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# AIR FORCE IMAGES OF RESEARCH AND DEVELOPMENT AND THEIR REFLECTIONS IN ORGANIZATIONAL STRUCTURE AND MANAGEMENT POLICIES

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AIR FORCE IMAGES OF RESEARCH AND DEVELOPMENT

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*And now I will describe in a figure the enlightenment or unenlightenment of our nature:--Imagine human beings living in an underground cave which is open towards the light; they have been there from childhood, having their necks and legs chained, and can only see into the cave. At a distance there is a fire, and between the fire and the prisoners a raised way, and a low wall is built along the way, like the screen over which marionette-players show their puppets. Behind the wall appear moving figures, who hold in their hands various works of art, and among them images of men and animals, wood and stone, and some of the passers-by are talking and others silent. "A strange parable," he said, "and strange captives." They are ourselves, I replied; and they see only the shadows of the images which the fire throws on the wall of the cave; to these they give names, and if we add an echo which returns from the wall, the voices of the passengers will seem to proceed from the shadows. Suppose now that you suddenly turn them round and make them look, with pain and grief to themselves, at the real images; will they believe them to be real? Will not their eyes be dazzled, and will they not try to get away from the light to something which they are able to behold without blinking?*

Plato,
Republic, vii
4th Oxford Edition, Jowell Trans.

## PREFACE

This study examines Air Force efforts to establish an R&D program based on lessons learned from World War II, a program which would give to research and development (R&D) the organizational priority that the Second World War indicated it should have. The aim here is to examine the images of R&D that Air Force leaders held to see how these images were related to the Air Force response to the challenges and opportunities posed by research and development, and to consider their effect upon Air Force management of R&D. The period of major concern begins in 1945 with the closing of World War II and ends in 1950 with the Air Force decision to establish a major organization with responsibility for R&D.

By an image I mean simply a mental impression or representation of reality. Research and development comprised an activity which for the most part was outside the professional experience of many of the civilian and military leaders who made the decisions regarding the R&D policies that the Air Force would follow. The images of R&D they came to accept assisted them to organize their thoughts about R&D and helped them to relate research and development to their experience and their major concerns both of which lay in the military-operational realm of Air Force activity. It was on the basis of their images of R&D, not on

the realities of R&D and the actualities of the situations within the National Military Establishment, that these leaders made the decisions that shaped Air Force R&D policy between the end of World War II and 1950. As Walter Lippmann once wrote:

> What each man does is based not on direct and certain knowledge, but on pictures made by himself or given to him. If his atlas tells him that the world is flat he will not sail near what he believes to be the edge of our planet for fear of falling off . . . . The way in which the world is imagined determines at any particular moment what men will do.[1]

Although this study examines the historical background of a facet of United States Air Force development, the reader must understand that the Air Force as he might know it today--an independent military service, coequal with the Army and the Navy within the Department of Defense--did not exist before 1947. Between 1907 and 1947 various institutional and organizational changes, usually accompanied by name changes, have affected the military aviation agency which became the U.S. Air Force. A brief sketch of these preliminaries here will provide the background for the events with which this study is principally concerned.

Prior to 1947 that part of national military aviation associated with the United States Air Force of today was a part of the United States Army. The aviation component of the Army was first organized in 1907 as the Aeronautical Division in the Office of the Chief Signal Officer. In 1914 the Army's air arm became the Aviation Section by act of Congress. Four years later Army aviation was removed from the jurisdiction of the Signal Corps and became known as the Army Air Service. By 1926

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[1]Walter Lippmann, Public Opinion (New York: The Macmillan Company, 1954), p. 25.

aviation had increased in importance and this change was reflected in a new designation--the Army Air Corps.[2]

Following the beginning of World War II in Europe, the Army Air Corps was expanded and became the Army Air Forces through a 20 June 1941 reorganization.[3] It was the Army Air Forces that conducted the great aerial war against Germany and Japan in the Second World War. Two years after the war the Army Air Forces were separated from the Army and became the United States Air Force. As will be seen later, this came about as a result of the 1947 Unification Act which merged the Department of the Navy and the War Department into the Department of Defense. Within the Department of Defense, three equal divisions were established: the Department of the Army, the Department of the Navy, and the Department of the Air Force.

It has been virtually impossible to avoid using some of the specialized language and abbreviations that were in vogue among the principals of this study. The need to quote from key documents, alone, necessitates the introduction of language and symbols that may be foreign to some readers. Accordingly, I have prepared a glossary of terms and abbreviations which may be found at the end of the work.

At times, for the sake of simplicity, I use the term "Air Force" to refer collectively to the Army Air Forces and the United States Air

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[2]Chase C. Mooney and Edward C. Williamson, Organization of the Army Air Arm: 1935-1945, USAF Historical Studies, no. 10 (Maxwell Air Force Base, Alabama: USAF Historical Division, Research Studies Institute, Air University, July 1956), p. 1 (hereafter cited as Mooney and Williamson, Organization of the Army Air Arm).

[3]Ibid., pp. 5, 7.

Force. This is usually done when referring to events, activities, and the like, that were common to both the AAF and the USAF. Thus, I may speak of "Air Force leaders" when referring to AAF and USAF leadership between 1945 and 1950.

The most pleasant task of preparing this study is giving credit to all of those who were so helpful. The person I owe the most to in this regard is my wife, Peggy. She has been a constant source of encouragement through almost four years of graduate school and through the additional year required to complete this dissertation. She has typed numerous pages of drafts and patiently proof-read all pages of this final version. My children--Don, Jr., Kathy, and Richard--have given me great moral support and have understandingly sacrificed by carrying on many family activities without the participation of their father.

Without the patience and untiring efforts of Dr. Thomas M. Smith this work could not have been brought to whatever level of acceptability it might represent.

Finally, to Dr. Smith and Dr. Duane H. D. Roller I owe a great debt for their toil in training me as an Historian of Science. Like all truly great teachers, they always seemed to enjoy their efforts as much as their student enjoyed being the focus of these efforts. My conversations with these two men are among the most pleasant memories of my life.

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## CHAPTER I

## INTRODUCTION

By 1950 standards the image of research and development (R&D) accepted in the pre-World War II Army aviation arm was unsophisticated. In 1939 within the Army at large research and development was little more than "a budgetary rubric common to all the supply services."[1] For the Air Corps, R&D involved "the engineering, research, and testing at Wright Field in connection with the construction by industry of new or improved models of airplanes, engines, and airborne and ground equipment peculiar to air operations."[2] Research was sometimes divided into fundamental and applied research, but in practice the Air Corps made no distinction between the two as far as administration was concerned.[3]

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[1] Martin P. Claussen, Materiel Research and Development in the Army Air Arm: 1914-1945, Army Air Forces Historical Studies, no. 50 (Washington, D.C.: AAF Historical Office; Headquarters, Army Air Forces; November 1946), p. 3 (hereafter cited as Claussen, Materiel R&D in the Army Air Arm).

[2] Ibid.

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

Although Wright Field had become the center for the Air Corps R&D function by 1939, it was not the original R&D center for the Army's air arm. In 1917 the Army Air Service had chosen McCook Field near Dayton, Ohio, as the location for its experimental center and before the end of World War I had constructed there such important laboratory facilities as dynamometer buildings, a propeller test laboratory, and a nine-inch wind tunnel.[4] But in 1927 the McCook-based research and development organization of the Army Air Corps moved into more extensive and modern facilities at Wright Field which was also located in the Dayton area.[5]

The R&D organization that used these facilities was small and uncomplicated in comparison with the R&D organization created by the Air Force in 1950. The Aviation Section's 1918 R&D organization was divided into the Experimental Engineering Department and the Production Engineering Department, both of which were under the direction of the Airplane Engineering Division. This last organization was directed by the Bureau of Aircraft Production which had been established in such a way as to make it independent of the Signal Corps to which the Aviation Section belonged.[6]

As a result of a 1926 reorganization the experimental

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[4]Ibid., p. 16.

[5]Ibid., pp. 23, 41; and Alfred Goldberg, "From the Balloon to the B-17, 1907-1939: Between World Wars," in A History of the United States Air Force: 1907-1957, ed. Alfred Goldberg (Princeton, N.J., Toronto, New York, and London: D. Van Nostrand Company, Inc., 1957), p. 37 (the volume is hereafter cited as Goldberg, History of USAF).

[6]Claussen, Materiel R&D in the Army Air Arm, pp. 16-17.

engineering and production engineering elements became part of the Aviation Section's Matériel Division.[7] When World War II opened, this Division was responsible for developing air service equipment and providing maintenance and supply services.[8]

Between 1936 and 1939 the Matériel Division had been administered directly by the Chief of the Air Corps whose advisor on matériel matters was the Supply Division Chief.[9] In 1939 the Chief of the Matériel Division and part of his staff moved to Washington and replaced the Supply Division Chief as the Air Corps Chief's advisor on matériel matters, including R&D. The Chief of the Matériel Division left his Technical Executive, Assistant Chief, and the bulk of the technical and laboratory staffs at Wright Field.[10]

By 1941 the work load of the Matériel Division had become so great that it was relieved of its responsibility for maintenance and supply and left only with responsibility for the development of new equipment for the Army Air Forces. The tasks of maintenance and supply were taken over by the Air Corps Maintenance Command which became the Air Service Command on 17 October 1941; the headquarters of this

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[7]Ibid., p. 53.

[8]Wesley Frank Craven and James Lea Cate, eds., The Army Air Forces in World War II, 7 vols. (Chicago: University of Chicago Press, 1948-58), vol. VI (1955) Men and Planes, USAF Historical Division of Research Studies Institute, pp. 64-65 (hereafter cited as Craven and Cate, Men and Planes).

[9]Ibid., p. 65.

[10]Claussen, Materiel R&D in the Army Air Arm, pp. 54-55; Mooney and Williamson, Organization of the Army Air Arm, pp. 14, 35-36.

organization was located at Patterson Field, Ohio.[11]

The Matériel Division became the Matériel Command as a result of a March 1942 reorganization. Its headquarters was at Wright Field.

> Until August 1944, the Materiel Command remained the AAF's only agency for research and development and for the procurement and modification of equipment. The experimental work of its engineers was centered in an elaborate plant at Wright Field; for procurement the command worked through a system of districts.[12]

The separation of maintenance and supply (under the control of the Air Service Command) from the development of new matériel (under the control of the Matériel Command) led to confusion and friction. To solve this problem the Air Technical Service Command, combining maintenance, supply, and the development of new equipment, was formed on 31 August 1944.[13]

In spite of the numerous name changes undergone by the R&D organization of the Army's aviation branch, this organization remained "relatively simple and consistent throughout the whole period 1917-1945."[14] This seems to have been especially true of the period from 1939 to 1945. As one official history described the situation:

> Wright Field activities continued, whether they were called the Materiel Division, the Materiel Center, the Materiel Command, or the Air Technical Service Command, while the staff office in Washington likewise merely underwent various changes in name,

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[11]Craven and Cate, Men and Planes, p. 65.

[12]Ibid.

[13]Ibid.

[14]U.S., War Department, Army Air Forces Historical Office, Comparative History of Research and Development Policies Affecting Air Materiel: 1915-1944, U.S. Air Force Historical Study no. 20 (Washington, D.C.: Headquarters, Army Air Forces, June 1945), p. 9.

> with, however, essentially the same leadership, the same nucleus of the key officers and civilians, and the same channels over the whole period 1939-1945.[15]

In the decade before World War II the importance of research and development to maintaining a combat air force comparable to those of other nations was constantly being pointed out to Air Corps leaders.[16] Aviation technology was progressing so rapidly that planes were rapidly becoming obsolete and having to be replaced.

> As of 1 September 1934 the first-line longevity of Air Corps models was six years for pursuit, attack, and bomber aircraft; eight years for observation planes; and ten years for all others. By 1 September 1939 first-line longevity was estimated at four years for pursuit, five years for attack and medium bomber, six years for heavy bomber and observation, eight years for transport, and ten years for all other aircraft.[17]

But the lesson of this high obsolescence rate may have been blurred by the manner in which the Air Corps conducted its research and development program. As previously noted,[18] Air Corps R&D was the work done at Wright Field in conjunction with the construction by private industry of new or improved aircraft models for the Air Corps. As one observer has expressed it, military technology in the period prior to World War II was "advanced mainly by drawing upon automotive and aircraft progress. In other words, the technology of warfare advanced primarily by feeding on advancing civilian technology."[19] The Air

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[15] Claussen, Materiel R&D in the Army Air Arm, p. 55.

[16] Craven and Cate, Men and Planes, pp. 176-77.

[17] Ibid.

[18] Supra, p. 1.

[19] Melvin Kranzberg, "Science-Technology and Warfare; Action, Reaction, and Interaction in the Post-World War II Era," in Science,

Corps research and development organization was not on the cutting edge of the aviation R&D community.

In addition to its dependence on civilian industries for necessary R&D, the Air Corps relied on the National Advisory Committee for Aeronautics for most of its basic research.[20] The development of aircraft weapons for the Air Corps was carried out by the Ordnance Department of the Army. The Air Corps did have responsibility for developing power plants, airframes, fire control systems, and aircraft armor.[21]

During World War II the Army Air Forces continued to depend upon Army Ordnance to develop its weapons and to rely on the Signal Corps for applications of radar to aircraft.[22] Furthermore, the exigencies of the war made production matters and short-range R&D projects the most engaging problems for Army Air Forces leaders.

The pressure of German victories in Western Europe prior to the American entry into World War II led to the assignment of a low priority

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Technology, and Warfare: The Proceedings of the Third Military History Symposium, United States Air Force Academy, 8-9 May 1969, ed. Monte D. Wright and Lawrence J. Paszek (Washington, D.C.: U.S. Government Printing Office, 1970), p. 161.

[20]Craven and Cate, Men and Planes, pp. 180-81, 235.

[21]Ibid., p. 194.

[22]Ibid., pp. 194, 232; and Constance McLaughlin Green, Harry C. Thomson, and Peter C. Roots, The Technical Services: The Ordnance Department--Planning Munitions for War, United States Army in World War II, Vol. VI, part 3, Vol. I (Washington, D.C.: Office of the Chief of Military History, Department of the Army, 1955), pp. 423-24. In this book an excellent example is presented of how military specifications that are too rigid can restrict development (p. 424).

to the development of new aircraft in this country. Emphasis was placed on aircraft that could be delivered ready for combat, in six months to a year. The Matériel Division was told that R&D must be given a lower priority during fiscal year 1941.

> During the summer, when deliveries of aircraft fell behind schedule, the manufacturers complained that developmental projects took the time of engineers needed to speed up production, and in September Arnold directed the Materiel Division to defer all such projects and to release the engineers until deliveries were once more up to schedule.[23]

By the end of 1940 a better balance between production and development was being sought, but this change was reversed when the United States entered the war at the end of 1941. From then until peak production was reached in 1943 the emphasis was again on quantity as opposed to innovation in design. As the war approached its conclusion, R&D was again given top priority.[24]

Thus one sees that although World War II may have been the most technical war in the history of man until 1945, the Army Air Forces benefitted little from its experiences as far as learning how to conduct an effective R&D program. The AAF depended on outside agencies for a great deal of the wartime research and development work. Its own R&D program was hampered by a low priority status throughout much of the war, and it possessed only a small, if not insignificant, R&D organization.

Many significant technical advances were made during World War

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[23]Craven and Cate, Men and Planes, pp. 228-29. The quotation is found on p. 229.

[24]Ibid., pp. 229-30.

II--the atomic bomb, radar developments, the DUKW amphibious vehicle, and others. One of the most famous examples of such advances is the proximity fuze that was developed under the direction of the Office of Scientific Research and Development.[25]

This device used the interference pattern caused by the interaction between a continuously radiated radio signal and a target to determine the distance to the target. The fuze detonated a shell, a bomb, or a rocket at just the right distance from the target to secure the "most lethal effect."[26]

The proximity fuze improved the accuracy of anti-aircraft fire considerably. In the case of five-inch naval guns, the improvement was at least five-fold.[27] Proximity fuzes in conjunction with advanced fire-control systems took a heavy toll of German V-1 buzz bombs that were aimed at England. For example, in the last full week of firings during the war, seventy-nine percent of those bombs engaged were destroyed; during the last day in which there were heavy firings against England 104 missiles were detected by radar--sixteen failed to reach the coast of England, fourteen were destroyed by the British Air Force, two were downed by barrage balloons, and sixty-eight were

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[25]James Phinney Baxter III, Scientists Against Time (Boston: Little, Brown and Company, 1947), pp. 222, 241 (hereafter cited as Baxter, Scientists Against Time).

[26]Vannevar Bush, Modern Arms and Free Men: A Discussion of the Role of Science in Preserving Democracy (New York: Simon and Schuster, 1949), pp. 38, 41 (heareafter cited as Bush, Modern Arms).

[27]Bernard and Fawn Brodie, From Crossbow to H-Bomb: The Evolution of the Weapons and Tactics of Warfare, rev. ed. (Bloomington and London: Indiana University Press, 1973; Midland Books, 1973), p. 214.

destroyed by anti-aircraft fire. When the fuze was combined with a different type of fire control system it proved to be a highly effective weapon against the Japanese kamikazes in the Pacific Ocean theater.[28]

Perhaps the most graphic illustration of the impact of the proximity fuze came in the case of land warfare where the fuze was used to detonate artillery shells at a preset distance above the terrain. Artillery shells so exploded produced more casualties in enemy troops.[29] General Patton wrote to General Levin Campbell, Chief of Ordnance:

> The new shell with the funny fuze is devastating. The other night we caught a German battalion, which was trying to get across the Sauer River, with a battalion concentration and killed by actual count 702. I think that when all armies get this shell we will have to devise some new method of warfare. I am glad that you all thought of it first.[30]

Vannevar Bush even went so far as to credit the proximity fuze with possibly saving Liége during this battle.[31]

Like the proximity fuze, most of the other major advances were the contributions of extraordinary R&D organizations in which the influence of civilian scientists was strong if not dominant.[32] The AAF

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[28]Baxter, Scientists Against Time, pp. 235, 237.

[29]Ibid., p. 233.

[30]George Patton to Levin Campbell, 29 December 1944, quoted in Baxter, Scientists Against Time, p. 236.

[31]Bush, Modern Arms, p. 31. For more on the impact of the proximity fuze on land warfare, see: Baxter, Scientists Against Time, pp. 115-17.

[32]Baxter, Scientists Against Time, passim; and Friedrich Klemm, A History of Western Technology, trans. Dorthea Waley Singer (New York: Charles Scribner's Sons, 1959), p. 371.

R&D program generally concentrated on such short-term projects as fighter aircraft range-extension tanks, computing gun sights, and gun turrets.[33]

As World War II approached its conclusion, the conditions that spawned the extraordinary R&D program associated with the war also came to an end. Faced with the loss of vital R&D support, General Henry H. "Hap" Arnold, wartime leader of the Army Air Forces, sought to create within the AAF an organization that could produce the same kinds of results as the extraordinary R&D organizations of the wartime era.

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[33]Craven and Cate, Men and Planes, pp. 242-43.

## CHAPTER II

## EARLY EFFORTS TO EMPHASIZE R&D: THE ARMY AIR FORCES PERIOD, 1945-47

Dr. Theodore von Kármán's Science: The Key to Air Supremacy[1] expresses an R&D philosophy that was to help guide Army Air Forces efforts to translate the experience of World War II into an effective research and development program. The circumstances and events surrounding the origins of this philosophy include a significant informal meeting in September 1944 between Dr. von Kármán and General "Hap" Arnold. Arnold was enroute to a conference in Quebec and asked von Kármán to meet him at La Guardia Airport. The scientist was driven to the end of the runway in an Army Air Forces car where he was met by Arnold. The General dismissed the driver and spoke to von Kármán alone.

> We have won this war, and I am no longer interested in it. I do not think we should spend time debating whether we obtained the victory by sheer power or by some qualitative superiority. Only

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[1] Th[eodore] von Kármán, Science: The Key to Air Supremacy. This study was formally produced as part of a larger report: U.S., War Department, A[rmy] A[ir] F[orces] Scientific Advisory Group, Toward New Horizons: A Report to General of the Army H. H. Arnold, 33 vols., 15 December 1945. (Von Kármán's study is hereafter cited as von Kármán, Key to Air Supremacy. The larger report is hereafter cited as AAF SAG, Toward New Horizons.)

> one thing should concern us. What is the future of air power and aerial warfare? What is the bearing of the new inventions, such as jet propulsion, rockets, radar, and other electronic devices?[2]

When von Kármán asked what Arnold wanted him to do, Arnold replied: "'I want you to come to the Pentagon and gather a group of scientists who will work out a blueprint for air research for the next twenty, thirty, perhaps fifty years.'"[3]

Von Kármán agreed to Arnold's request. The group of scientists he gathered around him produced the monumental, thirty-three-volume study, Toward New Horizons, which was completed in December 1945.[4] From the standpoint of this study, the most important of these volumes is von Kármán's own Science: The Key to Air Supremacy.

