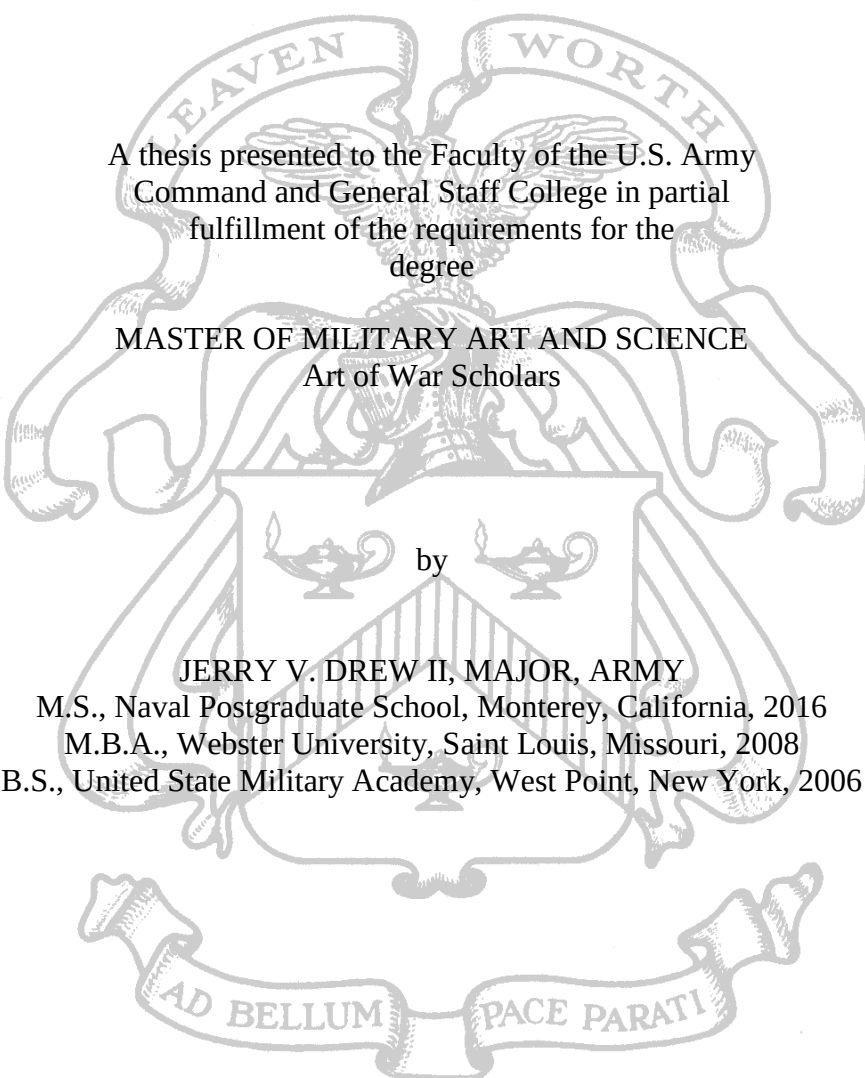


FIRST IN SPACE: THE ARMY'S ROLE IN U.S. SPACE EFFORTS, 1938-1958



A thesis presented to the Faculty of the U.S. Army
Command and General Staff College in partial
fulfillment of the requirements for the
degree

MASTER OF MILITARY ART AND SCIENCE
Art of War Scholars

by

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The opinions and conclusions expressed herein are those of the student author and do not necessarily represent the views of the U.S. Army Command and General Staff College or any other governmental agency. (References to this study should include the foregoing statement.)

ABSTRACT

FIRST IN SPACE: THE ARMY'S ROLE IN U.S. SPACE EFFORTS, 1938-1958, by Major Jerry V. Drew II, 120 pages.

From 1938-1958 the Army, largely through the Ordnance Department, engaged in a continuous effort to develop missile and upper atmospheric research technologies. With contributions of organizations such as the Jet Propulsion Laboratory (JPL) and the Army Ballistic Missile Agency (ABMA), the Army launched the first U.S. satellite, Explorer I, atop a Jupiter-C missile in 1958. Although multiple umbrella organizations such as the Advanced Research Projects Agency (ARPA) and the National Aeronautics and Space Administration (NASA) attempted to consolidate early space and missile efforts, inter-service rivalries coupled with political perceptions of the Cold War to inhibit a joint conception of military space. Despite its demonstrated successes in space and missile technologies, the Army struggled to find its place in the air-atomic world and ultimately lost its early leadership role in these fields.

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ACRONYMS

AAC	Army Air Corps
AAF	Army Air Force
ABL	Allegheny Ballistic Laboratory
ABMA	Army Ballistic Missile Agency
ARPA	Advanced Research Projects Agency
CALTECH	California Institute of Technology
CIA	Central Intelligence Agency
DOD	Department of Defense
GALCIT	Guggenheim Aeronautical Laboratory
ICBM	Intercontinental Ballistic Missile
IGY	International Geophysical Year
IRBM	Intermediate-range Ballistic Missile
JATO	Jet-assisted Takeoff
JCS	Joint Chiefs of Staff
JPL	Jet Propulsion Laboratory
LUSTY	Luftwaffe Secret Technology
NASA	National Aeronautics and Space Administration
NATO	North Atlantic Treaty Organization
NRL	Naval Research Laboratory
NSC	National Security Council
ORDCIT	Ordnance California Institute of Technology
RAND	Research and Development
SS	Schutzstaffel

SSM	Surface-to-surface Missile
UNESCO	United Nations Educational, Scientific, and Cultural Organization
US	United States
USAF	United States Air Force
USSR	Union of Soviet Socialist Republics
V-2	Vergeltungswaffe-2, or Vengeance Weapon-2
WAC	Women's Army Corps
WDD	Western Development Division
WSPG	White Sands Proving Ground

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CHAPTER 1

INTRODUCTION

Late on the night of January 31, 1958, a Jupiter-C missile blasted off from Cape Canaveral, Florida carrying not only the satellite Explorer I, but also the nation's hopes of technological and political redemption.¹ After nearly two hours of waiting for confirmation that the satellite had achieved orbit, Major General John B. Medaris, Commanding General of the Army Ballistic Missile Agency (ABMA), stopped pacing the floor at Cape Canaveral to send a teletype message to his colleagues in California. He suggested they take a cigarette break.² The response came back from Dr. Bill Pickering's team at the Jet Propulsion Laboratory (JPL) that they were "lighting up a marijuana."³

However much the banter may have lightened the mood, Medaris well understood the strategic gravity of the situation. Since the launch of the Soviet Union's two Sputnik satellites in the preceding months, the Eisenhower administration had downplayed the significance of the events. Public concern about falling behind the Communists in the new space race, however, soon grew into paranoia.⁴ The failure of the Navy's Vanguard program to launch a satellite increased national anxiety to the point that President

¹ Franklin O'Donnell, *Explorer I* (Pasadena: California Institute of Technology, 2007), 38.

² Matt Bille and Erika Lishock, *The First Space Race: Launching the World's First Satellite* (College Station: Texas A&M University Press, 2004), 132.

³ Ibid.

⁴ William E. Burroughs, *This New Ocean: The Story of the First Space Age* (New York: Modern Library, 1999), 200.

Eisenhower transferred the responsibility for the initial launch from Vanguard to the Army.⁵

By choosing the Army to launch the first American satellite, Eisenhower temporarily traded the strategic narrative of a peaceful space program for an expedient solution in response to the recent Soviet achievements. By the end of 1958, however, the political necessity of a civil space program manifested itself in the creation of the National Aeronautics and Space Administration (NASA). Faced with a new, civil organization and the Advanced Research Projects Agency (ARPA) to oversee military space programs, the launch of Explorer I represented both the Army's greatest success in space and the beginning of the end of its significant role in America's early space enterprise. Despite twenty years of technological development, inter-service rivalries and political perceptions of the Cold War drove the Army from its leadership role in missiles and satellites.

To explore the Army's changing role from 1938-1958, one must address several questions. How did the Army become the early leader among the services in rocketry? How and why were the organizational responsibilities of the Army and the other armed services redrawn during the early Cold War to meet policy objectives? What prevented the Army from successfully retaining its role in the space enterprise? One must address these questions in the context of the rising fears of Communism, the responsibilities of the Army and the other services to fulfill their primary combat roles, and the desires of

⁵ O'Donnell, 22.

the nation's political leadership to maintain the international order in a world that was increasingly threatened by the prospect of nuclear war.

The tale of the Army's role in early Cold War missile and satellite development that began in 1938 requires an examination of both the technical and political aspects of a period that witnessed World War II; the painful reorganization of the U.S. defense establishment; the Korean Conflict; and the onset of the Cold War. Throughout these crises, both the civilian and military leadership of the country sought technological solutions to provide the United States a relative advantage against potential adversaries. After the creation of an independent Air Force in 1947, the traditional Army-Navy inter-service rivalry expanded to include the new service and an additional layer of bureaucracy in the institution of the Department of Defense.

The Army's Investment in Missiles

The successful launch of Explorer I represented two decades of Army investment in missile technology and the scientific instrumentation necessary for satellites. While the cross-pollination of this technology had occurred among multiple academic, commercial, and government entities, the two centers of the Army's development efforts rested at the JPL in La Cañada Flintridge, California and the ABMA in Huntsville, Alabama. On the night of January 31, 1958, the largest stage of the launch vehicle, a modified Redstone missile, had come from Alabama. The vehicle's upper three stages, plus the small satellite at the top, had come from California.⁶

⁶ Ibid., 21.

Early investment by the U.S. Army Air Forces (AAF) and later the Army Ordnance Department provided direction for the work at a nascent JPL that proved foundational to subsequent rocket development, particularly in the field of solid-propellant missiles. Captured German missiles brought new technology to the United States during and after World War II, and the Army's role in Operation Overcast (later renamed Operation Paperclip) assured that the German scientists who built those missiles came to America and remained under the employ of Army Ordnance.⁷

Despite many instances of inter-service cooperation and information sharing, the Army's relationship with JPL and its control of the German rocket engineers gave it a distinct advantage over the other services in missile development until the end of the 1950s. But the role of the Army was changing, and during the tenure of Secretary of Defense Charles E. Wilson (1953-1957), the Army was at a disadvantage vis-à-vis the other services. The dawn of the atomic age brought into question the utility of large and expensive ground forces despite the conflict on the Korean peninsula from 1950-1953.⁸ A comment by Wilson reflected the attitude of the executive branch at the time: "We can't afford to fight limited wars. We can only afford to fight a big war, and if there is one, that is the kind it will be."⁹

⁷ Burroughs, 200.

⁸ Ingo Trauschweizer, *The Cold War U.S. Army: Building Deterrence for Limited War* (Lawrence: University Press of Kansas, 2008), 18.

⁹ James M. Gavin, *War and Peace in the Space Age* (New York: Harper and Brothers, 1958), 124.

The “New Look” policy and the concept of massive retaliation linked the security of the United States to the deterrent potential of atomic weapons, weapons that the Army did not possess until the very end of 1953.¹⁰ The introduction of atomic artillery, atomic rockets like the Honest John, and atomic missiles like the Corporal addressed the Army’s perceived lack of firepower and the need to compensate for decreasing numbers of troops. By the mid-1950s, short-range ballistic missiles (SRBMs, missiles with ranges less than 200 miles) provided both a tangible contribution to the Army’s tactical mission of defending Europe and a materiel contribution to strategic deterrence.¹¹ Furthermore, the use of similar missiles for space applications did not escape the Army leadership of the period. Aside from Medaris, Army Secretary Wilbur Brucker and Lieutenant General Jim Gavin, head of Army Research and Development, understood both the military utility and the strategic implications of satellites.¹² In fact, when news of Sputnik I reached ABMA, Medaris was hosting Brucker, Gavin, and General Lyman Lemnitzer, the recently appointed Army Chief of Staff.¹³ The group had spent the day acquainting Neil

¹⁰ Tauschweizer, 83.

¹¹ Tauschweizer, 56-57. Although definitions of missile types vary, Lieutenant General James Gavin provides a contemporaneous view. Intercontinental ballistic missiles (ICBMs) ranged from 1,500 to 5,500 miles; Intermediate-range ballistic missiles (IRBMs) ranged from 450 to 1,500 miles; Mid-range ballistic missiles (MRBMs) ranged from 200-750 miles; missiles with less than a 200-mile range were Short-Range Ballistic Missiles (SRBMs). Gavin, 3.

¹² Gavin, 14.

¹³ James B. Medaris, *Countdown for Decision* (New York: G. P. Putnam’s Sons, 1960), 154.

McElroy, the designated Secretary of Defense scheduled to replace Wilson, with the Army's missile programs, ABMA's people, and the prominent citizens of Huntsville.¹⁴

While the space fever of the late 1950s provided the Army unique opportunities for its missiles, the majority of the Army's investment in missiles during this period fell within its traditional service role. Ground-based artillery belonged to the Army, and rockets such as the German V-2 arguably provided the same function as conventional artillery—ordnance delivery from a distance.¹⁵ Indeed, the concept of rocket artillery in support of ground formations was not a new one. Gunpowder rockets had appeared regularly in warfare for centuries, but cannons had repeatedly outstripped rocket artillery in range and accuracy and therefore had remained the preferred method of ordnance delivery in most cases.¹⁶ Only during World War II did the Germans combine rockets with a guidance system, forming the first true missile. The Germans typically did not use their V-2s in support of its army formations—a notable exception was the bombardment of U.S. troops at the Remagen Bridge—but they had made the technological leaps necessary for missiles to outrange cannons and begin approaching them in accuracy.¹⁷ By

¹⁴ Ibid.

¹⁵ Burroughs, 125.

¹⁶ Hsue-shen Tsien, ed, *Jet Propulsion: A Reference Text Prepared by the Staffs of the Guggenheim Aeronautical Laboratory and the Jet Propulsion Laboratory* (Pasadena, CA: CALTECH, 1946), 6-7.

¹⁷ Nels A. Parson, Jr., *Guided Missiles in War and Peace* (Cambridge: Harvard University Press, 1956), 125. As Parson notes, "The Germans fired about a dozen V-2 rockets at the bridge, but accuracy was so poor that most of the United States troops in the vicinity did not even know that they were being attacked."

the end of the 1940s, the potential reach of atomic missiles promised to change wars of ground maneuver.

If surface-to-surface artillery was a primary concern of the Army, a secondary area of concern was air defense artillery.¹⁸ With the rise of air forces, the protection of ground forces required defense against aircraft (and eventually missiles) from the ground, a function heretofore accomplished with bullets, but another function that the rocket promised to revolutionize. The development of both short- and intermediate-range ballistic missiles (IRBMs) and the surface-to-air capabilities (most notably the Nike program), then, remained functions of the ground Army, but the division of responsibility was often unclear. Concerned with strategic missile development and air defense, the Air Force engaged in its own weapons programs, including the Thor IRBM, the Atlas and Titan ICBMs, and even a surface-to-air missile (Bomarc).¹⁹ After November 1956, the Army continued developing Jupiter, but Secretary Wilson transferred responsibility for its operational employment to the Air Force.²⁰ Throughout the Truman and Eisenhower administrations, parallel development efforts among the services were the norm, and on multiple occasions, the President served as final arbiter of the delineation of responsibilities. As missile technology matured to the point that civil and military

¹⁸ Amy S. Teitel, *Breaking the Chains of Gravity: The Story of Spaceflight before NASA* (New York: Bloomsbury, 2016), 98.

¹⁹ BDM Corporation, *History of Strategic Air and Ballistic Missile Defense, Volume I, 1945-1955* (Washington, DC: Center of Military History, 2009), 2.

²⁰ Medaris, 124.

operations in space became possible, the delineation of responsibilities for space required multiple creative solutions.

Following the launch of Explorer I in 1958, Eisenhower's fiscal conservatism and his desire to eliminate duplication of effort among the services led to the creation of ARPA to provide oversight for all the DoD's space technology development.²¹

Furthermore, the U.S. policy of "space for peaceful purposes" required a civilian umbrella organization to coordinate all non-military space programs.²² Within two years of the creation of the National Aeronautics and Space Administration (NASA) in July of 1958, the Army lost controlling interest of JPL and ABMA. ABMA became the NASA George C. Marshall Spaceflight Center on July 1, 1960.²³ With JPL the Army lost their satellite development capability, and with the loss of ABMA and the German rocket team, the Army lost the Saturn, a rocket that did not fit neatly within the Army's portfolio as a ground force but found its place in the efforts to take U.S. astronauts to the moon.²⁴ By the end of 1960, the political realities of the Cold War had relegated the Army to a secondary role in U.S. space efforts.

²¹ Annie Jacobsen, *The Pentagon's Brain: an Uncensored History of DARPA, America's Top Secret Military Research Agency* (New York: Little, Brown, and Company, 2015), 51.

²² Memorandum for the Secretary of Defense, Subject: U.S. Policy on Outer Space (NSC 5814), June 28, 1958, Disaster Box 38, Outer Space (3), 2, The Dwight David Eisenhower Presidential Library.

²³ Robert L. Rosholt, NASA SP-4101, *An Administrative History of NASA* (Washington, DC: NASA, 1966), 111.

²⁴ *Ibid.*, 108.

CHAPTER 2

WORLD WAR II AND THE BIRTH OF U.S. MISSILES

The family tree of the Jupiter-C missile that launched Explorer I originated from two separate lines of investigation into rocketry, one American and one German. The Army, through the AAF and the Army Ordnance Department, sponsored both investigations through their developmental stages, the JPL team from the late 1930s onward and the German team following the collapse of Nazi Germany. For the launch of Explorer I in 1958, the German team produced the liquid-propellant engine that served as the first stage. JPL developed the solid-propellant rockets used on the second, third, and fourth stages plus the Explorer I satellite itself. Both the liquid-propellant engine and solid-propellant motors of the Jupiter-C began as military weapons to support the belligerents of World War II.²⁵ Throughout the war period, both the Army and the Navy sponsored JPL projects, but the Army, through its work with JPL and captured German rocket scientists, consolidated its position as the early leader among the services in missile development.

The history of JPL began in 1936, two years before the War Department became involved. In that year, two rocket enthusiasts, Ed Forman and Jack Parsons, approached Dr. Theodore von Karman of the California Institute of Technology (CALTECH) for help with their hobby.²⁶ Not long out of high school, neither Forman nor Parsons were

²⁵ Roger E. Bilstein, *Stages to Saturn* (Washington, DC: NASA, 1996), 9-12.

²⁶ Franklin O'Donnell, ed., *JPL 101* (Pasadena: California Institute of Technology, 2002), 4.

