Chapter 1
Aircraft, Rockets, Missiles and Radar, 1907-1961

Powered Flight, Radio, Rockets and Sensors

The desire to enhance the intelligence, command, control, and communications functions of armies has been a preoccupation of military commanders ever since the first armies took to the field. Prior to the eighteenth century, military commanders achieved such enhancement by establishing their military positions and observation posts on the highest elevations possible. In 1783, this concept of seizing the high ground took on brand new meaning with the launch of the first balloon. The balloon quickly gained popularity as a military observation platform and was used with varying degrees of success in a number of 18th and 19th century conflicts. The use of military balloons reached its apogee in World War I, when every major belligerent used tethered balloons to report enemy movements, direct artillery fire; track infantry progress in attacks, give details of obstacles and describe the effects of bombardment.[1]

The advent of the airplane ended the dominance of the military balloon. The Army became interested in powered aircraft shortly after the first flight of the Wright Brothers. On 1 August 1907, the Chief Signal Officer, Brigadier General James Allen, issued a memorandum creating an Aeronautical Division within his office that would have "charge of all matters pertaining to military ballooning, air machines and all kindred subjects."[2] Conventional wisdom suggested that aircraft be used to transmit messages and for reconnaissance. Consequently, in 1908, the Signal Corps assumed responsibility for the development and operation of military aircraft. This changed in the First World War.[3] In June 1917, General John J. Pershing created the Air Service of the American Expeditionary Forces, an organization that was independent of the Signal Corps. The creation of an autonomous Army Air Service in May 1918 further reduced Signal Corps involvement with the airplane. Thereafter, the Signal Corps' responsibility was limited to the development of airborne radios.

Along with powered flight, the early 20th century witnessed the advent of wireless radio, an invention that laid the foundation for electronic sensors. The Army's interest in new communications technologies can be linked to the variety of its missions that encompassed an enormous geographical expanse. These include the Army's coastal defense mission, the mission to defend Alaska and Hawaii, and the Army's responsibility for cable communications. Congressional parsimony reinforced the Army's desire to search for a new technological fix to keep communications and defenses operating properly throughout its enormous area of responsibility. New technologies such as the wireless radio enabled the Army to fulfill its varied missions and to become both more efficient and effective.[4]

World War I produced a sea change in the way American society viewed the relationships between business and government. The war strengthened the ties between the military and business, especially with respect to radio technology, the cutting-edge technology of the day. In the 1920s and 1930s, the Army experimented with mobile communications devices for airplanes and mechanized equipment, and with developing tools for signals intelligence.[5] The Army was also developing radio navigation aids, beacons, compasses, direction finders and electronic detection aids to enhance situational awareness. Throughout the 1920s and 1930s, public opinion envisioned that the Army and Navy should be used for narrowly defined defensive purposes. The Navy's experiments with aircraft carriers and the Army's justification for developing heavy bombers, radio detection, and ranging (radar) emphasized their potential contribution to coastal defense.[6] The defensive mindset of Army planning also determined priorities with respect to weapons development. At the same time, Congressional thriftiness also served to stifle technical innovation.[7]

Guided missiles and rockets, however, were weapons systems not readily attached to any defense-oriented Army doctrinal concepts. Nevertheless in 1936, in partnership with the California Institute of Technology (CIT or Cal Tech), the Army's Ordnance Department began basic research in rocket design and fuel and propulsion systems. On the eve of the Second World War, the Army was moving toward developing radar and rockets.[8] The war served as a forcing house for these innovations.

World War II: A New Threat Emerges

By 1940, German rocket scientists were using a supersonic wind tunnel to test design alternatives for radio-controlled bombs, rockets and flak shells, while United States Army scientists were still trying to obtain subsonic velocity data for rockets and bombs. A rocket program initiated in 1942 had, by 1944, evolved into a separate division of the Army Ordnance Department engaged in research on solid and liquid rocket fuel and rocket manufacture. In 1944, shortly after the German V-1 attacks began, the Army divided responsibility for guided missile development between the Army Air Forces (AAF) and the Ordnance Department to lessen secrecy and promote data sharing. The AAF was given "development responsibility…for all guided or homing missiles dropped or launched from aircraft…[or those] launched from the ground which depend for sustenance primarily on the lift of aerodynamic forces." The Ordnance Department would develop missiles "which depend for sustenance primarily on momentum of the missile." In January 1945, the General Staff made the Ordnance Department responsible for developing a missile suitable for antiaircraft use.[9]

Despite these promising developments, the U.S. Army's interest in long-range rockets and missiles remained theoretical. By contrast, the German Army introduced the Allies to the practical effects of long-range rocketry and missile technology when they launched the first ten V-1 rockets against the city of London on the evening of 12-13 June 1944.[10] The V-1, a precursor to the cruise missile, was a cheap and simple weapon to construct.[11] Beginning in 1942, the Germans produced approximately 30,000 of these weapons. In one nine-month period, approximately 10,000 V-1s or "buzz bombs" were launched at London from sites along the English Channel and from medium bombers. More than half of these reached the United

Kingdom, killing over 5,800 people and seriously injuring another 15,000.[12] These attacks forced the U.S. Army to grapple with the effects of this new weapon, a weapon that had no representation in U.S. Army doctrine.

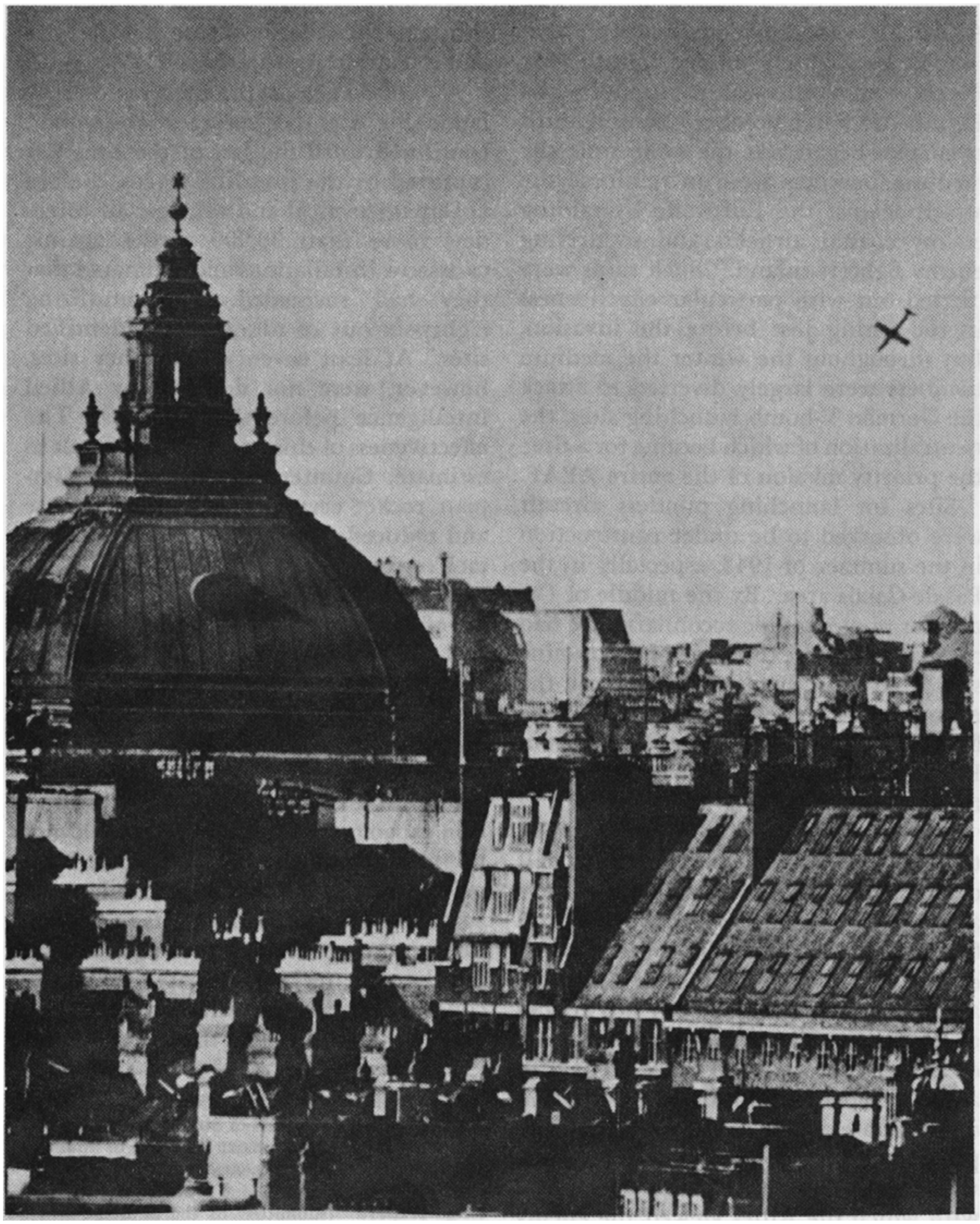

Fig. 1-1. V-1 flying bomb over residential area of London.