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[2]General Arnold quoted in Theodore von Kármán, The Wind and Beyond: Theodore von Karman--Pioneer in Aviation and Pathfinder in Space, with Lee Edson (Boston and Toronto: Little, Brown and Company, 1967), pp. 267-68 (hereafter cited as von Kármán, The Wind and Beyond). Arnold's connections with von Kármán may be traced back to the 1930's when Arnold was Commander of March Field, California, and von Kármán was at the California Institute of Technology. (H[enry] H. Arnold, Global Mission [New York: Harper & Brothers, Publishers, 1949], pp. 132, 139, 152-53 [hereafter cited as Arnold, Global Mission].) Arnold was interested in various practical technical problems at the time of his early contact with von Kármán and was introduced to von Kármán through Dr. Robert A. Millikan. (Interview with Theodore von Kármán, by Donald Shaughnessy, 27 January 1960.)

[3]General Arnold quoted in von Kármán, The Wind and Beyond, p. 268. For a discussion of the process that led to the selection of von Kármán for this task, see: Arnold, Global Mission, pp. 532-33. While Arnold did not describe the La Guardia Airport meeting with von Kármán, he did state that he attended a conference in Quebec on 11 September 1944. (p. 523)

[4]Thomas A. Sturm, The USAF Scientific Advisory Board: Its First Twenty Years, 1944-1964 (Washington, D.C.: USAF Historical Division Liaison Office, 1 February 1967), p. 9 (hereafter cited as Sturm, USAF SAB). For a complete listing of the volumes in Toward New Horizons, see Sturm's book, pp. 164-65. For von Kármán's comments on Toward New Horizons, see: The Wind and Beyond, pp. 289, 291, 294.

General Arnold was so pleased with the study that he distributed copies of it to key members of his staff. His view of the report in general and of von Kármán's volume in particular is concisely stated in a 3 January 1946 letter to Major General Edward M. Powers:

> This is the first Report of its kind ever produced. A preliminary review of the Report leads me to believe that it can be used for some time to come as a guide to the Commanding General, Army Air Forces, in discharging his responsibilities for scientific research and development in the Air Forces. I have had it reproduced and am submitting Volumes I and II to you and Generals Spaatz, Fairchild, Vandenberg, LeMay, Norstad and my Advisory Council. These volumes were prepared by Dr. von Karman and constitute the main report.
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> I would like you to review these volumes. I have asked General Spaatz to call you, Dr. von Karman and the above named together and prepare recommendations for me as to additional distribution which should be made of the main Report.[5]

The names mentioned in this letter should be kept in mind, for Spaatz, Fairchild, Vandenberg, and LeMay all became important figures in the development of Army Air Forces and Air Force R&D policy.

Von Kármán's study described the nature of research and development, examined its importance to the Army Air Forces, and discussed what the air service must do to assure itself of an adequate R&D program. During World War II such technological weapons as the atomic bomb, the proximity fuze, and radar had shown the importance of R&D to modern warfare.[6] And just as the war ended, von Kármán's report appeared; it explained what the Army Air Forces had to do to assure itself of

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[5]H. H. Arnold, Commanding General, Army Air Forces, to Major General Edward M. "Pop" Powers, 3 January 1946, p. 1, in von Kármán memorabilia in the United States Air Force Academy Library, Colorado. Volume I is Science: Key to Air Supremacy.

[6]Arnold, Global Mission, pp. 497, 509-10; and Dwight D. Eisenhower, Crusade in Europe (Garden City, N.Y.: Doubleday & Company, Inc., 1948), pp. 260, 455-56.

the blessings of R&D.

In Science: The Key to Air Supremacy von Kármán stressed that the research and development activity of World War II be continued in some form. In the first place, he argued that the pace of technological innovation in the war had indicated "the necessity for continuous scientific research to insure maintenance of our national security."[7] He noted that the Air Forces had enjoyed the fruits of an extraordinary research organization during World War II, but could not expect to rely on this organization during time of peace. To insure that the nation was prepared to wage effective aerial warfare, the Army Air Forces "must be able to call on all talents and facilities and creative work of scientists and industry." Furthermore, von Kármán held that the Army Air Forces "must be authorized to expand existing AAF research facilities and create new ones to do their own research and also to make such facilities available to scientists and industrial concerns working on problems of the Air Forces."[8] In short, von Kármán recommended that the Air Forces "lay down the leading principles of their own policy and establish the foundation of organized research in their own realm."[9]

In the area of specific organizational recommendations, von Kármán advocated the creation of "new facilities, under one command, entirely separated from procurement and supply, with the objective of developing supersonic and pilotless aircraft." This organization should

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[7]Von Kármán, Key to Air Supremacy, p. 81.

[8]Ibid.

[9]Ibid.

be called the "Center for Supersonic and Pilotless Aircraft Development (SPAD)."[10] He also favored the creation of a permanent scientific advisory group, "consisting of qualified officers and eminent civilian scientists" reporting directly to the Commanding General of the Army Air Forces "on important new developments and advising him on the planning of scientific research."[11]

In regard to the management organization for research and development von Kármán had this to say:

> The plan for management of research and development is a sore point in all large organizations or companies. It mostly undergoes periodic changes, which emphasize one or the other side of the question, ranging from separate and almost independent research laboratories to decentralization of research and development into the operating units. In the special case of the Air Forces, two solutions have been proposed: (1) the establishment of one Air Staff section for research and development; and (2) a supervising and directing agency attached to the office of the Chief of Air Staff. Both solutions have advantages and disadvantages. Obviously it would be extremely difficult to remove the actual operation of all research and development facilities from all the various existing staff sections and concentrate them in one new section. On the other hand, the central supervising and directing agency would have a hard task introducing new ideas into the operation of a large number of dispersed sections and commands engaged in research and development.[12]

Von Kármán showed himself to be a keen analyst, for his remarks proved to be prophetic of subsequent developments in the later history of the AAF and USAF R&D program. If he had hoped to avert the problems he foresaw, his efforts were in vain. The principals involved apparently had to learn by doing rather than by precept, as this study will show.

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[10] Ibid., pp. 95-96.

[11] Ibid., p. 101.

[12] Ibid.

It was characteristic of the depth of von Kármán's analysis that he regarded the Scientific Advisory Group as not the only function for which the Army Air Forces needed technically qualified officers. In the letter of transmittal accompanying Science: The Key to Air Supremacy, he told General Arnold: "The use of scientific means and equipment requires the infiltration of scientific thought and knowledge throughout the Air Forces, and therefore, certain organizatory changes in recruiting personnel, in training, and in staff work."[13] What he had in mind becomes clear when one reads in the body of the report the argument that the Air Forces must be able to recruit and train people so that the air service can procure and use technically advanced equipment.[14] Furthermore, as von Kármán noted later in his report:

> New scientific discoveries will continually have a profound influence on the concepts of air warfare, and the Air Forces must be flexible and capable of adjusting themselves to thse [sic] new concepts. This requires, above all, that the Air Forces be permeated by officers who have the training which will make them capable of evaluating scientific facts with good technical judgement and vision.[15]

Von Kármán also made recommendations regarding the technical training officers should acquire in order to manage R&D effectively. The Army Air Forces should "organize a broad training program for officers in various fields of science and engineering." Some of the

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[13]Theodore von Kármán to General of the Army H. H. Arnold, 15 December 1945, in von Kármán, Key to Air Supremacy, p. xi (hereafter cited as von Kármán to Arnold, 15 Dec 45). In Key to Air Supremacy, p. 86, von Kármán stated that the AAF should have as its ideal goal establishing a scientific attitude within the Air Forces and keeping the scientific community interested in AAF problems.

[14]Von Kármán, Key to Air Supremacy, p. 81.

[15]Ibid., p. 107.

officers would be trained through a program that employed civilian scientific institutions and colleges for the educational process. Others would be trained in an expanded Army Air Forces Engineering School; exceptional graduates would be sent to selected civilian schools for further scientific training.[16]

Although von Kármán's study presented a detailed blueprint for the R&D program the Air Forces should seek to establish in the post-World War II era, and although it provided general instructions on how its "blueprint" might be turned into an actual R&D program, it did not explain extensively the nature of the R&D enterprise itself. Instead, the report simply makes this statement about the relationship of basic science to national defense:

> It is generally recognized that an adequate national program for extending the frontiers of knowledge in various fields of basic science is a necessary adjunct to the maintenance of military security of the nation. Every scientific development eventually finds its way into the field of military applications.[17]

Then von Kármán went on to note that basic research requires time and "an atmosphere of freedom from immediate specific goals and time tables."[18] For this reason, he argued, government authorities should "foster, but not dictate, basic research." In fact, according to von Kármán's view, "the Air Forces do not desire to do basic scientific research in their own organizations; however, they wish to encourage and sponsor such research as they deem necessary for the defense of

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[16]Ibid., pp. 107-09.

[17]Ibid., p. 85.

[18]Ibid.

the nation."[19]

Von Kármán's highly acclaimed plan for the R&D program the AAF should seek to establish was not the only available source of guidance on the research and development enterprise. In August 1945, before the official completion of von Kármán's Science: The Key to Air Supremacy, Major General St. Clair Streett, Commanding General of the Continental Air Command, addressed a letter to General Hap Arnold. Streett remarked that the Army Air Forces was, in one sense, on trial for its life. The "fruits of scientific advances will be forced upon us whether we like it or not and if the Air Forces does not take them up as they develop, they will be snatched up at random by all other branches and the confusion and loss of effectiveness will be tremendous." Among actions he recommended to avoid the development of such a situation was the indoctrination of the AAF to maintain intimate contact with the scientific world and to foster in the scientific community an intense interest in Air Forces problems.[20]

Attached to General Streett's letter was an enclosure apparently prepared by F. Russell Bichowsky, a research consultant.[21] In the environment Bichowsky recommended for AAF R&D, research would be isolated from development, both in the management structure and in the

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[19] Ibid.

[20] St. Clair Streett to Commanding General, Army Air Forces, 31 August 1945, Subject: "Establishment of a Firm Plan for Research and Development," Air Force Archives, Maxwell Air Force Base, Alabama, pp. 1-2 (hereafter cited as Streett to Commanding General, 31 Aug 45).

[21] Bichowsky's name appears at the end of the enclosure as a research organization consultant.

laboratories. "It is vitally important, as all industrial experience shows, to separate completely research from development."[22]

In general, the discussions of R&D contained in the Streett letter and the von Kármán report were weak in their descriptions of the nature of research and development. This void subsequently was filled, at least partially, during a national debate on government science policy carried on between the end of World War II and 1950. At the end of that time the National Science Foundation was finally established.[23] Part of this debate was devoted to an extensive discussion of the nature of R&D. Many of the images that came to be used in dealing with research and development in government circles were articulated during this discussion.

One of the most important figures in this post-war discussion of national science policy was Vannevar Bush, wartime director of the Office of Scientific Research and Development (OSRD). As A. Hunter Dupree has remarked, OSRD was the nearest thing to a central science organization in the history of America to that time.[24] Because of the

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[22]Streett to Commanding General, 31 Aug 45, pp. 2a, 4, of the letter's enclosure. For a more complete exposition of Bichowsky's views of research and development, see his Industrial Research (Brooklyn, N.Y.: Chemical Publishing Co., Inc., 1942). Page i of this book states that Bichowsky organized the Navy's Divisions of Chemistry and Thermodynamics. For views similar to those expressed in the enclosure to Streett's letter, see: pp. 26-27, 30, 74-77, and especially pp. 100-01.

[23]Donald Ralph Baucom, "The Congress, the Armed Forces, and Basic and Applied Research: 1945-1953" (Master's Thesis, University of Oklahoma, 1970), passim (hereafter cited as Baucom, Thesis).

[24]"Paths to the Sixties," in Science in the Sixties: The Tenth Anniversary AFOSR Scientific Seminar, ed. by David L. Arm (Albuquerque, N.M.: The University of New Mexico Office of Publications, 1965), p. 5.

success of OSRD under Bush's leadership, many Congressmen viewed him as an authority on the management of research and development.[25]

In November 1944, President Franklin D. Roosevelt had asked Bush for his recommendation on a national science policy. In July 1945 Bush responded with Science: The Endless Frontier.[26]

In his report, Bush stressed the importance of "basic scientific research." Of its relationship to national defense he wrote: "Our defense against aggression demands new knowledge so that we can develop new and improved weapons. This essential, new knowledge can be obtained only through basic scientific research."[27]

Basic research he described as being performed without thought of practical ends and as leading to "general knowledge and an understanding of nature and its laws." From this knowledge, said Bush, come the answers to large numbers of practical problems, "though it may not give a complete specific answer to any one of them. The function of applied research is to provide such complete answers."[28] It is "statistically certain that important and highly useful discoveries will result from some fraction of the undertakings in basic science," argued Bush,

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[25]Baucom, Thesis, p. 13.

[26]Vannevar Bush, Science: The Endless Frontier--A Report to the President (Washington, D.C.: Government Printing Office, 1945) (hereafter cited as Bush, Science: The Endless Frontier). Roosevelt's request for Bush's recommendation is contained in Bush, Science: The Endless Frontier, pp. vii-viii. Daniel S. Greenberg, The Politics of Pure Science (New York: New American Library, Inc., 1967), pp. 104-06 (hereafter cited as Greenberg, Politics of Pure Science). Greenberg claims that Bush himself wrote the 17 November letter for the President's signature.

[27]Bush, Science: The Endless Frontier, pp. 1, 12.

[28]Ibid., p. 13.

"but the results of any one particular investigation cannot be predicted with accuracy."[29] Basic research more than ever before, he asserted, is the "pacemaker of technological progress."[30]

Bush was quite specific about where the cradle of basic research was to be found:

> Publicly and privately supported colleges and universities and the endowed research institutes must furnish both the new scientific knowledge and the trained research workers. These institutions are uniquely qualified by tradition and by their special characteristics to carry on basic research. They are charged with the responsibility of conserving the knowledge accumulated by the past, imparting that knowledge to students, and contributing new knowledge of all kinds. It is chiefly in these institutions that scientists may work in an atmosphere which is relatively free from the adverse pressure of convention, prejudice, or commercial necessity. At their best they provide the scientific worker with a strong sense of solidarity and security, as well as a substantial degree of personal intellectual freedom. All of these factors are of great importance in the development of new knowledge, since much of new knowledge is certain to arouse opposition because of its tendency to challenge current beliefs or practice.[31]

Basic science could rarely flourish under the conditions prevailing in an industrial laboratory, Bush continued.[32] Furthermore, most of the research conducted in governmental laboratories was of an applied nature. Because of this, governmental research, like industrial research, was largely dependent on the universities and non-profit research facilities for its basic knowledge.[33]

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[29] Ibid.

[30] Ibid., p. 14.

[31] Ibid.

[32] Ibid.

[33] Ibid.

This dichotomy, which would make basic research the child of the university and the non-profit research organization and applied research the offspring of industrial and government research institutions, Bush then applied to the military services.

> It is the primary responsibility of the Army and Navy to train the men, make available the weapons, and employ the strategy that will bring victory in combat. The Armed Services cannot be expected to be experts in all of the complicated fields which make it possible for a great nation to fight successfully in total war. There are certain kinds of research--such as research on the improvement of existing weapons--which can best be done within the military establishment. However, the job of long-range research involving application of the newest scientific discoveries to military needs should be the responsibility of those civilian scientists in the universities and in industry who are best trained to discharge it thoroughly and successfully. It is essential that both kinds of research go forward and that there be the closest liaison between the two groups.[34]

Later views presented by Bush in his 1970 book, Pieces of the Action, remain consistent with his 1945 position:

> There is a point here which is worth dwelling on. I have written that a military organization must be tightly formed and controlled in order to fight well. But this carries a great disadvantage when it comes to a question such as this one. Only officers of relatively junior grade have the technical background, the time, the interest, fully to understand a radically new departure in weapons and methods. The top brass does not. It does not even have time to listen and learn. Yet the top brass makes the decisions, and junior officers cannot protest. Fortunately, there are senior officers who appear once in a while who know how to break through this impasse.[35]

Bush did not limit himself to the written word when presenting his ideas on R&D. He was a frequent witness before Congressional

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[34]Ibid., p. 28. See also p. 12 where Bush discussed "military research" that must be carried out in secrecy and can only be undertaken by the government. Military research is research on military problems.

[35]Vannevar Bush, Pieces of the Action (New York: William Morrow and Company, Inc., 1970), p. 110.

committees interested in the various aspects of research and development. For example, on 22 May 1945 Bush appeared before the House Committee on Military Affairs, when that body was conducting hearings on research and development.[36] In 1947 Bush testified during House hearings on the National Security Act of 1947. In answer to a question about duplication between the proposed National Science Foundation and the military research and development program Bush said:

> The Science Foundation when it is formed will be concerned with basic and fundamental research. The military research and development programs are primarily applied to [sic] research, so that while the foundation will, I think, greatly aid in laying the foundation and background for the later-applied work, there really is no conflict between them.[37]

In addition to these appearances before Congress, Bush also seems to have influenced Congressmen who used Science: The Endless Frontier or Bush's advice when drafting science policy legislation.[38] Bush's unquestioned wartime achievements made him a man whose views could not be overlooked by any organization seeking Congressional action on a matter pertaining to research and development.[39]

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[36]U.S., Congress, House, Committee on Military Affairs, Research and Development, Hearings before the House Committee on Military Affairs on H.R. 2946. 79th Cong., 1st sess., 1945 (hereafter cited as House Military Affairs Committee, Hearings on H.R. 2946), pp. 7-8.

[37]U.S., Congress, House, Committee on Expenditures in the Executive Departments, National Security Act of 1947, Hearings before the House Committee on Expenditures in the Executive Departments on H.R. 2319. 80th Cong., 1st sess., 1947, p. 565 (hereafter cited as House Committee on Expenditures in the Executive Departments, Hearings on H.R. 2319).

[38]Baucom, Thesis, pp. 24, 26.

[39]As General Laurence C. Craigie once said: "Vannevar Bush was a big name, anything he said was accepted." (Laurence C. Craigie, Lieutenant General, USAF [Ret.], USAF Academy, United States Air Force

The policy view requiring separation of basic research from applied research, which Bush expressed, was a view to be found also in the testimony of the man who became the first Secretary of Defense in 1947, James V. Forrestal. During hearings on the Naval Appropriation Bill for fiscal year 1946, Forrestal advocated the formation of an independent research organization "devoted to longer-term, basic research, securing its own funds from Congress, and responsive to, but not dominated by, the Army and the Navy." This organization would not replace or compete with military R&D organizations, but would rather "supplement their efforts by providing the basic military research from which their own programs must stem and which they are themselves ill-equipped to pursue." This group's independence would prevent diversion of funds from the research program during tight-budget years and keep the research program from being dominated by military doctrine.[40]

Forrestal also presented this view to the Senate Military Affairs Committee in 1945. Here he contrasted "abstract research in the field of pure science" with "applied science." The Navy's real job was to see that the discoveries of abstract science were available to the Navy if they were applicable to war. The Navy's bureaus should continue

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Oral History Program, Interview Number 637 by Major Paul Clark and Captain Donald Baucom, 24 September 1971, p. 45 [hereafter cited as Craigie, Interview 637].)

[40]U.S., Congress, House, Committee on Appropriations, Navy Department Appropriations Bill for 1946, Hearings before a subcommittee of the Committee on Appropriations, Part 1. 79th Cong., 1st sess., 1945, pp. 11-12.

to carry out applied research.[41]

Secretary of War Robert P. Patterson expressed similar views during these 1945 hearings of the Senate Military Affairs Committee. He believed the War Department should conduct research, fundamental or otherwise, which might be required in carrying out the functions of the Department. But in most cases, according to Patterson, basic research could best be carried on by civilian institutions working under contract. He advocated a partnership between the military and the science foundation then being considered by the Senate subcommittee before which he was appearing. The foundation should be responsible for basic research.[42]

It was also during these same hearings that Senator Harley M. Kilgore divided research into basic and applied research and largely excluded basic research from the realm of military research. Kilgore remarked that "the national defense aspects of science are really applied science." The basic ideas are applied to some particular destructive use. National defense would "be well taken care of it we look after the basic research."[43]

In 1946 Congressional proceedings one finds more of the same

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[41]U.S., Congress, Senate, Committee on Military Affairs, Hearings on Science Legislation (S. 1297 and Related Bills), Hearings before a subcommittee of the Committee on Military Affairs Pursuant to S. Res. 107 (78th Congress) and S. Res. 146 (79th Congress) Authorizing a Study of the Possibilities of Better Mobilizing the National Resources of the United States, Part 2. 79th Cong., 1st sess., 1945, pp. 243-44 (hereafter cited as Senate Military Affairs Committee, Hearings on Science Legislation, 1945).

