University of Alberta

The United States Air Force and the Emergence of the Intercontinental Ballistic Missile 1945 - 1954

by

Christopher John Gainor

A thesis submitted to the Faculty of Graduate Studies and Research
in partial fulfillment of the requirements for the degree of

Doctor of Philosophy in History

Department of History and Classics

Fall 2011
Edmonton, Alberta

Abstract

In March 1954, the United States Air Force decided to give a high priority to developing an Intercontinental Ballistic Missile (ICBM). This missile, when armed with nuclear warheads, became the central and defining weapon of the Cold War. Following the political controversy in the United States that resulted from the Soviet Union's launch in 1957 of Sputnik, the first artificial satellite of the Earth, a number of historians strongly criticized the U.S. Air Force and the Administrations of President Harry S. Truman, who held office from 1945 to 1953, and President Dwight D. Eisenhower, who served from 1953 to 1961, for not moving more quickly on rocket and missile programs, which they argued allowed the Soviets to gain possession of the first ICBM before the United States. This study argues that the relatively limited power of early atomic weapons and the technical challenges involved in building long-range missiles were the most important reasons the United States government did not give ICBMs a high priority before 1954, rather than air force reluctance to give up crewed aircraft, as has been previously argued. Government policymakers and scientific and engineering experts were preoccupied in the late 1940s drawing up policies for nuclear weapons and developing bomber aircraft and aircrews capable of delivering nuclear weapons to the Soviet Union, and missiles to defend against Soviet bomber aircraft. In 1954 the advent of thermonuclear or fusion weapons with their enhanced firepower and small size caused experts and policymakers to move ahead with the development of America's first ICBM, the Atlas. Instead of working back from the political controversy that followed the 1957 launch of Sputnik, as influential historical accounts of this period have done, this dissertation places the actions of Truman and Eisenhower Administration policymakers into the broad context of the technical, scientific, political and economic environment that existed from 1945 to 1954. In doing so, this study seeks to show how technological, political and social forces combined to lead to the creation of a new technological system, the Intercontinental Ballistic Missile armed with nuclear weapons, which became a key part of America's nuclear forces.

Acknowledgements

The work of creating a dissertation involves many hours of solitary research, reading and writing for the author, but the work would never get done without the help of others. I am indebted to many people, both for making this dissertation possible and for making it far better than it would have been had I been left to my own devices.

First and foremost I want thank my faculty advisor, Dr. Robert W. Smith, whose contribution began with encouraging me to pursue graduate studies at the University of Alberta. Throughout my work, Dr. Smith showed great wisdom and patience in keeping me focused on the essential points of my studies and then this dissertation. His critical attention to my work has vastly improved it. During my studies and later during the preparation of this dissertation, I was also assisted greatly by Dr. Susan Smith and Dr. David Marples.

Also at the University of Alberta, I was helped by Dr. Frances Swyripa, Dr. Jane Samson, Dr. Heather Coleman, Dr. Rod Macleod, Dr. Ian MacLaren, Dr. Guy Thompson, Dr. Scot Robertson, Dr. Jan McEwen, Dr. Andrew Ede, and Dr. Rick Szostak. I would also like to acknowledge the staff of the Department of History and Classics, especially Lydia Dugbazah, and my fellow students, especially Katherine Zwicker, Brian Gold and Per Anders Rudling.

My graduate studies were built on the foundation of my undergraduate studies in history at the University of British Columbia, under great teachers such as Dr. Chris Friedrichs. More recently I pursued graduate work in space studies at the University of North Dakota, with special thanks to Dr. Stephen B. Johnson, who introduced me to the topic of military missile and space programs.

This study has also been informed by my work as an author, including my first book, *Arrows to the Moon,* on the Canadian and British engineers who built the CF-105 Avro Arrow in Canada before moving to key roles in NASA's human space programs in the 1960s. Before I began my studies at the U of A, I was commissioned by Colin Burgess to write a history of rocketry and space exploration prior to the first human spaceflight in 1961 as part of the University of Nebraska Press' Outward Odyssey series. My work on *To a Distant Day: The Rocket Pioneers* constituted my introduction to many of the issues that are covered here.

The topic for this dissertation was suggested to me by Dr. Roger Launius, a former NASA chief historian now at the National Air and Space Museum of the Smithsonian Institution in Washington, D.C. Dr. Michael Neufeld, also of the NASM, provided a great deal of assistance and encouragement. As the external member of my thesis committee, his close and critical reading of my dissertation vastly improved it. I would also like to thank Dr. Asif Siddiqi of Fordham University, Dr. Bart Hacker of NASM, Dr. James R. Hansen of Auburn University, and Dr. Tom Saunders of the University of Victoria.

I also want to thank the many archivists and librarians who helped me while doing their daily work. Much of the documentary evidence used in this study was obtained at the National Archives in College Park, Maryland. I also obtained papers at the Harry S. Truman Presidential Library in Independence, Missouri, the Dwight D. Eisenhower Presidential Library in Abilene, Kansas, and the U.S. Air Force Historical Research Agency at Maxwell Air Force Base in Alabama. NASM provided me with some of the primary source material used in this study, as did the NASA History Office in

Washington, where Dr. Steven J. Dick, John Hargenrader, Stephen Garber and Jane Odom were always happy to help. I made extensive use of the University of Alberta Rutherford and Cameron Libraries, the University of Victoria McPherson Library, the University of Washington Suzzallo and Allen Libraries, the University of British Columbia Library, the Library of Congress, the Greater Victoria Public Library, and the Vancouver Public Library.

Many friends extended a helping hand, including Steve Pacholuk, Ken Harman, Barry Shanko, Sue Birge, Forrest McCluer, Martha Starr, Mary O'Donoghue, Rolf Maurer, and Tom Hawthorn.

And finally, I thank members of my family, starting with my wife Audrey McClellan, whose contributions are incalculable. I am also grateful to members of her family, including Denise Thompson, Richard Bobier and their daughter Solomia, with whom I stayed in Edmonton; Sandra McClellan and Kirby O'Connor, who did many favours for me in Edmonton; and Audrey's parents Norman and Kathy McClellan. My own parents Don and Toni Gainor were always ready with help and encouragement, my brother Mark Gainor made a generous contribution when I began my studies, and my sister Mary Gainor provided me with a home away from home in Edmonton. I greatly regret that won't be able to share this dissertation with my dear brother Tim Gainor, who passed away just as I was moving from research to writing.

Victoria, B.C.

September, 2011

Table of Contents

Illustrations

Acronyms

AAF	Army Air Forces (1941-1947)
AEC	Atomic Energy Commission
ABM	Anti-ballistic Missile
AMC	Air Materiel Command, USAF
ARDC	Air Research and Development Command, USAF
ATSC	Air Technical Services Command, USAF (Predecessor to the AMC)
CIA	Central Intelligence Agency
FRUS	Foreign Relations of the United States
FY	Fiscal Year
GALCIT	Guggenheim Aeronautical Laboratory, California Institute of Technology (JPL grew out of GALCIT)
GMC	Guided Missiles Committee
HSTL	Harry S. Truman Presidential Library
ICBM	Intercontinental Ballistic Missile
IRBM	Intermediate Range Ballistic Missile
JCS	Joint Chiefs of Staff
JPL	Jet Propulsion Laboratory, California Institute of Technology
JRDB	Joint Research and Development Board (1946-1947)
MIT	Massachusetts Institute of Technology
NA	National Archives of the United States
NACA	National Advisory Committee for Aeronautics (Predecessor to NASA)
NASA	National Aeronautics and Space Administration (Founded in 1958)
NATO	North Atlantic Treaty Organization
NDRC	National Defense Research Committee (1940-1946)
OSRD	Office of Scientific Research and Development (1941-1946)
RDB	Research and Development Board, Department of Defense (1947-1953)
SAB	Scientific Advisory Board for the AAF and USAF
SAC	Strategic Air Command, USAF
SDI	Strategic Defense Initiative
UMT	Universal Military Training
USAF	United States Air Force
USSR	Union of Soviet Socialist Republics

Notes on Missiles and Terminology

The term Intercontinental Ballistic Missile (ICBM) was coined in 1954, and in this study the term is used in the period before 1954 to describe the type of missile that became known as an ICBM. The term ICBM denotes missiles designed to fly intercontinental distances, usually about 5,000 miles or 8,000 kilometres, the distance between the United States and Russia. They were called ballistic missiles because they follow an up-and-down flight path in which the very early moments of flight are powered, followed by a free-flight portion, either high in the atmosphere or above it, and then re-entry through the atmosphere to the target. Such an up-and-down path is similar to those followed by projectiles shot from cannons or guns. For ICBMs, these ballistic paths take the missiles above the Earth's atmosphere, so these missiles have always been powered by rocket engines.

ICBMs were designated as **strategic weapons** because they target urban, military and industrial centres away from battlefields, as opposed to **tactical weapons**, which are used against the enemy on the field of battle.

Missiles have sometimes been categorized by their place of launch and targets. For example, ICBMs were classed as surface-to-surface missiles because they are launched on the Earth's surface and also strike targets there. Shorter-range missiles have also fit into this category. Surface-to-air and air-to-air missiles defended against enemy aircraft. The latter type was launched from crewed aircraft. Air-to-surface missiles have also carried nuclear warheads for strategic bombing, extending the reach of bomber aircraft.

Ballistic Missiles

Atlas – The United States' first ICBM, built primarily by Convair (later General Dynamics) for the USAF. First flew in 1957 and deployed from 1959 to 1965. Atlas was also used for many years as a space launch vehicle.

MX-774 – Rocket test program contracted by the Army Air Forces in 1946 to Convair. Only three rockets were launched before the program ended in 1949.

R-7 – The first Soviet ICBM, which first flew in 1957 and deployed from 1959 to 1967. The R-7 was much better suited to be a space launch vehicle, and it remains in use for that purpose to the present day.

Redstone – Rocket developed by Army Ordnance in the 1950s with a range of about 320 km. A Redstone fitted with upper stages launched America's first satellite in 1958.

Titan – The Titan I ICBM was developed in tandem with Atlas and was deployed from 1962 to 1965. A more advanced missile, Titan II, was later on active duty for many years, and also served as a space launch vehicle.

Thor – The USAF developed Thor in the late 1950s as an Intermediate Range Ballistic Missile and deployed in England. Thor also served as the basis for several space launch vehicles, including one long-lived launch vehicle known as Delta.

V-2 – Developed by the German Army during World War II. The world's first effective long-range ballistic rocket missile. It could deliver a one-tonne warhead 320 km. After the war, captured V-2s were flown by the United States, the Soviet Union and the U.K.

Winged Missiles – This study uses the term winged missile to describe a missile that used wings to help sustain flight. These missiles are often known as cruise missiles, and they are usually are powered by jet engines, because jet engines draw on oxygen from Earth's atmosphere where a winged missile flies.

Matador – Jet-engine winged missile built by Martin for the USAF with a range of about 1,000 km. In service between 1954 and 1964.

Navaho – This missile, built by North American Aviation, developed into a two-stage intercontinental winged missile. The first stage was powered by a rocket engine, and the second stage was powered by two ramjets. Although the Navaho program ended in 1958 without the missile ever going into service, many technologies developed for Navaho, especially the rocket engine for its first stage, were used in other programs including Atlas and Titan.

Regulus – Navy winged missile similar to the Matador and deployed between 1956 and 1964.

Snark – Intercontinental winged missile with a jet engine deployed by the USAF between 1959 and 1961.

V-1 – Developed for the German Luftwaffe (air force) during World War II. In 1944 and 1945, the AAF in the United States built a missile closely modeled on the V-1 known as the JB-2.

Other missiles and rockets

Hermes – A missile program run by U.S. Army Ordnance and contracted to General Electric that involved a number of different missile types, including rockets and ramjets, that ran between 1944 and 1954. Many captured V-2 rockets were launched in the United States as part of the Hermes program. The army's Redstone missile had its origins in Hermes.

Nike – A series of anti-aircraft rocket missiles developed by Army Ordnance. The Nike program began in 1944 and was used as the foundation for America's first anti-ballistic missile systems.

Triton – A navy proposal for a long-range missile that never left the drawing board.

Viking – A rocket used mainly for scientific research, which flew between 1949 and 1955. The U.S. Navy contracted to build Viking, and later used it as the foundation for its short-lived Vanguard space launch vehicle in the 1950s.

Nuclear Weapons

Fission Bomb – Also known as the Atomic Bomb. Used by the United States against Hiroshima and Nagasaki in Japan in 1945. Fission bombs are based on the energy released when a large atomic nucleus such as that of uranium or plutonium is split.

Thermonuclear Bomb – Also known as the Hydrogen Bomb, the Fusion Bomb, or as the Super. The thermonuclear bomb releases a much larger amount of energy than a fission bomb, typically on the order of hundreds of times the power of fission bombs. This release begins when a fission bomb explodes and acts as a trigger. The gamma rays the fission explosion produces compresses a charge of hydrogen isotopes such as deuterium or tritium, and causes the fusion reaction.

U.S. Military Structure

During World War II and until the unification of the U.S. military in September 1947, the U.S. military was organized under two departments. The Department of the Navy contained the U.S. Navy and the U.S. Marine Corps. The Department of War contained the U.S. Army, which was composed of the Army Ground Forces, the Army Air Forces (AAF), and the Army Service Forces, which included the Ordnance Department.

In September 1947, the AAF became the United States Air Force under the Department of the Air Force, and the remainder of the army became the heart of the renamed War Department, the Department of the Army. The Navy and Marine Corps remained under the Department of the Navy. While there was a Secretary of Defense, the secretary presided over a weak but grandly named National Military Establishment. In August 1949, Congress passed a law that established the Department of Defense, and gave the Secretary of Defense more powers.

In 1946 and 1947, the Joint Research and Development Board (JRDB) worked to coordinate military weapons research and development between the War Department and the Navy Department. With armed forces unification, the Research and Development Board (RDB) was set up formally under the office of the Secretary of Defense.

Inside the air force, the Air Staff worked with the Commanding General of the AAF to run the AAF, and after the creation of the USAF, the Air Staff continued its functions with the Chief of Staff of the USAF.

Prior to March 1946, air force weapons research, including guided missiles, was under the jurisdiction of the Air Technical Services Command (ATSC). In March 1946, the command became known as the Air Materiel Command (AMC). Four years later in 1950, these functions were moved to the newly created Air Research and Development Command (ARDC).

Introduction

As World War II drew to an end in the summer of 1945, the United States' massive industrial and scientific effort to create nuclear weapons was capped with success with the first explosion of a fission bomb in New Mexico in July 1945, followed in August by U.S. bomber aircraft dropping atomic bombs on the Japanese cities of Hiroshima and Nagasaki. The creation of nuclear weapons was the most famous of the many advances in military technology that took place during World War II. Indeed, the war saw important changes in the process of creating military technologies, with the U.S. government vastly enlarging its role in scientific research and engineering. Within hours of the bombing of Hiroshima, some leading officers in the U.S. military began looking to the day when guided missiles would be available to deliver nuclear weapons to their targets. The V-2 ballistic rocket missile launched by the German military in the final months of the war impressed them because there was no defense that could be mounted against it once it was launched. The marriage of ballistic missiles that could not be intercepted to nuclear weapons that could destroy whole cities at a stroke promised to transform war.

In the months after World War II ended, tensions between the United States and its wartime ally the Soviet Union began to increase. By 1947, the two dominant powers and their allies were engaged in what became known as the Cold War, which continued at varying levels of intensity until the Soviet Union dissolved in 1991. The administration of President Harry S. Truman responded to what policymakers viewed as the Soviet Union's moves to control eastern European nations and challenge the United States in Asia and elsewhere by creating military and economic alliances in various parts of the world, and by using every political, diplomatic, cultural, economic and military means at its disposal short of direct military confrontation.

The massive enlargement of the U.S. government's role in scientific research and weapons development during World War II became a permanent mobilization with the Cold War, especially after the Korean War began in 1950. Although research and development work on rockets advanced this technology in the United States during the Truman years, historians have usually argued that rockets and missiles were neglected during this time. Only after a series of aborted efforts did the U.S. Air Force and its contractors begin a program that grew into America's first intercontinental ballistic missile (ICBM), a rocket that flies at extremely high speeds along a ballistic path that takes it above Earth's atmosphere before it falls to its target thousands of kilometers from its launching site.[1] ICBMs were designated as strategic weapons because they targeted urban, military and industrial centres in enemy territory rather than enemy armed forces in the field.

America's first ICBM program, the Atlas, began in earnest in 1954, under Truman's successor, President Dwight D. Eisenhower. Atlas began flying in 1957 at roughly the same time as the Soviet Union's first ICBM, the R-7. By the late 1960s, the ICBM had become the primary system used by both the U.S. and the Soviet Union to deliver nuclear weapons. Along with nuclear-armed bomber aircraft and submarine-launched ballistic missiles, ICBMs formed the nuclear weapons "triad" used by the

[1] The air force adopted the ICBM acronym for intercontinental ballistic missiles in 1954 to avoid confusion with the International Business Machines (IBM) Corporation after the term intercontinental ballistic missile system (IBMS) was used for a short time. Before 1954, missiles of this type were usually referred to as long-range missiles, and often by their range, in this case 5,000 miles and longer. See Jacob Neufeld, *Ballistic Missiles in the United States Air Force 1945-1960* (Washington, D.C.: United States Air Force History Office, 1990) 99.

United States to deter the Soviet Union during the remainder of the Cold War. These weapons promised previously unimaginable destruction within minutes based upon a single command – what was often called push button war. These weapons remain available today, albeit in reduced numbers. The unprecedented power of nuclear weapons and the lack of a defense against nuclear-armed ICBMs helped shape the nature of the Cold War, where the United States and the Soviet Union avoided direct military confrontation, and deterrence became the watchword. Both sides in the Cold War expended huge sums of money to create a defense against ICBMs, and American missile defense research programs continue to the present day with no effective defense system in sight.

The ICBM and other military rockets also made possible artificial satellites and probes into deep space that began to fly in the late 1950s. A Soviet R-7 ICBM launched the first artificial satellite of the Earth, Sputnik, on 4 October 1957. Sputnik and a string of Soviet achievements in space that quickly followed were catalytic events that led to the 'space race' of the late 1950s and the 1960s that culminated in the first flights of humans to the Moon. While other rockets were used to launch America's first satellites, the Atlas and Titan ICBMs launched many of America's important space vehicles of the twentieth century.

The combination of Soviet secrecy and bluster, backed up by its triumphs in space, led to the misconception in the late 1950s and early 1960s among the American public and media, and many members of Congress, of the superiority of Soviet missiles, a perception that fueled a crisis of confidence in the United States. This crisis led to increased spending on missiles and nuclear weapons, and even affected electoral politics in the United States, most famously the 1960 presidential election. But in reality, Atlas was a more effective ICBM than the R-7, and gave the United States the early lead in deploying nuclear-armed ICBMs. The R-7's greatest weakness as an ICBM was that it was designed to carry much larger payloads than the Atlas, which made it much more difficult and expensive to launch than Atlas, but this also made the R-7 far more useful as a space launch vehicle. The R-7's success as a space launcher misleadingly suggested that it was ready for use as an ICBM, an impression Soviet leaders worked hard to foster.

Prior Research and Context of the Study

Very few historians have written in detail about the development of American ICBMs during the time before the Atlas ICBM program began in earnest in 1954. The most influential historians who have looked closely at U.S. missile programs before 1954 viewed them backward through the lens of how these actions led to the shock of Sputnik. These works failed to fit the events of these years into the policy environment that immediately followed World War II, an environment that was very different from the time of Sputnik.

Missile development has had a very limited place in the historiography of the Truman administration. The Truman administration has had an equally obscure place in the historiography of missiles and space flight, in part because Truman himself rarely took direct part in decision-making affecting missile research and development. In contrast to this, historians have paid far greater attention to the Eisenhower Administration's treatment of ICBMs and space launch vehicles.

Historians Robert L. Perry and Edmund Beard, who focused on the actions and attitudes inside the U.S. Air Force, which won responsibility for America's ICBMs, criticized the air force for its concentration on aircraft during this period at the expense of guided missiles because of the attachment of air force officers to piloted aircraft.[2] Beard, in his influential book, *Developing the ICBM: A Study in Bureaucratic Politics,* argued that the Soviet Union had defeated the United States in the race to develop the first ICBMs, and that the United States could have developed its first ICBM "considerably earlier" than it did, but waited until 1954 to begin its ICBM program while the Soviet Union began work on its ICBM in 1946. Both these arguments reflected beliefs that were widespread in the United States in the wake of Sputnik.[3]

Much of the historical writing on this topic has come in the form of studies sponsored by the U.S. Air Force, including much of Perry's work, Jacob Neufeld's 1990 study, *Ballistic Missiles in the United States Air Force 1945-1960*, and more narrowly focused air force studies. These works do not question the idea of ICBMs or air force priorities, except to suggest as Beard and Perry did, that the air force could have moved more quickly to develop ICBMs.

While the so-called Sputnik crisis shaped the historiographies of ICBMs and the space race for many years, the passage of time since Sputnik has led to new interpretations of this event and its importance. Indeed, historian Alex Roland observed in 2001 that the crisis surrounding Sputnik pushed U.S. policymakers to support new and larger weapons, and expanded the role of the U.S. civilian economy in the service of the state. Roland's point is very germane to this study because of Sputnik's influence on the

---

[2] See Edmund Beard, *Developing the ICBM: A Study in Bureaucratic Politics* (New York: Columbia University Press, 1976), Robert L. Perry *The Ballistic Missile Decisions* (Santa Monica, CA.: RAND Corporation, 1967), and Robert Perry, "The Atlas, Thor, Titan and Minuteman," in Eugene M. Emme (ed.), *The History of Rocket Technology* (Detroit: Wayne State University Press, 1964) 142-61. Perry wrote the 1964 article while he was employed by the USAF.
[3] Beard, *Developing the ICBM,* 4, 8, 218.

historiography of ICBMs, where the utility of these weapons systems has not been questioned.[4] It will be argued here that the historiography of ICBMs has buttressed Sputnik's support for weapons programs.

The fall of the Soviet Union in 1991 and the end of the Cold War were especially important events in causing this reassessment, not least because they made possible the declassification of Soviet and U.S. government documents that shed new light on what decisions were actually made about missiles, and how and why they were made. The new interpretations of this history are part of what spaceflight historian Roger Launius has called the New Aerospace History, which aims to move beyond concentration on individual rockets or spacecraft to wider social, political and cultural issues relating to aircraft, missiles and space vehicles.[5] In the spirit of the New Aerospace History, this study seeks to focus on the technical, social and political issues driving American government and military decision-makers who set policies affecting the development of American guided missiles.

Launius also wrote that what has become known as the 'Huntsville School' of histories of American space travel and rocketry overstated the contribution of Wernher von Braun and his German rocket experts to the development of American rocketry during the period covered in this study, and underestimated the contributions of other individuals and agencies, including the U.S. Air Force.[6] Where these historical accounts mention the air force, they rely on Beard's narrowly focused analysis of air force actions.

---

[4] Alex Roland, *The Military-Industrial Complex* (Washington, D.C.: American Historical Association and the Society for the History of Technology, 2001) 8.

[5] Roger D. Launius, "The historical dimension of space exploration: reflections and possibilities," *Space Policy* 16 (2000) 23-8.

[6] Launius, "Historical dimension," 23-8. The term Huntsville School was coined by historian Rip Bulkeley in *The Sputniks Crisis and Early United States Space Policy* (Bloomington: University of Indiana Press, 1991) 204-8. Once settled in the United States, the von Braun team was based at Huntsville, Alabama.

By examining the actions of the air force but putting them into the context of the wider concerns of U.S. military policymakers, and by attempting to discuss the development of ICBMs free of the influence of Sputnik and the Huntsville School, this thesis seeks to help rebalance the historiography of ICBMs and rocketry.

Thesis and Working Assumptions

This dissertation will examine the development of ICBMs in the United States from the end of World War II, when the idea emerged of marrying two technologies that arose from the war – the long-range missile and nuclear bombs – through the time in March of 1954 when the U.S. Air Force decided to build the Atlas ICBM on a high priority basis. Because the ICBM took nine years to move from idea to active development, the title of this work speaks of the emergence of ICBMs. This dissertation will ask how missiles were seen between 1945 and 1954, and ask what caused the Atlas ICBM to move ahead in 1954 as opposed to an earlier time. Unlike Beard's account, this thesis does not rest on the assumption that the United States lost the race with the Soviet Union to build the first ICBM, but instead utilizes more recent information that shows that ICBM programs in both the Soviet Union and the United States began at roughly the same time – the spring of 1954 – and led to the first test flights of ICBMs by both powers three years later. This study seeks to follow the evolution of American ICBMs based on the political, military and technological concerns of the nine years following World War II, which were different from the security concerns that were raised by Sputnik in 1957. Those nine years include the term of the Truman Administration from 1945 to 1953 and the early months of the Eisenhower Administration in 1953 and 1954.

A major focus of this study is how the institutional and political changes in the U.S. government and military during this time affected military missile research, especially research leading to ICBMs. These changes included the Truman Administration's military reorganization of the late 1940s, which saw the creation of the military and security structure that served the United States until the terrorist attacks of September 11, 2001. Due to public demand for a return to peacetime conditions, including military demobilization, the Truman administration sharply reduced military spending from wartime levels and continued this policy until the Korean War began in 1950, which was followed very quickly by the expansion of the U.S. military that has continued, with occasional interruptions, to the present day.

Between 1945 and 1954, both nuclear weapons and guided missiles underwent major changes in terms of their power, size and ease of use. While some historical treatments of ICBMs have suggested that both of these technologies were ready to be put together into effective weapons very soon after the end of World War II, this study will argue that this was not the case. We will follow decision-makers in the U.S. military as they assessed various technologies for carrying nuclear weapons and decided which technologies would receive resources for more research and development. Unlike existing studies, this thesis will also examine the work of decision-makers in higher political positions, including the president, as they made decisions affecting the development of ICBMs, and it will also depart from previous studies by featuring the work of outside civilian experts engaged by the air force and the Department of Defense.

By focusing on the interplay of social, economic, political and technological forces as they existed between 1945 and 1954 and setting aside assumptions about the development of missiles made as a result of the political crisis that followed Sputnik, this dissertation seeks to explain the creation of ICBMs within the framework of the New Aerospace History. While the historiography of ICBMs has been strongly influenced by the historiography of space exploration, this thesis will instead focus on ICBMs as weapons systems, since military considerations and not their possible use as space launch vehicles governed their development until well after the time period covered in this study. Since the nuclear weapons of 1945 were vastly different in many respects from those ultimately used with ICBMs, this study will discuss how the development of nuclear weapons affected the evolution of missile research and development. As well, this study will also examine the state of technologies competing with ballistic rocket missiles, including bomber aircraft, winged jet-engine missiles, and nuclear propulsion, to provide context to the development of ICBMs.

Purpose and Questions

Historian Thomas P. Hughes has defined technological systems as socially constructed entities that also help shape the societies they operate in, and they encompass much more than physical artifacts, such as missiles. Following this definition, this study will focus on two technological systems, the first consisting of the ICBMs and their warheads. This system forms an integral part of the second and larger system, that of America's nuclear strike forces, which encompasses bomber aircraft carrying nuclear arms, other missiles with nuclear warheads, warning radars, and the command and control apparatus. While the creation of nuclear weapons transformed warfare because of their immense destructive power, their combination with missiles that could travel thousands of kilometers in minutes and accurately strike a target without a pilot on board represented a further transformation in warfare. In a wider sense, nuclear weapons and missiles changed the air force's thinking on warfare once they were deployed in the 1960s, after the period covered in this study. In asking how the air force in the United States came to its decision to build ICBMs, this study will examine the early stages of the air force's acceptance of strategic missiles into its arsenal and illuminate the air force's changing attitudes to this new technology.

This thesis will ask how United States military guided missile programs developed from the late days of World War II through the air force's decision in March 1954 to proceed with the Atlas ICBM. It will also ask why Atlas won approval and a high priority in 1954 and not at an earlier time. In an effort to invoke the policy issues of the years immediately following World War II, this thesis will begin by examining how the U.S. military's approach to missiles fit into the broad framework of the Truman Administration's evolving security policies as the administration dealt with fiscal and political challenges of its eight years in office, not least of which were its decisions about what to do with nuclear weapons and who should control them. The changes brought by the Eisenhower Administration in its first months in office will also be considered.

In focusing on the service that won jurisdiction over ICBMs, the U.S. Air Force, this study will ask how the people who ran the air force in the postwar period viewed missiles in general and long-range ballistic rocket missiles in particular. What role did technological issues such as the accuracy of long-range missiles, and the explosive power of different nuclear weapons play in the air force's treatment of various missile programs prior to 1954? Air force leaders called on civilian scientific experts to help overcome technological problems and weigh the merits of competing forms of technology, such as types of missiles. The impact of these civilian experts on air force decision-making will be featured in this dissertation to a far greater degree than in previous studies of ICBMs.

The role of higher-level policy makers in directing missile programs will also be examined here, including the Joint Chiefs of Staff, the service secretaries, the Secretary of Defense and presidents Truman and Eisenhower. How did these authorities view the role of missiles in America's defenses? Even more important to the story is the advice the air force received from experts it sought out through its own advisory committees and from think tanks such as the RAND Corporation. As well, coordinating bodies that the Joint Chiefs of Staff and the Secretary of Defense created in the early years after the war, such as the Research and Development Board and the Guided Missiles Committee attempted to bring order to military missile programs during the Truman presidency. Their failure to do so led Truman to appoint an industrialist, K.T. Keller, to serve as the military's 'missile czar' from 1950 to 1953. The Eisenhower Administration swept away the boards and committees of the Truman years for new management structures that have been widely credited with expediting ICBMs. This study will attempt to weigh the influence of these coordinating bodies and the missile czar in setting direction for military missile programs before 1954. In this examination of institutional factors, the author will also try to rate the importance of administrative and personnel changes made by the Eisenhower Administration in facilitating the creation of American ICBMs.

Materials and Methodology

The primary sources utilized in this study, some of them not used before in earlier works, include air force and army records relating to missile research and development from the decade ending in 1954. Earlier studies of ICBM programs have referred to but never examined in any detail key reports on missile technology, including the air force Scientific Advisory Group's *Toward New Horizons* reports from 1945 spearheaded by Theodore von Kármán, the RAND studies on missiles from the late 1940s, and the Augenstein Report of 1954 on ICBMs. These studies will be assessed here for the first time in this subject area. This thesis also utilizes documentation from the Guided Missiles Committee that operated under the aegis of the Joint Chiefs of Staff and the Secretary of Defense between 1945 and 1953, much of it for the first time, and records from the Harry S. Truman Presidential Library relating to the work of K.T. Keller as missile czar. Testimony to Congressional committees will also be used. Other sources include memoirs and oral history interviews of those who dealt with guided missiles, along with contemporary news media accounts. Contemporary government reports and later historical studies undertaken by the U.S. Air Force, the Department of Defense and the Department of State, some of which include document collections, also inform this study.

In addition, this dissertation will consider the ICBM program in the Soviet Union that ran in parallel with Atlas. New information about Soviet missile programs, which were veiled in secrecy until after the Cold War ended in the 1990s, belie assumptions made about them prior to that time by journalists and historians as a result of Sputnik. And there is also the question of whether U.S. intelligence on Soviet missile programs influenced decisions affecting American missile research. Intelligence reports that have become available in recent years provide a new picture of what American decision-makers knew and didn't know about missiles being developed by their Soviet adversary.

This thesis has been undertaken in the spirit of the New Aerospace History mentioned above. By illuminating the role of the U.S. Air Force and other government decision-making agencies up to and including the president, and taking into account the roles of concerned parties outside the government in making decisions on missiles, the author hopes that this work will provide a more accurate picture of early postwar American missile development than has existed before by discussing political, military and technological issues that were not considered in earlier works on this topic. Much of the historical writing on ICBMs relates to their use as space launch vehicles, yet they were developed to carry nuclear warheads. This study places the development of ICBMs into the context of the evolution of the nuclear weapons they were designed to carry.

As noted earlier, this dissertation will broadly follow the general approach to the history of technology enunciated by Thomas P. Hughes, who in his large body of work has argued that technological systems arise due to the interplay of various forces. In examining such systems and their history, Hughes argues, historians need to be alive to what he called a seamless web of possible factors of a social, cultural, political, technical, scientific, or economic nature. Following Hughes' definition of technological systems, this dissertation will give missiles a central place, but it will also consider them within the technological systems where they were embedded, which involved the various institutions, corporations, research programs, and laws that were related to these systems. Hughes has argued that the evolution of technological systems can be broken down into seven phases – invention, development, innovation, transfer, growth, competition and consolidation. The time period covered in this study falls into the development phase of American ICBMs, and the invention and development phases of America's nuclear forces.[7]

---

[7] Hughes elaborates on these themes most succinctly in his paper, "The Evolution of Large Technological Systems," in Wiebe Bjeker, Thomas P. Hughes and, Trevor Pinch, eds., *The Social Construction of*

This thesis will therefore provide a more complete picture than earlier studies of the evolution of American ICBMs between 1945 and 1954 by looking at the social, economic and political forces influencing the U.S. Air Force, along with the technological factors that helped shape the development of those missiles, a technological system that became central to the conduct of the Cold War.

Outline

Chapter One sets the context for the later chapters by discussing the Truman Administration, the Cold War, the early days of nuclear weapons in the United States, and the challenges facing the air force, which was known during and immediately after World War II as the U.S. Army Air Forces.[8] Subsequent chapters follow the development of American missile programs in a generally chronological manner, starting with a chapter that focuses on the air force, then moving to the boards and committees that attempted to coordinate missile programs, followed by the air force's work with rockets. Three more chapters trace the development of ICBMs through the 1950s, including Sputnik and its impact on the historiography of missile and space programs.

In considering the broad policy environment facing the United States government in the years between the end of World War II and the Korean War, Chapter One places special emphasis on factors that impacted military missile programs. These include America's transition from World War II to the Cold War, evolving government policies

---

Technological Systems (Cambridge: MIT Press, 1989) 51-82. See also Hughes, "The Electrification of America: The Systems Builders," *Technology and Culture*, Vol. 20, No. 1 (January 1979) 124-61; and Hughes, *American Genesis: A Century of Invention and Technological Enthusiasm, 1870-1970* (Chicago: The University of Chicago Press, 2004). Hughes is best known for his classic study, *Networks of Power: Electrification in Western Society, 1880-1930* (Baltimore: The Johns Hopkins University Press, 1983). Hughes also deals with the history of Atlas in a section of *Rescuing Prometheus: Four Monumental Projects that Changed The Modern World* (New York: Pantheon, 1998).

[8] In September 1947, the Army Air Forces or AAF became the U.S. Air Force or USAF. In this study, the term air force will be used to refer to generally to this service without regard to the time period covered. References to the AAF or the USAF will pertain to time periods when one or the other name applied.

on nuclear weapons, the evolution of nuclear weapons technologies, and the major technological challenges the air force believed it faced in the late 1940s, including the need to upgrade its bomber force.

Chapter Two discusses the Army Air Force's effort to gain control of military guided missiles research as a part of its larger battle to win autonomy from the U.S. Army, and in the process, it will show how guided missiles were seen by their potential military users at the end of World War II. It will also show how opinions on missiles varied inside the air force during these early months after World War II. This chapter will inquire into the impact of the air force winning control of missiles over the competing claims of the U.S. Army.

Chapter Three deals with the government's attempts to coordinate missile programs through the Guided Missiles Committee (GMC) that was first set up under the Joint Chiefs of Staff near the end of World War II. When the armed forces were reorganized in 1947, the committee moved under the wing of the Research and Development Board chaired by Vannevar Bush, the leader of the United States military's science and engineering efforts in World War II. This chapter will ask what the GMC and the Research and Development Board's failures to coordinate military missile programs show about the place of long-range missiles in the wider U.S. military during the late 1940s, and probe the impact of Bush's critical attitude to missiles.

Chapter Four concentrates on how the U.S. military developed rockets from World War II to the Korean War, and how ballistic rocket missiles emerged from a thicket of competing technologies in the late 1940s. The air force began several missile development programs in 1945, including a long-range rocket, the Convair MX-774 program, which ended in 1949. In examining the development of the MX-774 and other missile programs, this chapter asks how important for the air force was the expert advice it received from its own scientific advisory group and from the newly formed external think tank, the RAND Corporation.

The work of Harry Truman's "missile czar" is considered in Chapter Five. K.T. Keller, the president of Chrysler Corporation, took on the job in October 1950 as a result of growing disquiet inside the Department of Defense over the state of America's missile programs. This chapter explains how Keller's work as missile czar illuminates the attitude of President Truman and other military and political leaders toward missiles from 1950 to 1953.

Chapter Six deals with the rise of the Atlas ICBM from studies in 1951 to a full-fledged program in 1954. During this time, the Truman administration gave way to the Eisenhower administration, a change that has been widely credited with helping expedite the Atlas ICBM. This chapter will examine this claim and discuss the impact of technical changes in nuclear bomb design on missile research. It also traces the development of Soviet missile programs, and asks what Soviet missile development shows about the development of ICBMs on both sides of the iron curtain. United States intelligence on Soviet missile programs is also examined to answer the question of what impact this intelligence had on ICBM work in the United States.

Chapter Seven begins by briefly covering developments in the field of ICBMs after Atlas and its Soviet counterpart, the R-7, won approval in 1954 to illuminate developments that took place before that time. The heart of this chapter discusses how the Sputnik crisis of 1957 and the idea that the United States had fallen behind the Soviet

Union in fielding its first ICBM coloured historical treatments of the development of ICBMs and space exploration. Because this study rejects the premises underlying Sputnik-era historiographies, this chapter sets the stage for the final conclusions of this dissertation, which are outlined in Chapter Eight.

Chapter 1
Air Power in the Atomic Age

Within hours of the explosion of the atomic bomb at Hiroshima on 6 August 1945, officers in the Air Staff that directed the U.S. Army Air Forces (AAF) were studying how to mount atomic bombs on guided missiles. This would combine the most powerful bomb ever built with a delivery vehicle that could not be intercepted, as the German V-2 rocket had shown in the closing months of World War II.[9] Twelve years later, America's Cold War rival the Soviet Union announced that it had launched a missile capable of carrying a nuclear weapon in minutes to the United States, and then drove home the point by launching Sputnik, the Earth's first artificial satellite. In the wake of Sputnik, American politicians and historians criticized those responsible for U.S. missile programs for not having been first to build such a missile. Historians such as Edmund Beard focused their criticism on the U.S. Air Force for what Beard termed its bureaucratic resistance to missiles that delayed the air force's creation of America's ICBM force. Such criticisms suggest that the nuclear-armed Intercontinental Ballistic Missile was inevitable from the moment that the first nuclear weapon was created in 1945. But this was not necessarily the case, and to properly assess the air force's actions in the years following World War II, one must look at the political, military and technological contexts of that time.

This chapter will examine the published scholarship on the wider political and technological issues that occupied the attention of the U.S. government and military, particularly the air force, during the five years between the end of World War II and the start of the Korean War. The development of ICBMs and other military missiles during

[9] Max Rosenberg. *The Air Force and the National Guided Missile Program 1944-1950* (Washington D.C.: USAF Historical Division Liaison Office, June 1964) 85-6.

those five years took place against the background that will be outlined in this chapter, including the U.S. government's evolving policies on nuclear arms, the level of spending on the U.S. military, the struggle inside the U.S. military as it was reorganized after World War II, and the development of the United States Air Force. This chapter, therefore, sets the stage for the discussion in upcoming chapters on how the U.S. government in general and the air force in particular dealt with the matter of guided missiles.

Starting with the war's end in 1945, President Harry S. Truman and his military were faced with a tumultuous transition to peacetime conditions. Inside three years, the Soviet Union changed from being America's wartime ally to becoming its prime adversary in what became known as the Cold War.[10] Although the Truman Administration, Congress and the military acted on what they saw as strong public demand for military demobilization and reductions in the high wartime levels of taxation, Truman and his administration always believed that the United States could not return to the small military that existed before the war. Faced with the challenges of the postwar world and the many changes in military doctrine and technology that marked World War II, the president and many others inside and outside the military were determined to reorganize America's armed forces. Since the air force was then a branch of the U.S.

---

[10] There is a large and rich literature on the history of the Cold War, A thorough and recent treatment of the Cold War is contained in Melvyn P. Leffler and Odd Arne Westad, eds., *The Cambridge History of the Cold* War (3 volumes) (Cambridge: Cambridge University Press, 2010). A perceptive survey of literature on the Cold War can be found in Timothy J. White, "Cold War Historiography: New Evidence Behind Traditional Typographies," *International Social Science Review* (Fall-Winter 2000) 35-46. See also Melvyn Leffler, *For the Soul of Mankind: The United States, The Soviet Union, and The Cold War* (New York: Hill and Wang, 2007); and John Lewis Gaddis, *We Now Know: Rethinking Cold War History* (Oxford: Clarendon Press, 1997). Works that pertain to the Truman presidency and the Cold War include Michael J. Hogan, *Cross of Iron: Harry S. Truman and the Origins of the National Security State, 1945-1954* (Cambridge: Cambridge University Press, 2000) and Thomas D. Boettcher, *First Call: The Making of the Modern U.S. Military, 1945-1953* (Boston: Little, Brown and Company, 1992).

Army and most people inside the Army Air Forces were set on gaining autonomy from the army, the outcome of that reorganization became their overriding concern.[11]

Throughout the five years between 1945 and 1950, the air force saw itself as having been seriously weakened by postwar demobilization just as it had to turn to protecting America in the Cold War. The air force's Strategic Air Command, which was charged with delivering both conventional bombs and atomic bombs, showed itself early in 1949 to be totally unprepared to carry out its assigned task. It was only then that its commander began a shakeup that made SAC an effective force. Even in 1949, the vast majority of SAC's bombers were B-29 and B-50 propeller aircraft that could not reach targets in the Soviet Union from the continental United States. The B-36 bomber, America's first with an intercontinental range, was just coming into use that year. Because it also was a propeller-driven aircraft, it served as a stopgap until B-47 and B-52 jet bombers came into service in the 1950s. While the air force needed to conduct research on future weapons such as ICBMs, the weapons and the delivery systems that it required to create an atomic striking force were not in place in 1945 and were just coming into being five years later when the Korean War began.[12]

Truman and the Atomic Bomb

Because ICBMs were intended to carry nuclear weapons, it is important to look at how these weapons and the policies that governed their use were developed. In the first four years after World War II, the United States had a monopoly on nuclear weapons, but

---

[11] Walter Millis and E.S. Duffield, eds., *The Forrestal Diaries* (New York: The Viking Press, 1951) 146-7; Herman S. Wolk, *The Struggle for Air Force Independence 1943-1947* (Washington D.C.: Air Force History and Museums Program, 1997); Jeffrey G Barlow, *Revolt of the Admirals: The Fight for Naval Aviation, 1945-1950* (Washington, D.C.: Brassey's, 1998) 31-44.

[12] Two official air force histories covering this period are Robert Frank Futrell, *Ideas, Concepts, Doctrine: Basic Thinking in the United States Air Force 1907-1960* (Vol. 1. Maxwell AFB, Al.: Air University Press, 1989), and Wolk, *The Struggle for Air Force Independence*. See also Walter J. Boyne, *Beyond the Wild Blue: A History of the U.S. Air Force 1947-1997* (New York: St. Martin's Press, 1997).

for most of that time the monopoly had little meaning because the United States had very few bombs on hand – only thirteen in July 1947 and fifty a year later. The U.S. government did not begin producing atomic bombs in any quantity until 1947. While President Truman did not hesitate to use atomic bombs against Japan, he maintained tight control over nuclear weapons until late in his administration. Until 1948, the Truman administration's only published policy statements on nuclear weapons proposed they be placed under international control.[13] The difficulty and expense involved in making the early nuclear weapons and their resultant scarcity have been rarely raised in discussions of postwar missile development. Neither has the issue of custody and control of nuclear weapons.

The first atomic bombs were developed in great secrecy during World War II by a scientific, military and industrial team under the Manhattan District of the U.S. Army Corps of Engineers, which was led by Maj. Gen. Leslie Groves. Thirteen days after assuming the presidency upon the death of Franklin D. Roosevelt in April 1945, Truman received his first ever briefing on the atomic bomb from Secretary of War Henry L. Stimson and Groves. A few days later, the war in Europe was over, and that August, Japan surrendered after B-29 bombers of the U.S. Army Air Forces dropped atomic bombs on Hiroshima and Nagasaki, and after the Soviet Union declared war on Japan. Although Truman had not hesitated to use atomic bombs against Japan, debate continues over whether Truman used the atomic bomb purely to bring Japan to heel or also to send a message to Josef Stalin, the Soviet dictator. The many ambiguities in Truman's

---

[13] David Allan Rosenberg, "The Origins of Overkill: Nuclear Weapons and American Strategy, 1945-1960," *International Security,* vol. 7, no. 4. (Spring 1983) 3 –71.

handling of U.S. nuclear weapons in the first years after Japan's surrender have contributed to the controversy.[14]

President Harry S. Truman (HSTL)

Before he became president, Truman had spent only eighty-two days as vice president after Roosevelt chose him in 1944 as a last-minute compromise candidate acceptable to both the liberal and conservative wings of the Democratic Party. Truman grew up on Missouri farms and had limited success as a farmer and in business. Although he never earned a college degree, he avidly read history books, and his leadership qualities came to the fore when he served as an army artillery officer in France in World War I. After his haberdashery business failed in 1922, Truman became a politician at the county level in the Kansas City political machine of Thomas J. Pendergast. He then

[14] Historian Barton J. Bernstein has argued that while the bomb was primarily used to induce Japan's surrender, the idea that it would impress the Soviets was a "confirming" purpose. See Bernstein, "The Atomic Bombings Reconsidered," *Foreign Affairs,* January / February 1995, 135-52. The case that Truman used the bomb to send a message to the Soviets was put most controversially by Gar Alperovitz in his 1965 book *Atomic Diplomacy: Hiroshima and Potsdam, the Use of the Atomic Bomb and the American Confrontation with Soviet Power* (New York: Simon and Schuster). Truman's policies have also been criticized by historians who take a revisionist view of the Cold War, notably Walter LaFeber and Gabriel Kolko. The work of these historians is critically analyzed by Robert H. Ferrell in *Harry S. Truman and the Cold War Revisionists* (Columbia: University of Missouri Press, 2006). Truman's handling of nuclear weapons is also discussed in, among others, Samuel R. Williamson and Steven L. Rearden, *The Origins of U.S. Nuclear Strategy, 1945-1953* (New York: St. Martin's Press, 1993), D. A. Rosenberg in "Origins of Overkill" and Alperovitz in *The Decision to Use the Atomic Bomb and the Architecture of an American Myth,* (New York: Alfred A. Knopf, 1995).

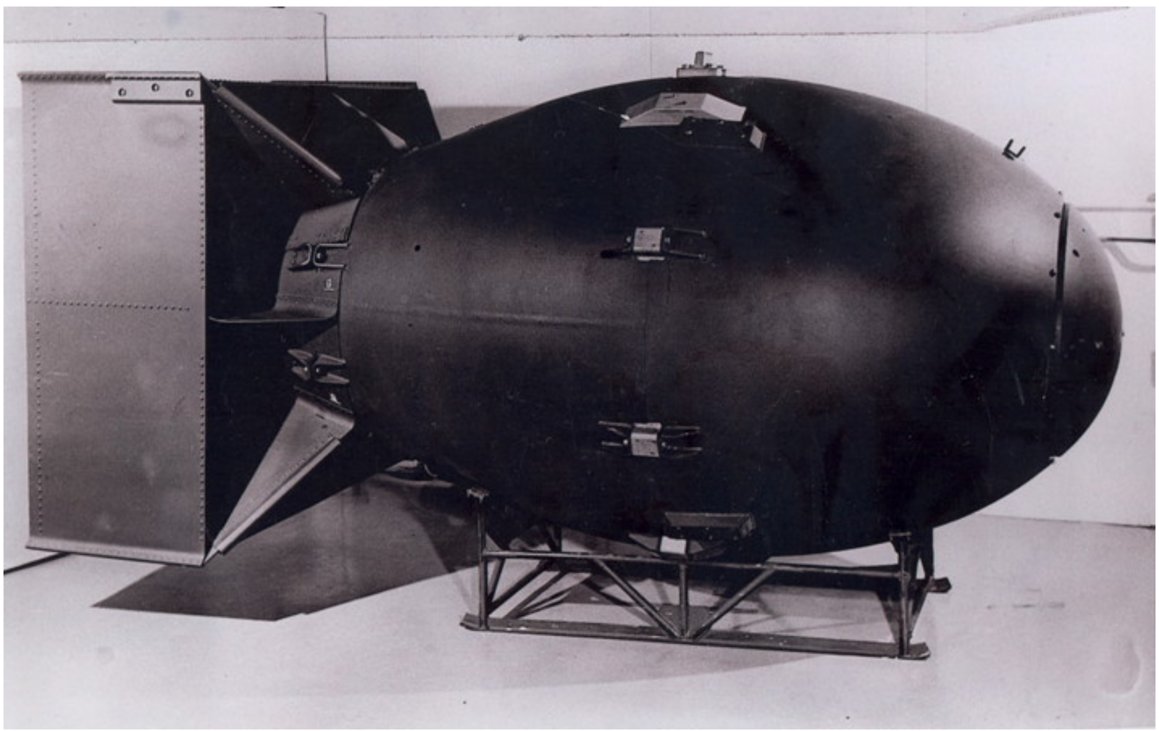
served for a decade in the U.S. Senate and overcame his past with the Pendergast machine by leading a wartime Senate committee that investigated military procurement contracts for waste and fraud. As president, Truman was known for his direct manner and populist sensibility that contrasted with the patrician manner of his predecessor. The political turbulence that accompanied America's emergence from hard years of depression and war into the Cold War and the Korean War cost him popularity through most of his time in the White House. But Truman defied all predictions by winning election as president in his own right in 1948, and his popularity rose after he left office in 1953.[15]

The first nuclear weapons, which Truman used against Japan, are known popularly as atomic bombs but more accurately as fission bombs. Fission weapons derive their energy from the fission or splitting of the nucleus of uranium or plutonium, which are very heavy atoms. The splitting is accomplished by bombarding the nucleus with neutrons, and as each nucleus splits, it gives off more energy and more neutrons, leading to a chain reaction and the release of a prodigious amount of energy. The early fission weapons were heavy and bulky, with the Nagasaki "fat man" bomb weighing in at about 4,600 kg and with a length of 3.2 m and a width of 1.5 m. The first fission bombs in 1945 were only about one-thousandth as powerful as the thermonuclear bombs that became

---

[15] The best-known biography of the former president is David McCullough's sympathetic treatment in *Truman* (New York: Simon & Schuster, 1992). An excellent source is Robert J. Donovan's two-volume history of Truman's presidency, *Conflict and Crisis: The Presidency of Harry S. Truman 1945-1948* (New York: W.W. Norton & Co., 1977) and *Tumultuous Years: The Presidency of Harry S. Truman 1949-1953* (New York: W.W. Norton & Co.: 1982). Other studies of his presidency include Robert H. Ferrell, *Harry S. Truman: A Life* (Columbia: University of Missouri Press, 1994); Alonzo L. Hamby, *Man of the People: A Life of Harry S. Truman* (New York: Oxford University Press, 1995); Melvyn P. Leffler, *A Preponderance of Power: National Security, the Truman Administration, and the Cold War* (Stanford: Stanford University Press, 1992); and Hogan, *Cross of Iron*. Truman wrote a two-volume memoir, *Memoirs: Vol. 1, Year of Decision.* (Garden City, N.Y.: Doubleday & Co., 1955) and *Memoirs: Vol. 2, Years of Trial and Hope,* (Garden City N.Y.: Doubleday & Co., 1956).

available after 1952. Instead of splitting atoms as in fission bombs, thermonuclear bombs derive energy from the fusion of atoms into heavier atoms. These weapons are popularly known as hydrogen bombs due to the fact that isotopes of hydrogen are used to power them, or thermonuclear weapons because of the great heat they generate. Thermonuclear bombs operate in two stages – the first stage being a fission explosion that creates radiation that increases pressure and heat on the fuel in the second stage, triggering the fusion reaction.[16]



Model of the 'Fat Man' Bomb used against Nagasaki (NA)

Early atomic bombs were difficult to assemble and required special equipment to load into aircraft. The first Mark III bombs, based on the "fat man" design, had to be assembled shortly before use and disassembled after only a few days in combat-ready status if they were to be used at a later time. These bombs were the main atomic bombs in

[16] John Clayton Lonnquest, "The Face of Atlas: General Bernard Schriever and the Development of the Atlas Intercontinental Ballistic Missile, 1953 – 1960" (Ph.D. Diss., Duke University, 1996) 67-8.

service until 1949.[17] The only aircraft capable in 1945 of carrying the weapons were two Boeing B-29 bombers specially modified to carry and drop the heavy bombs and operated by a crew specially trained to handle these weapons. The next year, twenty-seven B-29s underwent the structural and weight reduction modifications known as Silverplate to carry atomic bombs. Two "fat man" bombs were exploded for the July 1946 Operation Crossroads tests on Bikini Atoll. Contrary to popular belief at the time, the United States did not have any atomic bombs ready for immediate use. The following April, the leaders of the newly established Atomic Energy Commission informed Truman for the first time about the size of America's nuclear weapons stockpile, and the president was shocked to be told that it had no assembled atomic bombs in stock, and sufficient parts to complete only seven bombs. What historian David Allan Rosenberg has called excessive and obsessive secrecy surrounding nuclear weapons meant that very few military leaders knew how many bombs were in fact on hand.[18] The new commission moved quickly to bring atomic bombs into regular production, but this was much easier said than done. Most of the scientists who worked on the Manhattan Project had left to return to academic life as soon as they could after the war ended. New bombs needed to be developed and tested to make more efficient use of the highly limited supplies of uranium, which at the time came from a nearly tapped out mine in the Belgian Congo and another mine in Canada with limited output. The reactors used to produce plutonium in Hanford, Washington, were in a "precarious state" in 1947,[19] and many bomb parts were in short supply. The Sandstone nuclear tests in April and May 1948 proved new design

---

[17] David Alan Rosenberg, "U.S. Nuclear Stockpile, 1945 to 1980," *Bulletin of the Atomic Scientists,* May 1982, 25-30.
[18] D.A. Rosenberg, "Origins of Overkill," 11.
[19] Richard G. Hewlett and Francis Duncan. *Atomic Shield, 1947 - 1952, Volume II: A History of the United States Atomic Energy Commission* (University Park: Pennsylvania State University Press, 1969) 43.

concepts that modestly increased the explosive power of these bombs and enabled higher production rates due to more efficient use of plutonium and uranium inside the bombs. Truman gave little thought to the role nuclear weapons would play in the defense of the United States until 1949, when he came to accept nuclear weapons as the centerpiece of U.S. defense policy. That fall he agreed to a major increase in the production of nuclear weapons.[20]

The Truman administration also faced the question of who would have possession and control of the nuclear bombs and components, which in 1945 and 1946 were in the custody of the Manhattan Project. After the war ended, the U.S. Congress debated competing versions of a bill to control nuclear assets, including nuclear arms and nuclear energy resources. Truman initially supported the May-Johnson Bill, which provided a strong degree of military control over nuclear assets. Congressional support withered, however, for the May-Johnson Bill, in part due to opposition by scientists who did not want the military to control nuclear research. Early in 1946, Senator Brien McMahon of Connecticut introduced another bill to place nuclear research under civilian control with a minimal military involvement. After lengthy debate, Congress passed a bill based on the McMahon proposal, and Truman signed the Atomic Energy Act into law on August 1, 1946. The law established a civilian Atomic Energy Commission and gave it custody of America's nuclear arsenal, effective 1 January 1947. The military could obtain nuclear bombs with the president's approval, but as original documents show, Truman declined

---

[20] Harry R. Borowski, *A Hollow Threat: Strategic Air Power and Containment Before Korea* (Westport CT: Greenwood Press, 1982) 103, 105; Hewlett and Duncan, 47-8, 141-9; Williamson and Rearden, *Origins of U.S. Nuclear Strategy,* 189; Chuck Hansen, *US Nuclear Weapons: The Secret History* (Arlington TX: Aerofax, 1988) 31-4, 122-4.

several military entreaties for custody of the weapons until 1951, after the Korean War broke out, when he finally agreed to place some nuclear bombs under military control.[21]

During 1946, the debate over control of nuclear weapons and nuclear energy also took place on the international stage. Many U.S. scientists and political leaders who were disquieted by the toll of the atomic bombs at Hiroshima and Nagasaki proposed sharing information about atomic energy with other countries and establishing an international regime to prevent proliferation of nuclear weapons, while others called for tight government control of all atomic resources to keep them out of the hands of adversaries such as the Soviet Union. The former approach was explored in a U.S. State Department report issued in March 1946 known popularly as the Acheson-Lilienthal Report and officially as the Report on International Control of Atomic Energy. The report called for the creation of an international atomic energy authority that would control the mining and production of uranium, thorium and other fissile materials, and all nuclear production facilities. Truman appointed well-known financier Bernard Baruch as United States Representative to the United Nations Atomic Energy Commission, and Baruch presented a proposal in June similar to the Acheson-Lilienthal plan, but with international

---

[21] D. A. Rosenberg, "Origins of Overkill," 21-2; Office of the Assistant to the Secretary of Defense (Atomic Energy). *History of the Custody and Deployment of Nuclear Weapons July 1945 Through September 1977.* (Washington D.C.: Department of Defense, February 1978) 1-22; Melvyn P. Leffler, *A Preponderance of Power: National Security, the Truman Administration, and the Cold War* (Stanford: Stanford University Press, 1992), 406; Harry S. Truman to James Forrestal, 6 August 1948, Confidential Files, Atomic Bomb and Energy 1948-49 folder; Gordon Dean, Chairman, Atomic Energy Commission, to James S. Lay, National Security Council, 24 June 1952, President's Secretary's File, NSC- Atomic File, Harry S. Truman Presidential Library. There is a large literature on the history of nuclear weapons during this time, including Richard Rhodes, *Dark Sun: The Making of the Hydrogen Bomb* (New York: Simon and Schuster, 1995).

inspections of nuclear resources and assets, and no veto for participating nations. The Soviet Union used its United Nations veto to block the plan in December.[22]

Truman allowed Baruch to make the proposal, but in their recent account of Truman's nuclear diplomacy, historians Campbell Craig and Sergey Radchenko, argued that Baruch's proposals contained elements that the Soviets would likely oppose, and questioned whether the president sincerely supported international control of atomic energy. Baruch tabled his plan in 1946, a year noted for deepening antagonisms between the United States and the Soviet Union, with events such as State Department official George Kennan's call for a harder line with the Soviets and Winston Churchill's famous 'iron curtain' speech in Fulton, Missouri.[23] Craig and Radchenko argued that revelations of Soviet nuclear espionage in Canada and the United States early that year convinced Truman that international control of atomic energy would not work. Regardless of Truman's motives, the only policy on atomic weapons enunciated by the U.S. government before September 1948 was international control. That month, Truman approved NSC-30, a National Security Council paper that set out the first U.S. government policy governing the use of nuclear weapons. When Baruch asked military leaders to comment on the arms control proposals, the then commanding general of the air force, Gen. Carl A. Spaatz, not surprisingly replied that he believed that the security of the United States would be better served by retaining sole control of the bomb. The air

---

[22]Noel Francis Parrish, *Behind the Sheltering Bomb: Military Indecision from Alamogordo to Korea.* (New York: Arno Press, 1979) 155-62; McGeorge Bundy, *Danger and Survival: Choices About the Bomb in the First Fifty Years* (New York: Random House, 1988) 130-96. Greg Herken, *The Winning Weapon: the Atomic Bomb in the Cold War, 1945-1950* (New York: Knopf, 1980) contains a critical and perceptive discussion of the Acheson-Lilienthal Report and the Baruch plan, 151-91. U.S. Department of State, "The Acheson-Lilienthal & Baruch Plans, 1946," http://www.state.gov/r/pa/ho/time/cwr/88100.htm, accessed 24 June 2009; text of Bernard Baruch's address to the United Nations Atomic Energy Commission, 14 June 1946, President's Secretary's Files, file "Baruch," HSTL.

[23] Melvin Leffler wrote in his authoritative work on Truman's security policies that: "In early 1946, U.S. officials defined the Soviet Union as the enemy." Leffler, *Preponderance of Power,*100.

force proceeded on its work with atomic bombs without reference to the possibility that the United States might give up control of the weapons.[24]

Lawrence Freedman, a historian of military strategy, wrote that until well into 1947, "the limitations of the bomb governed US strategy," including the small number of bombs, the limited range of bombers, the superiority of Soviet conventional forces in Europe, the size and demonstrated resilience of the Soviet Union, and questions about how best to use atomic bombs. Historian David Allan Rosenberg argued that the National Security Council provided no guidance about the circumstances under which nuclear weapons would be used, leaving the decision and responsibility solely with the president. And Truman kept nuclear weapons out of the hands of the military and under the control of the Atomic Energy Commission until 1951.[25] Truman was criticized for not expediting decisions on the use of nuclear weapons and for lacking a nuclear strategy, but noted Cold War historian John L. Gaddis praised Truman's attitude, noting that "one might also argue that Truman was *more* mature than most others at the time because he saw, almost from the start, that nuclear weapons were going to change the meaning of 'strategy' itself."[26] As will be discussed in this dissertation, others feared that the meaning of strategy would be changed if nuclear weapons were placed on missiles that could take them to their targets in half an hour or less after the push of a button.

---

[24] Campbell Craig and Sergey Radchenko, *The Atomic Bomb and the Origins of the Cold War* (New Haven: Yale University Press, 2008) 111-134; D.A. Rosenberg, "Origins of Overkill," 11-2; Parrish, *Sheltering Bomb,* 161-2.

[25] Lawrence Freedman, *The Evolution of Nuclear Strategy, Second Edition* (London: Palgrave Macmillan, 1989), 48-51; D. A. Rosenberg, "Origins of Overkill,"14; Herken, *The Winning Weapon*, 196-9; Leffler, *A Preponderance of Power*, 406; Office of the Assistant to the Secretary of Defense, *History of the Custody of Nuclear Weapons,* 1-35. The military was allowed to take control of non-nuclear components of nuclear bombs in 1950, and Truman approved military custody of full components of a small number of nuclear bombs under tight restrictions in 1951, The restrictions were loosened in 1952 and again after Eisenhower took office in 1953.

[26] Gaddis, *We Now Know,* 111-2. Emphasis in original.

Through the late 1940s, atomic bombs were large, heavy and unwieldy – not promising weapons to mount on guided missiles. These bombs were also in very short supply, and the U.S. government's policy over their use is best described as uncertain. While the air force looked to the day when bombs would be available for use in quantity, it focused on creating bomber aircraft that were much more likely than missiles to be quickly available to transport the nuclear weapons to far-off targets in the Soviet Union. Moreover, until September 1948, the only U.S. government policy on nuclear weapons foresaw international control. Although a handful of bomber aircraft stood ready to drop nuclear weapons, the U.S. government was not actively looking for new delivery methods for nuclear bombs during the first four years after World War II.

Unification

American military missile programs operated during the first fifteen years after World War II in the shadow of great rivalries between the military services. The Truman presidency was a period of great turmoil for the U.S. military, and most famously included Truman's 1951 decision to remove Gen. Douglas MacArthur from his commands over differences arising from the conduct of the Korean War. But the five years between World War II and Korea saw major financial, strategic and organizational adjustments for the military, which generated great friction between the army, navy and air force, and between them and the administration. In his study of Truman's presidency, author and journalist Robert J. Donovan called this period "the worst feud among the armed forces that the United States has ever known," and Gen. Omar N. Bradley, the Army Chief of Staff in 1948 and 1949, and Chairman of the Joint Chiefs of Staff from 1949 to 1953, used similar words describe these disputes. The discussions that led to the reorganization of the military started in wartime and culminated in the reorganization that formally took place in 1947. This dissertation will explain how these wider conflicts affected the military's guided missiles program, particularly long-range missiles.[27]

During World War II the U.S. military was organized under two departments. The Department of the Navy contained the U.S. Navy and the U.S. Marine Corps. The Department of War contained the U.S. Army, which was composed of the Army Ground Forces, the Army Air Forces (AAF) and the Army Service Forces, which included the Ordnance Department. The AAF was created from the Army Air Corps in June 1941.

The idea of reorganizing the United States military with the air force becoming a separate branch of the armed forces had originated in the 1920s, when Brig. Gen. Billy Mitchell had agitated for a separate air force outside the army. The desire for an autonomous air force remained strong among the flyers and grew during World War II, when the elevation of AAF Commanding General Henry H. "Hap" Arnold to the newly created Joint Chiefs of Staff in 1941 appeared to foreshadow an autonomous air force, and the war saw the creation of some unified commands involving all the services. But President Roosevelt had to personally adjudicate disputes between the army and navy, particularly in the Pacific theatre. In 1943, U.S. Army Chief of Staff Gen. George C. Marshall put forward an army paper on unifying the military as a means of encouraging unity of command and eliminating duplication. The idea was not new because Congress had considered but rejected military unification in 1932 as an economy measure. The unified military would have ground, air and naval branches. The following year, a committee of the House of Representatives held hearings into military unification. When

---

[27] Donovan, *Tumultuous Years*, 53; Omar N. Bradley and Clay Blair, *A General's Life: An Autobiography* (New York: Simon and Schuster, 1983) 488. Williamson and Rearden, in *Origins of U.S. Nuclear Policy,* 55, use similar language to describe this dispute, and added that the wounds took decades to heal.

the war ended in 1945, the army promoted unification while the navy resisted the idea, and these contrasting viewpoints were brought forward in Senate hearings that fall.[28]

The debate on armed forces unification began in earnest when Truman sent a message to Congress on 19 December 1945 calling for the armed forces to be transformed from two separate departments into a single department of national defense. The new department would have three coordinated branches for the army, navy and air force, each headed by an assistant secretary serving under the secretary of national defense. Since there was no political support for creating a third military department for the air force alongside the war and navy departments, the AAF's hopes for independence from the navy and the army rested on unification of the armed forces in one department with three equal services. Truman's plan, however, sparked conflict within the military.[29] Two historians close to these events wrote that the navy "bitterly opposed" unification because it feared losing the Marine Corps to the army and its aviation assets, which it saw as "an indispensable element in naval warfare," to the air force.[30] The navy feared the precedent of Britain's Royal Air Force, which absorbed both the army's tactical air units and Royal Naval Air Service when it was founded in 1918. Mitchell advanced a similar vision for an air force in the United States. But the navy was also concerned that even if the army and navy air arms remained in place and a separate air force concentrated on

---

[28] Barlow, *Revolt of the Admirals,* 23-32. Barlow tells the unification story from the navy viewpoint, and the U.S. Air Force viewpoint is set out in Wolk, *The Struggle for Air Force Independence.* Omar Bradley's views of unification are set out in *A General's Life,* 487-513.Independent perspectives of this dispute are provided by Demetrios Caraley in *The Politics of Military Unification* (New York: Columbia University Press, 1966); Thomas D. Boettcher, *First Call: The Making of the Modern U.S. Military, 1945-1953* (Boston: Little, Brown and Company, 1992) 55-135; and Donovan, *Tumultuous Years,* 53-65.

[29] Truman Library, "Public Papers of the Presidents: Harry S. Truman: Special Message to the Congress Recommending the Establishment of a Department of National Defense," 19 December, 1945, http://www.trumanlibrary.org/publicpapers/index.php?pid=508&st=&st1= , accessed 25 June, 2009; Millis and Duffield, *Forrestal Diaries,* 146-7.

[30] Millis and Duffield, *Forrestal Diaries,* 146-9.

strategic missions with atomic weapons, naval aviation would face severe cutbacks in peacetime because money and support would flow to a nuclear-armed air force. The navy's concerns about air force use of nuclear weapons were deepened because naval leaders had different ideas from the air force about how to use nuclear weapons, including questioning the air force plan to use atomic bombs against large population centres. The air force, in turn, looked with unease on the navy's air arm, which it saw as cutting into its mission.[31]

Most of the army strongly supported unification in the belief that a single defense department that would insulate the army from political pressures to divert funding to the more glamorous air force and navy in times of peacetime retrenchment. The feeling was especially strong amongst those like Marshall who remembered the stalled army careers of the interwar years and did not want to repeat the experience.[32]

This feeling was not shared in the ranks of the Army Ordnance Department, which would compete with the AAF and later the U.S. Air Force for control of missiles. Army Ordnance Maj. Gen. John B. Medaris, who commanded the army's missile program in the 1950s, wrote in 1960 that he had major reservations about the creation of the USAF. Medaris believed that the Ordnance Department's future lay in missiles, and by 1960 the separate air force with control of missiles had sharply limited that future. Medaris and his colleagues were no doubt aware that army ordnance departments in the

---

[31] Barlow, *Revolt of the Admirals,* 24, 32-44, 105-30; Caraley, *Military Unification,* 96-8; Wolk, *The Struggle for Air Force Independence,* 38-40, 161-3; Boettcher, *First Call,* 82-8. For background on the RAF, see Harry Howe Ransom. "The Politics of Air Power – A Comparative Analysis." *Public Policy* (Cambridge, MA: Harvard Graduate School of Public Administration (Vol. 8), 1958) 87-119; and H. Montgomery Hyde, *British Air Policy Between the Wars 1918-1939* (London: Heinemann, 1976). The Royal Navy reabsorbed the Fleet Air Arm from the RAF in 1937.

[32] Barlow, *Revolt of the Admirals,* 30.

German Army in World War II and the postwar Soviet Red Army had responsibility for ballistic missiles, rather than their air forces.[33]

The debate over Truman's unification bill ran for months in Congress, where the army, navy and air forces had strong representation in the form of friendly members of Congress who had military installations in their states and districts, or had built up relationships with the individual military services through committee work. The National Security Act that Truman signed into law on 26 July 1947 was a compromise that departed from his proposal of December 1945. Instead of a department of defense, the law created a Secretary of Defense who with a small staff presided over the small, weak but grandly titled forerunner to the defense department known as the National Military Establishment. The secretaries who ran the Departments of the Army, Navy and Air Force kept their seats at the cabinet table and a great deal of power. The result was that the inter-service struggles that preceded unification continued unabated.[34] The Department of Defense was formally established two years later in 1949 when Congress amended the National Security Act, and it was only then that the Secretary of Defense became the sole voice in the cabinet for the military. With these changes, the Secretary of Defense gained control over all three services. But the disagreements between the services continued until they were temporarily subsumed by the more immediate problems of the Korean War.[35]

The United States Air Force gained its autonomy under the National Security Act on 18 September 1947. While the event marked the successful completion of efforts to

---

[33] Major General J.B. Medaris and Arthur Gordon. *Countdown for Decision* (New York: Paperback Library Inc.,1961) 45-8, 53-4.
[34] Barlow, *Revolt of the Admirals,* 52-5; Donovan, *Tumultuous Years,* 53-65.
[35] The National Security Act also established the Central Intelligence Agency and the National Security Council. Millis and Duffield, *Forrestal Diaries,* 296-7; Parrish, *Sheltering Bomb,* 175-90.

create an autonomous air force, it did not mean an end to challenges to its jurisdiction, particularly in the field of missiles. Because the air force's mission statement was vaguely worded, disputes continued at the highest levels between the services and Secretary of Defense James V. Forrestal, who had few means at his disposal to resolve them. In an effort to settle disputes over roles such as control and delivery of strategic weapons, the Joint Chiefs of Staff and their deputies met over a weekend in March 1948 in Key West, Florida. The agreement reached at the meeting gave the air force primary responsibility for "strategic air warfare" with atomic weapons, but the navy was also given the right to use atomic weapons in certain situations. The Key West meeting failed to end the disputes between the services, however, so the joint chiefs gathered again for a weekend in August 1948 at the Naval War College at Newport, Rhode Island.[36]

In part because of the financial restrictions of the time, the ill will between the services outlasted Forrestal's term as secretary of defense, and probably contributed to his leaving the post and his suicide shortly afterward. The new secretary, Louis Johnson, an ambitious West Virginia lawyer who took office on 28 March 1949, was a political associate of the president and quickly became known for his dedication to Truman's goal of restraining military spending. He was also considered to be friendlier to the air force than Forrestal, who had been secretary of the navy before heading up the National Military Establishment. On 23 April 1949, during his first month in office, Johnson abruptly cancelled the navy's long-awaited new supercarrier *United States*, which the navy saw as a key part of its own nuclear strategy. Secretary of the Navy John Sullivan

---

[36] Millis and Duffield, *Forrestal Diaries,* 389-95. 476-9; USAF functions from Executive Order, 26 July 1947, "Excerpt from Army-Air Force Agreements as to Initial Implementation of the National Security Act of 1947 dtd 15 September 1947;" "Secretary Forrestal Announces Results of Key West Conference," 28 March 1948, and attached "Functions of the Armed Forces and the Joint Chiefs of Staff," Box 142, Policy from Higher Authority, RG 341, National Archives.

resigned three days later, and the anger in the navy created by the cancellation led to an episode known as the revolt of the admirals. Naval officers and navy supporters began publicly attacking the air force's procurement of B-36 bombers and air force doctrine on the use of nuclear weapons. As a result of the controversy, the House Armed Services Committee held hearings into the B-36 in August 1949 that upheld the air force's confidence in the bomber. The committee's subsequent hearings on unification and strategy in October 1949 included Adm. Louis E. Denfeld's testimony criticizing the navy's treatment by the Joint Chiefs of Staff and Johnson that led to Denfeld's firing as Chief of Naval Operations. Denfeld's removal marked the end of the revolt, but his testimony was seen in the navy as a crucial defense of naval aviation against those who wanted to eliminate it.[37]

Throughout the period covered in this dissertation and beyond, the U.S. military services battled for control of guided missiles. This study will discuss how members of the Air Staff who ran the air force during this time spent a great deal of energy opposing guided missile programs proposed by the Ordnance Department of the army and by the navy in areas that they saw as being in air force jurisdiction. Although the air force emerged largely victorious in the first round of these disputes over missiles, including what would become ICBMs, these disputes continued until the beginning of the Korean War in 1950, and resumed later in the 1950s.

---

[37] Barlow, *Revolt of the Admirals,* 215-294; Donovan, *Tumultuous Years,* 105-13; Boettcher, *First Call,* 172-86. Bradley, *A General's Life,* 487-513.

B-36 Prototype (right) alongside the B-29 (USAF via Wikimedia)

Demobilization and Cutbacks

Budget issues in the late 1940s held back the development of guided missiles. The pressure of tight budgets arose from what the Truman administration interpreted as the American public's overwhelming appetite for postwar demobilization. A year after World War II ended, the armed forces were reduced to a quarter of their wartime strength, with the U.S. Army Air Forces reduced by 1947 to an eighth of its wartime complement. In December 1946, AAF Commanding General Spaatz estimated that only two air force groups were combat ready, compared to more than 200 that were operational eighteen months earlier. Not long after, he complained that demobilization "all but wrecked" the air force and added that there "was not left a single squadron with wartime standards of efficiency."[38] The fiscal year 1947 budget for the War and Navy Departments, including occupation duties in Europe and the Far East, was set at $13 billion, compared to the $80 billion spent by the departments in 1945. In the 1946 U.S. mid-term elections, voters gave majorities in both the House and Senate to the Republican Party, which was eager to lower taxes and spending. The Republican-dominated 80th Congress worked to reduce budgets, including Truman's $11 billion requests in fiscal year 1947 and FY 1948 to cover both the War and Navy Departments. As a result, the air force faced further cutbacks in both years.[39]

Air force leaders decided that they needed to have seventy aircraft groups to properly defend the United States, but this aspiration got caught in both the Congressional and presidential tight money policies. When the Republican Congress was persuaded to set aside financial restraint to appropriate a supplemental $822 million in 1948 to help the air force reach this seventy-group goal, Truman stuck to his tight money stand and impounded the funds. The Joint Chiefs of Staff estimated that the military needed $23.6 billion in 1950, but Truman held the defense budget under $15 billion and contemplated an even smaller defense budget for 1951 prior to the onset of the Korean War. Another complicating element was the proposal first raised in wartime and later championed by Marshall and Truman for Universal Military Training (UMT) for military-aged males as an alternative to maintaining a large standing army. The air force saw the concept as a threat to its hopes for a seventy-group air force, and many members

---

[38] Parrish, *Behind the Sheltering Bomb,* 111; David R. Mets, *Master of Airpower: General Carl A. Spaatz* (Novato CA: Presidio Press, 1988) 312; testimony of Gen. Carl Spaatz, 6 March 1947, House of Representatives, Subcommittee of the Committee on Appropriations, *Military Establishment Appropriation Bill for 1948.*, 1st Session, 80th Congress (Washington D.C.: U.S. Government Printing Office, 1947) 604.
[39] Edward A. Kolodziej. *The Uncommon Defense and Congress, 1945-1963* (Columbus: Ohio State University Press, 1966) 38-58.

of Congress and the public saw such an air force armed with atomic bombs as a relatively inexpensive and unobtrusive means of providing security to the United States. UMT was defeated in Congress in 1948. Truman's tight money policies had the effect of increasing the importance of America's limited stock of nuclear weapons because conventional forces were severely cut back.[40] With the air force fighting to reach its goal of seventy groups in a time of constrained budgets, it was inevitable that research and development budgets, including spending on guided missile programs, would feel the pinch.