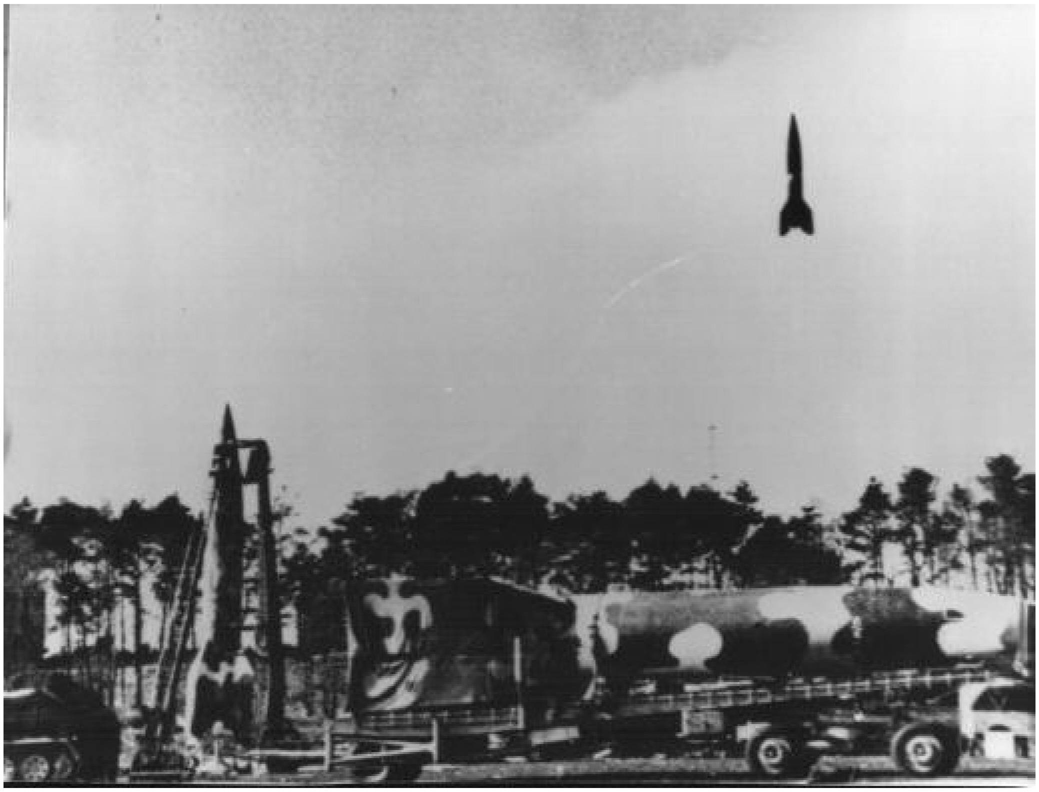

Fig. 1-2. Launch of a V-2 rocket.

The Germans improved upon their rocket technology and, in September 1944, fielded the V-2. Unlike the V-1, the V-2 was a supersonic missile, with a top speed of 3300 mph and a range of 190-200 miles.[13] Although equipped with a three-axis gyro pilot, the V-2 remained an unreliable system. Studies suggest that only one in three reached their intended target. Nevertheless, it proved to be an effective psychological weapon. Its speed precluded any substantial advance warning and its impact velocity generated more extensive damage than the V-1. During the six-month attack on London, for example, over 1,000 V-2s reached Great Britain, killing 2,855 people and seriously injuring 6,268 others.[14]

The Allies implemented a number of defensive measures against these weapons. The first, and perhaps most successful, effort to defeat the V-weapons involved offensive bombing raids on production facilities, support facilities, and launch sites. This was supported by a layered defense system against the V-1 which "included an excellent detection and control system, high speed interceptors, radar-directed guns firing proximity fused shells, and barrage balloons."[15] The combined network destroyed 52.8 percent of the 7,488 V-1 missiles observed. The cost of such a network was staggering. According to a 1944 British Air Ministry report, the estimated cost of defending against the V-1 was £48 million.[16]

Attempts to intercept a V-2 were less successful. Initially, available technology was incapable of tracking or directing aerial defenses against the V-2.[17] As radars improved experts began to assess the feasibility of creating a missile barrier using a barrage of anti-aircraft artillery. This option was dismissed, however, when it was realized that "a barrage of 320,000 shells would be required to produce a likely kill. Of these shells, about 2 percent would be duds that would then fall on London, causing more damage and casualties than a V-2."[18] Thus, once a V-2 was launched the Allies had no means to intercept it.[19]

The Second World War proved to be a fruitful time for scientific research and development in the Army. By 1945, the Army had developed shoulder-fired rockets, truck- and tank-mounted rockets, and was working on larger guided missiles. The Army's role in shooting, processing, and analyzing millions of photographs for intelligence purposes caused a dramatic expansion in the field of aerial reconnaissance photography. Additionally, the Army's code breaking capacity enabled American policy and decision-makers to eavesdrop on enemies, allies and neutrals.[20] Based on prewar experiments and experience gained with a rudimentary long-haul communications and radio direction finding system, the Signal Corps managed to create and operate the largest, secure, unified, global military communications network in existence at that time. The Army also developed ground-based and airborne radars used in early warning systems and aerial bombardment.[21] By 1945, the Army was routinely using aerial and signals intelligence methods to gather, process, and disseminate information. The Army developed and operated a secure (simultaneously encrypting and decrypting), worldwide communications system, anti-aircraft and anti-missile early warning systems, and was developing solid-fueled rockets and liquid-fueled missiles.

As the war ended in May 1945, Colonel Holger N. Toftoy and Major James P. Hamill began contacting German rocket scientists and offering to transport them to the American Occupation Zone. Before the zonal boundaries solidified, they recruited more than 120 scientists and technicians, removed more than 100 assembled V-2 rockets, and transferred more than 300 freight cars full of documents and machinery to the American Zone. The U.S. Joint Intelligence Objectives Agency continued with Operation PAPERCLIP, recruiting German scientists and "inviting" them to the United Stated to continue their rocket developmental work in the postwar period.[22]

Postwar Assessments

Postwar investigations revealed that the Germans were far ahead of the United States in several scientific fields, including rocket and jet engine propulsion.[23] Captured documents revealed plans for a two-stage, intercontinental ballistic missile (ICBM) with a range of 3,500 miles, capable of reaching New York City. The United States was interested in German technical capabilities because they would benefit the American military and American industry. On June 20, 1945, Secretary of State Cordell Hull approved the transfer of the German rocket specialists. Before the operation concluded, almost 500 rocket scientists and technicians were transported to the United States. Many of the German scientists were taken to Fort Bliss, Texas and given six-month contracts to work at the newly established Army Ordnance Research and Development Sub-office. While at Fort Bliss, the German scientists trained military, industry and university personnel in the intricacies of rocket and guided missile technology and helped refurbish, assemble and launch V-2s that had been shipped from Germany to the White Sands Proving Grounds in New Mexico.

In July 1945, in response to the experiments taking place at White Sands and elsewhere, a delegation of American officers recommended that the U.S. undertake a research and development program to develop a defense against these new weapons. A subsequent study by the Scientific Advisory Group of the Army Air Force, published in December 1945, took the issue further by exploring the use of missiles armed with nuclear warheads, and the use of an energy beam as a potential defense against missile attacks.