[42]Ibid., p. 231.

[43]Ibid., p. 324.

discussion of research as it related to the military. In Senate Report 1136 of that year there is the following statement: "There are two fields of applied research which should be supported in conjunction with the recommended program for basic research and scholarship. They are (1) health and medical sciences, and (2) national defense research."[44] And in the Congressional Record for 1946 there is a discussion of research that divides it into basic research which should be cared for by a proposed National Science Foundation and applied research that would be looked after by the Armed Forces.[45]

The debate on a national policy for science extended beyond Congress during 1947 when the Executive Branch of the government produced the extensive, five-volume Steelman Report, so called after the name of the Chairman of the President's Scientific Research Board, John R. Steelman. World War II had shown the importance of research and development in modern warfare, and the Steelman Report typically reflected the impact of the recent wartime experience in these words:

> A generation which has witnessed the awful destructiveness of the atom bomb or which has read newspaper accounts of developments in biological warfare needs no special demonstration of the relation of science to military preparedness. In the war, the laboratory became the first line of defense and the scientist, the indispensable warrior. There is no likelihood that this would be changed in event of another conflict.[46]

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[44]U.S., Congress, Senate, Committee on Military Affairs, National Science Foundation, S. Rept. 1136, 79th Cong., 2d sess., 1946, Senate Miscellaneous Reports, III, 9.

[45]U.S., Congress, Senate, Senator James M. Mead of New York speaking for S. 1248, 79th Cong., 2d sess., 1946, Congressional Record, XCII, p. 7936.

[46]U.S., President, President's Scientific Research Board, Science and Public Policy, 5 vols. (Washington, D.C.: Government Printing Office,

Volume three of the Steelman Report provided detailed definitions of the elements of research and development. Basic research was divided into fundamental research and background research. Fundamental research was referred to as "theoretical analysis, exploration or experimentation directed to the extension of knowledge of the general principles governing natural or social phenomena." Background research, according to the report, "is the systematic observation, collection, organization, and presentation of facts using known principles to reach objectives that are clearly defined before the research is undertaken to provide a foundation for subsequent research or to provide standard reference data."[47]

Applied research, commented the Report, "is the extension of basic research to the determination of generally accepted principles with a view to specific application, generally involving the devising of a specified novel product, process, technique, or device."[48] Development, the report continued, "is the adaptation of research findings to experimental, demonstration, or clinical purposes, including the experimental production and testing of models, devices, equipment, materials, procedures, and processes." Development is related to work on current models, devices, etc. "Developmental research differs from

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1947), vol. I: A Program for the Nation, p. 3 (hereafter cited as Steelman Report, I). The passage quoted here was italicized for emphasis in the Report. For other pronouncements of this lesson of World War II, see: Baucom, Thesis, passim.

[47]U.S., President, President's Scientific Research Board, Science and Public Policy, 5 vols. (Washington, D.C.: Government Printing Office, 1947) vol. III: Administration for Research, p. 6 (hereafter cited as Steelman Report, III).

[48]Ibid.

applied research in that the work is done on products, processes, techniques, or devices that have previously been discovered or invented."[49]

The armed forces were taking an increasing interest in basic research, the report pointed out, because military men had noted that "new weapons, as contrasted with modifications of existing weapons, must be based upon fundamental exploration at the boundaries of scientific knowledge." Additionally, the report remarked that the "conduct of research by the armed forces is an effective means of linking military men to scientific work. This link is vital."[50]

However, the report went on to say that the military interest in basic research was not the normal situation.

> The great bulk of the armed forces research and development funds are spent for development because the improvement of weapons, vehicles, food, clothing, transportation, and the whole array of equipment needed by the Army, Navy and Air Forces must take high priority. Research is generally supported only when the results of the research appear to be applicable to an end-product useful to the military. Basic research in universities supported by the Office of Naval Research is a major exception to this generalization.[51]

Or as the situation was described in volume one of the report: " . . . military research is overwhelmingly a matter of the application of known basic principles to military needs, . . . ."[52]

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[49]Ibid.

[50]U.S., President, President's Scientific Research Board, Science and Public Policy, 5 vols. (Washington, D.C.: Government Printing Office, 1947), vol. II: The Federal Research Program, p. 7 (hereafter cited as Steelman Report, II).

[51]Ibid.

[52]Steelman Report, I, 22.

The overall result of the national debate which produced such documents as Bush's report and the Steelman Report was the articulation of a view separating basic from applied research. Basic research, requiring an atmosphere of freedom, was an enterprise that was best performed in universities and non-profit organizations; its function was to produce new knowledge. Applied research, on the other hand, involved the application of scientific knowledge to practical problems; and such agencies as the armed forces, industry, and other government organizations might reasonably engage in it.

In general, basic research should be supported by a national organization for science; it would have some responsibility for assisting the military with its research program. The military establishment itself would conduct an R&D program that concentrated on applied research and development.

In the interest of getting Congress to establish a national organization to support basic research, America's statesmen of science[53] stressed the unique nature of basic science. It was the underpinning of all forms of research, including military research. At the same time it was unique in the enterprise of research and development in its requirement for a special environment of freedom from guidance and fluctuation of goals. The military services could not really provide such an environment, but national defense dollars could be used to

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[53]This term is used in the sense employed by Greenberg, Politics of Pure Science, pp. 5, 6-8, 14. Greenberg discusses men who were "concerned with the practical problem of administering the affairs of the scientific community" (p. 5), and he called these men politicans of science who "on the whole, . . . first made their mark in the substantive work of their professions, and then moved into the politics" (p. 14).

support basic research without unduly shackling it. Here was the ideal situation: there would be an organization (the National Science Foundation, established in 1950) responsible for fostering basic research, while at the same time additional funding for fundamental research would be provided by the defense establishment without the accompaniment of military control. As Eugene Rabinowitch stated in an editorial appearing in the Bulletin of the Atomic Scientists in November 1946:

> We realize that the Army or Navy is proceeding in a reasonable fashion in granting liberal contracts for fundamental research. But having granted this, we must realize that organizational subordination of science to the Armed Forces is an evil thing.[54]

There was emerging a national-science-policy position, and as debate on the issues progressed, Congress provided a forum in which the expressions of legislators and civilian experts evoked responses from military leaders and thereby opened the way for an interchange of views on national defense and science policy that was without precedent in the history of the nation. Under such circumstances, all parties were feeling their way, so to speak, even when their public statements were categorical and unequivocating. World War II had brought science and warfare together and made science practical in the minds of Congressmen.[55]

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[54]E[ugene] R[abinowitch], "Editorial: Which Way for American Science? Science, A Branch of the Military?" Bulletin of the Atomic Scientists, II, Nos. 9 and 10 (1 November 1946), 1. For an additional article in the debate over military control of science, see: Louis N. Ridenour, "Military Support of American Science, a Danger?" Bulletin of the Atomic Scientists, III, No. 8 (August 1947), 221-30. Other items in this debate may be found in the same edition of The Bulletin of the Atomic Scientists in which Rabinowitch's editorial appears.

[55]Baucom, Thesis, p. 102.

The statesmen of science wanted the nation to establish a national science policy, and this required Congressional action. The image of science as vital to national defense was an image that could inspire Congressmen to act. When authorities on R&D like Vannevar Bush appeared before Congress, they spoke about R&D in a manner consistent with the policy they wished Congress to adopt. This forced military leaders to articulate an image of R&D that was consistent, to a certain extent, with the views of these statesmen of science. The military leaders found themselves using terms consistent with these images when defending or discussing their own R&D programs before Congress. For, just as Congress must enact laws to establish and fund a national science program, so it must also approve legislation and funding for the R&D programs of the armed services.

During an early stage of the debate on a national science policy, General Hap Arnold appeared before a Congressional subcommittee that was conducting hearings on science legislation. At first he seemed to be in agreement with the views of research and development that we have already seen civilian experts expressing during this national debate. According to Arnold, there were primarily two types of research--fundamental, or basic, research and applied research. The former was obviously a task for an agency like the National Advisory Committee for Aeronautics, while the latter was carried out for the military services in their own laboratories or in commercial laboratories. Arnold held that there was "a well-defined line of demarcation between the types of research that we must have."[56] The Air Forces

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[56]Senate Committee on Military Affairs, Hearings on Science Legislation, 1945, p. 352.

did not desire to perform basic research in its own organization, but "must encourage and sponsor such basic research as they deem necessary for the defense of the Nation and see that it is accomplished."[57] The importance of basic research for the Army Air Forces lay in its relationship to applied research. "Applied research in and for the Air Forces will produce entirely new types of equipment originating from the results of basic research."[58]

But near the end of his appearance before the Senate subcommittee in 1945 Arnold received a question about pure research at Wright Field, Ohio. The well-defined line that in theory separated applied from basic research became an indistinct boundary as General Arnold began to speak about what he thought were the realities of research and development.

> Basic or fundamental research we try to eliminate completely from the Wright Field laboratory. You can't do it completely because they are so intimately tied one with the other, . . .. There are new ideas cropping up at the laboratory there at Dayton all the time. . . . That is why it is so difficult a problem to put down any hard and fast rule covering all the cases.[59]

In 1947 General Curtis LeMay who was serving as Deputy Chief of the Air Staff for Research and Development expressed sentiments similar to those of General Arnold. While appearing before a subcommittee of the House Appropriations Committee LeMay testified:

> The AAF is interested in all fields which can contribute to security from attack in the air, but in the ultimate we are interested in physical items of Air Force equipment. We cannot

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[57] Ibid., p. 345.

[58] Ibid., p. 357.

[59] Ibid., p. 360.

> draw a clear line of separation between research and development, although it is possible to recognize the two fields. The scientist is concerned primarily with research; the engineer, with development. The AAF is interested in research as a field which eventually will produce a development project of value to national security; but its interest, in terms of money, is far greater in the field of development than in the field of research. In the development field, the really top-flight scientist is not essential--in fact, it would be wasteful of our human resources to employ him here. Development is the field of the engineer; and the United States is fortunate in having a very large number of capable engineers and a somewhat smaller number of engineer-scientists.[60]

A third expression of this view of research and development which holds that R&D's components cannot be easily separated is to be found in a 1947 article by Colonel Frederic E. Glantzberg, Chief of the New Developments Division of the Air Command and Staff School, Air University.[61] Glantzberg had served as military director for von Kármán's Scientific Advisory Group and later participated with von Kármán in a study of German World War II inventions.[62] In his article he noted that there were many interrelated steps involved in the development of a particular weapon. In different cases, some of these steps could be omitted, but in general the steps included: "pure science, applied science, development, laboratory tests, service tests, . . .. As the steps are interrelated, they cannot easily be separated."[63]

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[60]U.S., Congress, House, Committee on Appropriations, Military Establishment Appropriation Bill for 1948, Hearings before the subcommittee of the Committee on Appropriations. 80th Cong., 1st sess., 1947, p. 641 (hereafter cited as House Appropriations Committee, Military Appropriation Bill for 1948).

[61]"The Contributors," Air University Quarterly Review, I, No. 1 (Spring 1947), 120.

[62]Von Kármán, The Wind and Beyond, p. 269.

[63]Frederic E. Glantzberg, "The New Air Force and Science," Air University Quarterly Review, I, No. 1 (Spring 1947), 8-9 (hereafter cited as Glantzberg, "Air Force and Science").

Glantzberg commented also on the relationship between basic and applied research:

> Strong interactions between pure and applied science occur as the latter develops better implements to probe the unknown. Furthermore, applied science uses all the methods of pure science to make advances in the major fields of knowledge.[64]

But of the two types of research, pure research was the more fundamental.

> To make significant progress, pure science must be supported in its efforts to advance fundamental knowledge. Many authorities have called attention to the fact that applied science has virtually caught up with knowledge of pure science. This is why the armed services are sponsoring basic research.[65]

The situation that led to applied research catching up with basic research was described by Glantzberg in these words:

> As already indicated, the background of basic scientific knowledge accumulated over a number of years prior to the war has been virturally exhausted by maximum exploitation during the war in the development of new weapons. While the war was being fought, little basic research was done because almost all of our scientists were engaged in developing projects essential for victory.[66]

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[64] Ibid., p. 9.

[65] Ibid.

[66] Ibid., pp. 12-13. For similar views of the effects of the war on basic research, see: Bush, Science: The Endless Frontier, pp. 2, 22; Steelman Report, I, 5; U.S., Department of the Air Force, Secretary of the Air Force, Report of the Secretary of the Air Force to the Secretary of Defense for Fiscal Year 1948 (1 July 1947-30 June 1948) (Washington, D.C.: U.S. Government Printing Office, 31 December 1948), pp. 96, 114 (hereafter cited as Secretary of the Air Force, Report for FY 1948); U.S., President, Air Policy Commission, Survival in the Air Age: A Report by the President's Air Policy Commission (Washington, D.C.: U.S. Government Printing Office, 1 January 1948), p. 73 (hereafter cited as President's Air Policy Commission, Survival in the Air Age); U.S., Congress, House, Committee on Appropriations, National Military Establistment Appropriations Bill for 1950, Part 2: Department of the Air Force, Hearings before the subcommittee of the Committee on Appropriations. 81st Cong., 1st sess., 1949, p. 507 (hereafter cited as House Appropriations Committee, Hearings on Military Appropriations for 1950, Part 2).

The result of this situation, as Glantzberg saw it, was that the U.S. was "practically bankrupt in fundamental scientific knowledge necessary to carry on applied research. This basic knowledge must be augmented and the frontiers of science pushed back if we are to make appreciable progress in the development of new weapons."[67]

Glantzberg's article was partly based upon the ideas of Dr. Hugh Latimer Dryden of the National Bureau of Standards[68] who had spoken on 10 January 1947 to the Air War College upon "Science and the Air Force."[69] A comparison of Glantzberg's article with Dryden's lecture reveals how extensively the former relied on the latter for his views on R&D. Dryden told the Air War College:

> Any development of a specific weapon involves a large number of steps, some of which may be omitted in special cases. We may label the steps as follows: Pure science, applied science, development, laboratory tests, . . .. The steps are interrelated and can not always be separated.[70]

In speaking of pure science, Dryden remarked: "Here we are in contact with the unknown and the mere existence of some practical goal is no help. The discovery of radio waves was not made by [Heinrich] Hertz because of any practical task such as a proximity fuze or even

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[67]Glantzberg, "Air Force and Science," p. 13.

[68]"The Contributors," Air University Quarterly Review, I, No. 1 (Spring 1947), 120.

[69]H[ugh] L[atimer] Dryden, "Science and the Air Force," Air War College Lecture, 10 January 1947 (hereafter cited as Dryden, "Science and the Air Force").

[70]Ibid., p. 2. Compare this quotation with the words of Glantzberg given on p. 33 above. The words omitted from this quotation are virtually the same words omitted from the appropriate Glantzberg quotation on p. 33 above. To illustrate what he meant by different, interrelated stages of research and development, Dryden took his audience through the development of the proximity fuze (pp. 2-3).

the goal of long distance communication."[71]

The words used by Dryden to describe the interactions between basic and applied research once again show how strongly Glantzberg relied on Dryden for his thoughts. "There are strong interactions between pure and applied science as applied science develops better tools to explore the unknown. Likewise applied science applies all of the techniques of pure science to exploit in detail major fields of knowledge and to make advances."[72] In the matter of the primacy of pure research, Dryden expressed the same ideas that Glantzberg was later to present: Basic research furnishes the foundation for applied and industrial research.[73]

Thus the dialogue on the nation's science policy and the discussion of research and development by Air Forces leaders show that although there were areas of agreement between the statesmen of science and AAF leaders, there were also areas of disagreement. Air Forces leaders agreed that basic research was of fundamental importance to the military R&D program. They also agreed in general that basic research by itself was not an area of valid concern for the Armed forces. But where basic research was inseparably involved in the R&D process the AAF must conduct basic research or have it accomplished by an organization outside the AAF.

In addition to disagreeing with the dichotomous view of R&D that

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[71]Ibid., p. 3.

[72]Ibid., pp. 3-4. Compare with Glantzberg's quotation on the same subject on p. 34 above.

[73]Ibid., p. 8.

would exclude the AAF from doing virtually any basic research, Air Forces leaders appeared to disagree with some of the concepts of organization expressed in the debate on a national science policy. This is not to say that there was no expression of support for a national science policy. In testimony before the Senate Military Affairs Committee in 1945 General Arnold informed the Committee that "the Air Forces favor the Magnuson bill (S. 1285) which implements the report of Dr. Vannevar Bush to the President."[74]

The Bush Report referred to is Science: The Endless Frontier. When Magnuson introduced his bill he claimed that the bill was based upon the Bush Report. Indeed, virtually every paragraph of the bill appears to have its origins in the ideas expressed in Science: The Endless Frontier. S. 1285 proposed to establish a National Research Foundation containing five research divisions; these divisions were the same five recommended by Bush in his report. One of these was to have been a "Division of National Defense" that would be dominated by civilians.[75] According to General Arnold: "It is clearly in the national interest to establish a national research foundation charged with the responsibility of furthering basic research and development in all branches of science."[76]

But Arnold did have one recommendation for an improvement in the organization of the National Research Foundation. It should have a

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[74]Senate Committee on Military Affairs, Hearings on Science Legislation, 1945, p. 347.

[75]Baucom, Thesis, pp. 15, 17, 24-25.

[76]Senate Committee on Military Affairs, Hearings on Science Legislation, 1945, p. 347.

Deputy Director whose sole duties would be to concern himself with the long-range problems of the Air Forces. This Director should be familiar with the functioning of the air arm and interested in its well-being.[77]

There is evidence that the displeasure of Air Forces leaders with the proposed National Research Foundation may have gone beyond the omission of a Deputy Director responsible only for Air Forces problems. In 1945 Roscoe C. "Bim" Wilson who eventually rose to the rank of Lieutenant General and held the position of Deputy Chief of Staff, Development, USAF, was an Army Air Forces colonel serving on the staff of General Curtis E. LeMay then the Deputy Chief of the Air Staff for Research and Development.[78] Wilson wrote in a memorandum to LeMay:

> There is considerable doubt, especially in the minds of the Army Services Forces, as to the desirability of a review of Army Research and Development by the National Academy of Science [sic]. They feel that service organizations of the Army should conduct their own review before calling upon the services of an outside agency.
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> The second reason for opposing General Borden's new suggestion [that the Research and Development Board be eliminated and its functions assumed by the National Academy of Sciences] is that it might weaken the Army's position with respect to the proposed National Research Foundation. It would seem better to have the Army present the NRF with its own review of research and development than to have the report made by some other agency, such as the National Academy of Science [sic].[79]

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[77]Ibid., p. 348.

[78]"Pentagon Profile: Lt. Gen. Roscoe C. Wilson, Deputy Chief of Staff, Development, USAF--AF Soft Spots Caused Reorganization Shifts," Armed Forces Management, VII, No. 8 (May 1961), 15-16 (hereafter cited as "Pentagon Profile: Roscoe C. Wilson"); Curtis E. LeMay, Mission with LeMay: My Story with MacKinlay Kantor (Garden City, New York: Doubleday & Company, Inc., 1965), p. 396 (hereafter cited as LeMay, Mission with LeMay).

[79]R[oscoe] C. Wilson, Memorandum for General LeMay, Subject: "Research Problems for the R[esearch] B[oard] [for] N[ational] S[ecurity]," 20 December 1945, p. 1. For a discussion of the Research Board

Further indications of apprehension among Air Forces leaders over possible interference of civilian science agencies with the AAF R&D program appear in a 28 February 1949 memorandum prepared for General Donald L. Putt's signature by Doctor Teddy F. Walkowicz who was an Air Force major at that time.[80] Walkowicz seems to have been a part of, or at least a witness to, many of the important events in the development of the Air Force R&D structure. He prepared one of the studies in the Toward New Horizons study that was prepared by the Scientific Advisory Group.[81] Theodore von Kármán credited Walkowicz with devising the name Toward New Horizons for the study.[82] In November 1948 Walkowicz became the secretary of the Scientific Advisory Board and held that post until November 1950. In late 1950 Walkowicz became the executive to the Air Force's Chief Scientist. In 1959 and again between 1961 and 1962 Walkowicz served as a member of the Scientific Advisory Board.[83] Walkowicz was also a member of the ad hoc Committee of the Scientific Advisory

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for National Security, see: Daniel J. Kelves, "Scientists, the Military, and the Control of Post-war Defense Research: The Case of the Research Board for National Security, 1944-46," Technology and Culture, XVI, No. 1 (January 1975), 20-47.