CALTECH students, but they both shared the dream of launching a rocket to the moon.²⁷

Von Karman, a world-renowned professor and expert in aeronautics, was not in a position to oversee such investigations himself. However, seeing a possible opportunity, von Karman referred Forman and Parsons to a twenty-two-year-old engineering graduate student named Frank Malina.²⁸

The son of a Czech father and a Texan mother, Malina had illustrated technical publications to help pay his way through Texas A&M as an undergraduate.²⁹ Upon his arrival at CALTECH, the need for additional income again presented itself, and while working on the illustrations for one of von Karman's books, the pair developed a lasting friendship.³⁰ Under the patronage of von Karman, Malina, Forman, Parsons, and the Chinese émigré Hsue-shen Tsien formed the embryo of a new rocket research organization at the university.³¹ Called the GALCIT (Guggenheim Aeronautical

²⁷ George Pendle, *Strange Angel: The Otherworldly Life of Rocket Scientist John Whiteside Parsons*, (New York: Harcourt, 2005), 47.

²⁸ O'Donnell, 4.

²⁹ *Beginnings of the Space Age: The American Rocketeer*. Directed by Blaine Baggett (Pasadena, CA: Jet Propulsion Laboratory, 2011), DVD.

³⁰ Robert Toth, "Former JPL Director Now Famed as Artist," *Los Angeles Times*, Walt Powell Collection, Magazine and Newspaper Clippings, Folder 30, Jet Propulsion Laboratory Archives. The article is undated, but based upon Malina's mentioned age, it must have been published in 1963.

³¹ Dr. Tsien's name appears in multiple forms depending on the transliteration of the Chinese. The spelling adopted in this thesis follows the spelling by which JPL's official records list him. However, it is interesting to note that in personal correspondence, Malina, a life-long friend, addressed Tsien as Hsue Shen Chien. In the response, Tsien transliterated his own name as Chien Hsueh-sen following the Chinese convention of putting the surname at the beginning. Malina then adopted Tsien's convention. In other sources Tsien appears as Qian Xuesen.

Laboratory) Rocket Research Project at CALTECH, von Karman meant the project to serve toward Malina's doctoral degree.³² In the process, Malina's goal was to develop a sounding rocket capable of reaching 100,000 feet and studying the upper atmosphere.³³ Considering that Dr. Robert Goddard, the father of American rocketry, did not reach altitudes of 9,000 feet until 1941, Malina's goal was decidedly ambitious.³⁴

Over the next two years, Malina's team continued their investigation into the fundamentals of rocketry as war clouds loomed over Europe. In 1938, General Henry "Hap" Arnold, a long-time friend of von Karman and the most prominent leader in the Army Air Corps (AAC), asked for the Air Corps Research Committee, an element within the National Academy of Sciences (NAS), to investigate the possibility of using rockets to increase aircraft performance.³⁵ Collaboration between the NAS, the AAC, and CALTECH resulted in GALCIT Project Number 1 (GALCIT 1) of 1939. As the JPL rocketeers' first government-sponsored project, GALCIT 1 guaranteed funding, but it

³² Carroll, P. Thomas. "Historical Origins of the Sergeant Missile Power Plant." August 1972, Walt Powell Collection, Articles by Other than Powell, Folder 13, 4, JPL Archives.

³³ Ibid.

³⁴ Ray A. Williamson and Roger D. Launius, "Rocketry and the Origins of Space Flight," in *To Reach the High Frontier*, eds. Dennis R. Jenkins and Launius (Lexington: University Press of Kentucky, 2002), 36.

³⁵ "Chronological Survey of Rocket Development at the Jet Propulsion Laboratory-California Institute of Technology," JPL 119, Folder 6, Historical File Organization 1945 to 1970, JPL Archives.

also required temporarily abandoning the goal of a building a 100,000-foot sounding rocket.³⁶

JATO

The idea behind GALCIT 1 was simple and one that the German Luftwaffe had suggested as early as 1935.³⁷ Airplanes must achieve a sufficient groundspeed in order to create enough lift to become airborne. Traditionally, an airplane's own engines provided the necessary acceleration as it sped down the runway. But for aircraft with limited runway space (for example, ones that launch from a ship or from an improvised runway), the plane's own engines may not be able to provide enough power to generate the required speed for lift. Furthermore, an extremely heavy plane (for example, one loaded with bombs) may not be able to achieve the necessary speeds even on a conventional runway. The concept of strapping rockets to airplanes to allow the use of shorter runways or heavier loads became known as Jet-assisted Takeoff (JATO).

While conceptually straightforward, the successful implementation of JATO was not a foregone conclusion for the JPL rocketeers. They had made substantial progress in the study of explosives and the manufacture of solid-propellant rocket motors, but rather than burning in a controlled manner, the motors often exploded.³⁸ Specifically, the

³⁶ Ibid.

³⁷ Paul H. Satterfield and David S. Akens, "Army Ordnance Satellite Program" (Monograph, Army Ballistic Missile Agency, 1958), 15, accessed February 24, 2017, <https://web.archive.org/web/20070212031256/http://www.redstone.army.mil/history/pdf/welcome.html>.

³⁸ Carroll, 6.

pressure inside the rocket casings increased to the point that it cracked the motor body. Instead of burning from one end like a cigarette, the flame spread into the multiple cracks, leading to uncontrolled burn and explosion.³⁹ In the spring of 1940, von Karman and Malina solved four differential equations that described “the operation of an ideal restricted-burning solid propellant rocket motor.”⁴⁰ The implementation of these equations solved the controlled burn problem and marked a significant advance in the evolution of solid-propellant rocket motors. By 1958, such motors had matured into the reliable upper-stage rockets on the Jupiter-C, but in 1941, the highly experimental JATOs required extensive testing.

Between August 6 and August 23, 1941, Captain Homer Boushey, an Army Air Corps pilot, conducted a series of sixteen JATO test flights at March Field in Riverside, California.⁴¹ Boushey and the JPL team fitted the plane, a civilian Ercoupe, with the JATO rockets. Of the sixteen flights, eleven coupled rocket power with the airplane’s engine for takeoff, four used the rockets to boost the plane after takeoff, and one flight—after deliberately detaching the propeller—demonstrated the possibility of rocket-only takeoff. Of the 158 JATOs fired, only six failed—four on the ground and two in flight.⁴²

³⁹ Ibid.

⁴⁰ Ibid., 5.

⁴¹ Richard West, “U.S. Marks 25th Year of Rocketry,” *Los Angeles Times*, Walt Powell Collection, Magazine and Newspaper Clippings, Folder 30. The article is undated, but 25 years after the JATO tests places the article’s composition in 1965. Boushey, who retired as an Air Force Brigadier General, remained active in the Air Force’s space efforts for the rest of his career.

⁴² Ibid.

Overall, the test campaign was a resounding success, and in light of the demonstration, the Navy awarded JPL with contract NSX-5879 for a 200-lb thrust JATO.⁴³ However, an unfortunate problem required attention.



Figure 1. A Successful JATO Test, August 1941

Source: JPL, “Jet-Assisted Takeoff,” accessed May 12, 2017, <https://www.jpl.nasa.gov/jplhistory/captions/jato-t.php>.

⁴³ Carroll, 60.

The original JATO motors, as it turned out, were not shelf stable. When lit after a short period in storage, they exploded.⁴⁴ The solution to the latest unpredictable explosive behavior came from Jack Parsons, the former hobbyist, who was now one of the world's leading experts on solid rockets. While watching a work crew fix a roof, the idea struck him to blend potassium perchlorate, an oxidizer, with asphalt to make it storable. The asphalt mixture could then be poured into a mold while hot. This concept, now known as "castable composite solid propellant" supplanted former extrusion and molding techniques.⁴⁵ With a viable solid-propellant motor, the JPL engineers expanded their interests to include liquid-propellant rockets.

While CALTECH continued to administer the organization, JPL depended extensively on the armed forces to fund its expansion. The Army Air Corps and the Navy showed early patronage through the JATO programs, including a liquid-propellant version for the Navy, the A-20, which JPL tested at Muroc Army Airfield (Edwards Air Force Base) in April 1942.⁴⁶ In addition to modest facilities at Muroc, the expansion plan for JPL's La Cañada facilities in the summer of 1942 called for a new engineering office (Building 11, which still stands on the JPL campus), new workshops for powder and liquid propellant experimentation, a liquid test pit at the west end of campus, a row of

⁴⁴ J. Frank Malina, "Origins and First Decade of the Jet Propulsion Laboratory," in *The History of Rocket Technology*, ed. Eugene M. Emme (Detroit, MI: Wayne State University Press, 1964), 57.

⁴⁵ Carroll, 8.

⁴⁶ West.

buildings for storage, refrigeration, ovens, mixing, cookers, and grinders.⁴⁷ With the improved JATO's, JPL met the Navy contract in 1942, and mass production began at Aerojet, a company whose founding members included von Karman and Malina.⁴⁸

Private and the V-2

The incremental engineering approach to rocket development had paid dividends, and with the war in full swing, the work being done at JPL became vital to the defense establishment. In late 1943, the first British intelligence reports of German missiles found their way to the desk of Dr. von Karman. If they were to be believed, the United States was woefully behind the Germans on liquid-propellant missile development.⁴⁹ In November, von Karman, Malina, and Tsien analyzed the possibilities for longer-range missile research and submitted their proposal to both the Army Air Forces Material Center at Wright Field in Ohio and to Colonel Gervais Triechele at the Rocket Development Branch of Army Ordnance.⁵⁰ Army Ordnance showed interest in the proposal, and although the air and naval components continued to maintain their ties with JPL, from 1944 until its annexation by NASA in 1958, Army Ordnance bore responsibility for JPL's facilities and equipment and the majority of its funding.⁵¹

⁴⁷ "GALCIT NO. 1 – Plot Plan," Drawing No. 5-256-B-8, 15 June through 8 September 1942, JPL 64, Walt Powell Collection, Folder 6, JPL Archives.

⁴⁸ Carroll, 10.

⁴⁹ Ibid., 10-11.

⁵⁰ Ibid.

⁵¹ Medaris, 234; Historical File Organizational Charts 1945-1970, JPL 119, Folder 6, JPL Archives. The organization charts depict a formal liaison structure between the Army and the JPL during this period. Following the war, the liaison structure

The Ordnance Department's request for a long-range missile effort led to the ORDCIT (Ordnance California Institute of Technology) contract of 1944.⁵² The spring of 1944 witnessed an array of nozzle tests, injector tests, large-scale engine tests, and basic research into propellant mixtures for the expanded liquid-fuel efforts, but the development of solid propellants continued as well.⁵³ By the end of the summer of 1944, American forces pushed through France, and JPL produced preliminary designs of Private A, the WAC Corporal, and the Corporal E.⁵⁴

expanded to include elements of Army Ordnance, AAF Material Command, the Navy's Bureau of Ordnance, Army Ground Forces, and the Army Signal Corps.

⁵² "Chronological Survey."

⁵³ Conference Minutes, GALCIT Project No. 1, 29 April 1944, JPL 64, Powell Collection, Folder 7, JPL Archives.

⁵⁴ "Chronological Survey."

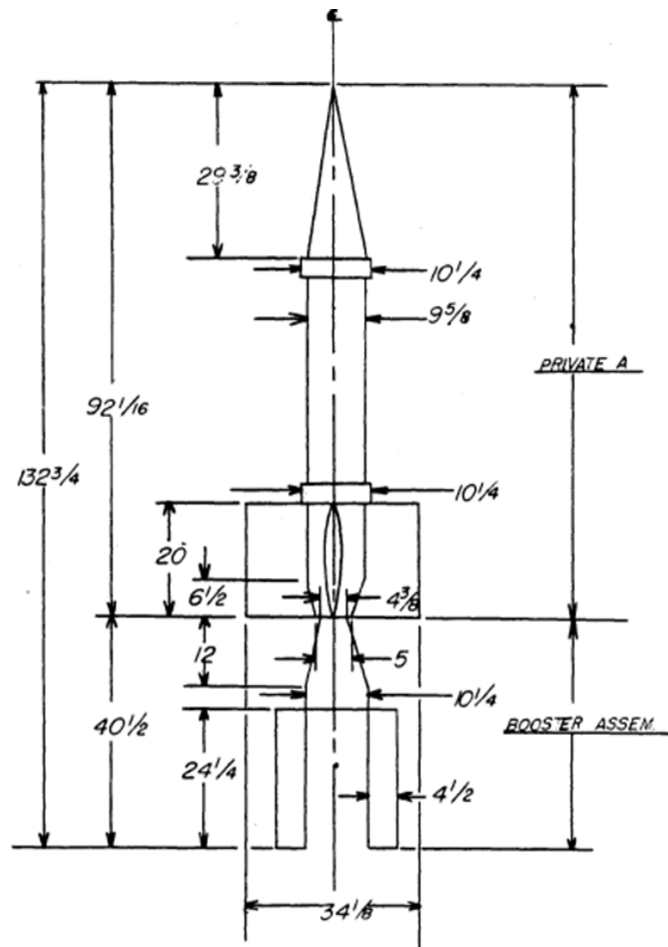


Figure 2. Schematic of Private A with Booster. Measurements are in Inches

Source: James W. Bragg, "Development of the Corporal: the Embryo of the Army Missile Program," Vol. 1 (historical monograph, ABMA, 1961), 21.

Dr. William "Bill" Pickering, a subdivision lead for the Corporal program and later JPL director, partly explained the naming convention for the early JPL vehicles. The progression from Private to Corporal to an eventual Sergeant followed the Army rank structure clearly enough, "and then we came along with this sounding rocket which really didn't fit the pattern." Sharing similarities with the Corporal design, the WAC Corporal

was so named for the Women's Army Corps.⁵⁵ As a sounding rocket, its envisioned mission was upper atmospheric research, not destruction of the enemy.

In November 1944, as the collapse of Germany loomed, General Arnold requested von Karman, head the Army Air Force Scientific Advisory Group, to study rocket and guided missile technology and how U.S. forces could put them to use.⁵⁶ While von Karman prepared for Europe by way of the Pentagon, the first Private flew at Leach Spring, Camp Irwin, California on December 1, 1944.⁵⁷ Although little more than four JATOs welded to a rocket body with fins, at eight feet tall, Private A was the first of its kind in the United States.⁵⁸ Like the WAC Corporal and the Corporal, the Private rockets existed for research and development purposes.⁵⁹ They were not intended for use as weapons, but their flights advanced both solid-propellant technology and the ground operations procedures necessary to track and receive in-flight data. These experiences allowed JPL to progress toward their ultimate goal of producing viable missiles for the Army.

⁵⁵ William Pickering, "Bumper 8, 50th Anniversary of the First Launch on Cape Canaveral, Group Oral History, Kennedy Space Center, Held on July 24, 2000," JPL 232, Group Oral History-Kennedy Space Center, 24 July 2000, JPL Archives.

⁵⁶ Teitel, 65.

⁵⁷ Carroll, 12.

⁵⁸ "Organized Research in Jet Propulsion," JPL 64, Walt Powell Collection, Folder 16, JPL Archives.

⁵⁹ Pickering, "Bumper 8, 50th Anniversary," 17. Pickering later recalled that the JPL engineers even viewed Corporal E as a research and development vehicle, but the Army was anxious to field it as a weapon, which they eventually did in 1954.

JPL's organization chart of January 9, 1945 noted von Karman's "temporary leave of absence as Expert Consultant to the Commanding General, Army Air Forces."⁶⁰ In his absence, Malina became the acting director with designated liaisons from the AAF and the Ordnance Department.⁶¹ In keeping with their desire for a longer-range missile, the Ordnance Department awarded the ORDCIT contract in mid-January, which included the following requirements for a battlefield missile:

1. Maximum weight of high explosives payload: 1,000 pounds.
2. Maximum weight of missile not to exceed a weight consistent with good design and a maximum payload.
3. Range of missile, 75-100 miles.
4. Dispersion at maximum range not in excess of two percent, or missile suitable for direction by remote control.
5. Velocity sufficient to afford protection from fighter aircraft.⁶²

An analysis of the ORDCIT requirements reveals Ordnance's understanding of both German missile capabilities and the limitations of existing U.S. technology. The first Private had flown just over one mile (5,400 feet) and at a total weight around 500 pounds, its capacity for a payload sat at sixty pounds.⁶³ The V-2, by comparison, had a range of

⁶⁰ Historical File Organizational Charts 1945-1970, JPL 119, Folder 6, JPL Archives.

⁶¹ Ibid.

⁶² Carroll, 12.

⁶³ James W. Bragg, "Development of the Corporal: the Embryo of the Army Missile Program," vol. 1 (historical monograph, ABMA, 1961), 35.

approximately 200 miles with a one-ton payload.⁶⁴ The achievements of Private fell far short of Ordnance's desired 75-100 mile range and 1,000-pound maximum payload. In essentially halving the V-2's specifications, Ordnance provided challenging, but attainable range and payload goals to the JPL team. The control requirement provided additional challenges. As a true rocket, Private A had no guidance system, the distinguishing characteristic between rockets and missiles, so precision control was not a factor in its flight. Both the V-1 and the V-2 did have on-board guidance and control systems, but fortunately for the Allies, the control systems were primitive and prone to inaccuracy.⁶⁵

Despite the shortcomings in range, payload capacity, and guidance, Private A had achieved the ORDCIT requirement for speed. Flying at about 886 miles per hour, it was more than twice as fast as the V-1, which, at 350 miles per hour, had been vulnerable to air intercept and ground fires.⁶⁶ At descent speeds of 2,200 miles per hour, however, the V-2 was more than twice as fast as the Private A.⁶⁷

While the Private program continued to advance fundamental technology, JPL turned to its two liquid-propellant concept vehicles, the Corporal and the WAC Corporal, to meet the ORDCIT contract. The 1,000-lb thrust motor for Corporal and the larger 1,500-lb thrust motor for WAC Corporal required larger and more isolated test facilities

⁶⁴ Williamson Murray and Allan Millett, *A War to be Won: Fighting the Second World War* (Cambridge: Harvard University Press, 2000), 599.

⁶⁵ Ibid., 600.

⁶⁶ Bragg, 35; Murray and Millett, 599.

⁶⁷ Murray and Millett, 600.

than the small, concrete pits hitherto used at JPL.⁶⁸ For the real estate, the JPL looked once again to the AAF's facilities at Muroc. Construction on the static test stand began in February.⁶⁹ While the JPL team built the infrastructure necessary for U.S. missile technology to progress, a second operation that involved both the Army and JPL was already underway to capture the missile technology of the Germans.

Paperclip and LUSTY

As Nazi Germany crumbled, the United States dispatched teams of experts to investigate and acquire the technological secrets that made the Third Reich such a formidable enemy. The Army was particularly interested in the missile technology that Adolf Hitler had employed in his campaign of terror against the Allies.⁷⁰ The V-1 cruise missiles and the V-2 ballistic missiles inflicted some 63,000 casualties in their attacks against Britain, France, Belgium and western Germany.⁷¹ Defense against the supersonic V-2, despite its relative inaccuracy and mechanical problems, proved nearly impossible.⁷² The fear of what might have been prompted General Dwight Eisenhower to reflect that

⁶⁸ Conference Minutes, AAF Aircraft Lab Research, JPL-1, Project MX121, Jet Propulsion Laboratory, GALCIT, December 30, 1944," 3, JPL 64, Walt Powell Collection, Folder 7, JPL Archives; Minutes of JPL-1 Conference, 19 May 1945, JPL 64, Walt Powell Collection, Folder 8, JPL Archives.