Dr. Vannevar Bush, the head of the War Department's Office of Scientific Research and Development, opposed the Army's case for missile development. He believed the Army overstated the benefits and advantages of missiles and satellites and argued that it would take many years to develop a reliable ICBM because of the relatively immature state of the technology. In the 1940s, first as Chairman of the Joint Research and Development Board of the War and Navy Departments, and later as Chairman of the Development Board of National Military Establishment, Bush challenged the Army and the Air Force to demonstrate that missiles and satellites could perform warfighting missions in a manner that was more cost effective than the available conventional means. In this manner, Bush successfully delayed large-scale research programs.[24]

On 29 May 1946, the War Department Equipment Board, headed by General Joseph W. Stillwell (the Stilwell Board), issued its report on the equipment needed by American ground forces in the postwar era. The Board recognized that "guided missiles, winged or non-winged, traveling at extreme altitudes and at velocities in excess of supersonic speed, are inevitable." The Stilwell Board went even further in their threat analysis by concluding that "intercontinental ranges of over 3,000 miles and payload[s] sufficient to carry atomic explosive[s] are to be expected." Based on this assessment, the board determined that no aircraft or missile could be allowed to gain access to areas deemed vital to the nation. Thus, future ground forces would require guided intercept missiles. Finally, the board advised that the development of defensive measures designed to counter atomic weapons should be "accorded priority over all other National Defense projects."[25]

Even before the Stilwell Board completed its report, the Army Air Forces had initiated research on the anti-missile concept. On 4 March 1946, the Army Air Force awarded two contracts for the study of anti-missile missiles. The University of Michigan received a contract for Project WIZARD (MX-794). General Electric received another for Project THUMPER (MX-795). The targets in both studies would be traveling at a rate of 4,000 mph at altitudes up to 500,000 feet. Project THUMPER went further, by specifically exploring "the interception of 'rocket-powered ballistic and glide missiles and supersonic ram-jets."[26] In 1947, the Air Force redefined these efforts as prolonged studies and, in March of the next year, canceled Project THUMPER. Project WIZARD meanwhile continued to develop new technologies until 1958, when it merged with the U.S. Army's NIKE-ZEUS project.

Early Division of Labor and Experiments

The first postwar years were a time of great turbulence. This brief period saw wartime demobilization, the beginnings of the Cold War and a massive military reorganization and unification effort that resulted, among other things, in the establishment of the Department of Defense. In 1947, Congress passed the National Security Act, unifying the armed services and establishing an independent Air Force. The next year, the Secretary of Defense, James V. Forrestal, negotiated specific roles and missions with each of the services. The Navy's primary responsibility remained sea operations and it retained the Marine Corps. The Army's primary responsibility remained land operations. In addition, the Army assumed responsibility for ground-based air defense of the continental United States as well as constabulary and occupation forces for Germany and Japan. The Air Force's primary responsibility lay in strategic air power, air transport and tactical air support of the Army's ground forces. The Air Force put forth a claim for jurisdiction over space and satellites, arguing they were a logical extension of strategic air power. The Army and Navy reluctantly conceded this point to the air arm.

After 1945, the Army remained interested in space age communications and missiles, despite the widespread belief that these devices were not military science but science fiction. On 10 January 1946, the Army demonstrated it could send radio waves anywhere when, as part of Project Diana, the "Evans Signal Laboratory succeeded in bouncing a radar signal off the moon." The signal was received seconds after it was transmitted. More than a technological trick, Project Diana's success showed that VHF radio signals could penetrate the electrically charged ionosphere around the earth. This was the beginning of space age signaling.[27]

Almost simultaneously, Operation PAPERCLIP yielded fruit at the White Sands Missile Range.[28] In mid-August 1945, 300 freight cars arrived in New Mexico. These carried 100 V-2 missiles and components and had been spirited out of the Russian Zone of Germany by Colonel Holgar Toftoy and Major James Hamill.

The rockets were refurbished, modified, and rebuilt for tests carried out between 1946 and 1952. Many of the parts brought from Germany were in poor condition or unusable. A total of 67 rockets were assembled and tested in this six-year period. These activities and tests provided the military with invaluable experience in missile assembly, static and pre-flight testing, as well as missile handling, fueling, launching and tracking. The project managers considered approximately two-thirds of the tests to be successful but even the failures yielded valuable information. In addition to the missile testing, scientific experiments conducted onboard the missiles produced new information about rocketry and the upper atmosphere.[29]

Rocket testing continued and the first multistage American rocket was the Bumper. The Bumper was a two-stage rocket comprising an Army Corporal rocket mounted inside a German V-2.[30] The Bumper Project began in June 1947 and the first Bumper flight was launched in May 1948.[31] The program sought to create a rocket that could reach higher altitudes at greater speed, to gain experience in launching two-stage missiles, and to investigate techniques for ensuring

Fig. 1-3. 120 mm gun in Chicago.

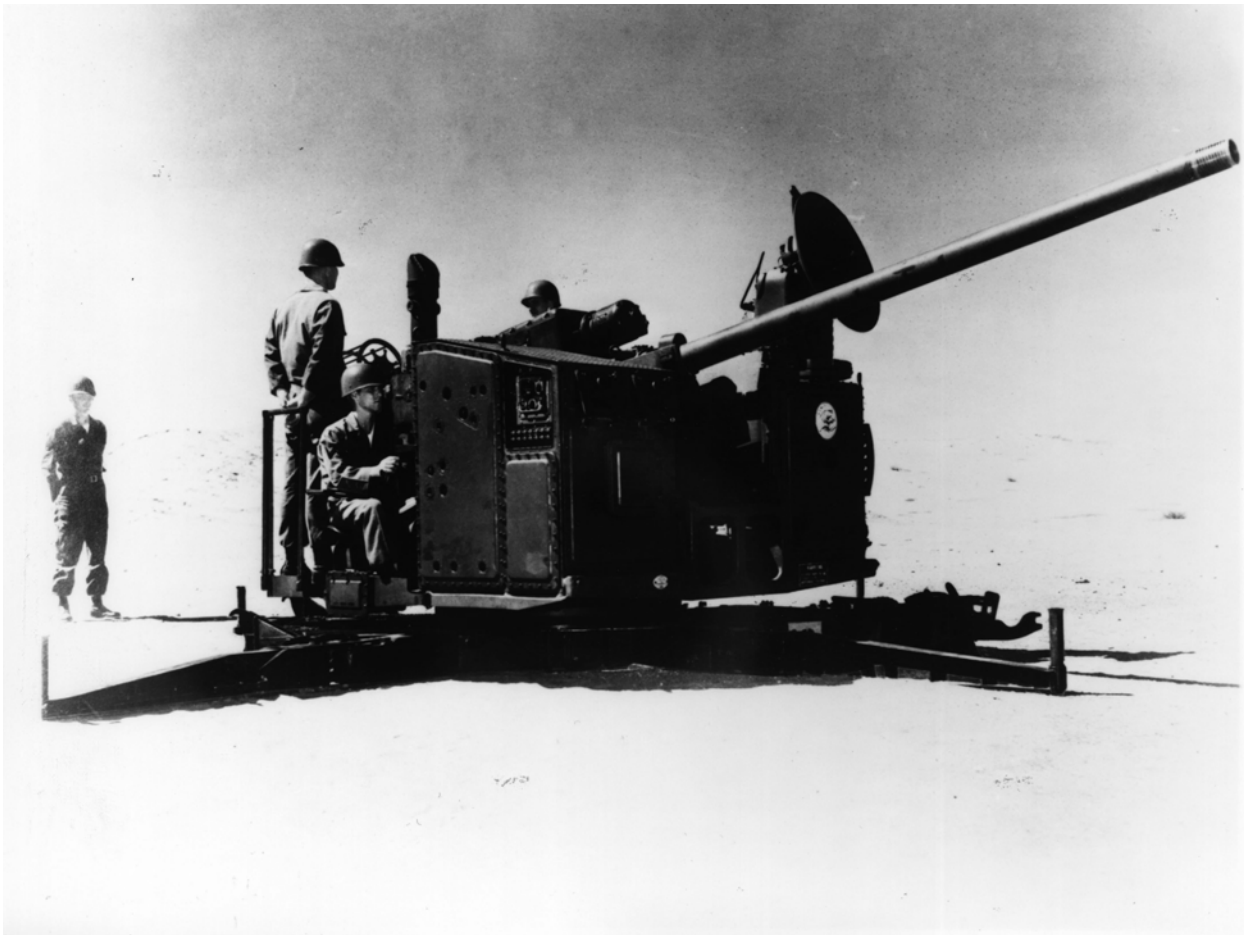

Fig. 1-4. The 75mm Skysweeper antiaircraft gun was the last conventional antiaircraft artillery weapon issued to ARADCOM. In this photo, soldiers practice with a Skysweeper at White Sands.

stage separation at high altitudes. The program also sought to investigate high altitude phenomena. Between May 1948 and July 1950 there were eight Bumper test flights. Six of these tests took place at White Sands, New Mexico and two occurred in Florida. The first fully loaded Bumper, launched in 1949, reached the greatest velocity and altitude ever attained by a man-made object up to that time, and measured temperatures at extreme altitudes. The WAC (Without Attitude Control) Corporal carried instruments that transmitted flight data to a ground station. This was the first time radio equipment operated at these extreme altitudes. The last two Bumper tests were conducted in Florida. One test ran into some difficulty because moisture had collected inside the missile. Despite errors in trajectory, however, the test missile flew at a speed of Mach 9, the highest sustained speed ever reached in the earth's atmosphere. The project demonstrated that adding multiple stages could increase a missile's speed. As a result of these tests, scientists were able to solve the problems of rocket motor ignition at high altitudes, as well as that of that attachment and separation of successive stages. These initial successes provided the necessary foundation for building larger and more complex missiles.