[80][Teddy F.] Walkowicz, Memorandum prepared for the Signature of Brigadier General Donald L. Putt, Subject: "Civilian Control of Military Research," 28 February 1949, p. 1, in U.S., Department of the Air Force, Air Research and Development Command Headquarters, Office of Command Historian, Air Adjutant General, History of the Air Research and Development Command: 23 January 1950-30 June 1951, II (the volume is hereafter cited as ARDC Office of Command Historian, History of ARDC: 23 Jan 50-30 Jun 51, II; and the memorandum is hereafter cited as Walkowicz, Memorandum, "Civilian Control of Military Research"). More will be said later about General Putt.

[81]T[eddy] F. Walkowicz, Future Airborne Armies: A Report Prepared for the AAF Scientific Advisory Group, September 1945 (Wright Field, Dayton, Ohio: Headquarters Air Matériel Command, Publications Branch, Intelligence T-2; May, 1946), in AAF SAG, Toward New Horizons.

[82]Von Kármán, The Wind and Beyond, p. 291.

Board that examined the Air Force research and development program in 1958.[84]

It was while Walkowicz was secretary of the Scientific Advisory Board that he prepared the memorandum for General Putt's signature. Here he referred to a July 1945 plan put forward by Vannevar Bush (probably Science: The Endless Frontier) that would provide for a civilian-controlled organization with clear authority to do military research, including the development of new weapons. According to Walkowicz, General Arnold, supported by Dr. von Kármán, opposed Bush's proposal.[85] Von Kármán seems to confirm this in his memoirs, for he reported that Bush opposed the efforts of the Scientific Advisory Group. Bush thought military research should be restricted to improving current weapons, and the production of new scientific ideas should be the work of a civilian agency. Von Kármán wrote: "Bush's statement, made in response to a direct request for an evaluation of research by President Roosevelt in 1944, was an open slap at the Air Force." And when von Kármán told General Arnold that he disagreed with Bush and could justify military research, even if it made him unpopular with the scientific community, Arnold, through a letter and a visit by General Norstad with

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[83]Sturm, USAF SAB, pp. 27, 45, 135.

[84]U.S., Department of the Air Force, Scientific Advisory Board, Report of the Ad Hoc Committee on Research and Development (Washington, D.C.: Headquarters United States Air Force, June 1958), p. 4 (hereafter cited as the Stever Report after the name of the chairman of the ad hoc committee Dr. H. Guyford Stever).

[85]Walkowicz, Memorandum, "Civilian Control of Military Research," p. 1. This reported opposition on the part of von Kármán seems to be in line with his belief that no single organization should become the single intermediary between science and the AAF (Key to Air Supremacy, p. 85).

Bush, persuaded Bush to publicly revoke his position.[86]

This incident which saw Arnold and von Kármán aligned against Bush is but one of several indications of the existence of an alliance between Arnold and von Kármán for the purpose of creating an R&D policy for the Army Air Forces. Earlier evidence for the existence of this alliance is to be found in General Arnold's October 1945 testimony before a subcommittee of the Senate Military Affairs Committee as we shall now see.

Although Major General St. Clair Streett's recommendations[87] for an AAF R&D program were being reviewed by the Air Staff just before and during the appearance of Arnold before the Senate subcommittee,[88] Streett's views do not appear to have influenced Arnold's testimony. However, there does seem to be sufficient similarity between some of the ideas Arnold expressed and ideas that appear in von Kármán's Science: The Key to Air Supremacy which was not officially completed until December 1945, two months after Arnold's appearance before the Senate

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[86]Von Kármán, The Wind and Beyond, pp. 271-72.

[87]Supra, pp. 18-19.

[88]Alfred R. Maxwell, Brigadier General, U.S.A., Requirements Division of the Air Staff, Interoffice Memorandum, Subject: "Establishment of a Firm Plan for Research and Development," 10 September 1945; E. M. Powers, Major General, U.S.A., Assistant Chief of the Air Staff, Supply, Memorandum for the Chief of the Air Staff, Subject: "Establishment of a Firm Plan for Research and Development," 12 September 1945; Hoyt S. Vandenberg, Lieutenant General, U.S.A., Assistant Chief of the Air Staff, Training, Memorandum for the Chief of the Air Staff, Subject: "Establishment of a Firm Plan for Research and Development," 12 September 1945. All of these memoranda are in the Air Force Archives, Maxwell Air Force Base, Alabama. Additionally, I have seen a draft letter in reply to General Streett's letter that carries a date after Arnold's 18 October testimony and indicates that a copy of Arnold's testimony was sent to Streett. This document is also in the Air Force Archives.

subcommittee, to suggest that the two men were exchanging ideas while von Kármán's report was still in preparation.

Arnold began by informing the subcommittee of the need for a balanced and continuous research program within the military. The research and development program that had served the nation so well during World War II must be continued in some form. As Arnold expressed it:

> During World War II the Air Forces have enjoyed the fruits of research work accomplished by several scientific research bodies organized or called upon for the duration of the war. The whole scientific manpower of the Nation was mobilized for the benefit of the services, and a great portion of it for the Army Air Forces. With the termination of the war, it is incumbent upon the Congress, with the advice of the executive branch of the Government, the services, industry and science, to find the best form of organization and the most efficient scheme for uniting all efforts to create the best possible peacetime basic and applied scientific research and development facilities and to utilize all available scientific talents to that end. Only by such efficient organization can our Air Forces reflect at all times the rapid advances in aerodynamics, physics, chemistry, electronics, the sciences basic to rockets, jet propulsion, radar, aviation medicine, and revolutionary developments as yet unconceived.[89]

Much of this statement by Arnold can be found in virtually identical wording in von Kármán's December 1945 study. On page eighty-one the following statement appears:

> During World War II, the Air Forces enjoyed the fruits of research work being done by several scientific bodies organized or called upon for the duration of the war. Moreover, the whole scientific manpower of the nation was available to the services, and a great portion of it to the Army Air Forces. How to secure the cooperation of science and industry during peacetime is a very different problem.[90]

The same relationship can be found between von Kármán's

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[89]Senate Committee on Military Affairs, Hearings on Science Legislation, 1945, pp. 345, 347.

[90]Von Kármán, Key to Air Supremacy, p. 81.

statement on what the AAF's position on basic research should be and Arnold's statement on this matter to the Senate subcommittee. The resemblance of von Kármán's position quoted on page seventeen above to the following statement by Arnold is apparent:

> The Air Forces do not desire to do basic scientific research in their own organization, but they must encourage and sponsor such basic research as they deem necessary for the defense of the Nation and see that it is accomplished.[91]

Although Arnold's testimony was given about two months before the official completion of Science: The Key to Air Supremacy, it is impossible to determine from the evidence at hand which man borrowed from the other. Von Kármán had been working on his project since late 1944,[92] and the work of the Scientific Advisory Group was carried out in the Pentagon with apparently close coordination with General Arnold.[93]

Since both von Kármán and Arnold were in close agreement on their views and had worked together for several years, each may be presumed to have been influenced by the other. There is little question that Arnold and his staff had advance knowledge of the contents of

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[91]Senate Committee on Military Affairs, Hearings on Science Legislation, 1945, p. 345. For further evidence of close similarities between Science: The Key to Air Supremacy and Arnold's testimony compare pp. 85-86 and 107-108 of von Kármán's report with Arnold's ideas as expressed on pp. 345-49 and 353-54 of the Hearings on Science Legislation.

[92]Von Kármán, The Wind and Beyond, pp. 267-68, and H. H. Arnold, Memorandum for Dr. von Kármán, Subject: "AAF Long Range Development Program," 7 November 1944, in von Kármán, Key to Air Supremacy, pp. iii-vii.

[93]Von Kármán, The Wind and Beyond, pp. 268-72. For brief comments on the work of the Scientific Advisory Group by General Arnold, see: Arnold, Global Mission, pp. 532-33.

Science: The Key to Air Supremacy and drew upon that knowledge when preparing Arnold's October 1945 comments. The apparent use of von Kármán's report by Arnold is an indication that Arnold's praise for the report, mentioned earlier in this chapter, was not merely bureaucratic verbiage designed to soothe egos while the Army Air Forces followed its own inclinations. Arnold, at least, was serious about using Science: The Key to Air Supremacy as a blueprint for AAF activities in the R&D area.

In January 1946 the Army Air Forces issued a regulation that established as Air Forces policy some of the recommendations made by the von Kármán report. This regulation established the Office of Deputy Chief of Air Staff for Research and Development and specified its functions. The task assigned to this office was described in these words:

> Mission. The Deputy Chief of Air Staff for Research and Development will direct and supervise research and development and test activities of the AAF in order to provide coordination, integration, and completeness and to eliminate duplication of effort; and will direct and prosecute long-range projects in the field of research and scientific study.[94]

Some of the specific duties of this office included liaison with technical agencies within the government and without and the preparation and defense of the AAF R&D budget. The R&D deputy also served as advisor to the Commanding General of the AAF on matters pertaining to R&D.[95]

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[94]U.S., War Department, Army Air Forces, Regulation 20-62, "Organization: Deputy Chief of Air Staff for Research and Development," Washington, D.C., 10 January 1946, p. 1 (hereafter cited as AAFR 20-62).

[95]Ibid., pp. 1-2.

The first officer to hold the position of Deputy Chief of Air Staff for Research and Development (DCAS/R&D) was Curtis E. LeMay, at that time a Major General. LeMay's assignment to this position in late 1945 reveals something about the nature of the Army Air Forces. He was one of the bright stars in the rising constellation of Army Air Forces officers. General Arnold referred to him as a "great group and Air Division commander," a "rugged" wing commander, and "a leading figure" in the bombing campaign to destroy Germany's industrial capacity.[96] But he had no particular qualifications for his job as the AAF's chief R&D officer.

LeMay, in his memoirs, described discussions among General Carl A. "Tooey" Spaatz, first Chief of Staff of the United States Air Force, himself, and other Army Air Forces leaders in post-war Washington. The topic of discussion was what had to be done in the AAF now that the war was over.

> Somebody must go out to Wright and take active command of Research and Development there, and somebody must do the staff job for R&D in Washington.
>
> It was decided that I'd be the one to go to Wright Field, and O'Donnell would stay on the staff. I remember his bitching about that. He was going to have to buy a house; and all I'd have to do was to breeze out there to Ohio and move into a nice set of quarters.
>
> Helen felt fine about the Ohio deal: it was our old stamping ground--our mutual native State--and why shouldn't we like to be in Ohio? Furthermore, I wasn't very keen on the idea of staff work. Told myself that I was a field commander. . . .[97]

But the situation did not work out as originally planned, and

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[96]Arnold, Global Mission, pp. 176, 446, 564.

[97]LeMay, Mission with LeMay, p. 395; and Ira C. Eaker, "Gen. Carl A. Spaatz, USAF: June 28, 1891-July 14, 1974," Air Force Magazine, LVII, No. 9 (September 1974), p. 43.

LeMay was appointed DCAS/R&D. LeMay wrote: "They were going to fire off an elaborate program. That would be my job, down there in the Pentagon. And Rosie [O'Donnell] was going out to Wright."[98]

LeMay noted that he had a great deal to do in his new job. He had "to get organized, and plan for the budget, and try to get some money into the account."[99] Speaking of his situation in the R&D staff position, LeMay wrote:

> I certainly hadn't been screeching with enthusiasm about my new duties, but it didn't take me long to become mighty interested. It was strictly a management job. I didn't know much about Research and Development . . . I'd had my little bit of engineering education. So they gathered in a lot of folks who did know something about the whole program: Bim Wilson and such.[100]

Yet although LeMay had become deeply involved in the R&D business by the time he left the assignment to become Commander of the United States Air Forces, Europe, in the fall of 1947, he wrote: "[I] could never forget that essentially I still considered myself a field commander."[101]

Shortly after the establishment of the office of the Deputy Chief of Air Staff for R&D, another recommendation of von Kármán's report was implemented when the temporary wartime Scientific Advisory

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[98] LeMay, Mission with LeMay, p. 395.

[99] Ibid., pp. 395-96.

[100] Ibid., p. 396.

[101] Ibid., pp. 400-01. LeMay's own words and the manner in which the Army Air Forces supplied him with a staff of "folks" who knew the R&D program indicates that there was more to selecting an officer for a position in the R&D hierarchy than selecting the man possessing the most experience with and knowledge of R&D. The exact nature of the additional factors involved (additional to R&D knowledge and experience) will become clearer when the selection of General Earle E. Partridge as Commander of the Air Research and Development Command is discussed later.

Group was institutionalized as the permanent Scientific Advisory Board in the office of the DCAS/R&D (then LeMay's office). The Board met for the first time in June 1946.[102]

In addition to following von Kármán's advice for changes in the organization of the Air Staff, Army Air Forces leaders seemed to have accepted his recommendations for educational reform.[103] In their efforts to implement these recommendations, AAF leaders responded in a pattern that was to be oft repeated in Air Force dealings with R&D: they called for the advice and assistance of civilian experts. John R. Markham, Associate Professor of Aeronautical Engineering at Massachusetts Institute of Technology, W. H. Pickering, Associate Professor of Electrical Engineering at California Institute of Technology, E. E. Sechler, Professor of Aeronautical Engineering at California Institute of Technology, and Th. Troller, Professor of Aeronautical Engineering at Case School of Applied Sciences, were experts in technical education.[104] Together they became known as the Markham Committee.[105]

In a report prepared for the AAF the Markham Committee noted

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[102]Sturm, USAF SAB, pp. 2-3, 15. See also U.S., War Department, Army Air Forces, Headquarters Office Instruction No. 20-76, "Organization: The AAF Scientific Advisory Group," Washington, D.C., 4 March 1946, p. 1. This HOI provided for the transferring of the Scientific Advisory Group "including all personnel, functions, records, and office equipment" to the office of the Deputy Chief of the Air Staff for R&D.

[103]Supra, p. 16-17.

[104]John R. Markham, W. H. Pickering, E. E. Sechler, and Th. Troller, AAF Officers Technological Education (Preliminary Report), 1 March 1946 (hereafter cited as Markham, Technological Education).

[105]Mervin E. Gross to Muir S. Fairchild, 27 June 1946, p. 1 (hereafter cited as Gross to Fairchild, 27 Jun 46).

that the Commanding General, Army Air Forces, through his Deputy Chief of Staff for Research and Development, had requested that a study be made of

a. The necessary technological educational needs of officers of the AAF as brought out by the last war and as anticipated for the future.
b. The best manner of supplying the necessary technological background to AAF Officer personnel.[106]

After defining "technological" as covering "the fields of Engineering, Maintenance, Procurement, and Logistics," the committee concluded that the AAF needed approximately one thousand technically educated officers. The committee's report noted that a technical school had already been set up in the AAF, but "advances in science and engineering in the immediate past indicate a need for an extension of the education program beyond the scope" of that which already had been established. The committee therefore recommended the establishment of the Army Air Forces Institute of Technology under the Air Technical Service Command. This school was to complement the Air University (of which more will be said later) and was to produce graduates having "a level of education corresponding to that of a student graduating with a Bachelor of Science Degree from a recognized college." Additionally, it was recommended that "the Bachelor of Science Degree should be awarded for the satisfactory completion of the prescribed courses." Selected graduates of this school should then be sent to existing civilian institutions for advanced or specialized study.[107]

An official description of the start of the Air Institute of

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[106] Markham, Technological Education, p. 1.

[107] Ibid., pp. 1-2, 4.

Technology states that it was designed to replace the Air Corps Engineering School at Wright Field. The new school would have a larger number of students (the first class was scheduled to include 300 officers) and a broader scope of instruction when it began operation in September 1946.[108] The mission of the Institute was to provide

> instruction to assure scientific technological development of AAF equipment, and efficient operation of procurement, supply, maintenance and engineering responsibilities assigned to the AAF. . . . Initially, emphasis will be given to develop young officers scientifically educated to act as links between the Air Force and the scientific world.[109]

For its Institute the Air Forces wished to recruit the finest teachers possible, and one glimpses AAF efforts along this line in a letter from Brigadier General Mervin E. Gross, Commandant of the Institute of Technology, to Major General Muir S. Fairchild, Commanding General of the Air University, in June 1946. Gross discussed his travel plans with Fairchild, informing him that he planned to visit Austin, Texas, to "confer with an educator whom we have hopes of acquiring for the AAFIT." Then Gross would travel to Los Angeles for the "Annual Summer Meeting of the Institute of The Aeronautical Sciences." This part of his trip Gross referred to as a "sort of personnel recruiting expedition."[110] After this discussion of his recruiting campaign, Gross

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[108]"Air Technical College," AAF Review: The Official Service Journal of the U.S. Army Air Forces, XXIX, No. 6 (July 1946), 34 (hereafter cited as "Air Technical College").

[109]David M. Schlatter, "Air University," AAF Review: The Official Service Journal of the U.S. Army Air Forces, XXIX, No. 6 (July 1946), 11 (hereafter cited as Schlatter, "Air University").

[110]Gross to Fairchild, 27 Jun 46, p. 1. General Gross was killed in an October 1946 crash of a P-80 jet fighter (Charles Villency, "The Big Stick," Air Force: Official Journal of the Air Force Association, XXX, No. 4 (April 1947), 45 [hereafter cited as Villency, "Big Stick"]).

told with chagrin how the Air Forces had just missed securing the services of highly regarded Dr. Clauser[111] as Dean of the College of Engineering. Clauser had been lured away from the Douglas Aircraft Company by The Johns Hopkins University, which had offered him the full use of the school's laboratory facilities and full freedom in research unencumbered by teaching or administrative duties.[112]

The AAF school would offer two basic courses. One would be a series of courses in fundamental engineering subjects, with some training in logistics to give its graduates the ability to coordinate the problems of engineering and supply. The second course would present the basic principles of logistics and business. For those desiring specialization in nuclear physics and electronics, courses in these areas were being considered for qualified students.[113] Selected graduates of the Institute would "pursue highly specialized post-graduate courses in nuclear physics and electronics."[114]

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[111]Subsequently, T[eddy] F. Walkowicz, "USAF Scientific Advisory Board," Air Force: The Magazine of American Airpower, XXXVIII, No. 6 (June 1955), 52, identified Clauser as Francis H. Clauser, Chairman of the Aeronautics Department at The Johns Hopkins University and member of the Scientific Advisory Board.

[112]Gross to Fairchild, 27 Jun 46, p. 2.

[113]"Air Technical College," p. 34.

[114]Schlatter, "Air University," p. 11. For an appraisal of the Institute approximately one year after its creation, see: Villency, "Big Stick," pp. 44-45, 60. Villency reported that the school consisted of two colleges, engineering and logistics, with the engineering college offering "instruction in aeronautical engineering with specific application to AF requirements and application of scientific developments and related subjects. . . . Specifically, the engineering program includes such subjects as aerodynamics, physics, mechanics, design, etc" (p. 44). It was expected that the Institute would be recognized as meeting the standards of civilian schools and would be able to grant a Bachelor of Science degree (pp. 44-45).

Four years later, on 1 April 1950, the Institute, then known as the U.S. Air Force Institute of Technology (AFIT), was transferred to the jurisdiction of the Air University from that of the Air Matériel Command under which it was originally established. The physical facilities of the Institute, however, remained at Wright-Patterson Air Force Base.[115]

The 1 April 1950 transfer was not the first association between Air University and AFIT. Major General David M. Schlatter in an article appearing in the July 1946 edition of the official journal of the Army Air Forces discussed the early relationship between these two organizations. Army Air Forces Regulation 20-61 required Air University to exercise broad supervision of the Air Institute of Technology as it was called in 1946.[116]

The Air University itself was established by the Army Air Forces on 12 March 1946 as one of its major commands, ranking organizationally on a level with the Tactical Air Command, the Strategic Air Command, and the Air Transport Command.[117] This organization marked the first time that the major responsibility for Army Air Forces education had been centered under the control of a single headquarters.

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[115]U.S., Department of the Air Force, Air University History: 1 January 1950-30 June 1950, II, 349-50, Air Force Archives, Maxwell Air Force Base, Alabama; and Schlatter, "Air University," p. 11.

[116]Schlatter, "Air University," pp. 9-10; and "Air Technical College," p. 34.

[117]"The Air University," Air Force and Space Digest: The Magazine of Aerospace Power, IL, No. 9 (September 1966), 158; and "Organization Chart of the AAF (As of June 1946)," AAF Review: The Official Service Journal of the U.S. Army Air Forces, XXIX, No. 8 (September 1946), 50.

