim that its BOMARC missile would have greater growth potential than the HERCULES, it was the HERCULES, rather than the BOMARC, that truly exhibited the capability of keeping pace with the changing air threat without the need for developing a brand new weapon. The BOMARC A missile, which was in final development during the 1958-59 controversy, was phased out as a tactical weapon in the mid-1960's and replaced by the new BOMARC B missile whose launching and control operation was still dependent on the expensive SAGE system and whose altitude was still limited by its liquid propulsion system.[1] In contrast, the Basic HERCULES missile and launching area equipment, which reached the field in 1958, was still in tactical use 14 years later, and the basic ground guidance and control equipment had been progressively updated to meet the advancing air threat through a series of field modifications. Indeed, modification kits for the first such improvement were already in production at the time of the HERCULES-BOMARC controversy, and the first tactical Basic HERCULES battery was retrofitted in June 1961, the scheduled combat readiness date of the first BOMARC system.

Program Philosophy and Military Requirements

(U) The peculiarities of air defense weapons, in general, and the NIKE HERCULES, in particular, dictated a radical departure from the usual policies governing engineering efforts following basic system deployment and cessation of major production. Most

[1] *Aerospace Technology*, 1 Jan 68, p. 39.

land-based weapons can be said never to lose their complete effectiveness, because their primary targets do not change appreciably. For example, a World War II artillery piece can still perform its major function; a REDSTONE or CORPORAL missile, however cumbersome to operate, may still destroy an enemy installation; and an obsolete rifle served to slay a President of the United States. In the case of a complex, electronically controlled air defense weapon, however, a breakthrough in countermeasure technology or even a major improvement in aircraft or countermeasure techniques may render the system completely ineffective. It is, therefore, never feasible to freeze the design of an air defense system until its imminent replacement by a follow-on system is assured. Moreover, research and development of system improvements to stay abreast of the state of the art must be undertaken as a parallel effort with the basic program, so that tactical hardware will be available to cope with the new threats as they materialize.

(U) In recognition of these factors, DA established requirements for the HERCULES improvement program at the very outset of basic system development in 1954. Guidance for the conduct of the NIKE program, set forth in a directive to OCO on 23 October 1954, stated:

. . . Concurrent with the prosecution of the NIKE I and NIKE B programs, studies and research and development must be conducted to insure that the NIKE equipment is modernized to the maximum extent within the limits of current technology and economics of improvement as compared to investment in a new system. . . .

Specific guidelines adopted for the program called for studies and research and development dealing with (1) targets to be expected in the 1960-1970 timeframe and means of improving system performance against these targets; (2) modifications required to improve the effectiveness of the basic system against low-altitude targets and against formations without the use of atomic warheads; and (3) improvements in kill effectiveness and target traffic handling ability.[2]

Feasibility Studies

(U) Early in 1955, just as the Basic HERCULES missile development flight tests began, BTL initiated a research study to determine the feasibility and practicability of providing a fundamentally improved antiaircraft system. Using this research and experimental work as a point of departure, BTL, in early 1956, re-examined the HERCULES system capabilities and made a detailed study of the precise modifications required to obtain adequate performance against the predicted threat of the 1960-65 period. In general, the expected threat centered around manned and unmanned aerodynamically supported vehicles, varying from comparatively large to very small radar cross sections and having velocities up to Mach 3 or more and large electronic countermeasure (ECM) capabilities. The Intermediate Range Ballistic Missile (IRBM) and Intercontinental Ballistic Missile (ICBM) also posed a threat; however, earlier studies indicated that it was undesirable to modify the HERCULES to combat these, because only limited capability could be obtained at a relatively high cost. Moreover, the third-generation NIKE ZEUS system was commissioned to solve this problem. The HERCULES improvement studies, therefore, were directed primarily at targets with high levels of ECM and at aerodynamically supported missiles and aircraft.

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[2] DF, Cmt #1, DCSLOG to CofOrd, 23 Oct 54, subj: Guidance for Conduct of the NIKE Program. Atchd to OTCM 35654, 30 Dec 54. RSIC.

(U) To achieve a system for defense against these targets, BTL proposed to develop vastly improved ground guidance and control equipment which would be employed with the Basic HERCULES missile. Essentially, three significant improvements were proposed to give the Improved HERCULES system the required threat handling capability. They were (1) the addition of a new L-band High Power Acquisition Radar (HIPAR) to detect small, high-speed, non-ballistic targets; (2) improvements to the existing X-band TTR to increase range performance; and (3) the addition of a Target Ranging Radar (TRR) operating in a very wide, fairly new frequency band to provide range information in a heavy ECM environment. The HIPAR and improved X-band TTR would extend the detection and tracking range of the system, thereby allowing sufficient time to achieve the required number of intercepts against the small cross section, high-speed threat. The new TRR would be slaved to the target tracking radar and have the function of providing target range information when the range-determining ability of the TTR was impaired by enemy electronic countermeasures. The development of a seeker-equipped missile was considered as a means of improving performance against low-flying aircraft at long ranges; however, this improvement was not adopted because of time and cost factors.[3]

(U) Since the proposed program was an improvement to the Basic HERCULES system, with changes confined to the ground guidance area, no detailed MC's were prepared. Instead, CONARC

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[3](1) Army Ord Tech Ln Rept for Feb 55, BTL/Whippany, pp. 19-20. RHA Bx 13-595. (2) BTL Rept 27675-W5-2394, 1 Oct 56, subj: NIKE B Imprv Study. RSIC. (3) BTL/DAC Rept, NH Sys & Adv Design NH Sys Presn at Ft Bliss, 6 Feb 58, pp. 14-17. Hist Div File.

and ARADCOM both concurred in BTL's feasibility study on the improved equipment; and DA approved the proposed development program following a BTL presentation on 24 August 1956.[4]

The Improved HERCULES System

(U) In developing the Improved NIKE HERCULES system, which constituted the first of several phases of the improvement program, the WECo-BTL team capitalized on the inherent growth potential of the basic system by adding to it the aforementioned new and modified ground guidance equipment to increase its capabilities. This equipment was to be supplied in the form of modification kits which could be applied either to systems in production or to field-emplaced batteries with a minimum of down time. The plan was to procure one set of modification kits for each basic tactical system and one set for each four non-tactical systems. The program was implemented as shown in Chart 12.

(U) WECo continued HERCULES development under the basic R&D contract (ORD-1082) until 1 June 1963, when this contract was replaced by DA-30-069-AMC-189(Z). Except for the addition of the General Electric Company as the principal subcontractor for the new L-band HIPAR, the contractor structure remained essentially unchanged (*see* Chart 13). The only new facilities required for the manufacture of improved equipment consisted of a $5 million expansion of the Tarheel Ordnance Plant for production of magnetron tubes.[5]

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[4] (1) BTL Rept 27675-W5-2394, 1 Oct 56, subj: NIKE B Imprv Study. RSIC. (2) ARGMA Rept, INH DCR, 2-4 Jun 59, p. 8-1. Hist Div File.

[5] (1) NH Msl Sys Plan (Improved), ARGMA MSP-1, 15 Oct 58, pp. A-1, C-3, C-5, D-5, D-11, E-1 thru E-5. (2) NH Prog Rept, Oct 61, p. 2-A. Both in Hist Div File. (3) BTL Smanl Prog Rept for Pd Ending 1 Nov 63, NH AAGM Sys, p. v. RHA Bx 13-342.

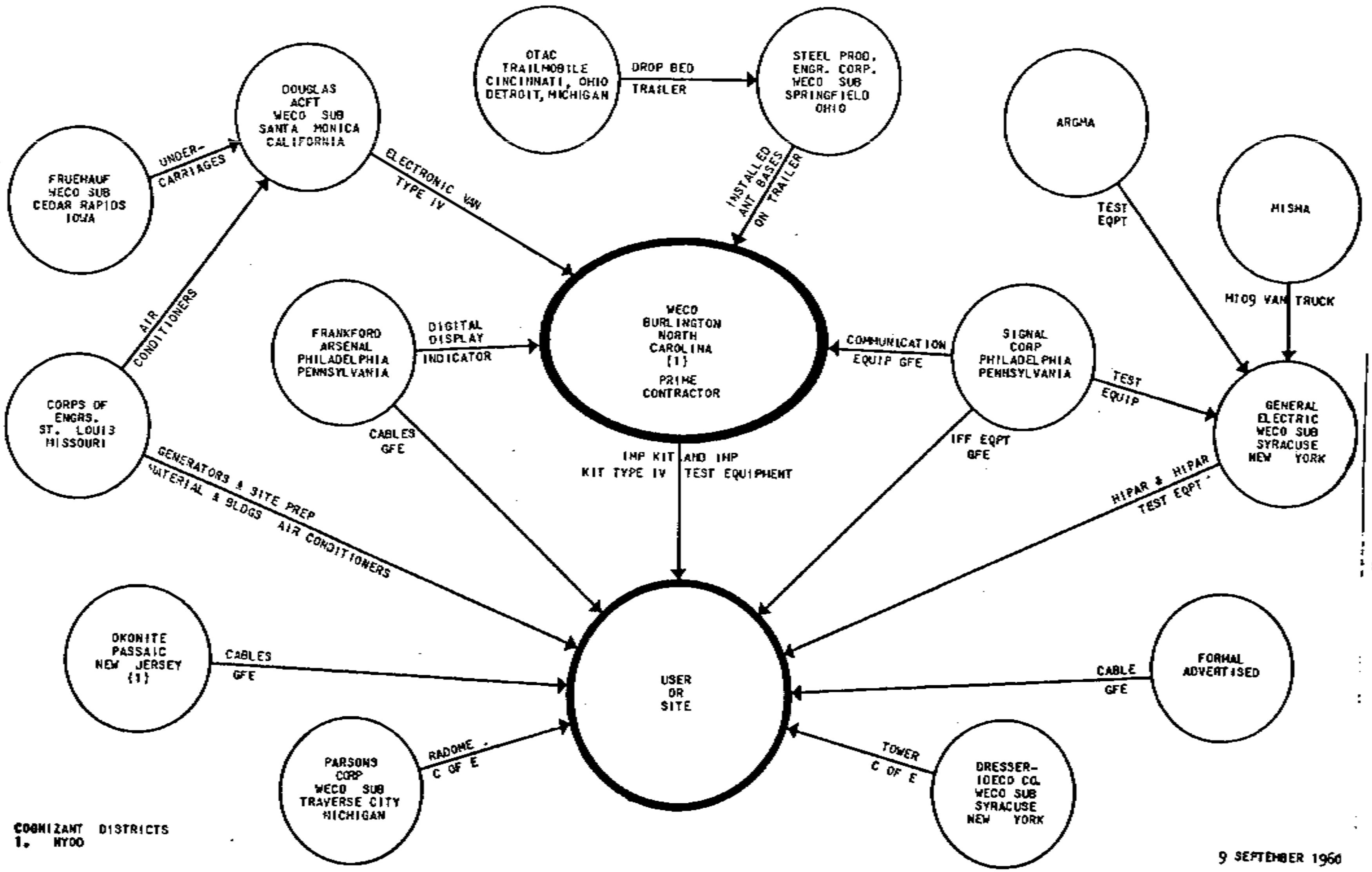

CHART 13. (U) NIKE HERCULES (IMPROVED) GROUND EQUIPMENT CONTRACTOR STRUCTURE

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Development and Production

(U) The engineering design of the improved equipment was completed in FY 1957 and the R&D drawings were released in 1958 for the procurement of one prototype set for use in the R&D test program. As stated earlier, this prototype equipment was produced under a supplement to WECo's Contract ORD-1447 at a cost of $6,771,500.[6] The improvement kit was classified as Limited Production (LP) in May 1959,[7] and the classification was renewed thereafter until FY 1964, when the kit became Standard A.[8]

Prototype Evaluation Tests

(U) In 1959, BTL conducted tracking tests of the prototype equipment at its Whippany plant, using a rented propeller-driven aircraft as a target. These experiments ended on 11 December,

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[6] *See* above, pp. 117, 119.

[7] OTCM 37075, 14 May 59. RSIC.

[8] (1) OTCM's 37548, 29 Sep 60; 37948, 14 Dec 61. RSIC. (2) Hist Rept, NH PM, FY 1964, p. 1. Hist Div File.

[9] SRI TR 24, Aug 61, p. 130. RHA Bx 13-592.

[10] (1) Procurement and production figures supplied by Sam Burns, ADSIMO, & Richard McPherson, Msl Sys Div, Dir for Mat Mgt. (2) *See also* NH PM_2P, 30 Sep 69, pp. 31-32. Hist Div File.

[redacted]

with a series of tests to check the instrumentation performance of the improved system. By the end of 1959, the HIPAR antenna and radar units had been installed at WSMR Area 3 and power-on tests were in progress preparatory to the upcoming evaluation flight tests.[11]

(U) Final checkout and tracking tests began at WSMR early in 1960. The prototype system was transferred to Government control on 31 March and the test program continued as a joint responsibility of Ordnance and the user, under BTL's direction. In accordance with the test plan (AOMC TP-5), arrangements were made for flight tests to exercise the improved system in all principal modes of operation against the highest performance targets available. Among these were engagements of HERCULES target missiles fired from the ZEUS Uprange Facility (ZURF). Located at Stallion Site about 90 nautical miles uprange from WSMR Area 3, this installation included a Basic HERCULES system modified to provide improved guidance control for the HERCULES target missiles. On 18 March 1960, Army personnel fired an AJAX missile in a successful test of ZURF. This was followed, on 8 April 1960, by the firing of a HERCULES missile from ZURF in a successful tracking and acquisition test of the defending Improved HERCULES system at WSMR Area 3. The *enemy* HERCULES missile was observed by the HIPAR and successfully tracked by the target tracking radar throughout the mission.[12]

(U) Evaluation of the Improved HERCULES prototype system, using a production model of the basic launching and handling equipment, began at WSMR on 14 April 1960 and continued through 13 April 1961. Nineteen firing tests (17 HERCULES and 2 AJAX) were performed during the evaluation, 16 of which were fully

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[11]ARGMA Hist Sum, CY 1959, pp. 97-98.

[12]BTL Smanl Prog Rept for Pd Ending 1 May 60, NH AAGM Sys, pp. 2, 38, 41, 43. RHA Bx 13-592.

[redacted]

successful and two qualified successes (intercept precluded by target malfunction). The one unsuccessful test was marred by missile beacon failure. Military personnel shared key operator positions with contractor personnel in all of the firings and throughout the tracking and electronic counter-countermeasure (ECCM) tests. This efficient operator team contributed greatly to the success of the test program.[13]

(U) Beginning the prototype evaluation, the test crew fired two NIKE AJAX rounds in April 1960, the first at a space point and the other at a jet-powered XM-21 drone. Both firings were fully successful, with radial miss distances of 14 yards and 18 yards, respectively. The XM-21 drone—the first live target engaged by the Improved HERCULES equipment—was destroyed. The first HERCULES firing from the improved system, on 1 June 1960, was a prove-in round at a space point target. The hypothetical target was successfully intercepted at intermediate range and altitude with a radial miss distance of only 15 yards, thus confirming the HERCULES mode of operation.[14]

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[13] BTL Rept, INH GM Sys Prototype Eval, 1 Jun 62, pp. 3, 21. RSIC.

[14] *Ibid.*, p. 22.