The Evolving Threat

These technological developments were made more significant by the beginnings of the Cold War in Europe and its extension to Asia. In 1947, the United States assumed Britain's role as guarantor of Greek independence and moved to assist both Greece and Turkey as part of the newly articulated Truman Doctrine. In 1948, the U.S. announced the Marshall Plan for European reconstruction. The subsequent two years witnessed a series of dramatic and troubling events. In August 1949, the Russians successfully exploded an atomic bomb. In October, the Communists achieved victory in China. In January 1950, the China and the Soviet Union signed the Sino-Soviet Alliance, forcing a critical reevaluation of American foreign policy as expressed in NSC-68 (April 1950).[32] In June 1950, the United States found itself desperately fighting the Soviet-backed North Korean invasion of South Korea. An initial retreat was followed by a successful U.N. offensive that advanced to the Chinese border. This provoked a Chinese Communist intervention (September-December 1950) that resulted in another retreat, stalemate, and eventual armistice (July 1953).

This sequence of events presented the Truman and Eisenhower Administrations with a world threatened by Soviet expansionism. The level of anxiety increased even further in 1953, when the Soviets detonated a hydrogen bomb.[33] At the same time, the Soviet Union experimented with long-range bombers and missile technology. During the 1954 May Day parade, the Soviets revealed the B-4 Bison, a long-range bomber. Finally, on 26 August 1957, the Soviet Union announced that it had successfully tested an ICBM – the SS-6. Concurrent with these offensive developments, the Soviet Generals had also initiated an anti-ballistic missile development program in September 1953.[34]

Nike II

As the race to develop powerful rockets proceeded, the Army had developed a missile for use against manned bombers. In 1945, the U.S. Army initiated Project NIKE to explore the use of missiles to counter the threat posed by supersonic aircraft.[35] In November 1951, the NIKE-AJAX missile intercepted an aircraft flying at a range of 15 miles, an altitude of 33,000 feet, and at a speed of 300 miles per hour.[36] Having successfully addressed the threat of a single long-range bomber, the Army began to focus on the threat posed by a mass aerial attack. This resulted in the development of the NIKE-HERCULES, a modified NIKE-AJAX.[37] The HERCULES intercepted its first drone aircraft in 1956. The next year, Operation Snodgrass demonstrated that the NIKE-HERCULES system could select a specific target within a formation of aircraft. Soon NIKE-HERCULES replaced AJAX in batteries across the country.[38]

Fig. 1-5. In June 1958, the first NIKE-HERCULES unit reached operational readiness status in Chicago. NIKE-HERCULES crew scrambles during exercises in Chicago.

In February 1955, the Army Ballistic Missile Agency (ABMA), located in Huntsville, Alabama, contracted with Western Electric Company and Bell Telephone Laboratories to conduct an 18-month study addressing means of countering the air defense threat of the future. Researchers were instructed to keep "in mind ballistic targets and the desire to defend against extremely difficult intercontinental ballistic missiles with a reasonable extension of current radar and missile technology."[39] As a result of intelligence data gathered on the Soviet long range missile program, however, later discussions placed greater importance on the threat posed by intercontinental ballistic missiles (ICBMs) and this became the primary focus of the NIKE II study.

In December 1955, Bell Labs presented the first full status report on the NIKE-II System to the Chief of Army Ordnance at Redstone Arsenal.[40] Bell Labs concluded that it was feasible to develop and deploy a missile defense system. Although many leading scientists scoffed at the concept of a missile intercept given the extreme high velocity (24,000 feet per second), Bell

Labs, using an analog computer, conducted a series of 50,000 computations simulating intercepts of ballistic missile targets. Armed with this data, Bell Labs concluded that it was possible to intercept an ICBM, or in other words, to "hit a missile with a missile."[41] Furthermore, they anticipated deploying such a system by late 1962.

The final concept proposed in October 1956 involved a common data gathering system used in conjunction with a missile equipped with interchangeable nose cones that could handle a full-range of potential threats. The missile would carry a 400-pound nuclear warhead, and be capable of executing 10-g maneuvers at 100,000 feet. Given the 95 to 100 percent attrition rate sought in an interceptor system, integrated multiple radars, high-speed communications, and data processing played key roles.[42] The ICBM's deceleration rate combined with the use of decoys would be countered with a series of three types of radars.[43] A series of forward acquisition radars and local acquisition radar would provide early acquisition data and relay data to target track radars. Finally, a missile tracking radar would guide the interceptor to its target. Researchers theorized that "a long-range, high-data-rate acquisition radar" combined with the NIKE-B/HERCULES could serve as an interim ICBM defense.[44] Although, "parts of the NIKE II system concept would be altered or discarded, the concept presented in 1956 defined ABM system technological requirements and its basing policy for the next 25 years."[45]

In November 1958, a NIKE-HERCULES intercepted a high altitude supersonic target missile. This feat was repeated in 1960, when the HERCULES shot down a CORPORAL ballistic missile and another HERCULES in tests at White Sands Missile Range.[46] These tests marked the first time a ballistic missile was destroyed by another missile.

Roles and Missions

The Truman-Eisenhower policy of forming a worldwide alliance system to contain the Soviet Union and China resulted in a shift in science and technology policy. In 1955, the Killian Committee (named after President Eisenhower's Chief Scientific Advisor Dr. James R. Killian) recommended the government continue developing intercontinental and intermediate range ballistic missiles (ICBMs and IRBMs), high altitude reconnaissance aircraft and reconnaissance satellites.[47] That same year, President Eisenhower proposed that the transit of satellites over the United States and the Soviet Union be unimpeded by either power.[48]

By May 1954, however, the *New York Times* reported that the Soviet Union might be gaining an advantage on the United States in rocket and missile development, to include the development of new supersonic missiles capable of intercontinental nuclear strikes.[49] The press dubbed these ICBMs the "ultimate weapons" for which there was no defense. On August 30, the National Security Council (NSC) recommended that the ICBM program be given the highest priority. President Dwight Eisenhower affirmed this measure on 13 September 1955, designating the ICBM program the nation's top research and development priority. Nevertheless, reports commissioned by the administration credited the Soviet Union with a substantial lead, talked of a "missile gap," and predicted that Soviet missiles would be able to overwhelm American retaliatory forces.[50] This worrisome scenario prompted greater attention to the need to develop a missile defense system.

In the 1950s, all three services were developing ballistic missiles of various ranges and exploring anti-missile systems. In August 1950, the Army and the Air Force signed the Vandenberg-Collins Agreement, establishing an integrated air defense effort incorporating antiaircraft artillery battalions and fighter squadrons.[51] As one political scientist noted:

> The fears of war breaking out at any moment, the perception of a hostile and potentially aggressive enemy capable of inducing heavy loss upon North America and the belief in the vast potency of a military technology capable of rendering obsolete whole weapons systems - all of these attitudes promoted duplication [of weapon systems] as a lesser evil to the possibility of unpreparedness.[52]

This attitude however began to change in 1956. In November, Secretary of Defense Charles Wilson, in a Memorandum to the Members of the Armed Forces Policy Council, further clarified Army and Air Force roles and missions.[53] He assigned to the Army responsibility "for the development, procurement and manning of land-based surface-to-air missile systems for point defense." Point or terminal defense focused on specific geographic areas, cities and vital military and industrial installations and addressed air targets at altitudes out to a horizontal range of 100 nautical miles. This assignment would be achieved with guided missiles, such as the NIKE I, NIKE B and land-based TALOS, and co-located radars.