The Strategic Air Command

To understand where guided missile research fit into the priorities of the air force in the late 1940s, one must look at the state of the air force's bombing mission during this time. Strategic bombardment of enemy cities, industries and military installations lay at the heart of the air force's mission in the eyes of most air force leaders. It was an independent, air-based means of warfare, and the idea that strategic bombardment in war was decisive to the outcome of war underlay the air force's crusade for autonomy.[41]

The Army Air Forces were already preparing for the postwar world by 1943, when its planners considered Japan and Germany the biggest threats to the United States once the war ended because of their demonstrated ability to use airpower. Historian Perry Smith's study of air force postwar planning found that for air force planners, the Soviet Union provided "the long-term threat, commencing no earlier than twenty years after the

---

[40] Borowski, *Hollow Threat,* 150-1, 198-200; Perry McCoy Smith. *The Air Force Plans for Peace 1943-1945* (Baltimore: The Johns Hopkins Press, 1970) 84-96. See also Willliamson and Rearden, *Origins of U.S. Nuclear Strategy,* 60, 78, 191; and Warner R. Schilling, "The Politics of National Defense: Fiscal 1950," from Warner R. Schilling, Paul Y. Hammond, Glenn H. Snyder, eds., *Strategy, Politics and Defense Budgets* (New York: Columbia University Press, 1962); Wolk. *The Struggle for Air Force Independence,* 49-85, contains a long discussion about how the 70-group figure was arrived at and defended. One major consideration was that the AAF believed it needed to be ready almost immediately to fight a new war.
[41] Smith, *Air Force Plans for Peace,* 27.

end of World War II."[42] But many AAF officers were already concerned during the war about the Soviets because of the difficulties they had dealing with them as allies. The AAF had refused to share long-range bombers with the Soviets as it did other equipment during the war. Overriding the fears many air force officers had about the Soviet Union was the fact that the Soviets did not possess or use long-range bombers during the war, which was chalked up to the poor state of Soviet technology. Smith quoted AAF Commanding General Arnold commenting as late as the summer of 1945 on the primitive nature of Soviet technology limiting its danger to the United States. Smith wrote that the AAF planners gave little thought to the doctrinal factors and immediate defense needs that moved the Soviets to fighter and light-bomber development and away from heavy bomber development. Another illusion held by many air force planners involved the role of the United Nations as an international police officer in the postwar world, and that belief influenced air force planning until the limitations of the UN became apparent when it was founded in 1945. In the fall of 1945, the AAF produced its first targeting study of twenty Russian cities.[43]

At war's end, the role and value of strategic bombing was controversial, both inside and outside the military, with the arguments focusing not only on the overall value of strategic bombing, but also the value of bombing directed to military targets versus wide area bombing aimed at destroying urban areas and killing large numbers of people, undermining civilian morale. The United States Strategic Bombing Survey found that "Allied airpower was decisive" in winning the war in western Europe, and that Japan

[42] Smith, *Air Force Plans for Peace,* 51.
[43] Smith, *Air Force Plans for Peace,* 50-3, 81-2; Herken, *The Winning Weapon,* 199-200, 219. See also Michael S. Sherry, *Preparing for the Next War: American Plans for Postwar Defense, 1941-45* (New Haven: Yale University Press, 1977) 159-90, 213-9.

would have surrendered before the end of 1945 under the weight of air attacks, even without atomic weapons or the threat of a Soviet involvement in the war. The survey also found that in both Europe and Japan, "heavy, sustained and accurate attack against carefully selected targets is required to produce decisive results when attacking an enemy's sustaining resources," and that "no nation can long survive the free exploitation of air weapons over its homeland."[44] Air force generals such as Spaatz and Curtis LeMay credited strategic bombing with being decisive in both Europe and Japan, and used this argument to build support for a stronger and more independent air force. Historian Harry R. Borowski reported in his landmark 1982 study of American strategic airpower that critics countered with assertions that most bombing had proven ineffective, and that both Germany and Japan had been seriously weakened by other means by 1944. Air force leaders responded to these criticisms by claiming that true strategic bombing did not begin until late in the war, and that too often bombers had been directed to tactical targets such as submarine pens rather than strategic assets such as synthetic oil facilities. More recent historical assessments have questioned the effectiveness of bombing during the war. In 1989 historian Lawrence Freedman stated that during the war, the "bomber was not a means of breaking a deadlock, but yet another instrument of attrition," and Michael Sherry wrote in the same year that while "antiaircraft defenses showed surprising capacities," bomber offensives usually did inflict some damage. Kenneth P. Werrell, in his perceptive 2009 history of strategic bombing, concluded that while its use in the

---

[44] United States Strategic Bombing Survey, *Over-all Report (European War)* September 30, 1945, 15-6; David MacIsaac, *Strategic Bombing in World War Two: The Story of the United States Strategic Bombing Survey* (London: Garland Publishing Inc., 1976) 145-6. Herken, *The Winning Weapon,* contains a more critical view of the effects of air force bombing, 209-13.

European and Japanese theaters fell short of the hopes of airpower theorists, strategic bombing made a "major yet expensive" contribution to the war.[45]

But to most of the public in the late 1940s, the arguments about strategic bombing were rendered moot as a result of the atomic bombing of Hiroshima and Nagasaki. "Strategic bombardment had won its case, and the ignored lessons of World War II could remain ignored by the public, Congress, the Air Force, and all others except the inquiring scholar or the parochial Army or Navy man," as Perry Smith put it.[46]

Once the war ended, the Army Air Forces concentrated on demobilizing, which saw its most experienced and skilled personnel leave for civilian life because their experience put them first in line to be discharged. Early in 1946, the AAF replaced its regionally based combat commands with functional ones by creating the Strategic Air Command (SAC), Tactical Air Command and the Air Defense Command. Gen. George C. Kenney, who had commanded air forces in the Pacific theatre, became the first commander of SAC. Because the most experienced personnel had top priority for discharge from military service, SAC faced the challenge of operating with large numbers of poorly trained and inept pilots and mechanics, and problems in obtaining the skilled personnel it needed to build a striking force, according to Borowski. As well, Kenney spent much of the year on duties related to AAF public relations and the United Nations. His deputy, who had effective charge of SAC, instituted an unpopular and ineffective program to train aircrews for various jobs both inside and outside the aircraft.

---

45 Borowski, *Hollow Threat,* 20-3; Freedman, *The Evolution of Nuclear Strategy,* 22; Michael Sherry, *The Rise of American Air Power: The Creation of Armageddon* (New Haven: Yale University Press, 1989) 360; Kenneth P. Werrell, *Death From the Heavens: A History of Strategic Bombing* (Annapolis MD: Naval Institute Press, 2009) 125-8, 152-4.

46 Smith, *Air Force Plans for Peace,* 17; Freedman, *Nuclear Strategy,* 22-4; Sherry, *Rise of American Air Power,* 353-5.

Kenney and his staff reorganized SAC in a bid to make it more efficient, but the reforms had mixed success. And SAC's efforts to extend the limited reach of its B-29 bombers to Russian targets through deployments to foreign bases in Europe, Asia and Japan presented more problems due to political issues such as the need to get permission from host governments before launching attacks, and logistical questions such as supplying parts and provisions far from home. Initial attempts to base bombers in the arctic climate of Alaska were stymied by the unforgiving cold and the major navigational problems found in the north.[47]

After the war, the Soviet Union did not demobilize to the same extent as the U.S. military, leading to concerns among American military planners about the Soviet Union's strength as a European land power. In October 1946, AAF Maj. Gen. Lauris Norstad briefed President Truman, calling the Soviet Union "the only probable source of trouble in the foreseeable future."[48] In case of Soviet aggression, the AAF could only respond with strategic air strikes from bases in England, North Africa and Japan. The AAF intelligence division warned in 1947 that choosing and finding bombing targets in the Soviet Union involved major difficulties. Many important targets would be hard for bombers to reach because they lay deep inside Soviet territory, beyond the reach of armies, naval-based arms and aircraft, and all but the longest-range bombers. Even more important, the United States had little information about potential targets and target areas. While captured German photographs gave the Americans good information about Soviet territory occupied by the Germans during World War II, no such information existed on territory further inland, where many important Soviet military installations were located.

---

[47] Borowski, *Hollow Threat,* 27-90.
[48] Borowski, *Hollow Threat,* 94-5.

Soviet secrecy made the location of many military facilities difficult for outsiders to determine. SAC bombers attacking the Soviet Union would also need to overcome Soviet defense measures that the aircraft used to drop the bombs on Hiroshima and Nagasaki did not have to face.[49] SAC planners were also aware that fissionable materials were in such short supply that only thirteen atomic weapons were available in July 1947 and fifty a year later; and that for the near term, atomic bombs would continue to be large, heavy and awkward like the two used against Japan. Therefore, in 1946, SAC planned to attack enemies using both atomic and conventional bombs. A few nuclear-armed B-29s were being prepared to strike on their own under cover of bad weather or nighttime, or as part of a larger group of bombers.[50]

Cold War tensions deepened between the United States and its erstwhile World War II ally, the Soviet Union, in 1947 and 1948. The communist seizure of power in Czechoslovakia in 1948 drove home to many Americans the severity of the Soviet threat. Late in June 1948, the Soviet government blocked rail and road access through the zone of Germany it controlled to the zones of Berlin controlled by the United States, Britain and France. The western allies responded with the Berlin Airlift, which continued until the following May, when the Soviets acknowledged its success by lifting their blockade. In July 1948, Truman authorized additional B-29 bombers to be deployed to Britain and Germany. No atomic weapons or bombers capable of carrying them were moved to Europe, and the only bomber group capable of delivering nuclear bombs remained in the

[49] Borowski, *Hollow Threat,* 94-105.
[50] Futrell, *Ideas, Concepts, Doctrine*, 215-6, 232, 237, 283.

United States but went on 24-hour alert.[51] The moves sent a message to the Soviets but also raised questions among American policymakers. Atomic weapons remained under civilian control at the time and Truman declined to indicate when or under what circumstances he would release those weapons to the military. This fact also complicated military planning. The United States' first emergency war plan of the post-World War II period had only been drawn up a few weeks before the Berlin Airlift began, and as Borowski concluded, it "left important questions unanswered."[52]

When Gen. Hoyt S. Vandenberg became the USAF's Chief of Staff in 1948, he was deeply concerned about SAC's state of readiness for war, in part because of a critical report on air force combat readiness prepared by famed aviator Charles A. Lindbergh. With the crisis in Berlin heightening the need for military readiness in the eyes of the Truman administration and U.S. military leaders, Vandenberg appointed Maj. Gen. Curtis E. LeMay as SAC's commander in October. If anyone personified the United States Air Force in its early years to both its supporters and detractors, it was Curtis LeMay. During World War II, he rose quickly up the ranks as he developed effective bombing techniques in the European theatre and then between March and July 1945, he directed the firebombing that laid waste to sixty Japanese cities and killed hundreds of thousands of Japanese civilians. LeMay led SAC for nine years, and then served as the USAF's chief of staff from 1961 to 1965. The cigar-chomping general became famous for his aggressive support of strategic bombing with nuclear weapons, and for his statement that the U.S. military should bomb North Vietnam "back into the Stone Age." His notoriety

[51] Craig and Radchenko, *The Atomic Bomb and the Origins of the Cold War,*128-30; Borowski, *Hollow Threat,* 123-9; Millis and Duffield, *Forrestal Diaries*, 456-8; Williamson and Rearden, 85-90. See also D.A. Rosenberg, "Origins of Overkill," 12-6.
[52] Borowski, *Hollow Threat,* 123-4; McCullough, *Truman,* 603.

was sealed in 1968 when he ran for vice-president as the running mate of Alabama segregationist George Wallace.[53]

Gen. Curtis LeMay in the 1960s (USAF)

In his early months commanding SAC, LeMay worked vigorously to deal with what he saw as SAC's organizational, logistical and morale deficiencies. He was

---

[53] Neil Sheehan, *A Fiery Peace in a Cold War: Bernard Schriever and the Ultimate Weapon* (New York: Random House, 2009) 130-6. See also Thomas M. Coffey, *Iron Eagle: the Turbulent Life of General Curtis LeMay* (New York: Crown Publishers, 1986); Barrett Tillman, *LeMay* (New York: Palgrave Macmillan, 2007); Gen. Curtis E. LeMay with McKinlay Kantor. *Mission with LeMay: My Story* (New York: Doubleday and Co., 1965).

determined to end lackadaisical peacetime routines and bring his aircrews to a state of full preparedness as if it were wartime. Before he began new training programs, LeMay gave his command a graphic demonstration of how unprepared they were for their mission when in January 1949, he organized a mass simulated bombing exercise over Wright Field at Dayton, Ohio. LeMay later wrote: "Not one airplane finished that mission as briefed. *Not one.*" Aircrews were not accustomed to flying as high as the required altitude of 30,000 feet, and this failed exercise led to an aggressive training program. Instead of the leisurely peacetime routine that had existed before and after World War II, LeMay made sure that SAC was prepared for a war that could start the next morning.[54]

LeMay also was concerned about the capabilities of his bombers. The AAF had finished the war with a fleet of propeller-driven aircraft that could not cover the great distances involved in reaching targets inside Russia from bases in the American mainland. The arrival late in the war of the first aircraft equipped with jet engines meant that the air force and contractors had to learn how to build and use the new engines and operate aircraft at the high speeds they made possible. It was only in October 1947 that an aircraft flew faster than the speed of sound, and years of work lay ahead after that before aerodynamics at supersonic speeds would be understood.[55]

In the meantime, LeMay had to deal with the limitations imposed by the bombers he had on hand. To get around the political problems involved with foreign bases for SAC's B-29s and its uprated B-29s designated as B-50s, LeMay sought to increase their range with new in-flight re-fueling technologies and tanker aircraft. He also pressed for

---

[54] Borowski, *Hollow Threat,* 163-8; LeMay and Kantor, *Mission with LeMay,* 432-9. Emphasis in original.
[55] Alfred Goldberg, ed., *A History of the United States Air Force 1907-1957* (Princeton, N.J.: D. Van Nostrand Company Inc., 1957). 122, 202-8; James R. Hansen. *The Bird is on the Wing: Aerodynamics and the Progress of the American Airplane* (College Station, TX: Texas A&M University Press, 2004) 110-8.

the development of longer-range bombers capable of delivering bombs directly from the United States to the Soviet Union despite the many technical difficulties that stood in the way of that goal. The first aircraft that had this capability was the B-36, which entered service in 1949 after a tough development process. The first jet-propelled long-range bomber, the B-47, also experienced some problems with its development before it came into service in 1951. The B-52, which became the mainstay of U.S. bombing capability for decades, came into service four years later.[56] The questions hanging over the basing of U.S. bombers in Europe were reduced in 1949, when the United States signed the North Atlantic Treaty with western European nations and Canada, which provided a legal basis to continue the United States military presence in Europe, including bombers.

SAC markedly improved its ability to deliver atomic bombs in 1949. By 1950, SAC had 225 bombers capable of dropping atomic bombs, including B-29s, B-50s and thirty-four of the new B-36s. The aircraft had 263 combat ready aircrews, and eighteen bomb assembly crews. More aircrews and assembly crews were being trained. Much of this increasing strength came at the expense of resources for conventional bombing.[57] The air force's ability to deliver a crippling blow to the Soviet Union was questioned by critics in the navy in 1949, and in two military reports the following year. In May 1950, the Harmon committee of top military officers determined that strategic bombing could cause serious damage to the Soviet Union but questioned whether this damage would cause a Soviet surrender or weaken the Soviet government. The Joint Chiefs of Staff's

[56] Borowski, *Hollow Threat,* 154-5. Michael E. Brown, *Flying Blind: The Politics of the U.S. Strategic Bomber Program* (Ithaca: Cornell University Press, 1992) contains thorough accounts of the development of the B-36 and B-47 bombers, 68-160.. Later versions of the B-36 were equipped with two jet engines to complement its six propeller engines.

[57] Borowski, *Hollow Threat,* 191-2; D.A. Rosenberg, "Origins of Overkill," 16. Werrell's history of strategic bombing, *Death From the Heavens,* contains an excellent summary of the personnel, political and technical issues facing SAC, 155-72. For the Soviet side of this matter, see David Holloway, *Stalin and the Bomb: the Soviet Union and Atomic Energy, 1939-1956* (New Haven: Yale University Press, 1994) 227-45.

weapons evaluation group completed a report on strategic bombing in February 1950 that warned of logistical deficiencies in SAC, along with the possibility of a high rate of bomber loss due in part to a lack of information on Soviet defenses against bombers.[58] Even with LeMay's reforms to SAC, the U.S. Air Force still faced major challenges developing the means to attack the Soviet Union with bomber aircraft.

During the late 1940s, engineers and scientists in the Soviet Union were also working to build nuclear weapons and the bombers and missiles needed to carry them. Although American estimates of when the Soviets would have a nuclear weapon varied widely, some knowledgeable Americans realized that they would not be far off, particularly after the 1946 revelations of Soviet espionage. [59] In the event, the first Soviet atomic explosion took place in August 1949. While the first Soviet nuclear explosion and the communist takeover of China in 1949 moved Truman on 31 January 1950 to order that research and development begin on thermonuclear weapons, a decision that would have important implications for missile programs, the president still hoped to keep the lid on military spending. But in April, the National Security Council produced a report known as NSC-68 that called for a major increase in defense spending, reflecting a growing consensus inside the State Department and the military for this increased spending. NSC-68 became one of the most famous and controversial documents of the Cold War. Historian Greg Herken argued NSC-68 amounted to a permanent mobilization for the Cold War. In that environment, the Korean War began with the North Korean communist invasion of South Korea on 25 June. Truman's responses to this act included

---

[58] Steven L. Rearden, *History of the Office of the Secretary of Defense, Volume I, The Formative Years, 1947-1950* (Washington D.C.: Historical Office, Office of the Secretary of Defense, 1984) 407-9.

[59] For a thorough discussion of the Soviet nuclear weapons program and American reactions to it, see Michael D. Gordin, *Red Cloud at Dawn: Truman, Stalin, and the End of the Atomic Monopoly* (New York: Farrar, Straus and Giroux, 2009).

loosening the restraints on defense spending and ratifying NSC-68. Within months, the USAF had grown well beyond seventy groups to 100 groups. .[60]

In considering the air force's position on bomber aircraft in the late 1940s, historian Thomas P. Hughes' ideas on technological systems apply to describe the new technological system being devised by the air force to deliver nuclear weapons to targets in adversary nations. Between 1945 and the end of the 1950s, that system was based exclusively on bomber aircraft carrying nuclear bombs. In the late 1940s, bomber aircraft constituted what Hughes called "reverse salient," a component that has fallen behind other system components. Hughes took this idea from the military concept of advancing fronts or lines in battle, and focused on sections of those battlefronts that do not advance as fast as other parts. The reverse salients in technological systems can have technical, economic, social and political causes, and sometimes they defy correction, which can lead to creation of whole new systems.[61] The U.S. air force at that time believed that its existing aircraft and aircrews were not up to the task of performing their central mission of carrying nuclear bombs into the heartland of the Soviet Union**.** The air force concentrated its limited financial resources on correcting this reverse salient.

During the five years between World War II and the Korean War, as Borowski explained, there had been a major gap between the air force's potential capability to

---

[60] Borowski, *Hollow Threat,* 186-210; Wilson D. Miscamble, "The Foreign Policy of the Truman Administration: A Post-Cold War Appraisal," *Presidential Studies Quarterly*, Vol. 24, No. 3 (Summer 1994), pp. 479-495; Herken, *The Winning Weapon,* 329-32. Secretary of State Dean Acheson and State Department official Paul Nitze provided the main inspiration behind NSC-68. For more on NSC-68, see, Paul Y. Hammond, "NSC-68: Prologue to Rearmament," in Schilling, Hammond, Snyder, eds. *Strategy, Politics and Defense Budgets,* 267-378; and Hogan, *Cross of Iron,* 291-314.
[61] Thomas P. Hughes, *Networks of Power: Electrification in Western Society, 1880-1930* (Baltimore: The Johns Hopkins University Press, 1983) 7-17. Hughes also discusses these themes in, "The Evolution of Large Technological Systems."

attack the Soviet Union with bomber aircraft and its real capability.[62] The Strategic Air Command was created in 1946 and had to build itself to meet the challenges of a possible war with the Soviet Union. This included building a bomber force with new aircraft using new technologies such as jet engines and capable of flying much longer distances than during World War II. Moreover, SAC had to recruit and train new aircrews after its most experienced personnel had left the forces at the end of the war. This work didn't begin in earnest until 1948, when Gen. Curtis LeMay assumed command of SAC. Finally, in 1950 the air force's bombing force was beginning to round itself into shape. Given the problems the air force faced with its bomber force during these years, combined with the restrictions on funding of the time, it is not surprising that development of an unproven technology like long-range missiles should suffer.

Conclusion

The atomic bomb had proven its power in Japan, but it remained difficult to produce, maintain and deliver to far-off targets in the late 1940s. President Truman's "apprehensions and prudence" about nuclear weapons after August 1945 contributed to the slow progress on developing American nuclear strategy, historians Samuel L. Williamson and Stephen Rearden wrote in their history of U.S. nuclear strategy under Truman.[63] The Cold War did not begin immediately after the end of World War II, and until 1948, the U.S. government's only policy on nuclear weapons called for international control. Even after that policy was abandoned, Truman did not allow the Atomic Energy Commission to release nuclear weapons to the military until 1951. The lack of fissionable materials, production problems with early nuclear weapons, and the time needed for

---

[62] Borowski, *Hollow Threat, 218.*
[63] Williamson and Rearden, *Origins of U.S. Nuclear Strategy,* 191,

policymakers and military strategists to incorporate nuclear weapons into their planning also slowed the incorporation of nuclear weapons into the U.S. military. At higher policy levels, the new and unprecedented power of nuclear weapons resulted in consideration, at least for a time, of internationalizing nuclear energy. Through the late 1940s, the United States government and military were learning to build, maintain and above all, live with this new weapon. Until the Soviet Union ended America's nuclear monopoly in 1949, the U.S. nuclear arsenal gave the United States a seemingly inexpensive means of holding the Soviet Union in check.

Between the end of World War II and the beginning of the Korean War, the air force underwent a set of major changes. When the war ended, the AAF began the work of transforming its bomber force from propellers to jet engines, and of increasing the range of these bombers to intercontinental ranges, tasks that continued well into the 1950s. The Strategic Air Command had to recreate America's bomber force to handle a new weapon, the atomic bomb, using new kinds of aircraft and new personnel to replace those who left in 1945. SAC was just beginning to round itself into an effective force when the Korean War began. In 1945, the air force was a branch of the U.S. Army, and in 1947 it finally achieved its long-sought goal of autonomy. But the establishment of the USAF in 1947 did not end the controversy between it, the army and the navy over their respective roles, especially where nuclear weapons were involved.

Edmund Beard, in his *Developing the ICBM: A Study in Bureaucratic Politics,* argued that the U.S. military's development of the ICBM was hindered by "organizational structures and belief patterns" inside the air force, especially its preference for bombers. Beard provided little information on the background to this preference beyond a summary of the Finletter Commission's 1949 report backing the air force's call for seventy groups.[64] The air force's preference for bombers was a reality, but policy makers and military leaders understood that U.S. bomber aircraft and bomber forces in the first five years after World War II were clearly inadequate for the job of delivering nuclear weapons to targets inside the Soviet Union from the United States. Moreover, the air force in the late 1940s operated in a policy environment where higher authorities were trying to decide how and under what circumstances nuclear weapons should be used. And the nuclear weapons available between 1945 and 1954 were unsuited for any delivery method other than crewed bomber aircraft. Given the state of the art of both nuclear weapons and bomber aircraft, it is little surprise that the air force saw missiles that could carry nuclear weapons intercontinental distances as a highly futuristic idea rather than something that needed immediate attention.

[64] Beard, *Developing the ICBM,* 8, 75-8, 218; Perry, *The Ballistic Missile Decisions,* 5.

Chapter 2
The Politics of Guided Missiles

The history of United States guided missile programs in the early years of the Cold War was punctuated by rivalries between the army, navy and air force over control of these new weapons. These struggles went on for more than a decade, but they were fought most fiercely in the early years after World War II as part of the larger battle over military reorganization. The Army Air Forces' overriding objective of the time was to win its independence from the army with the widest possible mission. The air force also sought control of missiles because of their potential for war making. The outcome of these rivalries led to the air force winning an initial victory in 1947 over the army in its struggle to gain control of America's ICBMs and other long-range missiles.

In recounting the background of this struggle, this study seeks to divine the AAF's attitudes to missiles as it emerged from World War II and moved toward its goal of autonomy in 1947. The existing historiography of America's ICBMs has cast a critical focus on the air force since it built America's ICBM force, and so it is important to see how missiles were viewed inside the air force in an effort to judge the validity of conclusions reached by historians on the development of ICBMs. And the matter of which armed service won the jurisdictional battle over America's long-range missiles is also important because the outcome of this dispute would affect all three services, the management and design of America's nuclear forces, and even the United States space program that emerged in part out of military missile programs.

This and upcoming chapters in this dissertation will deal mainly with a relatively small group of decision-makers in the U.S. government, starting with the officers at the top of the U.S. Army Air Forces, including the Air Staff, which assisted the AAF

Commanding General in setting policy and directing the AAF, and later the United States Air Force. As well, this chapter will examine the work of leading officers in the AAF's Air Materiel Command, which for much of the period covered in this study had vast responsibilities, including guided missiles development. This study will also examine the roles of officials in the U.S. defense bureaucracy, including the Joint Chiefs of Staff, the President of the United States, and scientific and engineering advisory groups involved in missile programs.

The findings of this chapter are based on a range of documentary evidence, some of it not used before, that follows how members of the Air Staff worked from 1944 up to the time the air force won its autonomy in 1947 to gain control of military guided missile programs. These sources are backed up by the most detailed study of the Air Staff's efforts on missiles during this time, air force historian Max Rosenberg's 1964 monograph, *The Air Force and the National Guided Missiles Program, 1944-1950*. Like similar air force historical studies quoted in this dissertation, Rosenberg's work focuses narrowly on air force actions and does not question air force priorities or the need for weapons systems. Primary sources used in this chapter will also illuminate how top officers in the Air Materiel Command thought the air force should use missiles.[65]

While a few air force officers in the late 1940s looked to AAF Commanding General Hap Arnold's vision of intercontinental missiles, many others saw guided missiles simply as a means of extending the reach of bomber aircraft with air-launched missiles, or as a means of defense against enemy aircraft. Air force officers were not alone in seeing missiles this way – many decision makers elsewhere in the military and

---

[65] Max Rosenberg, *The Air Force and the National Guided Missile Program 1944-1950* (Washington D.C.: USAF Historical Division Liaison Office, June 1964). Beard, *Developing the ICBM,* 15-44.

the U.S. government continued to place a higher priority on defensive missiles than long-range missiles up to 1953. This point, which will be explored later in this study, has been missed by previous accounts that were written with the perceived Soviet lead in missiles following Sputnik in mind.

This thesis has already argued that during the first months after the end of World War II the role of nuclear weapons in the American arsenal was far from being established, and the idea that the Soviet Union was America's adversary took some time to come into focus. These facts form the background to the inter-service struggles outlined in this chapter, where missiles became part of the contest in the military for resources and jurisdiction. This chapter will show that long-range missiles were not important to decision-makers in the air force in the late 1940s, except to a small but influential group in the Air Staff that sought to hold jurisdiction over these missiles to defend the air force's monopoly over nuclear weapons. One reason is that long-range strategic missiles such as ICBMs were just one of many types of missiles under consideration in the late 1940s, and one that seemed a particularly distant prospect. To properly tell the story of ICBMs, one must situate them amongst the many types of missiles under development during and after World War II.

Guided Missiles Background

In the late 1940s, guided missiles were seen in a different light from the present day. While today the term guided missile brings to mind a rocket with a guidance system, the popular definition in use in the United States in the 1940s was much broader. A missile can mean a variety of objects, including rocks, spears, arrows, bullets, bombs or rockets, projected or fired toward another object or target, and this definition remains in use when referring to ancient and medieval warfare. Guided missiles could have their courses altered by an internal mechanism controlled by radio or television signals, target-seeking radars or other devices, or through preset target information, as in torpedoes and the German V-1 and V-2 missiles. Not everyone at the time considered the last group to be guided missiles, and sometimes the term was narrowed to serve a particular purpose. Up to 1954, the air force used the term pilotless aircraft almost interchangeably with guided missile, although at times pilotless aircraft denoted a particular type of guided missile. As air force historian Max Rosenberg explained it, the air force promoted the term pilotless aircraft to "discourage the other services from encroaching on Air Force missions and roles."[66] The shifting definition of guided missile inside the AAF also reflected the air force's lack of knowledge about the full possibilities of this type of weapon.

The experience of the AAF and its predecessor organizations with guided missiles dates back to 1917, when it began experiments with remote-controlled aircraft and bombs that continued through the inter-war period. These programs proliferated during World War II, and air force historian Mary R. Self, writing in 1951, divided the AAF's wartime missile projects into four groups, illustrating the wide variety of weapons that fit into the definition of guided missile at the time:

> Group I consisted of various airplanes or airplane-like structures, powered conventionally, loaded with explosives, and remotely controlled into a target. Group II consisted of glide bombs or glide torpedoes, which were air launched and guided to the target by various means. Group III consisted of air-launched missiles of conventional bomb design and construction, controlled in range and/or azimuth from the launching plane, or by self-contained devices which sought out

[66] M. Rosenberg, *National Guided Missile Program,* 2-4.

> the target. Group IV consisted of a series of missiles evolved from the German 'buzz-bomb,' or V-1, a surface-to-surface missile.[67]

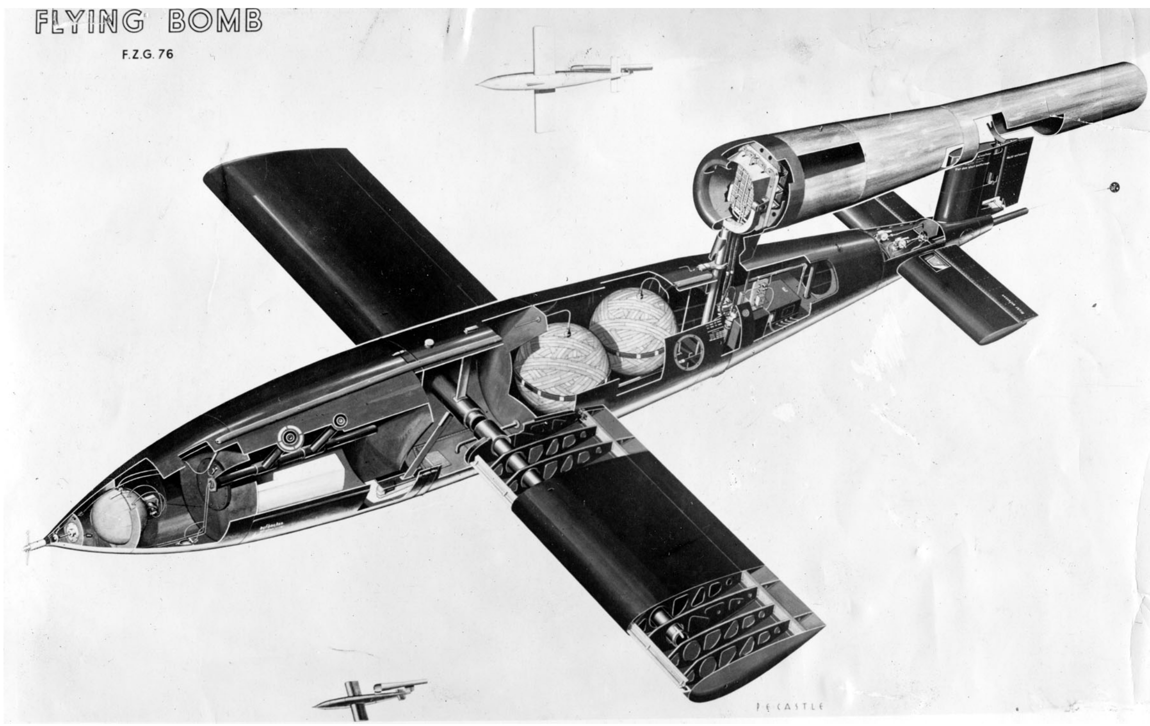
None of these guided missiles were surface-to-surface rocket-propelled vehicles, as ICBMs would be. Other U.S. military organizations, however, had developed surface-to-surface rockets during the war. The National Defense Research Committee (NDRC), a wartime agency set up to sponsor military-related research, supported research on solid fuel rockets that led to rockets launched by infantry and from aircraft and ships. The NDRC began its rocket work in 1940 at the suggestion of Clarence N. Hickman of Bell Telephone Laboratories, who had worked with American rocket pioneer Robert H. Goddard in World War I. Hickman was associated with the most famous product of the NDRC rocket program, the tube-launched "bazooka" that allowed infantry soldiers to fight against tanks. California Institute of Technology researchers at the Jet Propulsion Laboratory (JPL) carried out some of the NDRC rocket work, helping lay the foundation for JPL's work with solid rockets after the war.[68]

Guided missiles won widespread attention from American military leaders for the first time in June 1944, when the German military began launching its V-1 winged pulse-jet missile. The V-1 was developed for the German Luftwaffe (air force) and lived up to the title of pilotless aircraft. The AAF exploited recovered parts from V-1s to design a duplicate craft, which became known as the JB-2 or the Loon. The AAF and its contractors also began developing other 'flying bombs.' The AAF had hoped to use the JB-2 in combat while the war continued, and historian Donald J. Hanle argued in his recent study of the AAF's guided bomb projects that AAF Commanding General 'Hap'

---

[67] Mary R. Self, *History of the Development of Guided Missiles: 1946-1950* (Dayton Ohio: Historical Office of the Air Material Command, 1951) 1-4.
[68] James Phinney Baxter 3rd, *Scientists Against Time* (Boston: Little, Brown and Company, 1946) 201-11.

Arnold promoted AAF development of the missile in part to block Army Ordnance's aspirations to gain control of missiles. Production work on the AAF version of the JB-2 stopped, however, when the war ended, and early in 1946, the AAF cancelled all the 'flying bombs,' including the JB-2. In September 1944, the Germans began launching V-2 ballistic rocket missiles against targets in England, France and Belgium. Because the V-2 was far more advanced than every other missile of its type at the time, the AAF did not consider trying to replicate a similar rocket at that late point in the war.[69]



Cutaway of German V-1 jet-powered missile (USAF National Museum)

In general, the AAF's wartime missile development programs had been limited to the development of weapons that planners hoped could be quickly built for immediate use, but they were hampered by a lack of central direction, adequate funding and facilities, and qualified staff. In 1943, responsibility for guided missiles within the Air

[69] M. Rosenberg, *National Guided Missile Program,* 9-10; Donald J. Hanle, "Near Miss: The Story of the Army Air Forces' Guided Bomb Program in World War II" (Ph.D. diss., George Washington University, 2004) 327-8. The U.S. Navy also developed the JB-2 for its own purposes.

Staff had been given to the Air Communications Officer until shortly before the end of the conflict. Although this officer, Brig. Gen. H. M. McClelland, held a high rank, he was already burdened with many unrelated responsibilities. Hanle argued that the AAF guided missile programs failed to progress because the wrong person was put in charge of these weapons programs.[70]

The German use of the V-1 and V-2 also drew the interest of Army Ordnance and the U.S. Navy, and soon they were both contending with the AAF for control of military guided missile programs. The AAF looked on the V-1 and V-2 as new types of aircraft, while the other branches of the army thought of them as new forms of artillery. When Caltech researchers proposed developing rocket engines for the army in November 1943, the AAF turned down the idea but Army Ordnance signaled its interest. In January 1944 Army Ordnance asked Caltech to begin work on what became the solid-fueled Private and liquid-fueled Corporal rockets under the ORDCIT (Ordnance/California Institute of Technology) program. Also in 1944, Army Ordnance signed a contract with General Electric to begin the Hermes program, which had the aim of using captured German technology to develop guided missiles and associated technologies, including rocket engines and ramjets, a type of jet engine that appeared to hold promise for high-speed aircraft and missiles.[71] When the war in Europe ended in 1945, the army hired more than

---

[70] D. Hanle, "Near Miss," 78-80; M. Rosenberg, *National Guided Missile Program*, 11-3. The person in authority who assigned missiles to McClelland is unknown. The Air Staff continued in a similar form after 1947 to serve the Secretary of the Air Force and the Chief of Staff of the U.S. Air Force. For more information on the structure of the Air Staff, see Monro MacCloskey, *The United States Air Force* (New York: Frederick A. Praeger, 1967) 85-94.
[71] Frank J. Malina, "Origins and First Decade of the Jet Propulsion Laboratory," in Eugene M. Emme (ed.), *The History of Rocket Technology* (Detroit: Wayne State University Press, 1964) 60-2; Clayton R. Koppes, *JPL and the American Space Program: A History of the Jet Propulsion Laboratory* (New Haven: Yale University Press, 1982) 18-22; Julius H. Braun, "The Legarcy of HERMES," 41st Congress of the International Astronautical Federation, Dresden, GDR, 6-12 October 1990; "Hermes Guided Missile Research and Development Project," prepared for Technical Liaison Branch, Office of the Chief of

one hundred of the top German rocket experts headed by Wernher von Braun who had designed and built the V-2 rocket, and it also gathered partially assembled V-2 rockets, associated parts and blueprints. The German rocket group and the rockets were brought to the United States, where the Germans launched some of the V-2s under army and General Electric supervision for the Hermes program, and then carried on research in technologies related to rockets and ramjets as part of Hermes.[72]

Among several guided missile programs it initiated during the war, the U.S. Navy began work on an adapted version of the JB-2 for launch from aircraft carriers and submarines, and it even contracted the Applied Physics Laboratory at Johns Hopkins University to study anti-aircraft missiles and a "long-range bombardment missile."[73] The navy's foray into anti-aircraft missiles and the Army Ground Forces' request to Army Ordnance to develop an anti-aircraft rocket drew the AAF's attention because it wished to gain control of defenses against enemy aircraft. By September 1944 Air Staff officers were already lobbying the War Department General Staff to give responsibility for all military missile work to the AAF.[74]

Aircraft or Artillery

The question of which military service controlled missiles had been resolved in varying ways in different countries. In Nazi Germany, the Luftwaffe supervised the

---

Ordnance, Department of the Army, September 25, 1959, in NASA Headquarters History Office Historical Reference Collection; Lt. Col. John F. O'Neill, memorandum for record, "Air Force Administration of Army Ordnance Guided Missile R & D Projects," 18 July 1949, in RG 341, Guided Missiles Branch, Box 115, NA.

[72] Michael J. Neufeld, *Von Braun: Dreamer of Space, Engineer of War* (New York: Alfred A. Knopf, 2007) 199-222, 238-40. The extensive literature on von Braun is discussed in Chapter7.

[73] Statement of Rear Adm. John T. Hayward, Assistant Chief of Naval Operations for Research and Development, "History of the Navy Entry into the Guided-Missile Program," 3 March 1959, House of Representatives, Subcommittee of the Committee on Government Operations, *Organization and Management of Missile Programs*, 1st Session, 86th Congress (Washington, D.C.: U.S. Government Printing Office, 1959) 431-4.

[74] J. Neufeld, *Ballistic Missiles,* 17-8.

development of the V-1, a winged jet missile, while von Braun's team developed the V-2 rocket under the auspices of German Army Ordnance. In the Soviet Union, Stalin's Council of Ministers placed missile development under the artillery branch of the Red Army, although the aviation industry was also heavily involved in developing missiles. In the United States, the AAF's existence as a branch of the U.S. Army complicated the question of jurisdiction over missiles during the war and until the air force won its autonomy in 1947. Two branches of the U.S. Army, the AAF and the Ordnance Department, vied for control of army guided missile programs between 1944 and 1947, and the navy was also developing missiles.[75]

Because the air force viewed missiles as aircraft and the army saw them as a form of artillery, the results of the contest between the two services impacted the design, capabilities, and evolution of America's ICBMs and also its space launch vehicles. Aircraft design puts a premium on lightweight streamlined design, while cannons and other artillery pieces are designed with durability more in mind. The army missile team, which included many of the rocket experts who built the V-2 rocket in Germany, would have used different management techniques and fashioned their own technical designs from the air force to build ICBMs. For example, the army had a tradition of in-house development and production under its arsenal system, while the air force generally used private contractors to develop equipment such as aircraft and missiles.[76] In addition, the air force already controlled what was then America's only means of delivering nuclear

[75] M. Neufeld, *Von Braun,* 124, 134; Steven J. Zaloga, *Target America: The Soviet Union and the Strategic Arms Race, 1945-1964* (Novato CA: Presidio Press, 1993) 115-6. In 1959, the Soviet government placed control of all ballistic missiles under their own branch of the Soviet military, the newly created Strategic Missile Forces.

[76] For more on in-house development in the U.S. military during these years, see Thomas C. Lassman, *Sources of Weapon Systems Innovation in the Department of Defense: The Role of In-House Research and Development, 1945-2000* (Washington, D.C.: Center of Military History, United States Army, 2008).

weapons to its adversaries, crewed bomber aircraft, while the army had no involvement with nuclear weapons at the time. This fact alone would also have caused the army to handle ICBMs under its jurisdiction in a different manner from the air force. The differences between the air force and army research and development functions fit in with historian Thomas Hughes' ideas about how components of technological systems, in this case missiles, are socially constructed because they are developed by system builders and are not simply dictated by applied science and economics. To take his argument, there is no single best way of building a missile, and different system builders, such as the air force or Army Ordnance, build things in different ways and have their own technological styles.[77]

Indeed, the air force and its contractors formed a distinct management structure that developed new weapons in a decidedly different manner from that of Army Ordnance. Von Braun and his team developed a reputation of being conservative in their use of technology both at Army Ordnance and later on in the 1960s when they built the Saturn rockets in the Apollo program, while Convair, which built the Atlas ICBM for the air force, developed cutting edge concepts for Atlas such as the rocket's thin skinned fuel tanks.[78] For reasons of approach, background and style, America's first ICBM would have taken a different form from Atlas if the job had gone to Army Ordnance rather than the air force.

The Atlas and Titan ICBMs developed by the USAF ultimately became important launch vehicles for the U.S. space program. In addition, after the air force won control of

---

[77] Hughes, "Evolution of Large Technological Systems." 51-2, 68-70.
[78] M. Neufeld, *Von Braun,* 220, 365. Loyd S. Swenson Jr., James M. Grimwood and Charles C. Alexander, *This New Ocean: A History of Project Mercury* (Washington D.C.: National Aeronautics and Space Administration, 1966) 23-6.

ICBMs and most other long-range missiles in the late 1950s, many members of the army missile team were moved in 1960 to the United States civilian space program to direct the building of the Saturn rockets that powered Apollo spacecraft to the Moon.[79] The fallout from the inter-service dispute over ICBMs, therefore, had important consequences, not only for America's ICBM program but also its space program.

The McNarney Directive

When U.S. Army Chief of Staff Gen. George Marshall and the War Department General Staff first began looking into the question of who should be responsible for guided missiles in September 1944, the AAF expected to win clear jurisdiction over missiles because of its work on the JB-2 missile that replicated the V-1, but feared that Army Ordnance would also seek control over missiles. A decision came on 2 October 1944, when a memorandum signed by Marshall's deputy chief of staff, Lt. Gen. Joseph T. McNarney, set out responsibility for guided missile research and development within the War Department, covering the army and the AAF. The McNarney directive, as the memorandum became known, gave the AAF responsibility for "all guided or homing missiles dropped or launched from aircraft," and "all guided or homing missiles launched from the ground which depend for sustenance primarily on the lift of aerodynamic forces." The Army Service Forces, in practice the Ordnance Department, were assigned ground-launched missiles "which depend for sustenance primarily on the momentum of the missile" – that is, a missile that reached its target purely on its own thrust and not using wings – a definition that encompassed what would later become known as ICBMs. Under the directive, propulsion and control systems were to be developed by the service building the missile, while warheads, launching systems and other ground systems were

[79] M. Neufeld, *Von Braun,* 333-47; Medaris and Gordon, *Countdown for Decision,* 48.

to be developed by any service having technical competence in those areas. The directive also called on the services to "freely coordinate their efforts and exchange information" on their weapons projects to allow any service to develop missiles that they saw as being useful to meet their own goals, but it did not address who would gain operational control of missiles once they were developed.[80]

Since the AAF had not been involved in building ground-launched rockets, the McNarney directive meant no immediate change in its missile work. Army Ordnance, on the other hand, had already begun work on ground-launched rockets. The McNarney directive, an ambiguous document that was clearly a compromise between the army's contending services, governed guided missile work for two years and fueled inter-service rivalries over control of missiles.[81] Because the AAF and Army Ordnance both established missile programs at the time, the directive marked the beginning of a rivalry over long-range missiles that continued through the late 1950s.

Fighting the Directive

Almost as soon as the McNarney directive was issued, the AAF began trying to change it. The AAF was looking to the day it won its autonomy and worried that Army Ordnance winning control of missiles, which it saw as aircraft that came under its jurisdiction, might interfere with that goal. In January 1945, both the AAF and the Army Ground Forces contended for the right to deploy the JB-2 missile, the American version of the V-1. The matter reached Gen. Marshall, who decided in favour of the AAF since the JB-2 had been developed by the AAF and was nearly ready for use. The following

[80] Lt. Gen. Joseph T. McNarney to Commanding General, Army Ground Forces, "Guided Missiles," October 2, 1944, in Spaatz Collection. box 263, R&D 2, Library of Congress. Ironically, McNarney was an AAF officer. The directive applied only inside the War Department and did not affect the U.S. Navy. M. Rosenberg, *National Guided Missile Program*, 17-21; D. Hanle, "Near Miss*,"* 86-93.
[81] M. Rosenberg, *National Guided Missile Program*, 22-3.

month, the Air Staff proposed that the AAF gain operational control of missiles for which the air force had developmental responsibility, and that small changes be made to the McNarney directive. But in June, the assistant deputy chief of staff, Brig. Gen. Henry L. Hodes rejected the proposal on Marshall's behalf, saying it was premature to begin assigning operational control of missiles to services before their exact capabilities were known. Japan's surrender and the war's end on 2 September 1945 did not reduce the desire of a number of Air Staff officers to establish the AAF's primacy in guided missiles over the other services. The Air Staff's general view of its mission was expounded by one of its leading members, Maj. Gen. Lauris Norstad, who in a policy guidance statement in November 1945 called the AAF the United States' primary defense force, a force that required any weapon available to carry out its mission of repelling air attacks.[82]

With the Air Staff protecting the AAF's interests in the field of missiles by trying to overturn the McNarney directive and looking out for what it saw as transgressions of the directive by Army Ordnance and the navy, the AAF had a free hand to move into the field of missiles. Under the direction of Commanding General Arnold, the AAF proceeded energetically to begin new missile programs of its own. The AAF headquarters served notice in August 1945 that it intended to develop several types of missiles to fulfill both defensive and offensive missions, and called for tenders on these missiles in October. Early in 1946, it began signing contracts with contractors to begin developing these missiles. The AAF Scientific Advisory Group headed by Theodore von Kármán issued its preliminary report, *Where We Stand,* in August 1945, and in December, the group issued its final report, *Toward New Horizons.* Both reports, which will also be examined at length in Chapter Four, were produced under Arnold's orders and supported

[82] M. Rosenberg, *National Guided Missile Program*, 23-30.

research on missiles, including long-range missiles. By then, the stakes for control of missiles had grown because the AAF had just demonstrated the power of nuclear bombs dropped by aircraft, and AAF officers were already considering the idea of marrying nuclear bombs to long-range missiles.

Gen. Carl Spaatz and Gen. H.H. 'Hap' Arnold (HSTL)

Brig. Gen. Alden R. Crawford, the chief of the AAF's Research and Engineering Division under the deputy chief of staff for materiel in the Air Staff, had some responsibility for the air force's missile programs and was particularly active fighting the McNarney directive in the fall of 1945. He circulated a proposed directive for the army chief of staff assigning guided missiles responsibility in a manner amenable to the AAF.

Crawford wrote that Army Ordnance and the AAF had "widely differing interpretations" of the McNarney directive, and called for a clarification of the U.S. military's guided missiles policy.[83] Crawford also specifically sought AAF control for long-range missiles. In response to the revelation that the German rocket team had contemplated transatlantic missiles during the war, Crawford ordered "that it should be understood that development of these types falls within the purview of the Army Air Forces."[84] Crawford's views were shared by other leading figures in the air force, including Maj. Gen. Hugh J. Knerr, secretary-general of the AAF Air Board, which Arnold's successor Gen. Carl Spaatz created to provide him strategic advice. "The aerial missile, by whatever means it may be delivered, is a weapon of the Air Corps. Unless we recognize it as such and aggressively establish ourselves as the most competent in this field, the responsibility therefore will become established by the Army or the Navy," Knerr wrote in February 1946.[85]

The Air Staff chafed at the openings the McNarney directive gave to the other services, and it responded in kind by interpreting the directive's provision granting the AAF control over missiles using aerodynamic forces for lift to widen the AAF's jurisdiction to include virtually every guided missile. The AAF's interpretation of the McNarney directive also reinforced its own view of missiles as a form of aircraft. Crawford claimed that the aerodynamic forces provision of the McNarney directive gave the air force jurisdiction over missiles that use wings and fins to extend their flight or

---

83 Brig. Gen. Alden R. Crawford, "Recommended Assignment of Guided Missiles Development Responsibility in the Army," undated but before October 15, 1945, in RG 341, Guided Missiles Branch, Box 141, file "Miscellaneous on Relative Priorities 1945-7" NA. U.S. Air Force, Biographies, "Major General Alden Rudyard Crawford," 8 August 1952, http://www.af.mil/information/bios/bio.asp?bioID=4884, accessed, 21 August 2010.

84 Gen. Crawford to Commanding General, Air Technical Services Command, "Guided Missiles of the German A-9 and A-10 Type," 28 September 1945, in RG 341, Guided Missiles Branch, Box 134, file "Special Inter Departmental Board," NA.

85 Futrell, *Ideas, Concepts, Doctrine,* 479. For more on the Air Board, see Wolk, *Struggle for Air Force Independence,* 154-7.

change the direction of flight. Air Staff officers criticized the Army Ordnance Department's plans to equip its Nike anti-aircraft missile and the Private and Corporal surface-to-surface missiles with what it called aerodynamic surfaces, and its hiring of an air force contractor, Douglas Aircraft, to design those surfaces and the airframe for Corporal. Crawford and other Air Staff officers similarly argued that all types of aircraft, including missiles, need wings to turn and to glide, and that the air force must win control of all missile programs to avoid duplication of cost and effort.[86] Air Staff officers also got word that the Army Signal Corps was developing a missile detection and warning system, and that the navy was hiring aircraft contractors like Curtiss-Wright and Consolidated Vultee to build anti-aircraft missiles. Both these actions impinged on the air defense mission that the AAF coveted. [87] These air force complaints in late 1945 came as the battle in the U.S. Congress over reorganization of the U.S. military was being joined with Truman's introduction of his proposed unification legislation.

When Gen. Dwight D. Eisenhower became army chief of staff in November 1945, the AAF lobbied him to win control of missile research. Eisenhower played a key role in the development of U.S. military missiles as army chief of staff to February 1948, and later from 1953 to 1961 as President of the United States. He had risen to prominence during World War II when he was appointed as Supreme Commander of Allied forces in

---

[86] Brig. Gen. Alden R. Crawford to Maj. Gen. E. M. Powers, "Guided Missiles," 28 February, 1946, in RG 341, Guided Missiles Branch, Box 142, file "GM Policy within USAF 47 and 48," NA; Chief of Air Staff to the Chief of Staff, draft of proposed memorandum, "Memorandum of 2 October 1944, from the Chief of Staff, Assigning Guided Missiles Development Responsibility," 8 October 1945, plus three addenda: "Tab A: Guided Missiles Will be Pilotless Aircraft with Airframes Built By Aeronautical Manufacturers;" Tab B: The A.A.F. has the Basic Experience on Guided Missiles and Guided Missile Component Development;" and "Tab C: High Priority Long-Term AAF Guided Missiles Program," in RG 341, Guided Missiles Branch, Box 142, file "Policy from Higher Authority," NA. Col. V.A. Stace, acting chief, Guided Missiles Branch, to chief, Research and Engineering Division, "Desired Transfer from ASF of Guided Missiles Development Responsibilities," 6 December 1945, in RG 341, Guided Missiles Branch, Box 142, file "Policy from Higher Authority," NA.

[87] M. Rosenberg, *National Guided Missile Program*, 28-9.

Europe early in 1944 and commanded the Allied invasion of western Europe that began in France in June 1944 and continued through the end of the war in Europe. During that time, he had to deal with the threats posed by the German V-1 and V-2 missiles, which had caused him concern because of their effects on military and civilian morale. Eisenhower was sufficiently impressed with these missiles that he expressed concern in a memoir of his wartime command that had the Germans began using them six months earlier than they did, the invasion of Europe might have proven impossible. As the postwar army chief of staff, Eisenhower had to look out for the competing interests of both the AAF and Army Ordnance, and keep in mind the interests of the U.S. Navy.[88]

Two Abandoned Projects

As sociologist Trevor Pinch has observed, the testing of technology can serve many purposes, including testing as performances to promote a certain technology or a particular technology provider.[89] In an example of this kind of testing, the AAF decided in January 1946 to fly a demonstration model of a long-range guided missile with a range longer than 3,000 miles before a deadline of 1 August 1946, "to impress upon the public that the Army Air Forces have, and can use immediately, some form of guided missile." The AAF quickly fleshed out the idea into a concept using a B-29 aircraft under automatic control. As a result, what became known as Project Banshee grew with an enlarged goal of testing guidance equipment. But Banshee began to fall behind schedule

[88] Eisenhower discussed the German missiles during the war in his *Crusade in Europe* (Garden City, NY: Doubleday & Co.: 1948) 229-30, 258-60, 328. M. Rosenberg, *National Guided Missile Program*, 30-1. See also Donald R. Baucom, "Eisenhower and Ballistic Missile Defense: The Formative Years, 1944-1961," *Air Power History,* Winter 2004, 4-17. There is an extensive literature on Eisenhower, and works on Eisenhower as president will be cited in.chapters 6 and 7 of this study. A standard biography of Eisenhower's pre-presidential years is Stephen E. Ambrose, *Eisenhower, Vol. 1: 1890-1952* (New York: Simon and Schuster, 1983).

[89] Trevor Pinch, "'Testing – One, Two, Three… Testing!': Toward a Sociology of Testing," *Science, Technology and Human Values,* Vol. 18, No. 1 (Winter 1993), 25-41.

as ground crews and contractors with limited resources dealt with the project's greater than expected complexity, and competed with other air force programs with higher priorities. Banshee was finally cancelled in 1949 without ever having flown a long distance.[90] The air force's first attempt to show mastery of guided missiles to the public had failed, boosting the importance of lobbying military and political leaders in its effort to win control of missiles.

A similar fate awaited the AAF's first scheme to mate nuclear weapons to guided missiles, which got its start when Air Staff officers began considering the idea upon hearing the news of the atomic bomb striking Hiroshima. In testimony to Congress in October 1945, AAF Commanding General Arnold mentioned the possibility of launching atomic bombs on missiles, and by January 1946, the AAF had the matter under active study. A few weeks later in March, the Air Staff directed the Air Materiel Command to solicit bids from industry for an atomic-capable missile called Mastiff. But the AAF soon ran into resistance from the management of the Manhattan Project, which refused to share technical information about nuclear weapons without highly elaborate security measures that air force research officers deemed impractical. The Atomic Energy Commission, which took control of nuclear weapons and materials from the Manhattan Project in January 1947, was not any more amenable to sharing information, so shortly before the air force became an independent service in September 1947, Mastiff was quietly dropped. No new discussions about nuclear-armed missiles took place until 1949.[91]

---

[90] Col. John G. Moore to Commanding General, Air Technical Services Command, "Guided Missiles," 11 January 1946, in document collection appended to Self, *History of Missile Development*; Self, 26-30.
[91] M. Rosenberg, *National Guided Missile Program,* 85-95.

Resistance in the Ranks

While members of the Air Staff were lobbying to win control of guided missiles, not everyone in the air force shared its interest in guided missiles. As part of his drive to orient the air force toward new technologies, Arnold had appointed Maj. Gen. Curtis LeMay in December 1945 as the deputy chief of Air Staff responsible for research and development. But Arnold soon retired, and in the words of historian Martin Collins, LeMay was reluctant during the nearly two years he held the research and development post "to assume even the circumscribed control and planning authority" that had been contemplated for his position. LeMay had won fame commanding fleets of bombers, and he remained committed to crewed bombers through this period and beyond, when he headed the Strategic Air Command.[92] In common with most other American military and political leaders of the time, LeMay saw missiles first as a defensive rather than a strategic weapon. "We in the air force are assuming that guided missiles will be fired at bombing vehicles whatever their form may take and are already taking measures to develop and destroy enemy vehicles whether they are fighter planes or guided missiles," he wrote the assistant secretary of war for air in May 1946. He made it clear that he still believed that crewed bombers remained the primary offensive weapon, at least in the short term, and added:

> It may well be that in the future this power may be more efficiently delivered by rockets or guided missiles than by heavy bombers; however, it is not here yet and the science of strategic bombing and the development of bombing equipment will keep pace with the defensive missiles used to stop it.[93]

---

[92]Martin J. Collins. *Cold War Laboratory: RAND, the Air Force, and the American State, 1945-1950* (Washington, D.C.: Smithsonian Institution Press, 2002) 216-7; Futrell, *Ideas, Concepts, Doctrine,* 481. LeMay was appointed commander of USAF forces in Europe in October 1947, and the following year he became commander of the Strategic Air Command.

[93] Futrell, *Ideas, Concepts, Doctrine,* 481

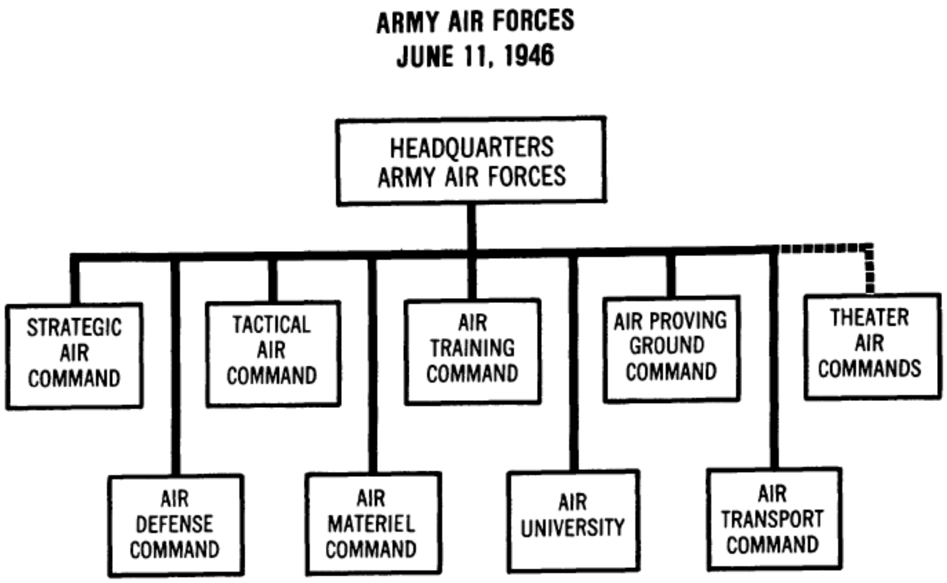
LeMay stated that even when offensive missiles were deployed, “military flexibility” would still demand use of crewed bombers. And while the record shows that he did not advocate for missiles as actively as Gen. Crawford, he always supported the goal of keeping missiles under air force control.[94]

As World War II ended, questions were raised inside the Air Staff about the AAF command that was responsible for guided missiles, then known as the Air Technical Services Command (ATSC) and after the air force reorganization of March 1946 as the Air Materiel Command (AMC). This command included a research and development organization based at Wright Field in Dayton, Ohio, that was responsible, among other things, for the air force’s guided missiles, The command’s responsibilities mainly involved managing contractors working on aircraft and missile programs. In September 1945, Gen. Crawford in the Air Staff called for a “decided change” in the thinking of the command’s leaders on missiles. Crawford complained that the command “has seemingly been content to let Ordnance get a decided jump on the long term guided missiles program” by placing contracts with traditional AAF contractors, including Caltech, Sperry Gyroscope, General Electric, Bell Telephone Laboratories, and Douglas Aircraft. He added that the navy “has the fastest moving development contract of any service for supersonic missiles.” Crawford charged that the command’s leaders considered guided missiles to be merely “’Buck Rogers’ gadgets,” and called on the command to prepare a comprehensive program for missile development.[95]

---

[94] Futrell, *ibid.* LeMay held a higher rank and a higher position in the Air Staff than Crawford. No information was found about the relationship between the two generals during the time when they held similar responsibilities in the Air Staff.

[95] Brig. Gen. Alden R. Crawford to Maj. Gen. E. M. Powers, “Army Air Force Long Term Guided Missiles Program,” 13 September 1945, in RG 341, Guided Missiles Branch, Box 144, file “Policy within A-4,” NA. In 1947, Wright Field was combined with nearby Patterson Field to create Wright-Patterson Air Force Base in 1948, and it remains the home of USAF research staff.



Source: Wolk, *Struggle for AF Independence*, 158.

Air Materiel Command's new commander, Lt. Gen. Nathan F. Twining, provided proof for Crawford's fears when he wrote Spaatz, the AAF's new commanding general, in March 1946 on the challenges of developing guided missiles for the armed forces. He listed twelve different types of missiles that he said needed to be developed to meet the air force's various needs. Two types of these missiles – ground-to-ground subsonic and supersonic missiles – were designated for varying ranges of 500, 1,500, 5,000, and 13,000 miles, some powered by rockets and others by jet engines.[96] "There have been endless jurisdictional arguments as to whether a given article is a Pilotless Aircraft or a Guided Missile; whether control fins were wings," Twining complained, and

[96] The officials quoted in this study refer to missile ranges in miles. To further complicate matters, U.S. military officials usually use nautical miles, which are longer than the statute miles commonly used in the English system of measures. A nautical mile (nm) equals 1.15 statute miles or 1,852 metres. This dissertation will therefore use miles for missile ranges and assume that nautical miles are being used. Five hundred nm are 926 km, 1,500 nm equal 2,778 km, 5,000 nm are 9260 km, and 13,000 nm are 24,076 km. Most ICBMs are designed to fly 5,000 nm (9,260 km) or farther.

disagreements over who had the right to build missiles with wings. Twining warned that duplication of missile contracts among the services would lead to as many as ninety-six missile contracts for the twelve types of missiles being contemplated by the military at the time, when there were only fifteen major aircraft manufacturers available. Twining raised an important point when he predicted that unless the number of missile contracts was limited, "American industry will have its development abilities heavily overloaded." He proposed that the AAF take responsibility for developing supersonic missiles and leave the navy subsonic missiles, with anti-aircraft missiles going to Army Ordnance, along with what he called the "V-2 type of Ground-to-Ground projectile," the type of missile that would include ICBMs. [97] Another air force general complained in early 1946 about "considerable duplication of responsibility and overlap of effort," and called for a single body to control missile programs based on one of three lines – an agency similar to the Manhattan Project, a War Department organization serving both the army and the AAF, or a single command of the AAF.[98] Although no response to these suggestions has been found, it seems very likely based on the evidence cited in this chapter that people in the Air Staff like Crawford and LeMay would have blocked any proposal that didn't involve making the AAF the military's primary agency for guided missile research, and no doubt they did not appreciate seeing the V-2 rocket called a projectile, a term that suggested it was an artillery piece and not an aircraft.

The AAF also watched how outside agencies dealt with the services' competing claims for missiles. Col. Marcus F. Cooper, chief of the AAF's guided missiles branch,

[97] Lt. Gen. N. F. Twining to AAF Commanding General, draft memo, "Guided Missiles," undated but probably early 1946, in RG 341, Guided Missiles Branch, Box 142, file "GM Policy within USAF 47 and 48," NA. Twining was a future U.S. Air Force Chief of Staff and Chairman of the Joint Chiefs of Staff.
[98] Brig. Gen. R.C. Coupland, "Guided Missiles Organization," 5 March 1946, in RG 341, Guided Missiles Branch, Box 93, file "AAF Policy 1946," NA.

advised Crawford that the National Advisory Committee for Aeronautics (NACA), the federal government agency charged with conducting aeronautical research, had formed a committee to coordinate its own guided missile work and had invited representatives from Army Ordnance and the Navy Bureau of Ordnance to sit on the committee alongside a representative from the AAF. Over the objections of AAF Generals Arnold and Ira Eaker, the NACA agreed to seat the ordnance and navy representatives. Cooper worried that this action could be seen as "[l]egitimizing the position of Ordnance in aeronautical development."[99]

Even AAF Commanding General Spaatz failed to support guided missile development in the crunch. When the Bureau of the Budget imposed cuts on the military in early 1946 as part of President Truman's decision to rein in military spending after the war, the AAF was a major target. Spaatz accepted a proposal to reduce AAF research and development funding that included work on missiles, but he tried to restore funds for aircraft building and civilian maintenance personnel.[100]

Historian Thomas Hughes has pointed out that technological systems can be made up of organizations, including private firms and governmental entities, and even legislative artifacts such as government laws and regulations. As well, Hughes argued that system builders have the ability to "construct or to force unity from diversity." In this section we have seen some of the diverse viewpoints in the air force around long-range missiles, amidst unity on points such as the need for the air force to win its autonomy and

[99] Col. Marcus F. Cooper to Brig. Gen. Crawford, "Inclusion of Ordnance Department and BuOrd Members in the NACA Guided Missiles Committee," 20 February 1946, in RG 341, Guided Missiles Branch, Box 129, file "NACA," NA.

[100] AAF Commanding General Carl Spaatz to the Budget Office of the War Department, "Reduction Air Force Estimates Fiscal Year 1947 by the Bureau of the Budget," 18 April 1946, in Spaatz Collection, General Correspondence, box 250, April – May 28, 1946, Manuscript Division, Library of Congress.

the importance of developing its strategic bomber force. The AAF embraced control of missiles as part of its wider goals of winning its autonomy and emerging from military reorganization with control of as many aspects of offensive and defensive military operations in the air as possible. But when it came to actually developing guided missiles, many leading figures were not as enthusiastic as some officers in the Air Staff.[101]

Review of the McNarney Directive

Despite the differing viewpoints on missiles inside the air force, the Air Staff's effort to win control of these new weapons by overturning the McNarney directive won a minor victory when the office of the army deputy chief of staff announced on 13 February 1946 that it would review the directive and the assignment of missile responsibilities between the army services and between the army and the navy.[102] A memorandum written by Crawford and signed by Spaatz on March 4 conceded that little duplication of effort had taken place up to then in the missile field, but it warned that "this condition cannot continue for long." After laying out proposals for a new division of guided missile developmental responsibilities, Spaatz promoted the assignment of missiles to the AAF, because the AAF had "the greatest amount of technical, background knowledge." The Spaatz memorandum ruled out the idea of a War Department coordinating office on the grounds that giving this responsibility to the director of research and development in the War Department General Staff would either require the creation of new rules for missile projects, or create a bottleneck in authorizing projects,

[101] Hughes, "The Evolution of Large Technological Systems." 51-2.
[102] Brig. Gen. H.I. Hodes to Commanding Generals, Army Air, Service and Ground Forces, "Policy on Research and Development of Guided Missiles," 13 February 1946, in RG 341, Guided Missiles Branch, Box 142, file "GM Policy within USAF 47 and 48," NA.

necessitating more people in the director's office who could better be used elsewhere.[103] The Army Service Forces, which included Army Ordnance, rejected the ideas advanced by Spaatz and the AAF. At LeMay's suggestion, representatives of the AAF and Army Ordnance met on March 25 to resolve their differences over responsibilities for guided missile work, but agreement proved impossible because both Army Ordnance and the AAF refused to move from their divergent positions on who should control missiles with wings.[104]

In May, the AAF made its case to Army Chief of Staff Eisenhower for assignment of guided missiles to the AAF, pointing to its Strategic Air Command as the repository of expertise for strategic missiles:

> The long range surface-to-surface strategic missiles are designed to supplement or substitute for piloted strategic bombers. The presently projected accuracy of the missile is expressed in miles [at a time when bombers were seeking an accuracy of about 450 meters, or about a quarter of a mile], so it will probably be used against area targets: cities, large factories, etc. … It is inconceivable that two agencies, one with piloted bombers and the other with pilotless aircraft, could do this independently, both must be under one commander.[105]

A staff study completed on 3 May 1946 for the Air Board, which included the heads of the AAF's major commands, characterized the missile field as having "a great deal of disjointed activity and an even greater amount of confusion." It added that coordinating committees run by the Joint Chiefs of Staff had been unable to coordinate the missile programs because of the inter-service struggles for control. The report recommended the creation of an agency responsible directly to the President of the

---

[103] Gen. Carl Spaatz to the Deputy Chief of Staff, , "Policy on Research and Development of Guided Missiles," 4 March 1946, in RG 341, Guided Missiles Branch, Box 93, file "AAF Policy 1946," NA.
[104] Gen. Crawford to Commanding General, Army Air Forces, "Policy on Research and Development of Guided Missiles," 26 March 1946, in RG 341, Guided Missiles Branch, Box 93, file "AAF Policy 1946," NA; M. Rosenberg, *National Guided Missile Program,* 33.
[105] Carroll L. Zimmerman, chief, Operations Analysis Section, to Chief of Staff, "Assignment of Cognizance and Control of the Pilotless Aircraft (Guided Missile) Program," 20 May 1946, in RG 341, Guided Missiles Branch, Box 93, file "AAF Policy 1946," NA.

United States to run all U.S. missile programs.[106] LeMay, then the AAF's top officer for research and development, questioned whether there really needed to be an agency under the president if the Joint Chiefs of Staff would simply "establish the primary responsibility" for military missiles. The AAF's Commanding General, Spaatz, for his part, said new policy direction would await Army Chief of Staff Eisenhower's plan to appoint a director of research and development as part of a reorganization of the War Department General Staff. In June 1946, Eisenhower named Maj. Gen. Henry S. Aurand the War Department's director of research and development.[107] Aurand had spent most of his career in Army Ordnance where he became well known as an expert in military logistics, moving, supplying and quartering troops, and for putting those skills to good use in both Europe and the Pacific in World War II. The fact that he was an ordnance officer could not have pleased AAF officers hoping to keep missiles out of the hands of Army Ordnance.[108]

In the following month, the AAF briefed Aurand on its missile programs, and stressed that it should be given control of missile research, primarily to avoid duplication of effort. The AAF admitted that Army Ordnance had given its rocket programs 1A priority, which "will produce an end item designed to meet a potential threat against this nation, the lack of which would result in national destruction and disaster in the event of

---

[106] Brig. Gen. E.L. Eubank to Maj. Gen. Hugh G. Knerr, "AAF Board Staff Study 'Guided Missile Policy,'" 3 May 1946,in Spaatz Collection, box 263, research and development file 2, Manuscript Division, Library of Congress. The study was conducted by staff of the AAF Board, a more narrowly focused group that the Air Board was in the process of replacing in early 1946. For more on the Air Board, see Wolk, *Struggle for Air Force Independence,* 154-7.

[107] Maj. Gen. Curtis LeMay to General Spaatz, "Guided Missiles Policy," 22 May 1946, and Gen. Carl Spaatz to Maj. Gen. Donald Wilson, 29 May 1946, in Spaatz Collection, box 263, research and development file 2, Manuscript Division, Library of Congress; M. Rosenberg, *National Guided Missile Program,* 34-5.

[108] Biographical information from Finding Aid on Henry S. Aurand, Dwight D. Eisenhower Presidential Library, Abilene Kansas.

war," while the AAF gave its guided missile programs 1B priority, defined as being assigned to "projects required for new tactical concepts of warfare or new concepts of warfare resulting from radically new weapons developed by great scientific advancement." These differing priorities would give Army Ordnance missile work priority over AAF missile programs, forcing the AAF to raise the priority of its missile work and devalue the priority system.[109]

The AAF and Army Ordnance then attempted to solve the disagreement on their own for a second time. On 13 August 1946, leading officers, including LeMay and Crawford from the AAF, and Brig. Gen. Henry B. Sayler, Army Ordnance's director of research and development, met to discuss the coordination of their guided missile programs but failed to reach agreement.[110] Inside the Air Staff, Crawford renewed his complaints about other services' missile programs overlapping AAF missile programs, implying to W. Stuart Symington, the Assistant Secretary of War for Air, that the AAF was following the McNarney directive while Army Ordnance was not.[111]

In September, Aurand tried to solve the missile standoff with a proposal where Army Ordnance and the AAF would share missile responsibility, with War Department staff coordinating the work. In a memo to Spaatz, LeMay denounced Aurand's proposals as being biased toward the interests of Army Ordnance, and warned that if the army won control of missiles, it would then move to gain control of its own aircraft, including

---

[109] "Prepared Briefing for General Aurand," undated but between mid-May and July 11, 1946, in RG 341, Guided Missiles Branch, Box 93, file "AAF Policy 1946," NA.
[110] Generals LeMay and Sayler to Director of Research and Development, War Department, draft memorandum for signature, "Coordination of Guided Missile Development," undated, in RG 341, Guided Missiles Branch, Box 93, file "AAF Policy 1946," NA. M. Rosenberg, *National Guided Missile Program,* 35.
[111] Gen. Crawford to Assistant Secretary of War for Air, "Overlap of Guided Missile Research and Development Between Army Ordnance and AAF," 30 August 1946, in RG 341, Guided Missiles Branch, Box 93, file "AAF Policy 1946," NA.

strategic aircraft, at the expense of the AAF. LeMay warned Spaatz that the AAF should fight to keep guided missiles because "the long-range future of the AAF lies in the field of guided missiles."[112] AAF officers had heard that Aurand was strongly critical of the quality of the AAF's missile program, and had suggested that since piloted aircraft were vastly different from guided missiles, the missiles need not go to the air force.[113] The air force was learning that it would not likely win acceptance for its plan to control missile programs by working inside the War Department.

Dispute Goes Public

The dispute had become public knowledge that year when newspaper articles speculated about control of military guided missile programs, and reported that outside parties wanted the dispute settled. *New York Times* military writer Hanson W. Baldwin wrote in May 1946, that the Army Air Forces were engaged in a "frank and outspoken" effort to gain control of military long-range missiles, with Army Ordnance united with the U.S. Navy in opposition to the air force's plans.[114] On 19 August 1946, a *Washington Post* article revealed that the War Department was reviewing AAF and ordnance missile contracts after a "series of protests by civilian manufacturers and scientists, who charged that the two service branches were competing for materials in their race for control of guided missile development." The story quoted Army sources as saying that no solution was likely "until and unless President Truman intervenes personally."[115]

---

[112] Maj. Gen. LeMay to Gen. Carl Spaatz, "Guided Missiles," 20 September 1946, in RG 341, Guided Missiles Branch, Box 93, file "AAF Policy 1946," NA.

[113] M. Rosenberg, *National Guided Missile Program,* 35-6.

[114] Hanson W. Baldwin, "Rocket Program Splits Services; Army Air Forces Seeking Control." *New York Times,* 12 May 1946, 1.

[115] "Guided Missile Contract Data Demanded." *The Washington Post,* August 19, 1946.