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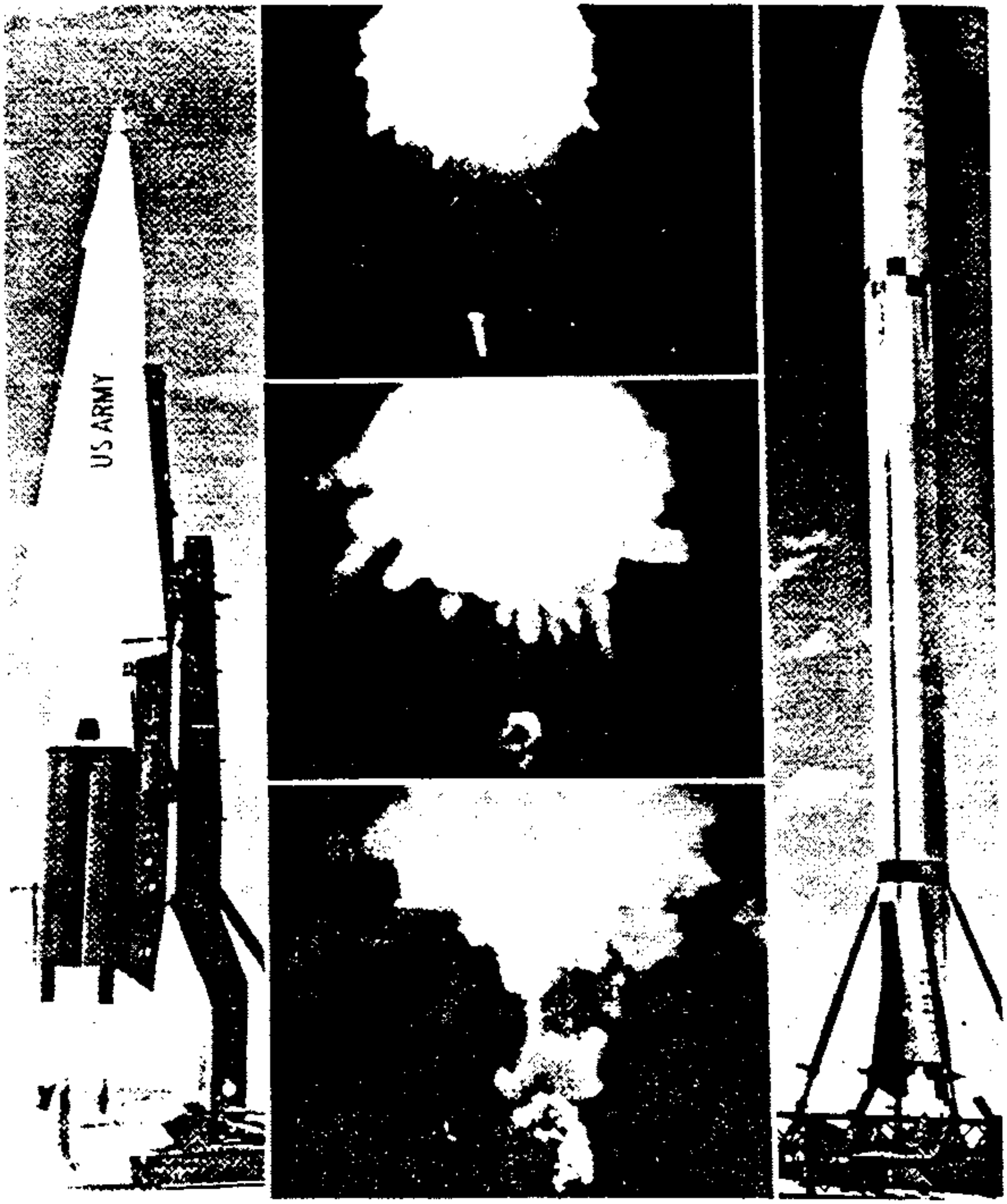


(U) FIRST MISSILE KILLED BY A MISSILE—Traveling at thousands of miles an hour, a NIKE HERCULES guided missile (left) tracked and shot down a CORPORAL ballistic missile (right) high over the WSMR, 3 June 1960. Picture sequence in center shows destruction of the target. This test marked the first time for a missile to be killed by a missile, and it was the first involving the NIKE HERCULES. Earlier in the year, a HAWK guided missile had shot down an HONEST JOHN, a short-range unguided rocket. (WSMR Photo, 3 June 1960)

(U) In the last two HERCULES-versus-HERCULES tests (INH-12 and INH-14), the unaugmented target missiles were programmed on shallow, semiballistic trajectories. System performance was flawless throughout the first test; however, the target malfunctioned 5 seconds before intercept. The second test was nullified when internal failsafe action destroyed the defending missile. This missile malfunction (loss of beacon signal) was the only failure of the entire prototype evaluation firing program.[18]

(U) The remaining eight prototype tests, all successful,

[16] *Ibid.*, pp. 24-27.
[17] *Ibid.*, p. 31.
[18] *Ibid.*, p. 30.

consisted of (1) the interception and destruction of a high-altitude POGO-HI (rocket-launched parachute target); (2) the detection and interception of an air-launched, Mach-3 Q-5 target drone of small radar cross section; (3) two firings in the surface-to-surface mode; (4) intercepts of a jet-powered XM-21 and a Q-2 drone in the low-altitude mode; and (5) two demonstrations of system performance against ECM aircraft.[19] (*See* Table 15.)

System Description

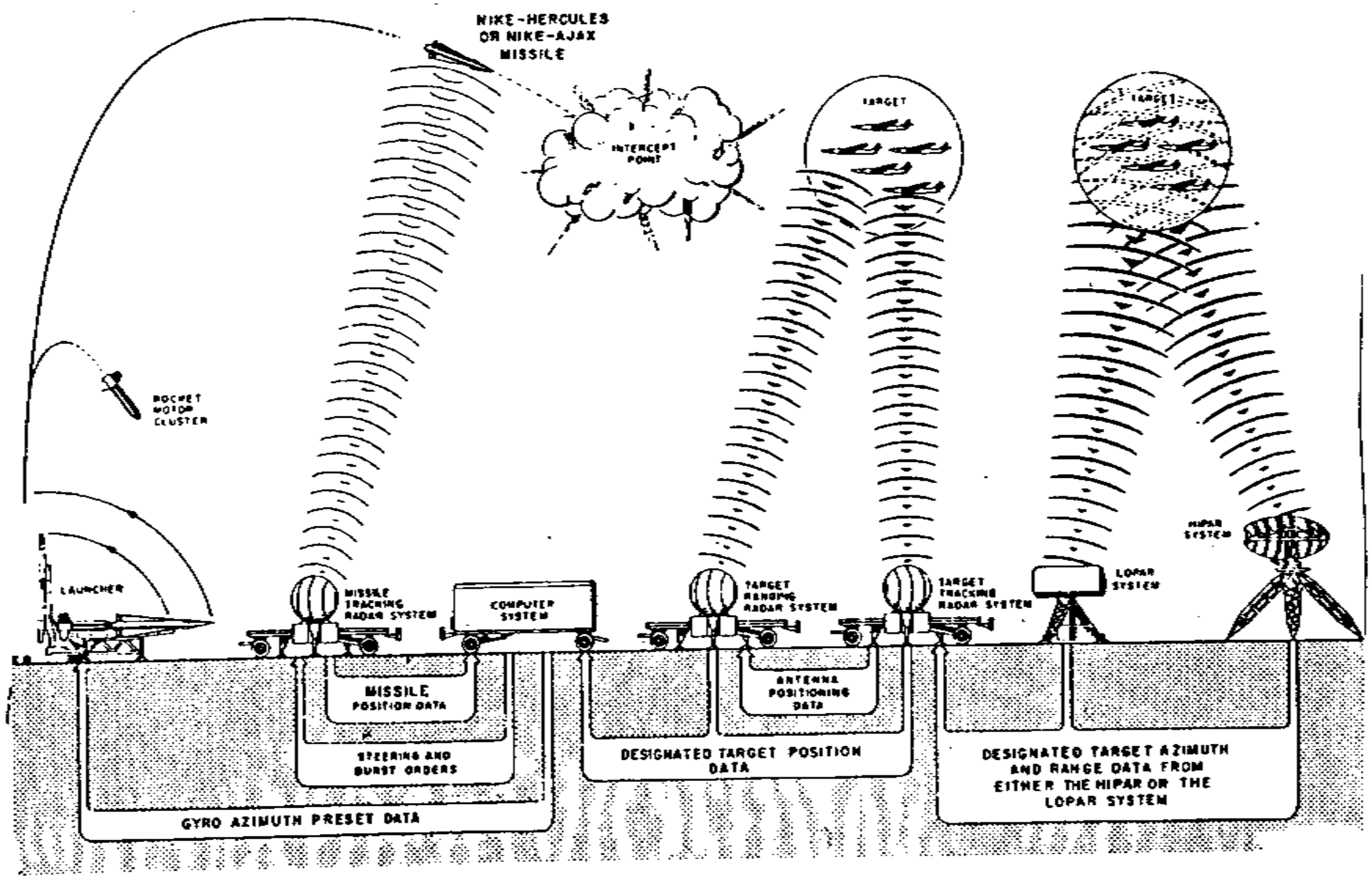
(U) The Improved HERCULES consisted of the standard (Basic) HERCULES system augmented by two new radars (the HIPAR and TRR) and the modified standard TTR to enhance the system's target acquisition and ECCM capabilities. In effect, these advanced radars extended the reach of the powerful HERCULES missile, permitting multiple intercepts against advanced ECM aircraft and small high-performance missiles.

[19] *Ibid.*, pp. 21-23, 28.

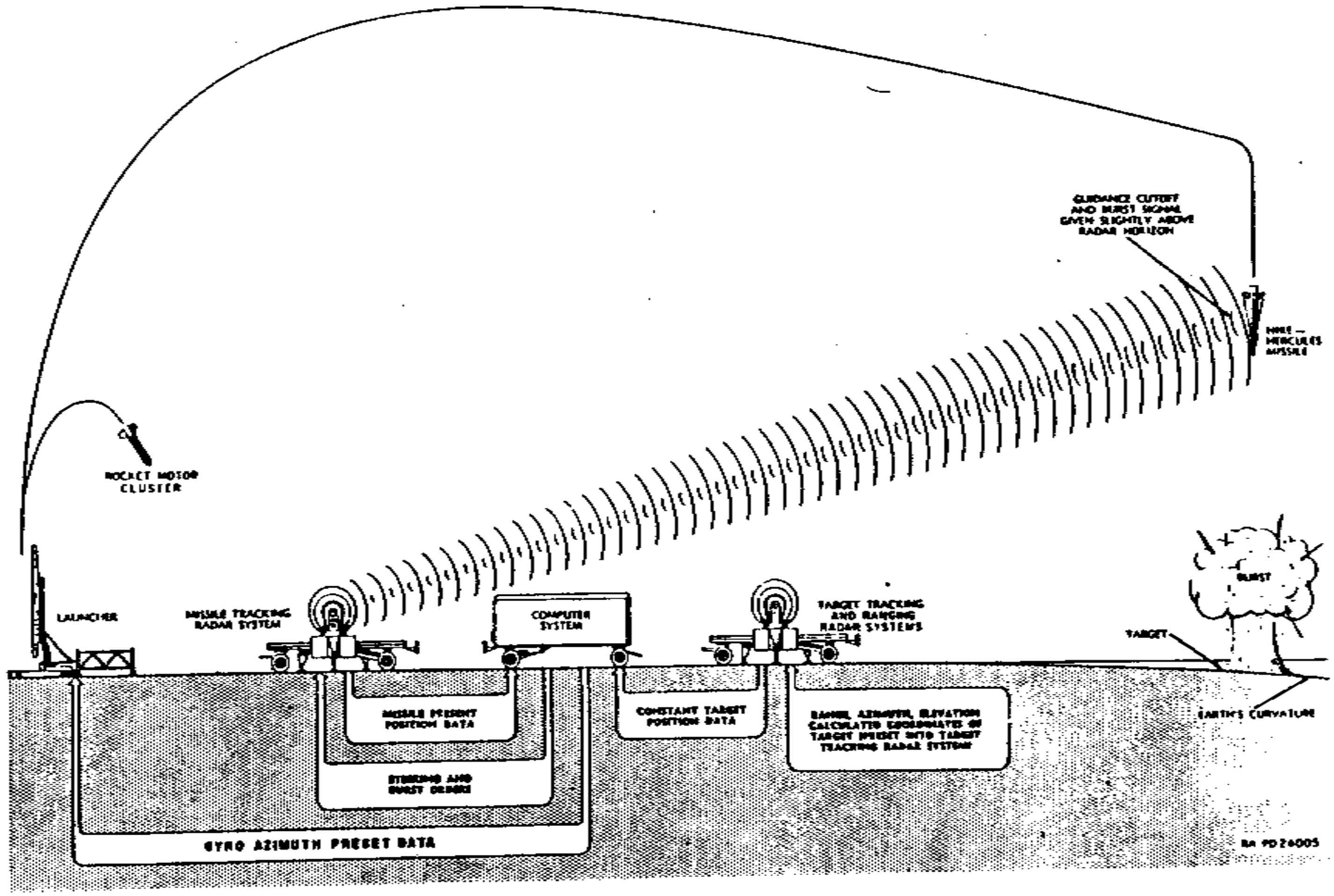
(U) The trailer-mounted target ranging radar was added to the improved system to aid in tracking targets when the enemy employed modern ECM equipment. Operating in the K_u frequency band, it could totally defeat X-band jamming of the target tracking radar. Under X-band jamming conditions, the TTR tracked the jamming signal and continuously provided the system with target angle data; while the TRR, angle-slaved to the TTR, supplied target range information. The K_u band was chosen for TRR operation chiefly because it was relatively unused in radar systems and consequently added to the Improved HERCULES' ECCM advantage. That is, an enemy's logistical requirement was again compounded by the amount of equipment needed to generate the wide-band level signals to jam these frequencies. Even if the system were subjected to K_u band interference, the TRR operator could readily tune around the jamming signal by means of a panoramic receiver display and two independently operating transmitter-receiver systems, one operating on the air and the other into a wave-guide system in a standby status. With the introduction of the K_u band, four operating frequency bands were used by the Improved HERCULES radars, each having frequency diversity within its own band. The fact

[20] (1) *Ibid.*, pp. 9-10. (2) AMC TIR 2-3-1(4), Aug 63, p. 15. RSIC.

[21] NH Prog Rept, Jun 60, p. 21. Hist Div File.



IMPROVED NIKE-HERCULES ANTIAIRCRAFT GUIDED MISSILE SYSTEM - FUNCTIONAL DIAGRAM OF A SURFACE-TO-AIR MISSION.



IMPROVED NIKE-HERCULES ANTIAIRCRAFT GUIDED MISSILE SYSTEM - FUNCTIONAL DIAGRAM OF A SURFACE-TO-SURFACE MISSION.

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that an enemy would be over-burdened with jamming equipment effectively to encompass these bands was an innate advantage held by the Improved HERCULES system.

(U) Also in the Improved HERCULES system were two new electronic displays to aid in the acquisition of small, high-speed targets by reducing the reaction time of the operation. One of these displays was an R-scope that expanded the range-sweep presentation to aid in detecting and gating the target video. The other was a B-scope, which showed an enlarged segment (target area) of the PPI presentation.[22]

[22](1) AMC TIR 2-3-1(4), Aug 63, pp. 15-16. (2) BTL Rept, INH GM Sys Prototype Eval, 1 Jun 62, pp. 11-12. Both in RSIC.

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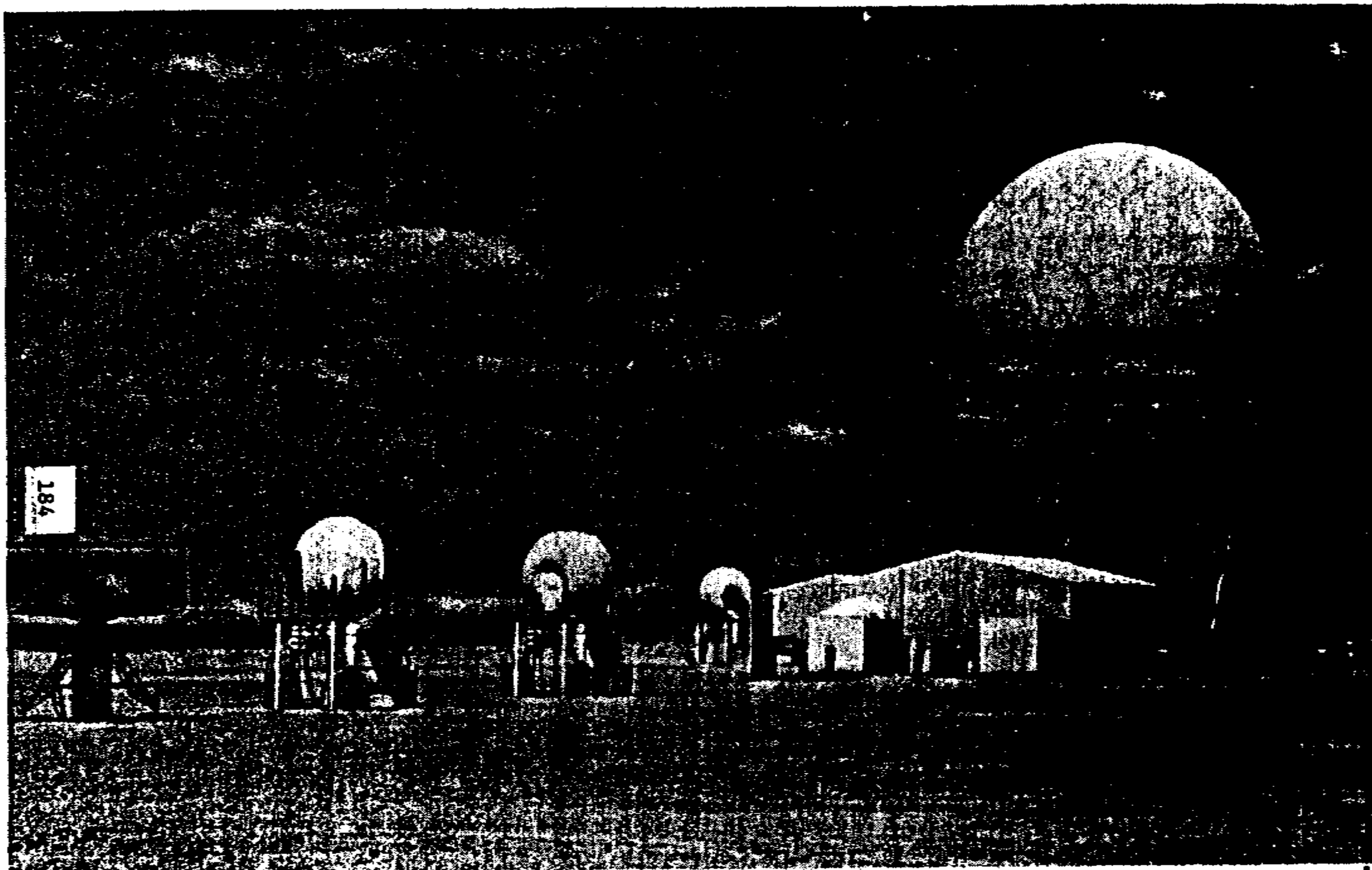

(U) Major Items of the Improved HERCULES System (left to right): LOPAR, TTR, MTR, TRR, and (Fixed) HIPAR.