In April 1957, a joint Army-Air Force committee, headed by Mr. Hector Skifter, reviewed the ballistic missile defense mission. They recommended "that the Army continue with the development of a terminal defense system and that the Air Force be given the responsibility for the early warning system against ballistic missiles." In addition to the missile system, the Army was responsible for developing Target Track Radar and Local Acquisition Radar. The new Secretary of Defense Neil McElroy affirmed this assessment with two memoranda issued on 16 January 1958. McElroy assigned to the Army primary responsibility for the BMD mission (missile, launch site, radars, and computer components). With its NIKE missile systems, the Army had progressed further than the Air Force, whose Project WIZARD had yet to produce a missile. However, the Air Force, based on their experience with early warning radars, continued to develop early warning radars, tracking and acquisition radars and communications links, ensuring that they were compatible with the NIKE-ZEUS system.[54]

Beginnings of Space Exploration

Initial American satellite launches were scheduled to be part of the International Geophysical Year (1957-1958) to foster multilateral exploration of the earth and its atmosphere.[55] The Soviets surprised the world by placing satellites in orbit in October and November 1957.[56] The public and congressional uproar resulted in the perception that the Soviets had surpassed the United

States scientifically. On 8 November 1957, President Eisenhower directed the Army to place a satellite in orbit by March 1958. On 31 January 1958, the Explorer I satellite was launched by an Army Redstone rocket. In addition to soothing the national pride, the instruments on the first Explorer satellite detected the Van Allen radiation belt circling the earth. It was not until 17 March 1958 that the Navy launched its first Vanguard satellite, which used solar cells (developed by the Army Signal Corps) to power its radio transmitters.[57]

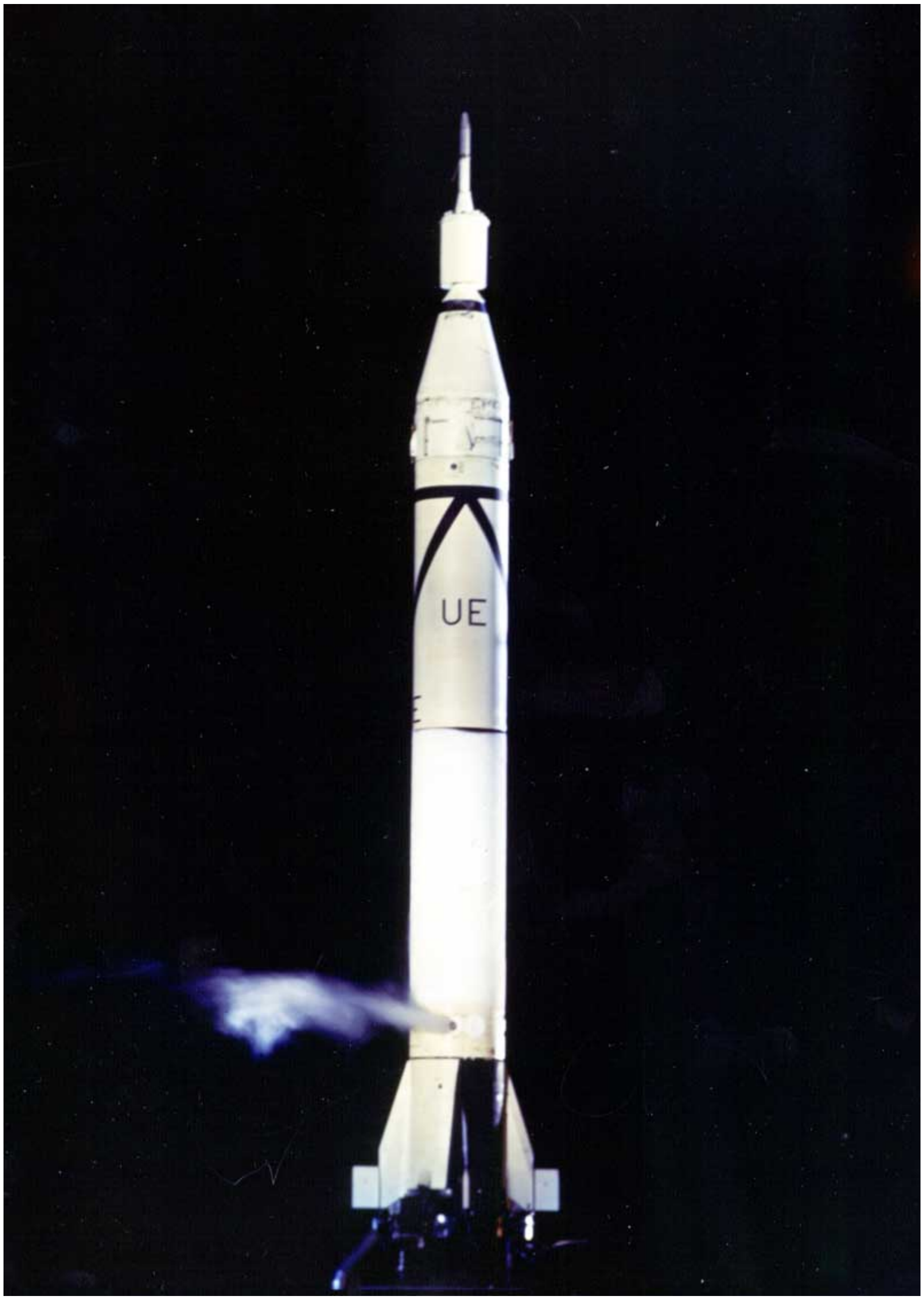

Fig. 1-6. An Explorer satellite atop a Jupiter-C rocket.

Fig. 1-7. Major General John C. Medaris, one of the founders of the Army's missile program.

The revelations that followed the Sputnik launch reinforced the belief of American technological inferiority and raised fears in among the public that the realm of space was about to be dominated by an enemy power, the very situation the Stilwell Board had cautioned against in 1946. Sputnik had significant and far-reaching effects on American space, scientific and educational policies.[58]

Launching the Explorer I satellite with a Redstone rocket ended a process that began with the successful conclusion of the Project Bumper tests in 1950. That year the Army consolidated its missile programs, moving those projects and personnel at White Sands and other places to the Redstone Arsenal in Huntsville, Alabama. In response to a Chief of Ordnance directive, the new agency began work on a surface-to-surface multistage missile with a 500-mile range. In 1953, the Redstone missile was successfully tested at Cape Canaveral. In 1955, the Army recommended to the Department of Defense (DoD) that the Redstone missile be developed as the intermediate range missile recommended by the Killian committee. On 1 February 1956, the Army established the Army Ballistic Missile Agency (ABMA) at Redstone. Later that year the ABMA began a series of tests in Florida that launched a Redstone-C missile nose cone 682 miles into space and 3335 miles down range. In November 1956, Secretary of Defense Charles Wilson divided missile development responsibilities between the Army and the Air Force. The Army would be responsible for developing missiles with a range of less than 200 miles while the Air Force would be responsible for developing missiles with ranges of more than 200 miles. By 1958, the Army finished developing the Jupiter and handed responsibility for its operation and deployment to the Air Force.

Before the Secretary of Defense's division of labor between the Army and Air Force, the von Braun team at ABMA began to design a 12,000-pound booster rocket for space investigation, tentatively called Juno. The Army expanded the design effort to include a complete missile (later renamed Saturn). In December 1957, a Juno missile launched the first American lunar exploration mission.

Although there was relative unity of effort concerning ballistic missile defense, the national space effort was dissipated in a myriad of programs supervised by a plethora of civilian and military agencies. Without a supervisory, coordinating or directing body both military and civilian programs would duplicate each other in vain attempt to garner prestige. There was no non-military body to direct civilian space research and, much to the chagrin of the Air Force, the Army developed into the most successful and most experienced military space organization.[59] A general realignment of responsibilities transferred the Jupiter-C missile program from the Army to the Air Force. In a more far-reaching reorganization of the national space effort, Congress created a civilian space agency, the National Aeronautics and Space Administration (NASA) in 1958.[60]

Before NASA's creation, the Army built and launched the nation's first ballistic missile and earth orbiting satellite. The Mercury astronauts were placed in orbit by modified Army Redstone rockets. These feats, a response to the U.S.S.R.'s first ventures into space, were the work of Dr. Wernher von Braun and his rocket team at Redstone Arsenal, Huntsville, Alabama, many of whom had come to the United States as a result of Operation PAPERCLIP. Army research also contributed to the Apollo moon landings. Von Braun's team began working on a heavy rocket booster, the Saturn I, in the late 1950s and when it was transferred to NASA in 1959, the work continued and eventually resulted in the Saturn V rocket used to power the moon flights.