A part of this headquarters was the Educational Services Division that was staffed by leading specialists who had been recruited from civilian universities because AAF leaders recognized the professional officer corps was weak in the field of higher education.[118]

To help guide its mission, Air University developed a doctrine that included the view that "technical developments must be given continuous study and presentation to keep abreast of scientific developments and to project doctrines toward the future."[119] For additional guidance General Carl Spaatz, Chief of the Air Staff, established a board of visitors composed of a number of the foremost educators and heads of great universities to periodically review the operation of the Air University.[120]

The initial meeting of the Board of Visitors was held at the Air University, Maxwell Field, on 15-16 July 1946.[121] The meeting was addressed by the Commanding General of the Air University, Major General Muir S. Fairchild. His address gives a clear picture of the role Air Forces leaders envisioned the Air University playing with regard to the AAF R&D program.

Fairchild noted that the Air University had been established "to remedy the difficulties which were recognized in the pre-war school

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[118]Schlatter, "Air University," p. 11.

[119]Ibid., p. 10.

[120]Ibid., p. 11.

[121]U.S., War Department, Army Air Forces, Air University, "First Report of the Board of Visitors," Maxwell Field, Alabama, 16 July 1946, p. 1 (hereafter cited as AAF, AU, "First Report of Board of Visitors").

system" of the air service. The Air University was "to coordinate the functioning of its constituent schools and to plan the overall educational program of the Army Air Forces both within service schools and in post-graduate work in civilian institutions."[122]

According to Fairchild there were two major aspects of this mission of the Air University. The first of these was the education of Air Forces officers so that they would have the knowledge needed for their profession. The second major aspect was the "creation of doctrine, and the maintenance of doctrine up to date and in constance [sic] with the latest scientific developments and the latest thought as to the grand strategy of any future conflict."[123]

This second major aspect was of special importance in the eyes of Fairchild. Its importance was due to the long, five-year period between the original idea for a new weapon and the time when a weapon based upon the idea is ready for mass production; an error in thinking in 1946 could mean a catastrophe in 1951. With the decline of civilian interest in military problems following wartime, it was imperative that the Air University take responsibility for guiding thought and doctrine toward appropriate goals. "This even applies, I believe, in the field of scientific research and development."[124]

In the Air Forces' efforts to improve its educational system, then, one sees the influence of von Kármán's recommendations and of the

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[122]Muir S. Fairchild, "Introductory Address" to the Air University First Board of Visitors, 15 July 1946, in AAF, AU, "First Report of the Board of Visitors," p. 9.

[123]Ibid., pp. 9-10.

[124]Ibid., p. 10.

civilian university as a model for the improvement effort. On the one hand, there were the extravagant, inspirational remarks attributed to General Schlatter, Deputy Commanding General of the Air University: ". . . the entire AAF is really a university, and the formal instruction presented in the Air University is simply the core or the heart of the system."[125]

On the other hand, there is the more tangible indication of this influence in the institutional titles invoked by AAF leaders for the components of their reformed educational system. The Air University would provide the intellectual activity to assure the proper interaction between doctrine and R&D. The AAF's Institute of Technology would be organized into colleges under the direction of deans.[126]

There is evidence of a still more direct influence of the university model on the AAF efforts to establish an effective R&D program. Some of those advising and speaking to AAF leaders about R&D thought there was a direct relationship between the university and effective research and development.

In Science: The Key to Air Supremacy, von Kármán advised the Air Forces on the type of environment which should prevail in its laboratory facilities. But he first instructed AAF leaders on the "physical attributes of scientific life" which he claimed were "libraries, laboratories, publications, [and] society meetings." Von Kármán then commented on the success of several laboratories started

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[125]Schlatter, "Air University," p. 11.

[126]Gross to Fairchild, 27 Jun 46, p. 2; and Villency, "Big Stick," p. 45.

by the National Defense Research Committee during the Second World War. These laboratories had been established "in close connection with universities and directed by scientists belonging to the universities."[127] The results of these "cooperative laboratories" suggested to von Kármán that the Air Forces should establish such laboratories

> in which the administration and financial responsibility and management would remain with the government, and the scientific direction would be undertaken by faculty members. This method would solve the security problem and yet have the advantages of the geographical and spiritual connection with a place of scientific learning.[128]

This was not the first time that von Kármán had mentioned the importance of ties with an institution of scientific learning. He had earlier noted the importance of initiative and freedom in research. Von Kármán considered freedom to be even more essential to a healthy scientific undertaking than are free enterprise and initiative to a sound economy. He then commented: "It is imperative from this point of view that the Air Forces continue and expand their present direct relations, spiritual and contractual, with various universitites, research laboratories, and individual scientists." This was a necessity

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[127]Von Kármán, Key to Air Supremacy, p. 86.

[128]Ibid. Von Kármán greatly enjoyed his life as a university professor. For some of his recollections of university life, see: von Kármán, The Wind and Beyond, especially pp. 152-55, 176-77. For a comment on the manner in which scientists tended to favor university science in advice they give the government, see: Greenberg, Politics of Pure Science, p. 16. Greenberg quoted Alvin Weinberg, who was director of the Atomic Energy Commission's Oak Ridge National Laboratory at the time, commenting on the nature of the thinking involved in advice from the scientific estate to the government. Weinberg said: "the whole structure and cast of thinking is geared to the problem of university science, and the limitations of the university as an instrument of government are overlooked. It would not be a great exaggeration to describe the advisory apparatus . . . as a lobby for the scientific university."

if the Air Forces was to have "the freedom to call on institutions and individuals whose assistance they deem to be of the greatest benefit for their program." No single agency must be allowed to become the "only source of information and the sole intermediary agency between science and the Air Forces."[129]

A slightly different view of the freedom required in an R&D program was presented in a January 1947 speech delivered to a group of prospective Air Forces leaders attending the Air War College. The speaker was Dr. Hugh Dryden of the National Bureau of Standards.[130] He spoke of the creation of a scientific atmosphere within the Air Forces which

> implies not only the building of an organization in which the scientific method and procedure is applied in the broadest possible way but still more the development of an esprit de corps favorable to these methods and procedures. There must be not only a willingness but a desire to use objective and quantitative procedures where possible, to rely in technical matters especially, on those with expert knowledge, and to look for technical leadership to technically qualified leaders.[131]

Dryden spoke specifically of the conditions necessary for basic research to flourish. He noted that basic research or the search for new knowledge is "an intellectual activity of the highest type and flourishes only in the atmosphere of greatest freedom." It must be free from immediate and specific goals, time tables, controls and restrictions.[132] Such freedom is to be found primarily in the

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[129]Von Kármán, Key to Air Supremacy, p. 85.

[130]"The Contributors," Air University Quarterly Review, I, No. 1 (Spring 1947), 120.

[131]Dryden, "Science and the Air Force," p. 7.

[132]Ibid., p. 8.

university environment if one accepts the views of Vannevar Bush. This belief in a direct relationship between universities and a healthy environment for R&D continued to be a strong element of the image of R&D entertained by some Air Force leaders, as will be shown later.

Another aspect of AAF efforts to establish a viable R&D program appeared during General Arnold's October 1945 appearance before Congress. This was the need to create personnel policies that would make working for the AAF an attractive career for scientists. He told the Senate subcommittee:

> As I see it in the Air Forces, the day is now over when we were all pilots. There was a time when the pilot was probably 60 percent of flying. Then, as time passed, we became more and more mechanical in our operation of our planes. . . . We are now coming to the point where the pilot hasn't the importance he used to have. We have to have a corps of scientists, of technicians, of equal importance to the pilot; we have got to have a corps of administrators; and then we have to have a corps of pilots to do the actual operation--three different pyramids building up within the Air Corps, all coming up to a common top.[133]

General Arnold believed the AAF had to have scientists in uniform as well as civilian scientists. But both the civilian and the military scientists had to be provided with a flexible status of employment where travel, working accommodations, continued education, honorary and social recognition, and opportunity to publish papers were emphasized.[134] A formal AAF Letter of April 1946 reflects an effort on the part of the Air Forces to establish this flexible status as a part of the R&D environment of the AAF. The Letter noted the following:

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[133]Senate Committee on Military Affairs, Hearings on Science Legislation, 1945, p. 355.

[134]Ibid., pp. 354-56.

> The air force of the future will require an even greater level of education in technical and scientific subjects on the part of its personnel. Recent developments have emphasized the necessity for such a background. Education should be a continuing process and the trend of thinking kept in current and progressive channels. This is particularly necessary for those officers of the AAF who have attended postgraduate college courses in selected scientific subjects or who possess technical skills.[135]

To enhance the value of officers to the AAF they were to be encouraged to participate in professional societies such as the American Society of Mechanical Engineers, the National Academy of Sciences, and the "American Academy [sic] for the Advancement of Science."[136]

Dr. von Kármán also expressed considerable concern about AAF personnel policies in Science: The Key to Air Supremacy. He recommended long tenure for officers in charge of laboratories. This tenure was essential if such officers were to learn their duties sufficiently well to be effective. This long period in one assignment must not be allowed to jeopardize the technical officer's career.[137]

In addition to the recommendations with respect to tenure of office, von Kármán argued that the size of the organization commanded by a technical officer must be a significant criterion for his promotion. The appropriate promotion criteria in the case of technical officers should be the importance of their work and technical achievements.[138]

With regard to civilian scientists, von Kármán commented on the

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[135]U.S., War Department, Army Air Forces Letter 35-104, "Membership of AAF Personnel in Scientific Institutions and Societies," Washington, D.C., 15 April 1946, p. 1.

[136]Ibid.

[137]Von Kármán, Key to Air Supremacy, p. 103.

[138]Ibid.

deficiencies of the civil service system. The Air Forces must be allowed to hire and fire civilian scientists outside the normal civil service system. Indeed, von Kármán even recommended the establishment of a special branch of the civil service for scientific personnel.[139]

In August 1946 the need for qualified scientific personnel was again noted, this time in a memorandum entitled "Need for a Coordination of Planning of Research and Development Activities." Here it was pointed out that sufficient trained personnel, along with ample funds, adequate facilities, and solvable problems, are the four essential elements in a successful R&D program.[140]

The effort to create a favorable environment for research personnel was not restricted to the undertakings of AAF officers and their civilian advisers. A conference of War Department scientific and professional civilian personnel was held in March 1947. After recommending that a long-range research program and a stable budget for research and development be established, the conference report called for a clearer establishment of the division of research (basic and applied) between the War Department and civilian research contractors. The report also called for the relief of top research scientists from administrative work by assigning them administrative assistants. Finally, the report recommended that the R&D field be opened up to

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[139] Ibid., pp. 103-04.

[140] "Need for A Coordination of Planning of Research and Development Activities," 28 August 1946. Unsigned memorandum with Col. Wilson's name (possibly Colonel Roscoe C. Wilson) penciled in at the top. The memorandum was marked for file under "Scientific Personnel." This document is available in folder 168.64-25A 1946-47 at the Air Force Archives, Maxwell Air Force Base, Alabama.

military personnel by offering them recognition and advancement.[141]

During that same spring of 1947 when the War Department personnel conference met, Colonel Glantzberg published his article on the Air Force and science in the Air University Quarterly Review. Colonel Glantzberg, it will be recalled, had served as military director for von Kármán's wartime Scientific Advisory Group. He was firmly committed to the close dependence of applied research upon basic research.[142]

For Glantzberg, a crucial factor in a good research program was good people.

> The effectiveness of these [research and development] facilities depends entirely upon the caliber of the men using them. It is a common mistake to judge the scientific competence of a laboratory by the number, variety, and appearance of special pieces of apparatus. The most impressive laboratories can conceivably turn out inferior scientific work and many major contributions to science have come from inadequately equipped and poorly supported laboratories. The point is that the effective use of scientific and technical facilities requires the best available personnel, and that good facilities are not a substitute for able scientists. . . .
> . . . Well qualified scientists are needed not only in research and development activities but also as members of staffs and of operating units. Moreover, all personnel in positions of responsibility should be able to evaluate scientific facts with sound judgment and with some vision of future developments.[143]

Not everyone in the Air Force should be trained as a specialist in all fields of science, but everyone should have a broad knowledge of

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[141]"Report of Conference of Scientific and Professional Civilian Personnel of the War Department," 10 March 1947, pp. 1-2. The subject of the conference was: "Creation of a True Professional Environment in War Department Research & Development Installations." The report of the conference may be found in the Air Force Archives, Maxwell Air Force Base, Alabama, folder 168.64-25A.

[142]Supra, pp. 33-34.

[143]Glantzberg, "Air Force and Science," p. 15.

scientific and technical matters. This is not to say the Air Forces must be composed entirely of "jacks-of-all-trades and masters of none." The Air Force must have some leaders in highly specialized fields or it will be doomed to mediocrity.[144]

Glantzberg noted that both General Arnold (in January 1945) and General Spaatz (in 1946) had stated the need for changing regulations that limited the responsibility and career opportunities of non-flying technical officers. In addition to these changes, the Air Forces must assure that research and development was not hampered by unrealistic security policies and that adequate facilities were available.[145] Concluding his article on a cautionary note, Glantzberg wrote:

> The problem of creating conditions within the Air Force that are attractive to technical personnel is extremely complex and difficult, but it is one which we must solve if America is to remain a first-class power.[146]

In retrospect, it can be seen that a spirit of change pervaded the policy atmosphere of the Army Air Forces during the early postwar period. Extensive changes in the AAF approach to R&D were recommended by such R&D experts as Theodore von Kármán and F. Russell Bichowsky. And in the wider context of the federal government a similar atmosphere prevailed, as Congress sought to work out a national science policy. Furthermore, several Air Forces leaders in high, policy-making positions--of whom the most influential was General Hap Arnold--had spoken out as strong advocates of a changed R&D policy.

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[144] Ibid.

[145] Ibid., pp. 12, 14-16.

[146] Ibid., p. 16.

Some changes had even been begun. A Deputy Chief of Air Staff for Research and Development had been established, and the temporary Scientific Advisory Group had been transformed into a permanent part of the AAF organizational structure.

But these turned out to be merely surface changes. And beneath the surface the AAF R&D program continued to be conducted along conservative and traditional lines. R&D continued to be regarded as properly a part of, and thoroughly subordinate to, the overall matériel function of the AAF, as events of the postwar forties were to demonstrate.

Such a view of the proper place for R&D derived from the policy view that the major functions involved in a fighting organization are operations (the combat arm), personnel, and supply. Personnel provides trained men that are equipped by the supply organization to accomplish military objectives sought by the operational organization.

The development of the AAF organizational structure during World War II reflects the deep-rooted adherence to this traditional view of military management and organization. On 2 March 1942 the United States Army issued Circular Number 29 in response to perceived realities that were being experienced in World War II. One of these realities, or images, was the growing importance of airpower. The Circular divided the Army into three basic components: the Army Air Forces, the Ground Forces, and the Army Services and Supply.[147]

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[147]Byron E. Gates, "Organization of the Army Air Forces," Air Force: Official Service Journal of the U.S. Army Air Forces, XXVI, No. 2 (February 1943), 13 (hereafter cited as Gates, "Organization of AAF").

The Circular described the mission of the AAF as follows: "'The mission of the Army Air Forces is to procure and maintain equipment peculiar to the Army Air Forces, and to provide air force units properly organized, trained and equipped for combat operations.'"[148] To assure accomplishment of this mission the AAF was reorganized in 1942. Since the AAF was a part of the Army, the new AAF headquarters organization paralleled that of the Army. The headquarters consisted of four major staff elements: Personnel (A-1), Intelligence (A-2), Training and Operations (A-3), and Supply (A-4). These agencies kept in constant touch with their Army equivalents which were designated as G-1, G-2, G-3, and G-4.[149]

The impact of this traditional view upon the management of research and development becomes obvious when one examines AAF regulations that pertain to R&D. About a month after the establishment of the DCAS/R&D in January 1946,[150] the Army Air Forces created its AAF Technical Committee. This committee was established as a part of the Air Technical Service Command at Wright Field, Dayton, Ohio. Its purpose was to

> provide a centralized agency to consider and recommend action upon all matters of research, development, classification, and procurement of materiel designed for and intended to be used by the armed forces coming within the jurisdiction of the AAF and upon

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[148]United States Army Circular Number 29, 2 March 1942, quoted in Gates, "Organization of AAF," p. 13.

[149]Gates, "Organization of AAF," p. 13. The close relationship between AAF staff agencies and those of the War Department was also noted on p. 45 of Craven and Cate, Men and Planes.

[150]AAFR 20-62, p. 1.

such matters as may be referred to it by the Commanding General, AAF.[151]

The following is a brief summary of some of the major functions assigned to the Technical Committee:

1. "Review all new research and development projects before initiation of work or prior to making contractual commitments, bearing in mind that it is often necessary that preliminary research and development work be conducted without a clear idea of what the results will be." Once it is decided that a development is desirable, an investigation was to be conducted to see if similar work that might be helpful has been done. Then a development project may be initiated.

2. Insure coordination with various other R&D agencies.

3. Rule on what equipment is to be considered obsolete.

4. "Assure that specifications for articles of equipment peculiar to the AAF, and not assigned to other Services, conform to approved military characteristics in all cases in which specifications for procurement are based upon approved military characteristics and that procurement is based on approved requirement programs."

5. Review AAF R&D programs.

6. "Recommend to the Commanding General, AAF (ATTENTION: AC/AS-4) [Assistant Chief of Air Staff, Matériel and Supply] [italics mine], the release of research and development projects for limited production, which have not progressed to a point justifying standardization."

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[151]U.S., War Department, Army Air Forces Regulation 20-63, "Organization: AAF Technical Committee," Washington, D.C., 15 February 1946, p. 1 (hereafter cited as AAFR 20-63, 15 Feb 46).

7. "Forward to Headquarters, AAF (ATTENTION: AC/AS-4) [italics mine], for review and approval, all major research and development projects desired to be initiated by Air Technical Service Command. The class of projects to be considered will be those with high development cost, the procurement of complete aircraft, and those upon which the opinion of higher authority as to eventual tactical usage are believed desirable."[152]

AAFR 20-63 also stated that the commander of Air Technical Service Command was responsible for initiating or recommending the initiation of R&D projects "as may be required to produce the most satisfactory article complying with or surpassing established military characteristics." He was also responsible for initiating or recommending projects "as may be required generally to advance applied research or to surpass performance of articles required by military characteristics or foreseen as a possible future requirement, though not specifically required by established military characteristics."[153]

In addition to the requirements levied on the AAF Technical Committee with respect to the Assistant Chief of Air Staff, Matériel and Supply (AC/AS-4), the secretariat of the Committee was required to furnish AC/AS-4 with an agenda and a complete set of minutes for each meeting.[154] One might well wonder, at this point, what had happened to the Deputy Chief of the Air Staff for Research and Development.

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[152]Ibid., pp. 1-3.

[153]Ibid.

[154]Ibid., p. 4.

In July 1947 a fundamental reorganization occurred at the Cabinet level of the Executive Branch, and although it offered potent implications for a reappraisal of R&D in association with military operations, a new day did not dawn immediately. Instead, the struggle between the conservative and the more innovative-minded managers continued, but within an altered institutional framework which offered greater flexibility of maneuver. For on 26 July 1947 President Harry S. Truman signed into law the bill that established the Department of the Air Force which was coequal to the Department of the Army and the Department of the Navy. All of these departments were contained within the Department of Defense.[155] Henceforth the Army Air Forces would be known as the United States Air Force (USAF).

In September 1947 an organization similar to the former AAF Technical Committee was established at Headquarters USAF; this was the USAF Aircraft and Weapons Board. Its mission was to "determine the aircraft and weapons development and procurement program for the armed forces which comes within the jurisdiction of the USAF." Additionally, it was to "consider such other related matters as may be referred to it by the Chief of Staff, USAF."[156]

The Board was to determine "the basic types of aircraft and weapons required to carry out the mission and plans of the USAF." It was also to determine military characteristics for weapons and planes,

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[155]Eugene M. Emme, 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), p. 57 (hereafter cited as Emme, Aeronautics and Astronautics).