Training and Deployment

(U) New Equipment Training Courses on operation and maintenance of the HIPAR and TRR were conducted under supervision of ARGMA during the period November 1959 to August 1960. The General Electric Company conducted six 6-week classes on the HIPAR at Syracuse, New York, with 96 key personnel completing the course. Field engineers of WECo trained 102 key personnel in operation and maintenance of the TRR in four 4-week classes at ARGMA.[23] WECo also conducted four 2-week classes on the Improved Type IV test equipment at OGMS during the period 20 March to 12 May 1961, with 120 personnel completing the course.[24]

(U) Early in 1961, Improved HERCULES kits were installed at OGMS and the Army Air Defense School, Fort Bliss, Texas, for use in resident training courses for Ordnance and user personnel required to support the initial tactical sites. Unit training began in May 1961, when the first system with HIPAR was turned over to the user at Fort Bliss.[25]

(U) The deployment concept for the Improved HERCULES was developed during FY 1959 in a limited war game conducted at the Operations Research Office, Johns Hopkins University, using the Remington Rand 1103-A computer. This war game was played for nine city defenses, which had from four to 25 Basic HERCULES batteries. Initially, it was assumed that none of the HERCULES batteries was improved. Then, increasing numbers of complete improved systems were added to the defense. The results of the game indicated that each added kit gave an increasing increment

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[23] INH Wpn Sys Plan, ARGMA WSP-1, Jul 61, p. VIII-4. Hist Div File.

[24] (1) *Ibid.* (2) NH Prog Rept, May 61, p. 6. Hist Div File.

[25] (1) INH Wpn Sys Plan, ARGMA WSP-1, Jul 61, pp. VIII-4 & -5. (2) ARGMA Diary, 1 Jan - 30 Jun 61, pp. 143-44. Both in Hist Div File.

of effectiveness, making it desirable to retrofit as many of the batteries as possible. However, budget limitations for air defense and the requirements for other missile systems within the same timeframe* made it unrealistic to retrofit all HERCULES batteries. The guidelines thus adopted for providing the minimum acceptable improvement in defense called for one complete retrofit kit for each group of three fire units in defenses having 12 or more units, and for each group of two fire units in defenses having less than 12 units. The Basic HERCULES batteries not receiving a complete improvement kit would receive all components of the system except the HIPAR, or a so-called partial system.

(U) In applying these guidelines to specific defense areas, several restrictions had to be considered. First, some batteries employed the AJAX missile system, there were no plans for converting these to HERCULES, and it was obviously impossible to apply an Improved HERCULES to an AJAX battery. Second, there were double HERCULES batteries in some defenses (i.e., two batteries in the same location) and it was not considered appropriate to apply complete improved systems to both halves of these double batteries. Third, the configuration and size of some sites were such that they would not readily accommodate an Improved HERCULES system. Finally, it was essential that improved systems with HIPAR be located as far as possible from existing or planned Air Force frequency diversity radars, in order to avoid unnecessary duplication and to eliminate radar interference. Hence, the makeup of an individual tactical site or defense area conceivably could consist of a mix of some or all of the NIKE systems—the AJAX, the Basic HERCULES, the Basic HERCULES retrofitted with the complete improvement kit, and/or the Basic HERCULES system with a partial improvement kit (i.e., all

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*The budget limitations here referred to were imposed at the climax of the HERCULES-BOMARC controversy in FY 1959, and resulted in a drastic reduction in authorized tactical HERCULES batteries. *See* above, pp. 144-49.

components except the HIPAR).[26] A typical AJAX-HERCULES mix in a metropolitan defense area is illustrated in the accompanying layout.

(U) Deployment of the Improved HERCULES began in June 1961 and continued into FY 1968, with the Improved EFS/ATBM* HIPAR modification being phased in during 1963. Deployments to CONUS sites started on 10 June 1961, when the first complete improvement kit was delivered, installed, and accepted by Ordnance at Site BA-30 in the Washington-Baltimore defense area.[27] The installation of complete kits in tactical units overseas commenced during 1962. The first system went to Taiwan and became operational on 7 December 1962.[28] Deployments to MAP countries (Europe) began early in 1963, the first system being installed at a site in Denmark during the period 1 February to 15 April 1963.[29] Equipment of the last tactical Basic HERCULES battery was updated in September 1967.[30]

Phaseout of the NIKE AJAX System

(U) Meanwhile, the NIKE AJAX missile system was phased out from all CONUS sites in May 1964, after a full decade of active air defense service. The final phaseout of the AJAX from CONUS defense areas began early in FY 1962, with deployment of the first Improved HERCULES systems. Many of the original AJAX sites had been converted to the Basic HERCULES after it became operational in mid-1958, and those remaining were operated by

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*Electronic Frequency Selection/Antitactical Ballistic Missile. *See* below, p. 195.

[26] ARGMA Rept, INH DCR, 2-4 Jun 59, pp. 24-1 - 24-3. Hist Div File.

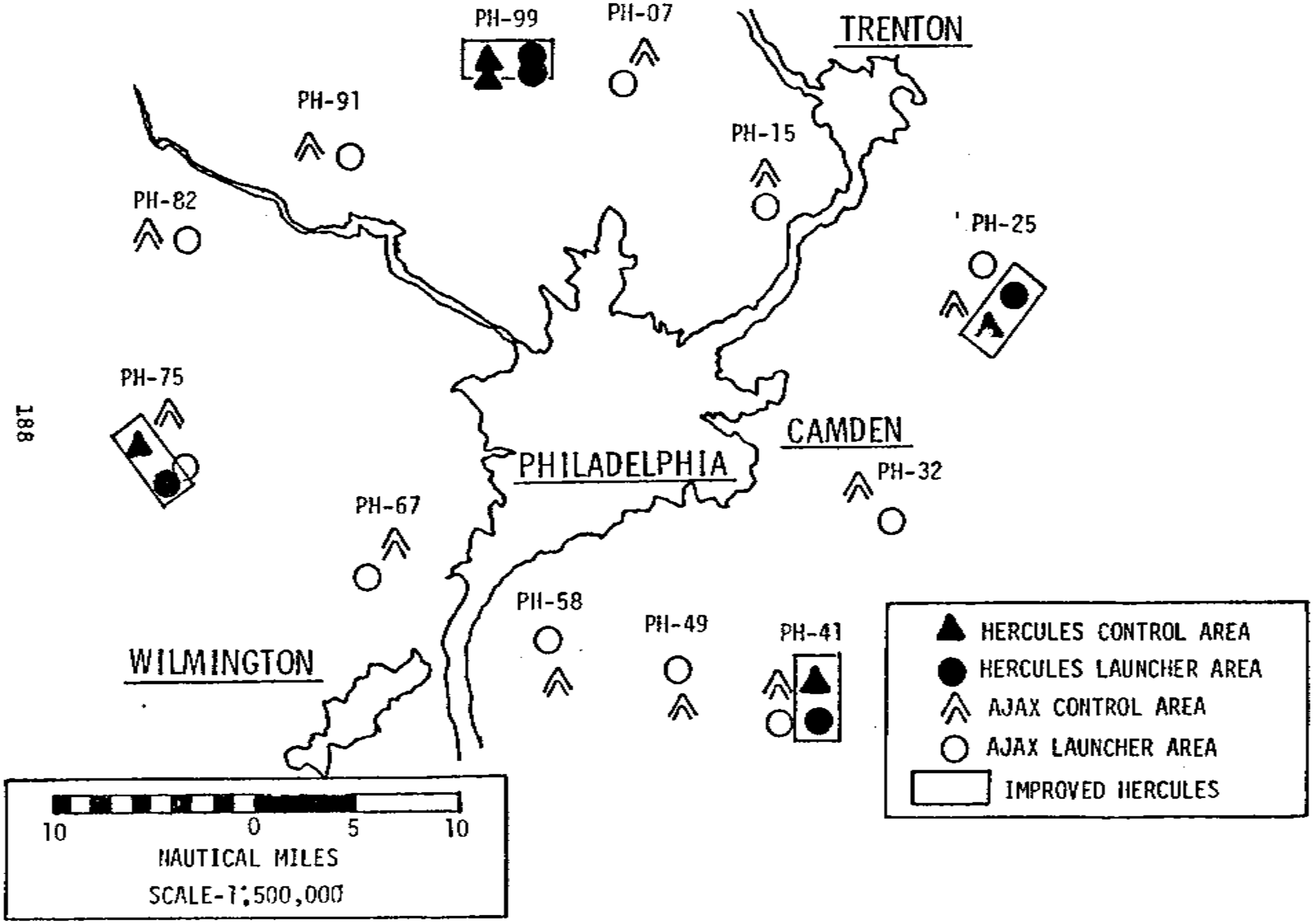
[27] (1) ARGMA Hist Sum, 1 Jan - 30 Jun 61, pp. 101-102. (2) NH Prog Rept, Jun 61, p. 6. Same file.

[28] Hist Rept, NH PM, 1 Jul - 31 Dec 62, p. 14. Same file.

[29] Hist Rept, NH PM, FY 1964, p. 19. Same file.

[30] Hist Rept, NH PM, FY 1968, p. 6. Same file.

PHILADELPHIA DEFENSE



the National Guard. These CONUS sites, when inactivated, were either converted to HERCULES or retained for possible future use.[31]

[31] (1) TT AMSMI-SS-2910-63, CG, MICOM, to CG, AMC, Jan 63, atchd to MFR, Costa E. Apostolakis, ISS Coord, MICOM, 14 Jan 63, subj: Phase-Out of NIKE AJAX Wpn Sys. (2) Hist Rept, NH PM, FY 1964, p. 17. Both in Hist Div File.

[32] (1) Ltr, COL B. R. Luczak, HERC PM, thru CG, AMC, to DCSLOG, DA, 21 May 63, subj: Recmd Plan for Phase-Out of AJAX Msls, w incls. (2) TT AMCPM-HE-SS-1982, CG, MICOM, to CG, 32d Arty Bde, Kaiserslautern, Germany, 23 Jul 63. (3) Hist Rept, NH PM, FY 1965, p. 24. All in Hist Div Files.

(U) The NIKE AJAX system (less launcher) had been reclassified from Standard A to Standard B in mid-1958, concurrently with deployment of the Basic HERCULES system. The AJAX launcher became Standard B in December 1958.[33] Effective 6 April 1965, all components of the AJAX system were declared obsolete except the missile and missile handling, servicing, and test equipment, which were retained as Standard B to meet continued MAP support requirements. At that time, there were six nontactical AJAX systems at Fort Bliss: three for use in integration training by the First Air Defense Guided Missile Brigade; two for use by the Air Defense Board as test bed systems; and one on display at the Army Air Defense School. Fort Bliss requisitioned repair parts covering the retention timeframe for these systems, thereby permitting the system to be classified as obsolete, allowing for the disposal of inventory not required, and eliminating some 3,000 items from the Federal Supply System.[34]

The Improved HERCULES ATBM System

(U) Realizing that advanced guided missile systems such as the Improved HERCULES would inevitably lead to enemy counter developments, DA again exploited the proven growth potential of the HERCULES to keep abreast of the advancing air threat. Aside from retrofitting the HIPAR and LOPAR with the Anti-Jam Display, as noted earlier, the WECo-BTL team developed and produced major modifications to extend radar surveillance and tracking capabilities, the advantage held over ECM, and tactical operability of the system. Chief among these improvements were the ATBM and EFS HIPAR modifications.

(U) The Improved HERCULES ATBM modification was developed during the 1960-62 period to provide the field army an interim

[33] OTCM's 36841, 10 Jul 58; 37272, 17 Dec 58. RSIC.

[34] AMCTCM 3454, 6 Apr 65. RSIC.

defense against the short-range ballistic missile threat.[35] The requirement for such a weapon, which had been projected by the War Department Equipment Board as early as May 1946, became a reality early in 1959, when reliable intelligence reports indicated that the Soviet Union possessed a significant short- and long-range tactical ballistic missile and rocket capability that could be employed against a field army. Judging from past technological developments, there was no reason to doubt that this capability would become increasingly extensive in the course of the next decade. The Army Field Forces, in 1951, had established MC's for an antimissile missile (AMM) defense system to meet "long-term requirements" of the field army, and the first attempt to develop such a weapon had begun under the Ordnance Corps' PLATO project in 1952. However, work on the PLATO was ordered terminated in February 1959, before completion of component development.[36] To satisfy the requirement for a weapon to counter the newly defined tactical ballistic missile threat in the 1960-1970 period, DA then established a program for development of the Field Army Ballistic Missile Defense System (FABMDS). Since this system was not expected to be operational until 1967 at the earliest, the Army, in 1960, decided to develop the Improved HERCULES ATBM system as an interim measure to fill the gap.[37]

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[35] NH PM_2P, 30 Jun 63, pp. 1-2. Hist Div File.

[36] For a history of AMM developments up to 1960, *see* Mary T. Cagle & Ruth Jarrell, *History of the PLATO Antimissile Missile System, 1952-1960* (AOMC, 23 Jun 61).

[37] (1) BTL Rept 27675-BU-1289, 13 Oct 61, subj: INH ATBM Sys, pp. 1-2. RSIC. (2) As it turned out, the HERCULES ATBM system filled a much wider gap than had been anticipated. Begun in 1959 as a follow-on to the PLATO, the FABMDS project was terminated in 1962, following a series of feasibility studies. The search for an effective ATBM system then shifted, in October 1962, to the Army Air Defense System, 1970's (AADS-70's). By direction of DOD, on 15 October 1964, the AADS-70's system was renamed the SAM-D (Surface-to-Air Missile Development), with concurrent redirection of the effort. (*See* John W. Bullard, --continued

(U) The ATBM study, conducted by BTL during the first quarter of CY 1960, took into consideration the Improved HERCULES' capability against such missiles and rockets as the REDSTONE, SERGEANT, CORPORAL, Missile B (now the LANCE), HONEST JOHN, LITTLEJOHN, and LACROSSE. The REDSTONE-type missile was considered to be the highest performance missile against which the HERCULES ATBM system could defend any practical land area. Further extension of ATBM system capabilities would require extensive redesign approaching the use of the NIKE ZEUS techniques. BTL engineers felt that such a program would be economically unfeasible and would doubtlessly entail a development timeframe approaching that of FABMDS itself.

(U) The primary objective thus established for the HERCULES ATBM system was to defend the field army against as great a portion of the 1960-1970 threat as timely and economically feasible modifications to the Improved HERCULES would permit. The HERCULES ATBM system was not intended to satisfy all objectives of the FABMDS, to serve as a substitute for it, or to render its development any less essential. It was intended, rather, to fill a critical field army defense requirement with a weapon system that capitalized upon an extension of proven ATBM capability,* existing production facilities, the existence of personnel trained in its use, and established logistic channels. This approach permitted the development of a potent weapon for interim use at minimum cost and in a minimum period of time.[38]

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*It will be recalled that the Improved HERCULES had successfully intercepted a CORPORAL and a HERCULES missile during the system evaluation firings in 1960. *See* above, pp. 172-75.

[37](Cont) *History of the Field Army Ballistic Missile Defense System Project, 1959-1962* [MICOM, 2 Dec 63]; & MICOM Hist Sum, FY 1965, p. 120.) As of June 1972, the SAM-D system had not reached the field and the HERCULES ATBM system was still filling the gap 5 years after its successor was to have been available.

[38]BTL Rept 27675-BU-1289, 13 Oct 61, subj: INH ATBM Sys, pp. 1-4. RSIC.