While building rockets to send satellites into orbit, the Army also sought to send soldiers into space. In 1958, the armed services were developing proposals for manned space flight. The Army's plan, Project Adam,[61] sought to launch a man in a sealed capsule on a sub-orbital trajectory using a modified Redstone rocket. The Army justified the project as the first step in improving troop transportation methods.[62] A Redstone rocket would carry a manned capsule to an altitude of 150 miles before splashing down in the Atlantic Ocean down range from Cape Canaveral. During the flight, the astronaut would perform psychological and physiological tests while undergoing acceleration and a brief period of weightlessness. The plan's elegant simplicity made it controversial and it was derided by many experts as the "shooting the lady out of a cannon" plan. Listening to the critics, the Secretary of Defense, Neil H. McElroy, ruled that the project needed further study and ABMA eventually abandoned it. However, with some minor changes, it became the basis for NASA's Project Mercury.

In the summer of 1959, ABMA made an even bolder proposal: plant a military colony on the moon. In Project Horizon, the Army planned, to land on the moon in 1965 and establish a 12-man outpost on the lunar surface in 1966. Providing the moon base with logistical support would require launching 64 Saturn rockets annually (one rocket every 5.7 days), with each rocket carrying more than 266,000 pounds of cargo. The Army expected the program to cost more than $6 billion. The Project Horizon cargo rockets would make a direct earth-to-moon trip, while the crew would first make a low-earth orbit, rendezvous with a space station, and only then fly to the moon. The space station would be manned by a crew of 10 men who would be rotated every few months, with some of them rotating to the moon. The lunar base would be constructed underground and include living quarters, storage areas, nuclear reactors, laboratories, a hospital, a communications center, dining rooms, and recreation rooms. Like Project Adam, Project Horizon never got off the ground. In 1959, the Eisenhower Administration decided to promote the civilian use of space, created NASA and transferred the von Braun team to the new agency. The Army gave Project Horizon to NASA, which shelved the plan.[63]

Between 1958 and 1961, the Army transferred most of its space programs to the new agency. NASA inherited not only the missile programs but also the Redstone Arsenal missile development facilities, renamed the Marshall Space Flight Center. NASA received the Redstone program, the Explorer satellite program, and the entire complement of rocket and missile contracts the Army had with the California Institute of Technology Jet Propulsion Laboratory. NASA also became responsible for developing the 1.5 million-pound thrust Saturn rocket. The Army also transferred technical expertise (approximately 6500 people) from the ABMA Development Operations Division to the new agency.

End Notes

[1]Lee Kennett, *The History of Strategic Bombing* (New York: Scribners, 1982), pp. 24-25, examines these issues as does Eileen Lebow, *A Grandstand Seat: The American Balloon Service in World War I* (Westport: Praeger, 1998) from a U.S. Army vantage point. A contemporary account of the American effort may be found in Spalding W. Ovitt and L.G. Bowers (ed.), *The Balloon Section of the American Expeditionary Forces* (New Haven: Tuttle, Morehouse and Taylor, 1919).

[2]The memorandum may be found in Charles DeForest Chandler and Frank P. Lahm, *How Our Army Grew Wings: Airmen and Aircraft before 1914* (New York: The Ronald Press Company, 1943), p. 80, note 6. The official birthday of the United States Air Force is 1 August 1907.

[3]Unmanned balloons as well as rigid and non-rigid airships were used for reconnaissance, bombing and transport in the First World War by France, Italy, Germany, Britain, and the United States. Easily accessible sources include Lord Ventry and Eugene M. Kolesnik, *Jane's Pocket Book of Airships* (New York: Collier Books, 1976), pp. 81, 96; Robert Jackson, *Airships* (Garden City, N.Y.: Doubleday and Co., 1973), pp. 119-120, 125-126; Douglas Botting, *The Epic of Flight: The Giant Airships* (Alexandria: Time-Life Books, 1981), pp. 51-73 and Kennett, *Strategic Bombing*, pp. 5-6. During World War II, the Japanese used unmanned balloons armed with incendiary bombs to attack North America unsuccessfully. The most comprehensive technical account is Robert C. Mikesh, *Japan's World War II Balloon Bomb Attacks on North America* (Smithsonian Annals of Flight #9, Washington, D.C.: Smithsonian Institution Press, 1973, reprinted 1990).

[4]See Emanuel Raymond Lewis, *Seacoast Fortifications of the United States: An Introductory History* (Washington, D.C.: Smithsonian Institution Press, 1970), Russell J. Parkinson, Politics, Patents and Planes: Military Aeronautics in the United States, 1863-1907 (Ph.D. dissertation, Duke University, 1963) and Hugh G.J. Aitken, *Syntony and Spark—The Origins of Radio* (Princeton: Princeton University Press, 1985).

[5]Initial experiments using AM (amplitude modulated) transceivers revealed that internal combustion engines caused radio interference. Early portable sets were relatively heavy and although field tests were conducted, they were not produced in quantity until the beginning of the Second World War in Europe. The FM (frequency modulated) radio was developed, tested and found to eliminate noise and interference, but a combination of factors, including the Army's technological conservatism and the communications industry's fear of technological obsolescence meant that this innovation was not adopted until 1940. See Robert A. Miller, The United States Army during the 1930s (Ph.D. dissertation, Princeton University, 1973), John W. Killigrew, The Impact of the Great Depression on the Army, 1929-1936 (Ph.D. dissertation, Indiana University, 1960), Tom Lewis, *Empire of the Air: The Men Who Made Radio* (New York: Edwin Burlingame Books, 1991) and Rebecca Robbins Raines, *Getting the Message Through: A Branch History of the U.S. Army Signal Corps* (Washington, D.C.: U.S. Army Center of Military History, 1996), pp. 229-233. Several of the more accessible works on signals intelligence include Ronald Clark, *The Man Who Broke Purple: The Life of Colonel William F. Friedman, Who Deciphered the Japanese Code in World War II* (Boston: Little,, Brown and Co., 1977), David Kahn, *The Codebreakers: The Story of Secret Writing* (New York: Macmillan Company, 1967) and Ronald Lewin, *ULTRA Goes to War* (New York: McGraw-Hill Book Co., 1978).

[6]The Army's sensor research dates back to the early 1920s and conducted the development work in its own laboratory at Fort Monmouth in the 1930s. The moving force behind the Army's effort was Colonel William R. Blair, whose interest in direction finding dated back to his service as the head of the Signal Corps Meteorological Section of the AEF during World War I. In 1936, the first field tests were held at Newark Airport and in 1937 the Secretary of War and the assistant chief of the air corps saw radar demonstrated at Fort Monmouth. See the biographical entry on "Blair, William S." in the *Dictionary of American Biography* (New York: Scribner, 1943-) supplement VII. Blair was awarded a patent for his radar work in 1937. A brief, accessible history of the Army's prewar interest in radar and its simultaneous development in the United States, Great Britain, France, Germany and Japan may be found in Dulany Terrett, The *Signal Corps: The Emergency (to December 1941) (United States Army in World War II, The Technical Services*) (Washington, D.C.: Center of Military History, 1956; reprint ed., 1986), pp. 35-48. Also see David K. Allison, *New Eye for the Navy: The Origin of Radar at the Naval Research Laboratory* (Washington, D.C.: Naval Research Laboratory, 1981), Robert Buderi, *The Invention that Changed the*

World: How a Small Group of Radar Pioneers Won the Second World War and Launched a Technological Revolution (New York: Simon and Schuster, 1996).

[7]The next paragraphs are based on Constance McLaughlin Green, Harry C. Thomson and Peter C. Roots, *The Ordnance Department: Planning Munitions for War* (*United States Army in World War II: The Technical Services*) (Washington, D.C.: Center of Military History, 1955; reprinted 1990), *passim* and LTC Eddie Mitchell, Apogee, Perigee and Recovery: Chronology of Army Exploration of Space (RAND Corporation Working Draft, May 1989). RAND published LTC Mitchell's chronology in 1991. In it, Mitchell gathered together many streams of information and his indefatigable research provided the basis for the chronological structure of this piece which was supplemented by the material in the SMDC archives as well as other primary and secondary sources. However, while chronology is useful for examining the manner in which events unfolded and were inter-connected, once the Army began to use space as a force multiplier and enhancer, the chronological approach must be combined with an analytical framework to understand the way this new field was perceived.