[156]U.S., Department of the Air Force, Air Force Regulation No. 20-10, "Organization: USAF Aircraft and Weapons Board,"

set requirements for new aircraft and weapons development projects, and select aircraft and weapons for procurement.[157]

The Assistant Chief of Air Staff for R&D was included as a member of this board. But the Board was heavily weighted in favor of operations; the Assistant Chief of Staff for Operations and the Commanding Generals of Strategic Air Command, Tactical Air Command, Air Defense Command, and Air Transport Command were also members. Additionally, the Assistant Chief of Staff for Matériel and the Commanding General of the Air Matériel Command were Board members.[158]

The operations element of the Air Force was given additional power on the Board by assigning to the Chief of the Requirements Division of the Office of Assistant Chief of Staff, Operations, the duties as Secretary of the Board. The Secretary was responsible for preparing the agenda and the minutes for each meeting. Furthermore, the Secretary was to "take action for the Board within the scope of authority delegated by the Board."[159]

When the Air Force first achieved independent status in 1947, there was, inevitably, discussion of organizational changes at Headquarters USAF. The major rationale for the changes was given as the need to reduce the number of staff elements that reported directly to the Chief of Staff USAF from thirteen to seven. Early evidence

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Washington, D.C., 29 September 1947, p. 1 (hereafter cited as USAFR 20-10, 29 Sept 47).

[157] Ibid.

[158] Ibid.

[159] Ibid., p. 2.

indicated that the Assistant Chief of Staff for Research and Development would become the Director of Research and Development and be given a staff position which would place him on the same organizational level as the Director of Personnel, the Director of Plans and Operations, the Director of Matériel, and the Comptroller. But eventually R&D was to be given lower organizational status.[160]

On 10 October 1947 the Air Force placed in effect a new organizational structure. The reorganization provided for four major staff elements under the office of the Chief of Staff, USAF: the Air Comptroller, the Deputy Chief of Staff for Personnel and Administration, the Deputy Chief of Staff for Operations, and the Deputy Chief of Staff for Matériel. The Assistant Chief of Staff for R&D had become the "Director of Research and Development," but this constituted an organizational demotion, for the various "Directors" on the USAF staff reported not to the Chief of Staff, but to the Deputy Chiefs of Staff. Research and Development staff responsibility had been absorbed by the Office of the Deputy Chief of Staff for Matériel, and the traditional emphasis still prevailed.[161]

On 31 October 1947 a new USAF Regulation 20-10 replaced the 29 September 1947 version of the regulation. It reflected the impact of organizational changes that had occurred since the appearance of the original regulation. The Assistant Chief of Staff for R&D was no longer

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[160]"Life Begins at Forty: US Air Force," Air Force: Official Journal of the Air Force Association, XXX, No. 9 (September 1947), 20-21 (hereafter cited as "Life Begins at Forty: USAF").

[161]"Air Staff Changes," Army and Navy Journal, LXXXV, No. 5 (4 October 1947), 107.

on the USAF Aircraft and Weapons Board.[162] Here one can see tangible evidence of what it meant for R&D to be relegated from the Assistant or Deputy Chief of Staff level to the Directorate level. There was no longer a member of the Aircraft and Weapons Board who represented strictly R&D interests.

A second revision of USAFR 20-10 appeared in November 1947. Only one change was made--a section of definitions was added.

> Definitions. "Aircraft and weapons" are defined for the purposes of this Regulation as complete military aircraft and weapons intended for assignment to and employment by organized combat units and training establishments of the armed forces; the term is not intended to include component parts of such aircraft and weapons, nor does it include purely research aircraft and weapons which have no immediate military application, but which promise to be useful research vehicles for future development.[163]

Thus the Air Forces had attempted to graft an R&D organization onto its traditional organizational structure without making any really fundamental changes in the way R&D was managed. The graft failed to take, and subsequent interpretations of this failure seem to have been related to the attitude held toward the management of R&D. Those who wished to have the management procedures and organization of the past continued largely as they had been tended to regard the failures as due to a violation of proper military organizational principles; the failure that their resistance to change had helped to produce was thus viewed as a vindication of their views on the

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[162] U.S., Department of the Air Force, Air Force Regulation 20-10, "Organization: USAF Aircraft and Weapons Board," Washington, D.C., 31 October 1947, p. 1.

[163] U.S., Department of the Air Force, Air Force Regulation 20-10, "Organization: USAF Aircraft and Weapons Board," Washington, D.C., 21 November 1947, p. 1.

management of research and development.

On the other hand, those who favored a new departure in the management of research and development thought that the failure resulted from making changes that were merely superficial in nature. According to the advocates of more fundamental change, the Army Air Forces and the new Air Force had simply failed to establish an organization capable of properly managing R&D. They did not abandon their efforts to give R&D the increased emphasis and qualified independence which they thought it required.

## CHAPTER III

## COMPETING IMAGES OF BASIC RESEARCH AND R&D: 1947-1949

The establishment of a Deputy Chief of Air Staff for R&D in January 1946 was regarded at the time as an essential step toward the implementation of the reforms recommended in von Kármán's Science: The Key to Air Supremacy. Yet in October 1947 this office was eliminated and its functions absorbed by the Office of the Deputy Chief of Staff for Matériel. Then, some fifteen months later, von Kármán again recommended the establishment of a DCS/R&D, this time to General Hoyt S. Vandenberg who was then serving as the USAF Chief of Staff.[1] And less than two and a half years after the elimination of the DCAS/R&D the Air Force established a Deputy Chief of Staff for Development and created the Air Research and Development Command (ARDC).[2] The circumstances which produced this turnabout are worth examining. How could such

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[1]Theodore von Kármán to Hoyt S. Vandenberg, 15 January 1949, p. 1, in ARDC Office of Command Historian, History of ARDC: 23 Jan 50-30 Jun 51, II (hereafter cited as von Kármán to Vandenberg, 15 Jan 49).

[2]Muir S. Fairchild, Vice Chief of Staff, USAF, Memorandum for the Assistant Vice Chief of Staff and The Deputy Chiefs of Staff for Personnel, Comptroller, Operations, and Matériel, "Organization for Research and Development in the USAF," 23 January 1950, in the Air Force Archives, Maxwell Air Force Base, Alabama, p. 1 (hereafter cited as Fairchild, Memorandum, "Organization for R&D," 23 Jan 50).

fundamental changes in organizational structure be affected within thirty months of the time when similar changes had been blocked and even undone?

Traditionalism continued to be a strong factor in the R&D milieu of the Air Force during the late forties and early fifties. Advocates of the traditionalist approach to R&D management continued to resist efforts to revise the Air Force research and development policy. One indication of how successful they were is to be found in a 1949 "in-house" report which received attention in upper echelons of Air Force command--the "Ridenour Report." Said this Report, in part:

> The entire complex of activities: fundamental research (new knowledge), applied research and initial development (the first approach to a specific end), engineering (for a tactically useful version), procurement, quality control, testing to specifications, technical evaluation, supply, maintenance, industrial planning and mobilization--are presently considered in the Air Force under one heading, Materiel.[3]

Perhaps the most prevalent element of this continuing traditionalism was the view that the Air Force is predominantly a combat arm. In literature dealing with the Air Force R&D program, this trait was frequently referred to in negative terms. Thus, Colonel Arthur A. Fickel observed the following during a July 1949 meeting of the USAF Scientific Advisory Board:

> The Air Force until a decade ago was a combat arm, leaning in all directions for its research and development. I do not intend to slight the excellent work of the Engineering Division starting in

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[3]U.S., Department of the Air Force, Scientific Advisory Board, Research and Development in the United States Air Force, Report of a Special Committee of the Scientific Advisory Board to the Chief of Staff, USAF, September 1949, p. V-5 (hereafter cited as the Ridenour Report). Louis N. Ridenour was the influential Chairman of the Special Committee. Other comments on matériel control of the R&D may be found on pp. III-1, V-1, and V-2 of the Report.

> 1945 and even before; I merely say that, at least in general impression, the Air Service, or the Army Air Forces, had been primarily a supplicant either to the other Services of the Army and the Navy or to the aircraft industry.[4]

Although Fickel referred to the air service as it was ten years earlier, his reference to the Army Air Forces indicates that he also had more recent times in mind.

There is little doubt that the drafters of the Ridenour Report were concerned about the combat orientation of the Air Force when they wrote:

> The Air Force is no longer merely a combat arm. It is now a Department with the responsibility of being self-sufficient. It cannot achieve self-sufficiency unless it becomes competent in research and development, . . ..[5]

Even more pointed was a comment contained in the "Air University Study" of USAF R&D that was prepared in 1949 by the Air University Committee headed by Major General Orville A. Anderson and including as members Major General Donald L. Putt, Brigadier General Ralph P. Swofford, Jr., and Colonel Keith K. Compton.[6]

> The USAF should be more than a combat arm in being. Its present emphasis is such that it <u>is</u> primarily a combat arm--and, if the present emphasis is continued, it is a combat arm which will radically decrease in significance and war potential as technology progresses beyond the familiar boundaries of

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[4]Transcript of Scientific Advisory Board Conference, Held 12 July 1949, Room 4C-961, the Pentagon, Washington, D.C., (Conference convened at 3:20 PM and adjourned at 5:05 PM), Dr. Louis Ridenour, Chairman, Presided. USAF Presentation by AFOAT, Gen. D. M. Schlatter, and Colonel A. A. Fickel, p. 15 (hereafter cited as SAB Transcript, 12 Jul 49).

[5]Ridenour Report, p. VII-2.

[6]U.S., Department of the Air Force, Air University Committee, "<u>Air University Study</u>: Research and Development in the United States Air Force," 18 November 1949, in ARDC Office of Command Historian, <u>History of ARDC: 23 Jan 50-30 Jun 51</u>, II (hereafter cited as Air University Study).

> World War II. Current emphasis upon day-to-day operational and materiel problems has been so great as to radically and adversely affect the long term development of the Air Force.[7]

Nearly ten years later similar sentiments that the Air Force was predominantly a combat arm were offered in a 1958 article by Colonel Edward N. Hall, Director of Weapon System 133A, the "MINUTEMAN" intercontinental ballistic missile program. Wrote Hall:

> Traditionally the military services have been combat-oriented; their major task has been operational, and everything else has been treated as an unfortunate diversion to be delegated whenever possible to appropriate civilian agencies.[8]

If it was not the primary cause, combat orientation at least contributed to certain attitudes, views, and situations which were not conducive to a flourishing Air Force R&D program. For one thing, there were those in the Air Force who thought that R&D should be subordinate, even subservient, to the operations and logistics elements of the service. An expression of this view is found in a briefing presented to General D. M. Schlatter prior to a 3 January 1950 meeting of the Air Staff. In its discussion of the establishment of a Deputy Chief of Staff for R&D the text of the briefing contains these words:

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[7] Ibid., pp. 2-3.

[8] Edward N. Hall, "Industry and the Military in the United States," Air University Quarterly Review, X, No. 3 (Fall 1958), 27, 39 (hereafter cited as Hall, "Industry and the Military"). For a more recent statement on the combat orientation of the American military, see: Robert G. Gard, Jr., "The Military and American Society," Foreign Affairs, IL, No. 4 (July 1971), 702. Here Colonel Gard, speaking of more recent events, wrote: "Bureaucratic imperatives demanded that the military develop within its ranks new technical, analytical and managerial skills of a high order. But continued military preoccupation with the combat function precluded an adequate response to this requirement."

> The other Deputies and staff personnel oppose a deputy [for R&D] on general principles and also on the basis of a philosophy that operations and logistics are the military concerns which technology serves. The three are not co-equal as would be implied by a deputy for "research and development."[9]

One of the most outspoken proponents of change in the Air Force R&D program was General Donald L. Putt. In November 1949 Putt addressed the Air War College on the subject of Air Force R&D. A statement in his address concerned the relationship between scientists and fighting men, and in this statement one sees another indication of the subordinate role in which research and development was cast by the emphasis on combat activities. As Putt expressed it: "Scientists must be more than mere consultants to fighting men. They must become full and responsible partners in the conduct of war."[10]

General Putt also indicated that there were those in the Air Force who did not possess favorable views of the activities of scientists:

> There are those in high positions in the Air Force today who feel that scientists and technical personnel, in and out of the military, are an odd group wasting millions of dollars promoting their own pet ideas and producing very little that will contribute

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[9]Text of a Briefing for General Schlatter prior to the Air Staff Meeting of 3 January 1950 on the Air Force Research and Development Studies, p. 3, in ARDC Office of Command Historian, History of ARDC: 23 Jan 50-30 Jun 51, II (hereafter cited as Text of Briefing for General Schlatter). See also Brigadier General N. B. Harbold, Inspector General, Air Matérial Command, Memorandum to General Streett, Subject: "Report of the Special Committee of the SAB," 5 December 1949, p. 1, in U.S., Department of the Air Force, History of the Separation of Research and Development from the Air Materiel Command, Vol. III (hereafter cited as History of the Separation of R&D from AMC, III). Harbold questions if R&D is important enough to be given separate command status.

[10]Donald L. Putt, "USAF Research and Development," Speech to the Air War College, Air University, Maxwell Air Force Base, Alabama, 17 November 1949, p. 16 (hereafter cited as Putt, "USAF R&D").

to the Air Force of today or tomorrow.[11]

The tendency to subordinate R&D to other considerations in the Air Force seems to be the underlying cause of another problem cited by General Putt. In July 1949 Putt remarked to a conference of the Scientific Advisory Board that the Comptroller of the Air Force had cut 1500 manpower spaces from the R&D program "to take care of repair and utility needs."[12] In his later address to the Air War College Putt noted that demobilization in the period following World War II had led to manpower raids on R&D functions to fill overseas manpower spaces. Since many of the R&D specialists were unwilling to serve overseas, the Air Forces lost the services of "several hundred highly trained technical officers."[13]

Another problem that combat orientation seems to have caused for R&D was in the area of the directives that governed the functioning of the Air Force. The Air University Study described the situation as follows:

> Standard Air Force regulations which are designed for the management and operation of tactical, administrative, or procurement organizations seriously interfere with the efficient management and operation of Research and Development activities.[14]

The battlefields of World War II were the training grounds for many post-World War II AAF leaders, and their wartime experience sometimes dictated their attitude toward R&D. An article in Air Force

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[11]Ibid., pp. 21-22.

[12]SAB Transcript, 12 Jul 1949, p. 27.

[13]Putt, "USAF R&D," p. 37.

[14]Air University Study, p. 2.

magazine described the situation well:

> Many of the men who are now in policy-making positions within the Air Force are men who were in the field during the last war, fighting with great courage and valor, but with airplanes that never seemed to go quite far enough nor carry quite enough bombs. Somehow they got the job done in spite of the limitations of their equipment, but when they came home after the war to assume administrative duties made vacant by older, retiring officers, their first and very natural resolve was to improve upon the weapons they had just laid down . . . to build a fighter that would go faster and turn more sharply, or a bomber that would go farther and carry a bigger load. These were the requirements as dictated by their own first-hand experience on the front. And so Research & Development became a job of perfecting and refining old weapons instead of what it was supposed to be--a search for new ones.[15]

Six months before the appearance of the article in Air Force General Putt had made similar comments in his address to the Air War College. He remarked that there were those people in the Air Force who "hold that research and development must be kept under rigid control by 'requirements' and 'military characteristics' promulgated by operational personnel who can only look into the past and ask for bigger and better weapons of World War II vintage."[16]

As late as 1960 there were descriptions of this traditional view of R&D being given. General Roscoe C. Wilson had this to say about R&D traditionalism before a subcommittee of the House Appropriations Committee:

> There was a time when the research and development activities came under the material part of the Air Force and our efforts were confined almost entirely to improving what we already had on hand. Under this system, the atomic bomb, for instance, could never have

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[15]"Key to the Future: A Special Report on Air Force Research and Development," Air Force: The Official Journal of the Air Force Association, XXXIII, No. 6 (June 1950), 16 (hereafter cited as "Key to the Future").

[16]Putt, "USAF R&D," p. 22

been invented. It was a matter of just creeping along bit by bit.[17]

But it would be unfair to the leaders that were guiding the activities of the Air Force after World War II to say their R&D decisions were totally controlled by traditionalism. This period was a time of exceptional activities; AAF and AF leaders faced numerous situations of crisis or near-crisis proportion between 1945 and 1950.

Perhaps the first major difficulty that confronted AAF leaders following World War II was demobilization. At the time of the Allied victory over Japan the Army Air Forces was made up of 2,253,000 men. By April 1946 this strength had been reduced to 485,000. AAF manpower decreased further to 303,000 at the end of May 1947. The number of aircrew members had decreased from 413,890 on V-J day to 24,079 in June 1947.[18]

Such drastic reductions in force could hardly have failed to alter the conduct of affairs in the Army Air Forces. In January 1945 fifty-four percent of the AAF's first-line aircraft were available for immediate use; by 31 October 1946 only eighteen percent of the combat aircraft were ready for combat. "Effective combat units--the most meaningful measure of combat strength--melted away from 218 groups on V-J Day to two groups in December 1946."[19] The situation was described

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[17]U.S., Congress, House, Committee on Appropriations, Department of Defense Appropriations for 1961, Part 6: Research, Development, Test, and Evaluation, Hearings before the subcommittee of the Committee on Appropriations. 86th Cong., 2d sess., 1960, p. 479.

[18]Alfred Goldberg, "The Establishment: Worldwide Air Force," in Goldberg, History of USAF, p. 105 (hereafter cited as Goldberg, "Worldwide Air Force").

[19]Ibid.

in these words by one author:

> Following VJ-Day, demobilization was pushed through in such haste that our armed services were literally ripped apart. Our mighty air forces shrank to a remnant as pilots and crews were discharged, helterskelter, and great armadas of bombers and fighters junked or pickled. By midyear, officers who had led the AAF to victory assessed their skeleton commands and had to admit grimly that it would be impossible to put a single B-29 squadron in the air, and that "Today we couldn't fight our way out of a paper bag!"[20]

The tremors of demobilization had hardly ceased to shake the Pentagon when the quake of "unification" struck, and the National Security Act of 1947 combined the War Department and the Department of the Navy into a single Department of Defense. From the standpoint of the Air Force, the key word describing the National Security Act of 1947 was not unification, but rather "separation," for the Act established the Department of the Air Force as a separate division of the Department of Defense.[21]

Separation was not achieved by a mere pronouncement; it involved a long and detailed process. Although 18 September 1947, the day the first Secretary of the Air Force, W. Stuart Symington was sworn in, is celebrated as the official birth date of the United States Air Force.[22] The Army and the Air Force had begun planning for the separation as early as July 1947. As finally approved, the plan involved "some 22

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[20]La Motte Cohu, "'Paper Bag' Air Force," Air Force: Official Journal of the Air Force Association, XXX, No. 3 (March 1947), p. 12.

[21]Wihelmine Burch, "The Establishment: September 18, 1947," in Goldberg, History of USAF, pp. 99-103 (hereafter cited as Burch, "September 18, 1947"). See also "Life Begins at Forty: 'The Day Billy Dreamed of,'" Air Force: Official Journal of the Air Force Association, XXX, No. 9 (September 1947), 20-21, 43 (hereafter cited as "'Day Billy Dreamed of'").

[22]Burch, "September 18, 1947," p. 89.

Army-Air Force agreements." Based upon these agreements, "formal transfer orders" were issued. It was not until 22 July 1949 that the final transfer order was signed.[23] And it was not until fiscal year 1950 that the Air Force operated on a budget presented to Congress independently of the Army.[24] Separation of the Air Force from the Army had made it necessary for the Air Force to develop a budget structure and improve Air Force "skills in the field of management by giving Air Force officers special business training in both military and civilian institutions."[25]

Additionally, in various documents of 1947 one glimpses some of the detailed negotiations involved in the creation of an independent Air Force. For example, there was a lengthy memorandum specifying what R&D functions the Air Force would begin to perform without War Department approval, what programs and equipment the Air Force would be responsible for, and what would be done about the division of personnel between the Army and the AF.[26] This same memorandum indicated that in the area of personnel allocation between the Army and the

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[23]Goldberg, "Worldwide Air Force," p. 106.

[24]Lt. Gen. E[dwin] W. Rawlings, USAF Comptroller, "Budgeting for the Air Force," Army and Navy Journal, LXXXVI, No. 43 (25 June 1949), 1227.

[25]Ibid.

[26]Major General Curtis E. LeMay and Colonel Cloyd H. Marvin, Memorandum for Lt. Gen J. Lawton Collins, Subject: "Proposed Action for Separation of Army and Air Force Research and Development," 26 August 1947, pp. 1-4. This document was found in folder 168.64-15A 1945-47 of the Correspondence of General Curtis E. LeMay in the Air Force Archives, Maxwell Air Force Base, Alabama.

new Air Force there was some disagreement.[27] Furthermore, TAB B of the memorandum listed fifteen officers who were to be assigned to the Air Force and established a schedule for each one to be phased out of the Army's R&D program.[28] In at least one case, the transfer of officers involved separate negotiations.[29]

The relative chaos created by demobilization and separation of the Air Force from the Army was further complicated by a deteriorating world situation. As Walter Millis, an American military historian wrote: "When James Forrestal took office as First Secretary of Defense in the late summer of 1947, the nation was facing a situation as grim as it had been, largely, unforeseen."[30] Having consolidated her satellite empire in Central Europe, the Soviet Union "was intensifying a remorseless pressure on territories beyond--on Czechoslovakia, Greece and Turkey."[31]

In early 1947 Britain had announced her inability to continue her efforts to keep Greece from falling into the hands of the

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[27]Ibid., pp. 4-5.