(U) The ATBM system, as such, was an Improved HERCULES system with modifications. Of particular significance were modifications to the HIPAR antenna, giving extended high-altitude coverage, and the introduction of a new Battery Control Console, with faster target transfer hardware and dual PPI's for long- and short-range presentations, as well as designate controls. The computer was also modified to incorporate within it a ballistic prediction function. Concurrently with the ATBM modifications, HIPAR capabilities of the system were extended in a major redesign program to include Electronic Frequency Selection (EFS) for improved ECM. With the original HIPAR, frequency change was done by mechanical means from autotune units and required 30 seconds to complete the operation, during which there was a loss of information. With the EFS modification, tuning could be accomplished in 20 microseconds.[39]

(U) Prototype ATBM and EFS HIPAR modification kits were installed in the Improved HERCULES system at WSMR during the latter part of 1962, and integrated engineering-service tests began in April 1963. Target missiles used in the ATBM performance evaluation consisted of the HERCULES, REDSTONE, SERGEANT, HONEST JOHN, and PERSHING. The HERCULES missile, with its steep trajectory and relatively low and varying radar cross section, did not present a realistic target. However, in a number of firings from the ZURF facility during the period 3 April to 5 September 1963, it was used as a training vehicle for developing operator proficiency against a ballistic target, and also as a target to test computer modifications.[40]

(U) The PERSHING represented a target beyond the design

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[39](1) Hist Rept, NH PM, 1 Jan - 30 Jun 63, p. 2. (2) NH PM_2P, 30 Jun 63, p. 2. Hist Div File.

[40](1) Hist Rept, NH PM, 1 Jul - 31 Dec 62, p. 5. Hist Div File. (2) BTL Smanl Prog Rept for Pd Ending 1 Nov 63, pp. 37-38. RHA Bx 13-342. (3) TT AMCPM-HE-1201-63, NH PM to CG, AMC, Apr 63. Hist Div File.

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capability of the ATBM system. In a test conducted on 16 October 1963, it was successfully acquired but not tracked. The REDSTONE, with its separating characteristics, did not fully fall within the expected enemy tactical ballistic missile (TBM) threat spectrum. There were two ATBM evaluation firings against the REDSTONE: one on 23 September and the other on 5 October 1963. In the first one, the target video was lost about 10 seconds before planned intercept. In the second firing, the target was successfully acquired and tracked, but an offset of 2,000 yards inadvertently placed by the operator precluded a kill.[41]

[41] (1) NH PM_2P, Ch 5, 30 Sep 64, p. 32a. Hist Div File. (2) BTL Smanl Prog Rept for Pd Ending 1 Nov 63, pp. 32-33, 37. RHA Bx 13-342. (3) TT AMCPM-HE-3654-63, NH PM to CG, AMC, 18 Oct 63. Hist Div File.

[42] (1) TT AMCPM-HE-4059-63, NH PM to CG, AMC, 13 Dec 63. (2) TT AMCPM-HE-329-64, same to same, 24 Jan 64. (3) NH PM_2P, Ch 5, 30 Sep 64, p. 32a. All in Hist Div File.

[redacted]

(U) Meanwhile, WECo began new/modified equipment training classes at OGMS in October 1962.[44] Field installation of the Improved HERCULES EFS/ATBM equipment commenced in 1963, overlapping deployments of the basic Improved HERCULES. Installation of the first production EFS HIPAR, less the ATBM capability, started in CONUS at Site NY-56 in February 1963 and was completed on 20 April 1963. During this initial installation, ARADCOM determined that CONUS HIPAR's would not be equipped with the ATBM antenna or the dual PPI console in their existing design.[45] Final checkout of the first tactical EFS/ATBM system was completed the week of 21 July 1963, and the system was turned over to the U. S. Army, Alaska, on 25 July—5 days earlier than scheduled.[46] The HIPAR/EFS retrofit program started in November 1963 and continued into the second half of FY 1965.[47]

The Mobile HIPAR Program

[43] Hist Rept, NH PM, FY 1964, pp. 11-12. Hist Div File.

[44] Hist Rept, NH PM, 1 Jul - 31 Dec 62, p. 16. Hist Div File.

[45] Hist Rept, NH PM, 1 Jan - 30 Jun 63, p. 6. Hist Div File.

[46] TT AMCPM-HE-2328-63, NH PM to CG, AMC, 26 Jul 63. Hist Div File.

[47] Hist Repts, NH PM, FY 1964, p. 20; FY 1965, p. 28. Hist Div File.

[48] For development of the mobility kit for the Basic HERCULES system, *see* above, pp. 94-95.

(U) The GOER vehicle, designed by the Army Tank-Automotive Command, met the basic requirements, and CONARC drafted the MC's for a GOER-mounted system in November 1961, following a study of the problem by BTL. Work on the GOER HIPAR mobility program began in March 1962 and continued until December 1962, when the Office, Chief of Research and Development (OCRD) directed that it be suspended in favor of an approach more adaptable to air mobility. The HERCULES Project Manager then reoriented the program, falling back on an earlier less mobile concept which envisioned the use of modified standard trailers and M52 truck tractors. The proposed alternate program for mobilizing the HIPAR equipment was presented to OCRD on 18 December 1962 and distributed to all interested agencies in February 1963. It consisted of six dropbed semitrailers: four to transport HIPAR electronic equipment in vans, one to carry the antenna, and one to carry the engine-driven power generators.[49]

(U) Work on the alternate system commenced with OCRD approval of the Technical Development Plan on 5 June 1963. The General Electric Company developed the Mobile HIPAR under subcontract to BTL and in conjunction with the Army Tank-Automotive Command. An acceptance inspection review of the complete R&D prototype was held on 11 February 1964 at the contractor's plant in Syracuse, New York. At this review, representatives of interested commands

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[49] (1) BTL Rept, Cross Country NH, 1 Oct 61, pp. 1-5. RHA Bx 13-594. (2) Hist Repts, NH PM, 1 Jul 62 - 31 Dec 62, p. 6; & 1 Jan - 30 Jun 63, pp. 2-4. Hist Div File.

and using agencies witnessed a demonstration of the R&D prototype, in which the six-trailer system was successfully march ordered in 1 hour and 13 minutes and emplaced in 1 hour and 43 minutes—well within the period required for the Improved HERCULES (without HIPAR) with mobility kit. Development was completed on 28 February 1964, when the R&D model was delivered via road march from Syracuse, New York, to Aberdeen Proving Ground (APG), Maryland. Having passed the mobility test at APG without degradation of system electronic components, the R&D model was shipped by rail to WSMR on 1 July 1964. Upon completion of engineering tests at WSMR, the R&D prototype was turned over to the Army Air Defense Board on 23 September 1964 for service tests.[50]

(U) The AN/MPQ-43 Mobile HIPAR was classified Standard A in August 1966. At the same time, the contractor delivered the first production unit and confirmatory tests were completed 4

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[50] (1) Hist Rept, NH PM FY 1964, p. 12. (2) NH PM_2P, Ch 5, 30 Sep 64, pp. 3, 32a. Hist Div File.

[51] (1) Hist Repts, NH PM, FY 1965, p. 1; FY 1966, p. 3; & FY 1969. (2) NH PM_2P, 30 Sep 69, p. 31. Hist Div File. (3) Intvw, M. T. Cagle w Ms. Jean Clark, Msl Sys Div, Dir for Mat Mgt, 8 May 72.

months later. The first system was deployed to USAREUR and became operational on 12 April 1967. By the end of FY 1968, all of the Mobile HIPAR's for U. S. Army units had been deployed except five, which were delayed by funding and personnel problems in USAREUR.[52] The last unit was to have been equipped with the Mobile HIPAR by July 1970; however, two systems were still being held in temporary storage at Seneca Army Depot as of 30 June 1971.[53] One of these was deployed in August 1971. The other was still in depot storage on 8 May 1972, awaiting call from the user.[54]

The AN/MPQ-T1 Simulator Station

(U) Concurrently with the rapid advancements in HERCULES system capabilities, a comprehensive updating program was in progress at Aircraft Armaments, Inc., to give the AN/MPQ-36 simulator Basic and Improved HERCULES capabilities. As an interim measure, ITT modified 10 of the AN/MPQ-36 devices for use in live ASP firings.[55] Work on the 10 modified training devices was completed during the first half of FY 1963, with eight of them being allocated to McGregor Range and the other two to U. S. units in Alaska. The updated AN/MPQ-36 device was designated as the AN/MPQ-T1 Simulator Station.[56]

(U) Parallel with the AN/MPQ-36 updating program, Aircraft Armaments, Inc., designed a new automatic test set (the AN/MPM-55) for field maintenance of the simulator. The contractor completed breadboard models of the AN/MPQ-T1 simulator and AN/MPM-55 test

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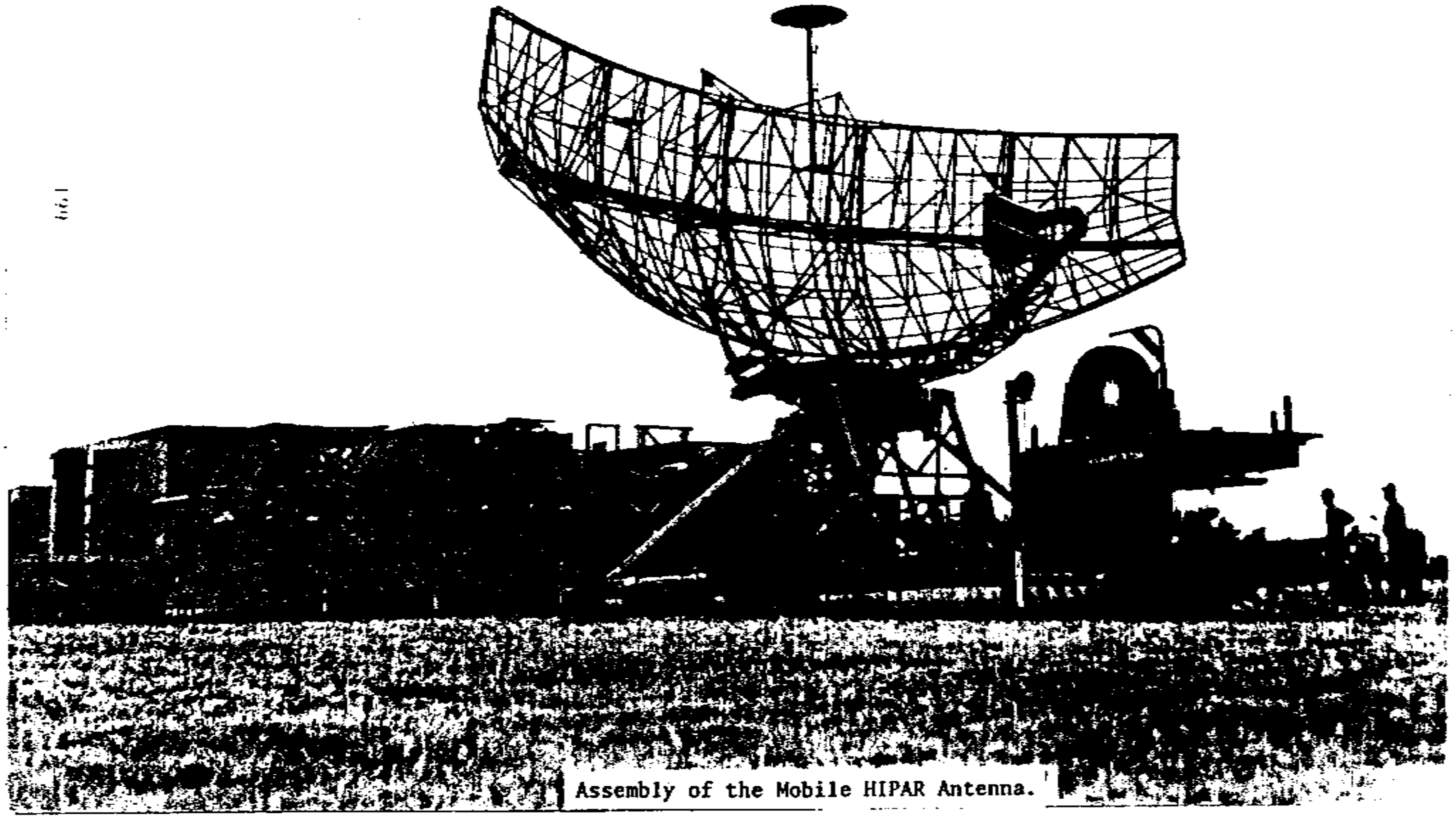
[52] (1) Hist Repts, NH PM, FY 1967, p. 3; FY 1968, pp. 5-6. (2) NH PM_2P, 30 Sep 69, p. 10. Hist Div File.

[53] (1) *Ibid.*, p. 10. (2) MICOM Hist Sum, FY 1971, p. 103.

[54] Intvw, M. T. Cagle w Ms. Jean Clark, Msl Sys Div, Dir for Mat Mgt, 8 May 72.

[55] *See* above, pp. 141-42.

[56] Hist Rept, NH PM, 1 Jul - 31 Dec 62, pp. 17-18. Hist Div File.



Assembly of the Mobile HIPAR Antenna.

(U) DESCRIPTION OF THE AN/MPQ-43 MOBILE HIPAR SYSTEM

The Mobile HERCULES HIPAR System consisted of three vans mounted on trailers, one antenna trailer, and a power plant trailer.

The antenna trailer, in the march order configuration, was 502 1/4 inches long, 116 inches wide, and 132 inches high. During assembly of the antenna, eight reflector panels were removed from the trailer and attached to a folding center section. The emplaced antenna reflector was 43 feet wide and 14 feet high. The fan pattern reflector could be easily converted into a cosecant squared beam pattern reflector by attaching five additional antenna sections to the top of the fan beam antenna and exchanging the feed horn assembly. For transit, these sections were stored on the deck and goose neck of the receiver trailer. The cosecant squared antenna reflector was the same size as the fixed antenna: 43 feet wide and 25 feet high. The base of either the fan beam or the cosecant squared reflector was 12 feet above the ground level in emplaced conditions.

Each van was 246 inches long, 108 inches wide, and 90 inches high. The maximum height of each mounted van was 132 inches. The electronic equipment, located in each van, was identical to amd mounted in the same type cabinets as the HIPAR equipment on fixed sites.

Each van trailer was 502 1/4 inches long and 116 inches wide. The prime mover used was the 5-ton tractor, 6 x 6, M52 or M52A1.

The power plant vehicle was the same basic semitrailer with a small van containing switch gear, protective devices, and the power generation equipment. Two lightweight 200-KW 60-cycle diesel generators were the major power source. Either diesel generator would support the basic power load under normal conditions. A 60-KW 60/400-cycle motor generator set furnished power for the IFC area. The power van would also act as a distribution center for commercial 60-cycle power should a commercial source be available. The vehicle contained a 24-hour fuel supply in the tank of the two diesels, and either engine could operate from the other or from an off-vehicle supply. The power plant was 502 1/4 inches long, 116 inches wide, and 127 7/8 inches tall, and weighed 56,000 pounds.

SOURCE: Fact Sheet, Mobile HERCULES HIPAR System.

set in March 1963. Following functional tests for compatibility with the Basic HERCULES and Improved HERCULES with HIPAR, procurement go-ahead was granted on the T1 simulator but withheld on the M55 test set pending completion of a feasibility study on possible cancellation of the program.[57] Since the AN/MPM-52 field maintenance test set, which was already deployed, could be modified to provide support capability for the T1 simulator, the HERCULES Project Manager, in July 1963, decided against production of the AN/MPM-55 test set. Development of the M55 was completed, however, and the two prototypes already built were used for factory test of the T1 simulator. The decision to cancel the M55 program resulted in a savings of at least $6 million and eliminated one specialized item of test equipment.[58]

(U) The AN/MPQ-T1 Simulator Station was classified LP in April 1964. By the end of that fiscal year, contracts had been awarded for production of 108 units. In addition to 52 T1's produced by the developer (including two prototypes), 56 were competitively procured from the Bendix Corporation.[59] Integrated engineering-service tests of the T1 simulator were completed in September 1965. Production deliveries commenced in March and continued into December 1966. Issuance to tactical units began in May 1966, enabling the troops to train on their own site in an environment similar to a tactical engagement. Classified as Standard A in June 1966, the AN/MPQ-T1 training device could simulate six targets, several types of ECM, chaff, passive interference, and masking to the Basic and Improved HERCULES systems. Distribution of the simulator station was

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[57](1) *Ibid.*, p. 18. (2) Hist Rept, NH PM, 1 Jan - 30 Jun 63, p. 5. (3) NH PM_2P, Ch 13, 30 Sep 66, p. 16. Hist Div File.

[58](1) NH PM_2P, Ch 1, 30 Sep 63, p. 7. (2) Hist Rept, NH PM, FY 1964, pp. 1, 7-8. Hist Div File.