[8]In an interesting aside, Dr. Robert Goddard offered the Army the fruits of his research into rockets in 1918. At the Aberdeen Proving Grounds that November he test fired a "recoilless gun" or "rocket gun" for the Army. The test "showed potential" and the Ordnance Department recommended further development as a possible antitank weapon shortly after the Armistice. The problems that needed to be solved to perfect this weapon included creating a suitable explosive charge for the shell and perfecting the electrical firing mechanism. These difficulties, along with the advent of peace, demobilization and austere budgets caused the Army to shelve the project. It was not taken up again until 1940. See Green, et al., p. 356.

[9]Green, et al., p. 234. While the AAF was responsible for developing missiles, Ordnance was responsible for developing and supplying warheads and "destructor sets" for these missiles.

[10]V-1 originally stood for Versuchmuster, meaning experimental model, but later meant Vergeltungswaffe, vengeance weapon.

[11]Constructed in 550 man-hours, the rocket was 26 feet long with a wingspan of 19 feet. The V-1 ran on a pulse-jet motor, which used low-grade petroleum. Flying at a speed of 350-400 mph, the V-1 with its 1870 pound warhead had a range of 250km/160 miles. Centre for Defense and International Security Studies (CDISS), *Cruise Missiles: A Brief History: 1900-1945*, http://www.cdiss.org/cmhist.htm.

[12]Figures cited in Forrest Pogue, *The Supreme Command* (*United States Army in World War II, European Theater of Operations*) (Washington DC: Center of Military History, 1954, 1989) p. 252. Great Britain was not the only target for V-1 attacks. Liege and Antwerp, for example, also suffered large casualties from this weapon.

[13]CDISS, *Ballistic Missiles: The German V-2 Campaign, 1944-1945*, http://www.cdiss.org/v2.htm. Also known as the Aggregat-4 (A-4), the V-2 measured 46 feet in length and five in diameter and carried a 2,201 pound warhead.

[14]Pogue, p. 252.

[15]An interesting discussion of the layered defense used against the V-1s and the difficulties encountered can be found in Kenneth P. Werrell, *Archie, Flak, AAA, and SAM: A Short Operational History of Ground-based Air Defense* (Maxwell AFB, AL: Air University Press, 1988) and at http://www.strandlab.com/buzzbombs/index.html.

[16]CDISS, Cruise Missiles.

[17] CDISS, *Countering the V-1 & V-2 in WWII*, http://www.cdiss.org/scdnt2.htm.

[18]William S. Mark, Jr., Joseph P. D'Arezzo, R.A. Ranson, and G.D. Bagley "Detection and Plotting of the V-2 (Big Ben) Missile as Developed in ETO," 4 July 1945, Document 142.0423-16 Jul-Sep 1945, cited by Donald R. Baucom. *The Origins of SDI, 1944-1983* (University Press of Kansas, 1992), p. 4.

[19]In some respects the only defense was what the British called a "Bob Hope" - bob down and hope for the best. Jim Garamone, "SECDEF outlines need for national missile defense," American Forces Press Service, in *Kwajalein Hourglass* August 21, 2001: 5.

[20]See Kahn, *Codebreakers* and Lewin, *ULTRA*, David Kahn, "Cryptology and the Origins of Spread Spectrum," *IEEE Spectrum* 21 (September 1984): 70-80, Ronald Lewin, *The American Magic: Codes, Ciphers and the Defeat of Japan* (New York: Farrar, Straus and Giroux, 1982) as well as Edward J. Drea, *MacArthur's Ultra: Codebreaking and the War Against Japan, 1942-1945* (Lawrence: University Press of Kansas, 1992).

[21]The Army's experience with radar illustrates the fallacy of thinking that technology is an end to itself as it included the failure to warn against the Pearl Harbor attack and provided the ability to track V-2 rockets but not the ability to destroy them in flight. As the war went on, skepticism about the efficacy of the technology was replaced by growing sophistication in its use.

[22]The dossiers of those "invited" were marked by paperclips.
[23]Baucom, *Origins*, p. 4.
[24]Vannevar Bush was one of the most effective public figures American science produced in the 20th century. He was a Professor of Electrical Engineering, Dean of the School of Engineering, Vice President and President of MIT. During World War I, he worked for the Navy devising ways to detect submarines. Between 1928 and 1935, he was part of the team that developed a "network analyzer" and a "differential analyzer," the beginnings of digital computing. An academic inventor and entrepreneur, he was one of the founders of Raytheon. As Chairman of the President's National Defense Research Committee, President of the Carnegie Institution and Director of the Office of Scientific Research and Development, he was instrumental in developing the atomic bomb. He also recommended forming the National Science Foundation in his 1945 report, *Science—The Endless Frontier*. The standard biography is G. Pascal Zachary, *Endless Frontier: Vannevar Bush, Engineer of the American Century* (New York: Free Press, 1997). Monographs that attest to his varied influence include, James M. Nyce and Paul Kahn (eds.), *From Memex to Hypertext: Vannevar Bush and the Mind's Machine* (Boston: Academic Press, 1991), Colin B. Burke, *Information and Secrecy: Vannevar Bush, Ultra and the Other Memex* (Metuchen, NJ: Scarecrow Press, 1994) and Montgomery C. Meigs, Managing Uncertainty: Vannevar Bush, James B. Conant and the Development of the Atomic Bomb, 1940-1945 (Ph.D. dissertation, University of Wisconsin—Madison, 1982). He was the co-author of one of the standard texts in electrical engineering and wrote *Operational Circuit Analysis* (New York: John Wiley and Sons, Inc., 1929), an early exploration of digital computing. As a public figure, he was the author of the 1945 report, *Science—The Endless Frontier: A Report to the President on a Program for Postwar Scientific Research* (reprint ed., Washington, D.C.: National Science Foundation, 1980) as well as *Endless Horizons* (Washington, D.C.: Public Affairs Press, 1946) and *Modern Arms and Free Men: A Discussion of the Role of Science in Preserving Democracy* (New York: Simon and Schuster, 1949). In a 1945 article, he predicted ways of augmenting human thought to make knowledge more accessible through "associative trails," thus predicting both hypertext and the internet fifty years before they took shape. See Vannevar Bush, "As We May Think," *The Atlantic Monthly* 176.1 (July 1945):101-108.
[25]Excerpted from the Appendix of *History of the Plato Antimissile Missile System: 1952-1960* by Ruth Jarrell and Mary T. Cagle (Redstone Arsenal, AL: U.S. Army Ordnance Missile Command, 1961), quoted in Baucom, *Origins*, p. 6.
[26]Baucom, *Origins*, p. 6.
[27]Raines, p. 329 and "Army's Role in Space, FY 86," chart 25, Project Diana. The project was named after the Roman goddess of the moon. In fact, the idea for geosynchronous satellites relaying radio and television signals was first developed in Arthur C. Clarke, "Extra-Terrestrial Relays: Can Rocket Stations Give World-Wide Radio Coverage?," *Wireless World* 51 (October 1945): 305-308. The technology was maturing and was seriously considered in John R. Pierce, "Orbital Radio Relays," *Jet Propulsion* 25 (April 1955): 153-157 and the first satellite was launched in 1962.
[28]For web pages associated with this project, see http://www.wsmr.army.mil/paopage/Pages/V-2.htm, accessed on 30 January 2003. The paragraphs on the V-2 experiments are based on the material found here.
[29]The V-2 tests went to higher altitudes (70 miles on 10 May 1946), saw the first separation of a nose cone (30 July 1946), took and returned the first motion pictures that showed the earth's curvature (24 October 1946), successfully demonstrated the use of an auto pilot system (23 January 1947) and mapped 800,000 square miles of the Earth's surface (26 July 26).
[30]The Corporal was the first operational American ballistic missile. Its roots lay in the experiments carried on by the Ordnance Department during World War II resulting in the Private rocket. They were tested in 1944 (Camp Irwin) and 1945 (Fort Bliss). See Green, et al., *passim*. The Corporal was its lineal descendent and both were the fruits of the ORDCIT program that began in 1936. Despite its initial unreliability, it was deployed and its accuracy improved with further modifications. With a 75-mile range and the capability to carry either nuclear or conventional explosives, the Corporal remained in service between 1955 and 1963. See http://www.wsmr.army.mil/paopage/Pages/Corppr.htm, accessed 31 January 2003.
[31]Material on the Bumper Project may be found at http://www.wsmr.army.mil/paopage/Pages/bump.htm, accessed on 30 January 2003.