[28]Ibid., TAB B.

[29]Major General Curtis E. LeMay, Memorandum for the Director of Research and Development, War Department General Staff, Subject: "Release of Air Force Officer," 30 September 1947, p. 1. The memorandum was found in folder 168.64-15A 1945-47 of General Curtis E. LeMay's correspondence in the Air Force Archives, Maxwell Air Force Base, Alabama. The officer involved in these negotiations was Colonel Frank R. Cook.

[30]Walter Millis, Arms and Men: A Study in American Military History (New York: G. P. Putnam's Sons, 1956), p. 314 (hereafter cited as Millis, Arms and Men).

[31]Ibid., pp. 314-15.

Communists. This situation inspired President Harry S. Truman to tell Congress and the American people on 12 March 1947 that the U.S. must adopt a policy of supporting all free peoples resisting subjugation by armed minorities or outside pressure.[32] The Truman Doctrine, as it came to be called, placed a heavy burden on the U.S. Armed Forces, for it "initiated a military foreign aid program which eventually included a large number of countries throughout the world and required a great deal of manpower and resources from the U.S. military services."[33]

About a year following the pronouncement of the Truman Doctrine the Russians began to restrict the flow of traffic between West Germany and West Berlin. This resulted in the initiation of a massive airlift to provide the necessities of life to West Berlin.[34] Although the blockade was lifted in May 1949,[35] the airlift was not officially concluded until 30 September 1949 to assure that reserve stocks in Berlin were adequate and that the international situation had been clarified.[36]

Operation VITTLES, as the Berlin Airlift was known to the Air Force, was a massive undertaking. The airlift began on a rather small

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[32]Norman A. Graebner, Cold War Diplomacy: American Foreign Policy, 1945-1960 (Princeton, New Jersey: D. Van Nostrand Company, Inc., 1962; Anvil Original, 1962), pp. 40-41 (hereafter cited as Graebner, Cold War Diplomacy).

[33]Goldberg, "Worldwide Air Force," p. 110.

[34]Graebner, Cold War Diplomacy, pp. 47-48.

[35]Ibid., p. 48.

[36]Harold Larson, "The Deeds: The Berlin Airlift," in Goldberg, History of the USAF, p. 241.

scale with only eighty tons of milk, flour, and medicine being delivered to Berlin by the United States Air Forces in Europe on 26 June 1948. But as the blockade continued it became obvious that such a large city could be supported from the air only if a vast operation were undertaken. The needs of the Berliners and Allied military personnel stationed in that city were estimated originally at about 4,500 tons of supplies a day, but in October 1948 this estimate was increased to 5,620 tons per day with 3,084 tons of coal comprising the bulk of the matériel.[37]

Although the Air Force was assisted in this effort by the British Royal Air Force and by the U.S. Navy, extensive USAF assets were committed to meeting the requirements of the airlift. Air Force C-54 aircraft constituted the backbone of the airlift force. Approximately 400 of these four-engined cargo planes were operational; of these, 319 were committed to the airlift at the peak of operations. The high point of the airlift came in mid-April 1949 when on one day 1,398 aircraft delivered 12,940.9 tons of cargo to Berlin. In all, the Americans alone airlifted 1,783 million tons of supplies to Berlin during Operation VITTLES.[38]

In conjunction with the Berlin airlift, the Air Force was called upon for another major effort. National leaders were concerned that we might have to fight over Berlin. Their reaction to this situation was that the United States should "get some force into the theater if

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[37]Ibid., pp. 235, 240.

[38]Ibid., pp. 35-36, 241.

only as a precaution." The only force available to the nation was that of atomic weapons. And in July 1948 the decision was made to dispatch two groups of B-29's to England where they would be within range of significant Soviet targets.[39] In addition to the B-29's the Air Force also dispatched a flight of P-80 fighter planes across the Atlantic. This entire effort was referred to in an article appearing in Air Force as the "'return of the USAF to Europe.'"[40]

In the midst of the situation described above, Air Force leaders were attempting to put together what they considered to be an adequate force to meet the worldwide commitments of the USAF. Speaking of the days immediately following unification, an article in Air Force noted: "The first task to be undertaken by General Carl Spaatz as Chief of Staff of the United States Air Force will be the forging of a ready-to-fight organization 'by Christmas.'"[41] This organization was to consist originally of only fifty-five groups, although the Air Force was authorized to develop a force of seventy groups.[42] "Until the Korean War changed the whole perspective of requirements for national defense, seventy remained the magic number for the Air Force--the number of groups it needed to do its job."[43]

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[39]Millis, Arms and Men, pp. 322-23.

[40]John G. Norris, "Airpower in the Cold War," Air Force: Official Journal of the Air Force Association, XXX, No. 9 (September 1948), 25-26.

[41]"Life Begins at Forty: USAF," p. 20.

[42]Ibid.

[43]Goldberg, "Worldwide Air Force," p. 106. For a disparaging comment on the decision that seventy groups was the minimum size Air

However, by 1949 the Air Force was forced to abandon its hopes for a force of seventy groups. Congress had voted the funds in 1948 to begin a five-year aircraft-purchase program that would have provided the equipment for a seventy-group Air Force. But in 1949 President Truman requested enough funds to maintain a force of only forty-eight groups during fiscal year 1950. This actually constituted a reduction in force since the strength of the Air Force had increased to fifty-nine groups by December 1948.[44]

The lack of funds to support the expansion of the Air Force to its desired seventy groups highlights another major problem facing USAF leaders during the post-World War II period. This was the problem of tight fiscal policies.

Between 1946 and 1950 President Truman considered a balanced budget to be a matter of high priority. In general, the budgeting

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Force that was acceptable, see Millis, Arms and Men, p. 309. For a view of the rationale behind the seventy-group Air Force see: President's Air Policy Commission, Survival in the Air Age, pp. 24-27.

[44]Alfred Goldberg, "The Establishment: Roles and Missions," in Goldberg, History of USAF, p. 116 (hereafter cited as Goldberg, "Roles and Missions"). For more details on the vicissitudes of funding for the seventy-group Air Force see the following articles: "Congressional Roundup," Aviation Week, L, No. 13 (28 March 1949), 15; Robert Hotz, "Air Power Budget at Record High," Aviation Week, L, No. 16 (18 April 1949), 12-13; "The Aviation Week," Aviation Week, L, No. 19 (9 May 1949), 7; "News Sidelights," Aviation Week, L, No. 25 (20 June 1949), 7; "News Sidelights," Aviation Week, L, No. 26 (27 June 1949), 7; "Hopes Brighten for Bigger USAF Budget," Aviation Week, LI, No. 15 (10 October 1949), 12-13; "Scant Hope for 58-Group AF," Aviation Week, LI, No. 16 (17 October 1949), 14; "The Aviation Week: The Budget Victory--A Staff Report," Aviation Week, LI, No. 17 (24 October 1949), 7; "Planes USAF to Buy in 1950," Aviation Week, LI, No. 24 (12 December 1949), 11; and John G. Norris, "Round Two in the Fight for Airpower: Will Congress Vote Money for the Second Installment of the 70-Group Air Force?" Air Force: The Official Journal of the Air Force Association, XXXI, No. 10 (October 1948), 13-15 (hereafter cited as Norris, "Round Two").

technique used by the Truman administration was to estimate revenues; subtract domestic program costs, foreign aid costs, and debt interest payments from the revenues; and allocate the remainder for national defense.[45] This policy resulted in the following expenditures for defense between FY 1947 and FY 1950:

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| FY 1947 | $14.4 billion |
| FY 1948 | $11.7 billion |
| FY 1949 | $12.9 billion |
| FY 1950 | $13.0 billion[46] |

As far as the Air Force's desired budget for FY 1950 was concerned, Secretary of the Air Force Stuart Symington stated that it was eight billion dollars. By the time the Army, Navy, and Air Force finished padding their budgets to compensate for expected cuts, the combined total sought was in excess of thirty billion dollars. One can well imagine the agitation with which some members of Congress and the Department of Defense greeted President Truman's submitted defense budget of fifteen billion dollars, to be divided equally between the three military services.[47]

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[45]Samuel P. Huntington, The Common Defense: Strategic Programs in National Politics (New York and London: Columbia University Press, 1961), p. 42 (hereafter cited as Huntington, Common Defense).

[46]Ibid., pp. 42-43. Secretary of Defense James Forrestal tried to secure seventeen billion dollars for the Department of Defense for FY 1950.

[47]"The Aviation Week," Aviation Week, L, No. 19 (9 May 1949), 7. For more information on budgeting in the late forties and early fifties see: Warner R. Schilling, "The Politics of National Defense: Fiscal 1950," in Warner R. Schilling, Paul Y. Hammond, and Glenn H. Snyder,

An earlier glimpse of what the specific impact of tight fiscal policies meant for AAF and AF R&D programs is afforded by a 10 September 1946 memorandum from General LeMay, Deputy Chief of the Air Staff for R&D, to General H. S. Aurand, Director, Research and Development Division, War Department General Staff. The memorandum explored the impact of possible budget reductions from the standpoint of the AAF R&D program:

> The present program as provided for by the F.Y. 1947 budget represents the minimum requirement in research and development and is 30% lower than the original AAF estimated program, which was considered to be an adequate well-balanced program. Further reduction will mean severe curtailment or complete elimination of research in specific fields.[48]

One can well imagine the energy that was required from the leaders who sought to overcome the difficulties associated with these policies and events. And demobilization, separation of the Air Force from the Army, world crises, efforts to create an effective and combat-ready Air Force, and tight fiscal policies were by no means all the problems faced by Air Force leaders. The B-36 controversy, the establishment of mission limitations for the three services, and the question of who should develop and use guided missiles were among the other major matters with which Air Force leaders had to struggle.[49]

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Strategy, Politics, and Defense Budgets (New York and London: Columbia University Press, 1962), pp. 135-213. See also Norris, "Round Two," p. 13.

[48]Curtis E. LeMay, Memorandum for H. S. Aurand, Subject: "Effect of 10, 20, and 30 Percent Reduction in Fiscal Year 1947 Research and Development Program," 10 September 1946, p. 1. The memorandum was found in folder 168.64-15A 1945-47 of General Curtis E. LeMay's correspondence in the Air Force Archives, Maxwell Air Force Base, Alabama.

[49]Goldberg, "Roles and Missions," pp. 115-19. For a summary of

Proponents of change in the Air Force R&D policy recognized that these events created severe obstacles to achieving the kind of the Air Force R&D program they sought. Tactfully, they pronounced these difficulties as the reason the Air Force had been unable to give adequate attention to R&D.

In the letter written by Dr. von Kármán to transmit the Ridenour Report to the Chief of Staff, USAF, he noted that the years following the Second World War were busy for the Air Force. One of the most pressing problems the Air Force faced was "to create, from the disordered fragments left by demobilization, an effective force-in-being capable of meeting the grave responsibilities of airpower in the support of national policy.[50] Confronted with this situation, the Air Force placed primary emphasis on current problems and gave a lower priority to its research and development program.[51] And in the Ridenour Report itself one reads much the same. After noting that in the past the Air Force had exhibited intentions of having a viable R&D program, the report remarked:

> The basic reasons for the failure to carry out such good intentions concerning research and development are entirely understandable. The Air Force has been preoccupied ever since the war with a series of major, immediate problems which left no effort

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some of the crises faced by the Air Force after World War II see: Trevor Gardner, "How We Fell Behind in Guided Missiles," The Air Power Historian, V, No. 1 (January 1958), 8 (hereafter cited as Gardner, "How We Fell Behind in Guided Missiles").

[50]Theodore von Kármán to Hoyt S. Vandenberg, General and Chief of Staff, U.S. Air Force, 21 September 1949, in Ridenour Report, pp. Letter 1 to Letter 2 (hereafter cited as von Kármán to Vandenberg, 21 Sep 49).

[51]Ibid., p. Letter 2.

available for investment in research and development activities.[52]

Another expression of such sentiments is to be found in a letter written by General George C. Kenney while he was serving as Commander of the Air University. He believed that the situations the Air Force had faced resulted in emphasis being placed on the current Air Force at the expense of research and development. As he put it: "the pressure of war and the subsequent explosive international situation have required support of a force in being which has deprived Research and Development of its proper emphasis."[53]

General Kenney's letter also contained a brief comment on the Air University Committee, noting that the findings of that committee "in general coincide with those of the Ridenour Committee."[54] In the study produced by the Air University Committee there appears the same statement that the situation and not the Air Force was to be blamed for past failures in the area of R&D. As it is stated in the Report: "The pressure of day-to-day operational, materiel and political problems has effectively prevented the implementation of a vigorous, real program which produced results."[55]

But in spite of the crises dutifully noted by the advocates of R&D program reforms and in spite of the continued existence of

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[52]Ridenour Report, p. IV-1.

[53]George C. Kenney to Hoyt S. Vandenberg, 19 November 1949, in ARDC Office of Command Historian, History of ARDC: 23 Jan 50-30 Jun 51, II, p. 1 (pagination refers to the letter)(hereafter cited as Kenney to Vandenberg, 19 Nov 49).

[54]Ibid.

[55]Air University Study, TAB A, pp. 1-2.

traditionalist elements in Air Force thinking about R&D, Air Force leaders at different organizational levels continued to be involved in a dialogue on R&D and on the policy the Air Force should adopt in improving its research and development capabilities. Occasionally, this dialogue extended beyond the Air Force to other echelons of the federal government. What was the nature of R&D? What was the importance of R&D to the Air Force?

Outside of the Air Force the Report of the President's Air Policy Commission, Survival in the Air Age, directed some comments to the importance of R&D for military aviation. The Commission, composed of five men, was headed by lawyer Thomas K. Finletter, who was later to become the second Secretary of the Air Force and serve in that capacity from 24 April 1950 until 20 January 1953.[56] The Finletter Report, as Survival in the Air Age is sometimes called, was so important in the eyes of the leaders of the Air Force Association that they devoted an entire issue of their journal to recounting its details.[57]

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[56]Carl Norcross, "Survival in the Air Age: The Report of the President's Air Policy Commission (Condensed)--An Introduction by Carl Norcross," Air Force: The Official Journal of the Air Force Association, XXXI, No. 3 (March 1948), 5 (hereafter cited as Norcross, "Survival in the Air Age"); Wayne E. Scrivener, "The Men: Leaders," in Goldberg, History of the USAF, pp. 156-57; and "The Secretaries of the Air Force," Air Force, Annual Air Force Almanac Issue, LVI, No. 5 (May 1973), 48.

[57]Air Force: The Official Journal of the Air Force Association, XXXI, No. 3 (March 1948). The Air Force Association was a national organization established in the wake of World War II to continue the camaraderie of the war and to campaign continuously for an adequate airpower policy for the nation ("The Air Force Association: Its Aims and Purposes, and its Present Leaders," Air Force: The Official Service Journal of the U.S. Army Air Forces, XXIX, No. 2

In addition to devoting an entire issue of its journal to the report, the Air Force Association (AFA) sent copies to its members throughout the nation and to thousands of local, state, and national leaders. Local AFA units held "airpower rallies" to spread the ideas of the report.[58]

Survival in the Air Age, being concerned with the broader subject of a national aviation policy as opposed to a specifically Air Force oriented program, related R&D's importance to national security.

> There is little need to stress the point that intensive research and development in aeronautics are essential to the national defense and to the national welfare. No witness before the Commission presented a contrary view. All agreed that whatever money is spent for this purpose can be looked upon as a vital form of national insurance, a direct contribution toward maintaining our leadership in the air.[59]

On the other hand, the Ridenour Report related R&D to the effectiveness of the Air Force. According to this report, competency in R&D was essential for the Air Force if it were to become a self-sufficient force.[60] General Putt expressed sentiments similar to those

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[February 1946], 45). When budget strictures forced the Army Air Forces to discontinue publication of its AAF Review, the journal was taken over and continued by the Air Force Association (General Carl Spaatz, Commanding General, Army Air Forces, to Members of the AAF Review staff, 19 August 1946, in AAF Review: The Official Service Journal of the U.S. Army Air Forces, XXXIX, No. 8 [September 1946], inside front cover).

[58]Ned Root, "The Finletter Report--A Year Later," Air Force: The Official Journal of the Air Force Association, XXXII, No. 4 (April 1949), 15 (hereafter cited as Root, "Finletter Report"). The information above comes from an italicized introduction that concludes with the initials JHS. This indicates that the introduction to Root's article was possibly written by James H. Straubel, one of the editors of Air Force.

[59]President's Air Policy Commission, Survival in the Air Age, p. 73.

[60]Supra, p. 73.

of the Ridenour Report in his 17 November 1949 address to members of the Air War College. He told these prospective leaders of the Air Force that the research and development enterprise is the

> cornerstone of operational competence. As the technical complexity of modern weapons increases, the technical competence of the Air Force must increase accordingly.
>
> By doing the research and development work on new weapons, the Air Force as an organization will develop the technical competence and ability to assume operational responsibility for those new weapons.[61]

Although the various documents that dealt with R&D may have been in agreement as far as its importance was concerned, they were by no means in total agreement on the nature of this enterprise. One of the most obvious matters on which one finds a lack of consensus is that of what the components of R&D are.

The Annual Report of the Secretary of the Air Force for fiscal year 1948 argued that research and development is composed of basic research, applied research, development, and testing.[62] In addition to basic and applied research, the Ridenour Report listed initial development, engineering, procurement, quality control, testing to specifications, technical evaluation, supply maintenance, industrial planning, and mobilization as parts of an "entire complex of activities."[63] The briefing that was presented to General David M. Schlatter in late 1949 or early 1950 reasserted that basic and applied research are parts of research and development. Additionally, "programmatic research" and

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[61]Putt, "USAF R&D," p. 15.

[62]Secretary of the Air Force, Report for FY 1948, p. 94.

[63]Ridenour Report, p. V-5.

development were listed as other components.[64] Finally, a 13 November 1950 RAND study suggested that research and development be divided into different kinds of research: pure, applied, fundamental, background, and design research.[65]

Basic, or pure, research was common to all the above discussions of the components of R&D. And in general those documents of the 1948-1950 period that dealt with research and development note that basic research is the basis of the R&D process.

In January 1948 the report of the President's Air Policy Commission defined research as "the seeking for new basic knowledge from which better aircraft, missiles, or other aeronautic devices may be developed."[66] Additionally, the report contained this statement:

> During World War II we concentrated on the development of existing types of aircraft for production, and practically abandoned fundamental research in the aeronautical sciences. By VJ-Day our reserve of research information was largely exhausted. If we are to have an air establishment of the first quality, we will have to concentrate, as other nations are doing, on our fundamental aeronautical research. Development, that is the making of new aeronautical devices, cannot move ahead faster than our fundamental research.[67]

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[64] Text of a Briefing for General Schlatter, p. 9.

[65] H. S. Rowen, "Research and Development Resources," Project RAND Research Memorandum RM-496 (Santa Monica, Cal.: The RAND Corporation, 13 November 1950, withdrawn from active inventory), p. 8 (hereafter cited as Rowen, "Research and Development Resources"). U.S., Department of the Air Force, Air Force Regulation 80-5, "Research and Development: Research and Development Policies and Procedures," Washington, D.C., 25 March 1946, pp. 1-2 (hereafter cited as AFR 80-5, 25 Mar 49). Here R&D is divided into research, development, test, and operational evaluation or service testing.

[66] President's Air Policy Commission, Survival in the Air Age, p. 73.

[67] Ibid.

Survival in the Air Age was referred to by the originators of the Air Force Master Plan for R&D that appeared in March 1948. In this plan one of the tasks listed under basic research was the "addition of new knowledge which may form the basis for future weapons."[68] And in an October 1948 article, Brigadier General S. R. Brentnall, who was serving as the Deputy Director, Research and Development, Headquarters Air Matériel Command, wrote:

> . . . the constant probing into the field of the unknown by systematic investigation of natural phenomena is of the utmost importance in assuring our future security. Paradoxically, it has been found that greater progress in producing revolutionary materiel comes from the theoretical investigation of natural phenomena. This determines accurately their special characteristics, the laws of nature that govern their behavior, and their relationships to other phenomena of which something is already known.
>
> Such basic research alone produces new scientific knowledge necessary for the development of radically superior materiel. Thereafter it is a matter of applied research which pushes experimental work along lines of attack which seem promising. All available scientific and technical resources that can be effectively used are brought to bear on the problem of adapting the new information to practical usage.[69]

Another example of the view that basic research is fundamental to the R&D process is found in the Annual Report of the Secretary of the Air Force for fiscal year 1948. According to this document, basic research provided fundamental knowledge to fill a reservoir upon which

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[68] U.S. Department of the Air Force, Deputy Chief of Staff for Matériel, Director of Research and Development, "Air Force Master Plan for Research and Development," 4 March 1948, in History of Separation of R&D from the AMC, vol. III, p. 5 (hereafter cited as "AF Master Plan for R&D," 1948).