⁶⁹ "The ORDCIT Test Station Muroc Army Air Base, undated, JPL 64, Walt Powell Collection, Folder 6, JPL Archives.

⁷⁰ Annie Jacobsen. *Operation Paperclip: The Secret Intelligence Program that Brought Nazi Scientists to America* (New York: Little, Brown, and Company, 2014), 56.

⁷¹ Murray and Millett, 599.

⁷² Ibid.

“if the German had succeeded in perfecting and using these new weapons six months earlier than he did, our invasion of Europe would have proved exceedingly difficult, perhaps impossible.”⁷³ To Eisenhower’s relief, the Germans never concentrated its missile attack on the major British ports around Portsmouth-Southampton, and within ten months of the Normandy invasion, U.S. troops reached Germany.⁷⁴

On April 11, 1945, soldiers of the 104th Infantry Division liberated Nordhausen, a concentration camp filled with slaves who labored in the Schutzstaffel’s (SS) underground missile construction facility.⁷⁵ The Allies had destroyed the northern and southern missile factories, and after the summer of 1944, the Mittelwerk facility in Nordhausen was the only one still in operation.⁷⁶ The plant was just what Colonel Gervais William Triechel, head of Army Ordnance’s Rocket Development Branch at the Pentagon hoped to find.⁷⁷ Triechel had been working through Colonel Holger N. Toftoy, Chief of Army Ordnance Technical Intelligence in Paris, who had established “Special Mission V-2” for the express purpose of finding German missiles and the men who built them.⁷⁸ The Army believed that it could leverage the new technology to affect the still-

⁷³ Dwight Eisenhower, *Crusade in Europe* (New York: Doubleday, 1948), 260.

⁷⁴ Ibid.

⁷⁵ Jacobsen, *Operation Paperclip*, 46-47.

⁷⁶ Satterfield and Akens, 17.

⁷⁷ Burroughs, 111.

⁷⁸ Ibid., 112-113.

raging war in the Pacific, but due to the unconditional surrender of the Japanese the following September, no German rockets ever found their way to that theater.⁷⁹

On the same day that U.S. troops entered Nordhausen, the second version of Private, Private F, flew at Hueco Range, Fort Bliss, Texas.⁸⁰ The Private F, based on the same solid-propellant motor as Private A, was primarily an experiment in using fins to stabilize the rocket for extended flight. Significantly, Private F demonstrated that a winged missile required a guidance system to ensure a stable flight.⁸¹ In the process, the launch team gained valuable experience with launch facilities, tracking, and data gathering procedures that informed the ongoing work with the WAC Corporal rocket and the Corporal missile programs.⁸² With the growing sense of German technological superiority, these programs could not advance fast enough.

On April 13, 1945, two days after the liberation of Nordhausen, elements of the 1st Infantry Division discovered the Hermann Göring Aeronautical Research Center at Völkenrode with its highly advanced aeronautics facilities.⁸³ While Army Ordnance exploited the liberation of Nordhausen, the AAF prepared Operation LUSTY (an acronym for “Luftwaffe Secret Technology”) to exploit the liberation of Völkenrode.⁸⁴

⁷⁹ Jacobsen, *Operation Paperclip*, 90.

⁸⁰ “Chronological Survey.”

⁸¹ Bragg, xiii.

⁸² Carroll, 12.

⁸³ Jacobsen, *Operation Paperclip*, 52.

⁸⁴ *Ibid.*, 50.

Dr. von Karman and the AAF's Scientific Advisory Group arrived in the European theater of operations on April 28, 1945 dressed as senior Army officers, von Karman in a brigadier general's uniform and Tsien in a colonel's.⁸⁵ For the scientific team, the aerodynamic facilities at Völkenrode were a treasure trove of advanced technology, including plans and models not only of the V-2 (originally named the A-4) but also of the A-9 and A-10 missiles, prototype ICBMs.⁸⁶ Unfortunately, without the scientists and engineers who built them, the United States faced an uphill battle of reverse engineering.

Fortunately for the Americans, a team of German rocket scientists led by Dr. Werner von Braun was looking for a new patron. After hiding their most important documents in a cave where only they could find them, the group began planning their surrender. On the morning of May 2, 1945, Werner's younger brother Magnus, the group's most capable English speaker, surrendered himself over to Private First Class Fred P. Schneikert of Sheboygan, Wisconsin on behalf of the group.⁸⁷ Among the first experts to interrogate von Braun was Tsien, who, on May 5, 1945, asked von Braun to draft a report on his past work and his ideas for future work.⁸⁸

With the success of both "Special Mission V-2" and Operation LUSTY, the U.S. military took advantage of a third clandestine operation, Operation Overcast, to transport

⁸⁵ Teitel, 79; *Beginnings of the Space Age: The American Rocketeer*. Directed by Blaine Baggett (Pasadena, CA: Jet Propulsion Laboratory, 2011), DVD.

⁸⁶ Teitel, 93.

⁸⁷ Burroughs, 116. Aside from his linguistic skill, Burroughs makes the point that Magnus was chosen to surrender partly because he was the least essential from an engineering standpoint.

⁸⁸ Iris Chang, *Thread of the Silkworm* (New York: Basic Books, 1995), 112.

the German scientists, engineers, and technicians back to the United States. Renamed Operation Paperclip in March 1946, the effort acquired experts in jet engines, chemical weapons, submarines, torpedoes, aerospace medicine, and other fields.⁸⁹ One of the initial beneficiaries of Operation Paperclip was Werner Von Braun.

Von Braun, a member of the Nazi party and a Major in the SS, had been the most important engineer in the Reich's missile development program. Like Malina, von Braun had begun his work among hobbyists before attracting the military's interest. In von Braun's case, patronage came from the German Army's Chief of Ballistics and Ammunition in 1932.⁹⁰ The German Army's sponsorship continued for the next decade, but after the invasion of Normandy, Heinrich Himmler and the SS assumed a direct role in the missile program.⁹¹ The end result of von Braun's work in Germany, the V-2, was a missile far beyond anything the Americans had mustered, especially in the field of liquid propulsion.

Work by the Americans on liquid-propulsion missiles had accelerated since the initial V-2 intelligence reports of January 1943, but the manner of propulsion used by the WAC Corporal and Corporal was distinctly different than the propulsion system of the V-2. The V-2's propulsion system mixed alcohol (fuel) with liquid oxygen (oxidizer).⁹² An

⁸⁹ Burroughs, 122.

⁹⁰ Teitel, 27.

⁹¹ Ibid., 62.

⁹² Murray and Millett, 600.

ignition system set the combination burning to produce thrust.⁹³ The WAC Corporal rocket and Corporal missiles used hypergolic propellant, meaning that the fuel and oxidizer spontaneously combusted on contact. Specifically, the WAC Corporal and the Corporal used red fuming nitric acid (oxidizer) and either aniline or a mixture of aniline/furfuryl alcohol for the fuel.⁹⁴ While eliminating the need for an ignition system and thereby simplifying the engine design, the fueling process required extreme care. In the development of both tactical missiles and space launch vehicles, the Army employed both types of liquid propulsion systems.

Conclusion

From the late 1930s through the end of World War II, rocketry had advanced significantly in both the United States and Germany. Out of military necessity, the AAF and the U.S. Navy had sponsored the rudimentary JATO rockets in both their solid-propellant and liquid-propellant forms. JPL made monumental advances toward a viable solid-propellant missile during this period, but the liquid-propellant systems showed greater promise for longer-range missiles. The ORDCIT contract ensured funding for the organization to continue development of the WAC Corporal and Corporal projects. When British intelligence reports arrived in California, JPL made significant efforts to uncover the V-2's secrets. The Army's willingness to invest in tactical ballistic missiles allowed

⁹³ Minutes of JPL-1 Conference, 11 August 1945, 1, JPL 64, Walt Powell Collection, Folder 8, JPL Archives.

⁹⁴ Not surprisingly, fuel/oxidizer combinations varied throughout testing and development. The variation in fuels derives from two sources: (1) Minutes of JPL-1 Conference, 10 September 1945, 5, JPL 64, Walt Powell Collection, Folder 8, JPL Archives and (2) "Organized Research in Jet Propulsion," 19.

the service to maintain control over JPL and postured it as an early leader among the services in missile development. Furthermore, this early work formed the basis for many future Army missiles, including the Jupiter-C.

In addition to the technical developments, the period of the defense establishment's early interest in rocketry reveals several trends that continued until the launch of Explorer I and beyond. First, the development of missile technology interested the Army, including the AAF, and the Navy. While inter-service rivalry had always existed, the priority of the war effort and the immaturity of missile technology prevented any significant ambitions for the military's control of space. Second, the relationship between the National Academy of Sciences, a civil organization, and the AAC, a military organization, demonstrates the intertwined nature of civil and military relations in America, a theme that appears repeatedly throughout the space age.⁹⁵ Indeed, such relationships muddled the waters for the political leadership of the 1950s, who, for propaganda purposes, wished to portray clear lines between civil and military space activity.

⁹⁵ In *This New Ocean*, Burroughs traces this theme from the German, Soviet, and American perspectives and concludes that, although the United States may boast the most civilian involvement in its space activity, its civil space activity is, in many cases, inseparable from its military activity.

CHAPTER 3

GROWING MISSILES, SHRINKING BUDGETS

When World War II ended in 1945, the Army stood at approximately eight million men with eighty-nine divisions.⁹⁶ By far the largest army that the country had ever fielded, such a force was not economically sustainable, and the reduction of service end-strength began at once.⁹⁷ During January 1946, the War Department settled eighteen cost-plus contracts “with cancelled commitments of \$415,000,000” and 614 contracts valued at an estimated \$10,500,000,000 remained.⁹⁸ Despite these cutbacks, however, emphasis on missile development continued. Throughout 1946, the Army continued to solidify its leadership role in missile development through the ORDCIT contract, Project Hermes, and the inauguration of test facilities at Wallops Island, Virginia, and at White Sands Proving Ground, New Mexico. As rocketry advanced, the services began to chart independent courses in upper atmospheric science and satellite development. No organization existed, however, to effectively regulate the space and missile rivalries of the services.

The period from the end of World War II to the election of President Eisenhower in 1952 witnessed a dramatic restructuring of the defense establishment. Under the Defense Reorganization Act of 1947, the War Department became the Department of the Army, the AAF became the United States Air Force (USAF), and the two combined with

⁹⁶ Trauschweizer, 18.

⁹⁷ Ibid.

⁹⁸ Bangs, 9.

the Department of the Navy under a new umbrella organization called the Department of Defense. As the DoD found its footing, President Truman attempted to reduce military spending despite the perceived need to counter communist aggression in Europe and to confront the North Koreans in 1950. Ironically, the Korean conflict demonstrated that limited war was still possible in the atomic age, but during and after the conflict, the Army still struggled to redefine its role at a time when the atomic weapons dominated much of the government's vision about future warfare.⁹⁹

The missile programs that the Army had begun during the war were essential to this redefinition. Not only did increased firepower compensate for troop reductions, but the missiles theoretically provided the means for waging limited, atomic war.¹⁰⁰

Advances in solid-propellant motors promised longer-range missiles, and the Corporal program moved toward weaponization and fielding. While the tactical missiles held top priority, the Army also began programs for upper atmospheric research and multi-stage missiles. Through these programs, the Army maintained its advantage among the services in missile technology from 1947-1952, but the Navy and Air Force surpassed the Army in their efforts to develop advanced satellite concepts.¹⁰¹ Prior to 1947, no bureaucratic entity existed to unify service efforts, but from 1947-1952, the new DoD failed to put forth a unifying concept for how the services might exploit outer space in a coordinated

⁹⁹ Trauschweizer, 2.

¹⁰⁰ Ibid.

¹⁰¹ Kalic, 8.

manner. Such disunity contributed to the Soviet Union's first two Sputnik satellites achieving orbit before Explorer I.

White Sands Proving Ground

The work at JPL during the spring and summer of 1945 was fast becoming diversified. After the end of the war in the European Theater on May 8, 1945, the JPL team tested a WAC Corporal motor on May 19, 1945 at Muroc.¹⁰² Meanwhile, following the success of Special Mission V-2, more than 360 metric tons of German missile parts began their journey to New Mexico. To accommodate their expanding missile efforts, Army Ordnance established a facility at Wallops Island, Virginia for air-to-air missile and sounding rocket testing (the inaugural launch on June 27) and a larger facility at White Sands Proving Ground (WSPG) near Las Cruces, New Mexico.¹⁰³ Technically an annex to the Aberdeen Proving Ground (APG) in Maryland, WSPG became active on July 9, 1945, and over the years, the facilities proved crucial to numerous missile programs.¹⁰⁴

The expansion efforts of Army Ordnance involved JPL's California facilities, as well. In addition to JPL's existing portfolio and their newfound work with German technology, Acting Director Malina oversaw the on-site construction. At a routine staff meeting on July 28, 1945, Malina announced that the next bi-weekly conference would

¹⁰² Minutes of JPL-1 Conference, 19 May 1945, 14, JPL 64, Walt Powell Collection, Folder 8, JPL Archives.

¹⁰³ Burroughs, 123.

¹⁰⁴ Ibid; for a listing of the numerous missile programs, see the White Sands Missile Range Museum webpage at <http://www.wsmr-history.org/>.

be in new Engineering Building.¹⁰⁵ Further discussion at the meeting focused on the delivery of the first replica of a V-2 motor, which was still very much a work in progress. Due to faulty welds, it had been returned to the manufacturer.¹⁰⁶ Two weeks later, on August 11, 1945, JPL exhibited two German missiles. Although uncertain about the missiles' capabilities, the group estimated that the first ran on liquid oxygen and alcohol, producing about 3,000 pounds of thrust, while the second possibly ran on hydrogen peroxide.¹⁰⁷ At 3,000 pounds, the estimated thrust output was double the amount produced by JPL's most powerful vehicle, the WAC Corporal.

The WAC Corporal continued to improve throughout the autumn. In September, the hypergolic fuel propelled the WAC for forty-five seconds, achieving an American altitude record of forty-three and a half miles.¹⁰⁸ Sixteen feet long, twelve inches in diameter, and weighing 665 pounds, the engine was JPL's most powerful to date. Even though the German V-2s had achieved altitudes of sixty miles, for Malina the WAC Corporal's success was professionally significant.¹⁰⁹ With the WAC Corporal, he achieved the goal that von Karman had originally assigned to him as a graduate student a

¹⁰⁵ Minutes of JPL-1 Conference, 28 July 1945, 1, JPL 64, Walt Powell Collection, Folder 8, JPL Archives. This building, Building 11, still stands on the JPL campus.

¹⁰⁶ Ibid., 4.

¹⁰⁷ Minutes of JPL-1 Conference, 11 August 1945, JPL 64, Walt Powell Collection, Folder 8, JPL Archives, 1.

¹⁰⁸ "Organized Research in Jet Propulsion," 19.

¹⁰⁹ Scholar Bangs, "Altitudes of more than 43.5 miles reached in Army Rocket Tests," *Aviation News*, Mar. 18, 1946, 9, JPL 64, Walt Powell Collection, Folder 30, Magazine and Newspaper Clippings, JPL Archives.

decade earlier. His rocket had more than surpassed the original goal of 100,000 feet, and Malina took the opportunity to graciously acknowledge the pioneering work of Dr. Goddard.¹¹⁰



Figure 3. Frank Malina beside a WAC Corporal

Source: Keck Institute for Space Studies, “CALTECH and JPL,” accessed May 12, 2017,

¹¹⁰ Ibid.

http://kiss.caltech.edu/Tolman-Bacher/caltech_jpl.html.

Although not a weapon, the hard-won lessons of the WAC Corporal and early Corporal variants directly contributed to the Army's quest for tactically useful missiles. Like the Private before it, the WAC Corporal served as a science experiment on the road to meeting the Army's ORDCIT contract. The Army's hopes for even greater performance than the WAC Corporal rested with the Corporal E, a more powerful member of the Corporal family with a 20,000-lb thrust motor (double the power of the original Corporal), which promised greater range and larger payload capacity.¹¹¹ Static tests of the Corporal E motor inaugurated the newly completed Muroc test stand in December 1945.¹¹²

In addition to significant progress on the Corporal E, autumn 1945 also saw the arrival of the German engineers in the American southwest. Von Braun arrived at Fort Bliss on October 8, 1945 with a lone Army escort, and three additional groups of Germans joined him on December 8, January 15, and February 20.¹¹³ By the end of January 1946, the same month that the War Department began cancelling its wartime contracts, Project Hermes, Army Ordnance's efforts to reconstruct and improve the V-2s, was in full swing. General Electric (GE) served as the prime contractor, and despite three hundred rail cars full of German rocket parts and more than one hundred German experts

¹¹¹ "The ORDCIT Test Station Muroc Army Air Base."

¹¹² Ibid.

¹¹³ Teitel, 96.

headquartered at Fort Bliss, Ordnance could, in the beginning, only manage to assemble two complete V-2s.¹¹⁴



Figure 4. A V-2 Launches from WSPG as Part of Project Hermes

Source: White, L.D. *Final Report, Project Hermes V-2 Missile Program* (Schenectady, NY: General Electric, 1952), page unnumbered, in Smithsonian Libraries, accessed May 16, 2017, <https://archive.org/details/finalreportproje00whit>.

¹¹⁴ Ibid., 91.

Upper Atmospheric Research and Satellite Studies

Following the war and the success of “Special Mission V-2,” Holger Toftoy had returned from the Army Ordnance Technical Intelligence Office in Paris to assume the duties of Rocket Development Branch chief for Army Ordnance.¹¹⁵ With the success of the WAC Corporal and the promise of a large number of forthcoming V-2s, Toftoy proposed using science instruments instead of warheads as payloads for the V-2s.¹¹⁶ Like Arnold, Toftoy saw the benefit in building relationships between the military, the scientific community, and academia and emphasized both the need for basic research and the need to avoid duplication of effort.¹¹⁷ To support Toftoy’s vision of interagency cooperation, the responsibility for coordinating experimentation fell to the V-2 Upper Atmospheric Research Panel, which included representatives from all services, the Army Air Forces, the Army Signal Corps, the Naval Research Laboratory (NRL), numerous civilian research institutions, and GE.¹¹⁸

Through GE’s Project Hermes and JPL’s ORDCIT, Army Ordnance funded two parallel (but sometimes complimentary) rocket development efforts. Within Project Hermes, Ordnance envisioned five variants: the Hermes A1, a planned anti-aircraft missile; the Hermes A2, a surface-to-surface missile (SSM); the Hermes A3, a longer-range SSM; the Hermes II, a ramjet engine; and the Hermes C1, a three-stage SSM

¹¹⁵ Ibid.

¹¹⁶ Burroughs, 129.

¹¹⁷ Ibid., 131.