President Truman (centre) signs Army Air Forces Day proclamation with (l to r) Gen. James Doolittle, Gen. Hoyt Vandenberg, Gen. Lauris Norstad, and Stuart Symington (HSTL)

The *Post* story set off more speculation in the press and memos inside the War Department. One came from Symington, the Assistant Secretary of War for Air who wrote the Secretary of War quoting LeMay's complaints about the McNarney directive published in an Associated Press story. Symington relayed the AAF's opinion "that there has been too much publicity on this topic," publicity that might undermine the AAF's efforts to win control of missiles. Symington, who called for more careful preparation of press announcements and "greater solidarity" inside the War Department, claimed that a similar debate on missiles was going on inside the navy, but without publicity.[116]

Symington, who had just begun nearly four years as the top civilian official responsible for the air force, had made his name as a successful executive in a number of businesses, notably the Emerson Electric Company of St. Louis, Missouri. As World War II was ending, the new president and fellow Missourian Harry Truman enlisted him for his administration. After helping move the AAF to the status of an autonomous service in 1947 in his role as Assistant Secretary of War for Air, Symington became the first Secretary of the Air Force and served in that office until 1950. During this time, Symington vigorously defended air force interests, including those involving missiles, but showed no special interest in missiles. In 1952, Symington was elected U.S. senator from Missouri and served for twenty-four years. During his tenure he was a strong supporter of the air force.[117]

As mentioned in the *Washington Post* story, by the fall pressure to change the McNarney directive was also coming from outside the military. The increasing visibility of the controversy outside the military and in the media caused top officials of the War Department to enter the missile dispute and end it. Lt. Gen. Thomas T. Handy, who had succeeded McNarney as deputy chief of staff, stated in a letter to Eisenhower, the army chief of staff, that "industrialists" were complaining that "there is great duplication and actual waste of money, [and] that they are being asked to accomplish practically the same

[116] Stuart Symington to the Secretary of War, "Guided Missiles Discussion," 22 August 1946, in Spaatz Collection, box 263, research and development file 2, Manuscript Division, Library of Congress. The same file also contains a memo on the same subject dated Aug. 20 from Brig. Gen. E. O'Donnell, the AAF Director of Information.
[117] For more details on Symington, see James C. Olson, *Stuart Symington: A Life* (Columbia: University of Missouri Press, 2003).

projects for several agencies" at a time when facilities and personnel were available for only one job each.[118] The industrialists' contention echoed a concern voiced by Crawford, Twining and others in the air force that this duplication would slow down missile programs and waste two resources that were scarce at the time – money and qualified personnel.

Spaatz, Symington, and Maj. Gen. Everett S. Hughes, the chief of ordnance, had considered establishing a task force to deal with the matter, placing missiles directly under Aurand, or assigning them to one agency. Handy told Eisenhower that these leaders "all agreed that the most practicable solution is the assignment of the responsibility to one agency, and that this agency should be the Air Force," although the ordnance chief agreed only reluctantly. Handy added that Aurand would have to control the AAF to make sure that ordnance's interests were protected, and the two branches of the Army would have to successfully settle their differences before the War Department could try to coordinate missile activities with the navy.[119]

The New Directive

A new directive replacing the McNarney directive was released on 7 October 1946 over the signature of Brig. Gen. Henry I. Hodes, the assistant deputy chief of staff, who signed on Eisenhower's behalf. The new directive gave the AAF's commanding general responsibility for "research and development activities pertaining to guided missiles," including countermeasures and all associated equipment. The directive called for use of the best-qualified agencies for missile work. It also gave the War Department's

---

[118] M. Rosenberg, *National Guided Missile Program,*36-7; Lt. Gen. T. T. Handy to Gen. D. E. Eisenhower, "Personal to Eisenhower from Handy," 3 October 1946, in RG 341, Guided Missiles Branch, Box 93, file "AAF Policy 1946," NA.
[119] Handy, "Personal to Eisenhower."

director of research and development, Gen. Aurand, a role in determining missile projects.[120]

Three days later, Aurand issued a directive of his own, which emphasized that the directive from Hodes was for research and development only and is not to be considered to grant any operational responsibility for guided missiles. He wrote that missile programs being carried out by the Ordnance Department and Signal Corps, which developed some missile-related systems, "will continue under the over-all cognizance of the Army Air Forces but under the sponsorship of the agencies now doing this work."[121]

Symington released the new missile directive to the media, calling it one of the most important national defense decisions ever because it would save millions of dollars by avoiding duplication of effort. In his own press statement, LeMay, the air force's top officer for research and development, explained that Aurand would make decisions in the absence of agreement between the different services working on missiles, and starting with fiscal year 1949, all budget estimates for missile programs would go through the AAF. LeMay stressed that the new directive would save money but warned that research and development of new missiles would be a lengthy process.[122]

The War Department approved a missile plan from AAF Commanding General Spaatz and published it on 26 November 1946. The plan established the AAF Technical Committee to determine the fate of War Department guided missile projects, with appeals

---

[120] Brig. Gen. H. I. Hodes to Commanding Generals of Army forces, "Guided Missiles," 7 October 1946, in RG 341, Guided Missiles Branch, Box 142, file "GM Policy within USAF 47 and 48," NA.

[121] Maj. Gen. H.S. Aurand to Commanding General, AAF, Chief of Ordnance, and Chief Signal Officer, "Review of Guided Missiles Projects," 10 October 1946, in RG 341, Guided Missiles Branch, Box 142, file "GM Policy within USAF 47 and 48," NA. The signal corps was involved in developing communications equipment for missiles.

[122] Major General Curtis E. LeMay, statement for guided missiles press conference, undated but shortly after November 26, 1946, part of an undated package of materials for the media on guided missiles, in RG 341, Guided Missiles Branch, Box 103, file "Guided Missiles Material," NA; M. Rosenberg, *National Guided Missile Program,* 38.

going to Aurand, but the committee was seldom called upon to settle disputes between the services. Spaatz's control over missile programs was "limited to studying and monitoring several projects."[123] This arrangement for guided missile research and development, continued until shortly after the United States Air Force won its autonomy in September 1947.[124]

The new missile directive and subsequent actions did not eliminate tensions between the AAF and Army Ordnance. The AAF gathered a number of complaints about Army Ordnance missile work, including changing missile contracts without reference to the AAF, and being slow to inform AAF of a new type of missile it was developing. The AAF and North American Aviation had wanted help with guidance problems from the German rocket experts working for Army Ordnance, but they got little help from ordnance for several months.[125]

While the army and air force fought hard over missile research and development work and over operational responsibility for anti-aircraft missiles as part of a larger dispute over the mission of defense against air attacks, they reached apparent agreement over operational responsibility for long-range strategic missiles. The agreements between the army and the emerging USAF on division of responsibilities in September 1947 granted operational responsibility for short-range tactical missiles to the army, divided control of the contentious group of anti-aircraft missiles between the army and air force, and awarded operational control of strategic missiles to the USAF. The vaguely worded

---

[123] Lt. Col. John F. O'Neill, memorandum for record, "Air Force Administration of Army Ordnance Guided Missile R & D Projects," 18 July 1949, in RG 341, Guided Missiles Branch, Box 115, NA.
[124] M. Rosenberg, *National Guided Missile Program,* 36-8.
[125] Commanding General, AAF, to the Chief of Ordnance, marked not sent, "War Department Guided Missile Program," 1 July 1947, in RG 341, Guided Missiles Branch, Box 142, file "GM Policy within USAF 47 and 48," NA.

agreement defined strategic missiles as those designed for use against targets that are normally reached by bombers and which did not affect army combat operations. The deal reflected the realities on the ground, where both services were actively developing anti-aircraft missiles and had yet to give serious thought to long-range strategic missiles.[126]

Navy Missiles

During the two years between the end of the war and the reorganization of the U.S. military, the AAF's missile concerns were usually focused on Army Ordnance. But the AAF also kept a wary eye on navy missile programs since the relationship between the navy and the air force was strained during this time as leaders of the two services jostled over military unification. Because missiles were just a small part of each service's mission and since the AAF could not deal with the navy on an equal footing while it was still part of the War Department, their dispute over missiles was generally lower key than the AAF dispute with Army Ordnance. Sparks did fly in 1945, however, when the AAF tried to block a navy request for funds to build a missile test range at Point Mugu, California.[127]

When Army Chief of Staff Eisenhower launched his 1946 review of army missile programs, he asked for and received navy cooperation from Chief of Naval Operations Admiral Chester W. Nimitz. The navy rebuffed an AAF proposal to consolidate army and navy missile programs. *New York Times* military writer Hanson W. Baldwin's May 1946 article on the inter-service missile dispute reported that the navy and Army Ordnance had worked together to head off the AAF's ambitions to take over military missile programs.

[126] "Excerpt from Army-Air Force Agreements as to Initial Implementation of the National Security Act of 1947 dtd 15 September 1947," in RG 341, Guided Missiles Branch, Box 142, file "GM Policy within USAF 47 and 48," NA; M. Rosenberg, *National Guided Missile Program,* 40-5.
[127] M. Rosenberg, *National Guided Missile Program,* 45-6.

Baldwin also quoted an AAF officer saying that the arrival of atomic bombs and rockets meant that the navy was "finished."[128]

Crawford in the Air Staff complained that the Air Materiel Command, which had responsibility for AAF missile development, did little to defend the AAF missile program against incursions by the navy, which "has embarked on a very aggressive program of placing development contracts for guided missiles and components" with aircraft contractors, having the effect of tying them up with navy missile work. The contracts would also put the Navy Department in a very strong position on guided missiles prior to the planned reorganization of the services, Crawford predicted.[129] He recommended a consolidation of all military programs under the AAF, which he claimed would save the U.S. government $77 million over the upcoming five years by reducing navy missile programs by nearly $67 million and War Department programs by $10 million, at a time when the military spent a total of $58 million on missiles in the fiscal year that began a few weeks later.[130]

The Aeronautical Board, which coordinated aviation work between the army and navy, ordered the AAF and the navy in November 1946 to agree to common military

---

[128] Gen. Carl Spaatz to the Deputy Chief of Staff, "Policy on Research and Development of Guided Missiles," 4 March 1946, in RG 341, Guided Missiles Branch, Box 93, file "AAF Policy 1946," NA; M. Rosenberg, *National Guided Missile Program,* 45-9. Hanson W. Baldwin, "Rocket Program Splits Services; Army Air Forces Seeking Control." *New York Times,* 12 May 1946, 1. The missile development centre was similar to a proposal contained in the AAF Scientific Advisory Group's *Toward New Horizons* report.

[129] Brig. Gen. Alden R. Crawford to Commanding General, Air Materiel Command, draft memorandum, "AAF Guided Missiles Development Program," 21 May 1946, in RG 341, Guided Missiles Branch, Box 93, file "AAF Policy 1946," NA.

[130] Brig. Gen. Crawford to the Commanding General, AAF, "Responsibility for Research and Development of Guided Missiles," 27 May 1946, in RG 341, Guided Missiles Branch, Box 93, file "AAF Policy 1946," NA; Maj. Gen. E. M. Powers to Commanding General, AAF, "Responsibility for Research and Development of Guided Missiles," 7 June 1946, in RG 341, Guided Missiles Branch, Box 142, file "GM Policy within USAF 47 and 48," NA. Missile budget figure from Testimony of Gen. Donald Putt, United States Senate, *Hearings before the Preparedness Investigating Subcommittee, Committee on Armed Forces, Inquiry into Satellite and Missile Programs,* 1st and 2nd Sessions, 85th Congress, December 17, 1957, 940.

requirements for missiles, but this order wasn't fulfilled. Rear Admiral Daniel V. Gallery, who ran the navy's missile program, was quoted by the AAF as saying that the Navy Department was reluctant to agree with the air force on specifications for a missile because of its fear that "once a common set was accepted, the AAF would use this as an argument to take over all of the national guided missile development program."[131] The navy continued to delay its response to air force calls to agree on missile requirements even as the air force won its autonomy from the army in September 1947.[132]

Indeed, tensions escalated as Gallery called that December for "an aggressive campaign aimed at proving that the Navy can deliver the Atomic Bomb more effectively than the Air Force can," leaving the air force responsible only for air defense. Although Gallery was talking about naval aviation in general rather than just missiles, such a campaign would certainly have affected air force ambitions in the area of guided missiles. Superior officers in the navy rejected his idea of naval control of all nuclear weapons because they opposed the idea of one service having exclusive control of these weapons. Gallery's sentiment, which generated ill will between the services, was shared by others in the navy, was one of the elements that underlay the admiral's revolt of 1949, which was aimed at the air force.[133] Gallery's stated interest in breaking the air force's monopoly on the use of nuclear weapons no doubt inspired the leaders of the AAF to press for control of missiles, especially those that could carry nuclear weapons, as a way of discouraging the navy's ambitions in this area. As the services moved into the new

[131] Document attached to Maj. Gen. Curtis LeMay to Executive Officer, Office of the Assistant Secretary of War for Air, "Guided Missiles Program," 18 July 1947, in RG 341, Guided Missiles Branch, Box 134, file "Surface to Surface Consolidated MX-774," NA.
[132] M. Rosenberg, *National Guided Missile Program,* 49-53.
[133] Wolk, *Struggle for Air Force Independence,* 238-41. Barlow, *Revolt of the Admirals,* 117, 120-1. Beard's account of AAF-navy relations during this time is in *Developing the ICBM,* 39-41.

arrangements that followed the military reorganization of 1947, the air force and navy kept wary eyes on each other's missile programs and aspirations.

Changes follow the creation of the USAF

The creation of the United States Air Force did not put an end to its contest with the army and navy for control of guided missiles. The War and Navy Departments had given way to three service departments nominally working under the supervision of what proved to be a weak National Military Establishment headed by the Secretary of Defense and the Joint Chiefs of Staff. Inter-service disputes over missiles in fact continued and moved to new arenas, and persisted until the USAF had successfully flown an ICBM in 1958. Although the army and navy held on to their roles in defending against attacking aircraft through programs such as the army's Nike anti-aircraft missile, the AAF's fight for control of missile programs inside the War Department from 1944 to 1947 laid the foundation for the new United States Air Force winning control of ICBMs.

The initial months after the military reorganization did see a temporary relaxation of the missile disputes between the army and air force. Nearly six months after the USAF won autonomy from the army, the guided missiles directive of 7 October 1946 was phased out. The army-air force agreement of September 1947 called for continued air force control of research and development of missiles, and provided for the adjudication duties of the War Department director of research and development to be taken over as soon as possible by the Research and Development Board (RDB), which was created as part of the armed forces unification.[134] In March 1948, the USAF and Army Ordnance agreed to rescind the 1946 War Department missiles directive and return to the army

[134] Col. Millard C. Young, "Relationship of the USAF with the Director of Research and Development, General Staff, U.S. Army in Relation to the Combined Air Force-Army Guided Missiles Program," 17 November 1947, Box 142, file "GM Policy within USAF 47 and 48," NA.

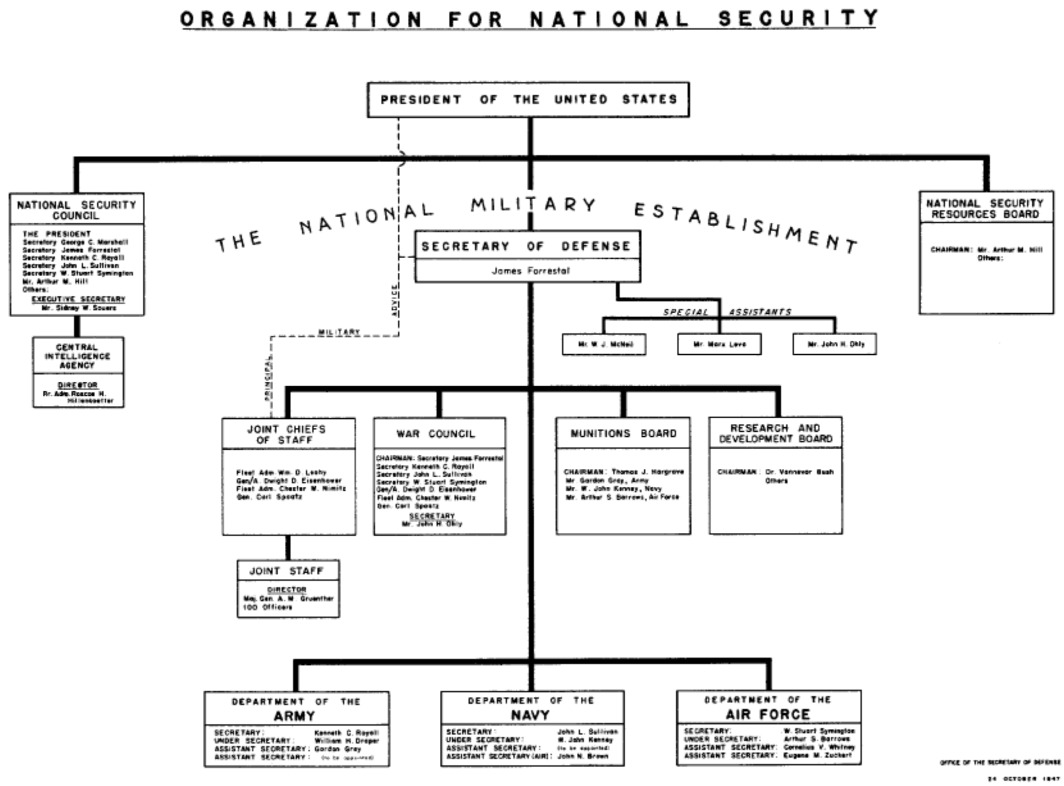
responsibility for research and development on missiles then being developed by the Ordnance Department.[135]

As the USAF won its autonomy, LeMay was transferred to head up air forces in Europe as Cold War tensions increased there, and the following year he was moved again to lead the Strategic Air Command. The research and development post in the Air Staff that LeMay had held for nearly two years, in theory one of the most powerful in the air force, was eliminated, and research and development was put under the control of a lower level officer inside the Air Materiel Command. Crawford, for his part, was moved out of the Air Staff to a senior engineering position in the AMC at Wright Field in Dayton, Ohio.[136]

A month after the USAF won its autonomy, it achieved an important technical breakthrough that showed how far it had to go to build missiles that could reach the speeds necessary for ICBMs. On 14 October 1947, air force Capt. Charles Yeager became the first person to fly an aircraft faster than the speed of sound aboard an X-1 rocket plane launched from a B-29 bomber. Despite this feat, the air force was still a long way from creating operational aircraft that could routinely fly supersonic speeds. For an air force moving from propellers to jet engines and greater speeds and distances, there was little wonder that ICBMs that would fly many times the speed of sound were then seen by many air force officers as something almost in the realm of science fiction.[137]

---

[135] Lt. Gen. H.S. Aurand to Chief of Staff, USAF, "Guided Missiles Research and Development, U.S. Army," 3 March 1948; Lt. Gen. H.A. Craig to Chief of Staff, U.S. Army, "Guided Missiles Research and Development, Department of the Army," 20 March 1948; and Maj. Gen. A.C. McAuliffe to Chief of Staff, USAF, "Guided Missiles Research and Development, Department of the Army," undated, all in RG 341, Guided Missiles Branch, Box 142, file "GM Policy within USAF 47 and 48," NA.
[136] Collins, *Cold War Laboratory,* 36-8, 156, 216-7. Crawford biography, U.S. Air Force, Biographies, http://www.af.mil/information/bios/bio.asp?bioID=4884,
[137] Hansen, *The Bird is on the Wing,* 110-8.



Source: Jacob Neufeld, Office of the Secretary of the Air Force: Organizational and Functional Charts 1947 – 1984, Washington D.C.: Office of Air Force History, United States Air Force, 1985

Conclusion

In the first two years after World War II, the Army Air Forces' actions on guided missiles operated along two tracks. The Air Staff worked hard to win control of missiles for the AAF over the army and navy, motivated in part by its wider goal of winning autonomy for the air force from the army. The Air Staff was also seeking to gain control of as many air-related operations as possible, including strategic bombing by bomber aircraft and missiles, and air defense, including defensive missiles. At the same time, the AAF officers charged with developing new weapons gave missiles a lower priority for funding than bomber aircraft that could reach Soviet Union because of the more immediate perceived need for bombers, and even questioned whether the air force needed to have jurisdiction over the types of missiles that would become known as ICBMs.

Within the AAF, differences existed. The officers in the Air Materiel Command charged with developing the air force's missiles put such a low priority on developing long range strategic missiles that some officers in the Air Staff worried that their attitude might undermine the Air Staff's efforts to win control over missiles.

The air force documents and air force historical studies on missiles showed that little thought was given at the time to how missiles would fit into military strategy or whether they needed to be used at all. The air force's arguments for jurisdiction over missiles were generally couched in terms of efficiency or suppositions on the air force's technical superiority.

The Air Staff's stand on missiles brought the air force into conflict with the aspirations of both the army and navy. With U.S. military budgets undergoing severe cuts after World War II and the future of every part of the military in question in the postwar world, the infighting amongst the services was particularly intense in the late 1940s. Differences over which services had access to nuclear bombs, then seen as the ultimate weapon of the future, helped deepen the tensions between the services. For the military officers involved in these jurisdictional disputes, arguments such as those over missiles involved more than financial resources and priorities, but also the future of their service and of their competing visions of how best to ensure the national security of the United States.

This chapter has concentrated on what was essentially a jurisdictional argument over control of the whole field of U.S. military guided missiles. Long-range missiles such as ICBMs got little attention in this dispute because they appeared to be a technology that would not soon be available for use. But the outcome of the opening round of the general dispute over missiles between 1944 and 1947 marked a crucial turn in the development of ICBMs. While the air force, army and navy continued to vie for control of missiles for another decade after 1947, the new United States Air Force had won the first and probably most critical round in the struggle for control of United States strategic missiles in 1946 and 1947. Unlike Nazi Germany and Soviet Russia, where army ordnance departments were charged with developing long-range ballistic missiles, the task in the United States eventually fell to the air force.

The question of which service won control of strategic missiles is crucial to the creation of America's ICBMs because each service had a distinct way of developing and building missiles and other weapons. The air force relied more than the army did on outside contractors to develop its weapons, for example. And the air force saw missiles as a form of aircraft, whereas the army saw missiles as a type of artillery. The outcome of the inter-service rivalry over missiles affected not only control of ICBM technology but also the designs and the capabilities of the missiles themselves. And because of the central role ICBMs came to take in America's Cold War arsenal starting in the 1960s, jurisdiction over these missiles impacted the air force's control of the United States' war-making capacity. The air force was able to maintain control over much of America's strategic striking forces, including the competing delivery systems of bomber aircraft and ICBMs, until the 1960s, when the U.S. Navy began to deploy nuclear weapons on submarine launched ballistic missiles. When the army was frustrated in most of its ambitions for long-range missiles in the late 1950s, much of its missile team was moved to the U.S. space program, where it played a key role in putting the first humans on the Moon. In addition, the air force's control of ICBMs gave it the central role in the United States military space program to the present day, and strong influence in the early years of America's civilian space program because the ICBMs were converted for use as space launch vehicles.

Chapter 3
The Guided Missiles Committee

The army, navy and air force were not the only bodies in the U.S. government concerned with guided missiles during and after World War II. Between 1944 and 1953, a committee on guided missiles worked with limited success to coordinate the missile programs of the three military services. This committee was part of a complex set of military-civilian advisory bodies operating under the umbrella of the Joint Research and Development Board (JRDB) in 1946 and 1947 and its successor, the Research and Development Board (RDB) from 1947 to 1953. These committees, which were set up as the military worked with leading scientists and engineers to establish new administrative devices to manage research and development for new weapons, replaced the temporary bodies that coordinated military research and development during World War II.

The JRDB and the RDB were in succession headed by Vannevar Bush, the MIT engineer who had previously directed America's weapons research and development efforts during World War II. As the best-known leader of American science and engineering in the 1940s, Bush was a prominent critic of the idea of long-range strategic missiles. He played an even more important role in missiles, however, because of his work to shape the relationship between the military and American engineers and scientists. The JRDB and the RDB were just a part of Bush's quest to enlarge the influence of engineers and scientists in setting priorities for military research and development, a quest that was ultimately frustrated by the military, as will be outlined in this study.

This chapter will begin to address the question of what outside expert advice the air force got on missiles by examining the work of the Guided Missiles Committee from its beginnings in 1944 to the eve of the Korean War in 1950, emphasizing its work from the time of armed forces unification in 1947, when it was attached to the JRDB and then the RDB. While historians such as Edmund Beard and Jacob Neufeld paid little attention to the workings of this committee in their studies of ICBMs, their conclusion that the changes made by the Eisenhower administration in 1953 were crucial in moving ICBMs forward implicitly suggests that these committees constituted an obstacle to ICBMs. Max Rosenberg's official study of the air force missile program up to 1950 is the only work that has followed the committee's work in any detail, but only from the viewpoint of the Air Staff of the U.S. Air Force.[138] This chapter will assess the work of these committees, and also weigh Bush's impact on military missile programs in the late 1940s. Later chapters will discuss other sources of expert advice used by the air force in its missile programs.

The heart of this chapter covers the time from armed forces unification in the fall of 1947 to early 1950, a period when U.S. military missile programs operated under President Truman's order to rein in military spending, an order that had strong but not total support in Congress. U.S. military spending in fiscal year 1947 was $11.8 billion and fell to $10.5 billion for FY 1948. Through FY 1949, spending remained flat, rising to $11.6 billion in FY 1950. Spending on missile programs rose steadily from $58 million in FY 1947 to $134 million in FY 1950.[139] In 1949, Secretary of Defense Louis Johnson

---

[138] See Beard, *Developing the ICBM,* 46-105, 216; J. Neufeld, *Ballistic Missiles,* 56-68, 93-107; M. Rosenberg, *National Guided Missile Program,* 54-170.

[139] Military budget figures in Warner R. Schilling, "The Politics of National Defense: Fiscal 1950," from Schilling, Hammond, Snyder, eds. *Strategy, Politics and Defense Budgets*, 29,30, 220, 221. Missile budget figures in Testimony of Gen. Donald Putt, United States Senate, *Hearings before the Preparedness Investigating Subcommittee, Committee on Armed Forces, Inquiry into Satellite and Missile Programs.* 1st and 2nd Sessions, 85th Congress. December 17, 1957, 940. During those years, U.S. government fiscal years began on July 1 of the preceding calendar year and ended on June 30. For example, FY 1950 began on July 1, 1949.

pressed hard to restrain military spending, and his efforts included paying personal attention to spending on missiles, which put additional pressure on the GMC, the RDB, and the Joint Chiefs of Staff.

This chapter will examine the effects of the financial restraints ordered by the president and the secretary of defense on military missile programs, including their impact on inter-service conflicts over missiles, and it will ask how these research boards and the Guided Missiles Committee helped set priorities for missile programs, including long-range missiles. The committee began its work hoping to establish a coherent national missile program for the U.S. military, but as will be seen in this chapter, it failed to fulfill even the more modest goal of coordinating existing missile programs. The work of this committee and the coordinating boards it operated under reveals concerns about the feasibility of long-range missiles in the late 1940s, and Bush's criticisms of long-range missiles provide a rare example of critical thought about the possibilities of the type of missiles that would become known as the ICBM.

The Committee's Beginnings

As the United States faced the growing prospect of entering a war that was already raging in Europe and Asia, President Franklin D. Roosevelt established the Office of Scientific Research and Development (OSRD) in June 1941 to coordinate U.S. military weapons development work. The National Defense Research Committee (NDRC), which had been established the previous year to support scientific research that could benefit the military, continued as the research branch of the OSRD. Vannevar Bush, the Massachusetts engineer, entrepreneur and inventor who was president of the prestigious Carnegie Institution of Washington and thus one of the most powerful figures in American science and engineering, had lobbied for a coordinating body for war-related scientific research, and he served as director of the OSRD throughout its existence. Bush wielded great power in this position during World War II, and his power was enhanced by his effective relationship with President Roosevelt. Bush's biographer called Bush and Roosevelt a "good team" despite philosophical differences – before the war, the conservative Bush had been strongly critical of Roosevelt's New Deal. Bush and the OSRD funded the creation of many weapons, devices and even medical advances related to fighting the war. Bush's work was capped off with his role shepherding the Manhattan Project that developed the first atomic bombs. Through the NDRC, OSRD-sponsored research on solid fuel rockets also led to rockets launched by infantry and from aircraft and ships, most famously the "bazooka" anti-tank weapon. As historian Donald J. Hanle wrote, the AAF, however, strongly resisted cooperation with the NDRC because much of the NDRC's missile work duplicated AAF programs, and the animosity generated then continued beyond the war.[140]

Because the services were conducting their own research into new weapons during the war, the Joint Chiefs of Staff established the Joint Committee on New Weapons and Equipment in 1942 to coordinate research and development among the services and agencies such as the NDRC, and put Bush in the chair. The joint committee established the Temporary Subcommittee on Controlled Missiles, reflecting growing military interest in guided missiles during the war, particularly in 1944 after the Germans introduced new missiles. In January 1945, the joint committee turned the temporary subcommittee into the Guided Missiles Committee (GMC) to make recommendations

---

[140] G. Pascal Zachary, *Endless Frontier: Vannevar Bush, Engineer of the American Century* (New York: Free Press, 1997) 113, 241; D. Hanle, "Near Miss," 68-80.

about guided missiles for the remainder of the war to the joint committee and the joint chiefs, and to approve plans for future guided missiles. The GMC was made up of officers representing each of the services and civilian experts from OSRD and the National Advisory Committee for Aeronautics, and its work was hampered almost immediately due to differences between the Army Air Forces and the rest of the army over who should represent the AAF on the committee. Bush later recalled the joint committee could not solve disagreements between the services, and when the disputes were put before the Joint Chiefs of Staff, they would disagree on the same basis.[141]

On 10 August 1945, as the war was in its final few days, the GMC issued a report to the Joint Committee on New Weapons about guided missiles that could be fired against Japan if the war continued into 1946. In a protracted war against Japan, the committee recommended deployment of guided bombs under development, along with the JB-2, the American copy of the winged German V-1 missile, and concluded its four-page report with the suggestion that, "special consideration be given to the potential value of guided missiles in connection with the use of special explosives [atomic bombs] which should be used with maximum efficiency because of short supply."[142] Thus, this document contains the first known suggestion by a responsible body that nuclear weapons be delivered using guided missiles, although the idea was already being raised

---

[141] Joint Research and Development Board, undated, probably fall or winter, 1946-7, in RG 156, Office of the Chief of Ordnance, Records Relating to the Army Guided Missiles Program, Box 5, NA; M. Rosenberg, *National Guided Missile Program,* 54-6. See also Baxter, *Scientists Against Time,* 28-30; Vannevar Bush, *Pieces of the action* (New York: Willliam Morrow and Company, Inc., 1970) 52. D. Hanle, "Near Miss," 70-4, 330, wrote that the GMC was formed in part because of the lack of cooperation between NDRC and the AAF over guided weapons such as the JB-2. The GMC had representatives from the army, navy and agencies such as OSRD and NACA.

[142] Guided Missiles Committee, OSRD, "Guided Missiles for Use Against Japan," August 10, 1945, with attached letter from Bradley Dewey to Vannevar Bush, in RG 156, Office of the Chief of Ordnance, Records Relating to the Army Guided Missiles Program, Box 79, NA.

in the *New York Times*.[143] And although the report did not suggest a specific role for such weapons, it reflected thinking in some military circles, including the AAF, where the bombing of Hiroshima four days earlier had inspired ideas of marrying missiles to nuclear weapons.

In November 1945, the GMC's first proposed policy for a national guided missiles program went to the Joint Committee on New Weapons. A report containing the policy argued that in the future, guided missiles: "must be evaluated against a background of the probable aircraft and aerial warfare of the future. But above all, guided missiles must evolve along lines dictated by the probable future development of atomic energy both in the warhead, and, more remotely in the future, as a potential propellant for the missiles themselves." This was significant, because many experts in the late 1940s saw a great potential for nuclear propulsion, a hope that has not materialized to the present day. The eight-page report set out some basic ideas for new types of missiles, but did not discuss how missiles might change military strategy. It predicted that the evolution of future missiles would be dependent on developments in atomic power, supersonic aerodynamics, guidance systems, launch systems, and "ram-jet and other propulsion schemes." The report called for missiles capable of destroying aircraft and other missiles, "[a]ccurate missiles for precision attack at short, medium and long ranges," missiles "for area attack guided with precision appropriate to the lethal range of various warheads, and covering ranges up to thousands of miles," and coastal defense and shipboard missiles. The report also recommended that organizations be set up to gather and share information

[143] See Hanson W. Baldwin, "The New Face of War: Veiled by Atomic Bomb's Potentialities, Strife with Japan Poses New Planning," *The New York Times,* 8 August 1945, 4. This article, written the day after the announcement that the atomic bomb had been dropped on Hiroshima, speculated about the impact of the "coupling of atomic-energy explosive with rocket propulsion."

on guided missiles and intelligence on missiles in potentially hostile countries, as well as coordination on launching and testing sites. While the report stressed the need for basic and applied research to make advanced missiles possible, it warned that "there will always be a limited supply of first class scientists and engineers," which meant that development must not be rushed ahead of knowledge. The report said work on wartime missile programs should be halted, except where new data could be obtained.[144]

The committee's report also addressed competition between the services. Because what it called the current "rules of cognizance" between the services were "far from logical," the report urged changes in these jurisdictional rules, notably a "joint Army-Navy board" with a secretariat and advisory committees reporting to the Joint Chiefs of Staff or to the war and navy secretaries. The board would coordinate research and also ensure full sharing of information on missiles and related research between the military agencies. Until the board was established, the GMC, which was facing elimination in postwar retrenchment, recommended that it remain in operation.[145]

The GMC's parent body, the JCS Joint Committee on New Weapons and Equipment, issued its own call for a national guided missiles program in February 1946 with a plan that bore many similarities to the GMC's proposal from the previous November, including the types of missiles it recommended. It predicted that coordination of missile work between the services would change as new scientific knowledge was gained, and added**:** "Some duplication is valuable" because of the need to learn as much as possible about the new technologies involved in missiles. The proposal's unusual declaration was followed by warnings about future enemies obtaining faster and better

---

[144] Guided Missiles Committee, OSRD, "A National Program for Guided Missiles," with covering letter from Bradley Dewey, November 21, 1945, in RG 341, Guided Missiles Branch, Box 115, NA.
[145] *Ibid.*

missiles that would require countermeasures. The document explained that missiles would become feasible when a military need developed that tied into the changing state of missile and atomic technologies. Chief of Staff Admiral William Leahy approved the document for the joint chiefs on 23 March 1946, and Secretary of War Robert Patterson ratified it shortly afterwards, making it military policy.[146]

The new policy was so vague it had little more effect than to encourage the services to proceed with their own research and development of guided missiles. The new policy certainly did not lead to any coordination of the services' missile programs. Nor did it have any impact on the services' escalating jurisdictional disputes over missiles. In April 1946, the GMC's chair, businessman Bradley Dewey, resigned when the Joint New Weapons Committee of the Joint Chiefs of Staff turned down the GMC's November recommendation for an army-navy board on guided missiles. Dewey did not want the GMC to decide which services would be responsible for specific missiles, and so he believed that the joint army-navy board was required to deal with disputes that would come up as missile work proceeded. The rejection of the joint board was met with relief at the AAF, which was pressing for control of missile development work.[147] With the

[146] Joint Committee on New Weapons and Equipment, JCS, "A Proposed National Program for Development of Guided Missiles," 5 February 1946, and Robert Patterson to JCS, "Proposed National Program for the Development of Guided Missiles," 1 April 1946, in RG 165, Papers of War Department Special and General Staffs, Box 565."Top Secret American British Canadian (ABC) Correspondence File Relating to Organizational Planning and General Combat Operations during World War II and the Early Post-War Period 1940-48," file: "471.6 (7 Oct 43) Sec 1-B," NA; Adm. William Leahy to the Secretary of War and Secretary of the Navy, "A Proposed National Program for Development of Guided Missiles," 23 March 1946, in RG 341, Guided Missiles Branch, Box 93, file "AAF Policy 1946," NA. Leahy's position was the equivalent of the Chairman of the JCS. That title would come into use with Leahy's successor, Gen. Omar Bradley, starting in 1949.

[147] Maj. Gen. Lauris Norstad to Gen. Carl Spaatz "Letter of Mr. Bradley Dewey Re His Resignation as Chairman of Guided Missiles Committee," May 17, 1946, in Spaatz Collection, box 250, General Correspondence, April-May 28, 1946, Manuscript Division, Library of Congress; M. Rosenberg, *National Guided Missile Program,* 58-62. While Rosenberg's otherwise thorough account did not mention Dewey's resignation, perhaps because the GMC was shifted to the JRDB from the joint chiefs later that year, it does accurately report his attitude toward missile development at the time.

navy, the AAF and Army Ordnance all involved in the area, guided missiles remained contested terrain.

When the GMC reviewed the military guided missile programs in 1945 and 1946, it came to the conclusion that there was no unwarranted duplication, contrary to the fears of members of the AAF Air Staff. When a civilian panel set up by the GMC was asked to review the services' guided missile programs, it concluded that the military agencies involved in missile research had their own approach to guided missiles resulting from their own special needs. The panel found that each service could make valuable technical contributions to missile design.[148] AAF personnel working on missile programs believed that it was necessary to generate as much missile work as possible with aircraft contractors so as to build up the contractors' engineering staffs and train engineers in the new science, and beef up America's industrial capacity to build these new weapons. But as a result of the 1947 defense budget cutbacks and the move of missile projects from the study phase to full development, both the navy and the AAF had reduced the number of aircraft contractors involved in missile work by nearly half, which eliminated much of the duplication.[149]

Vannevar Bush and Missiles

Vannevar Bush had wanted to close down the OSRD he directed immediately after the war ended, and he supported the proposal put forward by a committee made up of military and scientific leaders to replace the OSRD with an institution to be run under the wing of the National Academy of Sciences, the Research Board for National Security.

---

[148] Document attached to Maj. Gen. Curtis LeMay to Executive Officer, Office of the Assistant Secretary of War for Air, "Guided Missiles Program," 18 July 1947, in RG 341, Guided Missiles Branch, Box 134, file "Surface to Surface Consolidated MX-774," NA.
[149] Document attached, *Ibid.*

But both Roosevelt and Truman blocked the idea at the behest of the Bureau of the Budget, which believed that no new institution should be set up until the president had a chance to set out a policy covering military weapons research, and so the OSRD continued operations into 1946. When Secretary of War Patterson and Secretary of the Navy James Forrestal called for a replacement body that would coordinate scientific research and development for the military, Bush responded by setting up the Joint Research and Development Board in June 1946, which he chaired. The new body's jurisdiction included research on guided missiles. Bush did not have as close a relationship with Truman as he did with Roosevelt, which was symbolized by Truman's resistance to Bush's proposal contained in the 1945 report whose preparation he directed, *Science – the Endless Frontier*, for a National Research Foundation run by scientists without political and military control. But Bush still enjoyed great prestige with the public and with Congress, and he was known as a promoter of many technologies.[150]

In the months following the end of World War II, Bush had established himself as a critic of long-range missiles. On 22 August 1945, under questioning by military planners who were drawing up postwar plans for the Joint Chiefs of Staff, Bush expressed doubt that a rocket similar to the German V-2 ballistic missile could ever be built with a range greater than 1,000 miles, and he stated that it made more sense to concentrate on short-range missiles because such missiles could become the most effective weapon to defend against aircraft. Bush stressed the importance of securing

[150] Sherry, *Preparing for the Next War,* 141-58. Zachary, *Endless Frontier,* 250, 307, 317-8; Daniel J. Kevles, "Scientists, the military, and the control of postwar defense research: The case of the Research Board for National Security," *Technology and Culture*, 16 (1975), 20-47. In 1950, Congress finally passed legislation creating the National Science Foundation, which controlled less money and had more political control than the report had proposed. The NSF had no involvement in military research, contrary to the report's recommendations.

overseas military bases for shorter-range offensive missiles.[151] On 3 December 1945, Bush testified to a U.S. Senate committee that other security issues were more pressing than guided missiles. "There has been a great deal said about a 3,000-mile high-angle rocket. In my opinion, such a thing is impossible today and will be impossible for many years," he predicted. Bush told the committee that he disagreed with positive statements about long-range missiles made by AAF Commanding General "Hap" Arnold.[152]

Although Arnold and Bush had worked together during the war, and Arnold shared Bush's enthusiasm for new and advanced weapons, the two differed on the matter of missiles. Relations between Bush and the AAF were cooling as the AAF tried to assert control over guided missile research. Bush's attempts to assert control by civilian scientists over research and development, which included his support for a civilian Atomic Energy Commission, further strained his relationship with the military. Bush took his critical view of long-range missiles to his activities at the Joint New Weapons Committee and the JRDB, including their oversight of guided missiles. When the unification of the armed forces began with Forrestal's assumption of the job of secretary of defense in September 1947, both Forrestal and President Truman asked Bush to continue his military research coordination work with the new Research and Development Board (RDB) that replaced the JRDB.[153]

---

[151] James F. Schnabel, *History of the Joint Chiefs of Staff, Volume 1: The Joint Chiefs of Staff and National Policy 1945-1947* (Washington D.C.: Office of Joint History, Office of the Chairman of the Joint Chiefs of Staff, 1996) 64-5.
[152] United States Senate, *Hearings before the Special Committee on Atomic Energy.* 1st Session, 79th Congress, December 3, 1945, 178-80.
[153] Zachary, *Endless Frontier,* 228,291, 334-5.

Vannevar Bush (Library of Congress)

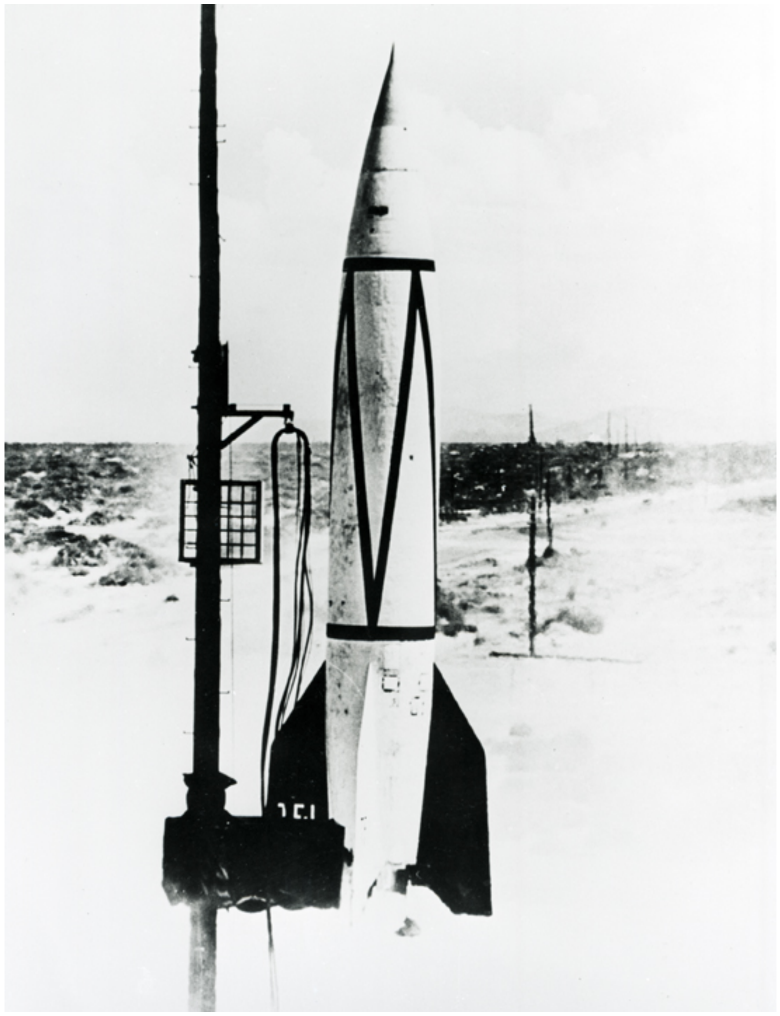
After he had directed the RDB for a year and then left government, Bush published a book in 1949, *Modern Arms and Free Men,* in which he expanded on his views on guided missiles. Before World War II, he wrote, all the elements were ready for a guided missile in the form of an aircraft set to fly automatically to a target carrying explosives, but “[p]ractically nothing” happened in this field, except for the V-1 jet-powered winged missile, which served the Germans because they had a large and important target, London, within range of the occupied French coast. The AAF had a “blind spot” to the limitations of the V-1, notably the many defenses that successfully stopped it. When the AAF copied the V-1 and manufactured it as the JB-2, he noted that the new missile was never used. Bush questioned the great cost of missiles like the V-1 versus their benefit, because of the fact that crewed bombers were far less susceptible to enemy defenses. Turning to the V-2 ballistic missile, Bush argued that it was nowhere worth the money and effort the Germans spent on its development and deployment:

> If the V-2 had destroyed a square mile of London, it would have done so at an overall cost to the Germans, in terms of interruption of war effort, far greater than the cost of rebuilding to the British. The ton of explosive a V-2 delivered was negligible in comparison with the ten-thousand-ton aircraft raids of the time. Development and production of the V-2 called for the very skills, facilities, and materials that could have been used to much greater advantage in the program of jet pursuit aircraft.[154]

Bush called the V-2 an effective psychological weapon that produced less damage than originally expected. But he admitted that once launched, the V-2 had been "very difficult" to intercept, which was why there was such great interest in long-range missiles of that kind. Reiterating his opinions expressed in 1945, Bush reckoned the V-2's 200-mile range and payload of a ton of explosives "was nearly at the limit of effective range for a chemically-propelled single-stage rocket." The range of such rockets could only be increased, at great cost, by reducing the payload, increasing the size of the rocket, or by using multistage rockets, but he neglected to mention the possibilities that different fuels offered in terms of greater range and speed. Bush also questioned the ability of such missiles to strike close to distant targets. He called the cost of these missiles "astronomical" and something that would "never stand the test of cost analysis." Long-range missiles might carry atomic bombs eventually, he wrote: "But as long as atomic bombs are scarce, and highly expensive in terms of destruction accomplished per dollar disbursed, one does not trust them to a highly complex and possibly erratic carrier of inherently low precision." Although Bush did not mention cost figures, the Manhattan

[154] Vannevar Bush, *Modern Arms and Free Men* (New York: Simon and Schuster, 1949) 83-4.

Project that produced a half dozen atomic bombs had cost $2 billion, and the German V-2 project has been estimated to have cost roughly half a billion in the dollars of the time.[155]



Launch of captured V-2 rocket in the United States in 1946 (NASA)

Bush then turned to new jet engines for aircraft, including the ramjet, which he explained would be more useful in short-range high-speed missiles because they would not have to carry a load of oxidizer to react with fuel as in rockets. Instead, they would draw oxidizer from the air. During this time, there was a great deal of interest in ramjets

---

[155] Bush, *Ibid.* Cost figures in wartime U.S. dollars from Michael J. Neufeld, *The Rocket and the Reich: Peenemünde and the Coming of the Ballistic Missile Era* (Cambridge: Harvard University Press, 1995) 272-3. Neufeld compared the V-2's impact on the German economy to the Manhattan Project's impact on the American economy because the German economy was much smaller. In today's U.S. dollars, the Manhattan Project cost nearly $24 billion and the V-2 nearly $6 billion.

in military circles. Army Ordnance was testing ramjets as part of the Hermes missile program, and the air force had started ramjet research on the X-7 missile, was building the Bomarc ramjet missile, and was in the process of adding ramjets to the Navaho missile. But as we will see in Chapter Four, the ramjet did not live up to the hopes that Bush and the U.S. military had for it in the late 1940s.[156]

Bush was out of government service in 1949 when he wrote his book, but his influence on military and government attitudes toward long-range guided missiles up to that time cannot be discounted. Bush's biographer G. Pascal Zachary explained that Bush's opposition to long-range missiles was grounded in his concern that Americans saw "push-button war" as an easy way out of the difficulty and expense of war. In 1946, when both the navy and the air force considered building satellites and launching rockets, Bush discouraged the idea. And while he headed the RDB in 1948, Bush advised Secretary of Defense Forrestal that long-range strategic missiles would be a waste.[157] Given the fact that missile research was still in its early stages and was hamstrung by spending restraint while he was in government, Bush likely did not have to do much else than state these criticisms to discourage development of long-range missiles. During the years covered in this study, Bush's opposition to the idea of long-range strategic missiles stood out because it was so rarely voiced by anyone in public.

Not all engineers and scientists shared Bush's opinions about missiles. Nobel chemistry laureate Harold Urey and Manhattan Project physicists Philip Morrison and Leo Szilard spoke favourably of missiles with atomic warheads at the same 1945 Senate

[156] Bush, *Modern Arms and Free Men,* 71-89. M. Neufeld, *Von Braun,* 239. Ramjets use the forward motion of the engine to compress air heading into the engine, rather than using a compressor, which is used in most jet engines.
[157] Zachary, *Endless Frontier*, 316-9, 337.

hearings where Bush criticized missiles. Lawrence R. Hafstad, the director of research at the Johns Hopkins Applied Research Laboratory and one of the top experts of the time on guided missiles, took the middle ground when he warned in 1946 that the creation of guided missiles would not be a short process because of the many technological advances that would be required. [158]

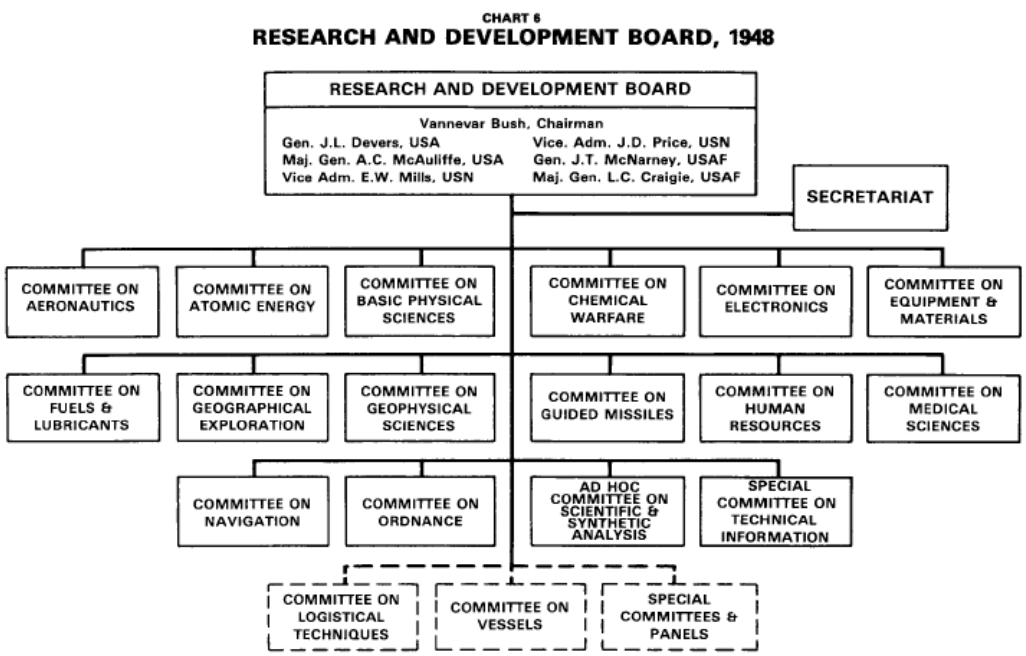
GMC Reconstituted

Bush's greatest impact on the development of long-range guided missiles, outside of his public statements against them, was his creation of the military research and development management infrastructure that lasted until the early months of the Eisenhower Administration in 1953. This infrastructure, which in part carried on the work of the bodies that Bush headed during World War II, marked an expansion of the American state because it permanently brought academic and corporate experts into the management of military weapons development in the Cold War, where before World War II this work had been managed directly by military officers. The Joint Research and Development Board that Bush set up in 1946 did not have statutory authority and thus simply operated under the personal authority of Bush and the secretaries of war and the navy as a stopgap between the wartime OSRD and the Research and Development Board, which was established in law as part of the National Security Act of 1947. The RDB inherited the organizational structure of the JRDB. Under the wing of the RDB, a welter of committees supported by a staff of 250 civilians and about 1,500 expert consultants from academia and industry worked to provide policy and technical advice to the military services, and to implement decisions made by the RDB. In his assessment of the RDB,

---

[158] Bulkeley, *The Sputniks Crisis,* 41; Sean M. Kalic, "U.S. Presidents and the Militarization of Space, 1946-1967: 'We Believe in the Peaceful Use of Space'" (Ph.D. diss., Kansas State University, 2006) 41-2.

Defense Department historian Steven Rearden argued that the committees were criticized for being better at "improving existing weapons than in exploring the potential of new ones." He explained the committees worked closely with military agencies developing weapons, and the agencies often had better ideas than the committees because the agencies worked full-time on specific weapons and the committees did not. While Rearden asserted that Bush and his successors provided effective leadership for the RDB, a consensus grew in the government that the committee system was flawed due to excessive autonomy given to each of the committees. Rearden concluded that the RDB "lacked the authority and organizational structure" to coordinate decision making because it was generally at the mercy of the services.[159]



Source: Rearden, *OSD: The Formative Years,* 100.

[159] Steven L. Rearden, *History of the Office of the Secretary of Defense, Volume I, The Formative Years, 1947-1950* (Washington D.C.: Historical Office, Office of the Secretary of Defense, 1984) 96-103.

In Zachary's more critical and what I believe to be more accurate assessment, he quoted Bush describing his time leading the RDB as "mostly shadow boxing" due to the RDB's shortcomings, including the welter of overlapping committees populated by part-time volunteer academics who had difficulty keeping up with the projects they had to consider. The committees were not effective in limiting duplication, because they were "not quite courageous enough," in Bush's words, to say no. Bush worsened the situation by insisting on having uniformed officers represent the services on the RDB, the higher the rank the better, rather than civilian consultants who were then taking a larger role in running military technology programs. As well, Bush and the RDB lacked authority to overrule the joint chiefs or individual services, dashing Bush's hopes to run a more unified research and development program with civilian scientists having a strong controlling role. The joint chiefs frustrated Bush's efforts to set up a group of civilian scientists to provide independent strategic and tactical advice on new weapons by allowing what became known as the Weapons Systems Evaluation Group to be formed, but under the control of the joint chiefs instead of the civilian scientists at the RDB, as Bush had wanted. While Bush had hoped to increase the influence of civilian experts over military research and development, in fact these committees helped enhance the influence of the military over civilians in universities and private industry. The weaknesses of the RDB and its committees were exacerbated, according to Zachary, by the inter-service feuding that marked the time. "We really had no authority whatever over anything," Bush complained after leaving the RDB in frustration after only a year heading it.[160] The problems with the RDB were recognized in the December 1948 report of the Task Force on National Security Organization, which called for closer coordination

[160] Zachary, *Endless Frontier,* 335-41. See also Bush, *Pieces of the Action,* 67.

between the joint chiefs and the RDB to ensure better use of advances in weapons technology. The RDB chair was given more powers when the National Security Act was amended a few months later and the RDB's staff was reorganized, but the changes did not increase the RDB's effectiveness.[161]

The Guided Missiles Committee had moved from the jurisdiction of the Joint New Weapons Committee of the joint chiefs to the JRDB in August1946, where it was charged with the: "continuing study, evaluation, improvement, and allocation of research and development programs on guided missiles" and "the formulation of an integrated program" for missiles as part of an integrated national defense program. Its membership included its chair, physicist and MIT president Karl T. Compton, and board members Edwin R. Gilliland from MIT and Hugh Dryden of NACA, along with representatives of the army, navy and the AAF, including Gen. Crawford. Compton agreed to chair the GMC for a short time as a favour to Bush.[162] In January 1948, the GMC was reconstituted again after the RDB formally replaced the JRDB as the body coordinating military research in the fall of 1947. This latest GMC, with roughly the same lineup as under the JRDB of three civilian members and two representatives each from the army, navy, and air force, was given the objective of implementing the mandate of the RDB in the field of guided missiles.[163]

---

[161] Futrell, *Ideas, Concepts, Doctrine,* 275-6. The task force, headed by Ferdinand Eberstadt, examined the United States' intelligence apparatus as part of the Hoover Commission on the organization of the U.S. government executive branch. Rearden, *Formative Years,*101.

[162] Committee on Guided Missiles, Joint Research and Development Board, "Publicity Release: Submitted to the Committee at its First Meeting," undated, in RG 156, Office of the Chief of Ordnance, Records Relating to the Army Guided Missiles Program, Box 5, NA; Zachary, 318.

[163] James Forrestal, "Directive: Research and Development Board," 18 December 1947; L.R. Hafstad, Research and Development Board, "Draft Directive: Formation of a Committee on Guided Missiles," 23 January 1948; in RG 341, Guided Missiles Branch, Box 105, NA. The draft was ratified at the 10th meeting of the existing guided missiles committee on February 3, 1948. The minutes are located in the same place as the directive.

When Compton replaced Bush as RDB chairman in October 1948, he was succeeded as GMC chairman for a short period by Purdue University president Frederick L. Hovde, a chemical engineer who had been close to Bush. In 1949 Clark B. Millikan, the Caltech aeronautical engineer and expert on rocketry, took the chair of the GMC, marking the first time the committee was clearly being led by a figure with experience in the field of guided missiles. The GMC was charged with gathering information on missiles, and evaluating that information with a view to determining the adequacy of U.S. military missile programs and to prevent duplication, to keep the RDB and the Joint Chiefs of Staff informed on the development of missiles, and with preparing integrated research and development plans and budget estimates for missile programs.[164]

Like the RDB, the GMC proved to be ineffective, Late in 1948, the GMC's own secretariat admitted that there was no national guided missile program but three programs, one for each service. Brig. Gen. James F. Phillips, the air force's member of the RDB secretariat, pointed to civilian members on the GMC and other RDB committees as the source of this problem, given the fact that committee service members were required to uphold the desires of their services: "It is no secret that 'when the chips are down' on a controversial problem, the civilian committee chairman and other civilians rarely vote."[165]

A civilian member who joined the GMC in 1947 had a different view. Lawrence A. "Pat" Hyland, an electrical engineer who was then an executive at Bendix and a future head of Hughes Aircraft, described the committee in his memoir as being made up of flag rank officers and "top technical people" from industry and academia, including deans,

---

[164] Hafstad, "Draft Directive," *ibid;* Zachary, *Endless Frontier,* 335.
[165] Quoted in Rosenberg, *National Guided Missile Program,* 110.

department chairs and university presidents. Hyland remarked that none of the generals and admirals "knew anything about missiles and very little about technology other than that represented in conventional military or naval equipment." The early meetings of the GMC were taken up by what he called "bitter wrangling" between a navy vice admiral and an army major general over allocation of funds, with an air force general occasionally sticking up for his service. These meetings likely took place during a period of relative peace between the air force and army over missiles between 1947 and 1949.[166]

The USAF did not always respect the limited authority of the GMC. In April 1948, the GMC had learned from the contractor that the USAF had made major changes to its Navaho guided missile program but did not inform the RDB "either officially or unofficially." This unilateral USAF action came after a technical evaluation group formed by the GMC had endorsed a step-by-step program for Navaho that was now being altered. The air force representative on the GMC later formally promised that the USAF would inform the committee of any major changes to missile programs, as all services had agreed to do. When the GMC set a policy calling for its approval for any major missile program change, historian Max Rosenberg accurately observed that the services subsequently kept the GMC informed "as they saw fit."[167]

The U.S. government set up the RDB and the GMC in an attempt as a technological system builder to impose unity from diversity, to use historian Thomas Hughes' description of technological systems. This idea was raised in the last chapter in

---

[166] L.A. "Pat" Hyland, *Call Me Pat: The Autobiography of the Man Howard Hughes Chose to Lead Hughes Aircraft* (Virginia Beach, VA.: The Donning Company, 1993) 330-6.

[167] H.F. Sweetser to Dr. Hafstad, "Air Force Practices Affecting the Guided Missiles Program," 6 April 1948; and F.O. Carroll to Research and Development Board, "Notification of Major Changes in Guided Missiles Projects," 8 July 1948, in RG 341, Guided Missiles Branch, Box 143, file "Research and Development Board Committee on Guided Missiles," NA. Rosenberg, *National Guided Missile Program,* 108-9.

the context of air force missile programs, and here it applied to the Secretary of Defense, starting with James Forrestal, the Joint Chiefs of Staff, and Vannevar Bush trying to create a unified and coherent weapons program, including a missile program, for the U.S. military. This attempt to create unity met strong resistance from all three branches of the U.S. military, which sought to preserve control over their own weapons programs. Like the hopes of the architects of military unification, the desire to create a coherent national missile program through the agencies of the RDB and the GMC failed to materialize. Bush had hoped to give civilian scientists and engineers more control over military weapons programs. Instead military influence over industry and academia began to grow during that time.[168]

GMC Looks at Long-Range Rockets

So far in this study, there has been little mention of missiles capable of flying over long distances. The questions about the feasibility of such missiles raised by Bush were a major reason. But in 1948, the GMC took its first serious look at long-range rocket missiles when it formed an ad hoc subcommittee on long-range rockets that was charged with studying "the problem of proper balance of emphasis in the long range missile program" and to recommend action for the committee. The subcommittee was also tasked with examining the possible effect on the national guided missiles program "of the absence of any specific project" for the development of long range rockets, Earth satellite vehicles, long-range ramjets, or associated equipment development programs. The subcommittee was chaired by Dr. Edwin R. Gilliland of MIT and included one member

---

[168] Hughes, "The Evolution of Large Technological Systems," 51-2.

from each of the services, including Col. Holger N. Toftoy, the ordnance officer who supervised the army's missile program.[169]

In its report, drawn up after a single meeting on 20 July 1948, the subcommittee "agreed that there does exist a gap" due to the lack of a specific project to develop a rocket missile with a range greater than 150 miles. The subcommittee recommended "no specific project" for a rocket missile greater than 500 miles be started "because of the present state of the art and the cost involved." Instead, it suggested that Project RAND, the think tank established at Douglas Aircraft to conduct research on new weapons and strategies for the air force, expand its study of earth satellite vehicles to encompass long range rockets in general, and that the study operate on a continuing basis to keep "the optimum design abreast of the art," and to determine the military worth of the vehicle. RAND should be able "to recommend initiation of the development phase of the project at the proper time." Finally, the subcommittee recommended that General Electric, which was Army Ordnance's contractor on the Hermes missile program, be given the task of developing a 500-mile rocket missile "as a logical step beyond their present 150 mile missile," then known as Hermes C1.[170]

The full GMC approved the subcommittee's report on 15 September, and Toftoy ordered General Electric to begin work on a 500-mile rocket as part of the Hermes program, and that the group of German engineers headed by Wernher von Braun and

---

[169] Karl F. Kellerman, Executive Director, Guided Missiles Committee, RDB, to Members of the Ad Hoc Subcommittee on Long Range Rockets, "Membership and Task of the Ad Hoc Subcommittee on Long Range Rockets," 24 June 1948, in RG 156, U.S. Army, Office of the Chief of Ordnance, Records Relating to the Army Guided Missiles Program, Box 7, file "Ad hoc Subcommittee – GM Committee – RDB (Long Range Rocket)," NA.

[170] "Report of Ad Hoc Subcommittee on Long Range Rockets to the Committee on Guided Missiles," RDB, 20 July 1948, and Ad Hoc Subcommittee on Long Range Rockets, Minutes of the 1st Meeting Held 20 July 1948 in Rm 3D 564 The Pentagon, in RG 156, U.S. Army, Office of the Chief of Ordnance, Records Relating to the Army Guided Missiles Program, Box 7, file "Ad hoc Subcommittee – GM Committee – RDB (Long Range Rocket)," NA.

employed by Army Ordnance be used in this project. Toftoy also decided that since the fiscal year 1949 and 1950 budgets had already been established, the project would have to get by without extra funds for nearly two years until July 1950, when the 1951 fiscal year would begin. With this financial constraint, Army Ordnance duly waited until July 1950 to began a formal study of a 500-mile range tactical missile, according to the official army history of Redstone, the missile that eventually grew out of this study.[171] This study showed that experts outside the air force did not see an immediate need for long-range missiles. The air force, through its representatives on the GMC and the subcommittee, agreed to let the army begin building a long-range missile, although no reason has been found for the air force's action. Possibly the air force believed that the 500-mile range was too short to threaten air force prerogatives, or the budget problems affecting all missile research led the air force to believe that the army would not be able to make much progress with the Redstone missile. Army Ordnance, which at the time was seeking control of many types of missiles at the expense of the air force, declined to run with the opportunity to take a lead in the field of long-range guided missiles because of tight budgets. The GMC did not consider long-range rocket missiles again until 1951.

Setting Priorities

The RDB's hopes for an integrated missile program took a back seat in 1949 to the continued and deepening military economy drive being pressed by the president and Congress. Truman proposed a $14.4 billion defense budget for FY 1950 and an even smaller $13.5 billion budget for FY 1951, rejecting the call of the joint chiefs for a much

[171] Col. H.N. Toftoy to Major J. P. Taylor, "Long Range Rocket," 6 October 1948, in RG 156, U.S. Army, Office of the Chief of Ordnance, Box 7, file "Ad hoc Subcommittee – GM Committee – RDB (Long Range Rocket)," NA; John W. Bullard, *History of the Redstone Missile System* (Huntsville, AL.: Historical Office, Army Missile Command, 1965) 22; Rosenberg, *National Guided Missile Program,* 109. Ultimately, Redstone had a range of only 200 miles.

higher $23.6 billion budget for FY 1950.[172] At a meeting in December 1948, the RDB had discussed proposals for a national guided missile program, including its hope "for a complete and comprehensive Guided Missiles program as opposed to the best possible program permitted under an arbitrary allocation of monies." The USAF members proposed to instruct the GMC "to proceed with the unification of the program," presumably under the USAF, with the hope of eliminating all unnecessary duplication. The USAF proposals were passed back to the GMC for information.[173]

The GMC also proved to be ineffectual when it came to cutting programs and saving money. Under orders from the RDB, a subcommittee of the GMC made up of service representatives reviewed missile programs early in 1949 to look for savings. As part of this exercise, the air force agreed to cancel two programs – the Gapa surface-to-air missile, which duplicated a navy missile program, and the Matador, a 500-mile surface-to-surface cruise missile, which had a low priority – because the USAF was looking to trim its missile budget. The army offered to cancel its stalled Redstone 500-mile missile program and rely on the air force for this type of missile, which gratified the air force as it sought control of long-range missiles. The navy agreed to cancel its 2,000-mile range Triton missile, which existed only on paper. An air force officer commenting on the meeting believed that the offers from the other services implied that the USAF would gain control of long-range strategic missiles in exchange for losing Gapa and Matador. But a technical evaluation group, an advisory team of civilian and military experts that helped the GMC on planning issues, recommended to the GMC that the Gapa program

[172] Schilling, "The Politics of National Defense: Fiscal 1950," discusses the debate in Congress and the administration over the FY 1950 budget in great detail.

[173] Excerpt of Minutes of Seventeenth Meeting, RDB. Held 16 December 1948, contained in agenda of 15th meeting of the Guided Missiles Committee, RDB, in RG 341, Guided Missiles Branch, Box 141, file "Miscellaneous on Relative Priorities 1945-7," NA.

should continue, apparently because of its technical value. Over the air force's objections sparked by its hopes to avoid spending scarce money on Gapa and to win control of strategic missiles over the other services, the RDB backed up the Guided Missiles Committee. The Matador was later restored when the Korean War caused air force staff to see a role for the missile, and the army's long-range Redstone missile survived the process but remained stuck in budget limbo for another year.[174]

The GMC's technical evaluation group submitted a report to the GMC on the national guided missiles program on May 20 based on briefings from the Joint Chiefs of Staff, the three services, and the Central Intelligence Agency. In a list of service priorities for missiles, long-range strategic ground-to-ground missiles were listed as the third priority for the USAF. The group assembled a consolidated military missile priority list, with surface-to-surface missiles "against strategic targets (launched from land, Naval vessel, or submarine)" fourth on the list, following surface-to-air missiles and air-to-air missiles, which both defended against bomber aircraft, and air-to-surface missiles for strategic bombing. The group found that the rate of spending at the time on various missiles was appropriate, and added that it anticipated that "the peak of guided missile research and development expenditures" would be reached in 1951 or 1952.[175]

The JCS found the technical evaluation group report satisfactory for use as the basis for program planning in guided missile research and development, and produced two priority lists for guided missiles. The first list, broken down by primary category, put

[174] Lt. Col. Charles H. Terhune to Brig. Gen. D. L. Putt, "Review of the National Guided Missile Program," with handwritten comments from Gen. John Sessums, 7 March 1949, in RG 341, Guided Missiles Branch, Box 104, file "Committee on Guided Missiles RDB," NA; M. Rosenberg, *National Guided Missile Program,*110-3; Beard, *Developing the ICBM,* 99-100.
[175] Technical Evaluation Group, Committee on Guided Missiles, RDB, "The National Guided Missiles Program," 20 May 1949, in RG 218, Records of the Joint Chiefs of Staff, Box 107, file "JCS 334 Guided Missiles Comm (116-45) Sec 2," NA.

surface-to-surface missiles fourth and last. A second list broken down by subcategory, put surface-to-surface long-range missiles with atomic warheads in eighth place and long-range missiles "with high explosive and incendiary warheads" eleventh out of thirteen subcategories. Top priority went to air defense missiles.[176] Max Rosenberg wrote in his official history that the air force found the low priority for long-range surface-to-surface missiles troublesome because its two existing programs in this category, Navaho and Snark, were consuming a larger portion of air force missile funds than their priority merited. As far as the air force was concerned, this priority problem complicated its efforts to defend its missile programs during the months of increased austerity in 1949 and early 1950 before the outbreak of the Korean War.[177]

Louis Johnson

Louis A. Johnson, a West Virginia lawyer who had served as assistant secretary of war from 1937 to 1940, became secretary of defense on 28 March 1949. Johnson had served in the army in World War I and had later headed the American Legion, but more importantly, he had stepped forward to become Truman's chief fundraiser in the 1948 election. He began his term of office with sweeping changes to the Pentagon, including reassigning 25,000 employees, eliminating several service boards, and most famously, canceling the navy's supercarrier *The United States*, sparking the resignation of the secretary of the navy and setting into motion the events that became known as the admirals' revolt. Johnson gained notoriety for his ambition for the presidency and his dedication to Truman's goal of reining in military spending, The new secretary wanted to

---

[176] Capt. W. G. Lalor of JCS to Chairman, RDB, "Establishment of a Military Basis for Guided Missile Program Planning," 26 October 1949, in RG 341, Guided Missiles Branch, Box 110, file "Agenda, 21st meeting of GM cttee," NA.
[177] M. Rosenberg, *National Guided Missile Program,* 152-8.

save money by making armed forces unification a fact, and Congress assisted him with the passage that August of amendments to the National Security Act that established the Department of Defense in place of the ineffectual National Military Establishment, and gave the secretary of defense more power.[178]

Defense Secretary Louis Johnson with President Truman (HSTL)

Johnson's first months in office took place against the background of events such as the first Soviet atomic bomb test, the latter stages of the Berlin airlift, and the communist takeover of China. Throughout this time, Johnson maintained that the biggest threat to the national security was bankruptcy resulting from unrestrained spending rather

[178] McCullough. *Truman,* 741-2; Barlow, *Revolt of the Admirals,*173-7; Schillling, "The Politics of National Defense: Fiscal 1950," 113.

than war with Russia. Johnson and Truman were not alone in urging spending restraint. Eisenhower, as president, expressed similar concerns as Johnson about the capacity of the U.S. economy, and Eisenhower warned of the dangers of a military-industrial complex as he left office in 1961. A recent biography of Johnson argues that he acted under strong pressure from Truman and with support from large segments of Congress and the public. Before he left government, Vannevar Bush had pushed to hold down annual defense spending for research and development for fiscal year 1949 and beyond at $500 million because he was concerned that more spending would lead to waste from mediocre researchers because the supply of quality people was finite.[179]

As Johnson tightened the financial screws, the wider disputes between the three services reached a climax in the summer and fall of 1949 with the congressional hearings over allegations made by angry naval officers that the B-36 bomber was a poor aircraft built by a well-connected contractor. The hearings, a key episode in the revolt of the admirals, addressed questions of the services' missions and roles, the USAF's continued monopoly of atomic bomb delivery capabilities, and the services' shares of defense budgets. Maj. Gen. John A. Samford, the air force director of intelligence, warned that if this dispute showed that armed forces leaders could not agree on the art of warfare, "civilian thought will go to work to help them." Robert Futrell, in his history of air force doctrine, argued that the congressional hearings into navy criticisms of the B-36 also "demonstrated that the Air Force had not given enough realistic thought to the problem of targeting nuclear weapons." And targeting was one of the key issues affecting the utility

---

[179] Futrell, *Ideas, Concepts, Doctrine,* 483-4; Keith D. McFarland and David L. Roll, *Louis Johnson and the Arming of America* (Bloomington, Ind.: Indiana University Press, 2005) 188-204; Leffler and Westad, *Cambridge History of the Cold War,* Vol. 1, 288-93; Roland, *The Military-Industrial Complex,* 3.

of long-range missiles.[180] The hearings, and the worries about the sustainability of military spending voiced by Johnson, Eisenhower and others, were unusual in that they questioned spending more on new weapons programs for the military. It is important to note that these arguments were couched in terms of America's ability to prosecute the Cold War, rather than whether such weapons were needed at all.

Continued Interservice Rivalries

Louis Johnson's active style saw him become far more involved in missile programs than his predecessor. Not long after Johnson took office, the army renewed its effort inside the GMC and the joint chiefs to enlarge its role in the missile field. Acting army secretary Gordon Gray wrote Johnson on 16 May 1949 pressing the army's case to take over operational control of surface-to-surface and surface-to-air missiles because these types of missiles "are an extension of present conventional type artillery" and "are inherent in land combat." Gray also proposed that the army take over research and development responsibility for these missiles. The air force strongly opposed Gray's proposal, calling it a violation of the 1947 agreements between the army and the air force. The navy generally supported the army as the two services worked to establish roles giving them access to atomic weapons. The dispute over operational roles was prosecuted inside the committees and staff attached to the joint chiefs as well as between the service secretaries and Johnson.[181]

---

[180] M. Rosenberg, *National Guided Missile Program,*120-2; Futrell, *Ideas, Concepts, Doctrine,* 258-9.
[181] Documents from the 17th Guided Missiles Committee meeting, June 1949, including Gordon Gray to Secretary of Defense, "Assignment of Responsibility for Guided Missile Operations and Development, "16 May 1949, responses from Louis Johnson, 25 May 1949, and Committee papers from 17th item of 17th meeting, in RG 341, Guided Missiles Branch, Box 108, NA; M. Rosenberg, *National Guided Missile Program,* 122-6.

The dispute also drew in the GMC. In response to Gray's memorandum, Johnson asked the Joint Chiefs of Staff on May 25,"whether, and if so, to what extent, how and when, operational responsibility for various types of guided missiles should be assigned to the several services." The request was passed to the GMC, which rejected the army's proposal because it had recently approved a policy at its 15 December 1948 meeting rejecting the allocation of broad categories of missiles to a single service. The GMC decision, which was supported by the RDB, emphasized that there was no reason to justify "drastic reallocation of responsibility" for missiles.[182] The RDB told the joint chiefs that it wished to defer making recommendations on assigning missile research and development responsibilities until the joint chiefs had made operational assignments.[183] In September, when the joint chiefs considered the army's case for assignment of operational responsibilities of surface-to-surface missiles, they deferred a decision on long-range surface-to-surface missiles until more was known about their operational capabilities.[184]

Air Force Secretary Stuart Symington wrote to Johnson on 19 August 1949 that establishing a policy on guided missiles meant that policies would also be needed to cover other new technologies, including atomic, biological and radiological weapons. He argued that it would not be in the interest of the military if a weapon were assigned to a service for either research and development, or operational use, and this assignment become construed as an "exclusive or perpetual right" to use a particular weapon.

---

[182] Documents from 17th GMC meeting, *Ibid.*

[183] Karl Compton, chairman, RDB to Louis Johnson, 2 June 1949. in RG 341, Guided Missiles Branch, Box 110, file "Agenda, 22nd meeting of GM cttee," NA.