[59](1) *Ibid.*, pp. 7-8. (2) NH PM_2P, Ch 13, 30 Sep 66, p. 16. Hist Div File.

completed in January 1967.[60] Subsequent product improvements were developed to keep the simulator station abreast of advancing HERCULES capabilities. Among these were simulation capabilities for improved ECM, Mark X/XII Selective Identification Features, and an ATBM target generator.[61]

Maintenance of HERCULES Capabilities

(U) With the "keep ahead" design policy adopted early in the HERCULES program, the system's defensive capabilities kept pace with the advancing air threat of the 1960's through the addition of "black boxes" to the basic system ground equipment. Looking to the future of the HERCULES, however, MICOM recognized that considerable additional development and engineering effort would be essential to keep the system abreast of the expected threat during the interval until a replacement system became available. During a conference held at the Combat Developments Command (CDC) Headquarters on 27-28 February 1964, MICOM discussed the future of the HERCULES missile system in the context of three options.

(U) Under Option I, the HERCULES, in effect, would be put in "moth balls," with no further improvements beyond those already underway, such as the Mobile HIPAR and ECCM programs. It provided for a limited amount of supporting type effort costing about $126 million over a 10-year period (FY 1965-74); however, this level of effort would not be sufficient to maintain a defensive capability commensurate with the threat expected through the projected useful life of the system.

(U) Under Option II, modest improvements would be undertaken to keep the system abreast, or hopefully ahead, of the threat

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[60] (1) *Ibid.*, p. 16. (2) NH PM_2P's, Ch 14, 31 Dec 66, p. 3; & Ch 16, 30 Jun 67, p. 4. Hist Div File.

[61] NH PM_2P, Ch 3, 30 Sep 68, p. 23. Hist Div File.

during the interval until it was replaced by a follow-on system, such as the AADS-70's.* It would provide for additional capability in the high explosive warhead area, motor area, video display area, and essential ECCM areas. In addition to these improvements, three-dimensional (3-D) battery acquisition radars would be provided to satisfy user requirements. Including the latter, the total estimated cost of Option II over a 10-year period was $242 million.

(U) Under Option III, a quantum jump in system capability would be attempted. It called for an advanced concept using the 3-D radars and other improvements to provide a defense capability better than that of the existing HERCULES ATBM system but less than that proposed for the AADS-70's (SAM-D). The estimated cost of Option III was $266 million. However, since Option III would be an addition to Options I or II, the total program cost would be $400 to $500 million.

(U) Recognizing that development and fielding of a new system would be the best long-term solution, as opposed to adding more and more "black boxes" to the HERCULES, MICOM recommended that Option II be adopted for future program effort and that a study be conducted to determine firm design characteristics and preliminary program definition for the requirements stipulated in Option III.[62] The Department of the Army, on 16 November 1964, concurred in the Option II approach contingent upon a review of the specific tasks to be included in such a program.

(U) The HERCULES Project Office, in cooperation with CDC and ARADCOM personnel, formulated a proposed Maintenance of

*Renamed the SAM-D in October 1964. *See* fn 37, pp. 191-92.

[62] (1) Ltr, CG, MICOM, to CG, AMC, 10 Mar 64, subj: Future HERC Program Review, atchd to SS, Act HERC PM, 10 Mar 64, subj: same. (2) Hist Rept, NH PM, FY 1965, p. 3. Both in Hist Div File.

HERCULES Capabilities (MOHEC) Program. Submitted to AMC on 5 January 1965, the proposed (Option II) program embraced nine tasks together with the required support effort. In a teletype to MICOM on 12 March 1965, OCRD stated that DA approved for study only the ECCM and high explosive warhead tasks proposed in the MOHEC program. Any decision on the remaining tasks would await completion of the SAM-D program evaluation.[63]

(U) Accordingly, OCRD revised the HERCULES FY 1966 RDTE budget guidance for MOHEC from $6.6 million to $3,250,000. The latter guidance was later reduced to $1 million, which DOD deferred.[64] In response, the HERCULES Project Manager advised AMC that if no FY 1966 RDTE program authority were received, the Government-contractor team would be phased out, the existing capability which allowed timely reaction to the changing and new threats would be lost, and the HERCULES system would become obsolete within 2 to 3 years. On 7 December 1965, AMC sent the project manager $1 million in FY 1966 RDTE program authority for the approved portion of the MOHEC program.[65]

(U) Earlier, in November 1965, OCRD asked the project manager for a proposed R&D program which would cope with the advancing threat. Upon receipt of the proposal, OCRD established the HERCULES Extended Life Program, which was to include the proposed ECCM, surface-to-air, and low-altitude improvement studies.[66] The DA, in February 1966, authorized a study of three broad areas (ECCM, medium- and high-altitude, and low-altitude improvements) to determine the additional capabilities that the HERCULES would require to keep abreast of the air-supported threat through the

[63] *Ibid.*, pp. 3-4.

[64] NH PM_2P, Ch 11, 31 Mar 66, p. 4. Hist Div File.

[65] (1) MICOM Hist Sum, FY 1966, pp. 106-107. (2) NH PM_2P, Ch 11, 31 Mar 66, p. 4. Hist Div File.

[66] *Ibid.*, pp. 4, 4a.

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1975 timeframe. The end product of this R&D study, conducted by BTL during the period April 1966 to 31 January 1967, was a complete report including the recommended MOHEC program package and its cost effectiveness. An AMC/CDC Task Group met on 21 February 1967 and formulated a program for updating the Improved HERCULES system.[67]

(U) After considering SAMCAP* and technical assessment study reports, in addition to the BTL report, the task group divided the MOHEC program items into three categories:

1. Technical Assessment Items, consisting of improved kits for all tactical sites, additional missile delay lines for each battery, and addition of a HIPAR to systems having only the LOPAR.

2. SAMCAP items which required development effort, but which could be made available in a shorter time than items falling in the integrated development category.

3. All other items comprising the integrated development program.

The SAMCAP items were listed in a special category because of the urgent need for their development to give the system the capability to overcome existing vulnerabilities. In submitting the task group's report to AMC Headquarters, on 6 April 1967, the Commanding General of MICOM emphasized the critical need for immediate initiation of the above MOHEC program and development of the SAM-D weapon system.[68]

(U) In May 1967, however, MICOM received word that OCRD had deferred implementation of the MOHEC program until FY 1969. To implement the proposed MOHEC development effort, $7.1 million in FY 1968 RDTE funds would be required. The AMC RDTE Command

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[67] NH PM$_2$P, Ch 16, 30 Jun 67, pp. 4-5. Hist Div File.

[68] Ltr, CG, MICOM, thru CG, CDC, to CG, AMC, 6 Apr 67, subj: MOHEC, w incl: Rept of USAMC/USACDC Task Group Mtg - 21 Feb 67. Hist Div File.

[redacted]

Schedule of 6 March 1967 had programmed a minimum of $1 million per year through 1972 for the previously approved portion of the MOHEC program (including SAMCAP) to cope with the changing threat. Since the SAMCAP items were included as part of the total MOHEC program, deferment of the project until FY 1969 reduced the RDTE budget for FY 1968 to zero. In a letter urging the restoration of SAMCAP funds, the Commanding General of MICOM wrote:

> *(U) The impact of the loss of an RDT&E Program for FY 1968 is of such magnitude to the future of the HERCULES System that I strongly recommend the reinstatement of the $1M RDT&E funds to the FY 1968 HERCULES Program.*[69]

(U) The failure of DA to restore the FY 1968 RDTE funds for continuation of the SAMCAP effort at BTL resulted in the termination of the R&D contract and the transfer of engineering effort to WECo before completion of the design. The dislocations and disruptions caused by this transition of design responsibility, together with the more limited design expertise of the WECo engineering group, significantly increased risks, both technically and timewise, and later contributed to a $1.5 million cost growth on the SAMCAP hardware contract.[70]

(U) WECo, in FY 1968, completed the construction and evaluation of the first R&D models of SAMCAP items, which included the HIPAR point logic circuit, imageless mixer for the TTR/TRR, multiple pulse for the TTR, ferrite switch for the TRR, and a computer modification. As available funds permitted, work was also continued on other previously approved portions of the program; i.e., the ECCM and low-altitude improvements. The technical development plan

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[69] Ltr, CG, MICOM, to GEN F. S. Besson, Jr., CG, AMC, 23 May 67, n.s., atchd to SS HE-MB-67-1, 19 May 67, subj: Reinstatement of HERC RDTE Program FY 1968. Hist Div File.

[70] Ltr, CG, MICOM, to CG, AMC, 5 Apr 71, subj: Cost Growth, NH SAMCAP Mod, atchd to SS AMSMI-TA-1-71, 26 Mar 71, subj: same. Hist Div File.

for MOHEC, approved for distribution in May 1967, was revised in October 1967. Implementation of the full MOHEC program, however, depended upon the availability of funds in FY 1969.[71]

(U) After being deferred in FY 1968, funding for the MOHEC program was again requested in the President's budget for FY 1969. When program authority had not been made available by mid-FY 1969, the Commanding General of ARADCOM sent a letter to the Assistant Chief of Staff for Force Development (ACSFOR) on 25 January 1969, emphasizing the need for improving the HERCULES capabilities to counter the postulated threat through the 1970's. During a meeting held at MICOM on 12-13 February 1969, representatives of ACSFOR, ARADCOM, AMC, and CDC reviewed alternate program approaches and selected modifications considered absolutely essential to improve the effectiveness of the HERCULES system. This scaled-down MOHEC program was presented during the Army Air Defense Review at Fort Bliss, Texas, on 1 and 2 April 1969. The Army Vice Chief of Staff then directed the Army Staff to review this reduced funding option.[72] Early in FY 1970, ACSFOR advised MICOM that the revised MOHEC program had become a casualty of the reduced Army budget and could not be funded in either FY 1970 or FY 1971.[73]

(U) With the full MOHEC program thus shelved, major improvements to the HERCULES system were limited to the SAMCAP items. Another closely related modification, completed in FY 1971, was the Anti-Jam Improvement (AJI), the development of which predated the proposed MOHEC program.

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[71] (1) Hist Rept, NH PM, FY 1968, pp. 1-2. (2) NH PM_2P, Ch 3, 30 Sep 68, p. 13b. Both in Hist Div File.

[72] (1) Hist Rept, NH PM, FY 1969. (2) Hist Sum, HQ AMC, FY 1969, p. 244.

[73] (1) MICOM Hist Sum, FY 1970, p. 62. (2) NH PM_2P, Ch 1, 31 Mar 70, p. 5. Hist Div File.

[74]Hist Rept, NH PM, FY 1965, p. 30. Hist Div File.

[75]Hist Rept, NH PM, FY 1967, p. 4; FY 1968, pp. 6-7. Hist Div File.

[76](1) MICOM Hist Sum, FY 1970, pp. 63-64. (2) Completion date supplied by Lemmie Bratten, Maint Engrg Div, Dir for Maint, 17 May 72.

[77](1) Hist Rept, NH PM, FY 1970, pp. 2-3. (2) Hist Rept, ADSIMO, FY 1971, pp. 2-3. Both in Hist Div File.

[78]Production figure supplied by Sam Burns, ADSIMO, and verified by Ray DeCoursey, Mat Mgt Dir.

[79]"Major Modification Seeks More Maneuverable Nike Hercules," *Redstone Rocket*, 9 Feb 72, p. 1.

CHAPTER VII

(U) ~~(C)~~ CURRENT STATUS AND COST SUMMARY (U)

(U) As noted in the chapter dealing with organization and management, the HERCULES Project Office was discontinued effective 4 January 1971 and its residual functions were assigned to the newly formed Air Defense Special Items Manager Office (ADSIMO). The staff of the new Systems Engineering and Integration Office, Directorate for Research, Development, Engineering, & Missile Systems Laboratory, was integrated with ADSIMO personnel.[1]

Engineering Support

(U) Concurrently with deprojectization of the HERCULES, plans were formulated for the phaseout of contractual engineering support and the provision of MICOM in-house support in three phases. In Phase I, completed on schedule in October 1971, MICOM assumed responsibility for engineering support of the HERCULES missile, launch equipment, test equipment, simulator, and auxiliary battery acquisition radar, less current design effort on SAMCAP, SILOFAB,* and the AN/TPX-46.** Under Phase II, planned for completion by 30 September 1972, MICOM would begin supporting SAMCAP, SILOFAB, AN/TPX-46-related items, and the HIPAR. Engineering support

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*The side lobe fast blanking (SILOFAB) modification was being designed to counter, or blank out, certain types of repeater jammers that might be used against the HIPAR. MICOM Hist Sum, FY 1971, p. 63.

**A component of the improved Mark XII aircraft identification system, the AN/TPX-46 was to serve as a link between the HERCULES system and the aircraft transponders. Hist Rept, NH PM, FY 1968, pp. 3-4. Hist Div File.

[1] *See* above, p. 33.

responsibility for HERCULES ground guidance and radar equipment would be assumed by MICOM sometime after 1 July 1973.[2]

Deactivation of HERCULES Batteries

Disposition of Equipment

(U) The HERCULES ground equipment located at deactivated sites

[2](1) Hist Rept, ADSIMO, FY 1971, p. 2. Hist Div File. (2) FONECON, M. T. Cagle w Merlin D. Berg, Chf, Prog Mgt Ofc, ADSIMO, 17 May 72.

was returned to one of three Army depots—Letterkenny, Pueblo, or Tooele. Being excess to Army requirements, most of it was offered to International Logistics Field Office customers and other government agencies through the MIMEX* and Project PLUS** procedures. In FY 1971, for example, the Directorate for Materiel Management redeployed five HERCULES systems under MIMEX procedures, and, in FY 1970-71, accepted 53 foreign military sales cases for a total of $17,953,868.[3]

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*Major Items for MAP from Long Supply or Excess.

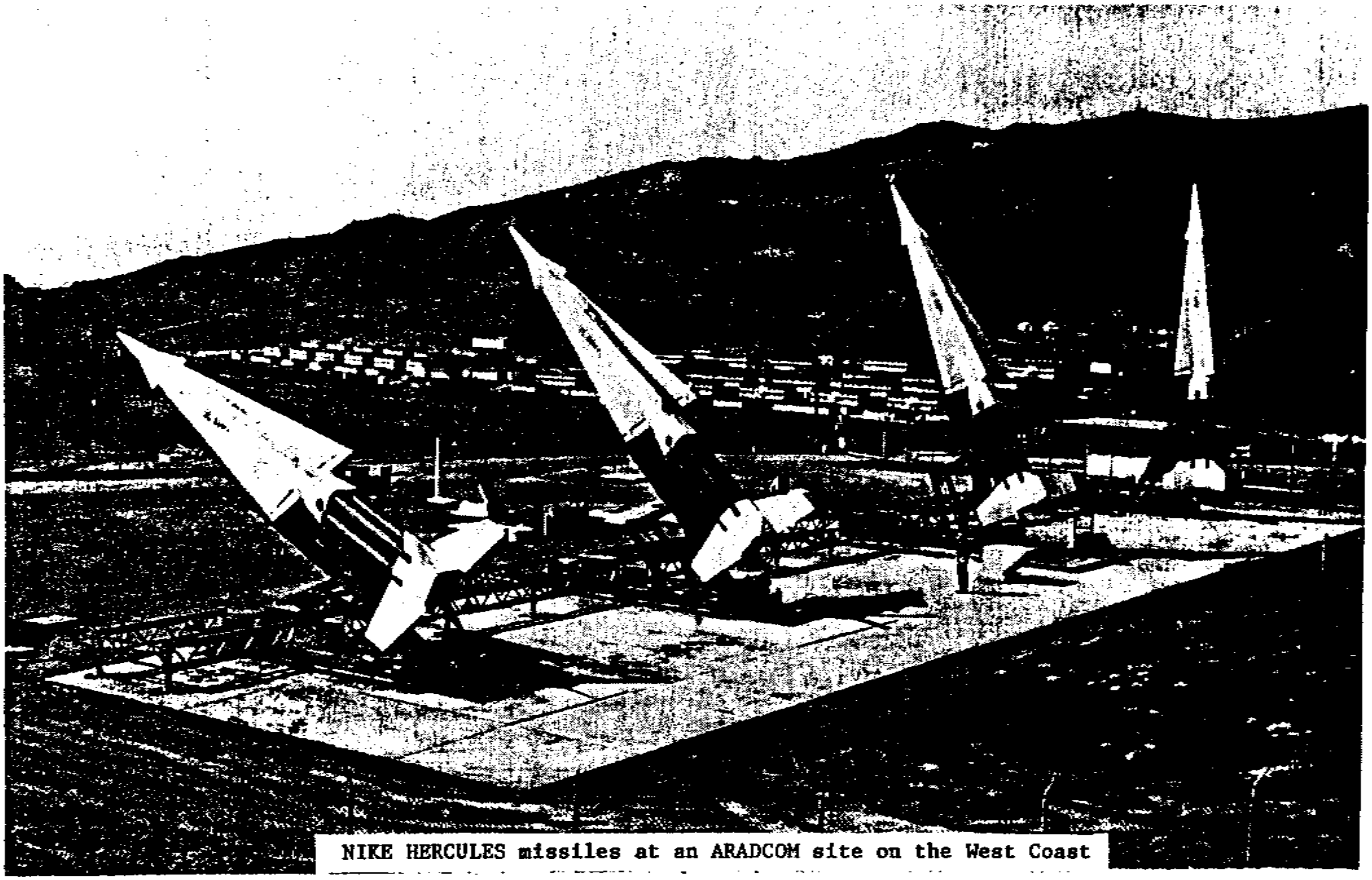
**Procedures for Long Supply Asset Utilization Screening.