¹¹⁸ Ibid., 130.

capable of longer range than any other variants.¹¹⁹ The envisioned Hermes A2 and A3 variants were functionally comparable to the JPL's Corporal, and like the JPL team, the GE team intended to reverse engineer the V-2 to learn its secrets. This arrangement, though duplicative, allowed the Army to leverage the creative energies of multiple engineering teams, reduced the risk inherent in having only one development stream, and provided incentive for success by creating competition. Further, the arrangement demonstrated the willingness of the Army to fund missile development (despite a shrinking budget overall) and the relative independence of the Army to manage its development programs. While the Army did agree to coordination for the payload experimentation campaigns, no joint service organization dictated the Army's rocket development priorities at this time.

While the Army pursued Project Hermes, the Navy's Bureau of Aeronautics investigated the possibilities of long-range communications over the open seas.¹²⁰ The report that Tsien had requested from von Braun the previous May (1945), *Survey of Development of Liquid Rockets in Germany and Their Future Prospects*, had come to the attention of the Bureau and piqued its interests in satellites.¹²¹ In late 1945, the NRL and Bureau of Aeronautics began a series of theoretical studies on satellites, making the Navy the first service to do so.¹²² On March 7, 1946, just two months after the first meeting of

¹¹⁹ Teitel, 98. In the event, the Hermes C1 became the predecessor of the Redstone missile, which was modified to form the first stage of the Jupiter-C.

¹²⁰ Burroughs, 125.

¹²¹ Chang, 112-113.

¹²² Kalic, 8.

the Upper Atmospheric Research Panel, the Bureau of Aeronautics invited the AAF to collaborate on the satellite problem. With the war over and Air Force service independence all but imminent, Major General Curtis LeMay, director of the Air Force's research and development efforts, refused collaboration and instead contracted with Douglas Aircraft's Research and Development Corporation (RAND) for a study all of the Air Force's own.¹²³

As a practical matter, the Army did not investigate satellites immediately following the war, but the payloads developed for the sounding rocket experiments influenced the later concept for early satellites. One of the significant contributors to the V-2 experimentation program was Dr. James Van Allen of the University of Iowa, who, a decade later, oversaw the radiation detection payloads on all five Explorer satellites.¹²⁴

Like the V-2 experimentation program, the WAC Corporal payloads performed upper atmospheric radiation experiments, among other tasks. In a March 18, 1946 interview, Colonel B.S. Mesic, the Ordnance Department liaison to JPL shared with the media that the WAC Corporal was capable of taking photographs and collecting data on atmospheric composition, temperature, pressure, density, and cosmic rays.¹²⁵ The Army Signal Corps, which often supported the WSPG test launches with communications and weather balloon activities, was a key beneficiary of the WAC Corporal's meteorological

¹²³ Ibid.

¹²⁴ James Van Allen, "What is a Space Scientist? An Autobiographical Example," *Annual Review of Earth and Planetary Sciences* (June 1989), James Van Allen Papers, 1938-1990, American Institute of Physics, <http://history.aip.org/history/ead/19990077.html>.

¹²⁵ Bangs, 9.

instruments.¹²⁶ Such sounding rocket technology, the news report asserted, was “expected to give the United States a dominant position in upper atmospheric research.”¹²⁷ These payloads did not achieve orbit, but they served as stepping stones toward achieving the technology necessary for future satellites. Indeed, the WAC Corporal and V-2 scientific payloads performed some of the same missions that RAND was envisioning for future satellites.

In response to LeMay’s request, RAND published its satellite study for the AAF entitled *Preliminary Design of an Experimental World-circling Spaceship* on May 2, 1946.¹²⁸ The report’s introduction concluded that “modern technology has advanced to a point where it now appears feasible to undertake the design of a satellite vehicle.”¹²⁹ Sufficiently powerful rockets were the *sine qua non* of orbital operations, and the study outlined, from an engineering perspective, the requirements necessary to achieve orbit using launch vehicles based on the V-2 concept but with multiple stages.¹³⁰ The study addressed practical engineering problems like drag, gravity, staging, winged deorbit, and the possibility of carrying humans aboard a satellite.¹³¹

¹²⁶ Ibid.

¹²⁷ Ibid.

¹²⁸ Douglas Aircraft Company, Inc. *Preliminary Design of an Experimental World-circling Spaceship, Report No. SM-11827* (Santa Monica, 1946), i.

¹²⁹ Ibid., i.

¹³⁰ Ibid., iii-iv. This concept for a multi-stage rocket based on the V-2 design is analogous to the Army’s concept for the Hermes C1 variant.

¹³¹ Douglas Aircraft Company, Inc. *Preliminary Design of an Experimental World-circling Spaceship, Report No. SM-11827* (Santa Monica, 1946), vi-viii.

The RAND study is remarkable for both its vision of the future and its ability to capture the zeitgeist of an era poised between one cataclysmic war and the prospect of a destructive confrontation with the Soviet Union. It captured the contemporary view of the importance of long-range and anti-aircraft missiles in future wars, but never distinguished between military or civilian uses of space—a political distinction that had not yet occurred.¹³² Satellites, the study claimed, could observe and guide long-range missiles or deorbit to strike terrestrial targets themselves. On the scientific front, they could conduct cosmic radiation research along with investigations into gravity, the earth's magnetic field, astronomy, solar physics, and biology.¹³³ And although the study mused about sending humans to the moon and beyond, like the Army's efforts at upper atmospheric research and photography with the WAC Corporal and the V-2, the scientific investigation proposed by RAND supported military ends.¹³⁴

On May 10, 1946, a week after RAND published their initial report, Malina and the WAC Corporal team displayed their rocket alongside a V-2 for a delegation of senior British Army and Navy officials visiting New Mexico.¹³⁵ Due to national security concerns, these technologies had remained largely hidden from the American public

¹³² Ibid, 9.

¹³³ Ibid., 12-14.

¹³⁴ For example, cosmic radiation research would “provide important clues to unleashing the energy of the atomic nucleus,” while an understanding of earth's gravity and magnetic fields would provide insights for how to build missiles that could successfully fly through space.

¹³⁵ “CALTECH's New Rocket Revealed,” *Pasadena Star News*, 10 May 1946, JPL 64, Walt Powell Collection, Magazine and Newspaper Clippings, FLD 30, JPL Archives.

throughout the war, JPL only revealed its involvement in the experimental programs during an open house on June 22, 1946. Despite the \$3,000,000 investment in facilities over the years, one Pasadena newspaper article described the JPL campus as “80-barren-looking buildings spread over a desolate 40 acres.”¹³⁶

The real attraction at the open house, however, was not the campus, but the technology. Two V-2s and an American variant of the V-1 “buzz bomb” cruise missile were on display, and a demonstration of the spontaneous combustion of nitric acid and aniline awed spectators.¹³⁷ The JPL’s unveiling continued with the announcement that, in addition to 100 hand-picked Army, Navy, and AAF officers destined to become graduate students,¹³⁸ CALTECH had decided to open its jet propulsion course to civilians for the first time, not only to military officers as had been the case during the war.¹³⁹ The shift in course demographics, however, amounted to only a minor change in the civil-military relationship at the JPL.

Among the JPL hierarchy, the relationship with the military was undergoing more significant changes. By July 3, 1946, the “Army Liaison” section at JPL had become the “Combined Military Liaison Office” with representatives from Army Ordnance, AAF

¹³⁶ “Atomic Age Turning Cultured Old Pasadena into U.S. Jet Capital,” *Pasadena Independent*, 23 June 1946, JPL 64, Walt Powell Collection, Magazine and Newspaper Clippings, FLD 30, JPL Archives.

¹³⁷ Ibid.

¹³⁸ Ibid.

¹³⁹ John Sage. “New Rocket Fields Being Explored,” *Pasadena Star News*, 23 June 1946, JPL 64, Walt Powell Collection, Magazine and Newspaper Clippings, FLD 30, JPL Archives.

Material Command, the Navy's Bureau of Ordnance, Army Ground Forces, and the Army Signal Corps.¹⁴⁰ The increased and diversified military presence spoke to the dominance of weaponry in future JPL work, but with one war recently over and the fear of a potentially worse war on the horizon, Malina "wanted to do something for peace."¹⁴¹

At 35 years old, Malina was "fatigued, terribly tired of explosions," and a future in administration was equally unappealing.¹⁴² The dissolution of his first marriage, and the Federal Bureau of Investigation's (FBI's) tendency to harass him over unsubstantiated ties to Communist organizations further contributed to Malina's emotional drain.¹⁴³ He stepped down as acting director but remained on JPL's executive board for another year. The last of the original JPL rocketeers resigned from the organization for good in 1947 and left California to join the United Nations Educational, Scientific, and Cultural Organization (UNESCO) in Paris.¹⁴⁴

Despite the end of World War II, Malina's departure coincided with a surge in the military's involvement at JPL and a growing role for Germans in U.S. missile development. As the Air Force's RAND study indicated, a future of ICBMs and satellites was on the near horizon, but no missiles yet existed to meet the tactical needs of the Army as outlined in the ORDCIT contract. The Corporal E and the Project Hermes

¹⁴⁰ Historical File Organizational Charts 1945-1970, JPL 119, Folder 6, JPL Archives.

¹⁴¹ Toth.

¹⁴² Ibid.

¹⁴³ *Beginnings of the Space Age: The American Rocketeer*.

¹⁴⁴ Ibid.

variants remained in development, and attempts to master the V-2 continued. At the end of 1947, the Army had enabled significant progress in upper atmospheric research, and it sponsored the Hermes C1 concept, a capability in keeping with the multi-stage V-2 variant that RAND had envisioned as necessary for a successful satellite launch.

Incremental Progress

Malina's departure marked the end of JPL's early days and the first decade of the Army's role in the development of missiles and the scientific instrumentation that served as the precursors to satellites. Although punctuated by failures and mishaps, the period witnessed the incremental growth of foundational rocket and missile technologies. Furthermore, from 1938-1947, important relationships grew among academia, industry, and the armed forces that proved essential in the development of more complex missile systems. A vehicle with enough thrust to deliver satellites into orbit required combining and improving existing technology to create multi-stage missiles and the ground control infrastructure to monitor them. Army programs remained critical to both efforts, but as technology progressed, the spread of Communism across the globe and the perceived need to project power in a nuclear world were changing the political dynamics of the country.

Motivated by the fear of Communist expansion, President Harry Truman delivered a speech before a joint session of Congress on March 12, 1947. The speech outlined what came to be known as the Truman Doctrine, the pledge of the U.S. to assist

“all democratic nations under threat from external or internal authoritarian forces.”¹⁴⁵

Although the official policy of containing Communism did not mature until NSC-68 in 1950, Truman’s speech envisioned a future of ideological confrontation. A technological edge over the Soviets would be essential.

The Soviet Union, in their own version of Operation Paperclip, had acquired German rocket scientists and technicians following the occupation of Germany, and realizing their inability to compete with the U.S. in terms of bomber fleets, it began looking to missiles for an asymmetric advantage.¹⁴⁶ By 1947, the Soviet Union had established the Council of Chief Designers as the central organization for missile development headed by Sergei Korolev, an extremely effective manager who was as vital to the U.S.S.R.’s efforts as von Braun was to the German and U.S. efforts.¹⁴⁷ Although Soviet rocket development continued apace with the Americans, for the time being, the Soviet Union did not have nuclear weapons.¹⁴⁸

The same month that the Truman announced his new doctrine, Army Ordnance notified JPL that they wanted a solid-propellant missile.¹⁴⁹ The project eventually resulted in the Sergeant missile and promised two tactical advantages over a liquid

¹⁴⁵ Department of State, Office of the Historian, “The Truman Doctrine, 1947,” accessed January 29, 2017, <https://history.state.gov/milestones/1945-1952/truman-doctrine>.

¹⁴⁶ James C. Moltz, *The Politics of Space Security: Strategic Restraint and the Pursuit of National Interests*, 2nd ed. (Stanford: Stanford University Press, 2011), 76.

¹⁴⁷ Ibid.

¹⁴⁸ Ibid.

¹⁴⁹ Carroll, 21.

missile. First, unlike liquid missiles, solid missiles did not require fueling, an inconvenient operation even under the best circumstances. Second unlike Parson's asphalt substrates, the new synthetic polymers did not have the problems of melting or cracking in extreme temperatures, which made it storable.¹⁵⁰ Along with the new substrate, JPL engineers J.I. Shafer and H.L. Thackwell introduced an internal-burning star grain.¹⁵¹

In the internal-burning star grain motor, the burning surface is in the shape of a star. The consequence of this core shape is greater acceleration for the rocket; the flame consumes more propellant surface area more quickly. Prior to the World War II, the British had pioneered the concept for antiaircraft rockets, but they largely abandoned the effort as a practical solution in 1937 because of technical difficulties.¹⁵² In March 1945, the Allegany Ballistics Laboratory (ABL) in Pinto, West Virginia picked up the work and began developing a rocket that it called "Vicar."¹⁵³ Like JPL, ABL was developing rocket technology in support of the war effort, but only a scale model of Vicar called "Curate" was successfully tested before ABL abandoned the work in November 1945.¹⁵⁴ The combined British and ABL efforts laid the groundwork for JPL to improve the design and make it tactically useful. In the meantime, JPL continued to develop the Corporal E.

¹⁵⁰ Ibid., 16.

¹⁵¹ Ibid., 27.

¹⁵² Ibid., 22-27.

¹⁵³ Ibid., 29.

¹⁵⁴ Ibid.

Although JPL had completed the first static tests of the Corporal E motor in December 1945, the first Corporal E flight did not fly until May 1947 with the second the following in July.¹⁵⁵ Also in July, foreseeing the need for a test range with even greater depth than WSPG could provide, the War Department selected a site on the Florida coast where a chain of islands stretching across the Caribbean to Ascension Island in the south Atlantic provided ideal locations for a network of land-based tracking stations.¹⁵⁶ This acquisition formed the basis for the Air Force's Atlantic Missile Range, later the Eastern Test Range.¹⁵⁷ The Florida land was necessary for the Army to test missiles of ever-increasing range.

Throughout 1947 the Corporal E and WAC Corporal continued to fly at WSPG. With the proven capability of the liquid rockets, the Army began to show interest in mass producing the Corporal E as a tactical weapons system for use in missile battalions. The choice caused considerable consternation for Dr. Bill Pickering whose duty it was to "band aid the research rocket into this production rocket."¹⁵⁸ As Army Ordnance pressed Pickering and JPL for a workable missile, efficiency efforts were going on within the still-new DoD.

¹⁵⁵ "Chronological Survey."

¹⁵⁶ Office of Public Affairs, John F. Kennedy Space Center, NASA, "America's Spaceport, KSC-601," 1 September 1967, JPL 64, Walt Powell Collection, Materials Created by Institutions, Folder 17, JPL Archives.

¹⁵⁷ Ibid.

¹⁵⁸ Pickering, 17.

One goal of consolidating the Army, Navy, and Air Force under a bureaucratic umbrella had been to eliminate duplication of effort among the services to save cost. Organizations like the V-2 Upper Atmospheric Research Panel performed similar functions, but lacked the weight of established authority. In preparation for the first “Secretary of Defense Annual Report” to Secretary James Forrestal, the DoD realized that the services were all running independent missile programs.¹⁵⁹ Despite the realization—one that most likely did not shock anyone familiar with the missile development world—untangling service interests required time and a deliberate effort. In the meantime, Army Ordnance proceeded with its solid- and liquid-propellant programs and began to look for new facilities.

By spring 1948, Ordnance authorized the development of a high-altitude, solid propellant rocket similar to the Experimental Solid Propellant Vehicle (XSPV) concept that JPL had developed. Like the WAC Corporal, the XSPV was intended for scientific purposes that enabled military objectives, and also like the WAC Corporal, it was given a confusing name: Sergeant. The Sergeant sounding rocket was distinctly different from the later Sergeant missile that JPL developed, but it contributed two very important developments in the Army’s quest for a battlefield missile.¹⁶⁰ First, it had nearly double the diameter of any previous solid motor, ensuring greater flight ranges and larger

¹⁵⁹ Moltz, 85.

¹⁶⁰ Carroll, 32.

payloads.¹⁶¹ Second, the guidance system (which technically made it a missile) designed for the Sergeant sounding rocket was later adapted for Corporal¹⁶²

As solid-propellant missiles increased in size, so did liquid-propellant ones. While larger propellant sources were essential to increase range, the mass penalty for launching a large rocket posed a difficult engineering problem. As the size of the launch vehicle grew, it reached a point where the extra fuel could not compensate for the extra mass of the rocket body required to hold it. To solve this problem, a combined team of JPL and General Electric engineers looked to staging, the process of stacking multiple rocket segments, each igniting after the previous stage had burnt its fuel and separated from the main body. Free from the dead weight of the empty stage, subsequent stages were able to fly further. The Bumper program became the Army's first missile to involve staging and the first to combine American missiles with German ones. The JPL and German engineers built upon this experience to achieve success with the Jupiter-C, another multi-stage missile with both German and U.S. components.

With General Electric as the lead contractor, the Bumper program incorporated two stages, a modified V-2 as the first stage, and a modified WAC Corporal as a second stage.¹⁶³ The modified WAC Corporal, known as a Bumper WAC, included attached spin-stabilization rockets, which caused the upper stage to spin during flight thereby

¹⁶¹ Ibid., 34.

¹⁶² Ibid.

¹⁶³ Hermann Bank, "Bumper 8, 50th Anniversary of the First Launch on Cape Canaveral, Group Oral History, Kennedy Space Center, Held on July 24, 2000," 7, JPL 232, Group Oral History-Kennedy Space Center, 24 July 2000, JPL Archives.

stabilizing its trajectory.¹⁶⁴ These spin-stabilization rockets consisted of solid motors with the internal-burning star grain pattern.¹⁶⁵

While Corporal, Sergeant, and Bumper progressed, Army Ordnance looked to two deactivated facilities still on the Army's wartime books to use in their development of larger liquid-propellant missiles. The Ordnance Research and Development Division Suboffice of Rockets at Fort Bliss took over the Huntsville Arsenal, and the nearby Redstone Arsenal became the Ordnance Guided Missile Center in November 1948.¹⁶⁶ After nearly three years of living in the Southwest, the Germans relocated to the Deep South, but their rockets, for the time being, continued to fly at White Sands.

Longer Range

By 1949 the Red Army had begun fielding a missile capable of flying 500 miles, a range unmatched by anything yet produced in the U.S.¹⁶⁷ With the formation of NATO on April 4, 1949 and an in-depth defense of Europe seeming more and more necessary, missile weapons remained an attractive option for long-range power projection. The Army had long struggled with the question of how to remain operationally relevant in a world where nuclear weapons seemed likely to decide future conflicts.¹⁶⁸ The Air Force, as the service with the majority of nuclear delivery capability, had ascended in primacy

¹⁶⁴ Carroll, 34.

¹⁶⁵ Ibid.

¹⁶⁶ Tietel, 105.

¹⁶⁷ Moltz, 78.

¹⁶⁸ Trauschweizer, 20.

among the services during this period, and with nuclear-capable bombers in development (the new AJ- Savage and the retrofitted P2V-3C Neptune), the Navy aimed to secure its role in the atomic campaigns of the future.¹⁶⁹ But the end of the U.S. atomic monopoly with the Soviet Union's first detonation on August 29, 1949, provided the Army an opportunity to argue for the value of ground forces as an essential element of deterrence.¹⁷⁰

The Army's ballistic missile development programs were a significant part of its strategy for relevancy and fit within larger defense establishment notions of future wars being waged through the air.¹⁷¹ In such a war, large ground formations presented a convenient target for atomic weapons. To offset this vulnerability, the Army looked to technologies that provided a credible deterrent.