[184] Briefing Sheet for the Chairman, Joint Chiefs of Staff for Item 7, meeting 29 September 1949, "J.S.C. 1620/B Assignment of Responsibility for Guided Missile Operations," with report by the Joint Strategic Plans Committee to the JCS, "Assignment of Responsibility for Guided Missile Operations," 28 September 1949, and Appendix to Enclosure "C" Draft Memorandum for the Secretary of Defense, in RG 218, Records of the Joint Chiefs of Staff, Box 107, file "JCS 334 Guided Missiles Comm (116-45) Sec 2," NA.

Symington attached a proposed policy in which new weapons would be available for use by any service where approved by the joint chiefs.[185]

A compromise on missiles was in the works. Staff officers attached to the joint chiefs worked to draw up a document that satisfied the various services, and a draft policy that contained proposals approved by Gen. Lawton Collins, the army chief of staff, formed the basis of a memorandum Gen. Omar Bradley, Chairman of the Joint Chiefs of Staff, sent to Secretary Johnson on 17 November 1949. Although Bradley's memorandum assigned operational, and by implication research and development, responsibility for some anti-aircraft, air-launched and short-range guided missiles, it was silent on the matter of long-range guided missiles. Bradley wrote that new weapons such as long-range missiles would be available to any service that decided it needed them to carry out its required functions, as approved by the JCS and the RDB.[186]

When the army tried to win control of all surface-to-surface missiles in May 1949, it also asked the joint chiefs to approve its bid for a tactical missile armed with a nuclear warhead, which it contemplated deploying in Europe under the umbrella of the North Atlantic Treaty Organization, which had been established the previous month. The army had support from the navy, which also wanted to deploy nuclear-armed missiles. At Secretary Johnson's behest, the joint chiefs placed the question before a three-member committee made up of the chair, Army Lt. Gen. John E. Hull, and two top-flight scientists, Frederick Hovde, President of Purdue University and a former chair of the

[185] W. Stuart Symington to Louis Johnson, "Assignment of Responsibility for Guided Missile Operations," 19 August 1949, with attached proposed policy statement, in RG 341, Guided Missiles Branch, Box 115, NA.
[186] Gen.Omar Bradley to Secretary of Defense, "Assignment of Responsibility for Guided Missiles," 17 November 1949, in RG 341, Guided Missiles Branch, Box 109. Agenda, 20th meeting of Guided Missile Committee, NA; M. Rosenberg, *National Guided Missile Program,*129-132.

GMC, and physicist Norris E. Bradbury the director of the Los Alamos National Laboratory. The committee's report in September 1949 suggested that by 1954, sufficient fissionable materials would be available to allow nuclear warheads to be used on four types of missiles, including two air force missiles, the Snark and the air-to-surface Rascal missiles, and one missile each from the army and navy. By early 1950, the committee's report, which also called for closer cooperation between the services, the Atomic Energy Commission, and the RDB, had won the approval of the joint chiefs and secretary Johnson. While the air force did not stand in the way of the other two services during this discussion, it urged caution to ensure that sufficient nuclear weapons remained available for the air force. The discussions showed that the services were capable of some cooperation in the area of missiles. More importantly, the Hull committee began the process of setting technical requirements for nuclear warheads on guided missiles, a process the air force had tried and failed to begin three years earlier with its Mastiff program.[187]

Economy Drives

While Johnson, the services and the RDB grappled with the issue of who was responsible for missile programs, the secretary of defense continued to apply pressure on missile programs to save money as part of his promise to cut $2 billion out of the $14.5 billion in annual military spending under consideration for FY1950. Johnson wrote RDB chairman Karl T. Compton on 15 July 1949 calling for major cutbacks in spending on guided missiles as part of a $50 million reduction he had ordered out of the Defense

[187] M. Rosenberg, *National Guided Missile Program,* 158-66; J. Neufeld, *Ballistic Missiles,* 60, 64.

Department's $500 million research and development budget. Over the next few months, the GMC resisted Johnson's cutbacks.[188]

GMC chairman Clark Millikan acting on behalf of the GMC, urged the RDB on August 26 to make an "aggressive presentation" on the missile program to both Johnson and President Truman to deal with what he called the insufficient information that the GMC believed Johnson had. Millikan defended the cost of missile programs by explaining that the development and testing of missiles was more expensive than crewed aircraft because few, if any, missiles could be used more than once, while a single piloted aircraft can be flown over and over in flight testing. Guided missiles were consuming about $100 million a year, a fifth of the Defense Department's research and development budget. Missile budgets were being cut just as missiles were moving into production and testing, when costs could be expected to increase. "The effects of maintaining an arbitrary level of expenditure for this program, from one year to the next, would inevitably result in the formation of gaps in the overall coverage of the program and in the non-fulfillment of the military requirements of the services," he warned.[189]

A month later, the RDB executive secretary Robert F. Rinehart told GMC executive director Fred A. Darwin that since prorating the $50 million cut among the various committees of the RDB was not the best way to make the reductions, the GMC should review missile programs by examining areas that had been questioned by RDB officials.[190] Darwin replied that the lack of increases in missile funding had already meant

---

[188] M. Rosenberg, *National Guided Missile Program,* 135-6.

[189] Members of the Committee on Guided Missiles to the Chairman, Research and Development Board, "Guided Missile Program," 26 August 1949, in RG 341, Guided Missiles Branch, Box 104, file "Committee on Guided Missiles RDB," NA.

[190] R.F. Rinehart to executive director, Committee on Guided Missiles, "Research and Development Areas Where Economies Might be Effected," 28 September 1949, in RG 341, Guided Missiles Branch, Box 110, file "Agenda, 21st meeting of GM cttee," NA; Karl Compton, Chairman RDB, to Clark Millikan, 26

cutbacks. Programs had also been harmed by the "complete lack of adequate guidance from the JCS as to the requirements, time scales, and relative priorities for guided missiles," and Darwin added that the GMC's own efforts to look for economies had not been fruitful.[191] When RDB staff made cuts later that fall based on what GMC officials called incomplete and erroneous evidence, Rinehart stated that the RDB was left with no choice but to decide the cuts itself or risk having decisions made by less well-informed groups outside the RDB. Despite the fact that the RDB suggested $15 million worth of cutbacks, Rinehart said secretary Johnson's management committee believed that the RDB "had not been particularly responsive."[192] As 1949 drew to a close, the fate of missile programs was being moved to a higher forum which would also consider which services should control missile research and development and which would have operational control over the new weapons.

The Stuart board

Johnson was dissatisfied with the responses from the joint chiefs, the RDB and the GMC to his requests for cutbacks in the military missile program, and on 13 December 1949 he brought his concerns to a meeting of the Armed Forces Policy Council, an advisory group made up of the service secretaries and the Joint Chiefs of Staff. The meeting agreed to have Air Force Secretary Stuart Symington report on the missile program to the policy council's next meeting a week later with a view to encouraging maximum coordination of effort and effective control of the missile

September 1949, in RG 341, Guided Missiles Branch, Box 110, file "Agenda, 21st meeting of GM cttee," NA.

[191] Fred A. Darwin to the Executive Secretary, RDB, "Economies Possible in the Guided Missiles Program," 14 October 1949, in RG 341, Guided Missiles Branch, Box 109. "Agenda: 20th meeting of Guided Missile Committee," NA.

[192] Clark B. Millikan to acting chairman, RDB, 1 December 1949; .R.F. Rinehart to Clark Millikan, 16 December 1949, both in RG 341, Guided Missiles Branch, Box 110, file "Agenda, 22nd meeting of GM cttee," NA.

programs.[193] Symington's report on 20 December suggested that the services form the Interdepartmental Guided Missiles Board to draw up changes to the services' missile programs. His suggestion was accepted, and the new board became known as the Stuart board, after its chairman, Air Force Assistant Secretary Harold C. Stuart. The board, which included Navy Under Secretary Dan A. Kimball, Army Assistant Secretary Archibald S. Alexander, and Rinehart of the RDB, met several times between 21 December 1949 and 1 February 1950 to draw up its recommendations. When the Stuart board reported to the service secretaries on 3 February, it could agree unanimously to continue only fourteen missile programs, including the air force's major long-range missile project of the time, the Navaho winged missile. The board was deadlocked on recommendations for the cancellation of ten other missile projects. But in the face of pressure from Johnson to save money by closing and consolidating missile test ranges, the Stuart board managed to agree on that previously contentious matter by granting each service its own launch site: Point Mugu, California, for the navy, White Sands, New Mexico, for the army, and Banana River, Florida, for the USAF.[194]

The three services set out their own proposals for the missile program when they passed the Stuart board report to Johnson. The navy called the air force missile program "out of balance" because it overemphasized long-range surface–to-surface missiles such as Navaho at the expense of air defense requirements, and recommended that the joint

---

[193] Memorandum for Mr. Symington, "Coordination and Control of Guide Missile Projects," 20 December 1949, in RG 341, Guided Missiles Branch, Box 131, file "Policy from Higher Authority," NA.

[194] Memorandum for Messrs. Symington, Gray and Matthews, "Review of the National Guided Missiles Program," undated, with attachments of army, navy and air force positions, dated 8 February 1950, in RG 341, Guided Missiles Branch, Box 121, file "Special Interdepartmental G.M. Board," NA; "Enclosure 1: History of Special Inter-Departmental Guided Missiles Board," undated, probably February 1950, in RG 218, Records of the Joint Chiefs of Staff, Box 108, file "JCS 334 Guided Missiles Comte (116-45) B.P," NA. The Banana River site is better known as Cape Canaveral. In his memoir, *Call Me Pat,* 331-6, Pat Hyland said Johnson had wanted to consolidate all the missile launching sites into one, but the GMC unanimously disagreed.

chiefs assign long-range surface-to-surface missiles to a service at the earliest opportunity. Navy Secretary Francis Matthews wrote without elaborating that he felt that in spite of the navy's criticism of the air force's long-range missile program, "the long range surface-to-surface category is vitally important and should not suffer from lack of ample effort to bring it into full development." Army Secretary Gordon Gray asked that the joint chiefs reconsider their support for the air force Navaho missile due to questions about the need for such a missile and its high cost, which was then estimated to be $190 million. Gray suggested that higher priority be granted for missiles with a range of 500 or 1,000 miles, ranges shorter than that proposed for Navaho, and expressed hope for a solution to guidance and propulsion problems for long-range missiles.[195]

The air force wanted to cut programs that it saw as duplicating other missile programs, including the navy's 2,000-mile surface-to-surface Triton missile, four army missiles, and the air force's 5,000-mile subsonic Snark. "No one service should henceforth pursue more than one current guided missile weapons project in any single field of its operational responsibility," Symington wrote. Symington proposed reducing the twenty-three existing missile programs to thirteen, with the air force continuing work on what would be the only long-range missile, the Navaho.[196] The Stuart board failed to break the deadlock between the services over missiles.

---

[195] Enclosure 1, *Ibid;* Gordon Gray to Secretary of Defense, "Guided Missiles Program," 8 February 1950, and Francis P. Matthews to Secretary of Defense, "Review of the National Guided Missiles Program," 8 February 1950, both in RG 341, Guided Missiles Branch, Box 121, file "Special Interdepartmental G.M. Board," NA.

[196] Stuart Symington to Secretary of Defense Louis Johnson, 8 February 1950, in RG 341, Guided Missiles Branch, Box 121, file "Special Interdepartmental G.M. Board," NA.

The Triton Missile

The navy's ambitious missile program continued to draw critical attention from the USAF. A 1950 briefing note for Symington contained strong criticism of the Triton missile, comparing the estimated $197 million to develop Triton to the then projected $190-million price tag to develop the Navaho, which was then being upgraded to have a much longer range of 5,000 miles. "These comparative costs are interesting, of course, in the light of the Navy's criticism that the Air Force Navaho project is over expensive. They are also interesting in the light of the Navy's contention that the long-range missile is not of prime importance," Symington observed.[197]

While the navy had indicated in 1949 that it would leave development of long-range missiles to the army and USAF, by the time the Stuart board was reporting the following year, the navy's representative on the GMC, Rear Admiral Walter G. Schindler, told the GMC that the navy would continue its research and development work for the Triton missile "at an extremely low level."[198] The navy's increased interest in Triton illustrates the heightened conflict between the USAF and the navy in the wake of the admirals' revolt, which was also shown in Air Staff warnings in 1949 and 1950 that the navy was using Triton to threaten the USAF's central role as America's strategic strike force.

---

[197] Thomas G. Lamphier Jr., Special Consultant to the Secretary of the Air Force, to Stuart Symington, 23 February 1950, in RG 341, Guided Missiles Branch, Box 129, file "National Guided Missile Program 1950," NA.

[198] Rear Admiral W. G. Schindler to Fred Darwin, "Navy Long-Range Surface-to-Surface Guided Missiles," 9 January 1950. in RG 341, Guided Missiles Branch, Box 111, file "Agenda, 23rd meeting of GM cttee," NA; Adm. Arthur Radford to Chief of Staff, USAF, "Air Force Collateral Functions with Respect to the Navy," 17 January 1949, in RG 341, Guided Missiles Branch, Box 131, file "Policy from Higher Authority," NA; M.Rosenberg, *National Guided Missile Program,* 106-7.

Widening Dissatisfaction

The inter-service dispute exposed by the Stuart board brought outside criticism from the body charged with planning and coordinating U.S. military weapons production and then from the secretary of defense. On 14 February 1950, Hubert E. Howard, chairman of the Munitions Board, warned that the missile program "calls for immediate correction" because the three services, "in the limited light of their own particular needs and loyalties, and in their drive to secure new areas of operation for themselves in important new fields, have not coordinated with each other and, in some cases, not even within their own Department." The services could not solve these problems on their own, and the RDB had not as yet lived up to its responsibilities to assign programs and prevent duplication in missile research and development. Karl Compton had resigned as chair of the RDB, and since this meant that the RDB would not be able to fully carry out its functions until a new chair took office, Howard called for a single individual to coordinate the services' missile programs.[199]

When the joint chiefs and the service secretaries met as the Armed Forces Policy Council on 15 February 1950, Johnson expressed his continued dissatisfaction with the guided missile program, and "stated his belief that an outside agency or individual should be brought in to straighten it out." The matter was referred to the JCS after Symington argued that the three services and their secretaries could take the necessary actions.[200] A month later, the joint chiefs recommended to Johnson without recorded explanation that

---

[199] Hubert E. Howard, Chair of Munitions Board, to the Secretary of Defense. "Guided Missiles," 14 February 1950, in RG 218, Records of the Joint Chiefs of Staff, Box 107, file "JCS 334 Guided Missiles Comm (116-45) Sec 3," NA. This memo and the Feb. 15 Armed Forces Policy Council meeting are also discussed in Chapter 5.

[200] Maj. James R. Dempsey, memo for record, "Sequence of Events Concerning SIB," undated but about 18 February 1950, in RG 341, Guided Missiles Branch, Box 129, file "National Guided Missile Program 1950," NA.

three missile programs be discontinued and others downgraded to technology development programs, including the USAF's long-range Snark. The Navaho was continued. The joint chiefs approved a Stuart board recommendation for an Interdepartmental Operational Requirements Group to advise both the Joint Chiefs of Staff and the three services about the coordination of operational features of the three services' guided missiles programs. The group would be called upon to draw up programs for guided missiles research and development, and for production of operational guided missiles. The joint chiefs also suggested changes in assignments of responsibility for missiles, including: "Surface-launched guided missiles which supplement, extend the capabilities of, or replace Air Force aircraft (other than support aircraft) will be a responsibility of the U.S. Air Force as required by its functions." This decision, at least in the view of the air force, effectively assigned long-range surface-to-surface strategic missiles to the air force.[201]

The JCS also proposed to review missile programs on an annual basis, with the first review beginning on 1 September 1950. Johnson, for his part, was at first dissatisfied with the JCS proposals because in his view the cutbacks did not go far enough, but after meeting with the joint chiefs and RDB officials on 20 March, he finally agreed to the proposals on the condition that the Interdepartmental Operational Requirements Group report to him every ninety days. While these discussions concentrated on operational

[201] Joint Chiefs of Staff to the Secretary of Defense, 15 March 1950, in RG 218, Records of the Joint Chiefs of Staff, Box 107, file "JCS 334 Guided Missiles Comm (116-45) Sec 4," NA

control of missiles, the GMC followed up the actions of the joint chiefs and Secretary Johnson by deciding not to change any existing missile development assignments.[202]

Symington's consultant Thomas G. Lamphier summed up the results of the Stuart board process this way: "The Air Force now has formal and exclusive responsibility for strategic guided missiles." The creation of the interdepartmental group "is, in effect, a dictate from the JCS to itself to arrive at a realistic priority listing for the research and development of guided missiles, and to do so soon." But Lamphier warned that the navy Triton missile and the army Hermes B-1 and II ramjet test missiles, which were in the design and study phase, could still compete with the air force Navaho missile in the strategic field.[203] The Stuart board process strengthened the hand of the USAF in the field of long-range strategic missiles, but not without ambiguity. As well, it marked the effective removal of decision-making on military missiles from the Guided Missiles Committee and the Research and Development Board to the Joint Chiefs of Staff and the Secretary of Defense. The already weak civilian influence over U.S. guided missile research and development was further diminished.

Conclusion

Aside from frustrating the aspirations of the army and air force to win greater control over guided missiles, the Guided Missiles Committee and the Research and Development Board proved to have little influence in setting priorities for research and development when there were differences between the services. The Research and

---

[202] Joint Chiefs of Staff, 15 March 1950, *ibid*; Richard I. Wolf, *The United States Air Force Basic Documents on Roles and Missions* (Washington D.C.: Office of Air Force History, USAF, 1987) 213; Rosenberg, 133-4. 151.
[203] Thomas G. Lamphier Jr., Special Consultant to the Secretary of the Air Force, to Mr. Symington, "Analysis of JCS 1620/17 on Guided Missiles," 22 March 1950, in RG 341, Guided Missiles Branch, Box 129, file "National Guided Missile Program 1950," NA.

Development Board and its committees were a final attempt by Vannevar Bush to give civilian scientists and engineers influence on military technology. Bush had previously tried and failed to put civilian experts in the driver seat of military research and development with his National Research Foundation that was blocked in Congress. Reflecting the overall problems with armed forces unification, the hopes for the creation of a unified national missile program also foundered in the late 1940s. Military leaders who wished to preserve the prerogatives of their forces in weapons development blocked Bush's attempts to increase civilian control over their programs and instead increased military influence over industry and academia.

During the late 1940s, the GMC took only one look at long-range guided missiles, when it appointed a subcommittee in 1948 to examine these missiles. The subcommittee chose Army Ordnance to build a 500-mile range missile, but deferred work on longer range missiles, except to support air force-sponsored studies. The subcommittee's actions are notable because they backed up the secondary priority set for these missiles by the air force, throwing into question the assertion by Edmund Beard that it was the air force bureaucracy that slowed the development of these missiles.

In its first year, the RDB was headed by Vannevar Bush, then America's best-known leader of science and engineering due to his work in World War II. He was also America's foremost critic of long-range guided missiles, and he did not hesitate to publicize his views on missiles. Bush criticized the shortcomings of the German V-2 ballistic missile, which cost a huge amount of money and was not effective as a weapon because it could not be guided accurately to targets. Perhaps more importantly, Bush questioned the need for missiles such as those that would become known as ICBMs because he was concerned about the political implications of what was called "push-button war."

The only long-range missile programs under way in the late 1940s were the air force jet-propelled Navaho and Snark missiles, and navy studies of its Triton missile. Due to the technical challenges involved in creating long-range missiles and the widespread preference for defensive missiles, the GMC and the RDB also gave long-range missiles a low priority, one well below that of defensive missiles. The air force, for its part, spent far more money on Navaho and Snark than their relative priorities merited because of the great technical challenges they represented. While long-range missiles were still given a low priority by United States military and scientific leaders in the late 1940s, the growing amounts of money they were consuming meant that they would soon gain more prominence in the debates over military missile programs.

When the inter-services missile dispute was bounced from the RDB up to higher-level officials, even the Joint Chiefs of Staff failed to settle the matter. The arrival of Louis Johnson as secretary of defense, and with him a new emphasis on cutting military spending, caused the RDB and GMC, along with the services, to focus on keeping programs off the chopping block in 1949 and 1950. Finally, following the Stuart Board process in 1950, the joint chiefs had effective responsibility for running U.S. military missile programs, with the air force gaining greater influence. This chapter ends on the eve of a series of major changes that took place in 1950, especially the beginning of the Korean War in June, which brought an end to the period of austerity in military spending.

Chapter 4
The Intercontinental Ballistic Missile

In the years following World War II, military weapons researchers were confronted with the choice of several emerging technologies to propel aircraft and missiles, including rockets, jet engines and nuclear propulsion. The German missile program during the war inspired interest in both winged missiles like the V-1 and missiles that followed a ballistic path like the V-2. German plans for a transatlantic rocket missile with wings strongly suggested to American experts that wings were an effective means of extending the range of long-range missiles. The U.S. Air Force, Army and Navy began developing a number of winged missiles in the late 1940s.

The previous chapters have outlined the context for the development of American military missiles in the late 1940s, including the political and fiscal environment for weapons research during those years, and the reasons the air force was focused on developing bomber aircraft. Where the air force and other military services were interested in missiles, the highest priority went to missiles designed to defend against Soviet bombers and extend the reach of American bombers. As well, coordinating bodies for U.S. military weapons research also supported the priority given to defensive missiles. In the late 1940s, the air force won control of long-range missiles, mainly at the expense of the army.

This chapter will now turn to the technological and political questions that surrounded long-range rockets that followed a ballistic path to a distant target. Out of the many guided missile programs that began in the late 1940s, only one, the air force MX-774, was designed to produce a long-range ballistic rocket missile. The intercontinental ballistic missiles that eventually became a mainstay of America’s nuclear-armed forces were ballistic rockets, and so the United States' first ICBM has its roots in the MX-774 program. Rockets capable of serving as ICBMs were also well suited to the task of carrying artificial satellites into orbit around the Earth, and this fact, as we shall see, brought this technology to the attention of the air force for the first time in 1946.

In the late 1940s, many major technical problems stood in the way of creating an effective ICBM, notably guiding a warhead to its target, and ensuring that the warhead survived the heat stresses that it would meet on its way to the target. Moreover, the expert advice that the air force received in the late 1940s on long-range ballistic rockets emphasized these problems and helped shape the air force's interest in other types of missiles, such as winged missiles propelled by jet engines. As well, the U.S. military had other propulsion technologies besides rockets to consider in the late 1940s for long-range missiles, including ramjet engines and nuclear propulsion.

This chapter will consider some of the central historical questions of this dissertation as it turns to long-range rocket missiles and the air force's work developing these weapons from the end of World War II until 1951. Central to this discussion is the air force's attitude to long-range rockets and how that led to the low priority given to these types of vehicles during the late 1940s. Most importantly, this part of the study will examine what outside sources of scientific and technical advice about long-range missiles the air force sought during this time, what that advice was, what the air force did with that advice, and how much that advice shaped the air force's approach to long-range ballistic rocket missiles. Previous historical treatments of this matter did not examine this expert advice in any depth. The previous chapter argued that experts were at best divided on the value of ballistic missiles, which differs from Edmund Beard's assertion in his history of ICBMs that the air force stubbornly resisted what he implied should have been obvious in the late 1940s – that ICBMs were the way of the future for delivery of nuclear weapons.[204] In asking whether the value of ballistic missiles was obvious to the outside experts who advised to the air force in the late 1940s, this dissertation turns to technical issues facing the air force – including the development of winged missiles that remain inside the atmosphere versus ballistic missiles that fly above the atmosphere, and plans for ramjet engines and nuclear propulsion. The air force's varying responses to these technologies will illustrate the role air force perceptions of new technologies played in the evolution of the air force's research and development priorities for missiles.

Rockets

There is an extensive literature on the history of rockets, but here we need to consider it only briefly. By the beginning of the twentieth century, rockets had been used for hundreds of years for military purposes. Before the twentieth century, rockets had been fueled only with black powder, also known as gunpowder. During the nineteenth century, advances in rocket technology by William Congreve and William Hale in Great Britain increased rockets' military utility. But that century also saw major advances in other forms of artillery, so by the early years of the twentieth century, rockets were largely sidelined from military uses and were best known for their association with fireworks.[205]

---

[204] Beard, *Developing the ICBM,* 8, 219.

[205] This history is covered in many texts, including Willy Ley, *Rockets, Missiles, and Men in Space.* (New York: Viking, 1968); Wernher von Braun and Frederick I. Ordway III, *The History of Rocketry and Space Travel* (New York: Thomas Y. Crowell, 1969)**;** David Baker, *The Rocket: The History and Development of Rocket and Missile Technology* (New York: Crown Publishers Inc., 1978); William E. Burrows, *This New Ocean: the Story of the First Space Age* (New York: Berkeley Books, 1988); T.A. Heppenheimer. *Countdown: A History of Space Flight* (New York: John Wiley and Sons, 1997); and the present author in *To a Distant Day: the Rocket Pioneers* (Lincoln: University of Nebraska Press, 2008).

At the same time, people who dreamed of space travel began to think about using rockets to carry humans into space. In 1903, an obscure Russian schoolteacher named Konstantin Tsiolkovsky wrote a paper suggesting that rockets using liquid fuels and oxidizers could fly far greater distances than gunpowder-based rockets. Although Tsiolkovsky's efforts remained in obscurity for years, other people began thinking hard about using rockets to go beyond Earth's atmosphere. In 1919, Robert H. Goddard, a physics professor at Clark College (later Clark University) in Massachusetts published his ideas on solid rockets, including a suggestion that a rocket could fly to the Moon. A press release in January 1920 from the Smithsonian Institution announcing this idea created a worldwide sensation. Goddard had worked for the U.S. Army during the First World War on a small rocket, but that work ended unfinished with the 1918 armistice, and the two decades between the world wars saw little military research on rockets in the United States. After the publication of his 1919 paper, Goddard began a new line of research on his own that led to the launch in 1926 of the world's first liquid-fueled rocket. Because Goddard kept his research secret, enthusiasts in Germany, France, Russia, the United States and elsewhere worked independently on liquid-fueled rockets that began to fly in the early 1930s.[206]

[206] Tsiolkovsky's and Goddard's lives are also extensively covered in the general histories cited in the previous footnote. Unfortunately, there is no thorough English-language biography of Tsiolkovsky that reflects the new findings on his life that have come to light since the fall of the Soviet Union. Asif Siddiqi, *The Red Rockets' Glare: Spaceflight and the Soviet Imagination, 1857-1957* (Cambridge: Cambridge University Press, 2010) does contain a great deal of up-to-date information on Tsiolkovsky. There are several books on Goddard, including David A. Clary, *Rocket Man: Robert H. Goddard and the Birth of the Space Age* (New York: Hyperion, 2003); and Milton Lehman, *This High Man: the Life of Robert H. Goddard* (New York: Farrar, Strauss, 1963). Un up-to-date interpretation can be found in Frank H Winter, "The Silent Revolution: How R.H. Goddard Helped Start the Space Age," paper, IAA.6.15.1, presented at the 55th Congress of the International Astronautical Federation, Vancouver B.C., Canada, October 4-8, 2004.

Both the German and Soviet militaries brought rocket research under their wings in the 1930s. Soviet rocket research was slowed when the Soviet secret police imprisoned and executed rocket engineers during the Great Terror of 1937 and 1938. In December 1932, the Ordnance Office of the German Army hired a young engineer and rocket enthusiast, Wernher von Braun, marking the beginning of Germany's rocket development program just a few weeks before Adolf Hitler became Chancellor of the German government. In 1942, von Braun's team successfully launched the V-2, which marked a huge advance in rocketry. The V-2, which stood fourteen meters high and could carry warheads weighing nearly a tonne a distance of 300 kilometres, was first used as a weapon in 1944. It was the world's first ballistic missile, a rocket that flew briefly under power before following a ballistic path up to the edge of space and then back down to its target. During the war, the German rocket team also did some preliminary development work on ballistic missiles that carried wings and more powerful engines to increase their range up to transatlantic distances. The fact that the V-2 couldn't be intercepted drew immediate interest from American, Soviet and other militaries. But its great expense, poor accuracy, and the fact that it failed to be a decisive weapon in the war, as recounted by experts such as Vannevar Bush, served to restrain military interest in this new weapon.[207]

Goddard had begun his rocket development work in Massachusetts and continued this work from 1930 to 1941 in New Mexico, flying rockets up to an altitude of 2,700 metres. In 1941 Goddard shifted to work with the U.S. military and died in August 1945

---

[207] The history of early Soviet rocket efforts is outlined in Siddiqi, *The Red Rockets' Glare*; Asif A. Siddiqi, *Challenge to Apollo: The Soviet Union and the Space Race, 1945-1974* (Washington, D.C.: National Aeronautics and Space Administration, 2000); and German rocket work in Michael J. Neufeld's 2007 von Braun biography, *Von Braun: Dreamer of Space, Engineer of War*. The V-2 was originally known as the A-4. Bush, *Modern Arms and Free Men,* 83-4. See also J. Neufeld, *Ballistic Missiles in the USAF,* 2.

as World War II was ending. His small team did not last long beyond his death. Other American rocket enthusiasts on the east coast formed in 1930 the American Interplanetary Society, which later became known as the American Rocket Society, and some began building and testing rockets. A group of society members set up Reaction Motors Inc. in 1941, which won military contracts during and after the war. On the west coast, the Guggenheim Aeronautical Laboratory of the California Institute of Technology was formed under the leadership of Theodore von Kármán, and in 1936 students and faculty there began work on rockets. The laboratory was transformed during the war into the Jet Propulsion Laboratory (JPL) and von Kármán and others from the laboratory also formed the Aerojet Engineering Corporation, later Aerojet General. Using the advances they had made in both liquid and solid rocket technology, the engineers at JPL began building liquid and solid-fueled rockets for the U.S. Army, and Aerojet won military contracting work.[208]

World War II had seen great advances in the technologies of liquid fuel rockets, which carry both fuel and oxidizer, and of jet engines, which burn fuel but take oxygen out of the atmosphere. Jets are limited to operating inside the atmosphere, but because they do not require an oxidizer or hypergolic fuels, they were much lighter, less complex and safer than rockets for use in crewed aircraft. The development of rockets provided many technical challenges, including highly volatile fuels, the design of fuel injectors, combustion chambers and engine nozzles, maintaining stability as fuel drains out of the tanks, dealing with vibrations characteristic of rocket engines, and the high standards required for all components in rockets, all of which added to their complexity and cost.

---

[208] See Eugene M. Emme, ed., *The History of Rocket Technology* (Detroit: Wayne State University Press, 1964) 19-27, 46-66.

There are many types of rockets, but the rockets that are discussed in this study are usually liquid-fueled rockets that used as an oxidizer liquid oxygen, which must be stored at extremely low temperatures. Alcohol was the fuel used in the V-2 and other early rockets, but more powerful fuels such as kerosene became more popular among rocket designers and builders in the late 1940s and the 1950s. Liquid rockets that used different fuels and oxidizers, and a new generation of solid fuel rockets, came to the fore after the time covered in this study. Detailed evaluation of these issues, however, would take us too far afield.

Two key technological problems affecting ballistic missiles that emerged with the V-2 were the need for a guidance system to take the warhead to its target, and developing protection for warheads re-entering the atmosphere at the high speeds reached by these vehicles. Both these issues will be considered in this chapter. As will be seen, rockets competed with jet-powered missiles in the first decade after World War II for priority and resources from the U.S. military. At first, the jet-powered missiles appeared to show greater promise to air force leaders and engineers than rockets for long-range flights, but by 1951 rockets began to win greater priority as the jet-propelled missiles encountered development problems. Only after this time did serious work begin in the United States on ICBMs.[209]

The Scientific Advisory Group

Historians such as Robert Perry and Martin J. Collins have argued that the AAF's commanding general at war's end, General 'Hap' Arnold, was more open to the use of rockets and other new technologies than most of his colleagues because his experience in

---

[209] For an excellent summary of technical problems facing rocket builders, see Stephen B. Johnson, *The United States Air Force and the Culture of Innovation* (Washington D.C.: Air Force History and Museums Program, 2002) 4-7.

World War II had convinced him of the importance of new weapons and strategies. Donald J. Hanle's 2004 history of AAF guided weapons also praised his vision but noted that Arnold's deficiencies as a manager slowed the development of air force missiles during World War II.[210] Before heart problems forced him to retire early in 1946, Arnold provided the AAF with the benefit of his views on rockets, and in his public report to the Secretary of War in November 1945, Arnold wrote that new types of rockets becoming available included "winged missiles for extreme range," anti-aircraft missiles, and rockets to launch and decelerate aircraft. In anticipation of improved defenses against bombers carrying nuclear bombs, Arnold called for the United States to be ready with weapons such as the V-2 that could frustrate those defenses. Arnold warned of the dangers of adversaries using missiles like the V-2 armed with atomic warheads, and said possible defenses against them could include projectiles launched from "unexpected directions," including "true space ships, capable of operating outside the earth's atmosphere," whose design is "all but practicable today; research will unquestionably bring it into being within the foreseeable future."[211]

At the time Arnold wrote this report, he had already begun to make sure that the AAF was preparing for future conflicts by obtaining the best scientific advice available. In September 1944, he asked von Kármán, then the world's top aviation theorist, to lead a group of three dozen experts from government, academia and business to prepare a long range study program that could guide the AAF for the next ten to twenty years. Arnold formally launched the study two months later on November 7, stating his beliefs that the

[210] Robert Perry, "The Atlas, Thor, Titan and Minuteman," in Emme, *History of Rocket Technology,*142. Collins, *Cold War Laboratory,* 9-16; D. Hanle, "Near Miss," 50-6.
[211] Gen. H.H. Arnold, *Third Report of the Commanding General of the Army Air Forces to the Secretary of War* (USAAF, 12 Nov. 1945) 67-8.

United States' prewar research had been inferior to that of other nations, that offensive rather than defensive weapons win wars, and that the American public would not be willing to support a large standing army. He then asked: "Is it not now possible to determine if another totally different weapon will replace the airplane? Are manless remote-controlled radar or television assisted precision military rockets or multiple purpose seekers a possibility?"[212]

Theodore von Kármán (centre) with Clark Millikan (left) (NASA)

[212] Gen. H.H. Arnold to Dr. Theodore von Kármán, "AAF Long Range Development Program," 7 November 1944, reproduced in David N Spires, *Orbital Futures: Selected Documents in Air Force Space History, Vol. 1* (Peterson Air Force Base, Colorado: Air Force Space Command, United States Air Force, 2004) 166-8. See also Michael H. Gorn (ed.), *Prophecy Fulfilled: 'Toward New Horizons' and Its Legacy* (Washington, D.C.: Air Force History and Museums Program, 1994).

Von Kármán's team of experts, the Army Air Forces Scientific Advisory Group, included nine scientists working full-time, twenty-two experts working part-time, and six expert military officers rounding out the team. Von Kármán and his full-time staff went to Germany, around western Europe and to Russia just as the war was winding down in May and June, 1945. A colourful Hungarian scientist who loved the good life and was doted on by his mother and a sister for much of his life, von Kármán dedicated his career to aviation after seeing his first aircraft in 1908, less than five years after the Wright Brothers first flew. On the eve of World War I, he became director of the Aachen Aerodynamics Institute in Germany. After his work was interrupted by the war and a sojourn back in Hungary following the armistice, von Kármán returned to run the institute through much of the 1920s. Despite the excellence of his work and his growing fame, von Kármán was a Jew whose career and safety came under increasing question due to growing anti-Semitism in Germany. In 1929, he agreed to move to Caltech in California, where his research established Caltech as a force in the world of aeronautics. His background in Europe made him uniquely qualified to assess the state of aviation and rocketry in Germany at the end of World War II.[213]

Von Kármán's group issued its preliminary report, *Where We Stand,* based in part on the findings of its visit to Germany on 22 August 1945. In his report, which covered both jet aircraft and rocket missiles, von Kármán was clearly impressed with the German rocket team's designs for a winged version of the V-2 that could carry a warhead across

[213] See Michael H. Gorn's biography, *The Universal Man: Theodore von Kármán's Life in Aeronautics* (Washington D.C.: Smithsonian Institution Press, 1992). Von Kármán chaired the group, Hugh Dryden was vice-chair, and other full-time staff included Tsien Hsue-shen, who worked on rocket and jet engines, and future Nobel physics laureate Luis W. Alvarez, who was in charge of radar, but didn't contribute to the group's final report. Further information on von Kármán's life and work is contained in Paul A. Hanle, *Bringing Aerodynamics to America* (Cambridge: The MIT Press, 1982).

the Atlantic Ocean. “Perhaps the most important result of the German effort in this [missile] field was to show that winged missiles are superior in performance to finned missiles. Thus the next stage in the development of the V-2 rocket was to have been the addition of wings,” von Kármán wrote, adding that many German rocket experts foresaw that “the ultimate guided missile would be completely automatic in its operation.” The report included an illustration of fourteen winged variants of the V-2 rocket and eight versions of the Wasserfall anti-aircraft rocket. Von Kármán added that the Scientific Advisory Group “agrees that the German results of wind tunnel tests, ballistic computations, and experience with V-2 justify the conclusion that a transoceanic rocket can be produced.” The report contained an illustration of a “6000-Mile Rocket” resembling a V-2 flying from the United States to Japan, and stated that the accomplishments of the German rocket group and the development of the atomic bomb meant that all the air force’s existing plans for future conflicts must be reconsidered.[214]

“A part, if not all, of the functions of the manned strategic bomber in destroying the key industries, the communication and transportation systems, and military installations of ranges of from 1000 to 10,000 miles will be taken over by the pilotless aircraft of extreme velocity,” the report predicted.

> For the future long-range strategic bomber, the Scientific Advisory Group foresees two types of pilotless aircraft, both with wings; one with a high trajectory reaching far into the outer atmosphere, and the other designed for level flight at high altitudes. The first one can be considered a further development of the V-2 rocket. In fact, this was planned by the German scientists.[215]

---

[214] Theodore von Kármán, director, Army Air Forces Scientific Advisory Group, *Where We Stand: First Report to General of the Army H. H. Arnold on Long Range Research Problems of the Air Forces with a Review of German Plans and Developments,* 22 August 1945, contained in *Toward New Horizons: A Report to General of the Army H. H. Arnold by the AAF Scientific Advisory Group,* (15 December 1945, in RG 341, Guided Missiles Branch, Box 136, NA) 18-26.
[215] *Ibid.*

This rocket would carry fins like the V-2 for steering, but it could also have larger wings to bounce off the lower atmosphere and glide toward a target, according to the report. "The second future strategic bomber is a supersonic pilotless aircraft, flying at altitudes of from 20,000 to 40,000 feet." This vehicle would fly at twice the speed of sound and could be preceded by an intermediate vehicle flying just below the speed of sound.[216] *Where we Stand* also contained extensive discussions of rocket engines of various kinds, jet engines and jet aircraft, radar, and advances in aerodynamics, and nuclear jet propulsion.

Toward New Horizons

The Scientific Advisory Group delivered its final report, *Toward New Horizons,* to Gen. Arnold on 15 December 1945. The thirteen-volume report contained von Kármán's introduction, along with *Where We Stand* and thirty other monographs on specific research topics by twenty-five authors. The whole report was classified for many years and was shown only to members of the Air Staff and AAF research staff at Wright Field in Dayton, Ohio. In his covering letter for the report, von Kármán called for a "global strategy for the application of novel equipment and methods, especially pilotless aircraft," and for "experimental pilotless aircraft units" to operate these new vehicles. In his introductory report, *Science: The Key to Air Supremacy*, von Kármán outlined research problems that he believed the air force should deal with, such as propulsion, aerodynamics and weapons targeting. This section suggested that using liquid hydrogen as a fuel for rockets would open the door to high altitude "rocket navigation" and satellites. In another section on organization of research, von Kármán called for the

---

[216] *Ibid.*

establishment of a permanent scientific advisory group for the AAF commanding general, research panels for coordination of research with government agencies and other institutions, and for wide use of universities, research laboratories and scientists outside the air force and military so that the military would not have to rely on a single source of information. It called for the establishment of a government "Center for Supersonic and Pilotless Aircraft Development" for research and development in this field, including wind tunnels and facilities for propulsion, control and electronics research.[217]

The thirty technical reports in *Toward New Horizons* written by twenty-five other members of the Scientific Advisory Group gave as much if not more emphasis to the technologies of piloted aircraft than to guided missiles. The reports covered areas such as aerodynamics and aircraft design, aircraft power plants, aircraft fuels and propellants, explosive and terminal ballistics, radar, communications and weather issues, and aeromedicine. The expert authors included Tsien Hsue-shen, then one of America's top rocket engineers and later the father of Communist China's space and rocket programs, who wrote on propulsion methods, including ramjets and rockets; William H. Pickering, future Director of the Jet Propulsion Laboratory, who covered automatic control of guided missiles; Lee A. DuBridge, a future president of Caltech and presidential science advisor, who wrote on communications; and physician William R. Lovelace II, who covered aerospace medicine.

[217] Letter from Theodore von Kármán, to Gen. H.H. Arnold, 15 December 1945, and *Science: The Key to Air Supremacy*, Vol. 1 of *Toward New Horizons*, reproduced in Michael H. Gorn (ed.), *Prophecy Fulfilled: 'Toward New Horizons' and Its Legacy* (Washington, D.C.: Air Force History and Museums Program, 1994) 89-186.

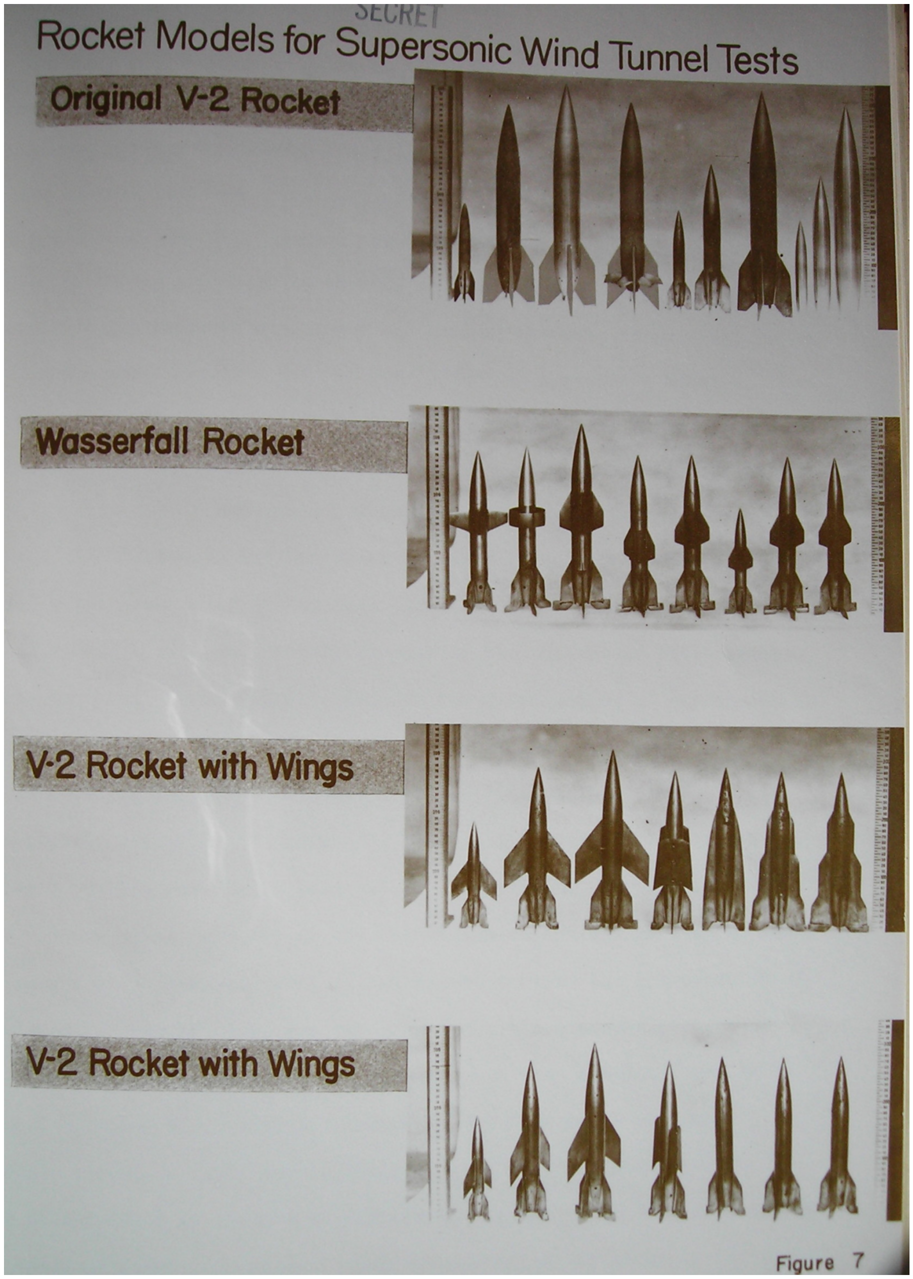


Illustration from Dryden's study in *Toward New Horizons*

Hugh L. Dryden from the National Bureau of Standards, who was soon to become the Director of the National Advisory Committee for Aeronautics and in the future, Deputy Administrator of NASA, wrote the study on the "Present State of the Guided Missile Art." Dryden began in dramatic fashion with his prediction that the military's experience with tactical missiles in World War II "indicate that another war will probably be opened by the descent in large numbers of missiles launched from distances perhaps of the order of 1000 to 6000 miles on an unsuspecting and unprepared country." Dryden used similar terms to describe the level of military interest in missiles: "Our military leaders are fully aware now of the necessity of pushing developments of guided missiles, and almost frantic efforts are being made to compress within a few months developments which ordinarily take years." But he warned that until more research and testing was done to determine the utility of various kinds of guided missiles, "there will be much confusion as to the military requirements which should be set forth." Unlike von Kármán in *Where We Stand*, Dryden did not indicate a preference either way on the use of wings with pilotless aircraft for long-range missions.[218]

While many research problems were obvious, he explained, experience with missiles had shown "other problems not so easily foreseen." Dryden listed five research problems, including aerodynamics, power plants and propulsion, autopilots and servomechanisms, intelligence devices and systems coordination. Research in these areas "will have to be extended far beyond the boundaries of information now available." He gave little attention to the problem of re-entry heating for rocket warheads, which later became a major issue for long-range missiles, likely because it was covered in another technical report. Dryden identified guidance as a key problem standing in the way of long-range guided missiles coming into wide use. German missiles such as the V-1 and V-2 both carried autopilots, he wrote, but their accuracy was "not high," with the V-1 being able to strike within five miles of a target at a range of 130 miles, one out of two

---

[218] Hugh L. Dryden, "Present State of the Guided Missile Art," in *Toward New Horizons: A Report to General of the Army H. H. Arnold by the AAF Scientific Advisory Group,* (15 December1945) in RG 341, Guided Missiles Branch, Box 136, NA.

times, and the V-2 being able to strike within ten miles at a range of 200 miles. In spite of this low accuracy, he estimated that "considerable military damage has been produced." Listing conventional guidance ideas such as using television, radar, heat or acoustic data to help direct missiles to targets, Dryden tacitly admitted the serious obstacles to improving their accuracy by also discussing the Japanese use of suicide pilots and even the possibility of utilizing animals as "intelligence devices" to direct missiles. Through his work in the National Defense Research Council during the war, Dryden was aware of psychologist B. F. Skinner's wartime work building a missile guidance system that used pigeons trained in pecking behavior pointing to targets in what was known as Project Pigeon. The idea never got beyond testing and Dryden's invocation of it in his report on rockets.[219]

As for *Toward New Horizons'* impact on long-range missiles, Gen. Crawford in the Air Staff raised them in September 1945, after *Where We Stand* and before the final report, discussing the transatlantic A-9 and A-10 missiles that the German rocket team was developing during the war. Crawford urged the air force to conduct research on similar missiles, saying that they were "considered decidedly promising by the Germans and that the Army Air Forces Scientific Advisory Group also considers that this development field should be thoroughly explored and exploited." As will be discussed later in this chapter, the AAF quickly embarked on developing various types of missiles, but when its research and development funds were reduced, the money for winged

[219] *Ibid.* James H. Capshew wrote in "Engineering Behavior: Project Pigeon, World War II, and the Conditioning of B.F. Skinner," *Technology and Culture*, Vol. 34, No. 4 (October 1993) 835-57, that Project Pigeon was cancelled due to the vast differences in outlook between Skinner and the NRDC engineers, including Dryden, rather than due to technical problems. Well-known physicist George Gamow questioned at the time whether inertial guidance systems, which operate without outside help, were physically possible, according to RAND physicist Bruno Augenstein in his interview by Joseph Tatarewicz and Martin Collins, 28 July 1986, RAND History Project, National Air and Space Museum, Smithsonian Institution, Washington, D.C.

missiles similar to those promoted by von Kármán in *Where We Stand* was continued while funding for ballistic missiles without wings was cut.[220]

Official air force histories praise *Toward New Horizons* and quote the plaudits given by Arnold and others who were cleared to read it. Many of its recommendations were carried out, including the creation of a permanent scientific advisory board for the air force, headed in its early years by von Kármán, and the creation of the air force's Arnold Engineering Development Center in Tennessee. In 1974, the USAF organized a study modeled on *Toward New Horizons* to rejuvenate the service. *Toward New Horizons* did lead however to at least one technological dead end, nuclear propulsion for aircraft, which will be discussed later in this chapter.[221] Unstated amidst the praise for this study was the fact that the study was run under the control of the air force, rather than under a more independent body like the Research and Development Board. Shortly after this study came out, the air force took steps to ensure that the Scientific Advisory Group would not be the only source of outside scientific and technical advice under the control of the air force.

The Creation of RAND

While von Kármán and Arnold had challenged the air force to look to missiles in its future, Dryden's report and other parts of *Toward New Horizons* summarized the serious technical problems that needed to be overcome before long-range missiles could compete with bombers like the B-29. By the time *Toward New Horizons* was completed

---

[220] Gen. Crawford to Commanding General, Air Technical Services Command, "Guided Missiles of the German A-9 and A-10 Type," 28 September 1945, in RG 341, Guided Missiles Branch, Box 134, file "Special Inter Departmental Board," NA.

[221] Michael H. Gorn, *Harnessing the Genie: Science and Technology Forecasting for the Air Force 1944-1986* (Washington D.C.: Office of Air Force History, United States Air Force, 1988) 39-42, 134-40. See also Gorn's introductory essay in *Prophecy Fulfilled.*

in December 1945, the AAF was fully engaged in winning its autonomy from the army, and that effort included making sure that the new air force would have control over guided missiles as well as other aircraft. Air force historian Mary R. Self wrote in 1951 that despite the research done by von Kármán's committee, the air force still lagged behind other services in initiating research on guided missiles because of its struggle with other services for control of guided missiles, and due to the effects of postwar demobilization.[222]

Following Arnold's strong and public support for research and development, the AAF Air Materiel Command, which was responsible for the air force's research and development work for new weapons, drew up a five-year research and development program in the first months after the war, based on the findings of *Toward New Horizons*. A major part of this program envisioned the development of new guided missiles, and it also called for the air force to use private agencies wherever possible to carry out the air force's research and development work.[223]

Arnold himself also sought to provide the air force with a new outside source of research work. The AAF commanding general met on 1 October 1945 near Los Angeles with Donald Douglas, president of the Douglas Aircraft Company, Douglas' chief engineer, Arthur Raymond, Raymond's assistant Frank R. Collbohm, and Edward L. Bowles, an MIT professor who served as a special assistant to Arnold, to discuss developing an "intercontinental guided missile." Historian Martin J. Collins wrote that Bowles and Arnold were contemplating new concepts for conducting research and development, and over the weeks that followed the meeting, discussions between

---

[222] Self, *History of Missile Development,* 24.
[223] Futrell, *Ideas, Concepts, Doctrine,* 219-20.

Douglas Aircraft and the AAF moved toward general research and away from developing a missile.[224] Shortly after Arnold retired in February 1946, the AAF and Douglas Aircraft signed a letter contract establishing what became known as Project RAND, which would conduct research on many topics for the air force and later others, and in its early years play a major role making ICBMs a reality. In Collins' insightful account, RAND was created when many competing visions for postwar research and development were coming into play. Arnold wanted to provide the air force with its own robust infrastructure for research and development, while Vannevar Bush pressed for scientist-directed agencies serving the entire military such as the Research and Development Board and the unrealized National Research Foundation to place scientists on an equal footing with the military in directing research and development. The army and the navy already had in-house organizations to develop new weapons, but the air force lacked such an organization and thus sought outside help. The air force was already using private contractors such as Douglas Aircraft to develop its aircraft, missiles and other weapons, but RAND became a not-for-profit corporation that assisted the air force by producing studies, strategies and plans, rather than aircraft and weapons. As air force historian Robert Futrell noted in 1989, Arnold may have been motivated in part to develop research capabilities outside of Bush's control because of their differing views about the potential of long-range missiles. In historian Alex Roland's more critical assessment, the creation of RAND and similar military-funded think tanks "undermined civilian authority" by providing the military a means of circumventing civilian institutions.[225]

---

[224] Collins. *Cold War Laboratory,* 29-54.
[225] Collins. *Cold War Laboratory,* 7-9, 29-54; Roland, *The Military-Industrial Complex,* 21. For more on RAND, see also Bruce L.R. Smith, *The RAND Corporation.* (Cambridge: Harvard University Press, 1966); Fred Kaplan. *The Wizards of Armageddon* (New York: Simon and Schuster, 1983); Futrell, *ibid.*

There appears little doubt that Arnold and the air force wanted a source of scientific and technical advice that they could control, not only on missiles but also nuclear weapons and other new weapons. The ultimate effect, whether it was intended or not, was to undermine civilian authority. In its early days, RAND played a key role in pointing the air force to ICBMs, and this study is the first to examine RAND's work in this field in detail.

Satellite Programs

In 1945, few in the AAF outside of Arnold and his scientific advisors were thinking about rockets that could fly into space, either as weapons or for any other reason. But in 1946 when a group of rocket enthusiasts inside the U.S. Navy promoted the idea of building a rocket to launch an artificial satellite into orbit around the Earth, the AAF gave serious thought to the concept. We know today that rockets that can put satellites into orbit can also be used to transport warheads anywhere on Earth. We also know today that the first rockets that launched satellites were developed as ICBMs. But the first time the AAF gave anything approaching serious consideration to building such a rocket, it was as a satellite launcher and not as an ICBM.

A group inside the navy's Bureau of Aeronautics (BuAer) began in October 1945 to work on a proposal to launch a satellite, building on wartime research it had supported on rocket engines using liquid hydrogen as the fuel. This rocket research led to the BuAer group proposing to launch satellites using a single-stage launch vehicle based on this advanced rocket technology. When it became clear that the navy would not support a flight test vehicle program because of its great cost, the BuAer group approached the

AAF.[226] On 7 March 1946, five officers from BuAer and the AAF met to discuss the navy's satellite work and its proposal that future work to develop a satellite and launch vehicle be split between the two services. The AAF officers promised to meet again to determine the air force's interest in the navy proposal after contacting the office of Maj. Gen. Curtis LeMay, the AAF's Deputy Chief of Air Staff for Research and Development.[227]

LeMay reacted to the news of the navy satellite proposal by working to protect what he saw as air force interests. LeMay summoned one of the navy officers to tell him that the AAF would not take part in the navy research work, but he also agreed to meet the navy again on the subject. At the same time, LeMay directed the newly established Project RAND to immediately begin studying the technical specifications and potential uses for a satellite. The AAF put off further meetings with the BuAer group until it could come armed with copies of RAND's very first study, *Preliminary Design of an Experimental World-Circling Spaceship*.[228] The report, dated 2 May 1946 but delivered to the air force ten days later, concluded that artificial satellites were then technically feasible. The RAND experts called for a multistage rocket to launch a 500-lb. or 226-kg. satellite. The study's chapter on the significance of satellites was written by Louis N. Ridenour, a physicist who had worked during the war at the Radiation Laboratory at

---

[226] R. Cargill Hall, "Early U.S. Satellite Proposals," *Technology and Culture* vol. 4 (Fall 1963): 410 - 434. The ambition of the BuAer plan can be illustrated by the fact that a single-stage orbital launch vehicle has yet to be developed.

[227] Captain W.F. Cogswell, Navy Bureau of Aeronautics, to Assistant Chief for Research, Development and Engineering, memorandum, 11 March 1946, in RG 341, Guided Missiles Branch, Box 133, file "Satellite Project," NA.

[228] Hall, "Early U.S. Satellite Proposals," 414-8; Collins, *Cold War Laboratory,* 74-5. See also Merton E. Davies and William R. Harris, *RAND's Role in the Evolution of Balloon and Satellite Observation Systems and Related U.S. Space Technology* (Santa Monica CA: RAND Corporation, 1988) 6-9.

MIT, where he helped develop radar devices and edited a series of books summing up knowledge of radar. In the RAND report, Ridenour wrote:

> There is little difference in design and performance between an intercontinental rocket missile and a satellite. Thus a rocket missile with a free space-trajectory of 6,000 miles requires minimum energy of launching that corresponds to an initial velocity of 4.4 miles per second, while a satellite requires 5.1. Consequently the development of a satellite will be directly applicable to the development of an intercontinental rocket missile.

Ridenour also predicted that missiles passing through space and even satellites would likely be used to deliver warheads in future wars. While he pointed to satellites as promising "observation aircraft" for the military, he only mentioned observations of weather conditions and verifying the impact points of bombs, missing the many intelligence applications that space-based observations of military installations could and would provide.[229]

The RAND study findings were discussed at an AAF briefing LeMay held on 21 May 1946. Bringing the payload back to Earth without burning up was listed as one of the "major problems" with satellites, the briefing was told, and the RAND study proposed that the solution was "to install wings … which will cause the missile to descend gradually as it strikes the atmosphere thereby allowing it to dissipate the heat generated." The estimated cost to build and launch a satellite in five years was $150 million at the time or roughly $1.4 billion in 2011.[230]

---

[229] Project RAND. *Preliminary Design of an Experimental World-Circling Spaceship* (Santa Monica, CA.: Douglas Aircraft Company, Inc., 2 May 1946. Republished in 1996 by the RAND Corporation.) 9-10; Frederick Seitz and A. H. Taub, " Louis N. Ridenour, Physicist and Administrator." *Science*, Vol. 131, No. 3392 (1January 1960) 20-1. Dwayne A. Day, *Lightning Rod: A History of the Air Force Chief Scientist's Office* (Washington, D.C.: Chief Scientist's Office, United States Air Force, 2000) 23-9. Ridenour's active involvement with missiles began with this RAND study and continued until his death in 1959 at age 47, when he was a vice-president of Lockheed Aircraft Corp.

[230] Col. M.F. Cooper, memorandum for record, "Satellite Project," 21 May 1946, in RG 341, Guided Missiles Branch, Box 133, file "Satellite Project," NA.

AAF and navy officers met again in June under the aegis of the Aeronautical Board, an army-navy coordinating body whose functions were later absorbed by the Joint Research and Development Board and then the Research and Development Board. The AAF officers presented the RAND report, and then blocked further discussion of a joint program. The navy pressed on with the BuAer satellite studies until 1948. RAND continued its satellite studies for another year, refining the information pulled together in the initial report.[231] In May 1947, LeMay said the AAF would "pursue practical aspects of the earth satellite vehicle," which he called "essentially a long range air vehicle." LeMay stressed that "the sponsoring and monitoring agency for earth satellite vehicle projects should be the AAF, with other interested agencies participating and contributing."[232]

Although the austerity measures that took effect in late 1946 curtailed the air force and navy satellite research, the JRDB gave the Guided Missiles Committee responsibility in 1947 for coordination of satellite programs as part of its mandate. Much like the air force sought control of missile programs, it also moved to control satellites. USAF Gen. Alden Crawford recommended to his Air Staff colleagues on December 8, 1947 that the newly autonomous U.S. Air Force "establish a satellite project" and have RAND prepare a specification for a satellite with the purpose of testing the vehicle and proving the concept of a satellite.[233] USAF Vice Chief of Staff Gen. Hoyt Vandenberg

---

[231] Hall, "Early U.S. Satellite Proposals." 415, 420-2.

[232] Brig. Gen. William L. Richardson, memorandum for record, "Earth Satellite Vehicle," 13 May 1947, in RG 341, Guided Missiles Branch, Box 133, file "Satellite Project," NA.

[233] Brig. Gen. Alden Crawford to Chief of Staff, USAF, "Project RAND, Satellite Vehicle," 8 December 1947, and Lt. Col. Charles Terhune to Col. Millard Young, "Rand (Satellite) Policy," in RG 341, Guided Missiles Branch, Box 133, file "Satellite Project," NA; Research and Development Board to the Committee on Guided Missiles, "Earth Satellite Vehicle," 7 January 1948, with attached Status Report on Earth Satellite Vehicle, 15 January 1948, in RG 341, Guided Missiles Branch, Box 105, file "Agenda of 10th meeting of GM Committee," NA.

signed a policy statement on 15 January 1948 that read: "The USAF, as the Service dealing primarily with air weapons – especially Strategic – has logical responsibility for the satellite." Inside the Air Staff, there were reservations. While the Air Staff considered a satellite vehicle to be "visionary, somewhat beyond the state of the guided missiles, of questionable utility, and exceedingly costly, the Navy has been fostering its early implementation with great vigor." An Air Staff memo termed a satellite vehicle "technically, although not economically, possible."[234] This idea brings to mind historian Thomas P. Hughes' thoughts about advances in technological systems needing to be politically, socially and economically feasible, as well as technically feasible. Although a satellite and its rocket were technically possible at this time, they did not meet the other requirements system builders look for.[235]

Those who had some knowledge about long-range missiles at the time also wondered whether or not they were politically and fiscally feasible. In a speech on 11 January 1949, Brig. Gen. Donald L. Putt, then the air force's director of research and development, told an audience at the National War College about the rapidly rising costs for a satellite launch vehicle, which he estimated at about $100 million (about $900 million in 2011 dollars), but his arguments also applied to intercontinental missiles. Putt warned that new military hardware cannot be developed "without due consideration to its potential impact on the national economy," including satellites, which appear to be "economically undesirable." He warned that America's adversaries could win simply by provoking the U.S. government to spend more on weapons than the economy could bear,

---

[234] Futrell, *Ideas, Concepts, Doctrine,* 488. Unsigned memo for record, "Satellite Vehicles," 16 January 1948; unsigned memorandum for the Vice Chief of Staff, "Earth Satellites Vehicles," 8 January 1948 with attached "Statement of Policy for a Satellite Vehicle," in RG 341, Guided Missiles Branch, Box 133, file "Satellite Project," NA.
[235] See Hughes, "The Electrification of America," 126, 135.

echoing the concerns of Defense Secretary Johnson, Gen. Dwight D. Eisenhower and others. In the course of researching this study, the author did not find any similar sentiment expressed by an air force officer involved in missile programs in those years, let alone a stronger criticism of the utility of large-scale weapons programs.

Discussing technical problems facing satellites, Putt highlighted an issue that also affected warheads on ICBMs. He predicted that "considerable research is required" to develop materials that would allow satellite vehicles to survive high-speed re-entry into the Earth's atmosphere.[236] By the time of Putt's speech, the air force's main interest in satellites was keeping them out of the hands of rival services. The AAF had looked briefly at satellites in 1946, and even though RAND had established a link between them and the rockets that would become known as ICBMs, their cost and technical problems had turned the air force away from satellites until RAND began studying the potential of military reconnaissance satellites in the 1950s. RAND's initial 1946 report on satellites, however, gave both the air force and RAND an early taste of the technical issues they would face with ICBMs.

MX-774

As World War II came to an end, the U.S. Army, the U.S. Navy and the AAF had either begun or were about to start developing and building their own rocket missiles. Army Ordnance had begun working on rockets in 1944 under the Hermes program, which it ran in cooperation with General Electric. Hermes included surface-to-air missiles, a ramjet test program that utilized captured V-2 missiles for test flights, and it developed a short-range surface-to-surface missile that evolved into the army's Redstone

---

[236] Brig. Gen. D. L. Putt, Lecture, National War College, 11 January 1949, in RG 341, Guided Missiles Branch, Box 131, file "Plans 1949-50," NA.

Intermediate Range Ballistic Missile in the 1950s. Army Ordnance hired Wernher von Braun and the core of his team of German rocket engineers after they surrendered to American troops as the war in Europe ended. The German engineers, who worked at Fort Bliss, Texas, and the nearby White Sands Proving Ground in New Mexico, restored and launched captured V-2 rockets in a variety of scientific and technical test programs. The army also contracted with the Jet Propulsion Laboratory at Caltech to develop tactical missiles including the Corporal rocket.[237]

In January 1946, the report of the War Department Equipment Board, which was formed to review what new weapons and other equipment would be needed in the postwar environment by the U.S. Army, including the Army Air Forces, called for the development of several kinds of guided missiles, including missiles to defend against enemy aircraft and missiles, and "Strategic" missiles carrying "atomic explosive[s]" intercontinental distances at high speeds and altitudes that would be "incapable of interception with existing equipment." The board, which was chaired by Gen. Joseph W. Stilwell, who had commanded American forces in the China- Burma-India Theater in the war, pointed to the need for research on guidance systems for missiles and on various forms of propulsion, including methods using nuclear energy.[238]

The U.S. Navy was interested in winged missiles and worked on adapting the AAF version of the V-1 winged missile for naval purposes. In the 1950s, the navy developed the Regulus, a winged missile capable of launch from ships and of carrying

---

[237] U.S. Army Ordnance Corps & General Electric Company, "Hermes Guided Missile Research and Development Project," September 25, 1959. NASA History Office, NASA Headquarters, Washington, D.C.; Malina, "Origins of JPL," 60-6; Koppes, *JPL and the Space Program,* 18-22; G. Harry Stine, *ICBM: the Making of the Weapon that Changed the World* (New York, Orion Books, 1991) 118-20.

[238] Joseph W. Stilwell et al., *Report of War Department Equipment Board* (Washington D.C.: War Department, 19 January 1946) 10-2, 68-70.

nuclear weapons 500 miles. The navy's postwar missile programs included the Viking rocket that was developed by the Naval Research Laboratory and the Glenn L. Martin Company for upper atmospheric research. Viking later formed one of the building blocks of the Vanguard satellite launch vehicle. In 1947, the navy launched a V-2 from the deck of a ship, and three years later, repeated the feat with a Viking rocket. In 1948, the Navy also began designing a long-range missile, the Triton, which never went into production. And while the Navy's work with solid-fueled rockets dated back to World War II, the program that led to the Polaris Submarine-Launched Ballistic Missile did not begin in earnest until 1955.[239]

The air force had no in-house expertise on rockets at the end of the war, and while German rocket experts met with air force research staff at Wright Field in Dayton, Ohio, they were not retained as a group as the von Braun group was by Army Ordnance. Instead, the air force made use of German engineers who went to work for U.S. aerospace contractors, most famously former general Walter Dornberger at Bell Aircraft. The air force's tradition of procuring aircraft from private contractors goes back to 1908, when the U.S. Army purchased its first aircraft from the Wright brothers. As the army's air arm grew into the AAF, it continued to procure its aircraft from outside contractors, which set it apart from the army's tradition of developing weapons in house through the arsenal system. By 1947, an estimated eighty-five per cent of the air force's research and development funds was spent in private industry.[240]

---

239 House of Representatives, Committee on Government Operations, *Organization and Management of Missile Programs,* 1st Session, 86th Congress, House Report No. 1121 (Washington D.C.: U.S. Government Printing Office, 1959) 431-4.; Werell, *Death from the Heavens,* 249; Wyndham D. Miles, "The Polaris," in Emme, *History of Rocket Technology,* 162-5. See also Milton W. Rosen, *The Viking Rocket Story* (London: Faber and Faber, 1955).
240 Testimony of Gen. Bernard Schriever, United States Senate, *Hearings before the Preparedness Investigating Subcommittee, Committee on Armed Forces, Inquiry into Satellite and Missile Programs.* 1st

The air force served notice that it wanted to expand its missile program in August 1945 when AAF headquarters published military characteristics – the physical and operational specifications it sought – for several types of air defense, tactical and strategic missiles. These included ground-to-ground missiles classified as short-range with ranges between 175 and 500 miles, medium range missiles between 500 and 1,500 miles, and long-range missiles between 1,500 and 5,000 miles.[241] In October, the AAF invited seventeen aircraft contractors to submit proposals for ground-to-ground missiles of various ranges, and eleven responded. Douglas Aircraft declined to compete but instead chose to continue its discussions on intercontinental missiles with Gen. Arnold that led to the creation of Project RAND. In February 1946, the AAF selected two pairs of proposals for each of the three ranges, including bids from Consolidated Vultee Aircraft Corporation and Northrop Aircraft to study long-range missiles. Consolidated Vultee's proposal included a winged, subsonic jet-powered missile and a rocket-powered ballistic missile sometimes known as Hiroc under project number MX-774. In project MX-775, Northrop began developing two winged missiles, a subsonic turbojet missile known as Snark and a supersonic version known as Boojum. At the same time, North American Aviation won a study contract under project MX-770 to begin work on a short-range winged rocket that later became known as Navaho. At that point, the AAF and its contractors were working on twenty-eight missile programs. Although this program

---

and 2nd Sessions, 85th Congress, January 9, 1958, 1637-8; testimony of Gen. Curtis LeMay, House of Representatives, *Hearings on the Military Establishment Appropriation Bill for 1948 before the Subcommittee of the Committee on Appropriations,* 80th Congress, 1st Session, 7 March 1947, 652; Futrell, *Ideas, Concepts, Doctrine,* 479. For more on procurement practices of the USAF and its predecessors, see Johnson, *The United States Air Force and the Culture of Innovation,* 27-58; Paul Hanle, *Bringing Aerodynamics to America,* 1-2; and Lassman, *Sources of Weapon Systems Innovation in the Department of Defense*, 67-93.

[241] As discussed in Chapter 2, the U.S. military generally used nautical miles rather than statute miles. By that measure, 175 nm equal 324 km, 500 nm are 926 km, 1,500 nm equal 2,778 km, and 5,000 nm are 9,260 km.

appeared to cover all possible defensive and offensive purposes the AAF might have for missiles, air force historian Max Rosenberg noted that a few categories of missiles were missing, including very short range missiles, which were under negotiation with the Army Ground Forces, and missiles with ranges greater than 5,000 miles, because advances in missile design needed to be made on shorter range vehicles before such very long range missiles could enter serious development.[242]

Like other aircraft contractors of the time, Consolidated Vultee, also known as Convair, was motivated to bid on the missile work because its heavy wartime aircraft work had ended with World War II. Convair had built thousands of aircraft during the war, notably the B-24 bomber, but unlike most other contractors at war's end, it had a major new contract building the B-36 long-range bomber for the air force. Convair's Vultee division in Downey, California, also had rocket experience from wartime in the form of the Lark anti-aircraft missile built for the navy. Under Project MX-774, Convair won a contract from the AAF for $1.4 million to spend a year studying its two concepts for long-range missiles. Karel J. (Charlie) Bossart, a Belgian-born aeronautical engineer, headed the project at Convair.[243]

As the year drew to a close, what became known as the "black Christmas of 1946" followed word that the Bureau of the Budget was cutting the air force's $186 million in research and development funds for fiscal year 1947 by $75 million. For missiles, that meant that more than half the budget was gone – from $29 million to $13

---

[242] M. Rosenberg, *National Guided Missile Program,* 74-7; Doris E. Krudener. *History of Ballistic Missiles Site Activation: Plans, Policies and Decisions 1954-1961, Volume 1 Narrative (Revised Edition)* (Norton AFB, Cal.: Historical Division, USAF Ballistic Systems Division, 1964) 4-6; Collins, *Cold War Laboratory,* 41-52. The ATSC, which was responsible for AAF missiles, was renamed the Air Materiel Command in March 1946. See the organization chart in Chapter 2.

[243] John L Chapman. *Atlas: The Story of a Missile* (New York: Harper and Brothers, 1960) 27-9.

million. By March 1947, after discussions with the Air Staff, the Air Materiel Command had cancelled eleven of the air force's twenty-eight missile programs and added one. Among the casualties was the winged, jet-engine version of MX-774, leaving the ballistic missile. Northrop's Boojum and Snark were folded into one jet-propelled winged missile that became known as Snark, and only after Northrop president Jack Northrop lobbied aggressively to save the program. While Convair was free to concentrate on the one ballistic missile, it was also told that the money it had been given for one year would have to last for two. The tight money policy followed the 1946 Congressional elections, when Republicans had won control of both the House and Senate, bringing with them plans to cut budgets and taxes. In the early months of 1947, the AAF became aware that President Truman and the new Congress would cut AAF research funding for Fiscal Year 1948. In response, the air force placed higher priority on projects likely to provide an immediate payoff in new or improved weapons. Missile research funds were set at $22 million, which at first appeared to be an increase from the final figure for 1947 but in fact led to further cuts to projects that were moving from the drawing board to fabrication.[244]

Maj. Gen. Benjamin W. Chidlaw, the Air Materiel Command's deputy commander for engineering, ordered a reduction in AAF missile programs from seventeen to twelve on 6 May 1947. While he called the individual programs all "desirable and technically sound," the missile program as a whole is "considerably overexpanded" for the available budget of $22 million, and therefore "must be drastically cut." Chidlaw called for elimination of "insurance missiles" such as subsonic missiles performing the same mission as supersonic missiles. "Also eliminated is the 5000-mile

[244] M. Rosenberg, *National Guided Missile Program,* 77-82; Futrell, *Ideas, Concepts, Doctrine,* 219-21; Beard, *Developing the ICBM,* 89-91.

range [MX-774] rocket which does not promise any tangible results in the next 8 to 10 years," he ordered, and instead missiles that show the promise of "early tactical availability" would get top priority. His order also called for fewer contractors to each make more kinds of missiles to save money and strengthen the selected contractors. In his list of missiles being continued, Chidlaw included a North American Aviation study of a 5,000-mile range supersonic missile, but interestingly he predicted it would likely take the novel form of a "nuclear energy ram jet." At the time, North American was building a shorter range winged rocket under the MX-770 program, and Chidlaw's order became a stepping stone toward that program becoming a long-range missile known as Navaho. But the nuclear ram jet idea disappeared from MX-770.[245]

A detailed Air Staff report attached to Chidlaw's order stated that the air force "should not expend funds on the development of a 5000-mile rocket" for two reasons. The first was the fact that the MX-774 was fueled with alcohol, whose power was "too low" for a long-distance missile. Convair envisioned developing a two-stage rocket with a more powerful fuel, but this rocket would only reach 1,500 miles with alcohol fuel, the report explained. The rocket planned by Convair would cost $47 million to develop and each rocket would cost $465,000, according to the AAF estimate, and further work on this rocket should await more powerful fuels. The second issue was the fact that very little was known about materials that would allow warheads to survive the heat of re-entry into the atmosphere, requiring what the report called a "long series of costly experiments." The report praised Convair's proposed guidance system and suggested that the unexpended money from the contract be used to develop the guidance system for

[245] Maj. Gen. B.W. Chidlaw to Commanding General, AAF, "AAF Guided Missiles Program," 6 May 1947, attached to Self, *History of Missile Development*.