[3]Hist Rept, Mat Mgt Dir, FY 1971, pp. 10-11, 19-20. Hist Div File.

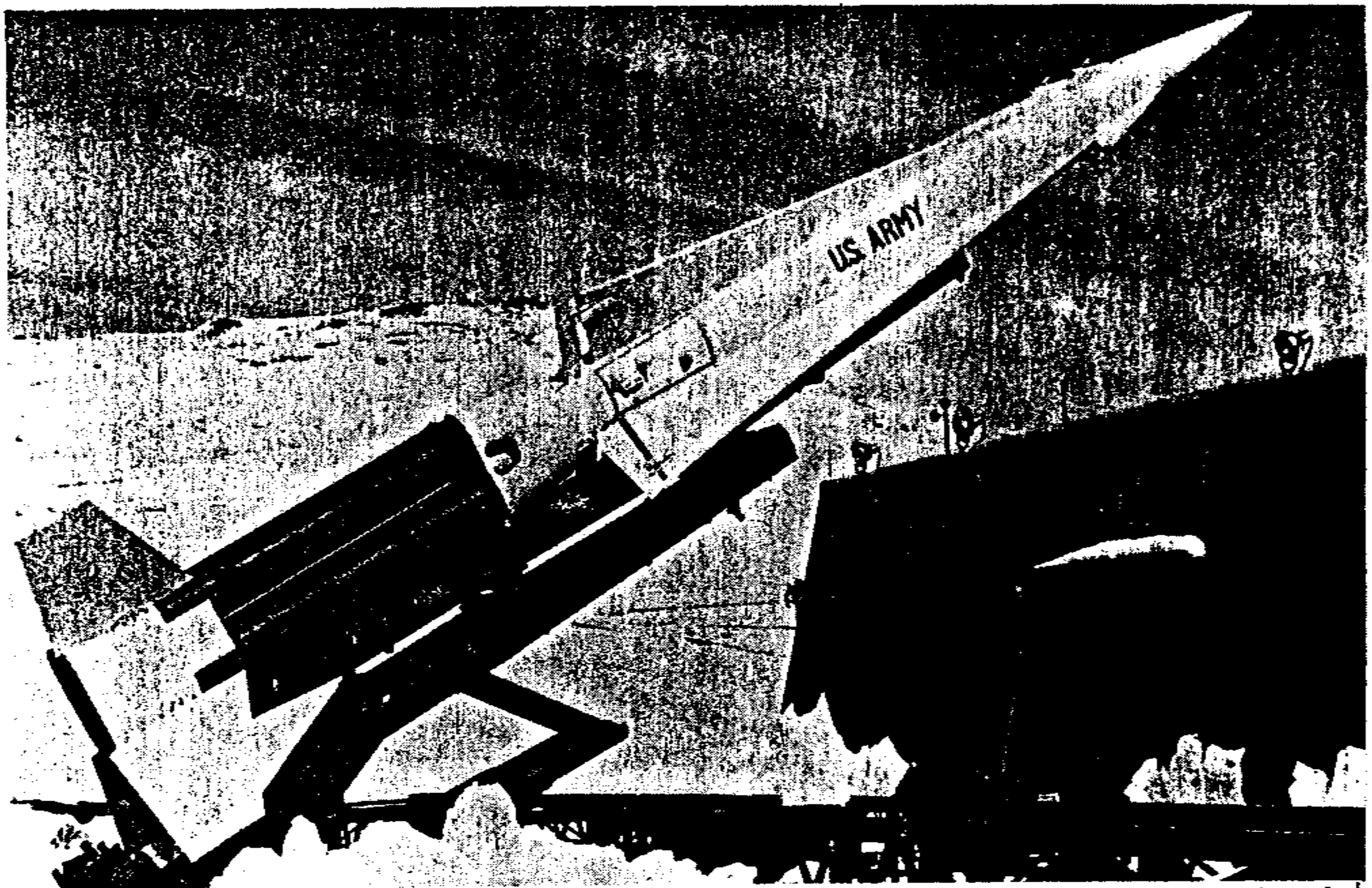
[4]Data extracted from NH Sys Configuration Status Rept, Maint Engrg Div, Dir for Maint; and supplemental report supplied by Ray DeCoursey, Mat Mgt Dir.

[5](1) ADSIMO Rept, Sys Program Sum for NH Msl Sys, 4 May 72, updated by Mrs. Clura M. Colquitt, ADSIMO, 11 Jul 72. (2) The obligation for customer orders furnished by Mrs. Colquitt in a separate report.

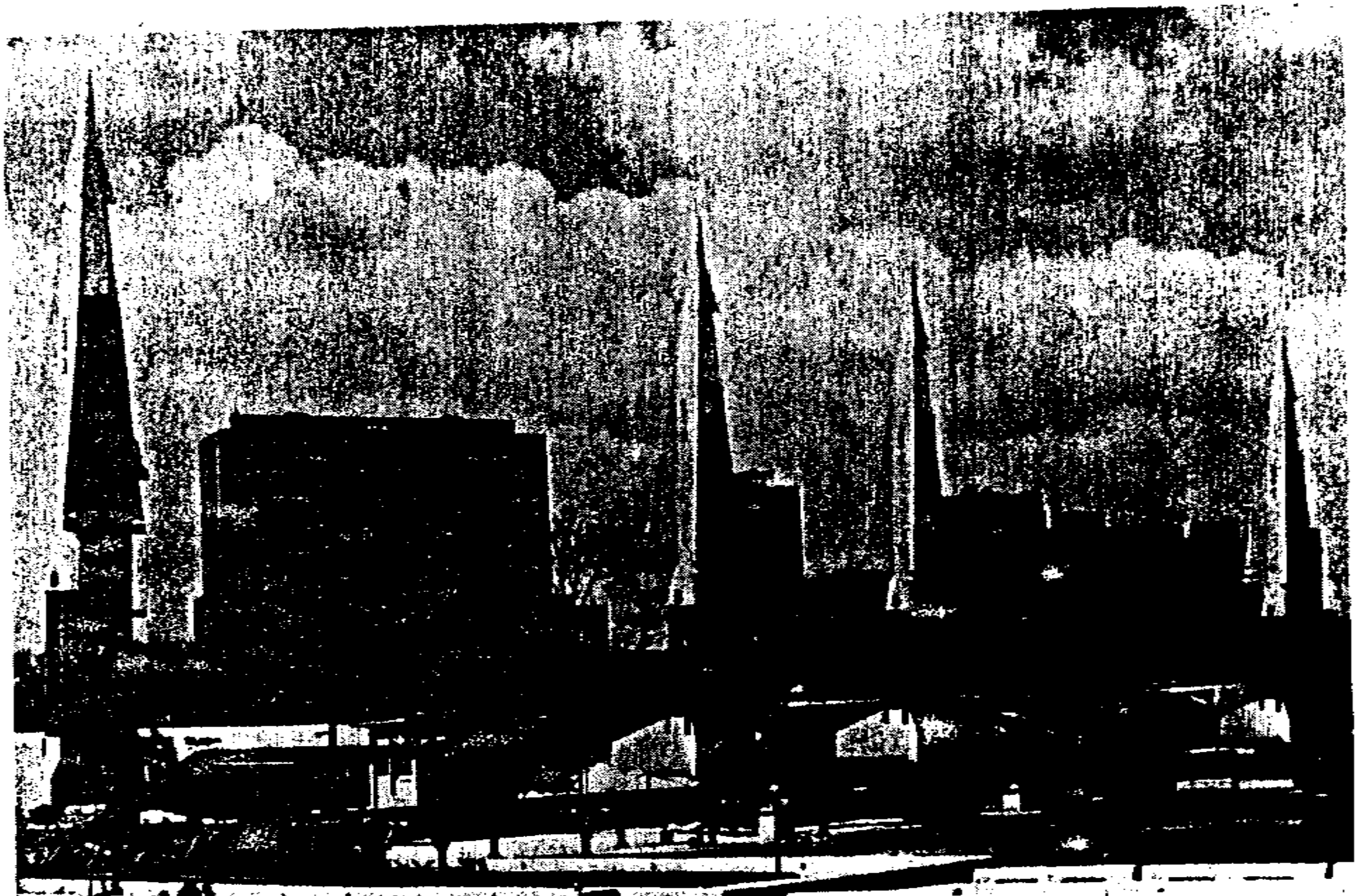
[6](1) Ltr, CG, AMC, to CofSA, 16 Jun 72, subj: Future Spt of NH. (2) Ltr, CofSA to CG, AMC, 14 Jul 72, subj: Future Spt of NH. Both in Hist Div File.



NIKE HERCULES missiles at an ARADCOM site on the West Coast



HERCULES SITE IN ALASKA—Except for about 3 months of the year, snow is the constant companion of men and missiles at the Summit NIKE HERCULES Site atop a 3500-foot peak of the Chugach Mountains east of Fort Richardson, Alaska.



One of the NIKE HERCULES sites in the Chicago defense area

APPENDIX B

(U) NOMENCLATURE FOR TYPE CLASSIFIED ITEMS IN THE BASIC NIKE HERCULES AIR DEFENSE GUIDED MISSILE SYSTEM

SOURCE: OTCM's 36763, 10 Apr 58; 36833, 10 Jul 58.

1. GUIDED MISSILE, AIR DEFENSE: M6 (XM6E3) - The complete HERCULES missile with booster cluster.

2. ROCKET MOTOR: M30 (XM30) - Main propulsion unit of the missile.

3. ROCKET MOTOR: M42 (XM42) - Booster cluster used to assist the initial boost action of the main propulsion unit.

4. WARHEAD, GUIDED MISSILE, HIGH EXPLOSIVE: M17 (T45) - A blast-fragmentation warhead adapted for use with the NIKE AJAX and HERCULES missiles.

5. EXPLOSIVE HARNESS ASSEMBLY, GUIDED MISSILE: M38 (XM38) - An explosive link between the arming mechanism, safety (2) and the M17 (T45) warhead in NIKE HERCULES.

6. EXPLOSIVE HARNESS ASSEMBLY, GUIDED MISSILE: M39 (XM39) - An explosive link between the arming mechanism, safety (2) and the T46 warhead in NIKE HERCULES. (The T46 cluster warhead was developed but never standardized for troop use.)

7. SELF-DESTRUCT CHARGE, GUIDED MISSILE: M44 (XM44) - An explosive (primacord) destruct ring and the explosive link to the arming mechanism, safety, for use in R&D flights of the NIKE HERCULES.

8. SAFETY AND ARMING DEVICE, GUIDED MISSILE: M31 (XM31) - A fail safe and arming device for the NIKE HERCULES.

9. BODY SECTION, FORE, GUIDED MISSILE: M9 (XM9) - A unit to house and protect the appropriate warhead during launching.

10. PROPELLANT, SOLID, GUIDED MISSILE: M25 (T17E3) - An ammonium perchlorate type solid propellant used in the M30 (XM30) sustainer motor for NIKE HERCULES. The propellants in the T17 series, including the original T17 and modifications E1, E2, and E3, differ slightly in chemical composition to adapt them to use in the SERGEANT, NIKE AJAX, and NIKE HERCULES missiles.

11. BEAM, HOISTING, GUIDED MISSILE: M7 (XM7) - Used to lift and hold the nose and warhead section in position while joining to Missile Body Section.

12. BEAM, HOISTING, GUIDED MISSILE: M8 (XM8) - Used to lift the Booster Cluster Assembly.

13. BEAM, HOISTING, GUIDED MISSILE: M9 (XM9) - Used in conjunction with the joining hoist or M62 truck w/Hydrocrane to lift the assembled missile.

14. BEAM, HOISTING, GUIDED MISSILE: M10 (XM10) - Used in conjunction with joining hoist or M62 truck w/Hydrocrane to lift the unfueled main body section of the missile.

15. HOISTING UNIT, PORTABLE, GUIDED MISSILE: M26 (XM26) - Used throughout the assembly, fueling, warheading, and launching areas to lift the booster cluster components, missile, and sections of the missile.

16. RAIL, LAUNCHING-HANDLING, GUIDED MISSILE: M2 (XM2) - The launching rail supports the missile and booster while the round is being handled on the storage racks, and releases the round for movement out of the launcher at the moment of launch.

17. TRAILER, VAN, DIRECTOR STATION: M424 (XM424) - Provides housing and permanent transportable mounting for Director-Computer Group GS 18135; also provides operational space for personnel.

18. TRAILER, VAN, TRACKING STATION: M428 (XM428) - Provides housing and permanent transportable mounting for Tracking Station Group GS 18134; also provides operational space for personnel.

19. TRUCK, GUIDED MISSILE TEST SET: M451 (XM451) - A hand-propelled, wheeled vehicle used to transport the portable test set from missile to missile for the electrical checkout on the launcher or test racks, or from section to section, as required.

20. PLATE, MOUNTING, SAFETY-ARMING DEVICE: M1 (XM1) - The mounting plate provided in the missile for the M30 S&A Device.

21. PLATE, MOUNTING, SAFETY-ARMING DEVICE: M2 (XM2) - The mounting plate is installed in the missile airframe and provides the electrical and explosive connections between the safety and arming mechanisms and the warheads and missile guidance section.

22. FILLER, HYDRAULIC SYSTEM, GUIDED MISSILE: M5 (XM5) - Used to fill the missile hydraulic power unit with Ethylene oxide.

23. CONTAINER, SHIPPING & STORAGE, GUIDED MISSILE: M400 (XM400) - A reusable shipping container used for transporting and storing the missile body section.

24. CONTAINER, SHIPPING & STORAGE, GUIDED MISSILE WARHEAD: M401 (XM401) - A reusable shipping container used for transporting and storing the warhead section of the missile.

25. LAUNCHER, MONORAIL, GUIDED MISSILE: M36 (XM36) - The launcher assembly receives, hold, and positions the missile ready for firing.

26. RACK, LOADING, GUIDED MISSILE: M10 (XM10) - Tracks on which a guided missile is stored prior to loading on a launcher.

27. SIDE TRUSS, LOADING RACK, GUIDED MISSILE: M1 (XM1) - This unit consists of side trusses to the top of which "T" section tracks are attached. These tracks engage the wheels of the launching and transporting rail as it is loaded on the rack.

28. MODIFICATION KIT, GUIDED MISSILE LAUNCHER: M93 (XM93) - Consists of a group of items that are installed on the launcher prior to movement from one area to another. Upon completion, the launcher is then towed by the prime mover to the new area.

29. MODIFICATION KIT, GUIDED MISSILE LAUNCHER: M94 (XM94) - Consists of a group of components necessary for the installation of the launcher when it is emplaced in the field installation.

30. MODIFICATION KIT, GUIDED MISSILE LAUNCHER: M95 (XM95) - Consists of the necessary components and accessories to modify the existing launcher for subsurface use and installation.

31. TRUCK, GUIDED MISSILE BODY SECTION: M441 (XM441) - Used to transport, support, and position the missile during test and repair, during assembly of the complete missile.

32. TRUCK, GUIDED MISSILE ROCKET MOTOR: M442 (XM442) - Used to transport the booster from the booster assembly and storage areas to the missile-booster joining area.

33. ADAPTER, ADJUSTABLE, TRAILER TO GUIDED MISSILE COMPONENTS: M36 (XM36) - When transporting the missile on the transporter trailer, the missile or booster is held in place by the adapter assembly, transporter. This assembly will hold either the missile or booster; not both. There are two adapters for each transporter trailer, being mounted side by side.

34. BOX, GUIDED MISSILE FINS, SHIPPING & STORAGE: M31 (XM31) - Used for transporting and storage of the missile fins and accessories.