Such large-scale Army reform required long-term investment and a vision for executing it, but in 1949 both prerequisites were lacking. The Army's 1949 version of Field Manual 100-5, *Operations*, envisioned nuclear artillery at higher echelons to disrupt enemy forces before they came into contact with the friendly main body, which still held conventional artillery to affect the closer fight.¹⁷² With the establishment of the Alabama arsenals, the Army and its rocketeers intended to develop missiles of unprecedented

¹⁶⁹ Rearden, 398.

¹⁷⁰ Trauschweizer, 25.

¹⁷¹ The idea that the rise of the Air Force and the incorporation of a tactical nuclear capability for limited warfare drove the Army's reforms of the late 1940s and early 1950s is the central thesis of Trauschweizer's chapters 1-3.

¹⁷² Walter Kretchik, *U.S. Army Doctrine from the American Revolution to the War on Terror* (Lawrence: University Press of Kansas, 2011), 170-171.

range. The Bumper program was essential to both long-range missile development and the future role of the Army in the atomic era.

Despite the need for investment in the Army, Secretary of Defense Louis Johnson planned to meet Truman's \$13 billion defense budget ceiling.¹⁷³ The fiscal goal, however, conflicted with the need to keep up with the Soviet Union. In light of the U.S.S.R.'s missile and atomic successes, technologies that the U.S.S.R. had not yet joined together, and with the justified fear that the U.S. was behind its adversary in missile development, Truman appointed Kaufman T. Keller, head of the Chrysler Corporation, to investigate American missile development programs and prioritize a way ahead. Keller's report led to the creation of the Atlas ICBM program in 1951 as part of a long-term solution.¹⁷⁴ With Atlas, the Air Force began development of its first ICBM. The Army continued to develop its SRBMs, but since no service received responsibility for IRBMs, both services began to develop their own IRBM programs. With the passage of NSC-68 and the outbreak of hostilities in Korea, significant additional funding for missile programs became available.

On June 25, 1950, communist North Korean forces invaded South Korea. On the eve of the Korean War, five years after beginning the drawdown from an eight-million-man Army, the United States fielded 591,000 soldiers comprising just ten divisions.¹⁷⁵ As in World War II, no U.S. surface-to-surface missiles entered the war, but budgets once

¹⁷³ Trauschweizer, 25.

¹⁷⁴ Moltz, 85.

¹⁷⁵ Trauschweizer, 18.

again increased, and the non-nuclear war demonstrated both the utility of ground forces and the DoD's appetite for missile weapons. From a defense missile budget of \$135 million in 1950, missile expenditures jumped to \$800 million then to \$1 billion the following year.¹⁷⁶ To accelerate the most promising missile programs, Secretary of Defense George C. Marshall established a directorate of guided missiles. The missiles chosen for priority included the Army's Honest John, Corporal, and Nike-Ajax; the Navy's Terrier; and the Air Force's Matador.¹⁷⁷ To support the DoD's needs, improved Corporal E and Bumper missiles continued to fly at WSPG.

The culmination of the Bumper program in July 1950 linked the Army's SRBM and IRBM efforts. For the flight of Bumper 8, the last in the series, the Army required longer ranges than those provided at WSPG. The Air Force's Eastern Test Range on the coast of Florida provided the necessary space, and the launch of Bumper 8 inaugurated the facility. Like the WAC Corporal, Bumper was not a weapons program *per se*, but the program's development of a multi-stage missile and the necessary buildup of test infrastructure made Bumper an essential part of the Army's missile development efforts.

Leveraging the lessons learned from Bumper, the Huntsville team sought to convert the Hermes C1, itself a V-2 variant, into a long-range missile that would meet the Army's requirements for within the next thirty-six months.¹⁷⁸ The Army rechristened the

¹⁷⁶ Nels A. Parson, Jr., *Missiles and the Revolution in Warfare* (Cambridge: Harvard University Press, 1962), 38.

¹⁷⁷ Ibid.

¹⁷⁸ Teitel, 129.

Hermes C1 as “Redstone” on April 8, 1952.¹⁷⁹ Although a single-stage missile, the Redstone was capable of greater range than the Corporal E, and the pair promised a defense-in-depth capability for the Army.



Figure 5. The Redstone Missile

Source: White Sands Missile Range Museum, “Redstone,” accessed May 12, 2017, <http://www.wsmr-history.org/Redstone.htm>.

¹⁷⁹ Ibid.

Conclusion

Following the end of World War II and the Truman administration's dramatic budget reductions, missile development took on an increased importance for the Army. The creation of the an independent Air Force and a preoccupation among policy makers with atomic weapons only furthered motivated the Army's quest for redefinition and its willingness to invest in the technologies that would restore its level of prestige.¹⁸⁰ Budgetary pressures and manpower reductions strained the Army, but the advent of the Korean conflict and the adoption of NSC-68 provided significant additional funding for weapons systems like the Redstone.

Cooperative efforts like the Upper Atmospheric Research Panel were a response to the reduced funding and served as a forerunner for later government activity. The intent of this joint effort was to orchestrate research that benefitted all parties while avoiding duplication of effort, but as Van Allen noted, the committee had no budget and no real authority.¹⁸¹ No such committee existed to coordinate the efforts of the services regarding their satellite development programs. Although the Navy flirted with cooperation on satellites in 1946, the strong service interests of the Air Force ensured service-independent programs. The need for a coordinating agency with the authority to

¹⁸⁰ Linn, *Elvis' Army*, 8. The Army theorists of the period needed to prove the relevancy of a ground force, transform the existing force to meet the demands of the atomic age, and reverse the downward spiral of prestige and public/political support.

¹⁸¹ Van Allen.

enforce its will surfaced again in the mid-1950s and served as the motivation for the creation of ARPA and NASA.

The need for separate agencies to oversee military and civil space grew out of political sensibilities after 1952 but was not a problem between 1947 and 1952. Like RAND's satellite study, the Upper Atmospheric Research Panel made no distinction between military functions of space and civil functions of space. On the contrary, the panel acknowledged the utility of using missile weapons for scientific purposes, a necessity that the Army fully embraced.

Not all of the products of the period were weapons, however. The WAC Corporal, although an outgrowth of technology developed for military purposes, was itself was not a weapon, but it contributed useful meteorological data to the Signal Corps. The Corporal E, a research-project-turned-weapon, promised to become an important means of projecting firepower in support of ground combat forces in Europe while JPL developed a more capable solid-propellant missile based on internal-burning star grain motors made from synthetic polymers. The distinction between missile weapons and missiles developed from weapons technology became politically significant in the years leading to the launch of Explorer I.

Perhaps the most significant technological developments during the period came as a result of the Bumper program. Through its investigation into staging, Bumper achieved advances necessary for long-range missiles and space launch vehicles. Furthermore, as the first launch from the Florida coast, the Bumper program established the communications architecture for post-launch tracking in the southern Atlantic. These successes proved essential to the eventual success of Jupiter-C.

Although 1947 witnessed the creation of the DoD, the challenge of consolidating missile development within the new organization continued. Marshall's deliberate attempt to push the most capable prototype missiles into production served as a minor consolidation effort, but it was a reaction to the situation in Korea more than a proactive measure. Similarly, the theory of satellites advanced between 1947 and 1952, but the DoD did not proffer a vision of how to develop complementary space and missile technologies within a joint construct. As a result, the services largely defined their own responsibilities in missile and satellite development, and duplication of effort continued both within the services and among them.

CHAPTER 4

THE INTERNATIONAL GEOPHYSICAL YEAR AND VANGUARD

By the time of President Eisenhower's election in 1952, the U.S. government had gained significant experience in rocket propulsion technology and in theoretical and practical scientific payload development. On the other side of the Iron Curtain, the Soviet Union engaged in similar lines of investigation. Under the auspices of the International Geophysical Year (IGY), a scientific effort sponsored by the United Nations (UN), both nations competed to launch the first satellite.

Longer-range missiles and, after 1952, a thermonuclear-capable Soviet Union drove Eisenhower's National Security Council (NSC) to shape a policy of deterrence. The resultant New Look policy relied upon air-delivered atomic weapons to both deter the U.S.S.R. and to respond with overwhelming force in the event of aggression against Western Europe. The resulting concept of "massive retaliation" left little room for employing ground forces in a future war.

As it had under the Truman administration, the Army under New Look sought a more extensive role in the nuclear military of the future. It embraced extensive doctrinal, organizational, and technological reforms culminating in the Pentomic concept, which Chief of Staff General Maxwell Taylor outlined in 1956.¹⁸² Among other weapons systems, Taylor envisioned the Corporal missile providing long-range fire support to ground formations defending NATO. Beyond Corporal, the Army looked to a generation of longer-range missiles, the liquid-propellant Redstone (200-mile range) and the solid-

¹⁸² Trauschweizer, 52.

propellant Sergeant (75-mile range).¹⁸³ With the realization that the Redstone was capable of launching a satellite, von Braun proposed Project Orbiter, originally a joint Army-Navy project, to accomplish that goal.¹⁸⁴

The choice of the Navy's Vanguard program in 1955 to launch the first U.S. satellite frustrated von Braun and the Redstone team.¹⁸⁵ Although derived from military technology, Vanguard itself was not a weapons program and therefore fit more in keeping with the Eisenhower administration's desire to promote the benefits of an open society and space as an arena for peaceful purposes.¹⁸⁶ Plagued by immature technology, cost overruns, and an increasingly unsupportive Secretary of Defense, Vanguard struggled. By 1957, only the Army's Redstone was capable of launching a satellite. Policy considerations forbade an Army space launch but did not stop the Army's conceptual development of missiles capable of exceeding 200 miles or reaching space.¹⁸⁷

The IGY

In 1952 the International Council of Scientific Unions agreed to sponsor a worldwide research program in anticipation of the upcoming solar maximum, the peak of

¹⁸³ White Sands Missile Range Museum, "Redstone," accessed April 18, 2017, <http://www.wsmr-history.org/Redstone.htm>; White Sands Missile Range Museum, "Sergeant," accessed April 18, 2017, <http://www.wsmr-history.org/Sergeant.htm>.

¹⁸⁴ Matt Bille, Pat Johnson, Robyn Kane, and Erika R. Lishock, "History and Development of U.S. Small Launch Vehicles," in *To Reach the High Frontier*, eds. Dennis R. Jenkins and Launius (University Press of Kentucky, 2002), 191.

¹⁸⁵ Ibid.

¹⁸⁶ Tietel, 207-208.

¹⁸⁷ Medaris, 125; Rosholt, 108.

the sun's eleven-year surface activity cycle.¹⁸⁸ The International Geophysical Year (IGY), a civilian effort for scientific purposes, provided a forum for both the United States and Soviet Union to compete in an ostensibly peaceful demonstration of technological prowess. Apart from benefitting science, the IGY provided two important political opportunities. First, a successful satellite launch meant a clear propaganda victory for the first nation to accomplish the feat, demonstrating both an edge in missile technology and, by extension, a superiority of political system. Second, in supporting the IGY, the United States supported the international world order that was still finding its feet in the wake of World War II.¹⁸⁹ Despite continued efforts by the military services and a growing industrial base, however, a missile to launch an IGY satellite did not exist in 1952.

New Look

Throughout the Korean conflict, which resulted in the signature of an armistice on July 27, 1953, the United States had never turned its attention away from the Soviet threat. Driven by European concerns, the NSC began an analysis of Soviet military capabilities. The Soviet Union's detonation of a hydrogen bomb on August 12, 1953 upped the ante, and NSC action in the subsequent months reflected both the fear of inadequate domestic air defenses in the event of a Soviet one-way bombing mission and

¹⁸⁸ Teitel, 191. R. C. Olsen, *Introduction to the Space Environment* (unpublished course text, Naval Postgraduate School, 2009), 54.

¹⁸⁹ Annex B to Draft Statement of Policy on U.S. Scientific Satellite Program, General Considerations, NSC 5520, 17 May 1955, Disaster Box 38, Outer Space (1), 11. The Dwight David Eisenhower Presidential Library.

the need to counter robust air defenses should an attack from Europe be necessary.¹⁹⁰ The President enacted NSC 162-2 on October 30, 1953, and the policy outlined by the document became known as the New Look.¹⁹¹ NSC 162-2 defined the two parts of the problem: “meet the Soviet threat to U.S. security” and “in doing so, to avoid seriously weakening the U.S. economy by undermining our functional values and institutions.”¹⁹² The rest of the document provided the analysis of and a recommended solution for this fundamental problem.

Foreseeing the Cold War as a protracted conflict requiring a greater need for allied involvement and facing a growing national debt, Eisenhower sought a cost-effective security solution that did not rely on a large, standing military.¹⁹³ Thus, growing and maintaining a large Army was out of the question, but the protection of “our striking force, our mobilization base, and our people” were the top priorities to “counterbalance

¹⁹⁰ A Report to the National Security Council by the NSC Planning Board on Review of Basic National Security Policy, 19 October 1953. NSC Series, Box 6, NSC 162-2, Basic National Security Policy (3), 2, The Dwight David Eisenhower Presidential Library.

¹⁹¹ Trauschweizer, 29

¹⁹² A Report to the National Security Council by the Executive Secretary on Basic National Security Policy, 30 October 1953, NSC Series, Box 6, NSC 162-2, Basic National Security Policy (2), 1, The Dwight David Eisenhower Presidential Library.

¹⁹³ Trauschweizer, 28; A Report to the National Security Council by the Executive Secretary on Basic National Security Policy, 30 October 1953, NSC Series, Box 6, NSC 162-2, Basic National Security Policy (2), 18, The Dwight David Eisenhower Presidential Library.

Soviet atomic power.”¹⁹⁴ Achieving the policy required the employment of “sufficient atomic weapons and effective means of delivery.”¹⁹⁵

At the time NSC 162-2 came into effect in October 1953, the only means of atomic delivery available were aircraft. Despite the ongoing research in both ballistic and cruise missiles, no service had fielded either.¹⁹⁶ For the Army, the coupling of conventional artillery with atomic weapons provided a stop-gap measure until ballistic missiles reached Europe. In December of 1953, the Army ground forces in Europe gained the capability of delivering atomic weapons with the 280-mm atomic cannon as their delivery system.¹⁹⁷ That same month, the Joint Chiefs approved a reduction of ground forces from 1.5 million to one million soldiers by 1957.¹⁹⁸ Fewer troops translated into a heavier reliance on technology and firepower.

In his testimony before Congress in February 1954, Army Chief of Staff General Matthew Ridgeway agreed to complete the reductions by June 1956 (the end of the fiscal

¹⁹⁴ Ibid., 7-8.

¹⁹⁵ Ibid.

¹⁹⁶ The history of the U.S. cruise missile is outside the scope of this thesis, but one should note that early variants—radio-controlled bombs and aircraft loaded with explosives—dated back to 1918. By 1951, the Air Force was testing the Northrup Snark (N-25), a subsonic missile with a 1,500-mile range. With limited operational employment in the late 1950s, President Kennedy cancelled the program in 1961. The Navy’s Regulus cruise missile did not become operational until 1955. See Kenneth P. Werrell, *The Evolution of the Cruise Missile* (Maxwell Air Force Base, AL: Air University Press, 1985), 82-96 and 114-116.

¹⁹⁷ Trauschweizer, 83.

¹⁹⁸ Ibid., 30.

year), leaving sixteen combat divisions and two training divisions.¹⁹⁹ The detonation of the first American “droppable” hydrogen bomb the next month continued to raise the nuclear stakes and profoundly affected the course of weapons development.²⁰⁰ In July 1954, the Air Force formed the Western Development Division (WDD) to consolidate its missile development efforts.²⁰¹ The smaller, lighter thermonuclear device eased the requirements for the WDD, allowing for a reduction in the initial lift capability for the Atlas ICBM program.²⁰²

In November 1954 with U.S. policy set on the preeminence of nuclear forces, NATO adopted the massive retaliation strategy, which authorized the immediate use of nuclear force in the face of any Soviet attack.²⁰³ That same month, Secretary of State John Foster Dulles acknowledged a softening in the Soviet position following Stalin’s

¹⁹⁹ Ibid., 33.

²⁰⁰ “Space and Missile Systems Organization: A Chronology, 1954-1979,” Space Division Chief, of Staff, History Office, AFSC Historical Publication, in *U.S. Military Uses of Space, 1945-1991*, The National Security Archive, text-fiche, p. 16-17, 00303.

²⁰¹ “Summary History: Air Force Missile and Space Development Facilities, Los Angeles, California 1954-1964,” Air Force Systems Command Historical Publications Series 65-22-1, prepared by Space Systems Division Historical Office, January 1965, in *U.S. Military Uses of Space, 1945-1991*, The National Security Archive, text-fiche, p. 3, 00302.

²⁰² “Space and Missile Systems Organization: A Chronology, 1954-1979,” in *U.S. Military Uses of Space, 1945-1991*, The National Security Archive, text-fiche, p. 16-17, 00303.

²⁰³ Tauschweizer, 46.

March 1953 death and the possibility for improved relations.²⁰⁴ He remained wary, concerned that the change in the stance of the Soviet Union may have been a ploy to reduce efforts at collective defense, and acknowledging that the destruction wrought by a general war would not allow the U.S. to attain its national objectives, he advocated for a “prolonged period of cold war.”²⁰⁵ To this end, the alliance needed “sufficient flexibility in NATO forces to avoid exclusive dependence on atomic weapons” and the capability to engage without promoting general war.²⁰⁶ The introduction of guided missiles, Secretary Dulles noted, complicated matters even further, and he recommended studies of their “effects on our military strategy and alliance.”²⁰⁷ With the acknowledgement of general war’s strategic bankruptcy and a hint at the need for more flexibility, Secretary Dulles, it seems, was arriving at the same conclusion that Ridgeway had reached about massive retaliation.

The desire among the U.S. political leadership for military flexibility provided the Army an opportunity to argue for its relevancy. General Ridgeway continued to develop the concept of how to integrate new organizational structures and new technologies into the atomic army of the future.²⁰⁸ For the time being, the Army’s tactical concept in 1954

²⁰⁴ Memorandum for the NSC from John Foster Dulles, Subject: Review of Basic National Security Policy, 17 November 1954, NSC Series, Box 6, NSC 162-2, Basic National Security (1), 1. The Dwight David Eisenhower Presidential Library.

²⁰⁵ Ibid, 2-4.

²⁰⁶ Ibid., 6-7.

²⁰⁷ Ibid., 7.