North American's Navaho missile.[246] Convair got an even more negative message from the air force when an official from the contractor went to Washington that spring to lobby for the MX-774. Military scientists told him they believed that missiles with ranges longer than 3,000 miles were "at least twenty-five years in the future" and some air force leaders shared their belief "that air vehicles without cockpits didn't belong in the Air Force."[247]

MX-774 Rocket (USAF National Museum)

By then, the Convair team had built the first of ten planned MX-774 rockets. The 9.6-metre tall MX-774 was significantly smaller than the V-2 but contained important design improvements, most of them aimed at cutting the weight that limited the range and speed of rockets like the V-2. First, Bossart's team eliminated separate internal walls for

[246] "Exhibit 'A' Subject: AAF Guided Missiles Program," attached to letter from Maj. Gen. B.W. Chidlaw, Deputy Commanding General, Engineering, 6 May 1947, attached to Self, *History of Missile Development*; Futrell *Ideas, Concepts, Doctrine,* 482.
[247] Chapman, *Atlas: The Story of a Missile,* 56.

fuel tanks and used the airframe itself to contain the fuel, cutting weight and increasing fuel capacity. As well, it removed stiffeners from the airframe and retained rigidity in the tanks by relying on the rocket's fuel, or nitrogen gas under pressure when the rocket was not fueled. The team also designed the rocket to separate the warhead after the rocket engine stopped firing so that heat protection would not be needed for the rocket body. As well, Bossart's team designed gimbaled or swiveling engines to steer the rocket. This innovation took the place of the tilting vanes that deflected the flames from the engine, as used in the V-2 and other early rockets. While the MX-774 contained a conventional guidance system for the time, Convair engineers were building a more advanced radio guidance system known as Azusa.[248] When Convair later won a contract to build the Atlas ICBM, many of these technical innovations and others were built into Atlas. The von Braun group that was building rockets for Army Ordnance was known as more conservative and used traditional airframe design and tilting vanes in the Redstone rocket it built in the 1950s. The MX-774 and the Atlas rocket that followed it represented a different technological style, as Thomas Hughes explained it, from Redstone.[249]

When the air force cancelled MX-774 on 1 July 1947, it allowed Convair to use the remaining funds from its contract to test and launch three MX-774 rockets. After extensive ground testing in California, the three MX-774 rockets were launched at the White Sands Proving Ground on 13 July, 27 September and 3 December 1948. All three fell well short of the planned altitude of 100 miles, with two exploding in the first minute of flight and another reaching an altitude of only ten miles. Convair reported that it came

[248] Chapman, *Atlas: The Story of a Missile,* 29-34.
[249] Swenson, et al., *This New Ocean,* 22-7; Hughes, "The Evolution of Large Technological Systems." 68-70.

to understand the reason for every failure, and thus the flights proved the new features designed into the missile.[250]

At the time the AAF was preparing to scale back missile programs, it was questioned in Congress about the cost of developing a long-range guided missile. Lt. Gen. Ira C. Eaker, the AAF's deputy commanding general, told the House Subcommittee on Appropriations on 6 March 1947 that a 5,000-mile-range guided missile could be developed in five years with a development effort equal to that for the atomic bomb, at a cost of a quarter billion dollars a year. Eaker estimated that the first prototypes would probably cost about $200 million each, and that production rockets could cost as little as $7 million each. While the air force must retain bombers as its primary long-range strategic weapon, he added that the air force "should, as a wise precaution," spend the money needed to build a long-range guided missile which could become "the primary weapon at some future date, but probably not within 15 years."[251] A year later, the air force was putting forward a different cost estimate for a similar weapon, although the differences between the two proposals could not be found. In July 1948, the air force's Guided Missiles Branch informed a committee of the Joint Chiefs of Staff that it would have to spend $64 million a year to develop a long-range supersonic missile to carry nuclear weapons by 1960, a much lower estimate but a much longer development period from that advanced by Eaker, and a very modest figure compared to what became the real costs of ICBMs.[252]

---

[250] J. Neufeld, *Ballistic Missiles,* 45, 49. The unexpended funds came from the original contract and another $493,000 the air force added to Convair's contract in June 1946.
[251] Futrell, *Ideas, Concepts, Doctrine,* 481-2.
[252] Guided Missiles Branch cost estimate quoted in Beard, *Developing the ICBM,* 88.

Snark missile at launch (USAF National Museum)

Priorities for Missiles

When the air force cancelled the MX-774 rocket, it allowed two long-range missile programs to continue, both of which were winged missiles: the jet-propelled Northrop Snark, which had a range of only 500 miles, well short of intercontinental distances, and North American Aviation's rocket that was evolving into a long-range missile known as Navaho.[253] The historical controversy over the air force handling of missile programs in the late 1940s in works such as Edmund Beard's revolves in part around the May 1947 air staff decision to halt the ballistic missile program while emphasizing bombers and continuing cruise missile programs. Some of the air force

[253] At the time, winged missiles were called glide missiles and today these missiles are known as cruise missiles.

thinking around this decision can be found in priorities for missiles and bombers set at this time. Beard did not take note of the fact highlighted in *Where We Stand* that the German rocket experts were also looking to winged missiles to carry warheads long distances, something that would have influenced the fate of air force missile proposals in 1947.[254]

To fit reduced budgets, the AAF worked in June 1947 to set priorities for missile programs. Deputy Assistant Chief of the Air Staff Brig. Gen. Thomas S. Power gave the top priority to bomber-launched air-to-air and air-to-surface missiles, followed by short-range surface-to-surface missiles, and then missiles launched from the ground or fighters to defend against enemy aircraft and missiles. Long-range surface-to-surface missiles had fourth priority, ranking above only "interim air-to-surface missiles." The category of long-range ground-to-ground missiles included four types of missiles, including aircraft drones, supersonic surface-to-surface missiles "in the 150-1000 mile range class with conventional and atomic warheads, for strategic and coast defenses," missiles in the 1000-10,000 mile class with both conventional and atomic warheads for strategic bombing, and surface-to-surface "reconnaissance missiles." Gen. Hoyt Vandenberg, Spaatz's deputy as commanding general, quickly approved the rankings.[255]

Power based these priorities in part on the assumption that for "the next ten years, at least, the subsonic bomber will be the only means available for the delivery of long range (1000 miles and over) air bombardment." The bombers would require air-to-surface missiles and other armament to attack defended targets. The U.S. had no means

---

[254] Beard, *Developing the ICBM,* 54-63.

[255] Brig. Gen. Thomas S. Power to Commanding General, Army Air Forces, "Operational Requirements (Priorities) for Guided Missiles, 1947-1957," 16 June 1947, and attached document, "Requirements for Guided Missiles" Detailed Recommendations," in RG 341, Guided Missiles Branch, Box 141, file "Miscellaneous on Relative Priorities 1945-7," NA; Self, *History of Missile Development.* 46.

of defending against ballistic missiles such as the V-2, Power added.[256] Behind the priorities lay the assumption that long-range supersonic guided missiles with ranges over 2,000 miles "will not be available for operations prior to 1957," and neither would long-range supersonic bombers. A background paper attached to Powers' decision predicted that by 1952, the Soviets would have both atomic bombs and long-range bombers. Because the U.S. would have only subsonic bombers and not supersonic bombers or missiles to deliver atomic bombs for the upcoming ten years, the paper claimed that there was an urgent and immediate need for defensive armament to protect these subsonic bombers, including air-to-surface supersonic missiles with both conventional and atomic warheads. Although long-range surface-to-surface guided missiles would not be ready before 1957, the paper called for research and development of these missiles to "proceed at the maximum rate" because of the need to keep ahead of potential enemies.[257]

Power's priority list was probably based in part on a similar list produced on 28 May 1947 by Brig. Gen. William L. Richardson of the AAF Guided Missiles and Air Defense Division in the Air Materiel Command. Richardson's list put surface-to-surface missiles with ranges between 150 and 1,000 miles and capable of carrying conventional and atomic warheads, in eighth place. The tenth and final priority was for a 10,000-mile surface-to-surface missile.[258] A few months later, USAF working group headed by Richardson on the USAF missile program suggested that the "first logical step toward an ultimate supersonic missile may be to contract for and build a low performance

---

[256] Power, *Ibid.*

[257] "Requirements for Guided Missiles: An Evaluation of the Situation, 1947-1957," attached to Powers memorandum of 16 June 1947, in RG 341, Guided Missiles Branch, Box 141, file "Miscellaneous on Relative Priorities 1945-7," NA. Emphasis in original.

[258] Vincent S. Roddy, memorandum for record, "Priorities of Guided Missiles," 5 June 1947, in RG 341, Guided Missiles Branch, Box 141, file "Miscellaneous on Relative Priorities 1945-7," NA.

(subsonic) vehicle," Richardson's group proposed. "It is not felt that the guided missile will ever replace the airplane. Rather the guided missile will supplement and aid in the air operations of the future."[259]

The accuracy of long-range missiles was an important issue for the air force, as had been shown in Dryden's report in *Toward New Horizons*, and in two documents attached to Richardson's priority list. A paper setting out military specifications for a surface-to-surface guided missile with a range between 1,500 and 5,000 nautical miles and carrying an atomic or biological warhead, specified an accuracy where "one out of two missiles launched shall strike within a circle of 1500 feet from the aiming point." The 1,500-foot or 457-metre accuracy requirement remained in place until 1954, when the committee that called for development of America's first ICBM, the Atlas, loosened it because of the vastly increased explosive power contained in the newly-available thermonuclear bomb. The second document noted that missiles would cost more to use than bombers due to their one-shot nature, the cost difference depending on the accuracy of the guided missile. For this reason, the document predicted that the USAF would set "stringent" standards for missile accuracy, and it also foreshadowed another important issue for ICBMs when it stated that payload weight is "one of the most controversial" matters because "very small increases in payload cause large increases in gross missile weight."[260]

---

[259] Office of the Deputy Chief of Staff, Operations, Guided Missiles Group, USAF, "Item 5: Guided Missiles Program," undated, in RG 341, Guided Missiles Branch, Box 141, file "Presentation for January 1948 meeting USAF ACFT and Weapons Board," NA.

[260] Office of the Deputy Chief of Staff, Operations, Guided Missiles Group, USAF, "Military Characteristics for a Surface-to-Surface Guided Missile," 7 November 1947, and "Tab A: approval of Military Characteristics for Guided Missiles," undated and unsigned, both in RG 341, Guided Missiles Branch, Box 141, file "Presentation for January 1948 meeting USAF ACFT and Weapons Board," NA. The one out of two striking requirement was also known as "Circular Error Probability," in this case of 1,500 feet. In his study of missile guidance, Donald MacKenzie wrote that the 1,500-foot accuracy requirement

Richardson raised the missile guidance and navigation issue in 1948 to justify the air force's preference for winged missiles over ballistic missiles. He disagreed with a technical evaluation group's statement that long-range ballistic missiles need to be guided only during the initial powered flight. Unless a way could be found to control the path of the warhead all the way to the target, he argued that the problems of accurately guiding ballistic missiles would be the same as those relating to "projectiles fired from guns." Richardson agreed that while the military possibilities of ballistic rocket missiles should be thoroughly explored, winged missiles appeared to offer "greater promise" than ballistic missiles and thus should have a higher priority.[261]

Maj. Gen. L.C. Craigie, the USAF's director of research and development, withdrew military characteristics statements in November 1947 for guided missiles with very long ranges between 5,000 and 13,000 miles, which had the effect of removing them from any research and development. While the air force believed that a military requirement existed for such missiles, he stated "no priority can be placed on the development of such a missile at this time."[262] The USAF laid out its reasons for this decision on 20 July 1948 to the Guided Missiles Committee subcommittee on long-range rockets. The air force originally gave Convair a contract for the MX-774 rocket because the air force saw that long range rockets "had certain advantages such as surprise, [and] non-interceptability." Since not all ideas for missiles could be funded, "those missiles

---

probably arose from the accuracy that could be attained by bombers, but he "had no evidence" to back up the idea. MacKenzie, *Inventing Accuracy: A Historical Sociology of Nuclear Missile Guidance* (Cambridge, Mass.: MIT Press, 1990) 114.

[261] Brig. Gen. William Richardson to the Chairman, Committee on Guided Missiles, RDB, "Comments on Report of Technical Evaluation Group, 9 June 1948, GM 50/3 HKG 9/5," 13 August 1948, in RG 341, Guided Missiles Branch, Box 143, file "Research and Development Board Committee on Guided Missiles," NA.

[262] Maj. Gen. L.C. Craigie, Director of Research and Development, to Commanding General, Air Materiel Command, "Military Characteristics for Very Long Range Surface-to-Surface Guided Missiles," I November 1947, attached to Self., *History of Missile Development.*

which were continued were least difficult to develop, both from the time and money standpoints." The USAF did not want to support a missile project "that would not end up in a tactical missile in less than two years – especially when less difficult missiles could be developed in about half this time." The result was that two winged missiles – Navaho and Snark – were funded while the Convair MX-774 ballistic rocket was wound down. The air force blamed difficult-to-handle rocket fuels for making long-range rockets "too large and complex for tactical utility," and explained that protecting warheads from the heat of a high-speed re-entry remained a "severe and unsolved problem" that would take years to solve. Celestial navigation will not work in rockets, the air force asserted. "We are thus forced to utilize an electronic 'gun barrel' type of system which requires that the missile be placed accurately on its trajectory at burn out," the time the engine stopped firing. Because this event took place early in flight, any aiming errors would thus be magnified over thousands of miles as the warhead coasted toward its target. The air force added that its project to develop nuclear propulsion for aircraft, and the hope of having nuclear ramjets that do not need to carry fuel, "influenced the decision not to proceed with an active rocket development program at this time." But the USAF remained active in promoting research and development in the fields of rocket propulsion, fuels, guidance "and practically all other components and systems required for a long range rocket." The subcommittee and the full Guided Missiles Committee accepted the air force's proposal that RAND continuously review developments in long-range rockets.[263]

Air force historian Max Rosenberg commented in his history of missile programs in the late 1940s that the low priority for strategic missiles "clearly indicated that the

[263] USAF Memorandum, "Attachment E: Long Range Rockets, " July 1948, in RG 156, U.S. Army, Office of the Chief of Ordnance, Records Relating to the Army Guided Missiles Program, Box 7, file "Ad hoc Subcommittee – GM Committee – RDB (Long Range Rocket)," NA.

AAF viewed guided missiles as having an auxiliary, not a primary, role in air operations in the coming decade" behind bombers. "Severe technological problems and austere budgets obviously caused this cautious guided missile approach," he explained correctly, but his statement that it was difficult to assess how the air force's "natural trust in aircraft and the inherent distrust in still-to-be-proven unmanned missiles" affected the setting of the priorities does not take into account the argument made in Chapter One of this study that bomber aircraft were still very early in their transitions from propellers to jets and from subsonic to supersonic speeds, strongly influencing decision-makers to focus on bombers. An additional illustration of the air force's attitude to long-range missiles was its statement to the GMC subcommittee that they were being held back because of hopes for nuclear-powered ramjets.[264]

It is clear that the air force in 1948 saw long-range missiles as an exotic and futuristic technology. At a time when it considered its budget to be very tight, the air force concentrated on more immediate needs, such as bomber aircraft and shorter-range missiles, and gave long-range missiles a low priority because they represented a challenging and futuristic technology with only a long-term payoff. This conclusion differs from the analysis of Edmund Beard relating this low priority to simple bureaucratic resistance in the air force to ICBMs.[265]

The Finletter Commission

President Truman set up the President's Air Policy Commission, which was made up of five civilians, to report on America's state of preparedness for air attack. Their report, *Survival in the Air Age*, was better known as the Finletter Report after the

---

[264] M. Rosenberg, *National Guided Missile Program,* 85.
[265] Beard, *Developing the ICBM,* 8.

commission chair, lawyer and future air force secretary Thomas K. Finletter. In January 1948, the Finletter Report called for a dramatic increase in air force spending to permit creation of a seventy-group air force.[266] It termed the development of long-range guided missiles a "tremendous problem" that will "require the most intensive application of our best research talent, coupled with the expenditure of very large amounts of money for experimentation, before we can hope to produce a pilotless weapon of either [V-1 or V-2] class that will have a reasonable chance of hitting a distant selected target." Funds for slower subsonic missiles were being reduced, but unnamed sources had advised the commission that "the subsonic missile offers the most practical means of testing and developing the intricate guidance mechanisms for supersonic types, and it suggests, therefore, that the technique be fully exploited before funds for subsonic research are entirely eliminated." While the commission recommended more and better resources for aeronautical research and development, it added that the "most serious bottleneck in the research and development picture, as laid before the Commission" was a lack of skilled personnel. The commission called for measures to ensure that more university trained scientists and engineers would be available to lead and carry out research and development.[267]

Testimony to the commission was given in private, but some of it is preserved in a commission memo summarizing aircraft industry testimony on missiles. This testimony

---

[266] The size of a group varied from 35 to 105 aircraft and between one and two thousand people, depending on the type of aircraft. For background on the formulation of the air force's seventy-group goal, see Wolk, *The Struggle for Air Force Independence.*

[267] The President's Air Policy Commission, *Survival in the Air Age* (Washington D.C.: Superintendent of Documents, January 1, 1948) 25, 82-3, 94-5; Borowski, *A Hollow Threat,* 116. Not long before the Finletter Report was issued, a presidential report on science policy warned of "serious shortages" of scientists, engineers and technicians, and the teachers needed to train them. See John R. Steelman, and the President's Scientific Research Board, *Manpower for Research: volume four of Science and Public Policy: A Report to the President* (Washington D.C.: Superintendent of Documents, October 11, 1947) 1.

argued that anti-aircraft missiles were in advanced development and could be put in production in two to five years. Development of a subsonic guided missile with a speed of 600 miles per hour and a range of 4,000 miles "was presented as a definite possibility within four to five years." These missiles, which should be ready to go into production in that time, would use existing engines and "automatic astronomical navigation devices" then under development. But some witnesses questioned the effectiveness of these missiles because anti-aircraft missiles could shoot them down. "The Supersonic missile has been discussed as a potentiality in ten to fifteen years. This rocket is reported to have a 5,000 mile range and a high degree of accuracy," according to the testimony.[268] In response USAF Maj. Gen. Earle E. Partridge told the commission that the long-range supersonic missile "will be possible from a technical viewpoint in fifteen to twenty years," but that it will only be possible with large expenditures and maximum development effort. He said that even if the great difficulties of developing guidance and control systems for missiles were overcome, the problem of determining the exact location of targets would remain. "The lack of accurate and coordinated mapping in many parts of the world is a very real problem," he explained, and geodesists say "there are very few places in Russia that can be located more accurately than 1/4 mile with respect to a point 4,000 miles distant." Partridge estimated that delivering a warhead to a target 5,000 miles away would be less expensive with a manned bomber than with a missile.

---

[268] Memorandum to Colonel Boatner and Captain Pihl, "Air Policy Commission," Memo No. 39, undated but probably October 1947, attached to Self, *History of Missile Development*.

Should there be difficulties developing long-range supersonic bombers, or such bombers have high crew loss rates, he believed that missiles would become more attractive.[269]

Ramjets

The air force in the late 1940s was looking at new forms of propulsion other than rockets, notably ramjets and nuclear propulsion. Air force officials had used these competitive forms of propulsion to justify restraining research on rockets, as we have seen in this chapter, and so a brief consideration of these two propulsion methods will illuminate air force actions during these years. Rockets, nuclear propulsion, and ramjets had all featured prominently in the 1945 reports by von Kármán and his colleagues, *Where We Stand* and *Science: The Key to Air Supremacy*.

Among the various types of jet engines, the one most commonly encountered is the turbojet, where air entering the engine is compressed, mixed with fuel in a combustion chamber, and then passed through a turbine that powers the compressor and then through a nozzle to generate thrust. Ramjets don't have compressors but use the forward motion of the engine to compress the air entering the engine. In 1945, this offered what appeared to be an appealingly simple means for high-speed flight. In *Science: The Key to Air Supremacy,* von Kármán wrote that the ramjet was the "logical power plant for supersonic flight with speeds greater than twice the speed of sound."[270] But ramjets could not work until they were boosted to high speeds, usually by another engine. In the U.S. military, ramjets attracted interest from Army Ordnance, the air force

---

[269] Maj. Gen. E.E. Partridge, acting deputy chief of staff, operations, to Secretary of the Air Staff, "Data for the President's Air Policy Commission Concerning Guided Missiles," Routing and Record Sheet, 28 October 1947, attached to Self, *History of Missile Development.*

[270] *Science: The Key to Air Supremacy*, Vol. 1 of *Toward New Horizons*, reproduced in Michael H. Gorn, ed., *Prophecy Fulfilled: 'Toward New Horizons' and Its Legacy* (Washington, D.C.: Air Force History and Museums Program, 1994) 120.

and the navy. The German rocket experts who came to work for the U.S. Army at the end of World War II were put to work on ramjet research despite the fact that their group had little expertise in that area. Some of the missiles built and launched under the Army's Hermes program were dedicated to ramjet research, but the army never pursued ramjets after Hermes ended in 1954. The navy built an anti-aircraft missile named Talos that used ramjet engines. Talos began flying in 1953 and was deployed on the fleet between 1958 and 1980. In 1946, the air force began research on ramjets with a missile called the X-7 that made its first flight in 1951. In 1950, the USAF began developing a ramjet-powered missile called Bomarc that was designed to intercept bomber aircraft. Bomarc missiles were on active alert in the United States and Canada from 1959 to 1972.[271]

The USAF's Navaho missile became famous as a two-stage long-range vehicle with the first stage being powered by rockets and the second stage using ramjets. Navaho began in 1946 at the same time as MX-774 when the AAF contracted with North American Aviation to build a winged rocket missile with a range of 500 miles. Under the technical leadership of William Bollay, North American began developing a new rocket engine for Navaho, which led to the engines that eventually were used for America's first ICBMs and space launch vehicles, including Atlas, Thor, Jupiter, and Redstone. In 1948, the USAF ordered North American to double the range of the missile to 1,000 miles. Since the existing design did not lend itself to doubling the range, air force research officers at Wright Field worked with the contractor to turn Navaho into a two-stage

[271] T.A. Heppenheimer, *Facing the Heat Barrier: A History of Hypersonics* (Washington D.C.: National Aeronautics and Space Administration, 2007) 91-6; "Hermes Guided Missile Research and Development Project," prepared for Technical Liaison Branch, Office of the Chief of Ordnance, Department of the Army, September 25, 1959, in NASA Headquarters History Office Historical Reference Collection; M. Neufeld, *von Braun,* 217, 238-9, 249; Jay Miller, *The X-Planes, X-1 to X-45, Third Edition* (Hinckley, England: Midland Publishing, 2001) 112-21.

vehicle with a rocket-powered booster and a winged second stage with ramjet engines. By August 1950, Navaho was designated as a two-stage winged vehicle with an intercontinental range of 5,500 nautical miles.[272]

1957 Launch of Navaho (NASA)

Ironically, ramjets were added to Navaho just as the military's interest in ramjets was beginning to wane. By 1950, the air force was realizing that ramjets would not be as

[272] Thomas A. Heppenheimer, "The Navaho Program and the Main Line of American Liquid Rocketry," *Air Power History,* Spring 1991, 4-17; Miller, *The X-Planes,* 134-141. For more on Navaho, see Kenneth P. Werrell, *The Evolution of the Cruise Missile* (Maxwell Air Force Base: Air University Press, 1985); Dale D. Myers, "The Navaho Cruise Missile: A Burst of Technology," 42nd Congress of the International Astronautical Federation, October 5-11, 1991, Montreal; *The Development of the Navaho Guided Missile 1945-1953,* USAF Historical Program, probably 1954 (On file in NASA Headquarters History Office collection).

easy to build and operate as it had previously hoped. And as T.A. Heppenheimer explained in his history of high-speed aerodynamic research, ramjets were losing their edge over turbojets. In the late 1940s, turbojets could not fly much faster than the speed of sound, but starting in 1950, technical innovations made possible turbojets that could fly at twice or three times the speed of sound. In the early 1950s, the creation of anti-aircraft missiles meant that no aircraft was as safe as it had been when it needed only to outrun other aircraft in dogfights. As a result, the military need for aircraft that could fly two or three times the speed of sound nearly disappeared except for specialized aircraft like the SR-71 reconnaissance aircraft. With very little further need to use them in crewed aircraft, ramjets continued to be used only in missiles like Bomarc, Talos, and the air force hoped, in Navaho.[273]

Ramjets fell by the wayside because of their technological deficiencies, and the changes in the aircraft market due to advances in turbojet technology and the military's turn away from high-speed jet aircraft. As Thomas Hughes wrote, while technological systems are growing and evolving, both the strengths and limitations of the technological artifact, in this case the ramjet, affect the growth of the system. But these systems are also affected by decisions made by system builders, in this case air force leaders apparently influenced by a reduced need for ramjets for high-speed military aircraft. While ramjets remained in development for missiles, the appearance of what Hughes called a reverse salient in their development, in this case, the need to build large and complex boosters to get missiles up to speed before ramjets could be used, caused many air force officials working on missiles to look at ramjets with a more critical eye.[274]

---

[273] Heppenheimer, *Facing the Heat Barrier,* 197-8; M. Neufeld, *von Braun,* 249.
[274] See Hughes, "Evolution of Large Technological Systems."

Nuclear Propulsion

The concept of nuclear propulsion for aircraft and missiles was probably more prominent in 1945 than ramjets, but it wound up never coming close to regular use. In *Where We Stand,* von Kármán found nuclear power a worthwhile source of power for aircraft because the fuel would not be a major weight factor, and if the weight of other parts of the propulsion system could be reduced, nuclear power could be used to power aircraft almost "without range limitations." In spite of many unresolved technical problems, he said that research in this area deserved the air force's "immediate attention." In *Science: The Key to Air Supremacy,* von Kármán acknowledged that radiation issues would limit the usefulness of nuclear propulsion in crewed aircraft, but this form of propulsion would still be useful in pilotless aircraft. He also proposed the establishment of a "Center for Nuclear Aircraft Development."[275]

The Finletter Report in 1948 said the "possibility of employing atomic energy for the propulsion of aircraft and guided missiles is sufficiently important to warrant vigorous action" by the Atomic Energy Commission (AEC), the USAF, the navy and the National Advisory Committee for Aeronautics. The report urged that work underway by the USAF and the AEC under the Nuclear Energy for the Propulsion of Aircraft program be "intensified." In his assessment of the relative utility of long-range missiles and bombers, Gen. Partridge wrote that "[d]evelopments in nuclear propulsion may have a great effect upon the situation."[276]

---

[275] Reports quoted in Gorn, 59-61, 125, 178. Tsien Hsue-shen wrote a monograph for *Where We Stand* on nuclear fuels for aircraft propulsion.
[276] The President's Air Policy Commission, 80; Maj. Gen. Partridge, *ibid.*

While the idea of nuclear propulsion had little direct bearing on missile programs, its existence caused some air force decision makers in the late 1940s to see a future for long range nuclear bombers and missiles before the failings of the concept, such as radiation exposure to aircrews, and the dangers presented by crashes spreading radiation, caused the idea to lose popularity. The air force and the AEC replaced the Nuclear Energy for Propulsion of Aircraft project in 1951 with an expanded program, the Aircraft Nuclear Propulsion program. In 1955 and 1956, a single modified B-36 bomber flew with a nuclear reactor on board to test radiation shielding for aircrews. While political scientist Michael E. Brown argued in his account of strategic bomber development that the idea of a nuclear powered bomber was effectively finished in 1956, the program continued until the Kennedy administration officially ended it in 1961. The whole program was estimated to have cost more than $9 billion in 2011 dollars. Earlier in this chapter, two air force documents mentioned the possibility of nuclear-powered ramjets, but the air force did not begin active work on the idea until 1957, when it and the AEC began Project Pluto. Its cancellation in 1964, brought to a finish the major dead-end research effort coming out of *Toward New Horizons*.[277]

Historian of technology George Basalla has listed nuclear-powered aircraft along with nuclear-powered spacecraft and cargo ships as being a prime example of a technological fad, in this case generated by the 1940s and 1950s enthusiasm for nuclear energy that he compared to the nineteenth century fad for railways and the early twentieth century enthusiasm for aviation, where many experts predicted that every family would

[277] Stephen I. Schwartz, ed., *Atomic Audit: the Costs and Consequences of U.S. Nuclear Weapons since 1940* (Washington D.C.: The Brookings Institution, 1998) 123-6; Miller, *The X-Planes,* 98-111; Brown, *Flying Blind,* 193-210; Gregg Herken, "The Flying Crowbar," *Air and Space Magazine*, Vol. 5 No. 1 (April/May 1990) 28-33.

own and use their own aircraft. In the late 1940s, many experts saw nuclear propulsion for aircraft and missiles to be just as promising as the idea of long-range ballistic missiles. But nuclear propulsion quickly showed itself to have many serious problems.[278] After a time and not without difficulty, rocket technology for long-range missiles began to advance where nuclear technology had failed and ramjets were faltering.

Efforts to Revive the MX-774

As the Convair team prepared the third and final MX-774 rocket for launch, air force officers and Convair worked to save the program by proposing that the rocket be used for technical testing, as a tactical missile, to launch scientific payloads, and even to train launch crews. Col. Millard Young, chief of the USAF Guided Missiles Branch of the Air Materiel Command, lobbied Gen. Putt, the AMC's Director of Research and Development, on 5 November 1948 to salvage MX-774 by "keeping at least one research rocket test vehicle in being" for propulsion tests, upper atmosphere research, testing of the Navaho missile guidance and control systems above the atmosphere, supersonic aerodynamic tests, testing countermeasures, and testing the idea from RAND experts that the size of wings on the missiles could be reduced. Young noted that the navy was experiencing continuing problems with its Viking research rocket, which was similar to the MX-774. While a request had been sent to the defense secretary for $1.5 million to procure fifteen MX-774 rockets out of extra funds being requested from the president for missile research, the Air Materiel Command appeared ready "to let the procurement of these fifteen missiles go in favor of something else (as yet not specified)," because the

---

[278] George Basalla, *The Evolution of Technology* (Cambridge: Cambridge University Press, 1988) 176-85. Basalla also raised the case of atmospheric railways, an ultimately unsuccessful technology tried in Britain in the 1930s where trains were driven not by engines but pistons inside a pneumatic tube laid between the rails.

AMC was inclined "to keep back rocket development in favor of ram jets, allowing the Army and Navy to take over the liquid rocket field." Young argued that the MX-774 was "a vehicle with considerable potential as a research medium and one which should be continued in substantiation of our guided missiles effort." Since the contract with Convair was due to end with the planned firing of the third missile on December 6, he urged that careful consideration be given to any proposal to drop the MX-774. A Convair official wrote Putt to point out that Convair is "intensely interested in the missile business, both from a development and production viewpoint, and I believe that we have produced more results at a lower cost than anyone else in the business." While Convair lobbied the air force to save the program, no evidence has been found indicating that Convair lobbied Congress on this matter.[279] When President Truman released $16.2 million requested by the USAF for guided missile research that November, the air force hoped to direct some of the funds to the MX-774, "for use in handling and launching training," but no further record of the proposal has been found.[280]

Convair made a formal proposal to the AMC that same November to revive the MX-774 program by developing two tactical missiles with a range of 1,000 miles, one carrying a 3,000 lb warhead and another carrying a 6,000 lb warhead. In the formal evaluation of the Convair proposal early in 1949, air force officers from the power plant laboratory in the USAF Engineering Division criticized the Convair proposal, stating it "does not appear to reflect a very reliable analysis of the cost and delivery schedule."

---

[279] Col. Millard C. Young to Brig. Gen. D.L. Putt, "Justification for Liquid Fuel Rocket Test Vehicle," 5 November 1948; and La Motte T. Cohu, Convair, to Brig. Gen. Donald Putt, 5 November 1948, in RG 341, Guided Missiles Branch, Box 134, file "Surface to Surface Consolidated MX-774," NA; Chapman, *Atlas: The Story of a Missile,* 56.

[280] Harry Truman to Secretary of Defense, 13 November, 1948; W. Stuart Symington to Mr. Forrestal, "Request for Release of Guided Missies Procurement Funds – Project 180 (Supplemental) F.Y. 1948," with attachment, 10 December 1948, in RG 341, Guided Missiles Branch, Box 129, file "F-180 'Production' Program, Fy-48," NA.

While Convair asserted that it could build its proposed missiles with minimal changes to the engine used on the MX-774, the evaluators believed that extensive modifications would be needed. The evaluators also suggested that the proposed missiles use more powerful fuels than the alcohol fuel proposed by Convair. Another evaluation criticized the Convair proposal for being "hastily prepared" and for lacking a stress analysis, a full rocket motor specification, or data to support claims that it would remain stable in flight. Evaluations from the equipment laboratory, aircraft laboratory and the electronics subdivision were more favourable. In spite of these criticisms, the Guided Missiles Branch stated its belief that Convair's arguments to continue with MX-774 were sound, and "that to neglect long-range rocket research is to close the door on our most promising avenue for improved missile performance."[281]

Convair was verbally informed on 16 February of the USAF decision not to accept the contractor's proposal to revive the MX-774 as a tactical missile. Lt. Col. Charles Terhune, then deputy chief of the Guided Missiles Branch, explained that taking on the Convair proposal would mean canceling another missile program. In the face of complaints from Convair, a few days later, Terhune wrote that all current missile programs had been considered in the light of the USAF's missions of strategic bombing and air defense, and that the missiles in development are "more desirable" than the MX-774. He added that a number of technical problems would have to be solved before such

[281] Col. R.J. Minty, "Evaluation of Proposal – Report No. ZP-48-35003," 4 January 1949; Col. John H. Carter, Routing and Record Sheet, "Evaluation of CVAC 1,000 Mile Range Missile." 28 February 1949, both. in RG 341, 127, file "MX-774 Convair Firing TWX's and Weekly Progress Reports" NA. Maj. Gen. Powers to Symington, "Consolidated Vultee Guided Missile Proposal," 21 Dec 1949, RG 341, Guided Missiles Branch, Box 134, file "Surface to Surface Consolidated MX-774," NA.

a missile could become feasible, including warhead re-entry at high speeds and guidance systems.[282]

The MX-774's supporters inside the USAF then tried to save the MX-774 by promoting it as a launch vehicle for scientific research packages for the upper atmosphere. Physicist Marcus O'Day, who led the air force's upper atmosphere research during the late 1940s, and other air force officials talked up the MX-774 in 1947 and 1948 to the Guided Missiles Committee of the Research and Development Board and to the Upper Atmosphere Rocket Research Panel, which coordinated scientific research in the new area of space science. The field was already crowded, with the army's WAC Corporal and Bumper rockets, and the navy's Viking and Aerobee sounding rockets in use for studies of the upper atmosphere.[283] When the Air Materiel Command made a formal proposal to the GMC on February 11, 1949 to use the MX-774 for upper atmosphere research in place of the navy's Viking rocket, the GMC appointed an "Ad Hoc Working Group" made up of one representative from each service "to resolve any duplication between the Navy VIKING and the MX-774." When the committee met on 21 March, it decided in favour of the Viking rocket.[284]

[282] Lt. Col. Charles Terhune to Brig. Gen. D.L. Putt, "Consolidated-Vultee Proposal for a 1,000 mile rocket-powered surface to surface missile," 25 February 1949, same sender, addressee, subject, 3 March 1949, in RG 341, Guided Missiles Branch, Box 127, file "MX-774 Convair Firing TWX's and Weekly Progress Reports" NA.

[283] The WAC Corporal was a liquid-fueled rocket developed by the Jet Propulsion Laboratory at Caltech, and the Navy developed the Aerobee sounding rocket as a larger version of the WAC Corporal. The Bumper was a two-stage rocket combining the V-2 and the WAC Corporal. For more on rockets and upper atmosphere research, see David H. DeVorkin, *Science with a Vengeance: How the Military Created the U.S. Space Sciences after World War II* (New York: Springer-Verlag, 1992) 167-82; David DeVorkin, "Organizing for Space Research: The V-2 Rocket Panel." *Historical Studies in the Physical and Biological Sciences*. Vol. 18, No. 1 (1987), 1-24.

[284] Lt. Col. Charles H. Terhune to Brig. Gen. D. L. Putt, "A Proposed Extension of Project MX-774," 23 March 1949, in RG 341, Guided Missiles Branch, Box 127, file "MX-774 1949 and 1950 (Consolidated) Surface to Surface," NA. Rear Admiral D.V. Gallery, Assistant Chief of Naval Operations for Guided Missiles, "MX-774 Viking," 22 March 1949, RG 156, Office of the Chief of Ordnance, Records Relating to the Army Guided Missiles Program, Box 14, NA; Beard, *Developing the ICBM,* 65-7.

Inside the air force, lobbying continued to save the MX-774. Gen. Putt was lobbied in April 1949 by air force officers for the Convair missile against the Navaho, which was evolving into a ramjet cruise missile with a rocket booster. An air force memo termed the ramjet engine for Navaho "a long way from reality and further away than a large rocket motor to do the same job," and warned that North American was running into problems finding materials for the skin of the Navaho missile and with obtaining aerodynamic data for heating generated at velocities above three times the speed of sound. As well, the Navaho's guidance and control problems remained daunting. Putt decided to make a last-ditch request to Arthur Barrows, the assistant secretary of the air force, for funding to keep the MX-774 going, but when Barrows declined, the MX-774 program was over as far as the air force was concerned.[285]

Growing Support for Ballistic Missiles

Even as the MX-774 program was going through its death throes in early 1949, opinion among experts inside and outside the air force was beginning to turn in favour of long-range ballistic missiles. In a presentation to a JCS committee in January 1949 on the USAF missile program, Col. Millard C. Young, chief of the Guided Missiles Branch, said that solving the technical problems holding back long-range guided missiles would require between one and two billion dollars, depending on the speed of development, and "the combined intellects of the best scientists and engineers in the Nation." He added: "<u>There is enough technical competence in this country to solve our longest term problem before 1960 if we are willing to provide the dollars.</u>" Young estimated that development

---

[285] Draft Inter-Office Memorandum, possibly from Maj. Cole, to Brig. Gen. D. L. Putt, "Proposed Extension of MX-774 by CONVAIR," 14 April 1949, with routing slips dated 22 and 30 March 1949, in RG 341, Guided Missiles Branch, Box 127, file "MX-774 Convair Firing TWX's and Weekly Progress Reports" NA; Beard, *Developing the ICBM,* 67.

costs for individual missile programs would range between $10 million for the least expensive missile and $150 million for the most expensive program. He believed that atomic bombs would only be carried in very reliable delivery vehicles, and that the "surest way to penetrate enemy defenses is by the supersonic surface-to-surface missile." He predicted that to develop even a 1,000-mile range supersonic missile to be ready by 1954 "would require an effort somewhat comparable to the Manhattan Project." He added that to date, "the program has not been progressing very swiftly."[286]

The RAND Corporation completed a series of missile studies for the USAF in the fall of 1949 that strongly suggested that the USAF should put a greater emphasis on rockets for long-range missiles than on ramjets. On October 14, RAND director Frank Collbohm informed Gen. Putt that an extended study comparing rockets with ramjets for various ranges and payloads and considering reliability, vulnerability and accuracy had found that ramjets were superior to rockets for "only a moderate spread of intermediate ranges where heavy, inexpensive payloads are carried." RAND found rockets superior for all other conditions, including short ranges, very long ranges, small payloads or costly payloads. Collbohm wrote that RAND recommended that the USAF reevaluate its guided missiles program "with a view to accelerating research" for winged long-range rocket missiles, but he added that research on winged ramjet missiles should continue.[287] James Lipp of RAND told the Research and Development Board that "Ram-jet missiles were superior for limited ranges, up to something in the neighborhood of 3,000 miles, and

[286] Col. M. C. Young, USAF Guided Missiles Presentation to Special Ad Hoc Committee of the JCS, 25 January 1949, in RG 341, Guided Missiles Branch, Box 115, NA. Emphasis in original. The estimated cost is similar to the $2 billion cost four years earlier for the Manhattan Project.

[287] The RAND Corporation, "Project Rand: Recommendation to the Air Staff, A Re-evaluation of the Guided Missiles Program," 14 October 1949, with covering letter from F.R. Colbohm, Director, to Maj. Gen. Putt, in RG 341, Guided Missiles Branch, Box 132, file "Rand, 1945-50," NA. RAND had split from Douglas and become the RAND Corporation on 1 Nov. 1948. Collins, 161; Davies and Harris, *RAND's Role,* 45.

rocket powered missiles were superior for all ranges over 3,000 miles." RAND was therefore calling on the air force to "consider realignment of its relative emphasis on Ram-jet and rocket power plants." Lipp explained that the RAND research was based on the assumption that "[n]o startlingly new high temperature materials" to protect warheads on their flights would be available before 1960, the time the missiles were projected to be ready.[288]

The USAF Guided Missile Branch recommended to Gen. Putt that the Navaho missile, which used ramjets as its primary power source, "be continued at its presently planned rate" because "RAND does not recommend development of rocket missiles to the exclusion of ramjets or any drastic change in emphasis from ramjets to rockets." The branch recommended that the air force develop a winged missile similar to Navaho but with a rocket engine. It called for the creation of an applied research program to obtain new information on high temperature materials, including titanium and ceramic coatings, to protect warheads, and on aerodynamics at high speeds. It also recommended that the MX-774 program be "reinstated to accomplish this research program" with specially outfitted rockets. Turning to the Navaho program, the branch argued that rockets had been rejected for Navaho because of the lack of data about aerodynamics at high speeds, the warhead re-entry heating problem, and the guidance problem. The USAF chose the ramjet missile for Navaho because those three problems "were not critical factors in its

[288] R.F. Rinehart, executive secretary, Research and Development Board, to Dr. Karl Compton, "Summary of Presentation by RAND Corporation on Friday, October 14, 1949," 18 October 1949, in RG 330, Records of the Secretary of Defense, Box 465, file "100 Guided Missiles – Marriage Program," NA.

design and because it was felt that a ramjet missile could be produced in less time than a rocket missile."[289]

The branch argued that a rocket "is less complex in the propulsion and fuel systems in that it has one instead of two types of power plants," as was being contemplated for Navaho. The branch concluded rockets had greater potential than ramjets for higher speeds and longer ranges. "Based on other factors such as reliability and vulnerability and empty weight, the rocket appears to be superior," but a high-speed rocket missile with a range of 7,000 miles "will not be available before 1960 and such a missile will depend upon our ability to solve problems in aerodynamics and materials in a manner favorable to rockets." Thus the branch called for continuing the development of Navaho in its current form to ensure that a long-range strategic missile would be available, and it also supported a new research program to test new technologies for rockets, which could be accomplished by using navy's Viking rocket, the army's Bumper rocket, which used salvaged V-2 rockets as the first stage, or by reviving the MX-774 rocket, which had the benefit of being under air force control. This guided missile branch statement provides a previously unseen glimpse inside air force thinking on the relative merits of rockets versus ramjets to propel missiles just as the limitations of ramjets were becoming clear to the air force. It outlined the technical problems – the unknowns in high speed flight, automatic guidance, and re-entry heating of warheads – that made long-range rockets less than a sure bet, and one that would not likely pay off for more than a decade.[290]

---

[289] Majors Cole and Carey to Gen. D.L. Putt, "Project RAND Analysis of Ramjet Versus Rocket Propelled Strategic Guided Missiles," 27 October 1949, in RG 341, Guided Missiles Branch, Box 98, file "Boosters 1949-1950," NA.
[290] Cole and Carey, *ibid.*

Inside the air force, the RAND study was met with a defense of the emphasis on ramjet research at the expense of more advanced missiles. “Ultimately, we might have enough knowledge of very high [speed] aerodynamics and control data at these high speeds to intelligently enter into a long-range rocket program,” Col. H.J. Sands, the Air Materiel Command Engineering Division’s assistant for guided missiles, wrote in February 1950, adding that the division believed that the “ramjet range of speeds is about as far as we can go in the next ten years.” By this time, Louis Johnson was secretary of defense, and his financial austerity policy and questions about the cost of existing missile programs had effectively put long-range rockets on hold for the rest of 1949 and much of 1950.[291]

As the guided missiles program tightened up in September 1950 under the stress of new needs related to the Korean War, Pat Hyland, an aircraft contractor manager who sat on the Guided Missiles Committee, wrote William Webster, then the chair of the Research and Development Board, saying that “[i]n my opinion no missile having a range of over 500 miles is likely to have adequate guidance for many years; hence these missiles should be given very reduced emphasis in view of the shortage of technical people.” He added: “In my opinion no missile in the range 100 to 500 miles is likely to have adequate guidance for five years.” Hyland recommended that short-range missiles be “developed and produced on a crash basis” and suggested cutbacks in longer range missile programs, including the Navaho missile. Expressing concern about the availability of engineers, Hyland said: “The long-range missiles should definitely be restricted if a technical shortage is felt. In my opinion we should learn to walk before we

[291] Krudener, *Ballistic Missiles Site Activation,* 16.

run, and I am confident that experience and development in short-range missiles will contribute to the ultimate development of long-range missiles."[292]

In spite of the technical and political problems facing long-range rockets and the troubled launches of the three MX-774 rockets discussed earlier in this chapter, Convair did not totally abandon its work on ballistic missiles. In 1949 and 1950, Convair allowed Charlie Bossart to continue with nine paper studies of the technical problems facing long-range ballistic missiles, and he was allowed to "borrow" members of the former MX-774 team to help with his studies, eight of which dealt directly with ballistic missiles and one which dealt with a ramjet-powered missile. During this time, Bossart and his colleagues thought of two technical advances that were later incorporated into the Atlas missile: dropping off engines during flight and keeping the fuel tanks rather than dropping a whole rocket stage, and using small steering rockets for fine-tuning the missile's velocity when the main engines stopped firing.[293] Despite the lack of government support, Convair's work on what became America's first ICBM, the Atlas, made progress during these two years.

Ballistic Missiles Return

A little more than a year after RAND put forward both winged ramjets and winged rockets as the main choices for long-range missiles, and in spite of many continuing reservations held by people such as Pat Hyland, RAND stopped advocating for ramjet vehicles in favour of low-altitude winged rockets and high-altitude ballistic

---

[292] L.A. Hyland, Guided Missiles Committee, to William Webster, Chairman, RDB, September 14, 1950, in RG 330, Records of the Secretary of Defense, Box 465, file "100 Guided Missiles – Marriage Program," NA.

[293] Chapman, *Atlas: The Story of a Missile,* 57-9; Enclosure to letter, J. R. Dempsey, Manager, Convair Astronautics, to Edwin L. Weisl, Special Counsel, Preparedness Subcommittee, Armed Services Committee, U.S. Senate, reproduced in report of Preparedness Investigating Subcommittee on Satellite and Missile Programs, Pt. 2, (Washington D.C.: Government Printing Office, 1958) 2254.

rockets. This was a significant change, because now RAND was looking at vehicles of the type that would be used for the first ICBMs, and moving away from ramjets and winged missiles. RAND's missile division had extensively studied surface-to-surface and air-launched missiles, and published the results in 1950 in a set of nine reports. In a presentation in January 1951 to the Guided Missiles Committee, the head of RAND's missile division, James Lipp, spoke as before of missiles projected to be built in 1960 carrying 8,000-pound payloads a distance of 4,000 miles. The ballistic rocket in his presentation would reach an altitude of 500 miles, a speed of 15,000 miles per hour, just below the speed required to put an object in orbit, and fly for twenty-four minutes, slowing to nearly 10,000 miles per hour as it struck the target on the ground. The winged rocket that RAND studied would reach a speed of 10,000 miles per hour when its engines stopped firing, reach an altitude of thirty miles, fly for forty minutes and then hit the ground at a speed of 1,900 miles per hour. Lipp projected that the winged rocket would have two stages, including a five-engine booster and a single-engine flat-bottomed gliding stage that would separate from the booster on reaching glide altitude. The ballistic missile also would have a five-engine first stage and a second stage with a large motor that would be "rocket steered" because it would be operating outside the atmosphere. Lipp's plan anticipated breaking the nose cone section apart from the rocket, leaving "a cone-shaped article containing the payload" to re-enter the atmosphere. Guidance systems for the ballistic rocket would use ground stations with computers to feed information on the missile's final path, while the winged rocket would use a "radar map matching system to make corrections in the neighborhood of the target." He estimated that the ballistic missile would weigh 1.3 million pounds, and the winged missile 180,000 pounds. Both missiles would be powered by a combination of gasoline fuel and liquid oxygen, representing a more powerful fuel combination than the alcohol and liquid oxygen combination used in the V-2 and the MX-774.[294]

Lipp said the ballistic rocket would be more reliable than the winged rocket because of a shorter flight time and simpler guidance equipment on board. He calculated that the winged rocket had a one in two chance of striking within one kilometer or 3,400 feet of a target with the technology predicted to be available in 1960, and the ballistic rocket had a slightly larger error. Discussing vulnerability to counter measures, Lipp stated that the ballistic missile was less vulnerable than a winged rocket, and the winged rocket was one-third as vulnerable as ramjet missiles. While rocket engines large enough for the winged rocket were already being tested, larger rocket motors would be needed for the ballistic missile. The ballistic missile, however, would cost three times as much as the glide missile. Lipp concluded that "the [winged] glide rocket has a very great advantage in flight economy; the ballistic missile has a moderate advantage in reliability."[295]

Edmund Beard argued in his history of ICBMs that winged missiles were more popular than ballistic missiles in the air force because winged missiles represented less of a change from crewed aircraft, an assessment shared by Donald MacKenzie in his history of ICBM guidance systems, and Kenneth P. Werrell in his 1985 history of winged missiles, although Werrell suggested in a more recent work that too much had been made of air force officers' love of winged aircraft. This argument fails to take into account

---

[294] Transcript, "Presentation of USAF Long Range Rocket Program by Dr. J.E. Lipp at the 30th Meeting of the Committee on Guided Missiles, RDB, Washington D.C., on 26 January 1951," in RG 156, Office of the Chief of Ordnance, Records Relating to the Army Guided Missiles Program, Box 12, file "GM 237/ Atlas," NA.
[295] Transcript, "Presentation of USAF Long-Range Rocket Program." *ibid.*

those experts outside the air force who also looked to winged missiles as being the design of the future. The German rocket team envisioned winged missiles carrying warheads across the Atlantic Ocean, and this vision heavily influenced Theodore von Kármán in *Where We Stand*, when he envisioned winged long-range rockets. It is also interesting to note that late 1940s and early 1950s studies about slowing down vehicles returning from Earth orbit prophesized winged vehicles. The 1946 RAND satellite study spoke about winged vehicles coming back from space, and in a 1949 scientific paper and an article he wrote in 1952 as part of the famous series of articles on space exploration in *Collier's* magazine, the head of the German rocket team, Wernher von Braun, featured winged re-entry vehicles. While landing a warhead is different from landing a crewed spacecraft, it is clear that the emphasis on winged vehicles was not peculiar to the USAF.[296]

While the air force's affinity for winged vehicles does account for some of its resistance to ballistic missiles, the documents quoted here show that Beard was closer to the truth when he argued that the air force supported winged missiles because they appeared to offer more opportunity for ground control during flight than ballistic missiles did, and because their lower speed avoided re-entry problems that arose from the lack of known materials to protect a warhead during re-entry from high altitudes. At the time, it appeared that ballistic missiles would simply burn up on re-entry because there appeared to be no materials available to protect the missiles and warheads from the extreme heat

[296] Beard, *Developing the ICBM,* 5; MacKenzie, *Inventing Accuracy,* 102; Kenneth P. Werrell, *The Evolution of the Cruise Missile* (Maxwell Air Force Base: Air University Press, 1985) 104, 106; Werrell, *Death From the Heavens,* 249; Project RAND. *Preliminary Design of an Experimental World-Circling Spaceship,* 198; Irene E. Powell-Willhite, ed. *The Voice of Dr. Wernher von Braun: An Anthology* (Burlington, ON: Apogee Books, 2007) 18; Wernher von Braun, "Crossing the Last Frontier," *Collier's,* October 18, 1952, 27-73, reproduced in John M. Logsdon, ed., *Exploring the Unknown: Selected Documents in the History of the U.S. Civil Space Program, Vol. 1: Organizing for Exploration* (Washington D.C.: National Aeronautics and Space Administration, 1995) 188.

encountered while returning from outside the atmosphere.[297] As shown by Lipp's presentation quoted above, ballistic missiles were also seen as being far larger and significantly more expensive than winged missiles.

The air force continued to fund two long-range jet-powered winged missiles, the Northrop Snark, and North American's Navaho. In spite of growing questions about Navaho, the Air Staff issued a new military requirements document in August 1950 for Navaho, which called for a ramjet vehicle capable of carrying a Mark IV nuclear warhead 5,500 nautical miles at a minimum speed of Mach 2.75. In September the USAF established a three-step development program for the missile that included a rocket booster that would carry the ramjet missile to speed and altitude before separating. The Navaho was to be available for use by 1958.[298] Air force officials running the Navaho program believed that a step-by-step approach to missiles was required, and so they defended the Navaho when RAND studies began to promote pure rocket systems as opposed to Navaho's rocket-ramjet combination.[299]

By the time Lipp appeared before the GMC in January 1951, he and his colleagues from RAND, backed up by Convair and its continued studies on ballistic missiles in 1949 and 1950, had convinced the Air Staff that active studies on ballistic missiles should resume. No doubt the removal of funding restraints that followed the onset of the Korean War also helped, with air force research and development funds growing from $238 million in fiscal year 1950 to $522.9 million in 1951. On 16 January 1951 the Air Staff issued a requirement to the Air Materiel Command for a "logical and

---

[297] Beard, *Developing the ICBM,* 96, 132-3.
[298] Krudener, *Ballistic Missiles Site Activation,* 17; Werrell, *Evolution of the Cruise Missile,* 97; Heppenheimer, "The Navaho Program and the Main Line of American Liquid Rocketry."
[299] Beard, *Developing the ICBM,* 96.

effective program of development of a rocket type missile capable of accomplishing the strategic bombing mission," in other words an Intercontinental Ballistic Missile. The Air Staff specified a range of 5,500 miles, a minimum speed of six times the speed of sound over the target, and an accuracy that would have at least half the missiles striking within 1,500 feet of the target. The AMC allocated $500,000 in Fiscal Year 1951 funds for an initial six-month study of problems associated with such a missile, followed by more intensive study of these problems, and it promptly issued a new contract to Convair on 23 January 1951 to pick up its ballistic missile work under Project MX-1593, which that summer became known as Atlas.[300]

Reorganizing Research and Development

After the departure of Arnold as AAF commanding general in early 1946, the importance of research and development inside the air force had faded, symbolized by the fact that the top research and development post in the air force had been moved down from the Air Staff and into the Air Materiel Command in October 1947 when LeMay vacated the higher echelon research and development position that Arnold had created. The Scientific Advisory Group that had written *Toward New Horizons* had been transformed into a permanent Scientific Advisory Board with von Kármán remaining as chair. But the air force made little use of the board, and in October 1947, shortly after the USAF was established, its leaders considered closing the board down. Some board members resigned due to its inactivity. But after von Kármán met USAF leaders in April

[300] "ATLAS Strategic Rocket Project," 7 May 1952, in RG 156, Office of the Chief of Ordnance, Records Relating to the Army Guided Missiles Program, Box 12, file "GM 237/ Atlas," NA; "(Restricted) Request for Approval of Popular Name for United States Air Force Guided Missile Project MX-1593," 30 July 1951, in RG 330, Office of the Secretary of Defense, Box 396, "237/GM," NA; Krudener, *Ballistic Missiles Site Activation,* 18-9; Chapman, *Atlas: The Story of a Missile,* 62; Futrell, *Ideas, Concepts, Doctrine,* 487-8; Beard, *Developing the ICBM,* 133-4; Davies and Harris, *RAND's Role,* 45.

1948, the board's authority was restored, and in 1949, with the support of Gen. Putt, the air force's new head of research and development, the board set up a working group under Louis Ridenour, the physicist and radar expert who had contributed to RAND's historic 1946 satellite study and by then a dean at the University of Illinois, to study research and development in the USAF.[301]

At the time that Ridenour and his group began preparing their report in 1949, the Hoover Commission on government organization had just criticized U.S. military research and development. In September, the Ridenour report was also critical of air force research and development, and called for restoration of the position of deputy chief of staff for research and development that LeMay had once held, along with separation of research and development from the Air Materiel Command. As a result of the Ridenour report and similar findings in November from a study run by the Air University, USAF Chief of Staff Gen. Hoyt Vandenberg ordered the restoration of the deputy chief of staff for research and development post in January 1950, and the creation of the Air Research and Development Command. In its early months of existence, the new command had to overcome resistance from the Air Materiel Command as it sought authority, and much of the time the new command continued to operate under the supervision of the AMC, limiting its impact in the field of guided missiles. And after the Ridenour report was completed, the influence of the Scientific Advisory Board faded again until later on in the 1950s.[302]

Beard argued that bureaucratic resistance inside the AMC played a role in slowing progress in development of ballistic rockets that became ICBMs, and his evidence is

---

[301] Gorn, *Harnessing the Genie,* 46-9; Collins, *Cold War Laboratory,*173.
[302] Gorn, *Harnessing the Genie,* 45-50, 59-62; Futrell, *Ideas, Concepts, Doctrine,* 276-8; Beard, 107-21; Johnson, *The United States Air Force and the Culture of Innovation,* 36-9.

backed up by Col. Young's comment earlier in this chapter that missiles took a back seat to aircraft in the eyes of the AMC leadership. Beard dedicated an entire chapter in his book to the reorganization that took missiles out of the AMC and into the Air Research and Development Command, but offered little evidence to support the idea that the existence of the new command expedited the development of ICBMs. Although high-level officers in the Air Research and Development Command were leading advocates for the Atlas ICBM, it is difficult to determine if they would have acted differently had they remained in the old AMC. A different interpretation of the rise of the ARDC was offered by U.S. Army historian Thomas C. Lassman, who suggested in a recent work that dividing research and development from procurement and production did not necessarily have the desired effects that civilian experts such as Ridenour had anticipated. Lassman also noted that that ARDC and AMC were rejoined in 1961 in the Air Force Systems Command, which endured for the remainder of the Cold War, which suggests that creation of the ARDC and the separation of research and development from other air force functions did not have an important effect on the development of ICBMs. This dissertation argues that the problems the air force faced up to 1950 with tight funding and the challenges of building a bomber force capable of delivering nuclear weapons to the Soviet Union, coupled with the technical challenges of long-range missiles enumerated in this chapter, overshadowed any bureaucratic resistance inside AMC in particular or the air force in general as factors standing in the way of the aggressive development of long-range rockets.[303]

---

[303] Beard's chapter in *Developing the ICBM* on the creation of the Air Research and Development Command is at 107-28. See also Beard, 129-40, and Lassman, *Sources of Weapon Systems Innovation in the Department of Defense*, 67-80.

Conclusion

As World War II drew to an end, many new technologies showed promise for military applications, most famously nuclear weapons. In the field of propulsion technologies, jet engines, rockets and nuclear propulsion showed great promise to experts such as Theodore von Kármán, who led the air force's *Toward New Horizons* study into emerging technologies in 1944 and 1945. The air force undertook research and development work for all three kinds of technologies. While many believed in the promise of nuclear propulsion for aircraft and missiles throughout the late 1940s, this promise was never borne out. The U.S. military also invested in a type of jet engine called the ramjet that showed great promise for long-range aircraft and missiles, but ramjets also posed technical challenges that were not quickly solved, and the demand for extremely high-speed aircraft dried up with the advent of missiles that could knock them out of the skies.

The air force contracted in 1945 and 1946 for the development of several kinds of missiles, including a number of long-range missiles powered by ramjets and one long-range missile powered by a rocket engine, the MX-774. Liquid-fueled rockets like the German V-2 missile and the MX-774 represented a new technology that appeared to be a long way from meeting its promise. The air force cancelled the MX-774 early in 1949 due to financial restraints on missile research and development, combined with concerns about the time needed to advance the necessary technologies for long-range rockets. Decision-makers such as Vannevar Bush and Pat Hyland, and also the Finletter Commission on air power, also raised concerns about the availability of trained personnel to develop and build missiles. Air force leaders had been warned in Hugh Dryden's rocket study in *Toward New Horizons* that major technical issues needed to be overcome to produce an effective intercontinental rocket weapon. Even as interest began to pick up in ballistic rockets in 1949 and 1950, concerns around technical issues such as guidance to the target and re-entry heating of the warhead remained.

While the idea of using long-range missiles to carry nuclear weapons was raised within hours of the news of the creation of the first nuclear weapons, the idea foundered at first on the shortcomings of existing rockets and existing nuclear weapons. The U.S. military's first serious look at a rocket that could carry nuclear weapons intercontinental distances came in studies carried out in 1946 by the U.S. Navy and by a newly created private think tank contracted by the air force, the RAND Corporation. While the satellite plans were put aside for nearly a decade, RAND continued to study the idea, and more importantly, it began to study the possibilities of long-range missiles, including those powered by rockets and ramjets.

While there are certainly strong grounds to support the belief that the air force's preference for winged aircraft caused it to support winged missiles such as Navaho over ballistic missiles such as MX-774 and later Atlas, this study has argued that the German rocket team's plans to follow up the V-2 ballistic missiles with winged transatlantic missiles also exercised a strong influence on the early direction of missile research. Kenneth P. Werrell, who in his time as an air force historian wrote about missiles such as the Navaho, in 2009 argued that the air force's bias for aircraft "can be overemphasized" because aircraft represented a known and proven technology, and he noted that the navy also favored winged missiles like the Regulus over ballistic missiles during the late 1940s and the 1950s.[304]

As the MX-774 project was being ended, winged missiles such as Navaho appeared to air force leaders to offer the quickest way to a missile that could strike from intercontinental distances. But soon the ramjets that were due to be used on the Navaho began to fall short of the bright future they once promised. RAND studies in 1948 and 1949 compared the merits of long-range missiles powered by ramjets and rockets, and as time went on, these studies gave greater support to rocket missiles flying ballistic paths above the atmosphere than to winged ramjet vehicles flying at lower speeds inside the atmosphere. By 1950, RAND had dropped studies of ramjet missiles and was instead comparing the potential of winged rockets to ballistic rockets. As the tight money policies restricting military spending ended in 1950 when the Korean War began, the USAF moved to restore funding to Convair's work on ballistic rockets that had begun with its contract to build the MX-774 rocket. These initial technical choices by RAND and the USAF in favour of rockets began to clear the way for the intercontinental ballistic missile, but many problems, including the weight, complexity and power of nuclear weapons, the guidance of the missile, and re-entry heating of the warhead, remained to be overcome before ICBMs could win widespread support in the air force or elsewhere.

While Edmund Beard's and Jacob Neufeld's studies of the creation of ICBMs featured internal air force bodies such as the Air Research and Development Command, this study and this chapter show the crucial role outside expert advice played in pointing the USAF toward the ICBM. Even before World War II ended, air force Commanding

---

[304] Heppenheimer, "The Navaho Program and the Main Line of American Liquid Rocketry;" Werrell, *Death From the Heavens*, 240-4.

General “Hap” Arnold made use of outside experts headed by Theodore von Kármán to help guide the development of new weapons. Arnold also inspired the creation of RAND, which became a major source of outside advice to the air force on many matters, including missiles. These sources of civilian expert advice were under the control of air force leaders, unlike the Research and Development Board and the Guided Missiles Committee of the Defense Department that Vannevar Bush promoted as a means of asserting civilian control over the military. Historians such as Alex Roland have argued perceptively that RAND and other military-controlled advisory bodies helped undermine civilian control over the U.S. military. Given RAND’s important role in the development of Atlas, the rise of this ICBM marked an important step in turning back civilian influence over the military.

Chapter 5
The Missile Czar

Nineteen-fifty was one of the most eventful years in the Cold War struggle between the United States and the Soviet Union. Responding to the explosion of the first Soviet atomic bomb the year before, President Truman gave the go-ahead on 31 January 1950 to the development of thermonuclear bombs, which promised far higher explosive force than existing fission bombs. In April, Truman received NSC-68, the groundbreaking National Security Council report calling for a massive buildup of American arms. Although he did not ratify the report at the time, he would do so in September after the Korean War had begun.

For the president and his military leaders, guided missiles remained a minor concern, even though the rivalries between the services over guided missiles had come to the attention of the Joint Chiefs of Staff, the service secretaries and the secretary of defense the year before. By June 1950, despite years of promises for guided missiles, "not one guided missile was operational," in the words of defense department historian Doris M. Condit. The reason, in her view, was that the military guided missiles program "suffered from too many cooks – the Research and Development Board to review and coordinate service programs, the Munitions Board to see that industrial capacity met military requirements, the JCS to adjust service requirements," plus other bodies to regulate atomic warheads. This caused the president and the secretary of defense to supersede the complicated and ineffective committees that were supposed to direct missile programs with a "czar" to run the programs before guided missiles could fall so far behind that they would become a major concern.[305] While Condit's analysis missed the tight budgets and inter-service rivalries that also slowed missile development, those problems receded with the increased funds that began to flow in 1950.

The new missile czar, K.T. Keller, took office in October 1950, shortly after George Marshall had replaced Louis Johnson as defense secretary. Johnson, however, had arranged Keller's appointment before he left office with the personal involvement of President Truman. Keller continued to direct missile programs for nearly three years, staying on through the end of the Truman administration and into the early months of the presidency of Dwight D. Eisenhower. In the accounts of historians such as Edmund Beard or Jacob Neufeld, Keller's work rated little more than a mention, and by focusing on the air force, their accounts paid little attention to outside influences on the air force's missile work. This chapter contains an in-depth appraisal of Keller's work as missile czar that goes beyond previous historical accounts by looking closely at the priorities he was handed by the president and the responsible leaders in the defense department. Keller's time in office showed that the slow pace of development on what became ICBMs was not simply a matter of air force bureaucracy or of inter-service rivalries, but reflected national priorities for missiles.

Truman and Missiles

President Truman's main impact on guided missile programs was indirect. His policy of restraining all military spending from 1945 to 1950 restricted the funds available for missiles. When the Korean War began Truman loosened the military's purse strings, and soon more money became available for missile development. Truman's

---

[305] Doris M. Condit, *The Test of War, 1950-1953: History of the Office of the Secretary of Defense, Volume II* (Washington, D.C.: Historical Office, Office of the Secretary of Defense, 1988) 473-4.

decision in January 1950 to proceed with the development of the thermonuclear bomb proved to be crucial to the creation of American ICBMs, but this would not become apparent until after he left office in 1953. Up to 1950, Truman had taken little if any direct hand in military missile programs. Truman's 1948 decision to release funds for missile research, as recounted in the previous chapter, was a rare instance of a direct presidential action on missiles in his administration. Truman spoke about missiles only in passing during his time in office, and his memoirs, which were published before Sputnik, made only one reference to missiles, again in passing.[306]

Major biographies of Truman, such as Robert J. Donovan's two-volume work and David McCullough's *Truman,* are silent on the matter of missiles. Rip Bulkeley's *The Sputnik Crisis and Early United States Space Policy* did not uncover any direct presidential intervention in the field of missiles before 1950.[307] In an attempt to divine Truman's attitude to missiles, Edmund Beard quoted Truman's memoirs to back up his contention that in July 1949, Truman and his National Security Council decided to place the top priority on increasing the size of America's nuclear weapons stockpile, and second highest priority on the B-36 bomber, without considering missiles.[308] Truman was referring in his memoirs to a decision known as NSC-52, which discussed general defense budget issues and included extra funds to enlarge the Atomic Energy

---

[306] A search of Truman's public papers online at the Harry S. Truman Presidential Library turned up only a few references to missiles and rockets, mainly in budget messages, in a speech dedicating the Arnold Engineering Development Centre, and a press conference where Truman took questions about a leak of information related to the Matador Missile. http://www.trumanlibrary.org/publicpapers/index.php . Accessed 9 November 2010. The author could not find documents on file at the Truman Presidential Library indicating direct presidential involvement with missiles outside of those discussed in this chapter and the previous chapter. Truman, *Memoirs: Vol. 2, Years of Trial and Hope,* contains a mention of missiles on 312. Here Truman lists guided missiles with atomic warheads along with other futuristic weapons.

[307] Donovan, *Conflict and Crisis,* and *Tumultuous Years.*

[308] Beard, *Developing the ICBM,* 82; Truman, *Memoirs: Vol. 2,* 304. Thomas P. Hughes, in his discussion of Atlas in *Rescuing Prometheus*, 77, highlights Beard's description of this episode.

Commission's nuclear stockpile. The paper contains no specific mention of the B-36 or any weapons delivery system.[309]

The previous three chapters have outlined how officials inside the air force, the Joint Chiefs of Staff, and the Guided Missiles Committee in the Research and Development Board treated missile programs in the late 1940s. In 1949, Defense Secretary Louis Johnson became involved in setting policy for missile programs. Political scientist Richard E. Neustadt wrote that President Truman did not look for issues to deal with, but was happy to decide on them when they were brought to his desk. Guided missiles landed on his desk for the first time in the summer of 1950.[310]

Calls for Change

As 1950 began, the leadership of the U.S. military, including the secretary of defense, was becoming more disenchanted with its guided missile programs. Missile programs were being slowed by inter-service rivalries and by tight peacetime military budgets that had not been increased to reflect the growing military challenges of the Cold War. The Joint Chiefs of Staff and the service secretaries attempted to rationalize missile programs with the Stuart board in February 1950, and then the joint chiefs organized the Interdepartmental Operational Requirements Group to expedite missile programs, as discussed in Chapter Three. But in the eyes of many leaders, bigger changes were needed. Lyndon Johnson, a U.S. Senator from Texas, called on 13 February for a review of missile programs, saying that the United States was falling behind other countries in this field and had no missile that could defend the country. Hubert E. Howard, chairman

---

[309] NSC-52 is reproduced in U.S. Department of State, *Foreign Relations of the United States 1949, Volume 1: National Security Affairs, Foreign Economic Policy* (Washington D.C.: Government Printing Office, 1976) 349-57. Another NSC staff paper considered in June 1949 on U.S. security resources mentions both bomber aircraft and ICBMs, which would be available in 1958-61, to fight a war. FRUS 1949 v. 1, 339.
[310] Richard E. Neustadt, *Presidential Power: The Politics of Leadership* (New York: Wiley, 1968) 173.

of the Munitions Board, which supervised production of weapons for the military, expressed strong dissatisfaction on 14 February with military missile programs to Defense Secretary Louis Johnson, recommending that he "assign to a single individual the sole responsibility for the definition and allocation of proper fields of research and development in guided missiles and for coordinating the Services' activities in this area." This individual should be able to turn his responsibilities back to the Research and Development Board after six months on the job, Howard recommended. He urged that the individual selected be a civilian to avoid a conflict of interest, although a military officer "may have to be accepted as a last resort." He suggested one civilian for the job, Edward Falck, who had worked at the War Production Board, and two military officers, Gen. Joseph McNarney of the USAF and Lt. Gen. Leroy Lutes, a former commander of the Army Service Forces.[311]

The next day, Secretary Johnson told the Armed Forces Policy Council, which brought together the service secretaries and the joint chiefs, that he planned "to establish a czar in the field of guided missiles for approximately three months." Johnson suggested that the job be given to either Falck, or John McCone, a business executive who had served on the Finletter Commission. The Joint Chiefs of Staff persuaded Johnson to "suspend action" until the chiefs could make a recommendation after having reviewed the Stuart board report.[312] The fact that both Johnson and Howard had a common name for

---

[311] Hubert E. Howard, Chair of Munitions Board, to the Secretary of Defense, "Guided Missiles," 14 February 1950, in RG 218, Records of the Joint Chiefs of Staff, Box 107, file "JCS 334 Guided Missiles Comm (116-45) Sec 3," NA. This memo and the Armed Forces Policy Council meeting are also discussed in Ch. 3. William S. White, "U.S. Willing to Discuss Atom With Soviet Union in U.N.," *The New York Times*, 14 February 1950, 1.

[312] R.F. Rinehart, Executive Secretary, RDB, to Chairman, RDB, "Guided Missiles Inquisition," 28 February 1950, in RG 330, Records of the Secretary of Defense, Box 465, file "100 Guided Missiles – Marriage Program," NA; Maj. James R. Dempsey, memo for record, "Sequence of Events Concerning

the missile czar suggests that the two men and probably other people had discussed the matter for some time before the February 15 meeting. A month later, the joint chiefs agreed to a muddy resolution to the inter-service missile disputes and forestalled the appointment of a missile czar for a time.

The communist North Korean invasion of South Korea on June 25 and the United States' full engagement in the war to save South Korea brought an end to the period of tight budgets for the U.S. military, and marked the beginning of massive increases in spending on all military programs, increases that would soon include guided missiles. That summer the military's problems with missiles were becoming well known, even to the public. A *New York Times* article in July contended that the missile program had "been marked by a great deal of duplication" due in part to the "so far insoluble problem of allocating the various types of guided missile warfare among the respective services."[313]

Renewed calls were made inside the Pentagon that August for a strong individual to take over the military's missile programs. The air force's new under secretary John McCone, who months before had been under consideration to be missile czar, wrote Air Force Secretary Thomas Finletter warning that the United States needs to "maintain in being at all times a powerful counter-offensive capacity, first as a deterrent," and that this deterrent "rests in the development, perfection and production of supersonic ground-to-air guided missiles" to defend against Soviet bombers. McCone wrote that poor organization and a lack of funds had held up progress on missiles. He urged the creation

---

SIB," undated but about 18 February 1950, in RG 341, Guided Missiles Branch, Box 129, file "National Guided Missile Program 1950," NA.

313 Cabell Phillips, "Why We're Not Fighting With Push Buttons," *The New York Times Magazine* (16 July 1950) 20.

of a program with the highest priority to develop the "entire field" of guided missiles "under the most capable man who can be drafted." While the military had spent $94 million on missiles up to August 1950, McCone urged that this spending be increased to $2 or $3 billion to begin. Five days later, McCone wrote Finletter that the ineffective missile programs being run by the three services be replaced by a single missile program under an individual with a "Pentagon Board of Directors" to link with various branches of government. "It will be more like the Manhattan Project," McCone suggested. He stressed the need for defensive missiles and did not specifically mention long-range guided missiles.[314] About that time, Finletter asked a former leader of the Manhattan Project, Army Maj. Gen. Kenneth Nichols, about setting up a Manhattan Project for missiles. "I consider it impossible to set up a Manhattan Project, and in particular, to establish the degree of secrecy that is essential to avoid interference with any such command," Nichols recalled explaining in his memoirs. "You can only do it in time of war." Finletter replied: "You think how to do it."[315]

The calls for firm direction over missiles were also heard outside the air force. The under secretary of the navy, Dan Kimball, wrote Johnson on August 21 to call for a director "of national reputation with broad experience and proven competence" to "accelerate" the guided missiles program by coordinating the work of the RDB and its missile committee, the guided missiles interdepartmental operational requirements group set up by the joint chiefs to coordinate operational issues, and the Munitions Board. Condit wrote in her history that the service secretaries proposed a guided missiles board,

---

[314] Arthur Krock, "In The Nation: Origins and Developments of the Missile Program: II," *The New York Times,* 5 November 1957, 30; J. Neufeld, *Ballistic Missiles in the USAF,* 79-80.
[315] Kenneth D. Nichols, *The Road to Trinity* (New York: Morrow, 1987) 281.

but the new Secretary of Defense, George Marshall, rejected the idea because it would affect the powers of the joint chiefs.[316]

By then, the RDB was already developing a set of directives for a "Director of the Guided Missiles Project" with objectives including providing the services "at an earlier date more effective guided missiles" following a "greater concentration of effort on the highest priority projects." The director would be charged with providing "more efficient utilization of funds, personnel, technical facilities and technical capabilities by elimination of unnecessary duplication and undue emphasis on lower priority or longer range objectives."[317]

The New Director

Louis Johnson resigned at Truman's request as secretary of defense on September 19, taking with him much of the blame for setbacks in Korea and for the effects of the military austerity program Johnson had championed at Truman's behest. Marshall took the job two days later, and on October 24, he announced the appointment of K.T. Keller as the "Director of Guided Missiles in the Office of the Secretary of Defense" to provide him "with competent advice in order to permit [him] to direct and coordinate activities connected with research, development and production of guided missiles." Keller would act as a "consultant and advisor" to both the RDB and the Munitions Board "without abrogation of responsibilities assigned to these agencies." As well, Keller would be called upon to give advice to the Armed Forces Policy Council, the JCS and other agencies in

[316] Dan A. Kimball, Under Secretary of the Navy, to the Secretary of Defense, 21 August 1950, in RG 330, Records of the Secretary of Defense, Box 465, file "100 Guided Missiles – Marriage Program," NA; Condit, *The Test of War,* 474.

[317] Draft memoranda attached to Memorandum from Charles F. Brown, counsel, to William Webster, Chairman, RDB, "Proposed Guided Missiles Project Organization," 22 August, 1950, in RG 330, Records of the Secretary of Defense, Box 465, file "100 Guided Missiles – Marriage Program," NA.

the Defense Department. Keller's new deputy, Army Maj. Gen. Kenneth D. Nichols, had been Gen. Leslie Groves' deputy in the Manhattan Project and was at the time the top Pentagon official involved with nuclear weapons.[318]

Kaufman Thuma Keller, who was known to all as "K.T.," was one of the best-known business leaders in the United States at the time. He had been president of Chrysler Corporation since 1935, having succeeded Walter Chrysler in that job. He had spent nearly forty years in the automobile business, starting as a machinist on the shop floor at General Motors, where he worked for fifteen years, followed by a quarter century at Chrysler, where he became known for his abilities in expediting production. A few days after he took the missile appointment, Keller stepped down as Chrysler's president to become chair of the automaker's board. Keller took the missile job on a part-time basis, but his papers show that he made lengthy trips where he visited universities, government facilities and contractor plants where work on missiles was being done.[319]

Keller's missile appointment had been in the works since at least August, and his name was suggested by Truman himself. On August 30, he and Louis Johnson went to the White House to discuss the job with Truman, who Keller already knew from previous government service in wartime and in his administration in 1947 as chairman of the President's Advisory Committee on the Merchant Marine. Keller later told Congress that when he and Johnson went to the White House for their 10-minute meeting:

---

[318] Secretary Marshall to the Deputy Secretary of Defense, etc., "Establishment of the Director of Guided Missiles in the Office of the Secretary of Defense," and associated correspondence, in RG 330, Records of the Secretary of Defense, Box 465, file "100 Guided Missiles – Marriage Program," NA.