35. BOX, ROCKET MOTOR FINS, SHIPPING & STORAGE: M32 (XM32) - Used for transporting and storage of the booster fins.

36. TRAILER, LOW BED, ANTENNA MOUNT: M406 (XM406) - Used to transport the missile or the target tracking radar antenna.

NOTE: The servicing items developed for use with the liquid propellant HERCULES missile have been deleted from the list. (The liquid propellant sustainer motor was replaced by the M30 solid propellant motor.)

APPENDIX C

News Release, Department of Defense, Office of Public Information, Washington 25, D. C., undated (*circa* September 1958).

QUESTIONS AND ANSWERS: HERCULES-BOMARC

The following questions have been asked concerning the HERCULES and BOMARC systems:

1. QUESTION: What are the ranges of the NIKE HERCULES and the BOMARC?

   ANSWER: The effective range of a surface-to-air guided missile depends upon several things other than the distance to which the missile can be fired. Among these are the reflective characteristics of the target, the target speed and even the target altitude. The exact performance of a weapon is classified. Therefore, we release only a nominal figure. The figure for the range of the NIKE HERCULES is "over 75 NM". Comparable figures for BOMARC are "over 200 NM" for the early model and "over 400 NM" for the advanced model.

2. QUESTION: What are the speeds of the NIKE HERCULES and the BOMARC missiles?

   ANSWER: Both missiles are supersonic. They have more than adequate speed to attack any known type of manned aircraft and will have a margin of speed advantage over any foreseeable manned aircraft.

3. QUESTION: What are effective altitudes of NIKE HERCULES and the BOMARC?

   ANSWER: Both missiles have adequate altitude capabilities to cope with any known or foreseeable manned aircraft. The BOMARC has air breathing engines and is therefore confined to atmosphere which will support combustion. The NIKE HERCULES is powered by solid propellant rocket and can operate at even higher altitude.

4. QUESTION: How do the NIKE HERCULES and the BOMARC systems differ in Air Defense Operation?

   ANSWER: The basic conception for the air defense of the United States is a defense in depth. Such a defense can subject invading aircraft to continuous attack of increasing severity as they approach a target area. Under this concept enemy aircraft detected by our early warning radar would first be attacked by manned interceptors. They would next be attacked by the BOMARC guided missiles and manned interceptors. Any which succeeded in approaching critical areas defended by NIKE HERCULES would come under attack by that system as well as BOMARC and manned interceptors. Both NIKE HERCULES and BOMARC would normally be assigned targets by the semi-automatic ground environment system known as SAGE where that system is available. NIKE HERCULES can be operated autonomously, that is, it is self sufficient and can operate either with or without SAGE. BOMARC is designed for fast reaction by being integrated with SAGE.

5. QUESTION: What test results are available on the NIKE HERCULES and BOMARC systems?

   ANSWER: Specific test data is classified. Both the NIKE HERCULES and the early BOMARC have passed through their development tests and have been launched by troops trained for operational units. During these tests each system has successfully intercepted high performance jet target drones. These test firings and troop training shots have demonstrated that both systems are very effective. There is an improved version of BOMARC still in development.

6. QUESTION: How do the services train personnel for the guided missile units?

   ANSWER: First of all, personnel are selected for a guided missile unit only if they meet specified criteria. Those who are to have technical responsibilities are then given special training courses. The Army trains technicians for the NIKE HERCULES units in schools established at Fort Bliss, Texas, and at Fort Belvoir, Virginia. Courses for the various specialties range from 8 to 51 weeks in duration. The Air Force currently conducts similar individual training of specialists at the Boeing plant in Seattle, Washington. This training program will be transferred to an Air Training Command school at Chanute Air Force Base.

7. QUESTION: What are the land requirements for HERCULES and BOMARC sites?

   ANSWER: A battalion of four batteries of HERCULES requires about 150 acres in fee and about 350 acres in easement, for a total of about 500 acres.

   A BOMARC squadron with approximately the same number of missiles requires about 70 acres in fee and about 30 acres in easement, for a total of about 100 acres.

   As most HERCULES units are replacing NIKE AJAX units, few additional land acquisitions will be required.

   BOMARC will be installed on military owned property, where possible. Where military property is not available sites will be located some distance from cities which will minimize interference with civilian activities.

8. QUESTION: Is there a difference in the hazard of life and property between the NIKE HERCULES Installation and a BOMARC Installation?

ANSWER: The safeguards included in both of these weapons and in the launching site arrangement make the chances of hazard to their civilian neighbors virtually impossible. In addition to the safeguards built into the equipment and into the launching site arrangement - the personnel who will man and handle the equipment are carefully screened and thoroughly trained. Moreover, the units are given thorough periodic inspections both to assure that the safety features of the equipment are operational, and that the established procedures are followed.

9. QUESTION: What is the cost of a NIKE HERCULES and of a BOMARC Missile?

ANSWER: A comparison of these two missile systems on a unit cost basis can be very misleading. While BOMARC does cost more per unit than does the NIKE HERCULES, it can reach out and defend a larger area than can the NIKE HERCULES. Each has its advantages and disadvantages. A defense comprised of both systems takes advantage of the desirable characteristics of both weapons systems. Actual cost figures are classified inasmuch as arithmetic could be applied to available contract information to produce approximations of our existing and planned missile stocks.

10. QUESTION: When will these missiles be incorporated in the U.S. Air Defense System?

ANSWER: There are HERCULES missiles in 8 operational NIKE units in the U.S. today. Additional NIKE AJAX units will be converted to HERCULES units this fiscal year (before next June). (HERCULES is also being installed overseas. Additional battalions are scheduled for overseas deployment in the near future. One battalion has arrived and is being turned over to the Chinese Nationalists in Taiwan.)

Four BOMARC sites are now under construction. Construction of additional sites is planned for this fiscal year.

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APPENDIX D

U
(~~C~~) SITE CONSTRUCTION & DEPLOYMENT
OF CONUS (ARADCOM) UNITS (U)

Table I. Converted Defense Sites

II. New Defense Sites

App D Downgraded to Unclassified by
Alfred H. James
H2MADS Mgt Ofc, MLC
876-7101
(all sites now deactivated*)
FONECON, 8 Nov 82

Mary Cagle

*Sites not listed (activated in 1963; now deactivated): Homestead AFB, Fla

Appendix D
TABLE I
U
(~~C~~) CONVERTED DEFENSE SITES (U)

Priority Number	Defense Area	Site Number 1/	Box Type 2/ & Number	Construction Period	Opnl Date w/HERC Msls
1	New York	NY 49 (½)	2B	Mar 58 - Jun 58	1 Jul 58
2	Washington-Baltimore	* W 25	2B	Mar 58 - Jun 58	2 Jul 58
3	Chicago	C 03 (½)	3B	Mar 58 - May 59	30 Jun 58
4	Philadelphia	*PH 25 (½)	2B & 2C	Mar 58 - Jun 59	10 Oct 58
5	New York	*NY 49 (½)	2B	Mar 58 - Sep 58	15 Oct 58
6	Washington-Baltimore	*BA 18 (½)	2B & 1C	Apr 58 - Jan 59	28 Oct 58
7	Los Angeles	*LA 88	1B & 2C	May 58 - Jun 59	8 Jan 59
8	Detroit	D 26 (½)	2B	May 58 - Jul 58	1 Oct 58
9	New York	*NY 24	3B	May 58 - Mar 59	4 Mar 59
10	Chicago	* C 32	3B	May 58 - Oct 58	19 Feb 59
11	Boston-Providence	* B 36	2B	May 58 - Nov 58	25 Mar 59
12	Pittsburgh	*PI 03	3B	May 58 - Nov 58	17 Feb 59
13	New York	*NY 04 (½)	2B & 1C	May 58 - Dec 58	26 Mar 59
14	Washington-Baltimore	* W 64 (½)	2B & 2C	Jun 58 - Mar 59	3 Apr 59
15	San Francisco	*SF 88	2B	May 58 - Nov 58	1 Apr 59
16	Cleveland	CL 69	3B	May 58 - Nov 58	28 Feb 59
17	New York	*NY 25	1B & 2C	May 58 - Jun 59	19 May 59
18	Pittsburgh	*PI 43	3B	May 58 - Nov 58	16 Mar 59
19	Niagara-Buffalo	NF 16 (½)	2B & 1C	May 58 - May 59	3 Apr 59
20	Hartford-Bridgeport	HA 08	1B & 2C	May 58 - Jan 59	1 Jun 59
21	New York	*NY 56 (½)	2B	May 58 - Jan 59	16 Jun 59
22	Washington-Baltimore	*BA 79 (½)	2B & 2C	Mar 58 - Feb 59	17 Apr 59
23	Chicago	C 61	2B	Jun 58 - Jan 59	6 May 59
24	Los Angeles	*LA 04	1B & 2C	Jun 58 - Jun 59	8 May 59
25	Philadelphia	PH 99 (½)	2B & 1C	Apr 58 - May 59	13 May 59
26	Detroit	D 16	2B	May 58 - Sep 58	unk
27	Milwaukee	M 20	3B	Jun 58 - Oct 58	24 Apr 59
28	Seattle	* S 92	2B	Jun 58 - Jan 59	19 May 59
29	Chicago	* C 93	2B	Apr 58 - Nov 58	15 May 59
30	Boston-Providence	* B 73	2B	May 58 - Dec 58	21 Apr 59

Appendix D - Table I (Cont.)

Priority Number	Defense Area	Site Number 1/	Box Type 2/ & Number	Construction Period	Opnl Date w/HERC Msls
31	Pittsburgh	*PI 71	1B & 2C	Jun 58 - Mar 59	7 May 59
32	San Francisco	SF 93	3B	May 58 - Feb 59	17 Apr 59
33	Cleveland	CL 02	3B	May 58 - Nov 58	7 Apr 59
34	Niagara-Buffalo	NF 41 (½)	2B & 1C	May 58 - Apr 59	5 Jun 59
35	Loring Air Force Base	L 13	2C & 1B	Jun 58 - Feb 59	22 May 59
36	Fairchild Air Force Base	F 87	2B & 1C	Jul 58 - Mar 59	29 Jun 59
37	Travis Air Force Base	* T 10	3B	Jun 58 - Jan 59	12 Jun 59
38	Ellsworth Air Force Base 3/	E 01	3B	Jun 58 - Oct 58	30 Sep 59
	to Hartford-Bridgeport 3/	HA 48	1B & 1C	Jul 60 - Jan 61	3/
39	Hanford 3/	H 06	2B	Jun 58 - Dec 58	9 Jul 59
	to Norfolk 3/	* N 52	2B	Jun 60 - Sep 60	3/
40	Norfolk	* N 25	2B & 1C	May 58 - May 59	23 May 59
41	New York	*NY 56 (½)	2B	May 58 - Apr 59	13 Jun 59
42	Washington-Baltimore	*BA 30 (½)	2B & 1C	May 58 - Mar 59	9 May 59
43	Los Angeles	*LA 55	2B	Jun 58 - Dec 58	12 Jun 59
44	Philadelphia	PH 99 (½)	2B & 1C	Apr 58 - Jun 59	25 Apr 59
45	Detroit	* D 58 (½)	3B	Jun 58 - Oct 58	2 Jul 59
46	Milwaukee	M 02	1B & 2C	Jun 58 - Jun 59	10 Jul 59
47	Hartford-Bridgeport	BR 04	3B	Aug 58 - Feb 59	23 Oct 59
48	Seattle	* S 13 (½)	2B & 1C	Jun 58 - Apr 59	17 Aug 59
49	New York	*NY 80 (½)	2B & 1C	May 58 - Jun 59	14 Aug 59
50	Chicago	C 41	1B & 2C	Jun 58 - Apr 59	26 Aug 59
51	Pittsburgh	PI 36	1B & 2C	Jun 58 - May 59	11 Jul 59
52	San Francisco	*SF 51	2B	May 58 - Apr 59	12 Jul 59
53	Los Angeles	*LA 32	2B	Jun 58 - Dec 58	19 Nov 59
54	Detroit	* D 87	1B & 2C	Jun 58 - Aug 59	12 Oct 59
55	Philadelphia	PH 75 (½)	2B & 1C	Jun 58 - Sep 59	10 Sep 59
56	Boston-Providence	*PR 38	1B & 2C	May 58 - Jun 59	11 Dec 59
57	Chicago	* C 72	1B & 2C	Jun 58 - May 59	29 Oct 59
58	New York	NY 54	2B	May 58 - Mar 59	22 Sep 59

Appendix D - Table I (Cont.)

Priority Number	Defense Area	Site Number[1/]	Box Type[2/] & Number	Construction Period	Opnl Date w/HERC Msls
59	Pittsburgh	PI 93	1B & 2C	Jun 58 - May 59	17 Sep 59
60	San Francisco	*SF 31	2B	May 58 - Jun 59	20 Sep 59
61	New York	NY 94 (½)	4B	May 58 - May 59	13 Nov 59
62	Boston-Providence	PR 99	1B & 2C	May 58 - Jun 59	23 Jan 60
63	Chicago	* C 50	1B & 2C	Jun 58 - Jul 59	7 Nov 59
64	Los Angeles	*LA 78	1B & 2C	Jun 58 - Jun 59	20 Nov 59
65	Philadelphia	*PH 41 (½)	2B & 1C	Jun 58 - Jun 59	19 Nov 59
66	Milwaukee	M 74	1B & 2C	Jun 58 - Aug 59	2 Dec 59
67	Cleveland	CL 11	3D	Jun 58 - Sep 59	24 Mar 60
68	Niagara-Buffalo	BU 18	3B	May 58 - Apr 59	25 Nov 59
69	Washington-Baltimore	W 44	2B	Jun 58 - Dec 58	26 Nov 59
70	Pittsburgh	*PI 37	3B	Jun 58 - May 59	22 Nov 59
71	San Francisco	SF 87	2B	May 58 - Jun 59	4 Nov 59
72	Washington-Baltimore	* W 92	1B & 2C	Jun 58 - Jun 59	27 Nov 59
73	Norfolk	* N 85	2B	May 60 - Aug 60	1 Dec 60
74	Loring Air Force Base	L 58	1B & 1C	Jun 60 - Nov 60	1 Dec 60
75	Fairchild Air Force Base	F 45	2B	Jun 60 - Jan 61[4/]	1 Dec 60
76	Seattle	* S 61	1B & 1C	Jun 60 - Mar 61[4/]	5 Jun 61[4/]
77	Boston-Providence	* B 05	1B & 1C	Jul 60 - Jan 61[4/]	5 Jun 61[4/]
78	Los Angeles	LA 29	1B & 1C	Dec 60 - Apr 61[4/]	5 Jun 61[4/]
79	Los Angeles	*LA 43	1B & 1C	Dec 60 - Apr 61[4/]	5 Jun 61[4/]
80	Detroit	* D 06	2B	Oct 60 - Apr 61[4/]	Oct 61[4/]
81	Chicago	C 47	1B & 1C	Oct 60 - Jun 61[4/]	Oct 61[4/]
82	New York	NY 60	2B	Jan 61 - May 61[4/]	Oct 61[4/]
83	New York	NY 65	2B	Jan 61 - May 61[4/]	Oct 61[4/]
84	Philadelphia	*PH 58	1B & 1C	Jan 61 - Jun 61[4/]	Oct 61[4/]
85	Washington-Baltimore	W 26	1B & 1C	Dec 60 - Jun 61[4/]	Oct 61[4/]
86	Los Angeles	LA 94	1B & 1C	Dec 60 - Jun 61[4/]	Oct 61[4/]
87	Chicago	C 46	1B & 1C	Oct 60 - May 61[4/]	Oct 61[4/]
88	Washington-Baltimore	*BA 03	1B & 1C	Dec 60 - Jul 61[4/]	Oct 61[4/]

Appendix D - Table I (Cont.)

Priority Number	Defense Area	Site Number[1/]	Box Type[2/] & Number	Construction Period	Opnl Date w/HERC Msls
89	Travis Air Force Base	T 86	1B & 1C	unk	Oct 61[4/]
90	Philadelphia	PH 41 (½)	2C	Jan 61 - Jul 61[4/]	Oct 61[4/]
91	Los Angeles	LA 96	1B & 1C	Dec 60 - Jul 61[4/]	Oct 61[4/]
92	Detroit	D 61	1B & 1C	Oct 60 - Jun 61[4/]	Oct 61[4/]

NOTES:

[*]Denotes active sites as of March 1972. (Others deactivated during 1966-71 period. *See* p. 210.)

[1/]When "(½)" appears, this means that one-half of the battery sites for a particular location was constructed and became operational as shown.

[2/]For an explanation of the letters indicating box (magazine) types, *see* p. 90.

[3/]Ellsworth Air Force Base Site E 01 and Hanford Site H 06 were redeployed to Hartford Site HA 48 and Norfolk Site N 52 in FY 1961.

[4/]Approximate.

SOURCE: SRI TR 24, Aug 61, pp. 231-35, 239-41. RHA Bx 13-592.