²⁰⁸ Linn, 87.

did not depart dramatically from existing doctrine: progressive ground maneuver supported by massive artillery barrages that would inflict the majority of the damage²⁰⁹ The Army's *Field Service Regulations* of October 1954 drew no distinction between the employment of conventional and atomic artillery.²¹⁰

The Army's preoccupation with missile development reflected its institutional preoccupation with firepower. This doctrinal approach reflected the deeply entrenched tactics from World War I rather than the expected realities of atomic warfare.²¹¹ Through the influence of General Marshall at the Infantry School, such tactics found employment by Generals Eisenhower and Bradley in the European theater of World War II. Despite successes at the operational level of war by maneuverists like General George Patton, Eisenhower and Bradley went on to lead the Army, and the methodical advance remained the approved solution to warfare into the 1950s.²¹² To the benefit of the JPL and the Army Ordnance Department, this firepower-centric view of warfare favored the

²⁰⁹ Trauschweizer, 13, 21.

²¹⁰ Kretchik, 169.

²¹¹ *Ibid.*, 171.

²¹² For a discussion on the methodical approach by World War II commanders in the European theater at the expense of operational opportunities: (1) Russell F. Weigley, "Normandy to Falaise: A Critique of Allied Operational Planning in 1944," in *Historical Perspectives on the Operational Art*, eds. Michael D. Krause and R. Cody Phillips (U.S. Army Center of Military History, 2010). Also, Williamson Murray and Allan R. Millet, Chapter 15, "The Invasion of France: 1944" in *A War to be Won: Fighting the Second World War* (Harvard University Press, 2000).

development of missiles. By the end of 1954, U.S. Army Europe (USAEUR) was expecting its first Corporal battalions.²¹³



Figure 6. A Corporal Missile on Display

Source: U.S. Army Aviation and Missile Life Cycle Management Command, “Corporal,” accessed May 12, 2017, <https://history.redstone.army.mil/miss-corporal.html>.

²¹³ Trauschweizer, 83.

In 1955, General Maxwell Taylor replaced Ridgeway as the Army Chief of Staff and began to forward his own concept for Army transformation. Like Ridgeway, Taylor reasoned that relevancy in a nuclear conflict required tactical nuclear weapons, which the Army now had, and the organizational structure and doctrine to employ them.²¹⁴ Also like Ridgeway, Taylor faced an uphill battle in Washington. With a total budget of \$7.6 billion, about 25 percent of the defense budget for the year, the Army was the only service to receive less funding than in the previous year.²¹⁵ Despite budget reductions and ongoing personnel cuts, February 1955 saw testing of the Atomic Field Army (ATFA-1) concept, revealing significant shortcomings in the construct, including the politically unacceptable realization that an ATFA-1 force required more soldiers to be effective than what the Army currently had on-hand.²¹⁶

Vanguard

On March 9, 1955, von Braun, now Chief of the Army's Guided Missile Division at Redstone Arsenal, appeared on the *Disneyland* television show to share his dreams of space travel with America.²¹⁷ After the host unabashedly introduced von Braun as the leader of the V-2 weapons program, von Braun shared with Americans his vision for a four-stage rocket to carry a reusable space plane into orbit.²¹⁸ The episode garnered

²¹⁴ Ibid., 3.

²¹⁵ Ibid., 29.

²¹⁶ Ibid., 55.

²¹⁷ Jacobsen, *Operation Paperclip*, 397.

²¹⁸ Wehrner von Braun, "Disneyland 1955-Man in Space-Wernher von Braun," YouTube, accessed February 10, 2017, <https://www.youtube.com/>

approximately 42 million viewers, the “second-highest-rated television show in American history at that time.”²¹⁹ What the episode did not say was that such a large missile could serve as an ICBM, and the Army’s lead rocketeer was planning to build it. Furthermore, the idea of a spaceplane no doubt appealed to the imagination of the viewing audience, but as a practical matter, simple satellites needed to come first.²²⁰

On April 16, 1955, a little more than a month after von Braun appeared on *Disneyland*, the U.S.S.R. announced the establishment of a commission for interplanetary communications, an organization at the time believed to be responsible for satellite development.²²¹ The NSC met to discuss prospects for a U.S. satellite on May 26, 1955. Based on DoD analysis, the NSC concluded that the technical possibility existed of launching a 5-10 pound satellite—“a hollow metal sphere about the size of a basketball”—within the 1957-58 timeframe, coinciding with the IGY.²²² The Technological Capabilities Panel of the President’s Science Advisory Committee

watch?v=8zcU85O82XE. Interestingly, the diagrams to which von Braun refers show hydrazine and nitric acid in each stage, a hypergolic fuel combination.

²¹⁹ Jacobsen, *Operation Paperclip*, 397.

²²⁰ In fact, Air Force feasibility studies of a manned spaceplane were already underway when von Braun appeared on *Disneyland*. Sambaluk, xxiii.

²²¹ Draft Statement of Policy on U.S. Scientific Satellite Program, General Considerations, NSC 5520, 20 May 1955, Disaster Box 38, Outer Space (1), 1-2, The Dwight David Eisenhower Presidential Library.

²²² Annex B to Draft Statement of Policy on U.S. Scientific Satellite Program, General Considerations, NSC 5520, 17 May 1955, Disaster Box 38, Outer Space (1), 13. The Dwight David Eisenhower Presidential Library.

supported the idea, recognizing the potential for satellite reconnaissance and the need to establish the legal precedent of “Freedom of Space.”²²³

The verbiage of the policy draft reminds one of the early RAND studies with its brief discussion of space science as an enabler of communications and missile technology and for the potential of large satellite reconnaissance.²²⁴ Perhaps more importantly from a political perspective, the policy acknowledged the “considerable prestige and psychological benefits” of being the first to launch a satellite.²²⁵ Two satellite vehicle concepts were already under study: Project Orbiter under von Braun and the Navy’s Project Vanguard with the potential to use Atlas ICBMs or Aerobee research rockets as backups.²²⁶ On May 27, 1955, the President approved NSC 5520, Statement of Policy on U.S. Scientific Satellite Program, and directed its implementation. The White House, however, did not publicly announce its plans to launch a satellite in support of the IGY until July 29, 1955.²²⁷

Throughout the summer of 1955, the NSC Planning Board turned its attentions to the Technological Capabilities Panel. Headed by Dr. James Killian, the President of the

²²³ Draft Statement of Policy on U.S. Scientific Satellite Program, General Considerations, NSC 5520, 20 May 1955, Disaster Box 38, Outer Space (1), 1. The Dwight David Eisenhower Presidential Library.

²²⁴ Ibid., 2.

²²⁵ Ibid., 3.

²²⁶ Ibid., 7.

²²⁷ The White House, Statement issued by Press Secretary James G. Haggerty, 29 July 1955, NSC Series Box 16, NSC 5520, Satellite Program (2), 1. The Dwight David Eisenhower Presidential Library

Massachusetts Institute of Technology (MIT), the panel provided expert analysis on the state of the U.S.S.R's missile development for the consideration of the NSC. The panel highlighted, among other military priorities like early warning and security of overseas communications networks, the need for the development of an ICBM and a "1,500-mile ballistic missile" (an IRBM, though not so-named).²²⁸ The DoD indicated that it had five potential missile programs that may meet the requirement and that it would report back on the prospects by the first of December.²²⁹ Although the members of the NSC realized the potential of the Soviet Union to attain an ICBM before the United States, they agreed that the United States must be in a position to produce its own as quickly as possible thereafter. To that end, the Planning Board proposed to the NSC that ICBM development take top priority.²³⁰ On December 1, 1955, Eisenhower assigned "highest and equal priority" to Atlas and Titan, two Air Force ICBMs, and the Thor (Air Force) and Jupiter (Army) IRBMs.²³¹ With Eisenhower's decree, the Jupiter, a variant of the Army's Redstone missile, became a tactical missile that contributed to strategic deterrence. Meanwhile, the Vanguard program's mission of strategic messaging continued.

²²⁸ Memorandum for the NSC, Proposed Council Action on The Recommendations of the Report to the President by the Technological Capabilities Panel of the Science Advisory Committee, Office of Defense Mobilization, 26 July 1955, NSC Series, Box 16, NSC 5522 Technological Capabilities Panel (1), 1. The Dwight David Eisenhower Presidential Library.

²²⁹ Ibid.

²³⁰ NSC Planning Board, Proposed NSC Action, the ICBM Program, 30 August 1955, NSC Series, Box 16, NSC 5522, Technical Capabilities Panel (1), no page number. The Dwight David Eisenhower Presidential Library.

²³¹ "Space and Missile Systems Organization: A Chronology, 1954-1979," p. 31, 00303.

From May 1955 to April 1956, the Navy received approval to proceed with its concept for Vanguard, which envisioned the launch of six satellites with a proposal by the National Science Foundation for six more.²³² Despite being a Navy program, the Army and Air Force received orders to participate.²³³ The launch vehicle concept in 1956 was a three-stage vehicle. The first stage was to be a Navy Viking, the second stage an “Air Force Aerobee,” and the third stage an Army Sergeant.²³⁴ The referral by the NSC to the Aerobee as an Air Force rocket illustrates the potential hazards of tracing the family tree of American rocketry. Although the Aerobee served under many masters as a vehicle for upper atmospheric research from 1947 until 1985, its heritages traces directly to the WAC Corporal and JPL.²³⁵ Of its three components, then, the Vanguard rocket cobbled together two sounding rockets and a solid motor developed for a military missile. While the basic research that produced each of the three stages linked directly to military spending, Vanguard was not developed to deliver a weapon, a distinction that allowed the Eisenhower administration to present Vanguard as the more acceptable alternative for launching the Free World’s first satellite.

Regardless of launch vehicle components, the initial high-end estimate for Vanguard was \$20 million, but that low figure underestimated the engineering challenges

²³² U.S. Earth Satellite Program (NSC 5520), 19 April 1956, Disaster Box 38, Outer Space (1), 1. The Dwight David Eisenhower Presidential Library.

²³³ Draft Statement of Policy on U.S. Scientific Satellite Program, 1.

²³⁴ U.S. Earth Satellite Program (NSC 5520), 1.

²³⁵ Ray A. Williamson and Roger D. Launius, “Rocketry and the Origins of Space Flight,” in *To Reach the High Frontier*, eds. Dennis R. Jenkins and Launius (University Press of Kentucky, 2002), 46.

of the project, Air Force operating costs, and costs for the Army to build observation stations throughout the western hemisphere.²³⁶ By April 1956, the IGY satellite program was already over budget, and Major General John B. Medaris, commanding general of ABMA, continued to advance his view that Redstone could place a satellite into orbit by January 1957.²³⁷ Vanguard aimed for October 31 of that year, but the importance of placing a civilian façade on the launch trumped expediency.²³⁸ To further add to Vanguard's troubles, it was losing support from the cost-conscious Secretary of Defense.²³⁹ Regardless of Wilson's misgivings, NSC Action No. 1545 of May 3, 1956 made it clear that the satellite must not miss the IGY window.²⁴⁰ Too much national prestige was at stake.

By the fall of 1956, Vanguard again required the attention of the NSC. DoD recommended a way-ahead that followed an incremental test plan for the rocket itself while cautioning against parallel programs using Redstone or Atlas for the sake of "cost

²³⁶ U.S. Earth Satellite Program (NSC 5520), 2.

²³⁷ *Ibid.*, 4.

²³⁸ *Ibid.*, 4.

²³⁹ Memorandum to the Director from Military Division, Subject: Alternative Courses of Action Relating to Project VANGUARD, 13 April 1956, NSC Series, Box 16, NSC 5520, Satellite Program (2). The Dwight David Eisenhower Presidential Library.

²⁴⁰ Draft Report on NSC 5520, U.S. Scientific Satellite Program, 9 November 1956, NSC Series, Box 16, NSC 5520, Satellite Program (1). The Dwight David Eisenhower Presidential Library.

in trained manpower, range time, and dollars of duplicating technical approach.”²⁴¹ This aversion to parallel development seems somewhat hypocritical considering the DoD’s long tradition of parallel missile development programs, but it demonstrates the effects of Eisenhower’s fiscal conservatism and Wilson’s growing conviction that the satellite program was of little military value.

Despite assurances that Vanguard was essentially on schedule for an initial launch on October 31, 1957, the program continued to struggle.²⁴² By the end of April 1957, the \$83.6 million estimate of three months earlier was insufficient for Vanguard. Defense had dedicated an additional \$50 million with an additional \$25 million from a separate DoD emergency fund, which was not replaced.²⁴³ The CIA chipped in an additional \$2.5 million for Vanguard, and the NSF provided additional funding for the satellites, instrumentation, and ground observation.²⁴⁴ Project estimates now sat at \$110 million with the possibility of reaching \$150-200 million, and DoD was unhappy, insinuating that the additional funding burden would, in direct violation of the President’s guidance, interfere with ballistic missile development.²⁴⁵ Furthermore, the USAF reconnaissance

²⁴¹ National Security Council Progress Report on the U.S. Scientific Satellite Program (NSC 5520) by the Department of Defense, 3 October 1956, Disaster Box 38, Outer Space (1), 2-3. The Dwight David Eisenhower Presidential Library.

²⁴² *Ibid.*, 2.

²⁴³ Executive Office of the President, Bureau of the Budget, Memorandum for the President, Subject: Project Vanguard, April 30, 1957, NSC Series, Box 16, NSC 5520, Satellite Program (1), 1. The Dwight David Eisenhower Presidential Library.

²⁴⁴ *Ibid.*, 1-2.

²⁴⁵ *Ibid.*

satellite program required \$10 million in FY57 and at least as much for the next year, and was judged more vital from a Defense standpoint than the IGY experiment.²⁴⁶ Secretary Wilson's interest in Vanguard waned further, but as the NSF pointed out, national interests demanded that the IGY project succeed.²⁴⁷

Conclusion

Within the framework of the international community, the IGY provided an outlet for the two main belligerents of the Cold War to compete in a contest of technological prowess that promised significant potential for propaganda victories. While the efforts to support the IGY depended upon military organizations, the desire to portray space as a domain for peaceful purposes necessitated a civil veneer on the space program, if not a separate civil organization.

Under guidance from Eisenhower and the NSC, U.S. missile development continued among the services with Secretary Wilson delineating responsibilities. Under the New Look policy, the Air Force remained the best funded of the services and increased its research and development efforts. The creation of the WDD (renamed the Air Force Ballistic Missile Division on June 1, 1957) to oversee its space and missile programs focused the service's efforts.²⁴⁸

²⁴⁶ Ibid., 4.

²⁴⁷ Ibid., 3.

²⁴⁸ "Summary History: Air Force Missile and Space Development Facilities, Los Angeles, California 1954-1964," text-fiche, p. 4, 00302.

For the Army, missile and satellite development plans remained under the Ordnance Department. As Medaris, Gavin, and other Army leaders argued for an opportunity to launch a satellite in the spring of 1956, Taylor finalized the concept of the Pentomic Division.²⁴⁹ With its organization based on five units per echelon equipped with atomic cannons and Corporal missiles, the construct, however unwieldy, secured the role of the Army as a nuclear-capable force and theoretically provided an alternative to full-scale nuclear war.²⁵⁰ Secretary Wilson's directive of November 1956, however, limited Army missiles to a range of 200 miles, effectively forbidding the Army to ever employ its Jupiter IRBM.²⁵¹ While simultaneously attempting to transform into the Pentomic force, the Army continued developing Redstone for its own tactical uses and the Jupiter IRBM for eventual employment by the Air Force. The Navy, meanwhile, proceeded with Vanguard and its associated satellite and launch vehicle development.

Despite the best efforts of Vanguard, the most experienced rocket scientists in the United States remained the von Braun team. At the time of the administration's decision to support Vanguard, the joint Army-Navy proposal had been, based on technological maturity, the most likely to succeed.²⁵² Unfortunately for the Army, the administration continued to view Vanguard as the politically preferable alternative because of its

²⁴⁹ Trauschweizer, 52.

²⁵⁰ *Ibid.*, 13.

²⁵¹ Medaris, 125.

²⁵² Bille, 191.

supposedly non-military, non-Nazi heritage.²⁵³ Unfortunately for the Navy, the difficulties of multi-stage rocket engineering required significant investment of both time and money.

²⁵³ Burroughs, 171.

CHAPTER 5

CONSOLIDATING SPACE EFFORTS

The Navy's Vanguard program demonstrates the challenges of accurately estimating the amount of time and funding required for technologically complex programs. In choosing Vanguard and supporting its development despite the program's difficulties, the Eisenhower administration assumed risk by relying on a less mature, but more politically acceptable launch vehicle.²⁵⁴ The Army, based on the maturity of its Redstone missile, the experience of its engineering teams, and a belief in the strategic importance of orbiting a satellite before the U.S.S.R. disagreed with the choice of Vanguard, but continued to develop systems capable of greater and greater ranges.²⁵⁵

As long as the Soviet Union had not launched a satellite, nothing was lost, but the U.S.S.R. had notified the world of its intentions to launch during the IGY, and the CIA expected them to do so before the end of 1957.²⁵⁶ The launch and successful orbit of Sputnik I on October 4, 1957 caused Eisenhower and his advisors to reconsider Vanguard, the pervasive inter-service rivalry that had inhibited progress, and the need for stronger bureaucratic measures to consolidate activities of both military and civil space. By the end of 1958, the United States had created the Advanced Research Projects Agency (ARPA) as an umbrella organization to oversee military space activity, and the

²⁵⁴ Bille, 191.

²⁵⁵ Ibid.

²⁵⁶ Discussion at the 310th Meeting of the NSC, NSC Series, Box 8, 310th Meeting, 2. The Dwight David Eisenhower Presidential Library.

National Aeronautics and Space Administration (NASA) as an umbrella organization to oversee civil activity, and a U.S. policy on outer space. While the creation of ARPA attempted to provide a joint vision of space, it was the creation of NASA that effectively ended the Army's role in launch vehicle and satellite development.

Sputnik I

On October 4, 1957, the Soviet Union launched Sputnik I, the world's first artificial satellite. Four days later, Eisenhower asked Assistant Secretary of Defense Donald Quarles if the reports that Redstone could have successfully beat the Soviet Union into space were true.²⁵⁷ Quarles said that Redstone "could have orbited a satellite a year or more ago" but to maintain the "peaceful character" of the project and to avoid spillage of military-specific technology, the Science Advisory Committee favored Vanguard.²⁵⁸ Quarles commented on the Army's confidence that it could still beat Vanguard's scheduled March launch by a month, but he tried to put a positive spin on the Soviet achievement by noting that the Russians "have in fact done us a good turn" by establishing the precedent of free satellite overflight.²⁵⁹ William H. Holaday, the Special Assistant to the Secretary of Defense, offered to engage the Army on the possibility of using Redstone as a backup to Vanguard.²⁶⁰ Given that the Department of the Army had

²⁵⁷ Memorandum of Conference with the President, 8 October 1957, DDE Diary Series, Box 27, October 57 Staff Notes (2), 1, The Dwight David Eisenhower Presidential Library.

²⁵⁸ Ibid.

²⁵⁹ Ibid., 2.