[319] "K.T. Keller, Chrysler President From '35 to '50, Dies in London." *The New York Times,* 22 January 1966, 29. For more on Keller's work at Chrysler, see "Motors: K.T." *Time*, 16 October 1939, and for more critical views, see Steve Jefferys, *Management and Managed: Fifty Years of Crisis at Chrysler* (Cambridge: Cambridge University Press, 1986); and Michael Moritz and Barrett Seaman. *Going for Broke: The Chrysler Story* (New York: Doubleday & Co., Inc., 1981).

> President Truman outlined to me in general the work that was being done on guided missiles and how important he thought it was to the country, and that he thought there was a great deal of money being spent on it. He did not know whether we could make any savings. But he was quite sure that it could be moved along faster. And he asked me if I would undertake to do the work. At that time he said 'I think we should put our emphasis on defense missiles in particular' and suggested that maybe I would find out that there would be other missiles that should receive attention.

Keller told the president that he knew nothing about missiles but that he would look into the matter and let him know if he could help out, and Truman replied that Keller could do the job any way he wished.[320]

Keller testified to Congress that he learned about the missile programs at the Pentagon with the help of William Webster, the chair of the RDB. Keller concluded that to organize the 15,000 people working on missiles into a single team would take between a year and eighteen months, and "that the best thing to do would be to work with those people with a small competent staff of our own to try to give it guidance and direction. And I wish to say that is the basis on which we did the job. And they put me in the organization as a consultant and advisor to anybody that had anything to do with guided missiles." Keller's staff was at first made up entirely of military personnel. His efforts to move missiles into production from the development stage were sometimes held up by changes in operational requirements, he explained.[321]

Nichols wrote in his 1987 memoir that he and Keller made good impressions on each other during the war despite some tough negotiations over some work Chrysler did for the Manhattan Project. Nichols emphasized his interest and that of others in building defensive missiles, such as the Army's surface-to-air Nike missile. "I am a firm believer

---

[320] Testimony of K.T. Keller, House of Representatives, *Hearings Before the Select Committee on Astronautics and Space Exploration*, 2nd Session, 85th Congress, on H.R. 11881, May 8, 1958, 1498-1519; Condit, *The Test of War,* 474.
[321] Keller testimony, *ibid,* 1499-1500.

that defense should be part of our deterrence plan," Nichols wrote. "I worked hard to get the Nike 1 ground-to-air missile and also Air Force and Navy air-to-air missiles into production and established as a reasonable defense against airplane atomic bomb attack." Nichols only briefly mentioned their work on studies for what became America's first ICBM, the Atlas.[322]

Nichols and Keller began their work by visiting missile test sites. "Few missiles were ready for production. The first thirteen firings we saw all failed," Nichols explained. After Keller had studied the various missile programs and met with the responsible military managers, he set production recommendations, and then ensured that the service involved set down in writing the production goals agreed to with Keller. When "three or four" programs reached this state, Keller and Nichols prepared a written report that was hand delivered to the president and to the secretary of defense or his deputy. Nichols then completed directives for the defense secretary's signature authorizing the spending of funds for the missiles. Only one of Keller's decisions was challenged, in this case by the navy, but the navy backed off when Keller stood his ground. Nichols recalled Keller never tried to stop a missile program he thought ineffective, but simply used his control of production funds to cause these programs "to fade away for lack of money," avoiding bureaucratic battles.[323]

Keller wrote RDB chairman William Webster that his office had reviewed and evaluated twenty-two guided missile programs in its first two months of operation. He called on the RDB to review these programs to look for "supporting projects [that] have outlived their value as originally conceived, or have been overtaken by progress in the

---

[322] Nichols, *The Road to Trinity,* 280-1, 294.
[323] Nichols, *The Road to Trinity,* 283-7.

primary [missile development] programs," and for projects where the level of effort being applied should be "altered to bring it in consonance with its current importance to the overall program."[324] When Fred Darwin, the executive director of the Guided Missiles Committee, appeared before a congressional committee in January 1952, he said: "We are undertaking to compress into a few years work an achievement of results comparable to that which in the field of piloted aircraft extended over the last 40 years, and in the field of Ordnance over a considerable [sic] longer period." He explained that Keller "has concerned himself primarily with helping to bridge the gap between research and development and production of entirely new weapons, the guided missiles."[325]

In January 1952, Keller told students at the National War College that the president and officials throughout the Pentagon were "agreed that first priority had to be given to missiles intended to take aircraft out of the air," and that this had been the priority for some time before 1950. While he discussed in detail the missile projects the military was working on, Keller only spoke briefly about long-range missiles.
Keller told the War College in another speech a year later that he was free to make major changes to the military missile programs, including setting up a centralized authority similar to the Manhattan Project, but he chose to leave the individual services in charge. "The first goal, as I saw it, was to get some of these weapons out of R&D and into the

[324] K.T. Keller to Chairman, RDB, "Evaluation of Guided Missile Program," 9 January 1952, in RG 156, Office of the Chief of Ordnance, Records Relating to the Army Guided Missiles Program, Box 23, file "1951-53," NA.
[325] Committee on Guided Missiles, RDB, "Points covered in presentation by Fred A. Darwin to House Military Appropriations Committee on 25 January 1952," in RG 330, Records of the Secretary of Defense, Box 392, file "106/Budget and Fiscal GM," NA. No public record from Congress of these remarks could be found.

hands of the fighting forces as soon as possible," and he added that his second goal was economical and timely production of missiles.[326]

Keller and Truman

On the occasions when Keller met Truman, Nichols explained that Keller spent only about ten minutes explaining the missile programs before turning to general topics. Nichols' statements that he and Keller met with Truman on several occasions differs with the official White House record, which shows only one meeting with Truman while Keller held the office. However, political scientist Richard Neustadt noted in his book on presidential power that Truman was very accessible, which suggests that Keller and Nichols could have seen Truman without a formal appointment.[327]

In July 1951, Keller prepared a report for the president and presented it personally in their only officially recorded White House meeting while Keller held the missile job. In a letter that accompanied his report, Keller estimated that 4,000 people in government and 11,000 contractor personnel were working on missiles, but he chose to keep existing organizations intact so not to slow down production. While many missile programs fell short of expectations he decided that "an accelerated program of a few missiles that showed great promise was the most logical way of moving the program forward." Following the priority set by the military and the president for missiles to defend against Soviet bombers, Keller chose to accelerate production of the army's Nike and the navy's Terrier anti-aircraft missiles, along with the navy's Sparrow air-to-air missile, which would be used for aerial defense. Keller explained that moving these missiles into production vastly reduced assembly times and costs per unit because each part could be

---

[326] K.T. Keller, Text of Address at War College, 30 January 1952, and Text of Address at War College, 27 January 1953, in Keller papers, National War College, HSTL.
[327] Nichols, *The Road to Trinity,* 283-4; Neustadt, *Presidential Power,* 172.

made in large quantities with specialized tooling and would not need to be individually machined. Turning to offensive missiles, Keller spoke of two 500-mile range winged missiles, the USAF Matador and navy Regulus, and the 5,000-mile range USAF Snark, as being put into limited production to advance their development. The accuracy of these missiles at distances from 100 to 500 to 3,000 miles, "has shown promise that these weapons can be effective as atomic warhead carriers," although he predicted that they would "require great reliability" but missiles carrying conventional warheads would "require much more work on guidance and simplification to reduce cost."[328]

Nike-Ajax anti-aircraft missiles at White Sands Missile Range (White Sands Missile Range Museum)

[328] K.T. Keller to President Truman, 10 July 1951, in Keller papers, Guided Missiles, Correspondence – 1950-52, HSTL.

In a formal report attached to his letter to the president, Keller stated that he found that the "highest priority had been assigned to air defense guided missiles. We have emphasized this priority." The Snark missile was being put in limited production to test guidance systems for missiles and to have a missile available in the short term for emergencies, he explained. "Development of a guidance system with sufficient accuracy and reliability is the crux of the problem for missiles in this field." He also mentioned that research and development was continuing for the long-range rocket-ramjet Navaho missile, which he called "the ultimate weapon that is being proposed in this category." He added that the navy Triton long-range missile was continuing in research and development because missiles launched from ships often require "a different approach in the matters of storage, propulsion and guidance" from land-based missiles. Keller's report showed how missile costs were ballooning – he projected spending of $1.2 billion for fiscal years 1951 and 1952, with costs growing further in 1953.[329]

In a letter he wrote Truman in December 1952, near the end of Truman's term. Keller thanked the president for his support and expressed regret that Truman was leaving office, "even though I have been a Republican, as you know, all my life." He recalled the president's instruction to "produce something to knock the enemy airplanes out of the skies," and the result was that the Army's Nike anti-aircraft missile was being brought into service two years ahead of schedule. Keller added that he started with thirty missiles and had some successes and failures, "I can say that having the freedom of

[329] Director of Guided Missiles, "Report to the President on Status of Guided Missiles," 10 July 1951, in Keller papers, Guided Missiles, Correspondence – 1950-52, HSTL. The Hermes-C1 missile became known as the Redstone missile.

action that you gave me made it possible to get the kind of cooperation I needed from everyone concerned to get concentrated effort on these jobs."[330]

In the end, guided missiles occupied very little of Truman's time and attention while he served as president, and so his record with missiles has not been widely discussed since he left office. One exception to that rule was during the political controversy in the United States that followed the Soviet Union's launch of Sputnik in 1957, when Democrats criticized the Eisenhower Administration for moving too slowly on ICBMs, and Republicans fired back by accusing the Truman administration of doing nothing with missiles. Truman responded by invoking his hiring of Keller. The former president said he brought in Keller when he saw missile programs were being slowed by inter-service rivalry, and gave Keller instructions to "knock heads together" to break production bottlenecks. Truman also accused Eisenhower of quickly removing Keller simply because he was a holdover from the Truman administration, an accusation that was unfounded, as we shall see below.[331]

Committees and Atlas

While Keller and his team were reorganizing missile production, the Guided Missiles Interdepartmental Operational Requirements Group set up by the Joint Chiefs of Staff early in the year continued to operate. In November 1950, the JCS approved the

---

[330] K.T. Keller to President Truman, December 8, 1952, in Keller papers, Guided Missiles, Correspondence – 1950-52, HSTL.

[331] Truman made these comments in a syndicated newspaper column he wrote in October 1957 and reprinted in Harry S. Truman, *Mr. Citizen* (London: Hutchinson & Co. 1961) 260-8. Almost identical comments from a newspaper interview are contained in Homer Bigart, "Truman is Caustic on Bipartisanship," *The New York Times,* 14 November 1957, 1. Republican criticism of the Truman administration is contained in James Reston, "Politics and Defense," *The New York Times,* 22 November 1957, 10. More Republican attacks on Truman's record on missiles can be found at the Dwight D. Eisenhower Presidential Library in the papers of Bryce Harlow, pre-accession series, National Security File, box 2. Keller's 1958 appearance before the House Committee on Astronautics and Space Exploration quoted in this chapter was no doubt intended to blunt criticism of Truman administration missile programs.

1951 research and development program prepared by the requirements group. Although the group claimed that the new program "changes the emphasis on guided missile research, development and production," it continued to give top priority to anti-aircraft missiles for all three services, reflecting growing concern about Soviet bombers. The list of eight air force priorities put the long-range Snark winged missile, which it called "interim," in sixth place, and the Navaho long-range winged missile in seventh place. A list of missile programs that should be accelerated to be ready for operational use by 1 July 1954, the assumed date from which the United States "must prepare for a change from cold war to total war," included only anti-aircraft missiles such as Nike and medium-range missiles for tactical purposes such as the Air Force Matador winged missile. The only long-range missiles at the time, Navaho and the Snark, remained on the list of missile programs not slated for accelerated development, since they would not be ready for deployment by 1954, and because defensive and tactical missiles had higher priorities.[332]

The previous chapter's account of Convair's work with ballistic missiles concluded in January 1951, when the USAF contracted with Convair under Project MX-1593 to officially resume its work on long-range ballistic missiles started on the MX-774 program. The air force resumed work on ballistic missiles in the wake of RAND's assessments in 1949 and 1950 that this type of missile was superior to winged missiles

---

[332] Rear Adm. N. G. Lalor, Secretary, JCS, to Chairman, RDB, "Strategic Guidance to the Research and Development Board on Guided Missiles," 2 February 1951, plus Appendix A, "Operational Requirements for Guided Missiles," Appendix B, "Accelerated Guided Missiles Program, and Appendix C, Other Missile Projects," and Report by the Joint Strategic Plans Committee to the JCS on Strategic Guidance to the Research and Development Board on Guided Missiles, 24 January 1951, both in RG 218, Records of the Joint Chiefs of Staff, Box 108, file "JCS 334 Guided Missiles Comte (116-45) Sec 3," NA. During the Truman administration, the military planned around the "year of maximum peril," then assumed to be 1954. In April 1953, the Eisenhower administration replaced this policy with what it called a "long haul" planning policy for the armed forces. For more detail on these planning policies, see Glenn R. Snyder, "The 'New Look' of 1953" in Schilling, Hammond, and Snyder, *Strategy, Politics and Defense Budgets,* 400-6.

with ramjets. Convair's initial studies on MX-1593, which quickly became known as Atlas, were completed in September 1951 and examined both ballistic and winged rockets. The winged vehicle, known as a glide rocket, would be shorter and lighter than the ballistic missile, but the USAF Air Staff decided to continue work only on the ballistic version of Atlas because it believed that the ballistic version offered better performance for cost. According to air force historian Jacob Neufeld, Brig. Gen. John W. Sessums of the Air Research and Development Command supported ballistic missiles and lobbied to continue the Atlas ballistic missile study but not the glide missile concept, while John Chapman, whose book on Atlas reflected the viewpoint of the Convair team, said Convair pressed the already known argument that the winged version would be traveling slow enough that defenders could shoot it down near the target, while a warhead from a ballistic missile could not be shot down because of the extremely high speeds it would be traveling. The Convair group also questioned a supposed advantage of the winged missile, that it would require less heat protection because it was traveling at a much slower speed than the ballistic missile. Because the winged missile would remain attached to the warhead to the end of the flight, the entire winged missile body would require heat protection, unlike the ballistic missile warhead that could separate from its spent missile body before re-entry.[333]

The results of Convair's study of the ballistic version of the Atlas missile were outlined in a presentation to the Guided Missiles Committee in 1952 by USAF Col. R.L. Johnston, chief of the Weapons System Division in the Air Research and Development Command, which was taking control of the air force's missile work from the Air Materiel

[333] J. Neufeld, *Ballistic Missiles in the USAF,* 70-1; Chapman, *Atlas: The Story of a Missile,* 63-4; E. Michael Del Papa and Sheldon A. Goldberg, *Strategic Air Command Missile Chronology 1939-1973* (Offutt AFB, Neb.: Office of the Historian, Headquarters, Strategic Air Command, 1975).

Command. The specifications for the 160-foot (49-metre) high ballistic missile included the ability to carry an atomic warhead, a range of 5,500 nautical miles with a speed greater than six times the speed of sound, and an accuracy requirement of at least one out of two hits within a radius of 1500 feet of the target. The ballistic Atlas would be equipped with five engines, uprated versions of North American's 120,000-lb. thrust rocket engine that it had developed for Navaho, and Atlas would be capable of carrying a 4,500-lb bomb. A seven-engine version would be able to carry a 7,000-lb payload. Johnston reported Convair's studies found great promise for ballistic missiles: "Not only do these studies show that the program is technically practical but they also show that this method offers promise of being the most economical method of conducting strategic warfare. Also this weapon is the most invulnerable of any type under consideration and in fact in the future it may well be the only method of penetrating the enemies [sic] defenses." Turning to cost, Johnston argued that, "when reliability, accuracy and vulnerability are considered, the rocket type missile is considerably cheaper" than bomber aircraft for conducting strategic warfare. He admitted that protecting the warhead from disintegrating in the extremely high temperatures encountered during re-entry remained the technical problem with the biggest set of unsolved issues. Johnston's lengthy discussion of guidance and control projected the use of an "autopilot" with a radio and computer control system using tracking stations between the launch site and the target, a system that still had technical problems, particularly with the computer.[334]

[334] Col. R.L. Johnston, "Initial Presentation of Atlas Project Made at the 40th Meeting of the Committee on Guided Missiles," 21-22 May, 1952, in RG 330, Office of the Secretary of Defense, Box 396, 42nd meeting of GM committee, file "237/GM," NA. Emphasis in original. Johnston commented that the MX-774 had been cancelled "due to lack of funds and the belief that the solution by other methods was closer at hand."

The Guided Missiles Committee got involved with Atlas at its 40th meeting on 22 May 1952, when it approved a request from the USAF to add the Atlas project to the list of approved guided missile projects in the "Study Projects and/or Component Development" category. The study that Convair formally began in January 1951 under MX-1593 claimed that "the development of an intercontinental rocket as a method of accomplishing the strategic mission of the United States Air Force is technically feasible, and that this development should be based on a ballistic rocket," a GMC report explained. The USAF estimated that spending of about $3 million for the Atlas project in fiscal year 1953 would be needed to continue studies, begin design of missile components, and initiate the fabrication of prototype missile systems. Beard wrote that the GMC warned Convair through the air force not to exceed its budget.[335] In his report to the GMC on Convair's study of Atlas, Col. Johnston proposed that the USAF build a test vehicle with a speed close to that of the final missile. He added that the program would begin in "a fairly modest way" with component development work followed the next year with building test vehicles.[336]

While the air force and the GMC were dealing with Atlas in 1951 and 1952, K.T. Keller took little action on the future ICBM. Keller told Congress in his 1958 testimony in the wake of the Sputnik crisis that the Atlas missile "was purely in the state of discussion" while he was in charge of missiles. At that point, in 1951, Keller explained

---

[335] Committee on Guided Missiles, RDB, "Item 5: Presentation of ATLAS Long-Range Surface-to-Surface Missile Project," Agenda of 40th meeting, 21-22 May 1952, with Col. B.K. Holloway to Chairman, Committee on Guided Missiles, "ATLAS Strategic Rocket Program," 7 May 1952, and Col. B.K. Holloway to Chairman, Committee on Guided Missiles, "ATLAS FY 1953 Program," 28 May 1952, in RG 156, Office of the Chief of Ordnance, Records Relating to the Army Guided Missiles Program, Box 12, file "GM 237/ Atlas," NA. Beard, 139, quotes air force correspondence from this time contained in a portion of an air force historical study that was denied to the present author because it is classified.

[336] Col. R.L. Johnston, "Initial Presentation of Atlas Project," *ibid;* J. Neufeld, *Ballistic Missiles in the USAF,* 71, 73.

that he brought in businessman and engineer Robert R. McMath, whose interest in astronomy led to his appointment as director of the McMath-Hulbert Solar Observatory in Michigan, as a consultant and the only non-military member of his staff, to help him assess Atlas. McMath went through "a wheelbarrow load of studies" on Atlas and concluded "that if we can do this and this and this, we think the missile will be a success." Keller told Congress that McMath "had one of his men from the University of Michigan" look into the studies in greater detail, and the man suggested that more study be done on the Atlas guidance system and the problem of warhead re-entry through the atmosphere. Keller added that the expert's encouragement of laboratory research rather than flight testing guidance and re-entry heating problems advanced Atlas "because you know what you are going to have to deal with." Pat Hyland, the aerospace executive who served on the Guided Missiles Committee, described McMath as a "crony" of Keller's who served as a liaison between the technical experts on the GMC and the military people who worked with Keller to direct the missile projects. Although Hyland did not speak of McMath's role in Atlas, he called the arrival of Keller and McMath on the missile scene as "fortunate."[337]

Keller and McMath weren't alone in thinking that Atlas needed more study. The GMC discussed the Atlas program again on 21 August 1952, and "unanimously concluded that additional detailed study was needed to achieve solutions to the problems encountered in the guidance, correction, composite propulsion system, and the re-entry and terminal phase of the trajectory." While the committee noted that several

[337] House of Representatives, *Hearings Before the Select Committee on Astronautics and Space Exploration*, 2nd Session, 85th Congress, on H.R. 11881, May 8, 1958, 1498-1519; Hyland, *Call Me Pat,* 338. For more on McMath, see O.C. Mohler and Helen Dodson-Prince, *Robert Raynolds McMath, 1891-1962, A Biographical Memoir* (Washington. D.C.: National Academy of Sciences, 1978).

"significant" studies have established the "probable technical feasibility" of Atlas, a "detailed study for establishment of a logical, economical approach for the pursuit of the ATLAS development program is required." The committee recommended that the USAF establish an "ad hoc group" to carry out the study.[338]

Inside the air force, discussions were also going on as officers in the Air Research and Development Command drew up proposed military specifications for Atlas in August, including a warhead weighing only 3,000 lbs, an estimate that showed that word about advances in the design of nuclear weapons had reached the air force. The specifications document went to air force headquarters on 1 October, 1952, a month before the first explosion of a new type of nuclear weapon known as a thermonuclear bomb would prove this new weapon. Jacob Neufeld and John Clayton Lonnquest wrote in their historical accounts that the continuing differences between the Air Staff and the Air Research and Development Command led to Lt. Gen. Laurence C, Craigie, the Deputy Chief of Staff for Development, to call for the new study when the military specifications documents, which would be necessary to proceed with the new program, were given to the USAF Scientific Advisory Board for approval.[339] Beard and Lonnquest added that officers in the Air Staff in Washington refused calls late in 1952 and early in 1953 from Sessums and Putt in the ARDC to move ahead aggressively on development of the ballistic missile and instead decided to continue research and development on Atlas at a relatively slow pace. This was nearly the reverse of the situation in the late 1940s, but then the point of dispute between the Air Staff and other officers was over guided

[338] Edwin A. Speakman to Deputy Chief of Staff, USAF, "Conduct of ATLAS missile program," 17 September 1952, in RG 330, Office of the Secretary of Defense, Box 196, file 42nd meeting of GM committee, NA.
[339]J. Neufeld, *Ballistic Missiles in the USAF,* 73-4; Lonnquest, "The Face of Atlas," 35.

missiles in general, and now the dispute was over a proposed ICBM just as the technological obstacles that stood in its way were starting to fall away.[340]

As a result of this dispute between the Air Staff and the ARDC, the air force's Scientific Advisory Board set up a committee of experts known as the Ad Hoc Committee on Project Atlas, with eight members headed by Clark B. Millikan, the distinguished Caltech professor of aeronautics who was also chair of the GMC. In December, the committee visited the Convair, North American and Bell Aircraft plants, and was briefed by several relevant agencies before it submitted a report to the USAF on 30 December 1952. The committee unanimously agreed that the USAF "should retain in its program a project leading to the development of an intercontinental ballistic missile to carry an atomic warhead." It also agreed that because of what it called, vaguely, "anticipated developments in atomic warheads," referring to the new thermonuclear bombs that would be a thousand times more powerful than existing fission bombs and new fuels for these bombs that made them much lighter than existing nuclear weapons, Atlas' accuracy and payload characteristics should be "relaxed" to allow for a wider accuracy requirement of one mile, and a reduced payload of 3,000 pounds. While work should continue on the 5,500 nautical mile range missile that could strike anywhere in the Soviet Union, the committee suggested that a shorter-range ballistic missile would also be militarily useful. And while the committee recommended that Convair remain as the prime contractor for Atlas, it opposed Convair's proposal to build "a very large test vehicle," and instead recommended tests of guidance, propulsion and re-entry systems for Atlas using Navaho, Viking and Snark missiles. The report concluded that it was still too

[340] Lonnquest, "The Face of Atlas," 32-33; Beard, *Developing the ICBM,* 133-9.

early to set a date for completion of a prototype missile, but that the "Convair estimate of 1962 can be considered as a minimum date."[341]

The ad hoc committee met again in March 1953 to consider proposals from the ARDC for an Atlas development plan. The ARDC stated that the committee's testing proposals were too slow and expensive, and disagreed with the idea of using Navaho, Snark and Viking as test beds for Atlas. The ad hoc committee then agreed to a new compromise development plan proposal that allowed testing to take place on test vehicles built by Convair as ARDC wanted. The new plan also fit in with the Air Staff's plans for step-by-step testing of missile components following what an Air Staff official described as a "slowed down" budget scheme. While Atlas received a formal weapons system designation, it was also given a relatively low 1-B program priority. The Air Staff approved the development plan that October.[342]

The bureaucratic foot dragging inside the air force criticized by Edmund Beard was clearly in evidence starting with the completion of Convair's Atlas study in September 1951, when the ARDC tried and failed to persuade the Air Staff to speed up work on Atlas. In August 1952, even before the crucial first test explosion of the thermonuclear bomb in November, which packed greater power and would be considerably lighter than existing fission bombs, experts in the ARDC began to estimate lower warhead weights, which would allow for a smaller ICBM. This shows that word of the possibilities opened by thermonuclear weapons were beginning to spread inside the

[341] Clark B. Millikan, "Report of the USAF Scientific Advisory Board's Ad Hoc Committee on Project Atlas," 30 December 1952, in RG 330, Office of the Secretary of Defense, Box 396, 42nd meeting of GM committee, file "237/GM," NA. The other members of the committee were: Hendrick W. Bode of Bell Labs; M.U. Clauser, who would later work at Space Technology Laboratories; Charles Stark Draper of MIT; George B. Kistiakowsky of Harvard University and later a presidential science advisor; G.F. Metcalf of General Electric; Homer J. Stewart of Caltech; and Maurice J. Zucrow of Purdue University.
[342] Lonnquest, "The Face of Atlas." 35-8; J. Neufeld, *Ballistic Missiles in the USAF,* 74-9.

USAF at that early date. The success of the test quickly led air force and other experts to begin believing the estimates of the thermonuclear bomb's far greater explosive power, which meant that the strict accuracy requirement imposed on missiles could be loosened. But the report of the ad hoc committee headed by Clark Millikan showed that differences over the technical problems facing ICBMs still remained.

Keller and Eisenhower

Keller had intended to resign when Truman left office in January 1953, but he agreed to remain when Eisenhower's incoming secretary of defense, Charles E. Wilson, who Keller knew as the head of General Motors, asked him to stay on. "I told him then that I would continue at least until June or July so he wouldn't have this problem of missile development suddenly on his hands while he was developing his organization and getting a line on his work," Keller wrote the new president in a letter on 12 May 1953. Keller also predicted that under the new organization Wilson was setting up in the Pentagon: "this work should be part of a very definite line of authority in the services. There really should be no place for my type of special organization when Mr. Wilson gets the Defense Department organized." Eisenhower responded two days later with a letter asking Keller to meet soon with him and Wilson, and adding that Wilson "would very much like to have you retain control of the program for at least another six months."[343] In a 1959 letter to Truman, Keller recounted his lunch meeting at the White House with President Eisenhower and Defense Secretary Wilson that took place on 16 June 1953, a month after the president's invitation. Keller recalled that he recommended that Nichols be promoted and put in charge of missiles. "Mr. Wilson took exception to this on the

---

[343] K.T. Keller to Dwight D. Eisenhower, 12 May 1953, and Eisenhower to Keller, 14 May 1953, in Harry S. Truman Post-Presidential Files, K.T. Keller, HSTL.

basis that you couldn't have an Army man tell the Air Force and the Navy what to do." When Keller "rather sharply" defended his idea, the conversation on that topic ended.[344]

Nichols recorded in his memoir that Keller agreed to stay on with Eisenhower only for a few months, since Keller believed that Wilson would be impossible to work with because he "will want all the details," unlike his predecessors Marshall and Robert Lovett, who were generally happy to have Keller and Nichols handle the details and the disagreements. "Working for Wilson turned out about as Keller predicted," Nichols wrote, and when Nichols moved that summer to a new job as general manager of the Atomic Energy Commission, "it gave [Keller] an additional excuse to resign."[345] Keller's involvement with the missile program ended on 17 September 1953, and his work was transferred to the newly created offices of two assistant secretaries of defense. A press announcement that day reported Keller had recommended to President Eisenhower in June that his office be wound up due to advances in missile development. "With several guided missiles already in production, others relatively far advanced through the evaluation phase, and some in the early stages of research, it is advisable at this time to channel the activities of the Office of Guided Missiles into the regular administrative and planning organs of the Department of Defense," Keller said in the announcement.[346]

In his final report, Keller wrote that: "top priority as indicated by the JCS was for defense weapons. The others were still high on the list." In a summary of missile projects

---

[344] K.T. Keller to Harry S. Truman, 6 November 1959, in Harry S. Truman Post-Presidential Files, K.T. Keller, HSTL. Eisenhower's appointment book, which recorded the date of the lunch, is available online from the Eisenhower Presidential Library at http://www.eisenhower.archives.gov/Research/Digital_Documents/Digital_Documents.html . Accessed 21 April 2010.

[345] Nichols, *The Road to Trinity,* 284-5, 297-8.

[346] Press release, Department of Defense, "K.T. Keller Completes Guided Missiles Assignment," undated but probably September 1953, in Keller papers, Guided Missiles, Correspondence – 1953-54, HSTL.

in effect at the time, the list of missiles in research was headed by the Atlas, which he called a "highly complex and long term project still in its study stage." The Navaho, also in research, was promising, but had "nasty technical problems still to be solved." The third 5,500-mile range missile was the Snark, then in development. "All aspects are in latter stages of development except guidance," which might be solved by using Navaho's guidance system.[347]

Shortly after he left office, Keller received an effusive thank you letter from Under Secretary of the Army Earl D. Johnson, who praised his effectiveness, and from Maj. Gen. E. L. Ford, the Chief of Army Ordnance.[348] Aside from expediting anti-aircraft missiles like the army's Nike, Keller probably made his biggest impact on the development of army tactical missiles, particularly the Redstone intermediate range ballistic missile, which was designed and built under the direction of Wernher von Braun and his German rocket team. Although Redstone had a range of only 200 miles, it played a key role in the early U.S. space program. By the time the von Braun team began work on Redstone in 1951, the group had been relocated to the army's Redstone Arsenal in Huntsville, Alabama. In congressional testimony in 1957, von Braun explained that his work on the Redstone missile was greatly helped by Keller: "I would say, when he came in, things began to move. … Mr. Keller was the man who said, 'Let us build an operational ballistic missile.'" He added that Keller pushed almost too hard, given that the German team had done little groundbreaking work for six years when Keller began making resources available and "asking for the impossible all of a sudden." Based in part

[347] K.T. Keller, "Final Report of the Director of Guided Missiles." 17 September 1953, in Keller papers, HSTL.
[348] K.T. Keller to Maj. Gen. E.L. Ford, 19 October 1953, and Earl D. Johnson to K.T. Keller, 3 October 1953, both in Keller papers, HSTL.

on this testimony, a report prepared for a Senate committee stated that "Mr. Keller has been credited with providing the guidance and inspiration needed to get the U.S. missile program accelerated to the point where operational missiles began to appear within a few years. One of his methods of speeding the program was to select the most promising of the missiles systems of the three services and concentrate upon these, starting production before the development was completed."[349] The Army history of the Redstone missile program explained that the army reorganized its missile program following Keller's visit to the Redstone Arsenal in February 1951, most importantly accelerating the Redstone missile according to what "quickly became known as the 'Keller' accelerated research and development program."[350]

Keller's success with the Nike anti-aircraft missile no doubt earned him the army's further gratitude when the army won effective control of anti-aircraft defenses and then defenses against ballistic missiles. Later versions of the Nike missile were used for America's first missile defense systems, the Nike-Zeus missile in the 1960s and the Spartan missile used in the Safeguard missile defense system of the 1970s, which was closed down as a result of budget cuts and questions about its effectiveness.[351] Keller also received praise from Rear Adm. John H. Sides, who headed the navy's missile program, and who highlighted Keller's work advancing navy programs, the Sparrow air-to-air

---

[349] United States Senate, *Hearings before the Preparedness Investigating Subcommittee, Committee on Armed Forces, Inquiry into Satellite and Missile Programs,* 1st and 2nd Sessions, 85th Congress, December 14, 1957, 584; Charles J. Donnelly, *The United States Guided Missile Program* (Washington D.C.: Prepared for Preparedness Investigating Subcommittee, U.S. Senate Committee on Armed Services, U.S. Government Printing Office, 1959) 10. Redstone served as the first stage of the launch vehicle for America's first satellite, *Explorer 1,* in 1958, and carried America's first two astronauts on suborbital flights in 1961.

[350] Bullard, *History of the Redstone Missile System,* 36-43. See also Lassman, *Sources of Weapon Systems Innovation in the Department of Defense,* 11-21.

[351] Baucom, "Eisenhower and Ballistic Missile Defense;" Donald R. Baucom, *The U.S. Missile Defense Program, 1944-1994: Fifty Years of Progress* (Washington, D.C.: Ballistic Missile Defense Organization, 1994) 1-3.

missile, the Terrier surface-to-air missile, and the Regulus medium-range winged missile.[352]

The Keller files do not contain a similar letter from anyone in the USAF. The air force was leery of Keller because Nichols, an army officer, was his deputy. Jacob Neufeld's history of air force ICBMs has explained that after the army proposed to the Munitions Board in 1950 that missile production be separated from aircraft production, the air force opposed this idea because it feared that a separation of missile and aircraft production would weaken its control of guided missiles. Keller and Nichols supported the army's position, but the air force managed to prevail in this dispute by foot dragging. Neufeld has argued that the dispute over missile roles between the air force on one side and the army and navy on the other continued during the final months of the Truman administration and into 1953. While the USAF continued to defend its missile role with the use of terms such as "pilotless aircraft," the army proposed in November 1951 that it get control of all surface-launched missiles. The dispute reached the level of the Joint Chiefs of Staff, but an attempt in the summer of 1952 to settle the dispute by accepting existing roles failed when the Army General Staff turned down the idea.[353]

Keller and Quarles

On leaving his office in September 1953, Keller exchanged short but warm letters with Eisenhower. The President wrote that "we are fortunate that you will still be available for informal consultation from time to time," and Keller praised the appointment of Donald Quarles as assistant secretary of defense for research and development as part of the organizational changes that saw the elimination of the RDB.

[352] Rear Adm. J.H. Sides to K.T. Keller, 26 October 1953, in Keller papers, Guided Missiles, Correspondence – 1953-54, HSTL.
[353] J. Neufeld, *Ballistic Missiles in the USAF,* 80, 82-92.

In November, the air force department's head of research and development, Trevor Gardner, met Keller to share information about missile programs.[354]

Early in 1954, as the USAF was preparing to gear up the Atlas Program, Keller and Quarles exchanged letters about the "RW-66-4" report, which probably was a draft from the Ramo-Wooldridge Corporation of the Tea Pot Committee report, whose recommendations leading to accelerated work on Atlas will be discussed in the next chapter. The letters followed a discussion Keller had had with Pat Hyland, who had served on the GMC and the Tea Pot Committee. "In general, I like the whole program," Keller wrote on 25 January, adding that he had "always approved of this ballistic job, provided we could get it on some kind of a basis that would make sense." He told Quarles that the missile was so important that it should have more than one contractor build it to ensure that the best people possible be involved in the program. Keller explained that progress on different kinds of guidance systems being developed for the Snark and Navaho was not as great as he had hoped. As a weapon, Keller estimated that "the Snark is going to be in a very doubtful category on account of its [subsonic] speed. I also feel the Navaho should be brought to realistic tests as soon as possible." Quarles replied on February 2 expressing satisfaction that Keller agreed with the findings of the RW-66-4 report, and agreeing that 'implementing the Committee's recommendations will be tough going." Quarles concluded that "this report makes it clear that a broad reorientation of the program is necessary."[355]

---

[354] Dwight D. Eisenhower to K.T. Keller, 28 September 1953; Keller to Eisenhower, 5 October 1953; and Telegram, Keller to Trevor Gardiner, 13 November 1953, in Keller papers, Guided Missiles, Correspondence – 1953-54, HSTL.
[355] K.T. Keller to Donald Quarles, 25 January 1954, and Quarles to Keller, 2 February 1954, in Keller papers, Guided Missiles, Correspondence – 1953-54, HSTL.

Conclusion

During Keller's three years in office, spending on research and development for missiles rose from $159 million in fiscal year 1951 to $275 million in 1953, and total funding for missile procurement rose at an even higher rate.[356] Keller did a great deal to advance army and navy anti-aircraft missiles, and the fact that these high priority missiles had reached production helped build military interest in ICBMs. Aside from the small study he ordered of Atlas, Keller and his office did little direct work to advance the ICBM. The Atlas program rose from the ashes of MX-774 during Keller's time in office, but mainly through the efforts of RAND and the air force. During the final months of the Truman administration and early months of the Eisenhower administration, the pace of Atlas development remained slow due in part to resistance in the Air Staff and despite new evidence, especially the possibilities of lighter weight warheads offered by thermonuclear bombs, that the ICBM would be an effective weapon.

Keller's period as missile czar represents the one time that President Truman took an active role in the missile program. Richard Neustadt has postulated that Truman's "instinct was to improvise arrangements around problems rather than to work through fixed procedures." His hiring of Keller as missile czar is a good example of improvisation, and one that was so effective that Eisenhower and his own defense secretary were happy to continue the arrangement for several months.[357] Interestingly, the defense department revived the position of director of guided missiles in 1957 to expedite production of ICBMs and intermediate range ballistic missiles. Historians such as Edmund Beard and Jacob Neufeld have dismissed Keller's importance, but this chapter

[356] Condit, *The Test of War,* 475.
[357] Neustadt, *Presidential Power,* 172.

shows that his work did have some impact on the development of ICBMs, if not a decisive one.

Eisenhower's appointment of General Motors president Charles E. Wilson to the position of Secretary of Defense, followed by Procter and Gamble president Neil H. McElroy, and President John F. Kennedy's subsequent appointment of Robert S. McNamara, president of the Ford Motor Company, as his Secretary of Defense, are well known, and historian Alex Roland has suggested that their appointments represented a merging of the military and business elites of the United States. In the fall of 1950 during the Korean war, however, Truman got a jump on Eisenhower by appointing Keller to the missile post, and then another Charles E. Wilson, this one the president of General Electric, to head the newly-established Office of Defense Mobilization, which controlled resources, industries and personnel needed for the Korean War and other defense needs. Industrialists, including "Electric Charlie" Wilson, had held less prominent positions in the U.S. government during World War II, and Truman set the stage for the Eisenhower and Kennedy's appointments with Keller and "Engine Charlie" Wilson.[358]

This chapter has shown that Truman and many officials in the defense department saw anti-aircraft missiles as the top priority in the field of guided missiles due to growing concern about the perceived threat presented by Soviet bombers carrying nuclear weapons, which will be discussed in the next chapter. Indeed, defensive missiles had fallen behind in their development process and assumed the role of a technological "reverse salient," as described by Thomas Hughes, in America's defenses against what was seen as the major direct Soviet military threat to the United States, its bomber

[358] Roland, *The Military-Industrial Complex,* 16-7; Donovan, *Tumultuous Years,* 324-5. Charles E. Wilson from GM was known as "Engine Charlie."

aircraft.[359] In the early years of the Cold War, the U.S. government endeavored to protect Americans against the Soviet nuclear bomb and bomber threat by creating anti-aircraft guns and missiles, interceptor jets, radars and a massive computer system, along with civil defense measures for this purpose, which constitute another technological system from the nuclear bomb delivery system described in the introduction to this study. In this case, the highest reaches of the administration intervened to correct this reverse salient by bringing in what Hughes called an "entrepreneur" to build up the system and improve its operation.[360] K.T. Keller succeeded in meeting the goals of the president and military leaders to expedite production of defensive missiles. The high priority placed on anti-aircraft missiles during this time also shows that many responsible and well-informed people outside of the air force put top priority on bomber aircraft and missiles to defend against them, rather than on strategic missiles. This study argues that the development of ICBMs was not unduly slowed down before 1954. Furthermore, the blame for slow pace of this development cannot be assigned exclusively or even largely to air force officers devoted to their piloted aircraft. The importance of defensive missiles to military and political leaders in the United States during the years covered in this study has been largely missed by historians such as Beard. Indeed, missiles to defend against incoming aircraft and missiles have become a durable political issue in American politics, especially since President Ronald Reagan launched his Strategic Defense Initiative in 1983.

---

[359] Hughes, "The Evolution of Large Technological Systems." 73.

[360] Hughes, "The Evolution of Large Technological Systems." 57. Hughes looked at the creation of the computer system used for America's Cold War air defense system in a section of *Rescuing Prometheus,* 15-67. America's air defense system is also discussed in Kenneth Schaffel, *The Emerging Shield: The Air Force and the Emergence of Continental Air Defense, 1945-1960* (Washington, D.C.: Office of Air Force History, United States Air Force, 1991); and John C. Lonnquest, and David F. Winkler. *To Defend and Deter: The Legacy of the United States Cold War Missile Program* (Rock Island, Ill.: Department of Defense Legacy Resource Management Program, Cold War Project, Defence Publishing Service, 1996).

It was in 1951 and 1952 that leading figures in the air force resisted calls from missile experts in the Air Research and Development Command to accelerate development of the Atlas program. While historians such as Beard, Lonnquest and Jacob Neufeld have shown that the Air Staff resisted Atlas during this period, their resistance was motivated in part by concerns that Atlas would not be ready for use for another decade. But technological factors in the field of missiles and nuclear weapons were undergoing rapid change in those years, and those changes would play a decisive role in accelerating the progress of Atlas.

Chapter 6
The Atlas ICBM

Three events in the fall of 1952 radically changed the political and technical constraints facing the Atlas intercontinental ballistic missile program. In September, high officials in the air force and the aircraft industry got word of a promising but surprising solution to the problem of re-entry heating of missiles and warheads. Then on 1 November, the first thermonuclear bomb, known popularly as the hydrogen bomb, was exploded successfully by the United States. Although that bomb weighed eighty-two tons and thus was too big to be transported by air, it proved the thermonuclear bomb concept and quickly opened the door to powerful and lightweight bombs that could be carried by ICBMs. And on 4 November, Gen. Dwight D. Eisenhower was elected to succeed Truman as president, heralding major changes to the U.S. government.

This chapter will look at all three events and how they impacted the Atlas program in 1953 and 1954. Historians such as Edmund Beard have credited the changes Eisenhower's administration brought to the Department of Defense as being the most important event in this period related to the acceleration of America's ICBM program.[361] This chapter will reach a different conclusion putting greater importance on the creation of thermonuclear weapons. As well, this chapter will examine what the Soviet Union was doing to develop its own ICBMs during this time, since it shows how another country dealt with the same technical issues in the same time period. This description of the Soviet missile program will set the stage using sources not used in previous examinations of this subject area for a discussion of what the United States government knew about

[361] Beard, *Developing the ICBM,* 153-65.

Soviet missile programs and how this information affected decision-makers in Washington, D.C.

The Eisenhower Administration

On 20 January 1953, Eisenhower became president and put in place the first Republican administration in twenty years. During the 1952 election campaign, Eisenhower promised to institute reforms in the Department of Defense, a pledge he renewed once in office, when he proclaimed a "New Look" policy that sought to lower costs by reducing troop levels and increasing reliance on nuclear weapons and other new technologies. Truman's outgoing Secretary of Defense Robert A. Lovett left a memorandum for the new administration about what he saw as the deficiencies in his department, including the Research and Development Board, which he called too rigid because service members sitting on the board had to judge programs run by their own services as well as competing programs from other services. The new defense secretary, Charles E. Wilson, appointed Nelson Rockefeller, the future Republican governor of New York and vice president of the United States, to head a Committee on Department of Defense Organization, which reported in April. The committee's membership included Lovett and Vannevar Bush, who both endorsed its recommendations to abolish the RDB and the Munitions Board, and take other measures to enhance the authority of the Secretary of Defense.[362]

[362] Futrell, *Ideas, Concepts, Doctrine,* 423-4; Richard M. Leighton, *Strategy, Money and the New Look 1953-1956, History of the Office of the Secretary of Defense, Volume III* (Washington, D.C.: Historical Office, Office of the Secretary of Defense, 2001) 21-36; Zachary, *Endless Frontier,* 364-5. For an overview of the "New Look" and "massive retaliation," see Snyder, "The 'New Look' of 1953," in Schilling, Hammond, and Snyder, *Strategy, Politics and Defense Budgets,* 379-524; Kaplan, *The Wizards of Armageddon*, 174-84; and Donald Alan Carter, "Eisenhower Versus the Generals," *The Journal of Military History,* 71 (October 2007) 1169-99. A standard biography covering Eisenhower's presidency is Stephen E. Ambrose, *Eisenhower The President* (New York: Simon & Shuster, 1984). Eisenhower's memoir of his

By the end of the month, most of the committee's recommendations were transmitted to Congress as Department of Defense Organization Plan No. 6. During Congressional hearings on the reorganization, Deputy Secretary of Defense Roger M. Keyes testified that the number of committees that had grown around the RDB was "nothing short of astounding" and required some people to do nothing but attend meetings. "In our recent studies of this problem, we found that the complicated board system was hindering rather than helping research and was proving to be an obstacle both to the services and to the scientists and engineers on whom we must depend," Keyes added. After Congress held a series of hearings, the new plan became law on June 30. The plan strengthened the National Security Council and the office of the secretary of defense by giving them more authority, and it wound up the RDB, the Munitions Board, and other agencies in favour of six new assistant secretaries of defense.[363]

Donald A. Quarles, an engineer and physicist who had been a vice-president at Bell Labs and president of the Sandia Corporation, which had a central role in developing nuclear weapons, was named in September as Assistant Secretary of Defense for Research and Development. The new Secretary of the Air Force, Harold E. Talbott, had already named Trevor Gardner as his special assistant for research and development. Gardner, who was thirty-seven at the time, had worked during the war on rocket and atomic programs for the Office of Scientific Research and Development, and after that he became vice president and general manger of the General Tire and Rubber Company of

---

first term in office is *The White House Years: Mandate for Change, 1953-1956* (Garden City NY: Doubleday and Co., 1963).

[363] Futrell, *Ideas, Concepts, Doctrine,* 423-4; Leighton, *Strategy, Money and the New Look,* 21-36; testimony of Roger M. Keyes, Deputy Secretary of Defense, 17 June 1953, House of Representatives, *Reorganization Plan No. 6 of 1953, Hearings before the Committee on Government Operations* 1st Session, 83rd Congress (Washington, D.C.: U.S. Government Printing Office, 1953) 11; Herbert F. York and G. Allen Greb, "Military research and development: a postwar history," *Bulletin of the Atomic Scientists* (January 1977) 13-26.

California before starting his own electronics firm, Hycon Manufacturing Company. Gardner, who was known as tough and abrupt, also had a reputation for getting things done. Wilson and Talbott put Gardner at the head of a committee that reviewed military missile programs in the summer and fall of 1953. While the committee avoided thorny inter-service issues, its recommendations led to new missile procurement procedures that of necessity required change after Keller's departure as missile czar in September.[364]

Gardner also recommended to Quarles and Talbott the creation of two committees – one to deal with strategic missiles and another for all other missiles. After overcoming resistance from the Air Staff, which wanted a review run by the air force's own Scientific Advisory Board, Gardner was given the green light to form an independent eleven-member Strategic Missiles Evaluation Committee in October, with John von Neumann, the mathematical genius from Princeton University, at its head. As will be explained below, von Neumann was already opening the eyes of air force officers and others to the possibilities of a new weapon, the thermonuclear bomb. To provide technical support to the committee. Gardner considered the RAND Corporation, MIT and Caltech, but he rejected them because of their already close relationships with the USAF. Gardner instead suggested Simon Ramo and Dean Wooldridge, who both had recently left Hughes Aircraft after having helped develop the Falcon air-to-air missile, and had formed a new company, Ramo-Wooldridge Corporation. Both Ramo and Wooldridge joined the committee and Ramo-Wooldridge was contracted to provide support to the committee. Gardner later recalled that his remaining appointments to the high-powered committee

---

[364] Michael H. Armacost, *The Politics of Weapons Innovation: The Thor-Jupiter Controversy* (New York: Columbia University Press, 1969) 57; J. Neufeld, *Ballistic Missiles in the USAF,* 95-9; Thomas P. Hughes, *Rescuing Prometheus: Four Monumental Projects that Changed The Modern World* (New York: Pantheon, 1998) 82-4; Sheehan, *A Fiery Peace in a Cold War,* 195-200.

were made with the hope that committee members would be able to influence air force officers and others in the government who were skeptical of the ICBM.[365] Although RAND wasn't a formal part of the committee, it began work on a report of its own on strategic missiles.

John von Neumann (Los Alamos National Laboratory)

[365] Besides Drs. Von Neumann, Ramo and Wooldridge, the committee's members included Dr. Charles C. Lauritsen, Dr. Clark B. Millikan and Dr. Louis G. Dunn of Caltech, a former director of the Jet Propulsion Laboratory, Dr. George B. Kistiakowsky of Harvard and Dr. Jerome B. Wiesner of MIT, both future presidential science advisors, Dr. Hendrik Bode of Bell Labs, Lawrence A. Hyland of Bendix Aviation Corp., and Dr. Allen E. Puckett of Hughes Aircraft. J. Lonnquest, "The Face of Atlas," 89-95; J. Neufeld, *Ballistic Missiles in the USAF,* 95-9; House of Representatives, Committee on Government Operations, *Organization and Management of Missile Programs,* 86th Congress, 1st Session, House Report No. 1121. (Washington D.C.: U.S. Government Printing Office, 1959) 9-13, 69-73.

The Thermonuclear Bomb

Gardner charged the members of the new strategic missiles committee with evaluating the air force's long-range strategic missiles program in the light of a major change in nuclear technology, the creation of the thermonuclear bomb, known better as the hydrogen bomb or the thermonuclear bomb. Amidst great controversy among scientists and some of the public, President Truman had given the go-ahead on 31 January 1950 to the Atomic Energy Commission to begin developing the thermonuclear bomb. While many scientists opposed the thermonuclear bomb in private and public, physicist Edward Teller played a key role in designing thermonuclear bombs and worked to win political support for building the new weapon. One of the most prominent opponents of creating the new weapon was physicist J. Robert Oppenheimer, the scientific director of the Manhattan Project. Based on Oppenheimer's past associations with communists, Teller and anti-communist officials in the Eisenhower Administration took active part in removing Oppenheimer's security clearance in 1954. This decision was one of the central episodes in the suppression in the 1950s of Americans associated with communism, and tied the thermonuclear bomb to this dark chapter in American history. Although Teller testified against Oppenheimer in hearings on his security clearance, von Neumann refused to take part despite his own fervent anti-communism and support of the thermonuclear bomb.[366]

---

[366] There are many accounts of this episode in Oppenheimer's life, including Rhodes, *Dark Sun,* 530-59; and Norman Macrae, *John von Neumann* (New York: Pantheon Books, 1992) 351-3. See also Kai Bird and Martin Sherwin. *American Prometheus: The Triumph and Tragedy of J. Robert Oppenheimer* (New York: A.A. Knopf, 2005). For a study of scientists' attitude to nuclear weapons, see Jessica Wang, *American Science in the Age of Anxiety: Scientists, Anticommunists, and the Cold War* (Chapel Hill, NC: University of North Carolina Press, 1999).

Existing atomic or fission bombs were based on the energy released when a large atomic nucleus such as that of uranium or plutonium is split. The thermonuclear or fusion bomb releases a much larger amount of energy and radiation when an explosive nuclear chain reaction, where atoms divide as in the fission bomb, causes a light element, hydrogen, to fuse to form a heavier element, helium. When the technical concepts for a thermonuclear bomb on hand at the time of Truman's decision proved inadequate, Teller and fellow physicist Stanislaw Ulam conceived of a new design in 1951 that ultimately worked. On 1 November 1952, the first thermonuclear bomb, code named "Mike," exploded with a force of 10.4 million tons of TNT on the Pacific atoll of Eniwetok. The explosion packed more than 800 times the power of the atomic bomb that leveled Hiroshima. The Mike device weighed eighty-two tons, too much for military use, because it used supercooled liquid fusion fuels. But smaller and lighter designs based on solid fusion fuels were already in the works. When the ad hoc committee on Atlas mentioned in the previous chapter reported to the USAF Scientific Advisory Board (SAB) on 30 December 1952 with a suggestion that accuracy requirements for Atlas be loosened because of developments with nuclear weapons, it was probably referring to the success of the Mike test.[367]

Von Neumann, who like Teller was an immigrant who left Hungary to flee inter-war anti-Semitism, was also heavily involved in developing thermonuclear weapons and sat on many military and scientific advisory groups, including SAB. In March 1953,

[367] Rhodes provides one of the best accounts of the development of the thermonuclear bomb. See Rhodes , *Dark Sun,* 246-7, 462-72, 495-512. Other important works are Hansen, *US Nuclear Weapons: The Secret History*; Herken, *The Winning Weapon;* Kaplan, *The Wizards of Armageddon;* Richard Rhodes, *Arsenals of Folly: The Making of the Nuclear Arms Race* (New York: Vintage, 2007); and Richard Rhodes, *The Making of the Atomic Bomb* (New York: Simon and Schuster, 1986). An account of von Neumann's life can be found in Macrae, *John von Neumann*.

Teller and von Neumann addressed a SAB meeting at Maxwell Air Force Base in Alabama. Among those at the meeting was an air force colonel who was just a few weeks away from promotion to brigadier general, Bernard A. Schriever. Although Schriever was at the meeting to talk about a proposed bomber aircraft, he was intrigued by comments from the two scientists to the effect that a thermonuclear bomb that weighed less than a ton and could explode with the force of one megaton of TNT, seventy times the force of the Hiroshima bomb and fifty times the power of the fission warhead originally envisioned for Atlas, would be possible by 1960. Understanding that such a weapon would be a good fit for an ICBM, Schriever went to Princeton in May to obtain confirmation of this idea from von Neumann. Soon Schriever informed the new assistant to the secretary of the air force for research and development, Trevor Gardner, and twelve days after Schriever had gone to Princeton, Gardner himself made the trip to hear from von Neumann about the future of thermonuclear weapons. Gardner likely needed little encouragement from von Neumann since he had already publicly called for a more aggressive ballistic missile program. But Gardner and Schriever sought further confirmation from the SAB, which had formed a nuclear weapons panel headed by von Neumann. The panel met between June and October 1953, and in a report to the USAF Chief of Staff in October it backed up von Neumann's prediction of a lightweight thermonuclear bomb and called for a loosening of Atlas' accuracy requirements.[368] Von Neumann played a crucial role as a scientific expert in turning the air force and the U.S.

---

[368] Sheehan, *A Fiery Peace in a Cold War,* 178-200. Gardner warned of possible Soviet ballistic missiles in a March 1953 article in *Air Force* magazine. John C. Lonnquest, and David F. Winkler. *To Defend and Deter: The Legacy of the United States Cold War Missile Program* (Rock Island, Ill.: Department of Defense Legacy Resource Management Program, Cold War Project, Defence Publishing Service, 1996) 33-4; Lonnquest, "The Face of Atlas," 60, 78-83; J. Neufeld, *Ballistic Missiles in the USAF,* 98. Interview of Gen. Bernard Schriever by Martin Collins, 5 September 1990, RAND History Project, National Air and Space Museum, Smithsonian Institution, Washington, D.C.

government in favour of ICBMs and in making Atlas a viable weapons program with a top priority.

Committee Reports

Von Neumann's revelations to Gardner and Schriever were instrumental in his being named to chair the Strategic Missiles Evaluation Committee, which also became known as the Von Neumann Committee, and more popularly as the Tea Pot Committee, after its code name.[369] Committee member Pat Hyland later recalled that the committee split into three subcommittees, with one headed by Clark Millikan reporting on Snark, a second headed by Hyland reporting on Navaho, and the third headed by von Neumann himself that reported on Atlas. After Hyland and Millikan reported on Navaho and Snark to a meeting of the committee, Hyland recalled that von Neumann summed up in a "masterly fashion" and persuaded the committee that the Atlas was likely to have the greatest success.[370] The committee's report went to Gardner on 10 February 1954. While the report said, "available intelligence data are insufficient to make possible a positive estimate of the progress being made by the Soviets in the development of intercontinental ballistic missiles," it added that evidence exists showing Soviet "appreciation" of these missiles and "activity" in the field. The committee report claimed that a Soviet lead in ICBMs "certainly cannot be ruled out." Based on von Neumann's strong beliefs about the danger presented by the Soviet Union, the report's original draft had contained stronger language about Soviet missiles. But faced with what Schriever's biographer Neil Sheehan called "sparse and inconclusive" information, the committee insisted on the compromise language quoted above. Von Neumann added a personal statement warning of his "grave

---

[369] Sheehan, in *A Fiery Peace in a Cold War,* provides an excellent account of the Tea Pot Committee, including how the code name Tea Pot was selected to help conceal the committee's purpose on 211.
[370] Hyland, *Call Me Pat,* 336-43.

concern" about a Soviet lead in this field. The concerns about Soviet missiles were the main justification given in the report to go ahead with Atlas and continue the other missiles.[371]

The report highlighted recent major increases in the explosive power of nuclear weapons arising from new developments in the field of thermonuclear weapons, which meant that the degree of accuracy required of such missiles was no longer as great as it once was. Improved weapons meant that an ICBM might have to carry a warhead that weighed only 1,500 pounds, and that the accuracy requirement could be relaxed from a 1,500-foot accuracy requirement for "at least two, and probably three, nautical miles." While the Tea Pot Committee complimented Convair for its work on Atlas, it called for a "radical reorganization" of the ICBM organization "transcending the Convair framework" to create an ICBM in the near future. This new "development-management agency" for Atlas could set up a new development program within a year, leading to an "operational capability" within six to eight years. It also reckoned that the Snark missile should be continued as a "simplified" program and that Navaho should be continued with emphasis on further development of its rocket engine, which would be useful for both the Navaho and an eventual ICBM. The Tea Pot Committee's report is widely seen by historians as the true beginning of the Atlas program, and indeed of the United States ICBM program. "What [Gardner] had essentially wanted was validation by these eminent

---

[371] "The Tea Pot Committee Report," including correspondence, Appendix 1 of J. Neufeld, 249-265; Sheehan, 217-20. In his memoir, Ramo highlighted 1953 intelligence findings that showed that the Soviets were well along developing their own ICBM, but the evidence that will be discussed later in this chapter does not support his account. Ramo did say that the ICBM presented major technical challenges, including rocket engines, guidance and re-entry problems. Simon Ramo, *The Business of Science: Winning and Losing in the High-Tech Age* (New York: Hill and Wang, 1988) 78-89.

scientists that an ICBM was technically feasible," Sheehan explained. "He got this and he got a great deal more."[372]

A RAND report written by physicist Bruno W. Augenstein and published on 8 February, two days before the Tea Pot Committee report, reached similar technical conclusions. Indeed, Augenstein had completed work on the report in November 1953 and had briefed top air force officers and the Tea Pot Committee on his findings in December. His report called for relaxation of "very severe performance specifications," including a reduction in warhead weight from 3,000 pounds to 1,500 pounds, and a decrease in required accuracy from 1,500 feet to 3,000 feet, both changes due to breakthroughs in thermonuclear weapon technology. If the ICBM program could get increased funding and a higher priority, he predicted that "an operational missile system of great value should be attainable before 1960," five years earlier than projected under the then existing plan. Augenstein noted that the warhead advances meant that the missile size could be reduced by forty per cent, and that the severe technical challenges of designing a re-entry body would therefore be reduced. He also wrote about preserving a retaliatory force of missiles after an adversary's first strike through dispersion and hardening of launch sites. The report also contained lengthy discussions of possible guidance systems, and re-entry vehicles. "The most important conclusion we have reached is that no technical obstacle is now foreseen which might prevent successful development of a long-range ballistic missile," Augenstein stated.[373]

---

[372] "The Tea Pot Committee Report,"*ibid*; Sheehan, *A Fiery Peace in a Cold War,* 214-20.
[373] B.W. Augenstein, *A Revised Development Program for Ballistic Missiles of Intercontinental Range*, Special Memorandum No. 21 (Santa Monica CA: U.S. Air Force Project RAND, 8 February 1954); Kaplan, *The Wizards of Armageddon,* 112-7; Augenstein interview by Collins and Tatarewicz.

A few days after he received the reports from the Tea Pot Committee and RAND, Trevor Gardner drew up a plan to accelerate of the Atlas program. Gardner's plan envisioned spending $1.5 billion over the next five years through 1959. In March, Gardner won endorsement of his plan from the air force's top commanders, who were spurred in part by concern that the air force could lose ICBMs to the army if they resisted Gardner's plan. On 19 March 1954, Air Force Secretary Talbott directed Air Force Chief of Staff Gen. Nathan F. Twining to proceed with Gardner's plan to build Atlas. The USAF had signed on to building America's first ICBM.[374]

Thermonuclear Breakthrough

The first proof of Teller and von Neumann's prediction that a smaller thermonuclear bomb was possible quickly came in a series of test explosions in the Pacific known as the Castle tests, which included the first explosion of a thermonuclear bomb that was significantly lighter the original thermonuclear bomb used in the Mike test because its solid fuel did not require the heavy equipment needed to lower the liquid thermonuclear fuel to cryogenic temperatures. The first explosion of a solid-fueled thermonuclear bomb in the Castle Bravo shot on 1 March 1954 was nearly three times more powerful than predicted, and became notorious because it contaminated a Japanese fishing boat and its crew. Along with further tests that went into May 1954, the Castle tests more than proved the design needed for lightweight thermonuclear bombs and with it the feasibility of nuclear-armed intercontinental ballistic missiles.[375]

---

[374] J. Neufeld, *Ballistic Missiles in the USAF,* 97, 104-110; Lonnquest, "The Face of Atlas," 101-4.
[375] Rhodes, *Dark Sun,* 541-3; Hansen, *US Nuclear Weapons: The Secret History,* 64-8; Sheehan, *A Fiery Peace in a Cold War,* 216-7; Kaplan, *The Wizards of Armageddon,* 112-7; Davies and Harris, *RAND's Role,* 46.

Air force generals Donald Putt and Bernard Schriever credited the new thermonuclear weapons with making ICBMs possible when they spoke to congress in 1956 – before the post-Sputnik controversy over ICBMs erupted – and after. In his 1956 testimony to a Senate subcommittee, Putt said that when the air force's ICBM work resumed in 1951, questions about the weight, size and relatively small power of nuclear warheads at the time stood in the way of rapid ICBM development.[376] Schriever told the same hearings that the creation of thermonuclear weapons opened the door for ICBMs in what he called the "thermonuclear breakthrough." He testified that the limited explosive power of early nuclear weapons did not suggest that an ICBM would be "a particularly useful military weapon" because it would require highly accurate guidance systems that were not available at the time and an extremely large missile. He repeated the statements in post-Sputnik testimony, estimating that a missile in 1951 would have to weigh a million pounds and have seven engines compared to the three engines and weight of a quarter of a million pounds in Atlas as flown. The arrival of lightweight thermonuclear weapons, he said, made ICBMs feasible from the viewpoints of both technology and cost.[377]

The strong evidence tying the air force's decision to move on ICBMs to the arrival of lightweight thermonuclear weapons in the early 1950s was cited by the first

---

[376] Gen. Putt testimony, 18 May 1956, United States Senate Subcommittee on the Air Force of the Committee on Armed Services, *Hearings: Study of Airpower*, 2nd Session, 84th Congress, 1956, 644.

[377] Maj. Gen. Bernard Schriever, testimony, 20 June 1956, Senate Subcommittee on the Air Force of the Committee on Armed Services, *Hearings: Study of Airpower*, 84th Congress, 2nd Session, 1956, 1156; Gen. Bernard Schriever, testimony, 21 February 1958, House of Representatives, Committee on Armed Services, *Investigation of National Defense Missiles,* 2nd Session, 85th Congress (Washington D.C.: U.S. Government Printing Office, 1958) 4852; Gen. Bernard Schriever, testimony, 4 February 1959, House of Representatives, Subcommittee of the Committee on Government Operations, *Organization and Management of Missile Programs*, 1st Session, 86th Congress (Washington, D.C.: U.S. Government Printing Office, 1959) 10. Schriever's article in Lt. Col. Kenneth F. Gantz, *The United States Air Force Report on the Ballistic Missile: Its Technology, Logistics and Technology* (Garden City: Doubleday & Company, Inc., 1958) also credits the "thermonuclear breakthrough" and the Tea Pot Committee with opening the door for ICBMs. Gantz, *USAF Report on Ballistic Missiles,* 27.

historians to write about the issue, the three authors of the official 1966 National Aeronautics and Space Administration history of Project Mercury, which used Atlas to loft the first American astronauts into Earth orbit.[378] But a decade later, Edmund Beard called this a "false issue" in *Developing the ICBM,* asserting that as early as 1948, lightweight atomic weapons appeared to be feasible because of modest increases in the power of fission weapons. Part of Beard's argument was that the success of thermonuclear bombs was almost assured when Truman decided to proceed with them in January 1950, and one of his major sources was Truman's memoirs, not the most reliable authority on the history of nuclear weapons. In fact, the most crucial theoretical breakthrough for thermonuclear weapons, the Teller-Ulam staged explosion concept, was not postulated until early 1951, long before it was tested. As part of Beard's argument that fission weapons were increasing rapidly in availability and falling in weight after the 1948 Sandstone fission bomb tests, he again quoted Truman as his authority that tactical nuclear weapons were ready as early as 1950, which wasn't the case. The biggest weakness in Beard's argument was his avoidance of the issue of the vastly greater power of thermonuclear weapons over fission weapons, which led to the loosening of accuracy requirements for ICBMs. Even the creation of lightweight thermonuclear weapons, Beard argued, "did not eliminate Air Staff resistance to ICBMs, but simply caused a retreat to other arguments."[379]

To many people, the thermonuclear bomb appears to be just a more powerful version of the fission bombs used in Japan in 1945. The thermonuclear bomb's far greater power and lighter weight, however, make it a distinct weapon from the fission bomb. To

---

[378] Loyd S. Swenson Jr., James M. Grimwood and Charles C. Alexander, *This New Ocean: A History of Project Mercury* (Washington D.C.: National Aeronautics and Space Administration, 1966) 23-6.
[379] Beard, *Developing the ICBM,* 124-8, 140-4; Rhodes, *Dark Sun,* 461-72.

describe the difference between the fission and thermonuclear bombs, McGeorge Bundy, who served as National Security Advisor to presidents Kennedy and Johnson and was therefore an expert himself, quoted the words of Winston Churchill from 1955: “There is an immense gulf between the atomic and the hydrogen bomb. The atomic bomb, with all its terrors, did not carry us outside the scope of human control or manageable events in thought or action, in peace or war.” But with the arrival of the thermonuclear bomb, he argued that “the entire foundation of human affairs was revolutionized, and mankind placed in a situation both measureless and laden with doom.”[380] Thomas Hughes has described inventions that lead to new technological systems as radical inventions. Inventions occurring during the later competition and systems growth phases of evolving technological systems are**,** in Hughes’ terms, conservative in that they help solve problems within a developing system. The thermonuclear bomb helped give birth to a new and arguably revolutionary invention, the intercontinental ballistic missile. The thermonuclear bomb arrived at such an early point in the development of nuclear-armed strategic forces that it decisively shaped them by making possible the ICBM and later the submarine-launched ballistic missile and even multiple warheads on strategic missiles, which first appeared in the late1960s, which along with bomber aircraft remain central features of strategic nuclear forces to the present day. In the view of the present author, the thermonuclear bomb qualifies as a revolutionary invention by Hughes’ definition. Strategic missiles, including ICBMs and submarine-launched ballistic missiles, together with bomber aircraft, were all armed with thermonuclear bombs and came under the

[380] Churchill’s speech to Parliament on 1 March 1955 was quoted in Bundy, *Danger and Survival,* 198.

command of the president, forming America's strategic deterrent, meeting Hughes' definition of a technological system.[381]

Re-entry Heating

Another of the more persistent technical problems standing in the way of an ICBM was the intense heating that the warhead would undergo as it re-entered the Earth's atmosphere on its way to the target, a problem that was mentioned several times in this study. Tests by National Advisory Committee for Aeronautics engineers on streamlined cone-shaped warheads showed that instead of cutting through the atmosphere and reducing heat inside the warhead, as some computer projections had suggested, the cones absorbed heat and melted under the strain. Test flights and wind tunnel measurements showed that so much heat would build up in cone-shaped ICBM warheads at the planned speeds that they would be destroyed by heating, and there was no known way to protect them. Early in the 1950s, the term "thermal barrier" had entered the lexicon of engineers working on ballistic missiles.[382]

A way to solve the problem was finally found in the summer of 1952 with a counter-intuitive idea by a rumpled, heavy-set aeronautical engineer at the National Advisory Committee for Aeronautics' (NACA) Ames Aeronautical Laboratory in the San Francisco Bay area not far from Stanford University. Harry Julian Allen, who signed his name H. Julian Allen but was known as "Harvey" by his friends, had developed a means of testing the behavior of bodies at up to fifteen times the speed of sound inside supersonic wind tunnels. "Half the heat generated by friction was going into the missiles. I reasoned that we had to deflect the heat into the air and let it dissipate," Allen recalled.

[381] Hughes, "The Evolution of Large Technological Systems." 51-8.
[382] Swenson, et al., *This New Ocean,* 59-61; T.A. Heppenheimer, *Facing the Heat Barrier,* 23-53.

The means he found to deflect the heat was the blunt body, which when it struck the atmosphere, would create a shock wave that would absorb and carry away much of the heat it generated in front of the blunt body. Allen briefed people involved in the ICBM program that September, and the following April, he and Alfred J. Eggers, also of Ames, authored a paper that remained classified for six years. Allen's and Eggers' findings were incorporated into Augenstein's RAND report on Atlas discussed above. Hugh Dryden, who by then was the director of the NACA, said later that Allen's idea met resistance in the early months after his discovery. While the concept pointed the way to new re-entry vehicles, complex design work and testing with new equipment and rocket-launched re-entry vehicles through the 1950s was still required to enable the engineers to decide what shapes and what kind of materials were best to shield the warheads. When Allen's discovery was revealed to the public in 1957, Dryden argued that along with the creation of the lightweight thermonuclear bomb, Allen's discovery converted the ballistic missile from "a practical impossibility to a virtual certainty." Despite the importance of this discovery, and the fact that reentry heating had been raised on several occasions as a critical problem, Allen's discovery has not received anywhere near the same amount of credit from experts or historians as the creation of lightweight thermonuclear bombs for changing decision-makers' minds in favour of ICBMs.[383]

Wings had been part of nearly all concepts in the late 1940s for long-range ballistic missiles and even human spacecraft. But Allen's discovery had the effect of removing wings from designs for ICBMs and most early human spacecraft. Although

---

[383] Swenson et al., *This New Ocean,* 59-63; Augenstein, *A Revised Development Program*, 21-31; Lonnquest and Winkler, *To Defend and Deter,* 32-3; John W. Finney, "Blunt-Nosed Concept in Ballistic Missile Hailed as Success," *The New York Times,* 18 May 1957, 2. See Hughes, *Rescuing Prometheus,* 126-31 and Miller, *The X-Planes,* 212-7, for discussions of warhead testing work after 1955.

Allen's work with blunt bodies played an important role in knocking down an important technical obstacle to ICBMs, he and the NACA received very little credit in historical treatments of Atlas, outside of NASA histories and Thomas Hughes' account of Atlas in 1998 in *Rescuing Prometheus*, in part because of Edmund Beard's focus on the political changes of 1953 as the cause of the acceleration of the ICBM program. Although the secrecy on the NACA work on blunt bodies was lifted in 1957, people involved in the Atlas program and historians have not given this discovery sufficient credit for making ICBMs possible.[384]

No similar kind of breakthrough was made in missile guidance systems in the early 1950s, although the Tea Pot Committee's easing of accuracy requirements made this problem a smaller one. At the time, many people involved in the ICBM decision-making process supported radio guidance, where radio beams from the missile to ground stations are used to determine the missile's position, speed and direction. Sociologist Donald MacKenzie wrote that in 1953 and 1954 that inertial guidance systems, where a computer uses inputs from motion sensors and orientation sensors to determine the missile's position, speed and direction, were still in a "very early phase" of development. Atlas D, the first operational version of Atlas, was equipped to use the Azusa radio guidance system, and even though it performed well within specifications for accuracy, inertial guidance gained favour for use in the Atlas E and F models and later missiles

[384] Swenson et al., *This New Ocean,* includes an extensive discussion of the development of shapes and materials for ICBM warheads and especially early spacecraft, 59-74, and so does Heppenheimer in *Facing the Heat Barrier.* Beard, *Developing the ICBM,* and Sheehan, *A fiery Peace in a Cold War,* do not mention Allen, and J. Neufeld, *Ballistic Missiles in the USAF,* mentions his work in a note on 79. Hughes' discussion of warhead design development in *Rescuing Prometheus* can be found on 126-31.

such as the Minuteman ICBM, after it was used in the Thor intermediate-range ballistic missile.[385]

Soviet Missiles and Bombers

So far, this study has not addressed the Soviet missile program, not even as something that sparked American work on the ICBM before the Tea Pot Committee report in 1954. One reason is that American officials knew very little about the Soviet missile program until well into the 1950s, after the period covered in this study. Aside from the few and insignificant pieces of intelligence about missiles that crossed the iron curtain before 1954, and the fears they generated among American policymakers and others such as von Neumann, the Soviet missile program was not an important factor in the evolution of the American ICBMs until the time of the Tea Pot Committee. Yet the outcome of the first Soviet ICBM program has coloured historical verdicts on the ICBM developments in the United States. Until the final days of the Soviet Union in the late 1980s, American intelligence and military officials knew little about the evolution of the Soviet ICBM program, particularly during the time period covered by this dissertation. Popular accounts and Edmund Beard's influential work had described Soviet rocket efforts as a coherent program with the aim of developing an ICBM that started in 1946, eight years ahead of the United States.[386] The revised account of the development of Soviet ICBMs, as it began to emerge in the 1990s, is surprisingly similar to the evolution of long-range missiles in the United States. To provide some perspective on events in the United States, a discussion of the Soviet nuclear bomb, missile and bomber programs will follow, along with an examination of American intelligence on these programs.

---

385 Donald MacKenzie, *Inventing Accuracy,* 113-23.
386 Beard, *Developing the ICBM,* 12, 218. See also Bulkeley, *The Sputniks Crisis,* 60-1.

The Soviet Union had begun work on the atomic bomb and long-range bomber aircraft before World War II ended. Assisted by spies in the United States, Canada, the United Kingdom and elsewhere, the Soviets were able to keep track of developments in nuclear physics and in the Manhattan Project that produced the first atomic bombs for the United States. But Truman's disclosure to Soviet dictator Josef Stalin at Potsdam in July 1945 of American possession of the atomic bomb, and the subsequent bombing of Hiroshima and Nagasaki, drove home to Stalin the power and importance of this new weapon, and it was only then that Stalin ordered his team of nuclear physicists headed by Igor V. Kurchatov to accelerate their work on developing nuclear weapons. This work bore fruit in August 1949 when the first Soviet nuclear weapon was exploded.