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APPENDIX D

TABLE II

U
(Ø) NEW DEFENSE SITES[1/] (U)

Type and Pri. No.	Defense Area	Site Number	Construction Period	Opnl Date w/HERC Msls
THULE SITES[2/]				
1	Thule, Greenland	01	May 57 - Sep 58	Early 1959
2	Thule, Greenland	13	May 57 - Sep 58	Early 1959
3	Thule, Greenland	40	May 57 - Sep 58	Early 1959
4	Thule, Greenland	60	May 57 - Sep 58	Early 1959
CITY SITES[3/]				
1	St. Louis	SL 10	Jun 58 - Oct 59	18 May 60
2	St. Louis	SL 40	Jun 58 - Oct 59	26 May 60
3	St. Louis	SL 60	Jun 58 - Oct 59	25 May 60
4	St. Louis	SL 90	Jun 58 - Oct 59	19 May 60
5	Minneapolis-St. Paul	MS 20	Jun 58 - Oct 59	14 Mar 60
6	Minneapolis-St. Paul	MS 40	Jun 58 - Oct 59	14 Mar 60
7	Minneapolis-St. Paul	MS 70	Jun 58 - Oct 59	2 Apr 60
8	Minneapolis-St. Paul	MS 90	Jun 58 - Oct 59	29 Feb 60
9	Kansas City	KC 10	Jun 58 - Nov 59	6 May 60
10	Kansas City	KC 30	Jun 58 - Nov 59	6 May 60
11	Kansas City	KC 60	Jun 58 - Nov 59	12 May 60
12	Kansas City	KC 80	Jun 58 - Nov 59	13 May 60
13	Cincinnati	CD 27	Jun 58 - Nov 59	19 Apr 60
14	Cincinnati	CD 46	Jun 58 - Nov 59	25 Apr 60
15	Cincinnati	CD 63	Jun 58 - Nov 59	24 Mar 60
16	Cincinnati	CD 78	Jun 58 - Nov 59	27 Mar 60
17	Dallas-Fort Worth	DF 01	Oct 58 - Jun 60	10 Sep 60
18	Dallas-Fort Worth	DF 20	Oct 58 - Jun 60	20 Aug 60
19	Dallas-Fort Worth	DF 50	Oct 58 - Jun 60	19 Aug 60
20	Dallas-Fort Worth	DF 70	Oct 58 - Jun 60	10 Sep 60

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Appendix D - Table II (Cont.)

Type and Pri. No.	Defense Area	Site Number	Construction Period	Opnl Date w/HERC Msls
SAC BASE SITES[4]				
1	Turner Air Force Base	TU 28	Aug 59 - Sep 60	1 Nov 60[5]
2	Turner Air Force Base	TU 79	Aug 59 - Sep 60	1 Nov 60[5]
3	Robins Air Force Base	R 28	Aug 59 - Sep 60	1 Nov 60[5]
4	Robins Air Force Base	R 88	Aug 59 - Sep 60	1 Nov 60[5]
5	Barksdale Air Force Base	BD 10	Aug 59 - Aug 60	1 Nov 60[5]
6	Barksdale Air Force Base	BD 50	Aug 59 - Aug 60	1 Nov 60[5]
7	Dyess Air Force Base	DY 10	Aug 59 - Jun 60	15 Oct 60[5]
8	Dyess Air Force Base	DY 50	Aug 59 - Aug 60	15 Oct 60[5]
9	Bergstrom Air Force Base	BG 40	Aug 59 - Aug 60	2 Nov 60[5]
10	Bergstrom Air Force Base	BG 80	Aug 59 - Aug 60	2 Nov 60[5]
11	Lincoln Air Force Base	LI 01	Aug 59 - Oct 60	15 Dec 60[5]
12	Lincoln Air Force Base	LI 50	Aug 59 - Oct 60	15 Dec 60[5]
13	Offutt Air Force Base	OF 50	Aug 59 - Oct 60	15 Dec 60[5]
14	Offutt Air Force Base	OF 10	Aug 59 - Nov 60	15 Dec 60[5]

NOTES:

[1] With NIKE HERCULES missiles only. All deactivated during 1966-71 period. *See* p. 210.

[2] The Thule sites defended CONUS and were therefore considered part of ARADCOM. Each site had two elevators per magazine, with no satellite launchers.

[3] Each site had three improved type "D" magazines. *See* pp. 90, 151-52.

[4] All aboveground installations.

[5] Approximate.

SOURCE: SRI TR 24, Aug 61, pp. 237-38, 242. RHA Bx 13-592.

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GLOSSARY OF ABBREVIATIONS

- A -

AAC----------	Antiaircraft Command
AADS-70's---	Army Air Defense Systems, 1970's
AAGM--------	Antiaircraft Guided Missile
ABMA--------	Army Ballistic Missile Agency
Accom-------	Accommodate
ACofS-------	Assistant Chief of Staff
ACSFOR------	Assistant Chief of Staff for Force Development
Act---------	Acting
AD----------	Air Defense
ADB---------	Air Defense Board
ADSIMO------	Air Defense Special Items Management Office
Adv---------	Advance, advanced
AEC---------	Atomic Energy Commission
AFB---------	Air Force Base
Agcy--------	Agency
Agrmt-------	Agreement
AJD---------	Anti-Jam Display
AJI---------	Anti-Jam Improvement
AMC---------	Army Materiel Command
AMCRD-------	Army Materiel Command Research & Development (Orgn Symbol)
AMCTCM------	Army Materiel Command Technical Committee Meeting
AMM---------	Antimissile Missile
Ammo--------	Ammunition
AMP---------	Army Materiel Plan
AMSMI-NEHC--	(office symbol) High-Altitude Air Defense Branch, Maintenance Engineering Division, Directorate for Maintenance
AMSMI-SSMA--	(office symbol) Major Items Branch, Missile Systems Division, Directorate for Materiel Management
AMSMI-TAP---	(office symbol) Procurement & Production, Air Defense Special Items Management Office
Anl---------	Annual
AOMC--------	Army Ordnance Missile Command
APG---------	Aberdeen Proving Ground
App---------	Appendix
Appr--------	Approve
Apprd-------	Approved
Apprl-------	Approval
APSA--------	Ammunition Procurement & Supply Agency
ARAACOM-----	Army Antiaircraft Command
ARADCOM-----	Army Air Defense Command
ARGMA-------	Army Rocket & Guided Missile Agency
ASA (I&L)---	Assistant Secretary of the Army (Installations & Logistics)

Asg(d)------	Assign(ed)
Asgmt-------	Assignment
ASM---------	Air-to-Surface Missile
ASP---------	Annual Service Practice
ATBM--------	Antitactical Ballistic Missile
Auth--------	Authority
Authzn------	Authorization
Aval--------	Available, availability

- B -

Bd----------	Board
Bde---------	Brigade
Bfg---------	Briefing
BG----------	Brigadier General
Bldg--------	Building
Bn----------	Battalion
Br----------	Branch
BRL---------	Ballistic Research Laboratories
BTL---------	Bell Telephone Laboratories
Btry--------	Battery
Bx----------	Box

- C -

C&DP--------	Comptroller and Director of Programs
CADP--------	Continental Air Defense Program
CAMP--------	Charlotte Army Missile Plant
CAPT--------	Captain
CDC---------	Combat Developments Command
Cfm---------	Confirm
Cfmn--------	Confirmation
CG----------	Commanding General
Ch----------	Change
Chf---------	Chief
Cir---------	Circular
Clas--------	Classification
Cmdty-------	Commodity
Cmt---------	Comment
CO----------	Commanding Officer
CofOrd------	Chief of Ordnance
CofS--------	Chief of Staff
CofSA-------	Chief of Staff, U. S. Army
COL---------	Colonel
Com---------	Committee
Comdr-------	Commander
COMP--------	Charlotte Ordnance Missile Plant
Con---------	Control
CONAD-------	Continental Air Defense Command
CONARC------	Continental Army Command

Conf--------	Conference
Const-------	Construction
Contr-------	Contract, contractor
CONUS-------	Continental United States
Coord-------	Coordination
Co-Pdn------	Co-Production
CRD---------	Chief of Research and Development
CWO---------	Chief Warrant Officer
CY----------	Calendar Year

- D -

DA----------	Department of the Army
DAC---------	Douglas Aircraft Company
DAGO--------	Department of the Army General Order
DCG---------	Deputy Commanding General
DCG/GM------	Deputy Commanding General for Guided Missiles
DCR---------	Design Characteristics Review
DCSLOG------	Deputy Chief of Staff for Logistics
Decn--------	Decision
Def---------	Defense
Dept--------	Department
Dev---------	Development
DF----------	Disposition Form
Dir---------	Director, Directorate
Div---------	Division
DOD---------	Department of Defense
Dpl(mt)-----	Deploy(ment)
Dspo--------	Disposition
Dtd---------	Dated
Dy----------	Duty

- E -

ECCM--------	Electronic Counter-Countermeasure
ECM---------	Electronic Countermeasure
EFS---------	Electronic Frequency Selection
Engr--------	Engineer
Engrg-------	Engineering
Equip-------	Equipment
Estb--------	Establish(ment)
ET/UT-------	Engineering Test/User Test
Eval--------	Evaluate, Evaluation
Expc--------	Experience

- F -

FABMDS------	Field Army Ballistic Missile Defense System
Fac---------	Facility(-ies)

Feas-------- Feasibility
FETP-------- Final Engineering Test Program
Fld--------- Field
Fn---------- Footnote
FONECON----- Telephone Conversation
fps--------- feet per second
fr---------- from
Ft---------- Fort
Func(1)----- Function(s)(al)
FY---------- Fiscal Year

- G -

GCO--------- Guidance Cutoff
GFE--------- Government-Furnished Equipment
GM---------- Guided Missile
Gnd--------- Ground
GO---------- General Orders
Govt-------- Government

- H -

Hdlg-------- Handling
HERC-------- NIKE HERCULES
HIPAR------- High Power Acquisition Radar
Hist-------- History, Historical
HQ---------- Headquarters

- I -

ICBM-------- Intercontinental Ballistic Missile
IFF--------- Identification Friend or Foe
Imprv------- Improvement
Incl-------- Inclosure
Ind--------- Indorsement
Indus------- Industrial
Inflt------- Inflight
INH--------- Improved NIKE HERCULES
Instl------- Installation
Intvw------- Interview
Inves------- Investigation
IRBM-------- Intermediate Range Ballistic Missile
ITT--------- International Telephone & Telegraph (Corporation)

- J -

JATO-------- Jet-Assisted Takeoff
JPL--------- Jet Propulsion Laboratory
JTF--------- Joint Task Force
Just-------- Justification

- K -

kw---------- Kilowatt

- L -

LAAP-------- Longhorn Army Ammunition Plant
Lab(s)------ Laboratory(-ies)
LAP--------- Load, Assemble, Pack
Lb---------- Pound
Lchg-------- Launching
Lchr-------- Launcher
Ln---------- Liaison
LOPAR------- Low Power Acquisition Radar
LOU--------- Launcher Operating Unit
LP---------- Limited Production
LTC--------- Lieutenant Colonel
Ltd--------- Limited
LTG--------- Lieutenant General
Ltr--------- Letter

- M -

MAAG-------- Military Assistance Advisory Group
MA&T-------- Military Applications and Training
Maint------- Maintenance
MAJ--------- Major
MAP--------- Military Assistance Program
Mat--------- Material, Materiel
Mbr--------- Member
mc---------- Megacycles
MC's-------- Military Characteristics
Memo-------- Memorandum
MFF--------- Memorandum For File
MFR--------- Memorandum For Record
MG---------- Major General
Mgt--------- Management
MICOM------- Army Missile Command
Mins-------- Minutes
Mod(s)------ Modification(s)
MOHEC------- Maintenance of HERCULES Capabilities
mph--------- miles per hour
Msg--------- Message
Msl--------- Missile
Msn--------- Mission
MTE--------- Multisystem Test Equipment
Mtg--------- Meeting
MTI--------- Moving Target Indicator
Mtr--------- Missile Tracking Radar
MUCOM------- Munitions Command

- N -

NASA--------	National Aeronautics & Space Administration
n.d.--------	No Date
NORAD-------	North American Air Defense Command
n.s.--------	no subject
NTDC--------	Naval Training Device Center
NYOD--------	New York Ordnance District

- O -

OAC---------	Ordnance Ammunition Command
O/C---------	Other Customer
OCO---------	Office, Chief of Ordnance
OCRD--------	Office, Chief of Research & Development
Ofc---------	Office
Off---------	Officer
OGMS--------	Ordnance Guided Missile School
OML---------	Ordnance Missile Laboratories
Op(s)(l)----	Operation(s)(al)
Ord---------	Ordnance
OrdC--------	Ordnance Corps
OTC---------	Ordnance Technical Committee
OTCM--------	Ordnance Technical Committee Meeting

- P -

PA----------	Picatinny Arsenal
P&C---------	Purchasing and Contracting
Part--------	Participation
Pdn---------	Production
PEMA--------	Procurement of Equipment and Missiles, Army
PEMA/S------	Procurement of Equipment and Missiles, Army, in Support of R&D
Pers--------	Personnel
Pkg---------	Package
Plcy--------	Policy
PM----------	Project Manager
PM_2P--------	Project Management Master Plan
PMS---------	Projects Management Staff
PPI---------	Plans Position Indicator
pps---------	pulses per second
Ppsd--------	Proposed
Ppsl--------	Proposal
Prelim------	Preliminary
Pres--------	President
Presn-------	Presentation
Proc--------	Procurement
Prog--------	Progress
Proj--------	Project

- R -

R&D----------	Research and Development
RDD----------	Research & Development Division
RDTE---------	Research, Development, Test, and Evaluation
Reasg(d)----	Reassign(ed)
Reg----------	Regulation
Rel----------	Release
Reorg--------	Reorganize
Reorgn-------	Reorganization
Rep----------	Representative
Rept---------	Report
Resp---------	Responsible, Responsibility
Rev----------	Revise, Revision
RF-----------	Radio Frequency
Rg-----------	Range
RHA----------	Records Holding Area
RI-----------	Release to Industrial
Rkt----------	Rocket
ROTCM--------	Reserve Officers' Training Corps Manual
rpm----------	Revolutions Per Minute
Rqrmt--------	Requirement
RSA----------	Redstone Arsenal
RSIC---------	Redstone Scientific Information Center
Rst----------	Redstone

- S -

SA-----------	Secretary of the Army
SAC----------	Strategic Air Command
SAGE---------	Semiautomatic Ground Environment
SAM----------	Surface-to-Air Missile
SAM-D--------	Surface-to-Air Missile Development
Sec----------	Section
Secy---------	Secretary
Smanl--------	Semiannual
SO-----------	Special Orders
Sp-----------	Special
Spt----------	Support
SRI----------	Stanford Research Institute
SS-----------	Summary Sheet
Sta----------	Status
Std----------	Standard
STRAF--------	Strategic Army Forces
Subj---------	Subject
Suc----------	Successful
Sum----------	Summary
Supv---------	Supervise
Supvn--------	Supervision
Suppl--------	Supplement, Supplemental

Svc---------- Service
SXR---------- Senior Agency/Command Representative
Sys---------- System

- T -

Tac---------- Tactical
TBM---------- Tactical Ballistic Missile
TCC---------- Thiokol Chemical Corporation
TCC/LOW------ Thiokol Chemical Corporation/Longhorn Ordnance Works
TCLAS-------- Type Classification
TD----------- Table of Distribution
TDA---------- Table of Distribution and Allowances
Tech--------- Technical
TECOM-------- Test & Evaluation Command
Termn-------- Termination
TIR---------- Technical Information Report
Tng---------- Training
TOE---------- Table of Organization & Equipment
TR----------- Technical Report
Trf---------- Transfer
Trns--------- Transition
TRR---------- Target Ranging Radar
TT----------- Teletype
TTR---------- Target Tracking Radar
TX----------- Texas

- U -

UMPC--------- Universal Moulded Products Corporation
Univ--------- Universal, University
Unsuc-------- Unsuccessful
USACDC------- United States Army Combat Developments Command
USAMC-------- United States Army Materiel Command
USAOMC------- United States Army Ordnance Missile Command
USARAL------- United States Army, Alaska
USAREUR------ United States Army, Europe
USARJ-------- United States Army, Japan
USARPAC------ United States Army, Pacific

- V -

Vol---------- Volume

- W -

w------------ with
WD----------- War Department
WECo--------- Western Electric Company
Whd---------- Warhead

Wpn---------	Weapon
WSMR--------	White Sands Missile Range
WSP---------	Weapon System Plan
WSPG--------	White Sands Proving Ground

- X -

XM----------	Experimental Model
Xmitl-------	Transmittal

- Y -

ZURF--------	ZEUS Uprange Facility

INDEX