[32]NSC-68 was the sixty-eighth National Security Council Memorandum. The NSC was one of the bodies established in 1947 in a reorganization of the defense establishment. This policy memo was prepared in April and signed by President Truman in September 1950. It was not declassified until 1975.
[33]The United States detonated its first hydrogen bomb in February 1954.
[34]Donald Baucom, MDA Historian, "Missile Defense Milestones 1944-2000," http://www.acq.osd.mil/bmdo/bmdolink/html/milstone.html.
[35]Named for Nike the Greek Goddess of Victory.
[36]The NIKE-AJAX, also known as NIKE-I, measured 34 feet in length and 12 inches in diameter and weighed 2,455 pounds. It had a range of 25-30 miles and up to 70,000 feet altitude. The first NIKE-AJAX battalion deployed at Fort Meade, Maryland, in March 1954. John Lonnquest and David Winkler, *To Defend and Deter: The Legacy of the United States Cold War Missile Program* (Rock Island, IL: U.S. Army Construction Engineering Research Laboratories, 1996).
[37]The NIKE-HERCULES, originally called NIKE-B, measured 41 feet in length and 31.5 inches in diameter, weighed 10,710 pounds, and had a range of 75miles. The Hercules could reach altitudes up to 15,000 feet. Lonnquest and Winkler, *To Defend and Deter*.
[38]The Army deactivated its last Nike-Hercules batteries in July 1979, but they remain operational elsewhere in the world. Christina M. Carlson and Robert Lyon provide an interesting overview of the NIKE deployment and life at NIKE batteries in *Last Line of Defense: NIKE Missile Sites in Illinois* (Denver, CO: National Park Service, 1996).
[39]Bell Laboratories, *ABM Research and Development at Bell Laboratories: Project History* (Whippany, NJ: Bell Labs for the U.S. Army Ballistic Missile Defense Systems Command, 1975), p. I-1.
[40]Bell Labs, *Project History*, pp. I-2-I-3.
[41]A second study conducted by the Atomic Energy Commission and Department of Defense concluded, in their September 1957 report, that it was feasible to develop a warhead capable of destroying an ICBM warhead for the NIKE II. They added that this warhead could be available by 1961.
[42]*Ibid*, pp. I-1-I-15. World War II air defense objectives found a 10-15 percent attrition rate acceptable.
[43]*Ibid*, p. I-4. Simulation calculations found that an ICBM would decelerate at a rate up to 60g's, based on the shape of the nosecone, thus easing interceptor maneuverability requirements.
[44]*Ibid*, p. I-5.
[45]James A. Walker, Frances Martin, and Sharon S. Watkins, *Strategic Defense: Four Decades of Progress* (Huntsville: U.S. Army Space and Strategic Defense Command, 1995), p. 10.
[46]The CORPORAL intercept took place on 3 June 1960 and the HERCULES in September 1960.
[47]Paul B. Stares, *The Militarization of Space: U.S. Policy, 1945-1984* (Ithaca: Cornell University Press, 1985), p. 31 and William E. Burrows, *Deep Black: Space Espionage and National Security* (New York: Random House, 1986), p. 71. Dr. Killian was the President of M.I.T. and also recommended establishing a civilian agency to handle research and development and have civilian scientists guide the space program.
[48]The Eisenhower Administration's proposal was imbedded in the Soviet and American dilemma over arms control, where much of the working vocabulary is borrowed from economics and game theory. The object of arms control is to allow each party to reach a state of normative parity in order to participate in the game, but not an overwhelming advantage to win. If either party achieves a destabilizing advantage, the incentive for surprise attack is increased. Allowing Soviet and American satellites free passage over each other's territory would be tantamount to giving each side access to the other's secrets in a limited fashion. Doing so would mean both parties would have their national security enhanced. This factor introduces a Byzantine complexity to the already complicated world of Cold War diplomacy and espionage. See also R. Cargill Hall, "The Origins of U.S. Space Policy: Eisenhower, Open Skies and Freedom of Space," *Colloquy* 14 (December 1993):5-6, 19-24.
[49]*New York Times*, 5 May 1954, quoted in Bell Laboratories, *ABM Research and Development at Bell Laboratories: Kwajalein Field Station* (Whippany, NJ: Bell Laboratories for U.S. Army Ballistic Missile Defense Systems Command, 1975), p. 23.
[50]The 1957 Gaither Report, for example, is often cited as a key document in this discussion.
[51]Document 14 - Vandenberg-Collins Agreement, 1 August 1950 in Richard Wolf, The *United States Air Force Basic Documents on Roles and Missions*, (Washington, DC: Office of Air Force History, 1987).

[52]Ernest Yanarella, *The Missile Defense Controversy - Strategy, Technology, and Politics, 1955-1972* (Lexington: University Press of Kentucky, 1977), p.19, quoted in Christina M. Carlson and Robert Lyon, *Last Line of Defense: NIKE Missile Sites in Illinois* (Denver, CO: National Park Service, 1996), p. 23.
[53]Document 21 Secretary of Defense Wilson's Memorandum, 26 November 1956 in Wolf, *Air Force Documents.*
[54]The memoranda only address the development of the system. There is no mention of organizational control over a deployed system.
[55]The International Geophysical Year programs are described in J. Tuzo Wilson, *IGY: The Year of the New Moons* (New York: Knopf, 1961).
[56]The Russian accomplishment should not have been a surprise. Russian scientists and engineers had been active in producing literature about space travel. Konstantin Eduardovich Tsiolkovsky theorized about rockets flying through space as early as 1883 and had fully developed a theory of rocket flights and space travel by 1903. The Red Army captured Peenemünde and part of the German design team in May 1945; moving them to the Soviet Union in 1946. Instead of trying to improve the V-2 design, the Russians embarked on a new design tack. By 1951, Russian scientists were convinced on the basis of their calculations and experiments that space flight was possible and began developing medium and intercontinental range ballistic missiles in 1953. In 1956, they announced they would launch a satellite during the International Geophysical Year the following year. See "Article on Space History." In his first chapter, McDougall points out that the Soviets had invested considerable resources in their rocket programs since the 1930s.
[57]Briefing, "Army's Role in Space FY 86."
[58]Paul Dickson, *Sputnik: The Shock of the Century* (New York: Walker and Co., 2001) is a recreation of Sputnik's effect on American public opinion and popular culture. Three of its immediate effects were an emphasis on language and science education and their funding in American schools. Contemporary critics recognized that Sputnik delivered its biggest blow to American complacency. Some called the Russian feat a gimmick rather than a real technological feat and merely a showcase for big booster rockets. They also pointed out that American scientists had achieved radical size and weight reductions of thermonuclear weapons as well as rocket and telemetry components and, given the American alliance system, big booster rockets were irrelevant as either weapons delivery or satellite orbiting systems. Their voices were discounted in the general rush to judgment. Senator Lyndon B. Johnson, Chairman of the Senate Armed Services Committee, called the launching of Sputnik I "a technological Pearl Harbor." See McDougall, p. 152.
[59]See Jane van Nimmen, Leonard C. Bruno, Linda N. Ezell, *NASA Historical Data Book* (4 vols., Washington, D.C.: Scientific and Technical Information Division, National Aeronautics and Space Administration, 1988-1994). The most pertinent volumes for this section are the first two, NASA *Resources, 1958-1968* and Programs *and Projects, 1958-1968*.
[60]See McDougall, chapters 6 and 7 and Roger E. Bilstein, *Orders of Magnitude: A History of NACA and NASA, 1915-1990* (Washington, D.C.: National Aeronautics and Space Administration, Office of Management, Scientific and Technical Division, 1989), pp. 47-48. The NACA was the National Advisory Committee on Aeronautics.
[61]For an overview, see Anthony M. Springer, "Project Adam: the Army's Man in Space Program," *Quest* Summer/Fall 1994:46-47 and Chapter 4 of Loyd S. Swensen, Jr., James M. Grimwood, Charles C. Alexander, *This New Ocean: A History of Project Mercury*, (Washington, D.C.: National Aeronautics and Space Administration, NASA History Office, Office of Policy and Plans, 1998) (NASA Special Publication-4201, NASA History Series, 1998).
[62]Army Ballistic Missile Agency, Redstone Arsenal, Alabama, "Development Proposal for Project Adam," ABMA Report No. D-TR-1-58, 17 April 1958, p. 2.
[63]For greater detail, see Anthony Springer, "Securing the High Ground: The Army's Quest for the Moon," *Quest* 7.2:32-38 and Frederick I. Ordway, Mitchell R. Sharpe and Ronald C. Wakeford, "Project Horizon: An Early Study of a Lunar Outpost," *Acta Astronautica* 17. 10:1105-1121.