Rocket and space travel enthusiasts in the Soviet Union began developing rockets and rocket engines starting in the late 1920s, and their activities came under the control of the Soviet military in 1933. Their experimental work on rockets was strongly affected by Stalin's Great Terror of 1937 and 1938, which decimated the ranks of the Soviet military and the Communist Party. Marshal Mikhail N. Tukhachevsky who was in charge of military armament programs, including rockets, was arrested in June 1937 and executed. The arrests also swept up many leading aircraft designers such as Andrei N. Tupolev and rocket engineers, most famously Sergei P. Korolev. While both men survived the terror and the war, many of their colleagues were executed or died of starvation, disease or overwork in the prison camps of the gulag. When war clouds gathered in 1939, Tupolev, Korolev and many of the surviving skilled prisoners, were put to work in prison-based design bureaus, where they spent most of the war. The Soviet Air Force required fighter aircraft to stave off the Luftwaffe more than it needed bombers, so designs for Soviet bomber aircraft languished during the war. The solid fuel Katyusha artillery rockets were the only rockets used by Soviet forces during the war.[387]

Late in the war Korolev, and Valentin P. Glushko, Russia's top rocket engine designer who had also been arrested, were allowed to shift from aircraft to rocket design, and in 1944 they were freed while they continued their work. In July 1944, British Prime Minister Churchill wrote Stalin asking for help locating parts from a German V-2 ballistic missile that had crashed in Poland shortly before the Red Army overran the area. Stalin let British and American experts inspect the area, but only after his own forces had scoured it for V-2 parts. The Americans repaid the compliment a year later when they surrendered the main V-2 production plant at Nordhausen to Russian forces as called for in allied agreements, but only after removing V-2 rockets, plans and parts. In 1945, the Red Army also occupied the former headquarters of the German rocket program in Peenemünde. And although many German rocket engineers, including their leaders, chose to surrender to American forces, others agreed to work with the Soviets. The Soviets set up an operation in Germany to work with German experts to exploit rocket and other technologies, including nuclear technology and aircraft engines. The leading rocket engineer who joined the Soviets was Helmut Gröttrup, who was responsible for the V-2's guidance, control and telemetry. Russian engineers, including Korolev and Glushko, came to Germany to help exploit rocket technology, and during this time, Korolev's talents as a rocket engineer and manager became known. [388]

---

[387] Zaloga, *Target America,* 64-7, 111-2; Asif Siddiqi, *The Red Rockets' Glare: Spaceflight and the Soviet Imagination, 1857-1957* (Cambridge: Cambridge University Press, 2010) 114-95. For more on Korolev, see Siddiqi, *Challenge to Apollo,* and James Harford, *Korolev: How One Man Masterminded the Soviet Drive to Beat America to the Moon* (New York: John Wiley & Sons, Inc. 1997).
[388] Asif Siddiqi, "Germans in Russia: Cold War, Technology Transfer, and National Identity," in Carol E. Harrison and Ann Johnson, eds., *National Identity: The Role of Science and Technology.* Osiris 2009: 24.

The Soviets invited German experts in various fields to parties on 21 October 1946 that went well into the night. At 4:00 a.m. the next morning, more than 2,552 German experts, including 302 involved in missiles, were ordered onto trains that carried them and their families to Russia. Although German rocket experts continued to work alongside Russians in the months that followed and played a key role in launching V-2s in October 1947 at the new Soviet launch site at Kapustin Yar, near Stalingrad, increasingly the Germans were made to work separately from Soviet engineers, and in 1948 the entire German rocket group was moved to an isolated location 300 km from Moscow. As the Germans' separation from the Russians and from outside information on scientific advances continued, their value to the Soviet program fell. All but a handful of the Germans were returned to East Germany by the end of 1953, and American intelligence officials quickly interviewed them. Because they had been separated by then from the Soviet missile program for five years or more, the information they had for the Americans was of little value.[389]

In 1945 Stalin read a report written for the German military on a rocket-powered long-range antipodal bomber by Austrian rocket engineer Eugen Sänger and his mathematician wife Irene Bredt. This prompted Stalin to commission the air force to work on a Soviet antipodal bomber. A scheme in 1948 to kidnap Sänger from his postwar home in France failed when Grigory Tokady-Tokayev, the air force officer sent to carry out the task, defected to the west. By then, the plans for the bomber were foundering over the great difficulties involved building such a craft, and Tokady-Tokayev's value to the

(Chicago: History of Science Society) 120-43; Zaloga, *Target America,*113-21; Siddqi, *The Red Rockets' Glare,* 196-240.

[389] Siddiqi, "Germans in Russia." Zaloga, *Target America,* 113-21.

west was limited because he was not involved in the missile program, which was controlled by the army.[390]

Stalin signed a ministerial decree on 13 May 1946 establishing a high-level committee to oversee missile programs similar to a structure used for the nuclear weapons program. In his 2010 account of Soviet missile and space programs, historian Asif Siddiqi argued that missile programs were far less important to Stalin and the top Soviet leadership than nuclear weapons and bomber aircraft. While Stalin met several times during these years with leading aviation designers like Tupolev and leaders of the nuclear weapons program like Kurchatov, Stalin met only once with Korolev, and Siddiqi noted that the high-level missiles committee was dissolved in 1949. Unlike the United States but like Germany, ballistic missiles in the Soviet Union were put under the jurisdiction of the Red Army's Main Artillery Directorate, because the army, which had enjoyed success with Katyusha rockets during the war, expressed a greater interest than the air force did in ballistic missiles. The main missile design bureaus were put under the Ministry of Armaments, which was also separate from the aviation industry. With the support of a powerful patron, Minister of Armaments Dmitri F. Ustinov, Korolev was put in charge of his own design bureau in the northern suburbs of Moscow.[391]

Korolev met Stalin for the only time in April 1947, and during the meeting, Stalin questioned Korolev about the relative merits of rockets and bomber aircraft. Stalin had set Tupolev to work in 1943 on designing a bomber aircraft after the Americans rejected requests to send the Soviets bomber aircraft through the Lend-Lease program that the

[390] Zaloga, *Target America,* 121-4.
[391] The 13 May decree is reproduced in Boris Chertok, *Rockets and People: Creating a Rocket Industry, Volume 2* (Washington D.C.: National Aeronautics and Space Administration, 2006) 10-5; Siddiqi, *Challenge to Apollo,* 25, 33-40; Siddiqi, *The Red Rockets' Glare,* 222-3, 232-40, 245-7; Zaloga, *Target America,* 115-8.

United States had set up to supply badly needed arms and equipment to wartime allies such as Britain and the Soviet Union. Stalin had hoped to get America's most advanced bomber, the Boeing B-29 Superfortress. In the last half of 1944, three B-29s made emergency landings in the Soviet Union after bombing raids on Japanese territory, and a fourth crashed in Soviet territory. Stalin refused to return the B-29s and ordered Tupolev to create a Soviet replica of the aircraft, which was far more advanced than any Soviet aircraft at the time. Stalin's orders were so strictly enforced by his notorious secret police chief Lavrenti Beria that Tupolev was only half joking when he asked if the replica, known as the Tu-4, should have Soviet rather than American markings.[392]

Like the B-29, the early Tu-4s had development problems, and the Tu-4 did not enter service until 1949. The Tu-4's limited range allowed it to reach only the western U.S. on a one-way flight from the Soviet Union, and only after passing over Alaska and Canada. Unhappy with the state of Soviet jet technology in 1951, Tupolev refused to attempt to build a jet bomber with the required range to attack the United States. Stalin gave the job to the design bureau of Vladimir M. Myasischev and provided Myasischev with lavish resources to do the job. Myasischev's long-range jet bomber still fell short of the range requirements for round-trip flights to the American mainland, and it was only built in limited numbers. Tupolev's bureau began work in 1950 on a long-range bomber with turboprop engines, the Tu-95, known in the west as the Bear. The aircraft first flew in 1952 and entered service four years later. Despite its limitations, it remains the

[392] Zaloga, *Target America,* 63-79; Steven J. Zaloga, *The Kremlin's Nuclear Sword: The Rise and Fall of Russia's Strategic Nuclear Forces, 1945-2000* (Washington, D.C.: Smithsonian Institution Press, 2002) 12-6, 35-9; Siddqi, *Challenge to Apollo*, 60-1. Many accounts, including Holloway, *Stalin and the Bomb,* 247, have stated that the Soviet ICBM program began at the April 1947 meeting, based mainly on the post-Sputnik writings of Tokaty-Tokaev, who had little direct knowledge of the Soviet missile program. Siddiqi's description of the meeting in *Challenge to Apollo* is based on Korolev's own accounts.

mainstay of the Russian long-range bomber force to the present day. Steven Zaloga, an authority on Russian forces, argued that American intelligence exaggerated the threat from Soviet bombers, creating the “bomber gap” controversy in U.S. politics in 1955 and sparking massive American spending on anti-aircraft missiles and radars in Canada, Alaska, Greenland and the northern states to defend against Soviet bombers. Only when the U-2 reconnaissance aircraft began overflying the Soviet Union in 1956 did American leaders learn the true dimensions of the Soviet bomber threat.[393]

In the late 1940s, Korolev and his team worked mainly on developing Soviet rockets to match the German V-2 ballistic missile. After replicating the V-2 with the R-1 rocket, Korolev’s design bureau proceeded in 1948 with the R-2 rocket, an uprated version of the R-1 with a range of 600 km, and then with three new rockets – a tactical missile known as the R-11 to replace the R-2 with easier to handle fuels, and two medium range missiles to strike targets in Europe and Japan, including forward deployed American forces, the R-3 with a range of 3,000 km and the R-5 with a range of 1,200 km. The R-11 tactical missile gained fame later as the Scud missile that was adopted by other countries, most famously Iraq during the first Gulf War in 1991. Korolev’s design and technical studies in 1951 and 1952 for the R-3, whose range was still far short of an ICBM but promised a major increase in range over the R-2, also looked at the technologies that would be needed for missiles of an intercontinental range. The R-3

---

[393] Zaloga, *Target America,* 79-88; Holloway, 227-45; Siddiqi, *The Red Rockets’ Glare,* 271-2, Kaplan in *The Wizards of Armageddon* discusses the origins of the ‘bomber gap’ in the United States in some detail, including its relationship to the ‘missile gap’ controversy that followed, 155-73. See also Werrell, *Death From the Heavens,* 176-9, 213; Leighton, *Strategy, Money and the New Look,* 379-88; and Clayton K.S. Chun, “Winged Interceptor Politics and Strategy in the Development of the Bomarc Missile,” *Air Power History,* Winter 1998, 44-59.

quickly ran into problems that slowed the program as rocket engine designers struggled to overcome problems with the new engines that would be needed for the missile.[394]

Tu-95 bomber (below) tracked by an F-15 (USAF)

Korolev’s team and a group of mathematicians under the tutelage of Mstislav Keldysh, one of the top Soviet scientists of the time, were also beginning studies of more advanced missiles, including ballistic missiles and winged missiles. Because Korolev had worked with aircraft in the 1920s before turning to rockets, he was alive to the possibilities of winged missiles, and his team designed a rocket-ramjet missile similar to the USAF Navaho missile. In 1953 Korolev shifted the winged missile work to two other design bureaus in the aviation industry so that he could concentrate on ballistic missiles. Boris Chertok, one of Korolev’s top managers, wrote that Korolev’s affiliation with the Ministry of Armaments dictated that he give preference to ballistic missiles over winged missiles, which would fall under the separate aircraft industry. Both cruise missile

[394] Zaloga, *Target America*, 125-32; Siddqi, *Challenge to Apollo*, 61, 71-88; Siddiqi, *The Red Rockets’ Glare,* 248-60.

projects continued, until one was cancelled in 1957 and the other in 1960, when ballistic missiles had carried the day and the Navaho had met the same fate.[395]

As mentioned, Stalin gave little attention in his final years to the development of missiles and instead focused on nuclear weapons and bomber aircraft. The relative priorities can be shown by the fact that nuclear weapons got roughly 14.5 billion rubles, nearly seven times as much money as missiles did during the 1947 to 1949 time period. The final months before Stalin died in March 1953 saw him reduce his day-to-day supervision of military programs, and ushered in a lengthy period of often haphazard change in the institutions and managers that controlled long-range missile programs, reflecting the many changes in the Soviet leadership from Stalin's death until Nikita Khrushchev consolidated power in 1957. Stalin's death and the political changes it brought made 1953 a key year for Soviet missiles just as the new administration in Washington that year played a role in bringing America's ICBM program to the fore. The Soviets exploded a low-power thermonuclear bomb in August 1953, and while the bomb was less advanced than American thermonuclear bombs of the time, this test opened the eyes of the Soviet leadership to the potential of thermonuclear bombs.[396]

Andrei Sakharov, the brilliant Soviet physicist who later became known as the father of the Soviet thermonuclear bomb and still later became a champion for human rights, was asked to give a report that fall to a meeting of the Soviet Politburo estimating the weight of upcoming thermonuclear bombs, which the Soviet leadership wanted to mount on an ICBM being proposed by Korolev. Sakharov wrote his report based on a

---

395 Zaloga, *Target America,* 132-4, 143-5; Zaloga, *The Kremlin's Nuclear Sword,* 42-5; Siddiqi, *Challenge to Apollo*, 125-8; Chertok, *Rockets and People,* vol. 2, 231-2; Siddiqi, *The Red Rockets' Glare,* 248-60, 274-8.

396 Siddiqi, *The Red Rockets' Glare*, 244-8, 264-70; Siddiqi, *Challenge to Apollo, 97-109*. The first true Soviet thermonuclear bomb was exploded in November 1955.

promising but ultimately unsuccessful concept, and estimated that the thermonuclear bomb would weigh five or six tons. Before the Politburo got Sakharov's report, Korolev obtained the cancellation of the R-3 program so that he could concentrate work on a true intercontinental ballistic missile. Korolev's bureau was forced to scrap its plan for a three-ton warhead for their proposed ICBM and scale up the size and power to carry the heavier warhead at the same time as the U.S. Air Force was making the Atlas smaller to carry a warhead weighing less than a ton. Based on the proposal of Korolev and his design bureau, the Soviet Council of Ministers approved a decree giving Korolev the go-ahead to work on an ICBM that became known as the R-7. The R-7 won its formal approval on 20 May 1954, within a few weeks of the Atlas winning similar approval in the United States following the report of the Tea Pot Committee in February 1954.[397]

Especially as outlined in Asif Siddiqi's most recent and authoritative historical account, *The Red Rockets' Glare*, the Soviet path to approval of the R-7 ICBM between 1945 and 1954 turns out have been quite similar to the American path to approval of Atlas – official indifference to the idea until 1953, when the possibilities of the marriage of long-range missiles to thermonuclear bombs, which packed much greater power than fission bombs, were realized by military authorities. During the years between 1945 and 1954, engineers in both superpowers had seen how German rocket experts had advanced rocketry during World War II with the V-2 ballistic missile. Building on captured knowledge and captured parts, American and Soviet experts slowly made advances in the technology needed for ICBMs until the arrival of thermonuclear weapons around 1953

---

[397] Siddiqi, *The Red Rockets' Glare*, 270-8; Siddiqi, *Challenge to Apollo,* 128-9; Zaloga, *Target America,* 134-41; Zaloga, *The Kremlin's Nuclear Sword,* 42-6; Chertok, *Rockets and People,* vol. 2, 275-6, 289-90; Holloway, *Stalin and the Bomb,* 294-319; Andrei Sakharov, *Memoirs* (New York: Alfred A. Knopf, 1990) 180-1.

caused military and political leaders to give them the resources they needed to build the first ICBMs.

Intelligence on the Soviets

The Soviet Union concealed its missile programs behind a curtain of secrecy, aided by its nature as a closed society. The deep frustration felt by American policy makers, fed in part by their memories of Japan's surprise attack on Pearl Harbor in 1941, led to various attempts with spies, balloons and aircraft to learn what the Soviets were doing to develop missiles and other weapons. The U-2 reconnaissance aircraft and sophisticated signals intelligence programs began after the period covered in this study. Probably the most important reason why Americans had little sense of Soviet plans for ICBMs was simply that the first Soviet ICBM, the R-7, did not officially win authorization until 1954, at roughly the same time the Atlas got its own go-ahead in the United States. Before that time, work on the R-7 involved only a small group of engineers headed by Korolev.

What did the U.S. military know about Soviet missiles prior to 1954? Probably very little, according to the information available today. The first few years after World War II were a time of "disarray" for U.S. intelligence services, in historian Michael D. Gordin's recent account. Truman closed down the wartime Office of Strategic Services in September 1945, leaving intelligence in the hands of the individual armed services. In 1946, the Central Intelligence Group was set up, followed by the Central Intelligence Agency in 1947. But in its early years, the CIA was "understaffed, underfunded and a long way from its goal of synthesizing and correlating American intelligence."[398] There was very little of the intelligence infrastructure that we take for granted today. The

[398] Gordin, *Red Cloud at Dawn,* 82.

National Security Agency, which gathers electronic and signals intelligence, was not formed until 1952, for example. And the CIA's early attempts to recruit or deploy spies in the Soviet Union bore almost no fruit.[399]

Frustrated that so little was known about its Cold War adversary, the USAF flew aircraft along the boundaries of communist countries to test radars and other defenses. In the late 1940s, the CIA and the U.S. military launched high altitude balloons from Western Europe with cameras in hopes that they would drift over Soviet territory for recovery near Japan. The plan failed. In 1950, Truman and Joint Chiefs of Staff agreed to try more aggressive overflights of Soviet territory. Many flights returned information about military emplacements near Soviet borders, but much territory remained out of range, and several aircrews lost their lives. Aware of reports that the Soviets were launching missiles deep inside Russia at Kapustin Yar near Stalingrad, the Royal Air Force in cooperation with the CIA sent a specially equipped Canberra bomber over the area in 1953. The aircraft was nearly downed by Soviet anti-aircraft fire, and this near failure ended aerial reconnaissance in Soviet airspace until the U-2 started flying in 1956. In 1955, the United States set up long-range radars and electronic signals listening posts in Turkey to gather information from Soviet missile tests.[400]

President Truman had received a report in November 1949 from the CIA on Soviet flame and combustion research that could be applied to rocket and jet research, which found that Soviet capabilities in this area "are clearly of a high order." The CIA

---

[399] Gordin, *Red Cloud at Dawn,* 80-3. Bulkeley discusses American intelligence on Soviet rocket and space programs in *The Sputniks Crisis*, although many of his conclusions are outdated. See also William E., Burrows, *Deep Black: Space Espionage and National Security* (New York: Berkeley Books, 1988); G.A. Tokaty, "Soviet Rocket Technology," in Emme, *History of Rocket Technology,* 271-84; and Beard, *Developing the ICBM,* 163-4.

[400] Michael R. Beschloss, *Mayday: Eisenhower, Khrushchev and the U-2 Affair* (New York: Harper and Row, 1986) 77-9; Sheehan, *A Fiery Peace in a Cold War,* 215-7. The U-2 flights ended abruptly in May 1960 when a U-2 piloted by Francis Gary Powers was shot down by the Soviet military.

found that there was “substantial evidence” that this research was aimed at improving rocket and jet engines. These projects, the report said, could increase the effectiveness of both defensive and offensive capabilities for the Soviet military.[401]

A National Intelligence Estimate produced by the CIA in November 1950 on “Soviet Capabilities and Intentions” did not mention missiles. A special National Intelligence Estimate the following October on “Soviet Capabilities for a Military Attack on the United States before July 1952” stated that the Soviet Union probably possessed V-1-type winged missiles with a range of one hundred nautical miles that could be launched from ships or submarines. A later National Intelligence Estimate, in March 1957, on “Soviet Capabilities and Probable Program in the Guided Missiles Field” contained the following statement: “We have no direct evidence that the USSR is developing an ICBM, but we believe its development has probably been a goal of the Soviet missile program.” The document projected that the Soviet Union would have a 5,500-nautical-mile range ICBM ready for operational use by 1960 or 1961. The estimate also stated, accurately, that the Soviet Union could orbit an artificial satellite in 1957. Later in 1957 after the launch of Sputnik, Eisenhower began receiving intelligence estimates that exaggerated the Soviet ICBM capability until photos from the U-2 and the first successful U.S. military reconnaissance satellite in August 1960 showed the true state of the Soviet ICBM threat.[402]

---

[401] Central Intelligence Agency, Office of Scientific Intelligence, “Soviet Flame and Combustion Research and its Relation to Jet Propulsion (Including Rocket Propulsion)” 10 November 1949, PSF, Intelligence, Box 258, Folder O.S.I./S.R, HSTL.

[402] National Intelligence Estimates are contained in RG 363.5, Records of the Central Intelligence Agency, Textual Records (General), NA. “Soviet Capabilities and Intentions,” NIE-3, 11 November 1950, is contained in box 1, folder 1. “Soviet Capabilities for a Military Attack on the United States before July 1952,” SE-14, 23 October 1951, is in box 1, folder 20. “Soviet Capabilities and Probable Program in the Guided Missiles Field,” NIE-11-5-57, 12 March 1957, is contained in box 10, folder 4. This NIE superseded another NIE, dated 5 October 1954, which was not available, probably because it is still

Intelligence for the GMC

The lack of American intelligence on Soviet missile activity is clear in once-classified documents relating to the work of the U.S. Air Force and the Guided Missiles Committee. In August 1947, the GMC discussed foreign intelligence information on Russian guided missile test ranges. "It is evident that little or no direct knowledge of work being done at Russian guided missile test ranges can be obtained," the GMC was told in a report, which suggested that "proper evaluation of intelligence from widely separated fields, many apparently having nothing to do with guided missiles" may be needed to determine what the Russians were doing on their missile test ranges.[403]

USAF Maj. Gen. E. E. Partridge, describing secret testimony in 1947 to the Finletter Commission, wrote: "The USSR appears to be conducting intensive research to produce surface-to-air guided missiles patterned after German developments, and in some measure in assembling and reconstructing German missiles." He wrote that there is "no specific intelligence" that indicates Russia is developing a long-range surface-to-surface missile, but that "we can presume the Russians are working on a long range guided missile." Partridge suggested that Russian forces had made use of a larger number of German scientists than had American forces. Because of this, he wrote, Russia could be farther advanced in guided missiles than the U.S.[404] Industry witnesses to the commission expected that the Russians "had absorbed" German development techniques for missiles,

---

classified. See Peter J. Roman, *Eisenhower and the Missile Gap* (Ithaca: Cornell University Press, 1995) 30-62, for post-Sputnik U.S. intelligence on Soviet ICBMs.

[403] "Background Data on Questions Submitted in Enclosure A," attached to Karl F. Kellerman, Committee on Guided Missiles, to the Program Division, RDB, "Foreign Intelligence," undated but probably November 1947, in RG 156, Office of the Chief of Ordnance, Records Relating to the Army Guided Missiles Program, Box 12, file "GM 291/ Foreign Intelligence," NA. Emphasis in original.

[404] Maj. Gen. E.E. Partridge, acting deputy chief of staff, operations to Secretary of the Air Staff, "Data for the President's Air Policy Commission Concerning Guided Missiles," Routing and Record Sheet, 28 October 1947, attached to Self, *History of the Development of Guided Missiles*.

and their testimony suggested that the "Russians are probably further advanced than we are in these fields."[405]

On 20 May 1949, three months before the first Soviet nuclear test, a technical evaluation group submitted a report to the GMC, based on briefings from the Joint Chiefs of Staff, the three services, and the CIA. The report projected that if war came in the 1950s, it would be a conflict of "extended duration" in which the Soviet Union would have strategic bombers comparable to the B-29 and guided missiles similar to German V-2 and Wasserfall anti-aircraft missile by 1951-52. In fact, Soviet bombers and missiles with those capabilities were coming into service that year. Gordin, in his recent study of the effects of the first Soviet nuclear explosion in 1949, wrote of the dramatic growth of U.S. intelligence estimates of the size of the Soviet nuclear stockpile in the months following the August 1949 explosion, along with larger estimates of the Soviet ability to deliver nuclear weapons with bombers. In November 1950, CIA analysts predicted the Soviet Union would have 165 nuclear bombs by the middle of 1953. The actual number was probably less than fifty. These growing figures no doubt bolstered the arguments of those who wanted to proceed with an American ICBM.[406]

Late in 1950, Fred Darwin, the executive director of the GMC, expressed his frustration about the amount of information available on Soviet missiles and bombers, saying the GMC "is being handicapped by insufficient technical intelligence information." He added that this problem "is further aggravated by the cumbersome and time-consuming methods now in use for bringing such meager information as is

---

[405] Memorandum to Colonel Boatner and Captain Pihl, "Air Policy Commission," Memo No. 39, undated but probably October 1947, attached to Self, *History of the Development of Guided Missiles*.
[406] Technical Evaluation Group, Committee on Guided Missiles, RDB, "The National Guided Missiles Program," 20 May 1949, in RG 218, Records of the Joint Chiefs of Staff, Box 107, file "JCS 334 Guided Missiles Comm (116-45) Sec 2," NA; Gordin, *Red Cloud at Dawn,* 257-9.

available" to the GMC. "This situation has made it difficult to assess the United States program in relation to that of the Soviet Union and to insure that our program is properly focused," he added, complaining that some information was still being held from the committee, some of it from intelligence more than a year old.[407]

Both Jacob Neufeld's and Doris Krudener's official histories of air force missile programs reported that in late 1951 and early 1952, the air force had received intelligence reports suggesting that the Soviets had developed a rocket engine capable of generating 265,000 lbs of thrust, twice the power of any American engine, and that bigger engines were being developed. The reports in fact were incorrect, as the Russians were experiencing greater difficulty than the United States developing large rocket engines.[408]

In August 1952, the GMC met at the Air Technical Intelligence Centre in Dayton, Ohio, to discuss Russian missile programs. A presentation on propellant development noted that since the German technical personnel and facilities had been moved to the Soviet Union in 1946, large quantities of ethyl alcohol and hydrogen peroxide had been found at Khimki near Moscow, where rocket engines were indeed being developed, and that a liquid oxygen plant was under construction in the area. All these substances are useful as rocket fuels and oxidizers. Another paper stated that "100 V-2 power plants were manufactured at factory 456" between 1948 and 1950. A paper on guidance systems said "captured Russian electronic equipment shows a marked improvement via German influence." In a trip report, a member of the committee wrote that much more needed to

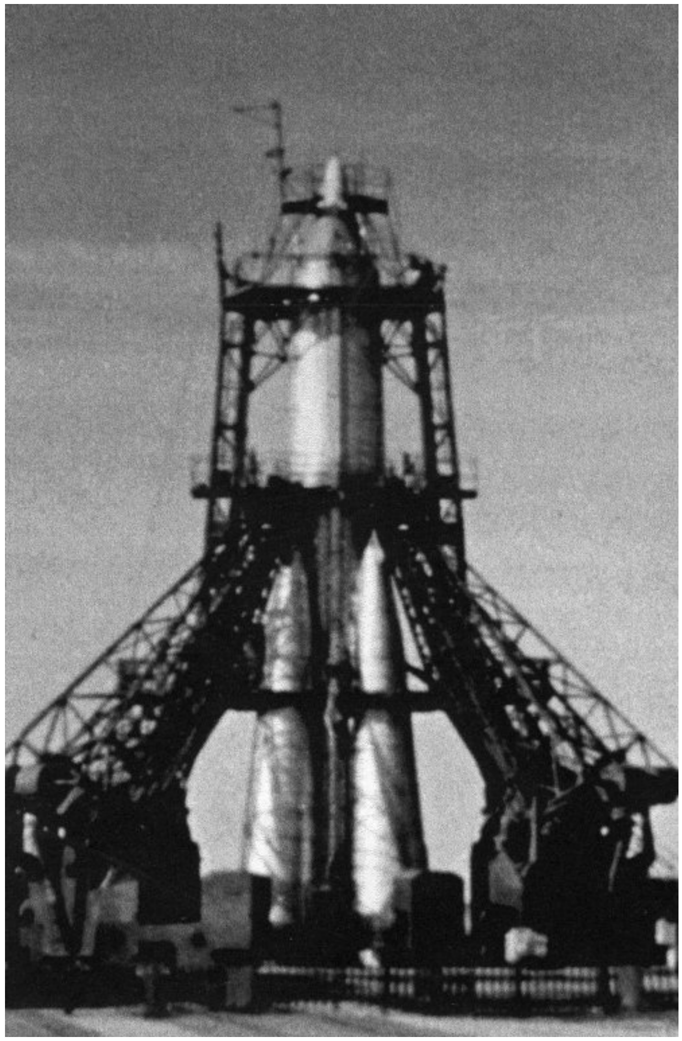
[407] Draft, Fred A. Darwin to Chairman, RDB, "Intelligence Information Pertaining to Guided Missiles," 20 December 1950, in RG 156, Office of the Chief of Ordnance, Records Relating to the Army Guided Missiles Program, Box 12, file "GM 291/ Foreign Intelligence," NA.
[408] J. Neufeld, *Ballistic Missiles in the USAF,* 71; Krudener, *Ballistic Missiles Site Activation,* 22; Sheehan, *A Fiery Peace in a Cold War,* 217; Zaloga, *Target America,* 140-1. The intelligence sources weren't specified. When the Soviets later began building the R-7 ICBM later in the decade, they turned to multi-chamber engines as a way to get around the problems of building large rocket engines.

be learnt about Russian missile research since most information had come from German rocket experts who had worked in isolation in Russia, none of who had information on what their Russian counterparts were doing. The report noted a lack of information on surface-to-surface ballistic missiles.[409]

In his congressional appearance in late 1957, Wernher von Braun testified that he was given access to intelligence debriefings of German scientists who had worked in the Soviet Union and had returned to Germany in 1952 and 1953. "On the basis of these reports, I came to the conclusion that the Russians not only had made very poor use of the German talent they had taken along to Russia, but actually that there had been a lot of mismanagement of their program," a conclusion that he admitted "proved to be entirely erroneous." When von Braun became an American citizen in 1955, he gained access to more information, including the fact the Germans did not work directly with the Russian engineers. The Germans who worked in the Soviet Union, in his words, were "left completely in the dark about the fact that there was a Russian program outside of their own operation" and were "poorly used."[410]

[409] I.D. Black, "Trip Report: Guided Missiles Intelligence Panel," 11 August 1952, in RG 330, Records of the Secretary of Defense, Box 394, file "123/Intelligence GM," NA. This presentation has been included in many historical treatments of ICBMs because it was mentioned in Ernest George Schwiebert, *History of the U.S. Air Force Ballistic Missiles* (New York: Praeger, 1965), 58.

[410] United States Senate. *Hearings before the Preparedness Investigating Subcommittee, Committee on Armed Forces, Inquiry into Satellite and Missile Programs.* 1st and 2nd Sessions, 85th Congress. December 14, 1957, 582.



R-7 ICBM used to launch Sputnik 2, 1957 (NASA)

Before embarking on their own ICBM program in 1954, decision-makers in the U.S. government had very little solid information on the state of Soviet missile programs. Their main source of information up to that time, German rocket experts who had worked in the Soviet Union, had been separated from Soviet rocket work since the Soviets had succeeded in replicating the V-2 in 1947. And the Americans had no information on the Soviet ICBM program because it did not win priority until 1954 at roughly the same time the USAF gave its go-ahead to the Atlas ICBM.

Conclusion

The assumption of power by the Eisenhower Administration and the creation of lightweight thermonuclear bombs gave the final impetus needed to get America's ICBM program fully under way in 1954. Of the two events, the thermonuclear bomb breakthrough was the most important because it convinced the two people who became champions of the ICBM in 1953 through 1955 and beyond – Trevor Gardner and Bernard Schriever – of the need to accelerate work on Atlas and other ICBMs. It also gave them the argument that persuaded others, including President Eisenhower, of the importance of ICBMs. Lightweight thermonuclear bombs vastly decreased the weight, size, complexity and cost of ICBMs in one stroke, and they also reduced the need for pinpoint accuracy in reaching the target, eliminating a major technical problem. The success of NACA engineers in overcoming the warhead re-entry heating problem has remained a relatively unknown but crucial technical advance that also helped make ICBMs a reality. The evidence linking the breakthrough in re-entry heating to the decision to proceed with Atlas is not nearly as strong as that tying the creation of the thermonuclear bomb to the go-ahead for Atlas, however.

The arrival of the Eisenhower administration led to a new Defense Department structure and the appointment of people like Trevor Gardner, Harold Talbott and Donald Quarles, who played important roles in promoting Atlas using devices like the Tea Pot Committee. In addition, support for the Atlas ICBM came from leaders in the air force like Gen. Bernard Schriever, Gen. Donald Putt and others who worked to overcome resistance in their service. What Schriever called the "thermonuclear breakthrough" was the crucial change that led the air force to begin serious work on ICBMs in 1954, if not totally embrace them until the following decade. Atlas could have begun without the new administration, but it would not have started in the mid 1950s without thermonuclear bombs.

The decisive voices for the Atlas ICBM were the scientists and engineers who lobbied the air force and others in the government for this new weapon. At the head of the list of scientists was John von Neumann, and experts from RAND like James Lipp and Bruno Augenstein, also helped turn the tide in favour of Atlas, along with the engineers and scientists who served on the Tea Pot Committee, and the ad hoc committee on missiles set up in 1952 by the USAF Scientific Advisory Board in 1952 headed by Clark Millikan, the chair of the Guided Missiles Committee of the Research and Development Board. The work of these experts built on earlier work including that of Theodore von Kármán, Hugh Dryden and others in 1945 with the air force Scientific Advisory Group. Von Neumann was the most important scientific figure in creating support for the Atlas ICBM, not only because he chaired the Tea Pot Committee in 1954 but perhaps more importantly because he persuaded Schriever and Gardner of the possibilities for ICBMs opened by thermonuclear bombs. Von Neumann's part in the development of Atlas is arguably more important than that of any figure associated with the new administration such as Gardner or Quarles.

The United States had very little intelligence on Soviet missile programs during the first decade after World War II. The lack of intelligence on Soviet missiles, especially after the Soviets exploded their first fission bomb in 1949, probably lent weight to those arguing in favour of ICBMs, simply because the secrecy that surrounded the creation of a Soviet nuclear bomb encouraged those who feared that missiles could also be produced in secrecy but had little or no solid evidence to back up that fear. The major reason for the lack of evidence for a Soviet ICBM program in the late 1940s and early 1950s was that the first Soviet ICBM program did not officially begin until 1954. Recent scholarship shows that the main impetus for the initiation of the Soviet ICBM program was the creation of the thermonuclear bomb.

The creation of the lightweight thermonuclear bomb was, in Thomas Hughes' terms, a radical invention that led to the creation of a new technological system, in this case the ICBM in both the United States and the Soviet Union. Thermonuclear bombs were a thousand times more powerful than the first fission bombs, and they weighed far less than those first fission bombs. At a stroke, the thermonuclear bomb vastly eased the problems of making ICBMs accurate, and its smaller size and weight also reduced the size and complexity of ICBMs. Indeed, the importance of the thermonuclear bomb throws into question whether ICBMs would have proceeded in as they did in the 1950s without it, and also raises the question of whether the air force's long-range strategic missiles would have progressed any further than they did before 1952, even if the air force received much higher levels of funding than it did in the early years after World War II or been distracted with creating bomber aircraft capable of flying intercontinental distances.

As has been noted previously in this study, outside scientific advice contracted by the USAF played the crucial role in alerting decision-makers in the USAF and elsewhere in the government to the importance of thermonuclear bombs and the possibilities of ICBMs. The birth of the thermonuclear bomb was not without controversy, and a dispute sparked by physicist J. Robert Oppenheimer's opposition to the thermonuclear bomb came to symbolize the suppression of dissent in the U.S. scientific community.

Chapter 7
Sputnik's Shadow

The main narrative of this study ended in the early months of 1954 with the Tea Pot Committee report and the USAF's decision to proceed with the Atlas intercontinental ballistic missile. We will now turn to how Atlas and other American ICBMs were developed, built and deployed following that decision. The account in this chapter will focus on developments that cast light on events that took place during the period covered in this dissertation. One of those later developments was the first use of an ICBM to launch an artificial satellite into orbit around the Earth, a feat performed by the Soviet Union with their R-7 ICBM and Sputnik on 4 October 1957 before the U.S. Atlas ICBM overcame its development problems. The fact that ICBMs can also be used as space launch vehicles has coloured how both the public and historians came to view the history of ICBMs. The worldwide acclaim that greeted the launch of Sputnik, which came early during the time that the R-7 missile was going through its test flights, missed the fact that a successful test flight of a missile is still just one step in developing an effective ICBM weapons system.

The reaction to Sputnik heavily influenced the historiography of the development of missiles during the years following World War II. Although this historiography has been discussed in earlier chapters of this dissertation, this chapter will examine in some depth the development of historical literature around the ICBM and other missiles and rockets. This historiography starts with the popular works that appeared after Sputnik kicked off the space race between the Soviet Union and the United States, through more serious works that appeared in the 1970s and 1980s, to the New Aerospace History that followed the end of the Cold War in 1991 and the rise of new perspectives on the missile race and the space race of the 1950s and 1960s.

U.S. ICBM Production

When the U.S. Air Force decided to proceed with development of the Atlas ICBM in March 1954, the commander of the Strategic Air Command, Gen. Curtis LeMay, who had long been associated with bomber aircraft, resisted Atlas because he expected it to fail, or at best become a weapons system with poor dependability. Like Vannevar Bush, LeMay also questioned ICBMs because of their push-button nature, which he claimed made them a "space age Maginot Line." But other air force leaders who had not supported Atlas soon began to cooperate with the program. Air Force Secretary Harold Talbott also directed USAF Chief of Staff Twining to accelerate the development of an ICBM through a field office on the west coast. On July 1, the USAF established the Western Development Division, and it soon began work under Gen. Bernard Schriever's command in Inglewood, California. At the same time, Assistant Defense Secretary Donald Quarles reconstituted the Tea Pot Committee into a more permanent group called the Atlas Scientific Advisory Committee. John Von Neumann became chair of the committee, and six other Tea Pot Committee members also agreed to serve on the new committee, along with nine new members.[411]

The new committee and the air force had to grapple with the organization of the new ICBM development program. That fall, the air force and the committee agreed on a controversial new management set up where Ramo-Wooldridge would act as a "deputy" for the Western Development Division with responsibility for technical direction and

[411] J. Neufeld, *Ballistic Missiles in the USAF,* 97, 104-110; Lonnquest, "The Face of Atlas," 101-4; Barrett Tillman. *LeMay* (New York: Palgrave Macmillan, 2007) 130-2; Sheehan, *A Fiery Peace in a Cold War,* 220-4. The committee was eventually renamed as the ICBM Scientific Advisory Committee.

systems engineering, on the condition that Ramo-Wooldridge not bid for other air force work as a contractor developing or building missiles or components. Convair got the airframe and assembly contract for Atlas rather than the traditional role of prime contractor that it sought, and North American was contracted to build the engines. Ramo-Wooldridge's role in the management of Atlas was controversial but was later seen as a landmark in the advancement of systems engineering by historians such as Thomas Hughes and Stephen B. Johnson. Reflecting the Tea Pot Committee's views on the diminishing size of thermonuclear warheads, Atlas was designed to use only three large engines instead of the five and even seven engines that were mooted in 1951 and 1952. Nevertheless, at the height of Atlas development in 1958, more than 18,000 scientists, engineers and others, along with 70,000 other people in twenty-two industries worked on Atlas. The ICBM utilized seventeen associated contractors, 200 subcontractors and 200,000 suppliers.[412]

Trevor Gardner and Schriever believed that the ICBM was such a high priority that they sought and won the authority to simultaneously produce a second set of each important system to increase the chances that the development effort would not fail. This concept, known as concurrent development or concurrency, was also used in the Manhattan Project with uranium and plutonium bombs. Ultimately, concurrency led to the development of a second ICBM, the Titan. As well, the air force decided that the Western Development Division should also produce an intermediate range ballistic

[412] J. Neufeld, *Ballistic Missiles in the USAF,* 110-5; Sheehan, *A Fiery Peace in a Cold War,* 253-60; Roland, *The Military-Industrial Complex,* 26-7; Maj. Gen. Bernard A. Schriever, "The USAF Ballistic Missile Program," in Gantz, *The United States Air Force Report on the Ballistic Missile,* 30. See also Hughes, *Rescuing Prometheus,* 69-139; and Stephen B. Johnson, *The Secret of Apollo: Systems Management in American and European Space Programs* (Baltimore: Johns Hopkins University Press, 2002). A sharply critical view of Ramo -Wooldridge's role in Atlas is provided in Harold L. Nieburg, *In the Name of Science* (Chicago: Quadrangle Books, 1966) 200-17.

missile (IRBM), which emerged as the Thor. In February 1955, President Eisenhower received a report from the Technological Capabilities Panel of the President's Scientific Advisory Committee, headed by MIT President James R. Killian, which warned of the possibility of a surprise missile attack on the U.S. from the Soviet Union. That summer, Gardner and Schriever won the opportunity to brief the president on the ICBM program, and as a result of that briefing, Eisenhower granted "top national priority" status to the ICBM program, completing the work of assigning top priority status to Atlas that began in earnest with the Tea Pot Committee report.[413]

During the months that followed President Eisenhower's assignment of top priority status for ICBMs in 1955, Atlas and Titan had to contend with financial restraints imposed on defense spending. The financial squeeze on the ICBMs was tightened by the air force decision to build the Thor. In a revival of the rivalry between the army and navy over missiles before the Korean War, Thor was locked in competition with an Army IRBM called Jupiter. In 1956, Defense Secretary Charles Wilson created a new Ballistic Missiles Committee to coordinate missile work among the services as the Truman-era Guided Missiles Committee was supposed to do, appointed a special assistant for guided missiles, and upgraded the air force's ICBM Scientific Advisory Committee into a committee serving the whole military. On 26 November 1956, Wilson issued a "roles and missions" directive that gave the air force operational jurisdiction over surface-to-surface missiles with a range greater than 200 miles and surface-to-air missiles with a range greater than 100 miles. The army had operational jurisdiction to missiles under those ranges, and the navy had operational jurisdiction over all missiles launched from ships. Wilson's directive failed to quell the inter-service dispute, as Army Ordnance took

[413] J. Neufeld, *Ballistic Missiles in the USAF,* 119-136; Hughes, *Rescuing Prometheus,* 102-9.

advantage of the problems that plagued Thor in 1957 to make a play to win control of IRBMs with its Jupiter. The army failed when the Thors began flying successfully, and both the Jupiter and Thor IRBMs were deployed in launching sites in Europe and Turkey.[414]

The first Atlas flew on 11 June 1957, but it and the second Atlas in September failed early in flight. The Soviet Union announced on 26 August a successful launch of its R-7 ICBM five days earlier, a success that followed two failed launches, the first in May. The R-7 launch in August was not as successful as advertised, because the dummy warhead broke up in flight due to the fact that the Soviets were behind the U.S. in realizing the importance of blunt re-entry bodies. While the Soviet announcement of its ICBM launch did not cause a strong reaction in the United States, a subsequent R-7 launch a few weeks later, which orbited Sputnik, the first artificial satellite of the Earth, led to a strong political and media reaction in the U.S. and around the world.[415]

That fall, the new Secretary of Defense, Neil H. McElroy, revived the position of director of guided missiles, and William M. Holaday worked to expedite the production of missiles, starting with the Thor and Jupiter IRBMs, much as K.T. Keller had done at the beginning of the decade. On 17 December 1957, the third Atlas launch was successful, but this achievement was drowned out in the reaction to a second Soviet satellite, which carried a dog, and the failure of the U.S. Navy's attempt to launch a

---

[414] J. Neufeld, *Ballistic Missiles in the USAF,* 137-68; Del Papa and Goldberg, *SAC Missiles Chronology*; Sheehan, *A Fiery Peace in a Cold War,* 343-61. At the same time, Army Ordnance was locked in a contest with the navy to launch America's first satellite into orbit. The army's Explorer 1 made it into orbit on 31 January 1958 before the navy's Vanguard. The air force focused on developing its missiles and stayed out of the satellite contest until the Atlas was proven later in 1958.

[415] Sheehan, *A Fiery Peace in a Cold War,* 396-9; Chertok, *Rockets and People,* vol. 2, 397-8; Zaloga, *Target America,*141-50; Robert J. Watson, *Into the Missile Age, 1956-1960: History of the Office of the Secretary of Defense, Volume IV* (Washington, D.C.: Historical Office, Office of the Secretary of Defense, 1997) 160-1. Walter A. McDougall. ...*The Heavens and The Earth: A Political History of the Space Age.* (New York: Basic Books Inc., 1985) describes the U.S. reaction to Sputnik, 141-56.

Vanguard satellite. The initial Atlas missiles were not equipped to fly the planned full range of 5,000 nautical miles, and it was not until August of 1958 that an Atlas flew all the steps necessary to complete its full range. Further successes, including the lofting of an Atlas fuselage into orbit late that year with a device that broadcast a Christmas message from Eisenhower, were followed by some failures in 1959 during flight tests of the operational versions of Atlas. Eventually the bugs were worked out, and in September 1959, a year later than Trevor Gardner had hoped, the first battery of Atlas D missiles went on operational duty at Vandenberg Air Force Base in California.[416]

ICBMs in the Cold War

In the months following Sputnik and other widely publicized Soviet space successes, the early Atlas failures, along with similar problems for Thor and Titan, led many Americans to believe that the United States was falling behind in what media commentators touted as the missile race against the Russians. At the time, Soviet Premier Nikita Khrushchev boasted that his government was turning out ICBMs "like sausages." But the truth was that the R-7 was difficult to assemble and launch, and was as unsuited to be an operational ICBM as it was suited to be an effective launch vehicle for satellites and space probes. The reason was that it had been designed to launch five-ton warheads rather than the smaller warheads the Atlas and Titan were designed to carry. The R-7's properties were a direct result of the Soviet leadership's decision in 1954 to begin building their ICBM based on Sakharov's incorrect estimate for the weight of a thermonuclear bomb. That year, the Soviets had proof of the thermonuclear bomb's power but not of the possibility of lightweight thermonuclear bombs. The R-7's prowess

[416] J. Neufeld, *Ballistic Missiles in the USAF,* 168-76; Sheehan, *A Fiery Peace in a Cold War,* 396-406; Watson, *Into the Missile Age,* 170-1; Del Papa and Goldberg, *SAC Missiles Chronology*. The competition between Thor and Jupiter is covered in depth in Armacost, *The Politics of Weapons Innovation.*

as a space launcher gave the world the illusion that it was far superior to Atlas as a weapons system, and ready for use first, when in fact Atlas was more effective and put America well ahead in the race to develop an ICBM deterrent. Only six R-7s could ever be put on alert at one time because there were only six R-7 launch pads, and Soviet ICBMs therefore fell far behind America's ICBM force until another design bureau succeeded in developing a rocket better suited to be an ICBM and the new ICBMs came into service starting in 1962.[417]

Only six launch pads were built for the R-7 because its design required a gigantic launch pad, a problem that symbolized the complex questions relating to the basing of missiles, procedures for launching them, and strategic questions related to their use. In 1955, the USAF decided to base its ICBMs in hardened sites and later silos to protect them against a Soviet pre-emptive strike, although the first Atlas ICBMs were based above ground. As Jacob Neufeld detailed in his history of ICBMs, the new Atlas and Titan bases arose from some of the largest construction projects of the time. Indeed, both the American and Soviet authorities were learning the hard way that basing missiles was an integral and expensive part of building the technological system, as Thomas Hughes would term it, created in part around ICBMs. The complexities involved in the design, construction and operation of Atlas and Titan missile silos caused many headaches for the air force, particularly because of their size and issues related to fueling the missiles with cryogenic fuels. The Titan II missile was fueled with hypergolic liquids that could be stored in the missile at room temperature, but these fuels had storage limitations because they were so corrosive. The Strategic Air Command also had to train crews to

---

[417] Sheehan, *A Fiery Peace in a Cold War,* 403-9; Zaloga, *Target America,* 150-60, 189-99; Zaloga, *The Kremlin's Nuclear Sword,* 47-57; Siddiqi, *Challenge to Apollo,* 212-19, 256-8. See also McDougall, *…the Heavens and the Earth,* 237-62.

maintain, fuel and launch the missiles. These problems delayed full deployment of Atlas missiles into 1962. It was only in the late 1950s that academics at RAND and elsewhere began to think seriously about how to fight wars with missiles. Following the initial success in 1960 of America's first military reconnaissance satellite, Corona, the U.S. military began launching satellites with mapping cameras and other equipment to allow precision targeting of bombers and ICBMs.[418] The Soviets were even slower to protect their missiles and create the necessary infrastructure to support its missile forces. Khrushchev claimed to have thought of the idea of missile silos himself, and the Soviets began building silos in the 1960s. The R-7 was far too big to launch from a silo, and so the Soviets had to await the development of newer missiles better suited for use with missile silos.[419]

The U.S. Navy had successfully launched the first Polaris two-stage solid fuel missiles from submerged submarines in 1960, debuting a new weapon that became a key part of America's nuclear deterrent because submarines moved and were difficult to track. In 1962, the air force began to deploy Minuteman solid-fueled ICBMs, which were far more suitable to the task than Atlas or Titan because they were smaller and thus were a better fit for protected missile silos. More important, because their fuel was solid and thus permanently loaded on board, Minuteman missiles did not require the dangerous and complicated fueling operations of liquid-fueled rockets and could be launched instantaneously at any time. They could also be deployed in much larger numbers than

---

[418] Sheehan, *A Fiery Peace in a Cold War,* 406-9; J. Neufeld, *Ballistic Missiles in the USAF,* 176-9, 205-22; Kaplan, *The Wizards of Armageddon,* 185-247; Del Papa and Goldberg, *SAC Missiles Chronology.* Very little has been written about mapping and geodesy satellites. An exception to the rule is Dwayne A. Day's "Mapping the Dark Side of the World" series in the July and August 1998 issues of *Spaceflight* magazine (Vol. 40 no. 7, 264-9, no. 8, 303-10). See also Major Kenneth A. Smith, "The Ballistic Missile and Its Elusive Targets," in Gantz, 261-70, for a 1958 view of missiles and geodesy.
[419] Zaloga, *The Kremlin's Nuclear Sword,* 64; Sergei N. Khrushchev, *Nikita Khrushchev and the Creation of a Superpower* (University Park, PA: The Pennsylvania State University Press, 2000) 279-89.

Atlas and Titan. Minuteman missiles were quickly shown to be more effective than Atlas and Titan because they were much easier to keep on alert. For these reasons, Minuteman won the support in 1958 of Curtis LeMay, by then the air force vice chief of staff, that he had withheld from Atlas. The Soviets could not field a similar missile for several years.[420]

Gen. Bernard Schriever with Atlas ICBM (USAF National Museum)

[420] Sheehan, *A Fiery Peace in a Cold War,* 409-20; Werrell, *Death from the Heavens,* note 15, 321; Tillman, *Lemay,* 130-2; Miles, "The Polaris," in *Emme,* 162; Zaloga, *Target America,* 203-4, 213, 233-42; Interview of Paul Blasingame by Martin Collins, 14 November 1990, RAND History Project, National Air and Space Museum, Smithsonian Institution, Washington, D.C., 15.

While the difficulties the USAF faced in building launch pads, missile silos and other infrastructure for ICBMs were not secret, they were not widely publicized. The Soviet problems with missiles were kept secret by both sides for some time, and detailed information did not become available until the end of the Cold War. The idea that the Soviets had the first effective ICBM with the R-7 must be reconsidered in the face of its weaknesses as a strategic missile. As well, the Atlas' drawbacks as an ICBM must also be taken into consideration when assessing the resistance shown to it by LeMay and other USAF leaders.

The concerns many Americans felt about their vulnerability to Soviet ICBMs in the wake of Sputnik meant that the Atlas missile faced a crisis similar to that involving defensive missiles in 1951 that led to the appointment of K.T. Keller as missile czar and caused the Eisenhower administration in 1953 to eliminate the welter of committees that attempted to coordinate research and development for guided missiles and other advanced weapons. In response to problems encountered four years later during the Atlas program, the Eisenhower Administration also returned to committees similar to those employed during the Truman administration, but with less power and visibility. By the time Atlas began to fly successfully in 1958, the navy was building its Polaris missiles and the submarines needed to launch them, and the navy turned the USAF's strategic nuclear duopoly into the nuclear "triad."

As for the Navaho missile, the air force had cancelled it in 1957 but allowed tests to continue through 1958. The Navaho left as its major legacies its rocket engine, new alloys for its skin, and its guidance system. The Kennedy administration cancelled Snark in 1961, just two years after it was first made operational. By the time the United States and the Soviet Union confronted each other in October 1962 when the Soviets tried to challenge America's nuclear advantage by placing medium range ballistic missiles just off the American coast in Cuba, the Americans were capable of delivering 4,000 nuclear warheads, mostly with bombers, 179 warheads were on ICBMs and at least 112 on submarine-launched ballistic missiles, while the Soviets could hit back with only 220 warheads, including twenty on ICBMs. In the years following the Cuban missile crisis, the United States continued to build up its forces, but the Soviets were determined never to be caught short again and worked even harder to match its adversary until missile forces reached an uneasy equilibrium that lasted for the final two decades of the Cold War. The United States' strategic nuclear forces, the technological system designed to deliver the U.S. military's strategic nuclear weapons to targets in the Soviet Union during the Cold War, were said to be comprised of the "triad" of ICBMs and bombers from the USAF and the navy's force of nuclear-powered submarines carrying ballistic missiles such as Polaris and later Trident.[421]

The nuclear-armed ICBMs deployed by the United States and the Soviet Union became a central fact of the Cold War, and have remained on alert since then, albeit in reduced numbers. They have been widely credited with deterring the two superpowers from engaging in a direct war. Cold War historian John Lewis Gaddis wrote in 1997 that this idea "is an old and familiar one, though not universally accepted."[422] Nuclear arms historian Richard Rhodes wrote at the conclusion of his 2007 book *Arsenals of Folly* that

[421] Werrell, *Cruise Missiles,* 96-101. Because submarines could be moved and hidden, some observers questioned whether there was any further need for bombers or ICBMs since the submarines carried sufficient firepower to destroy the Soviet Union. See D.A. Rosenberg, "Origins of Overkill," 57. Expanding on Rosenberg's point, nuclear historian Richard Rhodes suggested that the triad was nothing more "than an artifact of interservice rivalries." Richard Rhodes, *Arsenals of Folly,* 92.
[422] Sheehan, *A Fiery Peace in a Cold War,* xix, 450-5; Gaddis, *We Now Know,* 291.

both sides in the Cold War based their planning on the assumption that the other side would strike first with nuclear weapons, even though both sides shrank from a first-strike because of the consequences, and pointed to a study by political scientist Jacek Kugler questioning the effectiveness of nuclear forces in deterring the escalation of confrontations between nuclear states and other states. Quoting activist-scholar Richard J. Barnet, he noted that the United States has not won a decisive military victory since 1945. Instead, the United States has been saddled with the heavy costs of becoming a national security state, costs that continue to the present day.[423]

The monetary cost of the Atlas ICBM has been variously estimated at $38 billion and $43 billion in 2011 U.S. dollars. In 1965, historian Ernest George Schweibert put forward a figure of the equivalent of $120 billion in 2011 dollars for the Atlas, Titan and Minuteman ICBM programs from 1951 to 1964, including infrastructure, and another estimate puts the entire cost of the three programs up to 1996 at $204 billion in 2011 dollars. The cost of the air force program to develop ICBMs was certainly comparable to the Manhattan Project, which cost $25 billion in 2011 dollars. The final price tag for Atlas was significantly larger than any missile developed to that time and outstripped all cost estimates made in the late 1940s for such a missile.[424] The deployment of ICBMs also involved many other costs, including highly expensive research and development of

---

[423] Rhodes, *Arsenals of Folly,* 297-301. See also Jacek Kugler. "Terror without Deterrence: Reassessing the Role of Nuclear Weapons," *The Journal of Conflict Resolution,* Vol. 28 No. 3 (Sept. 1984) pp. 470-506; and Richard J. Barnet, "The Ideology of the National Security State," *The Massachusetts Review*, Vol. 26, No. 4 (Winter 1985), pp. 483-500.

[424] The $38 billion figure comes from an uninflated figure of $5.2 billion from an estimate that included deploying twelve squadrons of Atlas ICBMs that the USAF made in 1962 for a Congressional committee, quoted in Lonnquest, "The Face of Atlas," 244. The $43 billion figure is from the Brookings Institute's *Atomic Audit* study in 1998. The $120 billion figure is taken from an uninflated $17 billion figure from 1965 in Schwiebert, *History of the U.S. Air Force Ballistic Missiles*, 139. The $204 billion figure is based on costs for the programs listed in *Atomic Audit,* 149. In 1996, Minuteman III missiles remained deployed. Rhodes, in *Dark Sun,* 116, puts the cost of the Manhattan Project at $2 billion, or roughly $25 billion today.

missiles and other systems which have the hope, so far unrealized, of protecting against ICBMs. There are additional costs for the wider infrastructure for America's nuclear forces and as Barnet pointed out, for the national security state. Those costs not only involved large sums of money but also freedom of belief and expression, as J. Robert Oppenheimer and others learned when they came under attack in the 1950s for their opposition to thermonuclear weapons or the national security state itself.

The Sputnik crisis

When the Soviet Union launched the first artificial satellite of the Earth, Sputnik, atop an R-7 ICBM on 4 October 1957, the news surprised many Americans despite Soviet announcements in the preceding months that they intended to launch such a satellite. The orbiting of Sputnik, followed less than a month later by the far larger Sputnik 2 and the spectacular failure in December of an American attempt to launch a Vanguard satellite, created what top scientist James R. Killian called a "crisis of confidence" over national security, space exploration and the state of education in the United States.[425] While leading figures in the Soviet ICBM program like Sergei Korolev pushed to use their missile for space activities, Schriever and USAF leaders deliberately avoided offering Atlas for use in very early satellite programs until their missile was proven in 1958, leaving much less powerful rockets like the army's Redstone missile and the navy's Vanguard satellite launch vehicle to launch the first American satellites.[426] The Soviet R-7 ICBM was better suited than any American rocket of the time, including

---

[425] For a thorough treatment of America's reaction to Sputnik, see Robert A. Divine, *The Sputnik Challenge: Eisenhower's Response to the Soviet Satellite* (Oxford: Oxford University Press, 1993). Killian is quoted on xv.

[426] Michael J. Neufeld, "Orbiter, Overflight, and the First Satellite: New Light on the Vanguard Decision," in Roger D. Launius, et al., *Reconsidering Sputnik: Forty Years Since the Soviet Satellite* (Amsterdam: Harwood Academic Publishers, 2000) 237-8.

Atlas, for launching large payloads into space, and so the Soviets also launched the first probes to strike the Moon and enter solar orbit in 1959, and the first human, Yuri Gagarin, into orbit on 12 April 1961. In response, the new Democratic president, John F. Kennedy escalated the space race by setting the goal of landing humans on the Moon before the end of the 1960s. Both Cold War adversaries began programs to send humans to the Moon, but the Soviet program failed and twelve American astronauts landed on the Moon between 1969 and 1972.

"Sputnik was a sharp slap to American pride, but worse, it suggested Soviet technical and military parity with the West, which in turn, undermined the assumptions on which the free world defense was based," historian Walter A. McDougall wrote in his classic history of the Space Age, *...the Heavens and the Earth.*[427] Propelled in part by fear of Soviet nuclear weapons and ICBMs, American politicians and the media compared Sputnik to Japan's 1941 sneak attack on Pearl Harbor, and supported a number of schemes including a more aggressive space program and increased federal spending on education, to restore America's pride. Americans had to contemplate a weapon in foreign hands that could easily overcome the protection afforded by America's location in the Western Hemisphere. The fact that the supposedly technically backward Soviet Union had launched the Space Age rather than the United States added humiliation to the fear many Americans felt, and they soon were asking how the Soviets beat the United States to the first launch of an ICBM and of a satellite.

During the political controversy that followed Sputnik and through the 1960 election, Democrats sharply criticized the Eisenhower administration for the Soviet

---

[427] McDougall. *...The Heavens and The Earth,*132. See McDougall's discussion of Sputnik's direct impact on the U.S., 141-56.

successes in space and apparent lead in ICBMs, notably through the device of Senator Lyndon Johnson's Preparedness Subcommittee of the Senate Armed Forces Committee, which held highly publicized hearings on the matter. Republicans responded to the criticism by blaming the Truman administration for the United States' late start on ICBMs due to the cancellation of Convair's MX-774 contract and Truman's impounding of $75 million of appropriated research and development funds in 1947 as part of his economy drive. "As late as 1952 we were spending less than a million dollars a year" for both ICBMs and intermediate-range ballistic missiles, one Republican member of Congress falsely charged.[428]

With Americans holding misinformed views that America's ICBM program was behind the Soviet Union's program, missiles became a political issue in the 1960 presidential election, with Kennedy accusing his Republican opponent, Vice President Richard M. Nixon and President Eisenhower of allowing a "missile gap" to develop. In fact, as Neil Sheehan wrote in his biography of Gen. Bernard Schriever, by 1959, the "gap was widening steadily in favor of the United States, not the Soviet Union." In August 1960, the first photos from an American Corona reconnaissance satellite began to show to Eisenhower that the Soviet lead was an illusion, but he did not make the results public for fear of having to reveal this new and powerful intelligence tool. It was left to Kennedy to begin to tell the truth the following year after he moved into the White House.[429]

---

[428] "Congressman William G. Bray (R-Indiana), remarks at the luncheon meeting of the Indiana Republican Editorial Association, Indianapolis, March 26, 1960. Bryce Harlow Papers, Box 11, "Defense," Dwight D. Eisenhower Presidential Library.
[429] Sheehan, *A Fiery Peace in a Cold War,* 403-9; Zaloga, *Target America,* 150-60. See also McDougall, *the Heavens and the Earth,* 151-64, 325-35.

Popular Literature

Despite the fact that the danger presented by Soviet ICBMs in the late 1950s was much more an illusion than a reality, the crisis in the United States touched off by Sputnik has coloured the historiography of the space race and the missile race to this day. The space race of the late 1950s and the 1960s brought about a spate of books in the United States about the history of rocketry, but these histories, usually written by participants or advocates of space flight, stressed technical developments over political ones, and often focused on Wernher von Braun's group of Germans that worked for the U.S. Army from the time they began arriving in the United States in 1945 until they were transferred to the U.S. civilian space agency NASA in 1960. German rocket engineers played only minor roles in developing American ICBMs, but the von Braun team developed the Redstone short-range missile that helped launch the United States' first satellite, *Explorer 1*, in 1958 and launched the first two American astronauts on suborbital flights in 1961. At NASA in the 1960s, von Braun's team built the Saturn rockets that carried Apollo spacecraft and their crews to the Moon. Despite the fact that Atlas and Titan ICBMs developed by contractors under air force supervision carried America's first astronauts into orbit along with most American satellites and space probes in the first four decades after Sputnik, few of the histories of rockets and space travel written in the 1950s and 1960s paid serious attention to the development of ICBMs.[430]

Many of the books about the German engineers are popular accounts that either condemn them for their Nazi links or excuse them because of their successes in both their home and adopted countries. A book by Clarence Lasby in 1971 and various works by

[430] Von Braun himself helped write one of the more prominent works of the time: Von Braun and Ordway *The History of Rocketry and Space Travel*. His sometime collaborator Willy Ley was also a prolific and popular writer of books on rocketry before his death in 1969.

John Gimbel told this story in the context of wider initiatives by the U.S. government to benefit from the wartime work of German scientists in various fields, including radar, jet aircraft, rockets, communications and industrial processes for synthetic rubber and fuels. A large number of popular books concentrate on von Braun, but it was only in 2007 that a thorough and balanced biography of von Braun based on extensive archival research was published, this one written by Smithsonian Institution historian Michael J. Neufeld.[431]

Compared to the wealth of books on von Braun and his team, Atlas and the people who built it have received sparse attention. In 1960, John L. Chapman wrote a popular history of the Atlas missile that focused on the work of the Convair team under Karel J. "Charlie" Bossart that started with the MX-774 missile. Chapman blamed the demise of the MX-774 on the influence of the many "diehard fliers" in the air force. Even in 1951 and 1952, top officials in the Pentagon considered the Atlas program to be still in the realm of "Buck Rogers." In Chapman's account, the successful test of the first thermonuclear bomb in November 1952 caused people like Gen. Bernard Schriever and Trevor Gardner to see the potential of Atlas in 1953. The change of administrations in Washington was not mentioned.[432]

Nearly fifty years would elapse until the appearance of the first popular biography of Schriever, the most important figure in America's ICBM program. In his 2009 account of the Atlas program, which is based on author interviews and secondary documentary sources, the journalist and author Neil Sheehan discusses how Schriever and Gardner

---

[431] Michael J. Neufeld, *Von Braun: Dreamer of Space, Engineer of War* (New York: Alfred A. Knopf, 2007). See also Clarence Lasby, *Project Paperclip: German Scientists and the Cold War* (New York: Atheneum, 1971); and John Gimbel, *Science, Technology, and Reparations: Exploitation and Plunder in Postwar Germany* (Stanford: Stanford University Press, 1990). Popular accounts include the books by von Braun and Ley mentioned above, Frederick I. Ordway, and Mitchell R. Sharpe. *The Rocket Team* (London: William Heinemann Ltd., 1979), and the more critical Linda Hunt, *Secret Agenda: The United States Government, Nazi Scientists, and Project Paperclip, 1945 to 1990* (New York: St. Martin's Press, 1991).
[432] Chapman, *Atlas: The Story of a Missile,* 25-75.

worked to accelerate the Atlas program when John von Neumann and Edward Teller concluded in 1952 that lightweight thermonuclear bombs would soon be available, as was outlined in Chapter Six of this dissertation. Sheehan's brief discussion of the MX-774 and Atlas program before the Tea Pot Committee concentrates almost exclusively on Bossart and his team at Convair, except to state that the MX-774 was cancelled in 1947 due to "peacetime money rationing."[433] While Sheehan also mentions interservice rivalries and Gen. Curtis LeMay's antipathy to ICBMs, both were brought up in relation to events that took place after the Tea Pot Committee report.[434] And interestingly, given the timing of his book years after the end of the Cold War, Sheehan did not question the utility of ICBMs but instead stated that they played "a pivotal role in preserving peace during the grim years of the Cold War."[435]

Historical Works

An early scholarly treatment of Atlas came from NASA's history office, which gathers source materials for historians and sponsors the writing of professional histories of the work of the agency and related groups. In 1966 its history of NASA's first human spaceflight program, *This New Ocean: A History of Project Mercury,* dealt briefly with the history of Mercury's primary launch vehicle, the Atlas missile, emphasizing the importance of lightweight thermonuclear weapons in facilitating the development of Atlas. It also covered the development of technologies necessary for human spaceflight, including H. Julian Allen's work on blunt re-entry bodies. Other NASA histories relevant

[433] Sheehan, *A Fiery Peace in a Cold War,* 214.
[434] Sheehan, *A Fiery Peace in a Cold War,* 211-24, 223, 414-5.
[435] Sheehan, *A Fiery Peace in a Cold War,* xix.

to the time period in this study have covered the history of satellite proposals and research in hypersonic flight during the postwar years.[436]

R. Cargill Hall's 1963 article from *Technology and Culture* remains the classic study of proposals for artificial satellites in the United States between 1945 and 1949, starting with ideas being considered inside the U.S. Navy and concentrating on studies conducted for the air force by RAND. Hall's work highlighted Vannevar Bush's 1945 testimony that long-range missiles "will be impossible for many years." In keeping with the emphasis of the time on Sputnik, Hall concluded with predictions of the propaganda impact of satellites but also the "genuine failure to realize the tremendous strategic advantage it would give the Russians to be first into space."[437]

Historian Eugene M. Emme's 1964 collection of essays on the history of rocket technology in the preceding forty years, which reproduced Hall's article, became an important reference. This volume also includes air force historian Robert L. Perry's article on the history of early ICBMs. In a piece relying mainly on air force historical documents and public statements, Perry noted that while the Commander of the Army Air Forces, "Hap" Arnold, saw a need for ICBMs, "leading civilian scientists" and others were not as far seeing and believed the Soviet Union "was incapable of developing an advanced technology."[438] Money for the military was scarce between 1945 and 1950, and jet aircraft, intermediate-range missiles and new warheads appeared to fill America's immediate needs more than ICBMs. Even when the USAF re-instituted its ICBM

---

[436] Swenson, et al., *This New Ocean: A History of Project Mercury,* 18-31, 59-69; Constance McLaughlin Green and Milton Lomask. *Vanguard – A History* (Washington, D.C.: National Aeronautics and Space Administration, 1970); Heppenheimer, *Facing the Heat Barrier*.
[437] Hall, "Early U.S. Satellite Proposals."
[438] Robert L. Perry, "The Atlas, Thor, Titan and Minuteman." in Emme, *History of Rocket Technology,* 142-3.

program in 1950, Perry contended that bomber aircraft and air-breathing missiles retained their higher priority and the ICBM program "remained a pedestrian effort" for four years. Perry wrote that in 1953, U.S. intelligence "acquired reliable information that the Soviet Union was well along in the development of a long-range rocket weapon," and breakthrough in physics opened the door to lightweight thermonuclear weapons, although no evidence has emerged to back up this claim.[439] As well, "a generation of scientists and military planners more concerned about the danger of losing a new war than with preserving the tactics of the past war edged into the policy councils of the defense establishment." These developments led to the 1954 Tea Pot Committee report and the top priority effort given to the Atlas ICBM.[440]

Perry also wrote about ballistic missile decisions in a 1967 paper for RAND that called on his own previous work and other pieces from the Emme collection. He argued that the contending factions of the air force, including strategists and scientists, fought over whether to advance missiles at the possible expense of aircraft programs. Experts such as Vannevar Bush had used technological and financial shortfalls to justify the 1947 program cutbacks, but Perry claimed that "institutional influences and shortsighted technical planning appear, in retrospect, to have been at least as important." Alongside the Soviet nuclear bomb, the Korean War, and the arrival of lightweight nuclear weapons, he contended that missiles won new interest in the air force because many outside experts used by the USAF began to question whether bombers would be able to penetrate

---

[439] Perry, "The Atlas, Thor, Titan and Minuteman." in Emme, *History of Rocket Technology,* 143.
[440] Perry, "The Atlas, Thor, Titan and Minuteman." in Emme, *History of Rocket Technology,* 144.

defenses using missiles and more sophisticated electronics. As well, he argued that progress was being made in technologies necessary for long-range missiles.[441]

Developing the ICBM

The most influential historical work about the U.S. government's approach to missiles prior to 1954 has been Edmund Beard's 1976 book, *Developing the ICBM,* which focused on how the air force dealt with missiles during World War II and the decade that followed. *Developing the ICBM* was based heavily on air force documents pertaining directly to missiles, and it highlighted the Air Staff's differences over ICBMs with the Air Research and Development Command. These findings reflected the work of USAF historians Ethel M. DeHaven and Mary R. Self, who produced studies on the same topic that also included large collections of classified documents that were made available to Beard.[442]

Writing nearly twenty years after Sputnik, Beard emphasized the importance of the Sputnik crisis in the United States and the belief that the Soviets enjoyed an advantage in ICBMs over the U.S. in the late 1950s. He wrote that although "it became apparent that the early Soviet ICBMs were not readily producible and were not good strategic weapons, it remains true that the Soviet Union had indeed 'beaten' the United States to a vital weapon." To back up this idea, Beard quoted an article from 1962 claiming that the Soviet R-7 ICBM was superior to the American Atlas ICBM. As noted above, while the R-7 was and remains an excellent space launch vehicle, it was of little

[441] Perry, *The Ballistic Missile Decisions,* 5-11.
[442] Mary R. Self, *History of the Development of Guided Missiles, 1946-1950* (Dayton OH: Historical Office of the Air Material Command, 1951); and Ethel M. DeHaven, *Aerospace – the Evolution of USAF Acquisition Policy 1945-1961* (Los Angeles: USAF DCAS Historical Office, 1962). Unfortunately, most of the DeHaven study, including the portions relevant to this dissertation, remains classified. Beard was given access to some documents on the condition that his notes be cleared by security personnel. Beard, ix.

use as an ICBM, even when compared to the Atlas, which was deployed in much larger numbers despite its own shortcomings as an ICBM.[443]

Beard argued that the air force's bureaucratic resistance to ICBMs delayed the development of an American ICBM until 1954, when the changeover of administrations overcame the air force resistance and led to the creation of an American ICBM. "My opinion is that the United States could have developed an ICBM considerably earlier than it did but that such development was hindered by organizational structures and belief patterns that did not permit it," Beard wrote, noting the air force's preference for aircraft and particularly bombers, which he contrasted to its "neglect and indifference" of ICBMs before 1954. Beard gave very little attention to the problems that the air force faced with the pace of advances in jet aircraft and nuclear weapons.[444] He contended that missile development was slowed first because air force leaders saw long-range missiles as "Buck Rogers" weapons of the distant future, and quoted public statements by Wernher von Braun and Walter Dornberger about the possibilities at war's end for their own V-2s to back up his contention that the required missile technology was close at hand in 1945.[445]

While this dissertation has reached very different conclusions from those of Beard, the present author acknowledges that *Developing the ICBM* remains a groundbreaking work in the history of missiles because it was arguably the first book in this subject area to try to put these weapons into their social context and away from the all-too-common concentration on the individual artifact. For this, *Developing the ICBM*

---

443 Beard, *Developing the ICBM,* 4. As mentioned, only six launch complexes were built for the R-7. By the end of 1962, 123 operational Atlas ICBMs were on station. Siddiqi. *Challenge to Apollo*, 213; Sheehan, *A Fiery Peace in a Cold War,* 396-406.
444 Beard, *Developing the ICBM,* 8, 218; Perry, *The Ballistic Missile Decisions,* 5.
445 Beard, *Developing the ICBM,* 218-21.

represents an important milestone on the way to the New Aerospace History mentioned elsewhere in this dissertation.

Cultural Resistance

Both Perry and Beard were heavily influenced by Elting E. Morison, the eminent MIT historian of the culture of technology, and his classic 1950 essay, "Gunfire at Sea: A Case Study of Innovation." Morison outlined the troubles surrounding the U.S. Navy's adoption of continuous-aim gunnery from its ships in 1900 to 1902 after the process had been created in the Royal Navy in 1898. Prior to the invention of continuous-aim gunnery, guns could be fired from ships only at certain times while a ship was rolling. In 1900, a junior officer in the U.S. Navy, William S. Sims, introduced the idea to his colleagues. In spite of the great improvement this new method of gunnery represented for naval gunnery, the idea met strong resistance inside the U.S. Navy that was only overcome with the personal intervention of President Theodore Roosevelt. This change in practice was resisted because it portended and ultimately led to numerous social and procedural changes aboard ships, Morison explained. The sailors and officers identified themselves with the existing guns and procedures, and resisted change because of this identification. "The opposition, where it occurs, of the soldier and the sailor to such change springs from the normal human instinct to protect oneself, and more especially, one's way of life," Morison wrote. Perry, in his turn, compared air force officers' "deep and sincere opposition to the accelerated development of ballistic missiles" between 1950 and 1955 to the 1890s U.S. Navy as described by Morison.[446] The air force officers' stand, Perry explained, represented "cultural resistance to the innovation represented by

[446] Morison's essay was published as a chapter of Elting E. Morrison, *Men, Machines and Modern Times* (Cambridge MA: The MIT Press, 1966) 17-44. See Morison, 35-40.

ballistic missiles." Beard highlighted Perry's statements about the air force's cultural resistance to change, and Morison's ideas about the need for outsiders to make change in military practice. Beard concluded that the USAF's treatment of the bomber and the ICBM both show that a "revolutionary new weapon may be subordinated to outdated doctrine or outdated methods" in the wrong hands.[447]

This dissertation argues that the air force's attitude to missiles before 1954 is not directly comparable to the navy's resistance to the new method of gunnery from 1900 to 1902. The new gunnery method involved some minor changes to the guns, training and practice for the gunners, and it had already been invented and was ready for almost immediate implementation on ships. Despite the ease of implementation, the new process ultimately led to a major enhancement in the status of gunners and what Morison called the "dislocation" of naval society. ICBMs overtaking bombers would undoubtedly lead to a great dislocation in air force culture. But even in 1954, the deployment of the first American ICBM was still five years in the future and the maturation of ICBMs as a weapons system was another five years beyond that. Before 1954, the ICBM was far from being a proven weapon or even a viable concept. While air force leaders were aware in the early 1950s that a change from bombers to ICBMs would severely disrupt the society of the air force, it is questionable whether this was a major factor in decision-making at this time because the ICBM was so far from being proven. The position of those in the USAF and elsewhere in the U.S. government who supported ICBMs was strengthened by the possibility that the Soviet Union was developing ICBMs and the probability that the Soviets were developing missiles to shoot down bomber aircraft, rendering bombers more vulnerable and less effective. This study has shown that various

[447] Perry, *The Ballistic Missile Decisions,* 25-7; Beard, *Developing the ICBM,* 8, 229-35.

military and civilian leaders, including President Truman, had pressed defensive anti-aircraft missiles, which shows that this danger to bombers was being taken more seriously by 1951. As noted above, Curtis LeMay remained opposed to ICBMs until the Minuteman ICBM program began in 1958. While LeMay's opposition to ICBMs between 1954 and 1958 might more aptly fit the comparison that Beard and Perry made between the air force's resistance to ICBMs before 1954 and the U.S. Navy's opposition to new firing methods at the beginning of the twentieth century, the fact that LeMay's opposition disappeared in the face of an ICBM system that was far superior to Atlas and Titan suggests that LeMay's attitude to ICBMs represented something other than simple cultural resistance to missiles.[448] Indeed, the matter of the air force's changing attitude to ICBMs that came with the arrival of Minuteman would be a good topic for future study of how a large organization like the USAF adapted to such an important technological change.