²⁶⁰ Ibid.

sought approval for a satellite program on multiple occasions since the spring of 1955, there could have been little doubt in the minds of Holaday and Quarles about the service's response.²⁶¹

Later that day, Secretary Wilson updated the President on the status of the ballistic missile arsenal. Wilson judged that Thor, a spin-off IRBM from the Air Force's Atlas ICBM program, had been less successful in its tests than Jupiter, but neither had yet integrated guidance systems or a warhead.²⁶² As an MRBM, Redstone had drawn attention from the Joint Chiefs for performing beyond the imposed range limitations. Projected to be able to deliver a 6,500-pound warhead 500 miles, Redstone outperformed all other missiles in the inventory and surpassed Wilson's 200-mile range limit.²⁶³ Eisenhower ruled that the Army should be allowed to continue development because such long-range rockets could be placed well behind the front lines, a good thing "since the front will be extremely fluid."²⁶⁴ He evidently viewed Redstone only as a tactical missile, not as a missile capable of evolving to challenge established service boundaries.

Regarding Vanguard, Wilson recommended allowing the project to continue "for a few months more," while keeping the Redstone as a backup.²⁶⁵ The pervading

²⁶¹ Gavin, 14.

²⁶² Memorandum of Conference with the President, 8 October 1957, DDE Diary Series, Box 27, October 57 Staff Notes (2), 2, The Dwight David Eisenhower Presidential Library.

²⁶³ Ibid.

²⁶⁴ Ibid.

²⁶⁵ Ibid., 3.

atmosphere of competition among the services in the realm of missile development led Eisenhower to suggest a “Manhattan District” approach missile development.²⁶⁶ The creation of an umbrella organization akin to the one that oversaw the development of the atomic bomb would, in Eisenhower’s mind, eliminate the duplication of effort and DoD infighting that had plagued far too many projects, but, pending the imminent replacement of Wilson, he left the decision up in the air.²⁶⁷

With an update on the status of the missile and satellite efforts fresh on the President’s mind, the White House congratulated the Soviets on Sputnik the next day, October 9, 1957. In the official statement, President Eisenhower emphasized the role of the NSF and noted that although the Navy was in charge of Vanguard and that the DoD was very involved, the project “has been deliberately separated from our ballistic missile efforts” to highlight its scientific nature and avoid interference with ballistic missile development.²⁶⁸ Naturally, the statement did not mention the significant role of the NSC in steering Vanguard, the millions of dollars contributed to the project by the CIA, or the military heritage of each of Vanguard’s three stages.

Following the swearing in of Neil H. McElroy as the new Secretary of Defense the same day, Eisenhower made it clear that recent comments by two Army generals of the potential for beating the Soviets to space if we had used different missiles was the

²⁶⁶ Ibid.

²⁶⁷ Ibid.

²⁶⁸ The White House, Statement by the President, Summary of Important Facts in the Development by the United States of an Earth Satellite, October 9, 1957, Disaster Box 38, Outer Space (2), 2. The Dwight David Eisenhower Presidential Library.

wrong message, giving the impression of a race.²⁶⁹ Although Brigadier General Andrew Goodpaster, Aide to the President, did not name the loose-lipped generals in his account of the meeting, one was Major General Holger Toftoy, the long-serving Ordnance officer who had borne responsibility for “Special Mission V-2” and the V-2 Upper Atmospheric Research Panel.²⁷⁰

Race or not, the gravity of the situation did not escape Secretary McElroy, who had spent the previous day in Huntsville with Medaris, von Braun, Gavin, and Army Chief of Staff General Lyman Lemnitzer.²⁷¹ Upon hearing the news of Sputnik during the evening’s cocktail party, von Braun exclaimed “We knew they were going to do it!” and then promised McElroy a launch within sixty days of the decision.²⁷²

For CIA Director A.W. Dulles, the launch of Sputnik was not a surprise either. Intelligence estimates had put a Soviet launch sometime after November 1957, but Sputnik was early.²⁷³ At the NSC meeting on October 10, 1957, Dulles told the group that, based on the claims of the Soviet Union, the CIA expected between six and thirteen

²⁶⁹ Memorandum of Conference with the President, 9 October 1957, DDE Diary Series, Box 27, October 57 Staff Notes (2), 1. The Dwight David Eisenhower Presidential Library.

²⁷⁰ Medaris, 158.

²⁷¹ Ibid., 154-155.

²⁷² Ibid.

²⁷³ Discussion at the 339th Meeting of the National Security Council, 10 October 1957, NSC Series, Box 9, 339th Meeting of the NSC, 2. The Dwight David Eisenhower Presidential Library.

subsequent launches.²⁷⁴ To make matters worse, Sputnik was just the third in the trifecta of well-timed Communist technological achievements meant to impress Soviet scientific and military might upon the west. The other two, a successful ICBM launch and two recent hydrogen bomb tests, caused concern in themselves, but put together, the effect was all the more menacing.²⁷⁵ Deputy Executive Secretary of the NSC S. Everett Gleason paraphrased Allen Dulles: “Kruschev had moved all his propaganda guns into place.”²⁷⁶

Assistant Secretary Quarles reemphasized that it was never the goal to achieve a first-orbit capability despite the Cold War propaganda implications. Repeating the rationale from his discussion with the President two days earlier, Quarles reiterated that the primary drivers were science and establishing the principle of the freedom of outer space, which the Soviets had helpfully just established.²⁷⁷ To claim the primacy of science, however, ignored that the IGY participation was fundamentally a means for progressing the political goals of the United States, and it had been since the beginning. Furthermore, Quarles’ remark that orbiting a satellite first was never the goal countered the sentiment of urgency surrounding the project.

Eisenhower, of course, was not oblivious to the concerns of prestige. After Quarles’ remarks, the President asked whether the lower planned orbital altitude of the US satellite and a resulting lifespan shorter than Sputnik’s would damage U.S.

²⁷⁴ Ibid.

²⁷⁵ Ibid.

²⁷⁶ Ibid.

²⁷⁷ Ibid., 4.

prestige.²⁷⁸ In Quarles' view, the superior instrumentation onboard the U.S. satellite and the resulting scientific returns could be sold as more valuable than the Sputnik squawks.²⁷⁹ The President expressed further concern over newspaper reports that claimed Sputnik could take photographs.²⁸⁰ Quarles was uncertain but thought it unlikely.²⁸¹ Vice President Richard Nixon verified with Quarles that it was still the intent to make the satellite's data available to "all interested people in all countries." Quarles affirmed, and Nixon noted the "great propaganda advantage" that it would give the free and open society.²⁸²

While the Vice President's assessment of the propaganda potential was apt, the missed opportunity of orbiting a satellite before the Soviet Union angered and frustrated many within the Army.²⁸³ In Huntsville, Medaris and von Braun focused on the positive. The launch of Sputnik I, a new Secretary of Defense, and a struggling Vanguard program significantly increased the chances that Jupiter would have an opportunity to launch a satellite.²⁸⁴ But Vanguard was still making progress. On the day of Sputnik I's launch, the

²⁷⁸ Ibid.

²⁷⁹ Ibid.

²⁸⁰ Ibid.

²⁸¹ Ibid.

²⁸² Ibid.

²⁸³ James M. Gavin, *War and Peace in the Space Age* (New York: Harper and Brothers, 1958), 15.

²⁸⁴ Medaris, 157.

Vanguard team had shipped a test launch vehicle to Florida for an expected December test, and they had completed one satellite with three more in construction.²⁸⁵

With the recent success of Sputnik I, the eyes of the nation were watching Vanguard closely. Anticipating Congressional inquiry and media interviews, Eisenhower made his intent clear. The message was that “we have a plan—a good plan—and that we are going to stick to it.”²⁸⁶ The United States, if Eisenhower could help it, would not be drawn into a race for firsts, but would follow its own program of incremental advance as outlined in NSC 5520.

Thor and Jupiter

On October 10, 1957, the conversation at the 339th NSC meeting turned from satellites to missiles. Holaday informed the group that it was too early to choose between Thor and Jupiter, both of which had an objective range of 1,500 miles.²⁸⁷ The President asked Holaday why it mattered if the Army or Air Force tested it, and Holaday pointed to the Army’s mobility concept as the driving distinction. While the Air Force envisioned launching the Jupiter from fixed bases, the Army retained the opinion that IRBMs must be mobile for the sake of survivability.²⁸⁸ Recalling Allied attacks on the original German V-2 launch sites, Gavin, as the Army Chief of Research and Development, argued that

²⁸⁵ Discussion at the 339th Meeting of the National Security Council, 6.

²⁸⁶ Ibid., 7.

²⁸⁷ Ibid., 10.

²⁸⁸ Gavin, 10.

static facilities became easy targets during wartime.²⁸⁹ Although not present at the NSC meeting, his ideas on mobility carried forward.

Eisenhower approved continuation of Thor and Jupiter while acknowledging a “widespread belief in our country that we are competing among ourselves [the military services] rather than with the Russians,” that inter-service rivalry had slowed the satellite mission and was now doing the same to missile development efforts.²⁹⁰ Eisenhower instructed Holaday to be watchful of rivalries and reemphasized that the 1,500-mile missile was the important thing, not service desires, and the political and psychological effects of IRBMs and ICBMs were potentially more critical than the military ones.²⁹¹

On October 11, 1957, the day after the 339th NSC meeting, Eisenhower again addressed the question of inter-service rivalry to Secretary McElroy and Mr. Holaday. Multiple sources, including Milton Eisenhower, the President’s brother and President of Johns Hopkins University, had alerted the President that various factions within the DoD were isolating their work from sister service organizations that should be benefitting from the cross-pollination of research and development efforts.²⁹² Holaday assured the President that “decisive action was taken” to open the lines of communication between

²⁸⁹ Ibid.

²⁹⁰ Discussion at the 339th Meeting of the National Security Council, 10-11.

²⁹¹ Ibid.

²⁹² Memorandum of Conference with the President, 11 October 1957, DDE Diary Series, Box 27, October 1957 Staff Notes (2), 1, The Dwight David Eisenhower Presidential Library.

Thor and Jupiter groups, and Eisenhower subtly implied that he was coming to doubt Holaday's control over the situation.²⁹³

Three days later, on October 14, 1957, McElroy and Eisenhower sat down without Holaday present. Along with a discussion of the budget and the preliminary investigation of an ABM capability, the discussion covered Redstone, or rather a "longer range Redstone."²⁹⁴ Despite Wilson's range restrictions, Eisenhower agreed to allow the Army to proceed as long as development remained within "a reasonable cost."²⁹⁵

A Satellite

Despite efforts to assure the American public and its allies, within two weeks of Sputnik's launch, the pressure to get a satellite in orbit boiled over. On October 17, Mr. Robert Cutler, Special Assistant to the President, made it clear to Secretary McElroy and the NSF Director that the desire of the scientific teams to perfect their instrumentation must not be allowed to delay a March 1958 launch.²⁹⁶ Although the IGY continued through the end of the calendar year, the political need for a successful launch resulted in top-down pressure from the administration. When the Cabinet met the next day, Quarles

²⁹³ Ibid.

²⁹⁴ Memorandum of Conference with the President, 14 October 1957, DDE Diary Series, Box 27, October 1957 Staff Notes (2), 2, The Dwight David Eisenhower Presidential Library.

²⁹⁵ Ibid.

²⁹⁶ Memorandum for the Secretary of Defense and NSF Director from Mr. Robert Cutler, Subject: U.S. Scientific Satellite Program (NSC 5520), 17 October 1957, Disaster Box 38, Outer Space (2). The Dwight David Eisenhower Presidential Library.

briefed that the “satellite program would hold to schedule,” but the Army program would serve as a backup.²⁹⁷

Eisenhower’s desire for an incremental advance with initial satellite technology did not limit his ability to consider the implications of ideas still largely in concept. As Vanguard proceeded, the Air Force continued its more advanced satellite development program, Weapons System 117L (WS-117L), which included development efforts for satellite-based signals intelligence (codenamed “Sentry”), photo reconnaissance (codenamed “Discoverer”), and infrared detection of missile launches (uncreatively codenamed “Subsystem G”).²⁹⁸ The President, on October 24, 1957 discussed with Secretary McElroy attack warning methods for the purposes of protecting Strategic Air Command, the capability for nuclear retaliation, and “advanced reconnaissance means.”²⁹⁹ Given that another topic of discussion was improved CIA/DoD cooperation,³⁰⁰ the advanced reconnaissance means in question almost certainly included the nascent Project Corona, the classified name for Discoverer, which was in reality a

²⁹⁷ Minutes of Cabinet Meeting, 18 October 1957, DDE Diary Series, Box 27, October 1957 Staff Notes (1), 2, The Dwight David Eisenhower Presidential Library.

²⁹⁸ Jeffrey T. Richelson, *America’s Space Sentinels, The History of the DSP and SBIRS Satellite Systems* (Lawrence: Kansas University Press, 2012), 9-11. Subsystem G becomes MIDAS (Missile Defense Alarm System) in 1958.

²⁹⁹ Memorandum of Conference with the President, 24 October 1957, DDE Diary Series, Box 27, October 1957 Staff Notes (1), 1. Minutes of Cabinet Meeting, 18 October 1957, DDE Diary Series, Box 27, October 1957 Staff Notes (1), 2, The Dwight David Eisenhower Presidential Library.

³⁰⁰ *Ibid.*, 1.

joint CIA/Air Force project.³⁰¹ With WS-117L, the Air Force had proposed a satellite project that directly tied to national security needs, and they had the funding support to do it.

While the Air Force was advancing its equity in the space domain, the new Defense Secretary formulated his plan. First, on November 8, 1957, McElroy ordered the Army to prepare two launches for March 1958.³⁰² Next, he sought to consolidate all of the Pentagon's advanced technology under an umbrella organization in keeping with the President's vision. On November 20, 1957, McElroy proposed to Congress the creation of the Advanced Research Projects Agency (ARPA), which would assume oversight of all military space projects.³⁰³ In the meantime, program deconfliction continued to come from the chief executive. On January 22, 1958, Eisenhower set the priorities for ballistic missile and satellite programs. Perhaps to assuage competition among the services, he placed all major programs into the same priority level: Atlas, the Air Force's Titan ICBM, Thor, Jupiter, the Navy's Polaris, the Army's unnamed ABM, the yet-unnamed IGY satellites for Vanguard and Jupiter-C, and satellite programs not associated with the IGY.³⁰⁴

³⁰¹ Richelson, 9.

³⁰² Rosholt, 7.

³⁰³ Annie Jacobsen, *The Pentagon's Brain*, 51.

³⁰⁴ "Extract from Record of Actions of the 352nd NSC Meeting, 1/22/58," NSC Series Box 16, NSC 5520, Satellite Program (1), no page number, The Dwight David Eisenhower Presidential Library.

On January 28, 1957, a modified Redstone, the Jupiter-C, carried America's first satellite, Explorer I, into orbit. The Army's launch of Explorer I, while successful at mitigating further damage to American technological prestige, also complicated matters politically. The satellite program sponsored under NSC 5520 was now overtly linked to the military missile development, but given the components of Vanguard and the funding responsibilities of the DoD, the government's conclusion that Vanguard was a more civilian alternative to the Project Orbital missed the point that both missiles had originated from military programs. Furthermore, while concepts for ARPA were shaping up, the NSC began an investigation of what space and missile policy was required beyond that established within NSC 5520.³⁰⁵ The responsibility for recommending the direction of space science and exploration fell to Killian and the Science Advisory Committee.³⁰⁶ The results of the report carried significant consequences for the Army.

³⁰⁵ Memorandum to the President from Robert Cutler, 23 January 1958, Disaster Box 38, Outer Space (2), 2, The Dwight David Eisenhower Presidential Library.

³⁰⁶ Memorandum for the Special Assistant to the President for Science and Technology, Subject: US Objectives in Space Exploration and Science, March 10, 1958, The Dwight David Eisenhower Presidential Library.



Figure 7. Seated, Medaris and von Braun Gaze at Explorer I.

Source: U.S. Army Aviation and Missile Life Cycle Management Command, “Explorer I,” accessed May 12, 2017, <https://history.redstone.army.mil/space-explorer.html>.

The Killian Report

With the Killian report in hand, Eisenhower wrote to Congress on April 2, 1958. To the Select Committee on Astronautics and Space Exploration he recommended that space activities proceed under the direction of a civilian space agency, “except for those projects primarily associated with military requirements.”³⁰⁷ He further recommended the

³⁰⁷ 85th Congress, 2nd Session, House of Representatives, Document No. 365, Space Science and Exploration, Message from the President of the United States Relative to Space Science and Exploration, Executive Secretary Sub File, Box 12, NASA [1958-1960], 1, The Dwight David Eisenhower Presidential Library.

creation of the National Aeronautics and Space Board to advise the presidency and the absorption of the National Advisory Committee on Aeronautics (NACA) into the new NASA.³⁰⁸ Until such time that the recommended legislation passed, responsibility for oversight of all space programs fell to ARPA in coordination with NACA, the NSF, and the National Academy of Sciences.³⁰⁹

The pending creation of NASA spurred the NSC to begin work on the national space policy initially recommended by the NSF in November of 1956. And once again, nothing less than the security of the United States and the fate of the free world was at stake. The June draft policy acknowledged that the United States had fallen behind the Soviet Union in prestige and missile technology, and if the Communists were able to achieve military superiority in space, the results would be disastrous.³¹⁰

From the perspectives of the services, the draft Space Policy outlined the tentative schedule for the space launches to come over the next year. The roster included launch vehicles from all of the military services: five Vanguard launches in support of the remaining IGY efforts, three Thor-Vanguard combinations to launch lunar probes in the fall of 1958, three Army Juno II and one Juno I (derivatives of the Jupiter) missions into the Spring with various missions, two Army Juno I rockets for Project ARGUS.³¹¹ Six

³⁰⁸ Ibid., 2.

³⁰⁹ Ibid., 3.

³¹⁰ Draft Preliminary Statement of U.S. Policy on Outer Space, June 20, 1958, Disaster Box 38, Outer Space (2), 1, The Dwight David Eisenhower Presidential Library.

³¹¹ Ibid., 29. Project Argus was an experimental campaign to study the effects of detonating nuclear weapons in space. See Sambaluk, 129.

more “fly-up satellites” were planned to be launched, presumably from Navy aircraft, and the Air Force was looking at as many as nineteen Thor and thirteen Atlas tests on which the WS-117L program depended.³¹² Although not strictly space vehicles, the manifest also included the three high-performance X-15 Research Aircraft, one each for the Air Force, NACA (to be subsumed by NASA), and the Navy to test “problems related to re-entry of orbiting or space vehicles.”³¹³

For their part, the Defense establishment held reservations about the NSC’s draft policy. The Joint Chiefs of Staff considered the space weapons capabilities—those envisioned for ARGUS and those not yet developed—to more appropriately belong in the Basic National Security Policy.³¹⁴ Further, the publicly stated policy of the United States was “space for peaceful purposes,” but the policy did not address the disconnect between the policy and the need for “vital” security efforts until the diplomatic goals were achieved.³¹⁵ Assistant Secretary Quarles opined against including so much emphasis on ballistic missile activity in the proposed Outer Space Policy, citing that such emphasis might “raise the objectives and prescribed level of activity of the paper to a higher degree

³¹² Draft Preliminary Statement of U.S. Policy on Outer Space, 30.