Thomas Hughes' analysis

One of today's foremost historians of technology and technological change, Thomas P. Hughes, examined the Atlas program in a section of his 1998 book *Rescuing Prometheus.* There he argued that "a conservative momentum, or inertia" slowed the program before 1953, an inertia that involved "both institutions and hardware."[449] But he wrote that in 1952 and 1953, a "confluence of scientific and technological events substantially altered Air Force policy" when it learned that lightweight thermonuclear warheads were possible, and a decline in Soviet bomber production suggested that the

---

[448] Morison, *Men, Machines and Modern Times,* 23-37; Sheehan, *A Fiery Peace in a Cold War,* 412-5.
[449] Hughes, *Rescuing Prometheus*, 77.

Russians were turning to missiles.[450] Summarizing Morison's arguments in the case of naval gunnery, Hughes explained that Donald Quarles and Trevor Gardner provided the necessary force to overcome this inertia both among air force officers and skeptics of missiles in the scientific community such as Vannevar Bush, much as Theodore Roosevelt had done a half-century earlier with the navy's resistance to new gunnery practices. Hughes added that "physical objects with specific characteristics generate a resistant mass weighted in favor of the status quo."[451] While Hughes did not elaborate further on this point in *Rescuing Prometheus*, he wrote elsewhere that large technological systems become large vested interests of their own as the people who run them develop specialized skills and knowledge especially for individual systems. A change in or loss of the system would result in these people becoming de-skilled and would result in the loss of hardware capital. The skilled operators and financial backers of these systems "construct a bulwark of organizational structures, ideological commitments, and political power to protect themselves and their system," Hughes explained, generating conservative momentum where mature systems can block newer systems that challenge them. In the case of the air force, the conservative momentum of bomber aircraft and their skilled personnel were seen as standing in the way of ICBMs.[452]

In the period covered by this dissertation, the U.S. Air Force was consumed in building a technological system to deliver nuclear weapons to its Cold War adversary, the Soviet Union, should war break out. As has been argued in the first chapter, the air force faced a number of problems in creating this system – reverse salients in Hughes'

---

[450] Hughes, *Rescuing Prometheus,* 80.
[451] Hughes, *Rescuing Prometheus*, 77.
[452] Hughes, *Rescuing Prometheus*, 76-84; Thomas P. Hughes, *American Genesis: A Century of Invention and Technological Enthusiasm, 1870-1970* (Chicago: The University of Chicago Press, 2004) 459-61.

terminology – including the need for bomber aircraft that could deliver bombs deep inside the Soviet Union and return to base, measures to protect these bombers including fighter aircraft and air-to-air missiles, training crews capable of flying bombers in a timely and effective manner, and building and making available sufficient stocks of nuclear weapons. In *Rescuing Prometheus,* Hughes quoted Perry saying that air force officers resisted ICBMs because of their "affection" for bombers and Beard arguing "the Air Force bureaucracy instinctively resisted radical innovation as disrupting established procedures and diluting the power of the bureaucracy."[453] While there is some truth to these assertions, they suggest that the air force was a comfortable and almost static institution during the first decade after World War II. In fact, that decade saw many changes in the air force that severely challenged feelings, established procedures, and the "status quo" mentioned by Hughes. In the early months after the war, the air force went through a rapid demobilization and then in the next few years had to rebuild its personnel base. The air force had to make the change from propeller to jet aircraft, itself a major shift. And the arrival of nuclear weapons in 1945 also marked a radical departure in doctrine and operating procedures. And as was discussed in the first two chapters of this study, the air force fought for and gained its long-sought autonomy from the U.S. Army in 1947. Even without missiles in the mix, the first decade after World War II was one of serious change for the U.S. Air Force.[454]

[453] Hughes, *Rescuing Prometheus,* 76-9. Hughes also provided a good summary of Schriever's and Simon Ramo's work in advancing systems engineering and in making Atlas and Titan a reality, 73-139.
[454] See Borowski, *A Hollow Threat.* The air force's postwar challenges are also extensively canvassed in Chapter1 of this dissertation.

From McDougall to the New Aerospace History

Walter A. McDougall's landmark history of the space race appeared in 1985. Although McDougall, a historian of diplomacy, took a more critical look than previous writers at the underpinnings of the space race, he continued the trend to view the Sputnik-sparked space race as a major turning point in human history, despite mounting evidence that this was not the case. In his discussion of early postwar missile work in the U.S., McDougall used many points from Beard's book, but he firmly placed missile development inside the context of wider developments in the Cold War and in the struggle between the services in Truman's postwar military reorganization. He argued that "the navy could scarcely penetrate Soviet waters, and no one wanted to maintain land forces comparable to the Red Army. That left air power as the only deterrent to renewed Soviet expansion – as well as the only means by which the USSR might assault North America."[455] Because Congress declined to create a unified military research and development agency, the services were left to run their own research and development, with the army and navy using the traditional arsenal system and the air force opting for private contractors that were hurting badly in the wake of the loss of wartime business, McDougall explained. The deepening confrontations of the Cold War in the late 1940s, culminating in the Korean War, ended Truman's attempts to restrain military spending, including spending on missile programs. McDougall's research led him to endorse Beard's judgment that Keller was ineffectual. He concluded that the creation of lightweight thermonuclear weapons broke down air force resistance to ICBMs, this decision being formalized early in 1954 following reports from RAND and the Tea Pot committee. This brought McDougall's account to a central point of his thesis – that the

[455] McDougall, *…the Heavens and the Earth,* 88.

space race and the Cold War arms race created competing technocracies in the United States and the Soviet Union.[456]

USAF historian Jacob Neufeld, in his 1990 book on the air force's missile programs between 1945 and 1960, concentrated on the air force's institutional rivalry with the army and navy for control of missile programs and gave little attention to the wider political situation or the other issues facing air force leaders at the time. He did not highlight outside advice the air force received, either from bodies like the RDB or from the RAND Corporation. Neufeld wrote that inter-service rivalry over ballistic missiles "postponed final decisions and unnecessarily delayed the programs." The air force ballistic missile program "foundered" because it lacked "an institutional advocacy group when it competed for funds." In Neufeld's account, the jostling for position between the services went on until the reorganization of military research and development under Eisenhower.[457] Like Beard, Neufeld used air force documents and official air force histories by Ethel DeHaven, much of which is classified, and by Mary Self and Max Rosenberg, which have been declassified.[458]

In his 1996 Ph.D. dissertation on Gen. Bernard Schriever's role in Atlas, John Clayton Lonnquest argued that the air force did not strongly support missiles, and that Trevor Gardner and Schriever "waged a carefully orchestrated campaign, much of it conducted outside of the Air Force," to accelerate Atlas. Lonnquest wrote that Atlas' success has been attributed to three factors, including new technology in the form of lightweight thermonuclear warheads, new leadership by Schriever, and the new management philosophies that helped bring Atlas to completion. In a prelude section to

---

[456] McDougall, *...the Heavens and the Earth,* 3-6, 81-107, note 28, 480.
[457] J. Neufeld, *Ballistic Missiles in the USAF,* 1-107.
[458] M. Rosenberg, *The Air Force and the National Guided Missile Program 1944-1950.*

the main body of his work, Lonnquest argued that before 1953, the air force favoured winged missiles over ballistic missiles for several reasons, including winged missiles' resemblance to aircraft. One reason for this bias was that wingless ICBMs might strengthen Army Ordnance's case to run the missile program because ballistic missiles resembled artillery shells more than winged aircraft. In the late 1940s, the USAF's "small cadre of missile advocates had neither the organizational support nor the technological viability" to press for the ICBM, he wrote, a situation that had changed by 1951.[459]

Rip Bulkeley's 1991 study of the Sputnik crisis in the U.S. included the most thorough examination to date of the attitudes of those in the upper reaches of the Truman administration toward rockets and space. But, like so many other writers, Bulkeley looked backward from the launch of Sputnik and the perceived security crisis that followed it, rather than examining the actions of the Truman years in their own context, arguing that "the Republican point about Truman's neglect of missile projects was considerably more relevant than was conceded at the time." In a work based on congressional and presidential documents, along with secondary sources, Bulkeley minimized the impact of air force preference for aircraft over missiles, writing that the air force faced severe budget pressures at the time.[460]

Unlike most other writers, Bulkeley explained that ICBMs, along with other nuclear weapons delivery systems, were hobbled due to inadequate target maps and other information about potential targets, both inside and outside the Soviet Union. Because even maps of parts of the United States were inadequate for targeting, a great deal of work on geodesy was required before these long range systems could be deployed. He

---

[459]Lonnquest, "The Face of Atlas: General Bernard Schriever and the Development of the Atlas Intercontinental Ballistic Missile, 1953 – 1960," 1-6, 23-4, 40.
[460] Bulkeley, *The Sputniks Crisis and Early U.S. Space Policy,* 11, 12, 38-44.

also wrote that administration officials were able to obtain limited intelligence information on Soviet rocket programs through open literature, questioning of German experts who worked for the Soviets but were isolated from them, and defectors such as Grigory Tokady-Tokaev. Bulkeley wrote that the intelligence estimates of Soviet rocket programs were more accurate in the late 1940s than the intelligence estimates in the early 1950s, and tended to downplay Soviet capabilities. To him, the intelligence on the Soviets and what was done with it constituted a "neglected historical puzzle." His book asserted that Theodore von Kármán of Caltech had wanted ICBM research to proceed in a "gradualist" manner, and while Bulkeley did not dismiss the work of Keller as others had done, he argued that Keller promoted winged missiles and defensive missiles at the expense of ICBMs.[461]

A technical issue that has often been raised is the poor accuracy that sharply limited the effectiveness of German V-2 missiles and early postwar American missiles. But Donald MacKenzie's landmark 1990 study *Inventing Accuracy* questioned widely held assumptions about the importance of accurate guidance to the early development of ICBMs. In a section based largely on Beard's *Developing the ICBM* and other secondary sources, MacKenzie wrote that before the time of the Tea Pot Committee, accuracy requirements were set too strictly for ICBMs. But even so, ICBMs were going to require a "quantum leap in accuracy from the V-2." The air force's preference for bomber aircraft over missiles during this time may have driven accuracy requirements for missiles, he suggested. In discussing the factors that led to a higher priority for ICBMs in 1953 and 1954, MacKenzie highlighted the importance of the change of administration over the thermonuclear breakthrough and intelligence on Soviet missiles. MacKenzie

[461] Bulkely, *The Sputniks Crisis and Early U.S. Space Policy,* 49, 61-78.

wrote that Eisenhower's appointees, particularly Trevor Gardner, brought a new attitude to missiles to the Pentagon.[462]

In the late 1980s and 1990s, the fall of the Soviet Union and the temporary openings of relevant archives in both the United States and Russia made new information available about the history of the Cold War, including missiles and space exploration. As the Cold War, the space race and the missile race recede into the past, historians are re-examining the suppositions that underpinned previous treatments of the development of missiles and spacecraft. As mentioned earlier, historian Roger D. Launius wrote in a 2000 essay on the historiography of space exploration that a New Aerospace History was emerging out of the changes that came with the passage of time and the end of the Cold War. Among other things, Launius critiqued the "overemphasis" placed on the role of the von Braun rocket team in the development of United States rocket technology at the expense of the missile development carried out by the USAF and American aerospace contractors.[463]

Historians are also reassessing the place of Sputnik. In 1997, McDougall wrote that he was moving away from his 1985 judgment that Sputnik was a "saltation, an evolutionary leap," saying that: "In retrospect … the post-Sputnik burst of enthusiasm for state-directed technological revolution seems to have been an ephemeral episode in the larger history of the Cold War, rather than the Cold War having been an episode in the

[462] MacKenzie, *Inventing Accuracy,* 98-115.
[463] Roger D. Launius, "The historical dimension of space exploration: reflections and possibilities," *Space Policy* 16 (2000) 23-8. Many of the issues considered here are also explored in recent volumes from the NASA History Office, such as Steven J. Dick and Roger D. Launius, eds. *Critical Issues in the History of Spaceflight* (Washington, D.C.: National Aeronautics and Space Administration, 2006), especially Asif A. Siddiqi's essay, "American Space History: Legacies, Questions, and Opportunities for Future Research," 433-80.

larger story of the march of technocracy."[464] Historian Alex Roland in 2001 called the post-Sputnik controversy in the United States a turning point in the campaign of military and industrial interests for "more and better weapons, expansion of roles and missions, and mobilization of the civilian economy in the service of the state," where the public fear of that time compounded the power of what Eisenhower in 1961 famously called the "military-industrial complex."[465] Such an assessment of Sputnik opens the question of whether the Sputnik-influenced historiography of the Cold War period itself helped fuel the arms race of that time.

Conclusion

The Atlas, Titan and Thor rockets produced by the USAF for use as strategic missiles eventually played important roles in America's space programs. But they were not used for that purpose until more than a year had passed after Sputnik, so they did not take a prominent place in the early historiography of military missiles and rockets used in space programs. Instead, the air force and its contractors took a back seat in historical accounts to the work Wernher von Braun and his army missile team did leading to the launch of America's first satellite. With the exception of official NASA histories, Atlas received very little attention from historians until Robert Perry and Edmund Beard produced their influential accounts. While Beard tried to put Atlas into a perspective that accounted for social forces influencing the people producing it, his viewpoint was still strongly influenced by Sputnik and the perception that America had lost the early space

[464] McDougall, *...the Heavens and the Earth*, 6; Walter A. McDougall, "Introduction: Was Sputnik Really a Saltation?" from Roger D Launius, John M. Logsdon, and Robert W. Smith. *Reconsidering Sputnik: Forty Years Since the Soviet Satellite* (Amsterdam, The Netherlands: Harwood Academic Publishers, 2000) xviii.
[465] Roland, *The Military-Industrial Complex,* 8.

race and the early missile race. That belief is falling out of favour in the face of new information and fresh analyses by historians.

Among the factors that must be considered in assessing the historiography of Atlas and its Soviet R-7 competitor is their history as ICBMs, which was briefly recounted in this chapter. The popular and historical writing on these missiles took little account of what happened while these ICBMs were being brought into military use following their early test flights in the late 1950s. America's first ICBM, the Atlas, was better suited to its task than the Soviet R-7 and thus gave the United States a decisive edge in the early years of ICBM activity. This overturns the premise underlying Edmund Beard's account and others that the Soviets developed their ICBM ahead of the United States. Historians such as McDougall and Roland have reassessed the place of Sputnik in history. This study reassesses the place of the R-7 missile that carried Sputnik into space, and above all America's first ICBM, the Atlas.

This study has argued that the leaders of the USAF did not show undue resistance to the idea of ICBMs before moving ahead with them in 1954. Indeed, the idea that air force resistance to ICBMs before 1954 is similar to the U.S. Navy's resistance to new firing methods early in the twentieth century does not seem to make sense because even in 1954, ICBMs were still years away from being introduced. And the air force of the first decade after World War II was undergoing major changes even without considering missiles. Even when Curtis LeMay showed resistance to Atlas after 1954, he changed his tune on ICBMs years later when the Minuteman ICBM showed itself to be superior to Atlas as a weapon.

To properly consider the forces that led to the development of Atlas, this missile and the Soviet R-7 missile it was so often compared with must be considered as weapons, which was their primary function, rather than as space launch vehicles. The launch of Sputnik by an R-7 led to a crisis of confidence in the United States that affected the historiography of early space efforts and ICBM programs. The idea that the United States lost the race with the Soviet Union to build the first effective ICBM has obscured a realistic examination of the development of these weapons and of the forces that drove that development. Indeed, as Alex Roland has pointed out, the narrative that surrounded ICBMs and early space programs itself became a force driving their development.

Chapter 8
Conclusions

This dissertation disagrees with the major conclusion advanced by historians such as Edmund Beard that bureaucratic resistance inside the U.S. Air Force unduly slowed down the development of America's first ICBMs. Indeed, this study does not even accept the premise behind that conclusion – that the United States fell behind the Soviet Union in the competition to develop ICBMs, as was widely believed in the wake of Sputnik.

The most important factor leading to the creation of America's first ICBM, the Atlas, was the creation of the thermonuclear bomb, which at a stroke made ICBMs feasible as a weapons delivery system. The thermonuclear bomb was much lighter than early fission bombs, sharply reducing the weight, size and complexity required for the ICBM. And due to the fact that thermonuclear bombs were hundreds of times more powerful than early fission bombs, the necessity of accurately guiding these weapons to their targets was greatly diminished.

Recent scholarship on the Soviet missile program has shown that its evolution shares a number of similarities with the United States missile program between 1945 and 1954. Even though Soviet ballistic missiles were assigned to the army's artillery forces, the Soviets also worked to develop long-range winged missiles in the 1950s, and earlier on, the Soviets seriously examined the idea of building a rocket-powered antipodal bomber. Like the United States, the Soviet Union did not formally approve building an ICBM until 1954. In both cases, the ICBM programs began in earnest after the creation of powerful thermonuclear weapons, although the Soviets started building ICBMs without being aware of the possibility of lightweight thermonuclear bombs. The evolution of Soviet ballistic missiles underlines the importance of thermonuclear bombs and the vast increase in explosive power they represented over fission bombs in making ICBMs a viable weapons system.

The criticism directed at the U.S. Air Force for not moving on ICBMs before 1954 flies in the face of several realities. The air force in the United States saw most of its wartime personnel return to civilian life when World War II ended. As Cold War tensions began to mount in the months that followed, the air force had to rebuild itself by designing and manufacturing new aircraft using new technologies like jet engines that were capable of carrying nuclear weapons and for a time, conventional bombs, intercontinental distances. The air force also had to recruit and train personnel to fly these aircraft. These tasks took years to accomplish.

In the early years after the war, the U.S. government moved slowly to develop policies to deal with control of nuclear weapons. The Cold War struggle between the United States and the Soviet Union took some time to get under way, and the U.S. had a monopoly on nuclear weapons until the first Soviet nuclear explosion in August 1949. Many Americans, recoiling from the destruction wrought by the two nuclear bombs dropped on Japan in August 1945, understandably questioned the need for nuclear weapons. America's first policy on nuclear weapons was a proposal for international control of nuclear weapons and resources that the Soviet Union rejected late in 1946. In September 1948, President Truman finally promulgated the first policy statement covering the use of nuclear weapons. Against this background, U.S. military and political leaders of the late 1940s did not view long-range strategic missiles as a priority.

The five years between World War II and the Korean War was a time of relative austerity for the United States military, including the air force. In contrast to the huge outlays that sustained the U.S. military during World War II, the sharp budget cuts after the war stretched the resources of armed forces involved in occupation work and preparations for future conflicts, duties never borne by the military before the war. Historians have written a great deal on Truman's financial restraint policy for the military and the effect it had in several areas.[466] Ballistic missile programs such as the MX-774 rocket were cut because the promised a payoff in the long term, while other weapons programs seen to have short-term utility, such as bombers and anti-aircraft missiles, continued to receive funding.

In the first two years after the end of World War II, air force leaders were focused on their effort to win autonomy from the army and to fight off challenges to its new roles, especially those involving nuclear weapons, from the army and the navy. The air force won its autonomy from the army in 1947, but the army and the navy both continued to contest the U.S. Air Force's monopoly on nuclear weapons. The navy's challenge to the USAF's nuclear monopoly continued until the 1949 admirals' revolt, and resumed in the 1950s with Regulus winged missiles, and later with submarine-launched ballistic missiles that broke the air force's control over strategic nuclear weapons. Long-range guided missiles became a prime area of contention between the army and the air force, and this contest continued into 1950, when the issue appeared to be settled in the air force's favour, before resuming later in the decade. In contrast to the United States, Nazi Germany and the Soviet Union had given control of long-range missiles to their armies. While it is futile to speculate how United States ICBMs would have developed under the

---

[466] The histories of the air force during this time, including Borowski,'s *A Hollow Threat: Strategic Air Power and Containment before Korea* deal with these financial issues. An in depth treatment is found in Schilling's essay, "The Politics of National Defense: Fiscal 1950" in Schilling et al., *Strategy, Politics and Defense Budgets.*

control of the army, the outcome of the missile dispute between the services had important impacts on the development of missiles and the space race in the 1960s.

The air force's formal priority lists for missile development in the late 1940s put anti-aircraft missiles and missiles that supplemented the capabilities of bomber aircraft at the top, with long-range missiles well down the list. In 1950, growing concern over the slow pace of missile development caused Truman to get involved in the matter and appoint a missile czar, a policy entrepreneur to expedite missile programs. Truman and his military leaders renewed the top priority placed on missiles to defend the U.S. against Soviet bombers, and K.T. Keller, the Defense Department's Director of Guided Missiles, brought the Nike anti-aircraft missile into production and expedited other similar missile programs. Longer-range guided missiles were not a priority for anyone outside of a small circle that included the contractor that had worked on a prototype long-range ballistic missile, the MX-774, and a few air force officers. So Keller did little to move long-range strategic missiles ahead.

The high priority placed on missiles designed to defend against both aircraft and other missiles by the air force and higher authorities, including the Guided Missiles Committee and even President Truman, is a theme that has appeared repeatedly in this study. The U.S. Army's Nike anti-aircraft missile topped the list of programs expedited by K.T. Keller, and later generations of Nikes were built to defend against Soviet ICBMs in the 1960s and 1970s. These systems were shelved temporarily as a result of budget cuts and questions about the effectiveness against ICBMs. The Anti-Ballistic Missile Treaty of 1972 also sharply restricted missile defenses. But on 23 March 1983, President Ronald Reagan launched the Strategic Defense Initiative (SDI), which involved a massive increase in spending on defenses against missiles. Since that time, missile defense programs have consumed large amounts of money – an estimated $60 billion was spent on missile defense between 1983 and 1999 – and remain an issue that divides liberals and conservatives in the United States to the present day. President George W. Bush withdrew the United States from the ABM Treaty in 2002 and ballistic missile defenses have been deployed despite continuing questions about their utility. Edward Teller, who a generation before had lobbied to build political support for the thermonuclear bomb, was a key public supporter of SDI.[467] The repeated emphasis given to defensive missiles during the time covered in this study suggests that the political support for missile defense systems in the United States has deeper roots than has been believed. Beard's *Developing the ICBM,* which ignores the issue of defensive missiles, was completed and published in 1976, during the decade between the signing of the ABM Treaty and Reagan's launch of SDI when ballistic missile defense was not formally on the political agenda in the United States.

During the late 1940s and 1950, air force research into long-range rocket missiles moved slowly, in part due to technological problems affecting these weapons, including difficulties hitting distant targets with any accuracy and protecting warheads from the great heat encountered on the return from high altitudes to the target. While its experts grappled with these problems, the air force also conducted research into other propulsion technologies, including ramjet engines and nuclear propulsion, and both those technologies fell by the wayside. Kenneth P. Werrell, a former air force historian, wrote

---

[467] The $60 billion figure comes from one of the best known critical works on SDI: Frances FitzGerald, *Way Out There In the Blue: Reagan, Star Wars and the End of the Cold War* (New York: Simon and Schuster Inc., 2000) 498. FitzGerald also discusses Teller's role in SDI. See also Donald R. Baucom, *The Origins of SDI, 1944-1983* (Lawrence, KS: University of Kansas, 1992).

in 2009: "With limited funds the ballistic missile faced a 'Catch-22' situation of not having enough money to develop and demonstrate its capabilities, and not being able to get money because it had not demonstrated its capabilities."[468] There is some truth to this argument, but these missiles would not be able to fully show their capabilities until the thermonuclear bomb became available after 1954.

This study argues that the Research and Development Board and the Guided Missiles Committee of the Department of Defense were ineffective and did little to move military guided missile programs ahead, particularly in a period of conflict between the services over roles and responsibilities for missiles in the late 1940s. The RDB and the GMC, which the RDB's first leader, Vannevar Bush, hoped would provide civilian experts with a powerful and independent role guiding military weapons research, failed because military leaders successfully resisted losing control of their weapons programs to such independent bodies. These bodies were scrapped when the Eisenhower Administration took over from the Truman Administration in 1953.

Instead of the independent civilian scientists and engineers directing weapons research as hoped for by Bush, civilian experts hired by the air force and effectively under their control played key roles in persuading politicians, administrators and military officers of the importance of new weapons such as the ICBM. Scientists like Edward Teller had lobbied politicians to move ahead with the thermonuclear bomb in 1950. Three years later, John von Neumann persuaded leaders of the USAF like Trevor Gardner and Gen. Bernard Schriever that light weight thermonuclear bombs of great power could be built, making ICBMs technically and economically feasible. Von Neumann also influenced other scientists who served on the air force's Scientific Advisory Board, and

[468] Werrell, *Death From the Heavens*, 249.

he chaired the Tea Pot Committee that drew up the recommendation that Atlas proceed. Other experts from RAND endorsed his recommendations. Von Neumann and others built on the work of air force-affiliated engineers and scientists who took part in the debates on nuclear-armed long-range missiles from the moment they were conceived in 1945, starting with Theodore von Kármán and Hugh Dryden's advocacy for long-range missiles. In the late 1940s, the USAF received outside technical advice from the RAND Corporation supporting winged missiles until new research findings at end of the decade caused RAND to change its advice to change and promote ballistic missiles without wings. The RAND report by Bruno Augenstein in 1954 helped herald the importance of thermonuclear weapons in changing requirements for ICBMs. Furthermore, the 1952 discovery by U.S. government scientists of blunt body re-entry vehicles for warheads was also important in opening the way for ICBMs.

Technological, scientific and political events in 1952 and 1953 transformed the Atlas program from a study into an active and high profile program to develop an ICBM. The arrival of the Eisenhower administration saw the RDB and the GMC give way to new administrative structures and the arrival of new policy entrepreneurs such as Trevor Gardner. But by far the most important scientific and technological event in the development of U.S. ICBMs before 1954 was the creation of the thermonuclear bomb in 1952, and the prediction, soon realized, that lightweight thermonuclear bombs would soon be available. This thermonuclear breakthrough meant that the ICBM would not have to be a behemoth as was projected before 1954, and that stringent accuracy requirements could be relaxed because of the great power of thermonuclear bombs relative to fission weapons.

While the creation of the lightweight thermonuclear bomb was crucial to the development of Atlas and other ICBMs, this does not mean that technology was "in the driver's seat," as Ohio State history professor John F. Guilmartin argued in a recent paper. Technology remained one of the factors that led to the creation of Atlas, including political, economic and military factors, as argued by Thomas Hughes. Guilmartin himself acknowledged that both Atlas and the R-7 contained compromises in their designs to get them into production as soon as possible, an acknowledgement of human agency in their creation and design.[469]

Atlas and other ICBMs were part of a technological system created by the U.S. government to deliver nuclear weapons to strategic targets in its Cold War adversary the Soviet Union. The system began with fission bombs and bomber aircraft in 1945 and grew in the 1950s and 1960s to encompass thermonuclear weapons carried by bombers, ICBMs and submarine-launched ballistic missiles. This study has featured historian Thomas Hughes' ideas about technological systems as entities subject to social, political and economic influences as well as technical factors, and as entities that help shape the societies they operate in. The influence of governmental bodies and experts from the world of science and engineering on the development of this technological system has been emphasized in this dissertation. While social, economic and political factors such as postwar budget austerity and the air force's effort to win control over guided missiles affected the development of U.S. military guided missiles in the late 1940s, changes in technological factors, notably the creation of lightweight thermonuclear bombs in 1953 and 1954, along with advances in the development of technologies such as blunt bodied

---

[469] John Guilmartin, "The ICBM and the Cold War: Technology in the Driver's Seat," from Robert Cowley, ed. *The Cold War: A Military History* (New York: Random House, 2005) 423-37. Siddiqi, in *Red Rockets' Glare,* 243, also takes issue with Guilmartin's thesis.

re-entry bodies, outweighed political factors such as the1953 change of administration in facilitating the 1954 decision to aggressively develop the Atlas ICBM. This judgment contrasts with Beard's contention that social factors inside the air force blocked development of the Atlas prior to 1954.

The final price tag for the Atlas ICBM was significantly larger than any missile developed to that time and outstripped all cost estimates made in the late 1940s for such a missile. It was clear to air force leaders that research and development costs for ICBMs would outstrip similar costs for piloted aircraft, simply because each missile could only be flown once, while crewed aircraft are usually flown multiple times. As historian Stephen Johnson put it, the air force policy of "fly before you buy" using a few or even a single prototype would not apply with missiles; even for testing a production line would be needed.[470]

In considering these monetary costs, one should remember Gen. Donald Putt's 1949 speech quoted in Chapter Four, where he estimated that the cost of a satellite launcher would put a strain on the national economy. Putt's speech was unusual because instances of air force leaders questioning the cost of potential weapons systems in public were extremely rare. The author found no such statements from air force officials before 1954 raising such a question about missiles or bomber aircraft. Just the year before Putt spoke, Walter Dornberger, who had headed Germany's development program for the V-2, had predicted that 500 missiles would have to be test fired before a missile could be considered operational. Launching and losing 500 missiles in a test program would be

---

[470] Johnson, *The Secret of Apollo,* 32.

very expensive.[471] It turned out that Dornberger's prediction was overly pessimistic, but the monetary costs of developing ICBMs and satellite launchers were certainly much higher than Putt and others had feared in 1949.[472]

This dissertation has attempted to transcend the heavily Sputnik-influenced views of early historical work on America's ICBMs, but it has not tried to evaluate the overall value or the ultimate cost of ICBM weapons. While the Cold War that led to the creation of ICBMs ended two decades ago, ICBMs and the systems being developed to defend against them remain a prominent part of the arsenals of the United States, Russia and China, and nuclear-armed missiles have been deployed and are being developed by many other nations. Hence the ultimate value or utility of these missiles remains open to debate. The claims that ICBMs and other nuclear weapons deterred a major war between the superpowers is widely believed, as has been noted earlier in this study, but the author believes that these claims require more study.

Historian Alex Roland, in his monograph on the military-industrial complex of the Cold War period, argued that U.S. weapons systems were often not measured against those possessed by the Soviet Union or by potential adversaries, but against "the next generations of weapons systems that industry could envision" for fear that America's adversaries might develop such weapons first.[473] Although Roland did not specifically mention ICBMs in this context, the controversy in America over ICBMs following the launch of Sputnik in 1957 fueled missile programs for many years, and was frequently

---

[471] Col. Millard C. Young, Procurement Presentation Guided Missiles United States Air Force to Special Committee of the JCS, 9 September 1948, in RG 341, Guided Missiles Branch, Box 129, file "F-180 'Production' Program, Fy-48," NA.

[472] Interestingly, the Vanguard satellite and booster program cost $110 million up to 1958, or $840 million in 2011, similar to Putt's $100 million estimate in 1949. But larger and more expensive rockets were used to launch satellites after that time. Green and Lomask. *Vanguard – A History,* 130.

[473] Roland, *The Military-Industrial Complex,* 15.

invoked to support weapons programs of all kinds during the Cold War. Beard's *Developing the ICBM,* written in the 1970s at a time when the air force was lobbying for new weapons systems such as the B-1 bomber and the MX ICBM, and when these types of weapons were facing organized public opposition for the first time, may have unwittingly fed into the phenomenon of promoting the next weapon system by warning of bureaucratic foot dragging leading to what was seen as the Sputnik debacle. Today we know that the peril America faced at the time of Sputnik was more illusory than real.

This study has examined how the development of American long-range missiles was affected by the policies of U.S. government agencies, contractors and experts during the nine years between the end of World War II and March 1954, when the Atlas ICBM won air force approval. Strongly influenced by the political crisis that followed the launch of Sputnik in 1957, historians have written that the government, and particularly the U.S. Air Force, slowed the development of these missiles. But in the past two decades, newly available information that followed the end of the Cold War and other changes have caused historians to re-examine the history of missiles and the space race. This new information, and the perspective that comes from moving out of Sputnik's shadow, suggests that the air force acted quickly to develop ICBMs when progress in nuclear weapons and missile technologies made them feasible. Moreover, the air force proceeded with ICBMs based on expert advice it received from outside experts, albeit experts the air force had chosen and strongly influenced.

The historiography criticizing the air force for not moving ahead more aggressively with ICBMs and at an earlier time than it did has been highlighted throughout this study. In defending the air force against this criticism, it is important to note that the author uncovered no criticism of the air force for moving too aggressively with ICBMs once Atlas began in earnest in 1954. Until the Sputnik controversy in 1957, the U.S. military's work with missiles received only limited degrees of interest from the public, the media, and Congress. In 1957 and for some time afterward, the U.S. military and its political overseers came under strong attack for having lost the race with the Soviet Union to develop ICBMs, a charge which does not stand up to scrutiny. Because the line of reasoning that the United States had fallen behind the Soviet Union in ICBMs has been shown to be incorrect, it is important to correct the historiography of this matter, if only to restore balance to the dialogue over highly expensive weapons systems.

Bibliography

Archival Sources

Records Group 156, Records Relating to the U.S. Army Guided Missiles Program, National Archives, College Park, Maryland.

Records Group 165, War Department Special and General Staffs, National Archives, College Park, Maryland.

Records Group 218, Records of the U.S. Joint Chiefs of Staff, National Archives, College Park, Maryland.

Records Group 330, Office of the Secretary of Defense, National Archives, College Park, Maryland.

Records Group 341, Records Relating to the United States Air Force, Guided Missiles Branch, National Archives, College Park, Maryland.

RG 363.5, Records of the Central Intelligence Agency, Textual Records (General), National Archives, College Park, Maryland.

Papers from the Dwight D. Eisenhower Presidential Library, National Archives and Records Administration, Abilene, Kansas.

Papers from the Harry S. Truman Presidential Library, National Archives and Records Administration, Independence, Missouri.

General Carl Spaatz Collection, Manuscripts Division, Library of Congress, Washington D.C.

Wernher von Braun Collection, Manuscripts Division, Library of Congress, Washington D.C.

National Aeronautics and Space Administration Headquarters History Office, Historical Reference Collection, Washington, D.C.

Interview of Dr. Bruno Augenstein by Joseph Tatarewicz and Martin Collins, 28 July 1986 and 9 January 1987, RAND History Project, National Air and Space Museum, Smithsonian Institution, Washington, D.C.

Interview of Paul Blasingame by Martin Collins, 14 November 1990, RAND History Project, National Air and Space Museum, Smithsonian Institution, Washington, D.C.

Interview of Gen. Bernard Schriever by Martin Collins, 18 May 1990 and 5 September 1990, RAND History Project, National Air and Space Museum, Smithsonian Institution, Washington, D.C.

Government Reports

Arnold, Gen. H.H. *Third Report of the Commanding General of the Army Air Forces to the Secretary of War.* USAAF, 12 Nov. 1945.

Augenstein, B.W. *A Revised Development Program for Ballistic Missiles of Intercontinental Range*, Special Memorandum No. 21, Santa Monica CA: U.S. Air Force Project RAND, 8 February 1954.

Burchard, John E. *Rockets, Guns and Targets: rockets, target information, erosion information, and hypervelocity guns developed during World War II by the Office of Scientific Research and Development*. Boston: Little Brown and Company, 1948.

Committee on Government Operations, House of Representatives, 86th Congress, 1st Session, House Report No. 1121: *Organization and Management of Missile Programs.* Washington D.C.: U.S. Government Printing Office, 1959.

Donnelly, Charles J. *The United States Guided Missile Program,* Washington D.C.: Prepared for Preparedness Investigating Subcommittee, U.S. Senate Committee on Armed Services, U.S. Government Printing Office, 1959.

Joint Chiefs of Staff, *Organizational Development of the Joint Chiefs of Staff, 1942-1989.* Washington D.C.: Historical Division, Joint Secretariat, Joint Chiefs of Staff, 1989.

Office of the Assistant to the Secretary of Defense (Atomic Energy), *History of the Custody and Deployment of Nuclear Weapons July 1945 Through September 1977.* Washington D.C.: Department of Defense, February 1978.

Steelman, John R., and the President's Scientific Research Board, *Manpower for Research: volume four of Science and Public Policy: A Report to the President.* Washington D.C.: Superintendent of Documents, October 11, 1947.

Stilwell, Joseph W., et al., *Report of War Department Equipment Board.* Washington D.C.: War Department, January 19. 1946.

The President's Air Policy Commission. *Survival in the Air Age.* Washington D.C.: Superintendent of Documents, January 1, 1948.

United States Strategic Bombing Survey, *Over-all Report (European War)* September 30, 1945.

United States Department of State. *Foreign Relations of the United States*. Washington D.C.: Government Printing Office. Multi-volume, multi-year publication.

Von Kármán, Theodore, and others. *Toward New Horizons: A Report to General of the Army H. H. Arnold by the AAF Scientific Advisory Group.* Washington, D.C.: United States Army Air Forces, 15 December 1945.

Wolf, Richard I. *The United States Air Force: Basic Documents on Roles and Missions.* Washington D.C.: Office of Air Force History, USAF, 1987.

Congressional Testimony

United States House of Representatives, Subcommittee of the Committee on Appropriations, *Military Establishment Appropriation Bill for 1948*, 1st Session, 80th Congress, Washington D.C.: U.S. Government Printing Office, 1947.

United States House of Representatives, *Reorganization Plan No. 6 of 1953, Hearings before the Committee on Government Operations* 1st Session, 83rd Congress, Washington, D.C.: U.S. Government Printing Office, 1953.

United States House of Representatives, Committee on Armed Services, *Investigation of National Defense Missiles*, 2nd Session, 85th Congress, Washington D.C.: U.S. Government Printing Office, 1958.

United States House of Representatives, *Hearings Before the Select Committee on Astronautics and Space Exploration*, 2nd Session, 85th Congress, on H.R. 11881, Washington D.C.: U.S. Government Printing Office, 1958.

House of Representatives, Subcommittee of the Committee on Government Operations, *Organization and Management of Missile Programs,* 1st Session, 86th Congress, Washington, D.C.: U.S. Government Printing Office, 1959.

United States Senate, Special Committee on Atomic Energy, *Hearings before the Special Committee on Atomic Energy,* 1st Session, 79th Congress, Washington D.C.: Government Printing Office, 1946.

United States Senate, Subcommittee on the Air Force of the Committee on Armed Services, *Hearings: Study of Airpower*, 2nd Session, 84th Congress, Washington D.C.: Government Printing Office, 1956.

United States Senate, *Hearings Before the Preparedness Investigation Subcommittee, Committee on Armed Forces, Inquiry into satellite and missile programs,* 1st and 2nd Sessions, 85th Congress, Washington D.C.: Government Printing Office, 1958.

Primary Published Sources

Bradley, Omar N., and Clay Blair. *A General's Life: An Autobiography.* New York: Simon and Schuster, 1983.

Bush, Vannevar. *Modern Arms and Free Men.* New York: Simon and Schuster, 1949.

---. *Pieces of the Action*. New York: William Morrow and Company, Inc., 1970.

Chertok, Boris. *Rockets and People: Volume 1.* Washington D.C.: National Aeronautics and Space Administration, 2005.

---. *Rockets and People: Creating a Rocket Industry (Volume 2).* Washington D.C.: National Aeronautics and Space Administration, 2006.

Eisenhower, Dwight D. *Crusade in Europe.* Garden City, NY: Doubleday & Co.: 1948.

Emme, Eugene M., ed. *The History of Rocket Technology,* Detroit: Wayne State University Press, 1964.

Gantz, Lt. Col. Kenneth F., *The United States Air Force Report on the Ballistic Missile: Its Technology, Logistics and Technology.* Garden City: Doubleday & Company, Inc., 1958.

Gorn, Michael H., ed. *Prophecy Fulfilled: 'Toward New Horizons' and Its Legacy.* Washington, D.C.: Air Force History and Museums Program, 1994.

Hyland, L.A. "Pat." *Call Me Pat: The Autobiography of the Man Howard Hughes Chose to Lead Hughes Aircraft.* Virginia Beach, VA.: The Donning Company, 1993.

Khrushchev, Sergei N. *Nikita Khrushchev and the Creation of a Superpower.* University Park, PA: The Pennsylvania State University Press, 2000.

LeMay, Gen. Curtis E. with McKinlay Kantor. *Mission with LeMay: My Story.* New York: Doubleday and Co., 1965.

Logsdon, John M., ed. *Exploring the Unknown: Selected Documents in the History of the U.S. Civil Space Program, Volume 1: Organizing for Exploration.* Washington: National Aeronautics and Space Administration, 1995.

Medaris, Major General J.B., with Arthur Gordon. *Countdown for Decision,* New York: Paperback Library Inc., 1961.

Millis, Walter, and E.S. Duffield, eds. *The Forrestal Diaries,* New York: The Viking Press, 1951.

Myers, Dale D. "The Navaho Cruise Missile: A Burst of Technology," 42nd Congress of the International Astronautical Federation, October 5-11, 1991, Montreal.

Nichols, Kenneth D. *The Road to Trinity,* New York: Morrow, 1987.

Powell-Willhite, Irene E., ed. *The Voice of Dr. Wernher von Braun: An Anthology.* Burlington, ON: Apogee Books, 2007.

Project RAND. *Preliminary Design of an Experimental World-Circling Spaceship,* Santa Monica, CA.: Douglas Aircraft Company, Inc., 2 May 1946. (Republished in 1996 by the RAND Corporation)

Ramo, Simon. *The Business of Science: Winning and Losing in the High-Tech Age.* New York: Hill and Wang, 1988.

Rosen, Milton W. *The Viking Rocket Story.* London: Faber and Faber, 1955.

Sakharov, Andrei. *Memoirs.* New York: Alfred A. Knopf, 1990.

Spires, David N *Orbital Futures: Selected Documents in Air Force Space History, Vol. 1*. Peterson Air Force Base, Col.: Air Force Space Command, United States Air Force, 2004.

Truman, Harry S. *Memoirs: Vol. 1, Year of Decision.* Garden City, N.Y.: Doubleday & Co., 1955.

---. *Memoirs: Vol. 2, Years of Trial and Hope.* Garden City, N.Y.: Doubleday & Co., 1956.

---. *Mr. Citizen.* London: Hutchinson & Co., 1961.

Von Kármán, Theodore. *The Wind and Beyond: Theodore von Kármán, Pioneer in Aviation and Pathfinder in Space.* Boston: Little, Brown, 1967.

York, Herbert. *Race to Oblivion: A Participant's View of the Arms Race.* New York: Simon and Schuster, 1970.

Secondary Published Sources

Alperovitz, Gar. *The Decision to Use the Atomic Bomb and the Architecture of an American Myth,* New York: Alfred A. Knopf, 1995.

Ambrose, Stephen E. *Eisenhower, Vol. 1: 1890-1952.* New York: Simon and Schuster, 1983.

Armacost, Michael H. *The Politics of Weapons Innovation: The Thor-Jupiter Controversy.* New York: Columbia University Press, 1969.

Balogh, Brian. *Chain Reaction: Expert Debate and Public Participation in American Commercial Nuclear Power, 1945-1975*. Cambridge: Cambridge University Press, 1991.

Baker, David. *The Rocket: The History and Development of Rocket & Missile Technology.* New York: Crown Publications Inc., 1978.

Barella, Jessica Rose. "Landscape of Fear: A Social History of the Missile During the Early Years of the Cold War, 1950-1965." Ph.D. diss. Florida International University, 2007.

Barlow, Jeffrey G. *Revolt of the Admirals: The Fight for Naval Aviation, 1945-1950.* Washington, D.C.: Brassey's, 1998.

Barnet, Richard J. "The Ideology of the National Security State," *The Massachusetts Review,* Vol. 26, No. 4 (Winter 1985), 483-500.

Basalla, George. *The Evolution of Technology,* Cambridge: Cambridge University Press, 1988.

Baucom Donald R. "Eisenhower and Ballistic Missile Defense: The Formative Years, 1944-1961," *Air Power History,* Winter 2004, 4-17.

---. *The Origins of SDI, 1944-1983.*Lawrence, KS: University of Kansas, 1992.

---. *The U.S. Missile Defense Program, 1944-1994: Fifty Years of Progress.* Washington, D.C.: Ballistic Missile Defense Organization, 1994.

Baxter, James Phinney 3rd. *Scientists Against Time.* Boston: Little, Brown and Company, 1946.

Beard, Edmund. *Developing the ICBM: A Study in Bureaucratic Politics.* New York: Columbia University Press, 1976.

Bernstein, Barton J. "The Atomic Bombings Reconsidered." *Foreign Affairs,* January-February 1995, 135-52.

Beschloss, Michael R. *Mayday: Eisenhower, Khrushchev and the U-2 Affair.* New York: Harper and Row, 1986.

Bird, Kai, and Martin Sherwin. *American Prometheus: The Triumph and Tragedy of J. Robert Oppenheimer*. New York: A.A. Knopf, 2005.

Boettcher, Thomas D. *First Call: The Making of the Modern U.S. Military, 1945-1953.* Boston: Little, Brown and Company, 1992.

Borowski, Harry R. *A Hollow Threat: Strategic Air Power and Containment Before Korea.* Westport CT: Greenwood Press, 1982.

Bottome, Edgar M. *The Missile Gap: A Study of the Formulation of Military and Political Policy.* Rutherford NJ: Fairleigh Dickinson University Press, 1971.

Bower, Tom. *The Paperclip Conspiracy: The Battle for the Spoils and Secrets of Nazi Germany.* London: Paladin, 1988.

Boyne, Walter J. *Beyond the Wild Blue: A History of the U.S. Air Force 1947-1997.* New York: St. Martin's Press, 1997.

Brodie, Bernard. *Strategy in the Missile Age,* Princeton: Princeton University Press, 1959.

Brown, Michael E. *Flying Blind: The Politics of the U.S. Strategic Bomber Program.* Ithaca: Cornell University Press, 1992.

Bullard, John W. *History of the Redstone Missile System.* Huntsville, AL.: Historical Office, Army Missile Command, 1965.

Builder, Carl H. *The Icarus Syndrome: The Role of Airpower Theory in the Evolution and Fate of the U.S. Air Force.* New Brunswick N.J.: Transaction Publishers, 1994.

Bulkeley, Rip. *The Sputniks Crisis and Early United States Space Policy.* Bloomington: University of Indiana Press, 1991.

Bundy, McGeorge. *Danger and Survival: Choices About the Bomb in the First Fifty Years.* New York: Random House, 1988.

Burrows, William E. *Deep Black: Space Espionage and National Security.* New York: Berkley Books, 1988.

---. *This New Ocean: the Story of the First Space Age.* New York: Random House, 1998.

Capshew, James H. "Engineering Behavior: Project Pigeon, World War II, and the Conditioning of B.F. Skinner," *Technology and Culture*, Vol. 34, No. 4 (October 1993) 835-57.

Caraley, Demetrios. *The Politics of Military Unification,* New York: Columbia University Press, 1966.

Carter, Donald Alan. "Eisenhower Versus the Generals." *The Journal of Military History,* 71, October 2007, 1169-99.

Chang, Iris. *Thread of the Silkworm,* New York: BasicBooks, 1995.

Chapman, John L. *Atlas: The Story of a Missile.* New York: Harper and Brothers, 1960.

Chun, Clayton K.S. "Winged Interceptor Politics and Strategy in the Development of the Bomarc Missile," *Air Power History,* Winter 1998, 44-59.

Cochran, Bert. *Harry Truman and the Crisis Presidency.* New York: Funk and Wagnalls, 1973.

Cochran, Thomas B., William M. Arkin, and Milton M. Hoenig. *Nuclear Weapons Databook: Vol. 1 U.S. Nuclear Forces and Capabilities,* Cambridge Mass.: Ballinger Publishing Company, 1984.

Coffey, Thomas M. *Iron Eagle: the Turbulent Life of General Curtis LeMay.* New York: Crown Publishers, 1986.

Colhoun, John Humphrey. "The Frustration of Power: United States Military Policy. 1945-60." Ph.D. Diss., York University, 1976.

Collins, Martin J. *Cold War Laboratory: RAND, the Air Force, and the American State, 1945-1950.* Washington, D.C.: Smithsonian Institution Press, 2002.

Condit, Doris M. *The Test of War, 1950-1953: History of the Office of the Secretary of Defense, Volume II.* Washington, D.C.: Historical Office, Office of the Secretary of Defense, 1988.

Craig, Campbell, and Sergey Radchenko. *The Atomic Bomb and the Origins of the Cold War.* New Haven: Yale University Press, 2008.

Davies, Merton E. and William R. Harris, *Rand's Role in the Evolution of Balloon and Satellite Observation Systems and Related U.S. Space Technology.* Santa Monica CA: RAND Corporation, 1988.

Day, Dwayne A., John M. Logsdon and Brian Latell, eds. *Eye in the Sky: The Story of the Corona Spy Satellites.* Washington D.C.: Smithsonian Institution Press, 1998.

---. *Lightning Rod: A History of the Air Force Chief Scientist's Office.* Washington D.C.: Chief Scientist's Office, United States Air Force, 2000.

---. "Mapping the Dark Side of the World," *Spaceflight,* Vol. 40. Part 1, July 1998, no. 7, 264-9; Part 2, August 1998, no. 8, 303-10.

Del Papa, E. Michael and Sheldon A. Goldberg. *Strategic Air Command Missile Chronology 1939-1973,* Offutt AFB, Neb.: Office of the Historian, Headquarters, Strategic Air Command, 1975.

DeVorkin, David. "Organizing for Space Research: The V-2 Rocket Panel." *Historical Studies in the Physical and Biological Sciences*. Vol. 18, No. 1 (1987), 1-24.

---. *Science with a Vengeance: How the Military Created the U.S. Space Sciences after World War II*. New York: Springer-Verlag, 1992.

Dick, Steven J., and Roger D. Launius, eds. *Critical Issues in the History of Spaceflight,* Washington, D.C.: National Aeronautics and Space Administration, 2006.

Divine, Robert A. *The Sputnik Challenge: Eisenhower's Response to the Soviet Satellite.* Oxford: Oxford University Press, 1993.

Donovan, Robert J. *Conflict and Crisis: The Presidency of Harry S. Truman 1945-1948.* New York: W.W. Norton & Co.: 1977.

---. *Tumultuous Years: The Presidency of Harry S. Truman 1949-1953.* New York: W.W. Norton & Co.: 1982.

Dupuy, Trevor N. *The Evolution of Weapons and Warfare,* Fairfax Va.: Hero Books, 1984.

Emme, Eugene M. *Aeronautics and Astronautics: An American Chronology of Science and Technology in the Exploration of Space 1915 – 1960.* Washington, D.C. National Aeronautics and Space Administration, 1961.

England, Merton *A. Patron for Pure Science. The National Science Foundation's Formative Years, 1945-57,* Washington D.C.: National Science Foundation, 1958.

Ermenc, Joseph P., ed. *Atomic Bomb Scientist Memoirs, 1939-1945.* Westport, CT: Meckler Corp., 1989.

Esper, Mark T. "The Role of Congress in the Development of the United States' Strategic Nuclear Forces, 1947-68." Ph.D. diss. George Washington University, 2008.

Evangelista, Matthew. *Innovation and the Arms Race: How the United States and the Soviet Union Develop New Military Technologies.* Ithaca: Cornell University Press, 1988.

Ferrell, Robert H. *Harry S. Truman and the Cold War Revisionists.* Columbia: University of Missouri Press, 2006.

FitzGerald, Frances. *Way Out There In the Blue: Reagan, Star Wars and the End of the Cold War.* New York: Simon and Schuster Inc., 2000.

Ford, Daniel. *The Button: The Pentagon's Strategic Command and Control System.* New York: Simon and Schuster, 1985.

Freedman, Lawrence. *The Evolution of Nuclear Strategy, Second Edition,* London: Palgrave Macmillan, 1989.

Friedberg, Aaron L. "A History of U.S. Strategic 'Doctrine' – 1945 to 1980," in Amos Perlmutter and John Gooch, eds., *Strategy and the Social Sciences: Issues in Defense Policy.* London: Frank Cass and Co., 1981. 37-71.

Futrell, Robert Frank. *Ideas, Concepts, Doctrine: Basic Thinking in the United States Air Force 1907-1960.* Vol. 1. Maxwell AFB, Al.: Air University Press, 1989.

Gaddis, John Lewis. *We Now Know: Rethinking Cold War History.* Oxford: Clarendon Press, 1997.

Gainor, Chris. *To a Distant Day: the Rocket Pioneers.* Lincoln: University of Nebraska Press, 2008.

Galison, Peter, and Bruce Hevly, eds. *Big Science: The Growth of Large-Scale Research.* Stanford: Stanford University Press, 1992.

Gimbel, John. "German Scientists, United States Denazification Policy, and the '*Paperclip* Conspiracy." *International History Review* 12 (August 1990), 441-85.

---. "Project Paperclip: German Scientists, American Policy and the Cold War." *Diplomatic History* 14 (1990), 343-65.

---. *Science, Technology, and Reparations: Exploitation and Plunder in Postwar Germany.* Stanford: Stanford University Press, 1990.

---. "U.S. Policy and German Scientists: The Early Cold War." *Political Science Quarterly* 101 (1986), 433-51.

Goldberg, Alfred, ed. *A History of the United States Air Force 1907-1957,* Princeton, N.J.: D. Van Nostrand Company Inc., 1957.

Gordin, Michael D. *Red Cloud at Dawn: Truman, Stalin, and the End of the Atomic Monopoly.* New York: Farrar, Straus and Giroux, 2009.

Gorn, Michael H. *Harnessing the Genie: Science and Technology Forecasting for the Air Force 1944-1986.* Washington D.C.: Office of Air Force History, United States Air Force, 1988.

---. *The Universal Man: Theodore von Kármán's Life in Aeronautics.* Washington D.C.: Smithsonian Institution Press, 1992.

Grant, C.L. *The Development of Continental Air Defense to 1 September 1954.* Maxwell Air Force Base, Alabama: USAF Historical Division, Research Studies, Air University, 1954.

Green, Constance McLaughlin, and Milton Lomask. *Vanguard – A History,* Washington, D.C.: National Aeronautics and Space Administration, 1970.

Greenwood, John T. "The Atomic Bomb – Early Air Force Thinking and the Strategic Air Force, August 1945-March 1946." *Aerospace Historian.* Fall, September 1987. 158-166.

Gruntman, Mike. *Blazing the Trail: The Early History of Spacecraft and Rocketry.* Reston, VA.: American Institute of Aeronautics and Astronautics, 2004.

Guilmartin, John. "The ICBM and the Cold War: Technology in the Driver's Seat," from Robert Cowley, ed. *The Cold War: A Military History.* New York: Random House, 2005, 423-37.

Hall, R. Cargill. "Early U.S. Satellite Proposals," *Technology and Culture* vol. 4 (Fall 1963): 410 - 434.

---. "Earth Satellites: A First Look By The United States Navy," from R. Cargill Hall, ed., *History of Rocketry and Astronautics: Third through Sixth History Symposia of the International Academy of Astronautics.* AAS History Series, v. 7, part II. San Diego: AAS Publications Office, 1986: 253.

---. "The Origins of U.S. Space Policy: Eisenhower, Open Skies, and Freedom of Space," from Philppe Jung, ed., *History of Rocketry and Astronautics: Proceedings of the Twenty-Sixth History Symposium of the International Academy of Astronautics.* AAS History Series, v. 21. San Diego: AAS Publications Office, 1997: 75.

Hanle, Donald J. "Near Miss: The Story of the Army Air Forces' Guided Bomb Program in World War II." Ph.D. diss. George Washington University, 2004.

Hanle, Paul A. *Bringing Aerodynamics to America,* Cambridge: The MIT Press, 1982.

Hansen, Chuck. *US Nuclear Weapons: The Secret History.* Arlington, TX: Aerofax, 1988.

Hansen, James R. *Engineer in Charge: A History of the Langley Aeronautical Laboratory, 1917-1958.* Washington: National Aeronautics and Space Administration, 1987.

---. *The Bird is on the Wing: Aerodynamics and the Progress of the American Airplane.* College Station, TX: Texas A&M University Press, 2004.

Harford, James. *Korolev: How One Man Masterminded the Soviet Drive to Beat America to the Moon.* New York: John Wiley & Sons, Inc. 1997.

Hartmann, Edwin P. *Adventures in Research: A History of the Ames Research Center 1940 – 1965.* Washington D.C.: National Aeronautics and Space Administration, 1970.

Heppenheimer, Thomas A. *A Brief History of Flight: From Balloons to Mach 3 and Beyond.* New York: John Wiley and Sons, Inc. 2001.

---. *Countdown: A History of Space Flight.* New York: John Wiley and Sons, Inc. 1997.

---. *Facing the Heat Barrier: A History of Hypersonics.* Washington D.C.: National Aeronautics and Space Administration, 2007.

---. "The Navaho Program and the Main Line of American Liquid Rocketry," *Air Power History,* Spring 1991, 4-17.

Herken, Gregg. *Cardinal Choices: Presidential Science Advising from the Atomic Bomb to SDI*. Oxford: Oxford University Press, 1992.

---. *Counsels of War.* New York: Knopf, 1985.

---. *The Winning Weapon: the Atomic Bomb in the Cold War, 1945-1950.* New York: Knopf, 1980.

Hewlett, Richard G. and Francis Duncan. *Atomic Shield, 1947/ 1952, Volume II, A History of the United States Atomic Energy Commission.* University Park: Pennsylvania State University Press, 1969.

Hogan, Michael J. *Cross of Iron: Harry S. Truman and the Origins of the National Security State, 1945-1954.* Cambridge: Cambridge University Press, 2000.

Holloway, David. *Stalin and the Bomb: The Soviet Union and Atomic Energy, 1939-1956.* New Haven: Yale University Press, 1996.

Hughes, Thomas P. *American Genesis: A Century of Invention and Technological Enthusiasm, 1870-1970.* Chicago: The University of Chicago Press, 2004.

---. "The Evolution of Large Technological Systems," in Wiebe Bjeker, Thomas P. Hughes and, Trevor Pinch, eds., *The Social Construction of Technological Systems*. MIT Press, Cambridge, 1989. 51-82.

---. *Networks of Power: Electrification in Western Society, 1880-1930*. Baltimore: The Johns Hopkins University Press, 1983.

---. *Rescuing Prometheus: Four Monumental Projects that Changed The Modern World.* New York: Pantheon, 1998.

Hunley, J.D. *U.S. space-Launch Vehicle Technology: Goddard Rockets to Minuteman III.* Gainesville: University Press of Florida, 2008.

Hunt, Linda. *Secret Agenda: The United States Government, Nazi Scientists, and Project Paperclip, 1945 to 1990.* New York: St. Martin's Press, 1991.

---. "U.S. Coverup of Nazi Scientists." *Bulletin of the Atomic Scientists.* April 1985, 16.

Jefferys, Steve. *Management and Managed: Fifty Years of Crisis at Chrysler.* Cambridge: Cambridge University Press, 1986.

Johnson, Stephen B. "Bernard Schriever and the Scientific Vision." *Air Power History*, Summer 2002.

---. *The Secret of Apollo: Systems Management in American and European Space Programs.* Baltimore: Johns Hopkins University Press, 2002.

---. *The United States Air Force and the Culture of Innovation.* Washington D.C.: Air Force History and Museums Program, 2002.

Joiner, Helen Brents, and Elizabeth C. Jolliff. *The Redstone Arsenal Complex in its Second Decade, 1950-1960,* Redstone Arsenal, Ala.: Historical Division, Army Missile Command, 1969.

Kalic, Sean M. "U.S. Presidents and the Militarization of Space, 1946-1967: 'We Believe in the Peaceful Use of Space.'" Ph.D. diss. Kansas State University, 2006.

Kaplan, Fred. *The Wizards of Armageddon*, New York: Simon and Schuster, 1983.

Kevles, Daniel J. "Scientists, the military, and the control of postwar defense research: The case of the Research Board for National Security," *Technology and Culture*, 16 (1975), 20-47.

Kirkendall, Richard S., ed. *The Truman Period as a Research Field: A Reappraisal, 1972.* Columbia Mo.: University of Missouri Press, 1974.

Kolodziej, Edward A. *The Uncommon Defense and Congress, 1945-1963.* Columbus: Ohio State University Press, 1966.

Koppes, Clayton R. *JPL and the American Space Program: A History of the Jet Propulsion Laboratory.* New Haven: Yale University Press, 1982.

Kotz, Nick. *Wild Blue Yonder: Money, Politics and the B-1 Bomber.* New York: Pantheon Books, 1988.

Krudener, Doris E. *History of Ballistic Missiles Site Activation: Plans, Policies and Decisions 1954-1961, Volume 1 Narrative (Revised Edition)*. Norton AFB, CA: Historical Division, USAF Ballistic Systems Division, 1964.

Kugler, Jacek. "Terror without Deterrence: Reassessing the Role of Nuclear Weapons," *The Journal of Conflict Resolution,* Vol. 28 No. 3 (Sept. 1984) 470-506.

Lasby, Clarence. *Project Paperclip: German Scientists and the Cold War.* New York: Atheneum, 1971.

Lassman, Thomas C. *Sources of Weapon Systems Innovation in the Department of Defense: The Role of In-House Research and Development, 1945-2000.* Washington, D.C.: Center of Military History, United States Army, 2008.

Launius, Roger D. "The historical dimension of space exploration: reflections and possibilities," *Space Policy* 16 (2000) 23-8.

---, Dennis R. Jenkins, eds. *To Reach the High Frontier: A History of U.S. Launch Vehicles.* Lexington: University of Kentucky Press, 2002.

---, John M. Logsdon, and Robert W. Smith. *Reconsidering Sputnik: Forty Years Since the Soviet Satellite*. Amsterdam, The Netherlands: Harwood Academic Publishers, 2000.

---, Howard E. McCurdy, eds. *Spaceflight and the Myth of Presidential Leadership.* Urbana: University of Illinois Press, 1997.

Leffler, Melvyn P. and Odd Arne Westad, eds. *The Cambridge History of the Cold War: Vol. 1, Origins.* Cambridge: Cambridge University Press, 2010.

---. *For the Soul of Mankind: The United States, The Soviet Union, and The Cold War.* New York: Hill and Wang, 2007.

---. *A Preponderance of Power: National Security, the Truman Administration, and the Cold War.* Stanford: Stanford University Press, 1992.

Leighton, Richard M. *Strategy, Money and the New Look 1953-1956, History of the Office of the Secretary of Defense, Volume III.* Washington, D.C.: Historical Office, Office of the Secretary of Defense, 2001.

Liddell-Hart, Basil H. *Revolution in Warfare.* London: Faber and Faber, 1946.

Lonnquest, John Clayton. “The Face of Atlas: General Bernard Schriever and the Development of the Atlas Intercontinental Ballistic Missile, 1953 – 1960.” Ph.D. Diss., Duke University, 1996.

---, David F. Winkler. *To Defend and Deter: The Legacy of the United States Cold War Missile Program.* Rock Island, Ill.: Department of Defense Legacy Resource Management Program, Cold War Project, Defence Publishing Service, 1996.

MacCloskey, Monro. *The United States Air Force.* New York: Frederick A. Praeger, 1967.

MacIsaac, David. *Strategic Bombing in World War Two: The Story of the United States Strategic Bombing Survey.* London: Garland Publishing Inc., 1976.

MacKenzie, Donald. “From Kwajalein to Armageddon? Testing and the social construction of missile testing,” in David Goooding, Trevor Pinch, Simon Schaffer, eds., *The Uses of Experiment: Studies in the Natural Sciences.* Cambridge: Cambridge University Press, 1989, 409-33.

---. *Inventing Accuracy: A Historical Sociology of Nuclear Missile Guidance.* Cambridge, Mass.: MIT Press, 1990.

Macrae, Norman. *John von Neumann.* New York: Pantheon Books, 1992.

McCullough, David. *Truman.* New York: Simon & Schuster, 1992.

McCurdy, Howard E. *Space and the American Imagination.* Washington, D.C.: The Smithsonian Press, 1997.

McDougall, Walter A. *...The Heavens and The Earth: A Political History of the Space Age.* New York: Basic Books, 1985.

McFarland, Keith D. and David L. Roll. *Louis Johnson and the Arming of America.* Bloomington, Ind.: Indiana University Press, 2005.

Mets, David P. and Harold R. Winton. *The Challenge of Change: Military Institutions and New Realities.* Lincoln: University of Nebraska Press, 2000.

Miller, Jay. *The X-Planes, X-1 to X-45, Third Edition.* Hinckley, England: Midland Publishing, 2001.

Mindell, David A. *Digital Apollo: Human and Machine in Spaceflight*. Cambridge MA: MIT Press, 2008.

Miscamble, Wilson D. "The Foreign Policy of the Truman Administration: A Post-Cold War Appraisal," *Presidential Studies Quarterly*, Vol. 24, No. 3 (Summer 1994), pp. 479-495.

Moritz, Michael, and Barrett Seaman. *Going for Broke: The Chrysler Story.* New York: Doubleday & Co., Inc., 1981.

Morrison, Elting E. *Men, Machines and Modern Times.* Cambridge MA: The MIT Press, 1966.

Needell, Allan A. *Science, Cold War and the American State: Lloyd V. Berkner and the Balance of Professional Ideals.* Amsterdam: Harwood Academic Publishers, 2000.

Neufeld, Jacob. *Ballistic Missiles in the United States Air Force 1945-1960.* Washington, D.C.: United States Air Force History Office, 1990.

Neufeld, Michael J. *The Rocket and the Reich: Peenemünde and the Coming of the Ballistic Missile Era.* Cambridge: Harvard University Press, 1995.

---. *Von Braun: Dreamer of Space, Engineer of War.* New York: Alfred A. Knopf, 2007.

Newell, Homer. *Beyond the Atmosphere: Early Years of Space Science.* Washington, D.C.: National Aeronautics and Space Administration, 1980.

Neustadt, Richard E. *Presidential Power: The Politics of Leadership.* New York: Wiley, 1968.

Nieburg, Harold L. *In the Name of Science.* Chicago: Quadrangle Books, 1966.

Offner, Arnold A. "'Another Such Victory:' President Truman, American Foreign Policy, and the Cold War." *Diplomatic History,* Vol. 23, No. 9 (Spring 1999), 127-155.

Olson, James C. *Stuart Symington: A Life.* Columbia: University of Missouri Press, 2003.

Ordway, Frederick I., and Mitchell R. Sharpe. *The Rocket Team.* London: William Heinemann Ltd., 1979.

Parrish, Noel Francis. *Behind the Sheltering Bomb: Military Indecision from Alamogordo to Korea.* New York: Arno Press, 1979.

Pearton, Maurice. *Diplomacy, War and Technology Since 1830,* Lawrence, Kansas: University Press of Kansas, 1984.

Peebles, Curtis. *Guardians: Strategic Reconnaissance Satellites.* Novato CA.: Presidio Press, 1987.

Perry, Robert L. *The Ballistic Missile Decisions,* Santa Monica, CA.: RAND Corporation, 1967.

Pinch, Trevor. "'Testing – One, Two, Three… Testing!': Toward a Sociology of Testing," *Science, Technology and Human Values,* Vol. 18, No. 1 (Winter 1993), 25-41.

Ransom, Harry Howe. "The Politics of Air Power – A Comparative Analysis," in *Public Policy.* Cambridge, MA: Harvard Graduate School of Public Administration (Vol. 8), 1958, 87-119.

Rearden, Steven L. *History of the Office of the Secretary of Defense, Volume I, The Formative Years, 1947-1950.* Washington D.C.: Historical Office, Office of the Secretary of Defense, 1984.

---. *Arsenals of Folly: The Making of the Nuclear Arms Race,* New York: Vintage, 2007.

Rhodes, Richard. *Dark Sun: The Making of the Hydrogen Bomb.* New York: Simon and Schuster, 1995.

Richelson, Jeffrey T. *America's Secret Eyes in Space: The U.S. Keyhole Satellite Program.* New York: Harper & Row, 1990.

Roland, Alex. *The Military-Industrial Complex,* Washington, D.C.: American Historical Association and the Society for the History of Technology, 2001.

Roman, Peter J. *Eisenhower and the Missile Gap*. Ithaca: Cornell University Press, 1995.

Rosenberg, David Allan. "American Atomic Strategy and the Hydrogen Bomb Decision." *The Journal of American History*, Vol. 66, No. 1. (Jun., 1979), pp. 62-87.

---. "The Origins of Overkill: Nuclear Weapons and American Strategy, 1945-1960," *International Security,* vol. 7, no. 4. (Spring 1983) pp. 3 –71.

Rosenberg, Max. *The Air Force and the National Guided Missile Program 1944-1950.* Washington D.C.: USAF Historical Division Liaison Office, June 1964.

Rothstein, Maj. Stephen M. *Dead on Arrival? The Development of the Aerospace Concept, 1944-1958*. Maxwell Air Force Base, Alabama: Air University Press, 2000.

---. *Plans and Policies for the Ballistic Missile Initial Operational Capability Program.* Washington D.C.: USAF Historical Division Liaison Office, February 1960.

Ryan, Craig. *The Pre-Astronauts: Manned Ballooning on the Threshold of Space.* Annapolis, Md.: Naval Institute Press, 1995.

Satterfield, Paul H. and David S. Akens. *Historical Monograph: Army Ordnance Satellite Program.* Huntsville, AL.: Army Ballistic Missile Agency, 1958.

Schilling, Warner R., Paul Y. Hammond, Glenn H. Snyder, eds. *Strategy, Politics and Defense Budgets,* New York: Columbia University Press, 1962.

Schnabel, James F. *History of the Joint Chiefs of Staff, Volume 1: The Joint Chiefs of Staff and National Policy 1945-1947.* Washington D.C.: Office of Joint History, Office of the Chairman of the Joint Chiefs of Staff, 1996.

Schwartz, Stephen I., ed. *Atomic Audit: the Costs and Consequences of U.S. Nuclear Weapons since 1940.* Washington D.C.: The Brookings Institution, 1998.

Schwiebert, Ernest George. *History of the U.S. Air Force Ballistic Missiles,* New York: Praeger, 1965.

Seitz, Frederick, and A. H. Taub, "Louis N. Ridenour, Physicist and Administrator." *Science*, Vol. 131, No. 3392, 1 January 1960, 20-1.

Self, Mary R. *History of the Development of Guided Missiles, 1946-1950,* Dayton OH: Historical Office of the Air Material Command, 1951.

Sheehan, Neil. *A Fiery Peace in a Cold War: Bernard Schriever and the Ultimate Weapon.* New York: Random House, 2009.

Sherry, Michael S. *Preparing for the Next War: American Plans for Postwar Defense, 1941-45.* New Haven: Yale University Press, 1977.

---. *The Rise of American Air Power: The Creation of Armageddon.* New Haven: Yale University Press, 1989.

Siddiqi, Asif A. *Challenge to Apollo: The Soviet Union and the Space Race, 1945-1974.* Washington, D.C.: National Aeronautics and Space Administration, 2000.

---. "Germans in Russia: Cold War, Technology Transfer, and National Identity," in Carol E. Harrison and Ann Johnson, eds., *National Identity: The Role of Science and Technology. Osiris 2009: 24.* Chicago: History of Science Society, 120-43.

---. *The Red Rockets' Glare: Spaceflight and the Soviet Imagination, 1857-1957.* Cambridge: Cambridge University Press, 2010.

---. "The Rockets' Red Glare: Technology, Conflict, and Terror in the Soviet Union," *Technology and Culture* 44 no. 3 (2003): 470-501.

Smith, Bruce L.R. *The RAND Corporation.* Cambridge: Harvard University Press, 1966.

Smith, Perry McCoy. *The Air Force Plans for Peace 1943-1945*, Baltimore: The Johns Hopkins Press, 1970.

Spalding, Elizabeth Edwards. *The First Cold Warrior: Harry Truman, Containment, and the Remaking of Liberal Internationalism*. Lexington KY: University Press of Kentucky, 2006.

Spires, David N. *Beyond Horizons: A Half Century of Air Force Space Leadership.* Honolulu: University Press of the Pacific, 2002.

Stares, Paul B. *The Militarization of Space: U.S. Policy, 1945-84.* Ithaca: Cornell University Press, 1985.

Stine, G. Harry. *ICBM: the Making of the Weapon that Changed the World.* New York: Orion Books, 1991.

Sturm, Thomas A. *The USAF Scientific Advisory Board: Its First Twenty Years, 1944-1964.* Washington, D.C.: Office of Air Force History, United States Air Force, 1986.

Swenson, Loyd S., James M. Grimwood and Charles C. Alexander. *This New Ocean: A History of Project Mercury.* Washington D.C.: National Aeronautics and Space Administration, 1966.

Terry, Michael R. "Formulation of Aerospace Doctrine From 1955 to 1959," *Air Power History,* Spring 1991, 47-54.

Tillman, Barrett. *LeMay.* New York: Palgrave Macmillan, 2007.

Van Creveld, Martin. *Technology and War.* New York: The Free Press, 1989.

Von Braun, Wernher, and Frederick I. Ordway III. *The History of Rocketry and Space Travel, Revised Edition,* New York: Thomas Y. Crowell Co., 1969.

Wang, Jessica. *American Science in the Age of Anxiety: Scientists, Anticommunists, and the Cold War*. Chapel Hill, NC: University of North Carolina Press, 1999.

Walker, Chuck, and Joel Powell, *Atlas: The Ultimate Weapon.* Burlington, ON: Apogee Books, 2005.

---. *The Office of the Secretary of the Air Force, 1947-1965,* Washington D.C.: Center for Air Force History, 1992.

Watson, George M. "Stuart Symington – The First Secretary of the Air Force, 18 September 1947 – 24 April 1950," *Aerospace Historian.* Fall, September 1987. 185-189.

Watson, Robert J. *Into the Missile Age, 1956-1960: History of the Office of the Secretary of Defense, Volume IV.* Washington, D.C.: Historical Office, Office of the Secretary of Defense, 1997.

Werrell, Kenneth P. *Death From the Heavens: A History of Strategic Bombing.* Annapolis MD: Naval Institute Press, 2009.

---. *The Evolution of the Cruise Missile.* Maxwell Air Force Base: Air University Press, 1985.

White, Timothy J. "Cold War Historiography: New Evidence Behind Traditional Typographies," *International Social Science Review* (Fall-Winter 2000) 35-46.

Wildenberg, Thomas, "A Visionary Ahead of His Time: Howard Hughes and the U.S. Air Force, Part III: The Falcon Missile and Airborne Fire Control," *Air Power History*, Summer 2008, 4-13.

Williamson, Samuel R., and Steven L. Rearden. *The Origins of U.S. Nuclear Strategy, 1945-1953.* New York: St. Martin's Press, 1993.

Winter, Frank H. "The Silent Revolution: How R.H. Goddard Helped Start the Space Age," paper, IAA.6.15.1, presented at the 55th Congress of the International Astronautical Federation, Vancouver B.C., Canada, October 4-8, 2004.

Wolk, Herman S. *The Struggle for Air Force Independence 1943-1947.* Washington D.C.: Air Force History and Museums Program, 1997.

Yanarella, Ernest J. *The Missile Defense Controversy: Strategy, Technology and Politics, 1955-1972.* Lexington KY: University of Kentucky Press, 1977.

Yergin, Daniel. *Shattered Peace: The Origins of the Cold War and the National Security State.* Boston: Houghton Mifflin Company, 1977.

York, Herbert F., and G. Allen Greb. "Military research and development: a postwar history," *Bulletin of the Atomic Scientists* (January 1977) 13-26.

Zachary, G. Pascal. *Endless Frontier: Vannevar Bush, Engineer of the American Century.* New York: Free Press, 1997.

Zaloga, Steven J. *The Kremlin's Nuclear Sword: The Rise and Fall of Russia's Strategic Nuclear Forces, 1945-2000.* Washington D.C.: Smithsonian Press, 2002.

---. *Target America: The Soviet Union and the Strategic Arms Race, 1945-1964.* Novato CA: Presidio Press, 1993.

Zubok, Vladislav M. A Failed Empire: The Soviet Union in the Cold War from Stalin to Gorbachev. Chapel Hill: University of North Carolina Press, 2007.