³¹³ *Ibid.*, 31.

³¹⁴ Memorandum for the Secretary of Defense, Subject: U.S. Policy on Outer Space (NSC 5814), June 28, 1958, Disaster Box 38, Outer Space (3), 2, The Dwight David Eisenhower Presidential Library.

³¹⁵ *Ibid.*, 3.

than might otherwise be warranted.”³¹⁶ In less diplomatic terms, the thrust of Quarles’ argument was that the space policy statement should focus on space, which was not to be confused with truly important matters like missiles and defense. The July 3, 1958 meeting of the NSC considered the studies of an “Ad Hoc Subcommittee on Outer Space” led by Killian with representatives from State, Defense, the JCS, CIA, U.S. Information Agency, NSF, and NACA.³¹⁷ It is telling that the U.S. Policy on Outer Space struck from its final draft the following:

The beginning stages of man’s conquest of space have been characterized by national competition in which U.S. and Soviet successes in launching earth satellites have captured the admiration of the world. However, the most important problem which faces the world today may well be that of assuring that outer space is used only for peaceful purposes. Progress toward this objective will undoubtedly require greater emphasis in the future on international cooperation in space as contrasted with unilateral national programs.³¹⁸

On July 29, 1958, the White House announced the signing of House Resolution 12575, the National Aeronautics and Space Act of 1958, heralding its potential for the peaceful cooperation with other nations and groups.³¹⁹ The creation of NASA did not end

³¹⁶ Memorandum for the Executive Secretary, the National Security Council, Subject: U.S. Policy on Outer Space, July 1, 1958. Disaster Box 38, Outer Space (3), 1, The Dwight David Eisenhower Presidential Library.

³¹⁷ Note by the Executive Secretary to the National Security Council on U.S. Policy on Outer Space, June 20, 1958, Disaster Box 38, Outer Space (2), 1. The Dwight David Eisenhower Presidential Library.

³¹⁸ U.S. Policy on Outer Space, Proposed Revisions to NSC 5814, August 14, 1958, Disaster Box 38, Outer Space (3), 3, The Dwight David Eisenhower Presidential Library.

³¹⁹ The White House, Statement by the President, National Aeronautics and Space Administration [1958-1960], Executive Secretary Sub File, Box 12, NASA, The Dwight David Eisenhower Presidential Library.

inter-service rivalry, nor did it remove the military's presence from the space arena, but it did provide a civilian organization to advance the concept of "space for peaceful purposes." For Eisenhower, the DoD, and the NSC, however, the idealism of space exploration would not be allowed to interfere with the realities of confronting the red menace.

Conclusion

The launch of Sputnik I, the shortcomings of Vanguard, and the weight of public opinion eventually forced the Eisenhower administration to turn to the Army's Jupiter-C for an initial satellite launch. But the use of a military missile to achieve the launch soured the accomplishment for the President, who insisted upon furthering a policy that promoted the peaceful use of space. Quarles' admission that the Army could have beat Sputnik into orbit by a year coupled with reports of inter-service bickering further solidified in Eisenhower's mind the need for organizations with the necessary authority to oversee space and missile programs.

In Secretary McElroy, the Army found a new leader who would listen to their case, and Eisenhower found the man who would further his desire for a "Manhattan District-type" organization to oversee defense programs. The result was ARPA, but ARPA, while necessary, was a military establishment and did not square with Eisenhower's policy of space for peaceful purposes. The investigation of Killian and his committee provided an acceptable answer: create an umbrella organization to serve as the nation's space agency. While these organizations stood up, the services continued along the path outlined in the NSC's U.S. Space Policy. For the meantime, the Army continued to develop its launch vehicles and satellite technologies. The choice of Vanguard over

Orbiter had stunted the Army's satellite development efforts, and Wilson's missile restriction had limited the Army's role in the field of long-range missiles, but the political sensibilities manifested in the creation of NASA ultimately kept the Army from retaining its space-launch and satellite development capabilities.

CHAPTER 6

THE ARMY'S LOST ROLE IN SPACE, 1938-1958

The Army's Jupiter-C launch vehicle and the Explorer I satellite resulted from the complex political and technological developments of more than twenty years. During this period, competition among the services and policy fixated on an atomic vision of future warfare inhibited a joint conception of space and missile development. With neither aircraft nor atomic weapons, the Army of the 1940s and early 1950s struggled to fit into the new security environment, and despite the challenges, produced the first U.S. space launch vehicles and satellites. Although responsibilities for missiles and satellites evolved throughout the period, the most dramatic changes occurred following the creation of ARPA and NASA. With a core formed from NACA, NASA acquired JPL to build satellites and the ABMA to build its missiles. Although the Army continued to participate in space-related projects under ARPA, the loss of JPL and ABMA eliminated its capacity to build satellites and space-launch vehicles.

The Beginning of JPL to The Beginning of DOD (1938-1947)

The late 1930s saw the field of rocketry blossom as the United States and German governments became increasingly enveloped in World War II. The domestic rocket technologies developed by JPL progressed solid rocketry significantly, while the liquid-propellant technologies of the Germans offered a very different approach. Even before the war ended, JPL had replicated Germany's technology. The arrival of von Braun and his team at the war's end, provided the Army a significant advantage vis-à-vis the other services in missile development experience. The AAF's solid JATO; the Navy's liquid

JATO; and the Army's Private, WAC Corporal, and Corporal programs laid the foundations for Bumper, Redstone, Jupiter-C, Sergeant, and ultimately the Saturn family.

In addition to the technical advances, the period through the end of the Second World War illustrates the complex nature of inter-service and interagency relationships. From an initial relationship between General Arnold and Dr. von Karman grew an opportunity for Frank Malina and the early JPL rocketeers, indirectly sponsored by the National Academy of Sciences, to further their scientific ambitions. The patronage of Army Ordnance in the early JPL years changed the focus of the organization to ballistic missile development in support of the war effort. Meanwhile, the relative immaturity of rocket technology and extreme amount of funding available during the war limited the amount of competition among the services for rockets and missiles. As yet, satellites and space launch vehicles had not come to the fore, but that was about to change.

The atomic blasts that ended the war with Japan heralded both the beginning of the atomic age and a period of cold war between the U.S. and U.S.S.R. As defense budgets shrank and a vision of atomic warfare prevailed among the nation's policymakers, the Army struggled to retain its relevancy among the other services. Missiles became essential to the Army's vision of ground combat beginning in 1945, and despite considerable need for investment in other portions of the force, heavy investment in missiles continued throughout the 1950s. With no joint conception of missile development, the Army retained significant latitude to chart its own course, but inter-service and inter-agency coordination did occur. The V-2 Upper Atmospheric Research Panel and its test campaigns at WSPG beginning in 1946 provide a significant example of interagency coordination at a time when force reductions, budgetary pressures, and a

sense of political uncertainty were pervading the landscape. The panel, however, possessed no real authority and proceeded at the consent of its members. In contrast to the Upper Atmospheric Research Panel, the refusal of the AAF to join with the Navy in satellite development in 1946 provides just one notable example of service parochialism that led to a significant duplication of effort.

Defense Restructuring to Explorer I (1947-1958)

The events of 1947 mark a significant turning point for the Army and its involvement in missiles and satellites. Despite the intent of the National Security Act of 1947 to “provide for the establishment of integrated policies and procedures for the departments, agencies, and functions of the Government relating to the national security,” achieving a unity of effort in missile and satellite development proved to be an ongoing task.³²⁰ Although lawmakers envisioned the DoD as the ultimate umbrella organization to coordinate the military activities of the services, the creation of an additional layer of bureaucracy added little efficiency to the nation’s missile and satellite development efforts. The fact that each of the services retained independent and often duplicative missile and satellite programs throughout the 1950s testifies to the difficulty of untangling the Gordian knot of defense programs.

Following 1947, the Army, Navy, and Air Force all continued with their missile and satellite programs despite significant budget and force reductions under Truman. To

³²⁰ The National Security Act of 1947—July 26, 1948. Public Law 253, 80th Cong.; Chapter 343, 1st Sess.; S. 758, Sec. 2. Declaration of Policy, accessed October 10, 2016, <http://global.oup.com/us/companion.websites/9780195385168/resources/chapter10/nsa/nsa.pdf>.

the Army, the advent of the Korean conflict confirmed the possibility of limited war in an atomic world, but to Eisenhower and Wilson, the episode demonstrated the folly of limited conflict.

The desire of both Truman and Eisenhower to decrease national debt often sat at odds with military spending needs, and both men sought a military solution to the threat of the Soviet Union that would not impose financial hardship on the United States. Under Eisenhower's New Look policy, the NSC looked to fulfill the nation's security requirements within its economic constraints. Army Chief of Staff General Matthew Ridgeway saw massive retaliation as immoral and potentially catastrophic.³²¹ To add to his consternation, the prevailing view of future warfare meant significantly less funding and fewer troops for the Army—a difficult proposition considering the Army's peacekeeping role in western Europe.

The fear of a general war against the Soviet Union, its nuclear weapons program, and its long-range missiles ensured continued U.S. investment in comparable technologies. Under ORDCIT and Project Hermes, the Army continued with the WAC Corporal, the Corporal, and the Bumper programs. Coupled with the V-2, the WAC Corporal provided significant experience for the Army in upper atmospheric research, photography, and in-flight tracking. Bumper demonstrated the feasibility of a large, multi-stage launch vehicle and inaugurated Florida's Eastern Test Range in 1950.³²² Finally, Corporal grew into the first short-range, atomic ballistic missile, a technology

³²¹ Linn, 87.

³²² Bilstein, 14.

that was essential for the Army's vision of itself as a modern force in defense of Europe, but it did not reach initial operational capability until 1954.

While the military waited for missile weapons, the announcement of the IGY in 1952 provided a constructive arena for international competition. Despite the heavy reliance on the military to develop missile and satellite technologies, Eisenhower insisted on a policy that advanced the use of space for peaceful purposes. The choice of the Navy's Vanguard program to launch the IGY satellite fit into this political message because Vanguard, even though it was a DoD-sponsored project with significant CIA and NSC involvement, had never been a military weapons project. From a technological standpoint, however, the Army's proposal used more mature technology. And although the USAF had initiated its Atlas and Thor programs under the WDD, at the beginning of 1957, the only U.S. launch vehicle capable of putting a satellite into orbit was ABMA's Redstone with JPL solid rocket motors for the upper stages.³²³

After Explorer I

When Eisenhower made the decision to launch Explorer I atop an Army missile, he bowed to public pressure and abandoned the logic that had insisted on the Vanguard program. In the aftermath of the decision, he came to blame the late launch on inter-service rivalry and sought two umbrella organizations to coordinate space and missile activities. The creation of the Advanced Research Projects Agency and the National

³²³ Atlas had its first successful launch in June 1957. Thor had its first successful launch in September 1957. Vanguard had its first successful launch in March 1958. Bilstein, 19; Boeing, "Thor Missile," accessed May 4, 2017, <http://www.boeing.com/history/products/thor-missile.page>; "The Atlas Missile," National Park Service, accessed May 4, 2017, <https://www.nps.gov/articles/atlas-icbm.htm>.

Aeronautics and Space Administration, a military agency and a separate civilian space agency, served as a compromise between the desire for a program to promote the peaceful uses of space and the acknowledged necessity of the military's involvement in space. This desire to separate military and civilian space efforts had developed as a political sensibility under the Eisenhower administration and found its clearest expression in the juxtaposition of Jupiter and Vanguard and in the creation of the new agencies. Although ARPA and NASA sought to consolidate space activities, creating two agencies fell short of total consolidation.

Among those who saw the distinction between military and civilian space efforts as artificial was General Medaris. In his view, the proposal to separate military and civilian space activity entirely missed the point of consolidating resources and focusing efforts. A separate ARPA and NASA, he argued, would continue "our fatal policy of splintering our limited resources into uncoordinated and competing fragments."³²⁴ In the context of a Cold War in which the Soviet Union led the United States in missile technology, the results of such inefficiency invited disastrous consequences.

In the period from 1938-1958, organizations attempting to solve the problems of inefficiency ranged from informal coordinating boards to new bureaucratic agencies enacted by law.³²⁵ But even the DoD, the ultimate umbrella organization, was unable to wrangle the multitude of research and development projects or reconcile the differences

³²⁴ Medaris, 5.

³²⁵ This paper mentions many agencies who sought to consolidate efforts. They include the Air Corps Research Committee of the National Academy of Sciences, the V-2 Upper Atmospheric Research Panel, the Directorate of Guided Missiles, the DoD, the Western Development Division, ABMA, ARPA, and NASA.

among the services. In keeping with his sense of fiscal responsibility, Eisenhower meant to fix the research and development inefficiencies by creating even more bureaucratic structure. To this end, McElroy implemented ARPA, and Congress approved of the President's plan for NASA. Both ARPA and NASA fell short of the Manhattan District ideal in their span of control, but the two entities served Eisenhower's dual political ends of security in space and the use of space for peaceful purposes.

By the time of the creation of ARPA and NASA in 1958, the Army's role as a leader among the services in space and missiles was already waning. Over the previous twenty years, the Army had developed the Corporal short-range ballistic missile, the Redstone medium range ballistic missile, and the Jupiter intermediate range ballistic missile. The multi-stage Jupiter-C had achieved ranges of slightly over 3,000 miles (ICBM ranges) and altitudes over 600 miles.³²⁶ Furthermore, the launch of Explorer I had demonstrated a space-launch vehicle and a scientifically valuable satellite. At the peak of its success in space and long-range missile development, however, the service found itself largely displaced from these fields.

The Army lost its role in these fields because of inter-service competition and a policy environment obsessed with minimizing defense spending. Despite multiple coordinating agencies and organizations, the defense establishment repeatedly missed opportunities to proffer a joint vision of space and missile development, and in the period before defense reorganization, the services were too often unwilling or unable to reach mutually beneficial agreements. The services had recognized as early as 1946 that the

³²⁶ Medaris, 120.

exploitation of space was imminent, and the Air Force and Navy invested in separate theoretical satellite studies to prepare for this eventuality. Meanwhile, the Army sponsored missile development and upper atmospheric research programs with some interagency coordination through the Upper Atmospheric Research Panel. After 1947, despite knowledge of the duplication of efforts among the services and a desire to address them, other priorities like troop reductions, the defense of Europe, and the Korean conflict required the attention of the new DOD.

The announcement of the IGY in 1952 provided another opportunity for a joint vision of space, but the administration did not develop one. Throughout the Eisenhower administration, service responsibilities for missiles and satellites evolved gradually through Wilson's often divisive interpretation of Eisenhower's intent. Under the New Look policy that favored large air forces, the Air Force, and to a lesser extent the Navy, benefited in terms of budget and influence, while the Army atrophied. Despite budgetary constraints, Ridgeway and Taylor made efforts to incorporate tactical atomic weapons like Corporal and Redstone into the Army, and missile development flourished.

For the Army, the creation of ARPA was insignificant compared to the creation of NASA and the forfeiture of JPL and the ABMA to the new agency. Dr. Bill Pickering, who had risen from manager of the Corporal program to become the director of JPL, welcomed the move away from missile development and viewed the early successes of the Explorer program as an opportunity for his organization to expand into the new field of satellite development.³²⁷ Although CALTECH continued to administer JPL, control of

³²⁷ Burroughs, 206.

the laboratory officially transferred from the Army to NASA on December 1, 1958.³²⁸ As the lead agency for planetary exploration under the new space organization, JPL began its efforts to explore the solar system, and in December of 1962, JPL's Mariner 2 spacecraft became the first to observe another planet.³²⁹

Unlike the fairly immediate transfer of JPL, the ABMA remained in Army control for nearly two years after the creation of NASA. Following the success of Jupiter, ABMA continued with its super-booster program, Saturn. Within its service responsibilities, the Army had no use for such a vehicle, but NASA continued Saturn's sponsorship.³³⁰ While Saturn matured, Project Mercury began in October 1958 and required the ABMA to provide NASA with ten Redstones and three Jupiters in support of the new manned spaceflight program.³³¹

The transfer of the ABMA, renamed the George C. Marshall Spaceflight Center, occurred on July 1, 1960 at the beginning of the fiscal year.³³² In the acquisition of ABMA, NASA gained more than 5,000 employees (roughly a third of NASA's total personnel) to support its mission of putting an astronaut into space.³³³ In the spring of

³²⁸ O'Donnell, *JPL-101*, 44.

³²⁹ JPL, "Mission to Venus, Mariner 2," accessed April 20, 2017, <https://www.jpl.nasa.gov/missions/details.php?id=5898>.

³³⁰ Rosholt, 108.

³³¹ NASA, "Mercury-Redstone Launch Vehicle," accessed April 20, 2017, <https://www.nasa.gov/centers/marshall/history/mercury-redstone.html>.

³³² Rosholt, 111.

³³³ Parson, 45.

1961, two Mercury-Redstone missiles launched the first two Americans into space.³³⁴ No longer under the employ of an army for the first time since the age of nineteen, Dr. von Braun and his team continued developing the Saturn program, which eventually produced the Saturn V, the launch vehicle that put Americans on the moon.

Without the JPL and ABMA, the Army no longer possessed the organizational structure to continue its satellite and missile development roles in the same capacity. The political realities of the Cold War and a vision of national security dependent upon atomic power ensured the primacy of the Air Force and a secondary role for the Army within the defense establishment and in the fields of satellite and missile development. Ultimately, the creation of ARPA and NASA consolidated U.S. space efforts under two umbrella organizations, but by the time an early vision for joint and interagency coordination in space emerged, the golden age of Army space had already passed.

Nonetheless, the Army's experiences from 1938-1958 offer valuable lessons in dealing with emerging capabilities and the service interests that shape them. At the end of the 1930s, very few people envisioned the future utility of space launch vehicles or spacecraft. Men like von Karman and von Braun were in the minority, and they faced a war that simultaneously limited international cooperation while intensifying the support from domestic militaries. The U.S. Army brought together the best U.S. and German missile engineers following World War II, and while they developed essential technology for the space age, the service was not effective in convincing the defense establishment of their necessity to the ground force. Furthermore, more immediate concerns than space

³³⁴ NASA, "Mercury-Redstone Launch Vehicle."

dominated the service in the early Cold War. In contrast, the Air Force, particularly through RAND, adopted something close to a vision. The high level of funding available to the Air Force and its role in fulfilling the requirements of nuclear policy placed it in an advantageous position to exert its influence as a service.

In a larger sense, the failure of the U.S. military services to develop a joint vision for missile and satellite technologies invited the creation of additional layers of bureaucracy to address the problem. The V-2 Upper Atmospheric Panel provides an example of inter-service cooperation, but it did not have the necessary authority to affect a broader vision. The creation of NASA and ARPA added the organizational structure with the necessary authorities, but somewhat ironically, the civilian space organization reduced the Army's equity in missiles and spacecraft more than any military organization. As the concept of joint space develops within the U.S. military, it is worth asking whether the attempts to implement emerging capabilities into a joint vision was effective, or, as Army leaders like Gavin and Medaris argued, did new organizations simply squander already limited resources?

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