[69] S. R. Brentnall, "Message: Basic Research is Essential to Security," Air Technical Intelligence Technical Data Digest of the Air Materiel Command, USAF, XIII, No. 19 (1 Oct 1948), 2 (hereafter cited as Brentnall, "Message").

applied research could draw to produce weapons. "Without such a reserve the entire research and development program eventually would become static."[70]

One final example of this manner of thinking about basic research should suffice to show how widespread the view was. This example comes from the September 1949 Ridenour Report.

> Fundamental research comprises investigations carried on for the purpose of increasing man's knowledge and understanding of the natural world. . . . Almost always, the results of fundamental research are useful for one practical purpose or another, yet prediction of such usefulness cannot be made in terms of specific application, but only--and then with difficulty--in terms of fields of application. Major discoveries of fundamental significance can almost always be traced back to their roots in a fundamental investigation.[71]

The difficulty of predicting the usefulness of the results of basic research mentioned by the Ridenour Report touches on another widely accepted idea about basic research, namely, that it is difficult to know what the outcome of basic research will be.

Survival in the Air Age did not distinguish between different types of research. But the definition of research given in this report[72] indicates that the drafters of the report meant "basic research"

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[70]Secretary of the Air Force, Report for FY 1948, p. 115.

[71]Ridenour Report, p. II-2. For other examples of this view of basic research see: E. M. Powers, Major General, USAF, Department of the Air Force, Office of the Chief of Staff, United States Air Force, Memorandum to the Chairman, Research and Development Board, Subject: "Basic Research in the Military Establishment," 28 October 1948, in History of the Separation of R&D from AMC, III, 1 (hereafter cited as Powers, "Basic Research in the Military Establishment"); "Basic Research," Air Force: The Official Journal of the Air Force Association, XXXIII, No. 6 (June 1950), 16, 18 (hereafter cited as "Basic Research," Air Force, June 50); and Brentnall, "Message," p. 2.

[72]Supra, p. 93.

when they used the term "research." The following statement appears in the Finletter Report: "Research by its very nature is unpredictable. No one can forecast with accuracy the time at which the end result will be available."[73]

The unpredictability of basic research was also described in a June 1950 article appearing in Air Force. Here one finds the following statement:

> There is, in the field of basic research, only the faintest trace of what can be called a predetermined objective. In truth, the only real goal is the broadening of man's understanding of natural phenomena. Since the scientist engaged in this field does not know precisely what it is he seeks, it follows that he cannot know what he is apt to find.[74]

Not only was basic research considered unpredictable, but it was also thought to be largely uncontrollable. Survival in the Air Age had this to say about efforts to control basic research:

> As far as research is concerned, a clear distinction should always be made between coordination and control. Research of all kinds welcomes coordination, but resists control. Researchers must be kept informed of the work of others in their own and in related fields in order to avoid duplication of effort, but it is fatal to try to steer their thinking toward any predetermined goal. . . . [R]esearch must be unrestricted to be of value.[75]

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[73]President's Air Policy Commission, Survival in the Air Age, p. 92.

[74]"Basic Research," Air Force, Jun 50, p. 18. Similar views were expressed in a companion article to "Basic Research;" see "Applied Research," Air Force: The Official Journal of the Air Force Association XXXIII, No. 6 (June 1950), 21 (hereafter cited as "Applied Research," Air Force, Jun 50).

[75]President's Air Policy Commission, Survival in the Air Age, p. 92. For a view of the entire R&D enterprise that highlights the difficulty of managing research and development, see: Arthur A. Fickel, Memorandum for Record, 23 January 1950, p. 4, in ARDC Office of Command Historian, History of ARDC: 23 Jan 50-30 Jan 51, II (hereafter cited as Fickel Memorandum for Record, 23 Jan 50). See also Ridenour Report, p. IX-1.

If something is uncontrollable and unpredictable, how can it be managed? In discussing the functioning of management, one observer has written:

> [The] managerial endeavor is one which seeks to bring practice into line with policy--to transform what is into what ought to be. The dynamic, ceaseless interplay between policy and practice is better understood if policy is distinguished from practice at all times. On the policy level, the ideal norms are order, control, and the responsible carrying out of instructions. On the practice level the actual norms are (1) tension and disagreement over the mating of ends and means, and (2) the occurrence of the unexpected. The efforts of institutional managers are devoted to reducing the disruptive effects of the norms of practice upon the policy norms by introducing new courses of action which will become routine practice, for that which is routine is fully under control, no longer needs the vigilant attention of policy makers and top administrators (who are frequently one and the same), and frees these managers to turn to other disruptive theaters of practice which have not yet been routinized and are demanding attention.[76]

How could basic research ever be routinized?

And if a thing cannot be managed how can it be a part of a highly organized, disciplined, closely directed military organization? As a June 1950 article appearing in Air Force expressed it:

> In its [R&D's] initial stages at least, it is movement down an ever-widening path, like running through a funnel the wrong way. In many ways it defies direction or organization, which in many ways, contrarily, are the essence of the military establishment. A military man likes to have his mission stated precisely, the better to organize his forces for its accomplishment. The scientist--at least those concerned with basic research--will likely accomplish more if he is given no particular mission at all. One is basically Bohemian, the other basically West Point.[77]

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[76]Thomas M. Smith, "A Study of the Origins of MINUTEMAN" (Unpublished manuscript, University of Oklahoma, n.d.), p. iii.

[77]"Key to the Future," p. 16. For another view of the unmanageable nature of basic research see Survival in the Air Age, pp. 88-90.

This was the sort of argument employed by those who thought that basic research was separable from the other components of R&D and was no concern of the Air Force. In their discussion of aeronautical research and development, the drafters of Survival in the Air Age generally separated research from development by having the military services responsible for development while NACA was responsible for research.[78]

The RAND study previously mentioned in this chapter tended to agree with the Finletter Report. This RAND report noted that it was generally difficult and arbitrary to separate and identify the components of R&D. But at least basic research was sufficiently unique to justify its separation from the other aspects of R&D, and the author of the RAND report listed three reasons for separating basic research from the other parts of R&D.

> First, the aims of, methods used, and facilities required by basic research differ from those required by applied research or development. Basic research explores avenues of interest with no immediate application, and the laboratory facilities required are in general less expensive (one exception is aeronautical research).
>
> Second, the basic research phase is usually the least costly, the applied research phase the next costly, and the design phase the most costly.
>
> Third, fundamental research provides the foundation for advancement in any field. It is possible to advance without fundamental

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[78]President's Air Policy Commission, Survival in the Air Age, pp. 76-77. This position was taken in spite of the expression of the view that research was not always clearly distinguishable from development (p. 73). It is interesting to note that a different opinion was expressed in the article "Applied Research," Air Force, Jun 50. On page twenty-one of the article the reader is told that "there is a very clear-cut distinction between basic and applied research."

> research but the great strides in most fields have usually occured when there was a body of basic knowledge.[79]

One of the most pointed and detailed statements about the relationship between basic research and the Air Force R&D program appears in a 2 March 1948 memorandum from the Secretary of the Air Force. Stuart Symington, responding to an earlier statement by the Secretary of the Navy that the Air Force did not understand the meaning of basic research, wrote:

> It is quite true that the primary objective of the Air Force basic research program is to seek answers to problems posed by the development program; this, for the reason that an orderly program for development must be backed by a series of research projects which will permit step-by-step advances as new knowledge becomes available. However, we do not wait until these problems appear as by-products of specific development projects; rather these problems are visualized long before the end products appear, and research projects are initiated in the proper fields to solve them.[80]

But one should not be deceived by this statement that apparently supports an Air Force basic research program, for Symington continues in these words:

> While we are in agreement with the general definition of basic research and with the importance of basic research to the military establishment as expressed by the Secretary of the Navy we do not agree that the Navy Department--or for that matter, any agency of the military--should pursue basic research solely for

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[79] Rowen, "Research and Development Resources," pp. 8-9.

[80] Stuart Symington, Secretary of the Air Force, Memorandum for Secretary [of Defense James] Forrestal with copies to Secretary of the Army and Secretary of the Navy, Subject: "Air Force Concept of Basic Research," 2 March 1948, p. 1, in History of Separation of R&D from AMC, III (hereafter cited as Symington to Forrestal, 2 Mar 48). The views expressed here are quite similar in some respects to those given in President's Air Policy Commission, Survival in the Air Age, p. 92. The wording is so similar that it suggests a possible reference to Survival in the Air Age by the drafter of the Symington memorandum.

> the pursuit of knowledge for its own sake. Truly basic research, having no tangible and immediate object except to increase the store of knowledge in some sphere, should be fostered by an agency having an overall outlook not strictly military. We feel, therefore, that it is more fitting that an agency such as the proposed National Science Foundation look after basic research of a long-term nature and having broad application.[81]

Since the National Science Foundation had not yet been established "to fill the gap, the military establishment must, for the present, pursue basic research on a broader scale." But this was simply an interim measure; once established, the National Science Foundation should assume the major responsibility for basic research "which has as its goal the pursuit of knowledge for its own sake."[82] Symington's remarks would seem to be aimed squarely at the Navy's Office of Naval Research that was established by act of Congress during the summer of 1946.[83] This organization was responsible for research within the Navy.[84]

The view stated in the Symington memorandum was also expressed in a memorandum to the Chairman of the Research and Development Board from Major General E. M. Powers who was serving in the office of the Chief of Staff, USAF. Powers stated that the Department of the Air Force strongly supported the establishment of a National Science

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[81]Symington to Forrestal, 2 Mar 48, p. 1.

[82]Ibid., p. 2.

[83]Baucom, Thesis, p. 46.

[84]Ibid., p. 44. For a discussion of the establishment of ONR see: The Bird Dogs, "The Evolution of the Office of Naval Research," Physics Today, XIV, No. 8 (August 1961), 30-35. The Bird Dogs were a group of Naval Officers composed of "two highly capable regular officers, . . . and four young Naval Reserve Officers having technical backgrounds." These officers were trained by Dr. J. C. Hunsaker who called the men "bird dogs" (p. 31). For a general discussion of the establishment of ONR see: Baucom, Thesis, pp. 43-46.

Foundation that would have primary responsibility for government subsidizing of basic research.[85]

A June 1949 interoffice memorandum at Headquarters, Air Matériel Command, also cited Symington's memorandum as evidence that the Air Force supported the establishment of the National Science Foundation. The drafter of this 1949 memorandum, Colonel Floyd B. Wood, Executive Secretary of the Air Matériel Command, considered this position relative to the National Science Foundation to be directly related to the fact that basic research is not an appropriate part of a military R&D program. As he stated it:

> The position taken by the National Military Establishment on this matter can be justified on the basis that the pursuit of knowledge purely for the sake of knowledge is not an appropriate basis for the conduct of research and development for military purposes, and that limited military budgets do not permit any substantial amount of R&D activity unless aimed toward the solution of specific military problems. True basic research, which by its very nature has no tangible or concrete objective, should be fostered by an agency having an over-all outlook rather than a strictly military point of view. The proposed National Science Foundation is envisioned as such an agency.[86]

Six months before the writing of the Wood memorandum the view that basic research should not really be a part of the Air Force R&D program was expressed in the fiscal year 1948 report of the Secretary of the Air Force. According to the report, virtually all basic research in aerodynamics and thermodynamics was done for the Air Force by agencies outside the Air Force.

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[85]Powers, "Basic Research in the Military Establishment," p. 1.

[86]Floyd B. Wood, Colonel, USAF, Executive Secretary, Air Matériel Command, Memorandum to General Carroll and General Crawford, Subject: "Proposed National Science Foundation," 23 Jun 1949, p. 1, in History of Separation of R&D from AMC, III.

> Only in such areas as electronics, where no Government agency conducts basic research, does the Air Force itself assume responsibility. Even in those cases, most of the work is carried out on a contract basis by universities, industrial concerns, scientific organizations, and the National Bureau of Standards.[87]

And somewhat later in the Secretary's report one reads:

> Basic research, because of its tremendous scope and its very great value and importance to the commercial life and general welfare of the United States, is primarily a national rather than an Air Force responsibility. Yet, the Air Force must exercise the closest coordination possible with basic research organizations, both public and private, in order to realize the maximum military potentialities of their discoveries. The Air Force must also conduct a basic research program of its own in the general fields not covered by other agencies because of the excessive costs involved or because of the purely military nature of the experimentation.[88]

But there were those in the Air Force who thought basic research should be an integral part of an Air Force R&D program, even if basic research was uncontrollable, unpredictable, unmanageable, and produced only intangible results.

We have already seen that Air Force leaders considered basic research to be the foundation of the R&D process.[89] And at times concern was expressed that the R&D process might out-strip the reserve of basic knowledge and become static.[90] We have also noted that Air Force

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[87] Secretary of the Air Force, Report for FY 1948, p. 92.

[88] Ibid., p. 94. For an earlier expression of similar views see: Glantzberg, "Air Force and Science," p. 13. Glantzberg wrote: "It must be remembered that basic research may have commercial as well as military value. Therefore it is hardly reasonable to charge the whole cost to the military establishment."

[89] Supra, pp. 94-95. Similar sentiments were expressed by Vannevar Bush, Science: The Endless Frontier (see p. 20 above) and von Kármán, Key to Air Supremacy (see p. 17 above).

[90] Supra, p. 93. Similar views were also expressed in 1947 (supra, pp. 34). See also Brentnall, "Message," p. 2.

leaders tended to believe that in spite of its unpredictable nature, the results of basic research would eventually prove useful.[91] Just as Georges Clemenceau thought war too important to be left to the generals, perhaps some Air Force leaders considered science too important to be left to the scientists.

Another apparent reason for Air Force interest in basic research is that Air Force personnel thought that research and development was a unified process that involved everything from the conception of an idea to the development of equipment or weapons based on the idea. Basic research was an inseparable part of the R&D process and provided that process with certain essential ingredients.

In his briefing before the 3 January 1950 meeting of the Air Staff, General Schlatter was told that the difference between research and development is "a philosophic one, . . .. No one can make an operating distinction between basic research, programmatic research, applied research, and development."[92] And somewhat later Colonel Victor Haugen, Chief of the Aircraft Division of the R&D Directorate at USAF Headquarters, commented on the difficulty of cleanly separating basic research from "the applied research that is organic to all

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[91]Supra, pp. 93-95. Another expression of this view may be found in "Basic Research," Air Force, Jun 50, p. 18. Here one reads: "experience has proved that almost always the results of basic research are useful for one practical purpose or another. Nearly all great inventions have their roots in basic investigation." Another statement to this effect was previously quoted on p. 17 above.

[92]Text of Briefing for General Schlatter, p. 9.

development."[93] Then he offered one reason why basic research should be regarded as inseparable from the R&D process. He noted that the isolation of research from development introduces

> a major difficulty in the matter of recruiting competent scientists for the development programs. Scientists of the quality desired normally insist on working under conditions where they can engage from time to time in fundamental investigations of particular interest to them. If an artificial separation exists which would prohibit such activity, it will be impossible to recruit first-class scientists for any but research programs.[94]

Earlier, General Putt had also expressed the opinion that basic research has a salutary effect on R&D personnel. Putt argued that every technical organization must do some basic research "to retain and maintain the technical competence of its staff." Allowing technical personnel to carry on nothing but administrative functions would cause them to stagnate.[95]

Another argument for Air Force activity in the area of basic research appears in the briefing for General Schlatter mentioned above.

> In consonance with its mature understanding of technology, the Air Force will be an active participant in the production of knowledge; because knowledge cannot be economically purchased without such participation. And all sciences participate in the progress of any one of them. Furthermore, impetus to discovery is derived only from those who have a personal interest in the application of such discovery.[96]

Thus we see that at least some Air Force leaders considered basic research an integral part of the R&D process, and thought that it

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[93] Victor R. Haugen, "The Staff Direction of Research and Development," Air University Quarterly Review, IV, No. 1 (Summer 1950), 63, 134 (hereafter cited as Haugen, "Staff Direction of R&D").

[94] Haugen, "Staff Direction of R&D," p. 63.

[95] Putt, "USAF R&D," pp. 30-32.

[96] Text of Briefing for General Schlatter, p. 8.

was essential that the Air Force R&D program include at least some basic research. Furthermore, it was widely accepted that basic research was the very foundation of the R&D enterprise. Since basic research was so important in the minds of these Air Force leaders, it should come as no surprise that they would be concerned to see that it received adequate support when the efforts to establish a national science policy ran into difficulties.

In the preceding chapter we saw that a dichotomous view of research and development emerged in the years following World War II and achieved rather widespread acceptance in the federal government.[97] According to this view, military R&D organizations would be responsible for the development-related aspects of R&D, while a civilian government organization would foster basic research.

Although this dichotomous image of research and development began to be articulated even before the end of World War II, with the appearance of Vannevar Bush's Science: The Endless Frontier, it was not until 10 May 1950 that the civilian government organization was established when President Truman signed the National Science Foundation Act.[98] Congress had managed to agree on a bill that would have established a National Science Foundation-type organization in 1947, but President Truman had found the bill unacceptable and vetoed it.[99]

In consequence, for five years government research and development activity was guided by policies for R&D without having an

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[97] Supra, pp. 19-30.

[98] Baucom, Thesis, p. 65.

[99] Ibid., pp. 51-53.

established government structure that could fully implement these policies. The existence of this situation, combined with the importance Air Force leaders attached to basic research, make it clear why Symington and other Air Force leaders would be concerned to insure that basic research would be supported adequately until the National Science Foundation was established. And perhaps the concern about adequate support for basic research was more than just a temporary expedient for those leaders who thought that basic research was inseparably related to the R&D process and that it made vital contributions to any effective research and development program. To rationalize Air Force support of basic research in a government milieu dominated by the dichotomous view of R&D, AF leaders articulated what may be called an "applied basic research" concept.

Stuart Symington's March 1948 memorandum, previously discussed, actually contains a hint of this image of basic research. Symington said that the purpose of the Air Force basic research program was to answer questions raised by the Air Force development program. The Air Force did not wait for these problems to appear, but rather tried to anticipate them and initiate research accordingly.[100] Here is a form of basic research which cannot be eliminated from an R&D program; it is directly related to the R&D program itself. No effort was made to square this image of basic research with the view which held basic research to be unpredictable, uncontrollable, and unmanageable.

Evidently, the Secretary of the Navy did not think these two

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[100]The "germ" of the concept appears in the quotation from the memorandum given on p. 99, supra.

images compatible, for it was the "applied basic research" concept that prompted the Secretary of the Navy to attack the Air Force for having an "erroneous concept of the meaning of basic research."[101] The Navy's experience with the Office of Naval Research had placed it in a stronger political position to support basic research than was the Air Force. Consequently, it can be argued, the Navy could take a more idealistic position on military support of basic research than could the Air Force.

The Navy's Office of Naval Research (ONR) was sanctioned by Public Law 558, which stated that the ONR was established

> to plan, foster, and encourage scientific research in recognition of its paramount importance as related to the maintenance of future naval power, and the preservation of national security; to provide within the Department of the Navy a single office, which, by contract and otherwise, shall be able to obtain, coordinate, and make available to all bureaus and activities of the Department of the Navy, world-wide scientific information and the necessary services for conducting specialized and imaginative research; . . ..[102]

The Navy would probably not have to be as careful when requesting funds for basic research since funding for "specialized and imaginative research" was specifically authorized by Public Law 588.[103]

On the other hand, the Air Force had no such legal status for its R&D program and had to be careful not to offend a Congress that adhered to the dichotomous view of research and development. This may have been one reason why the idea of "applied basic research" was

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[101] Symington to Forrestal, 2 Mar 48, p. 1.

[102] Office of Naval Research Act, Statutes at Large, vol. LX, pt. 1, Chapter 727, p. 779 (1946).

[103] Ibid., p. 780.

articulated by Air Force leaders. Such a view of basic research would rationalize Air Force support of basic research in a government milieu dominated by the dichotomous image of R&D. Here was an image of basic research that could be used before Congressional appropriations committees that thought military research should be practical.[104]

One example of the "applied basic research" concept appears in the Air Force R&D master plan for 1948. Here one function of basic research was seen as the elimination of problems "imposed by or which arise during the development program."[105] Another example appears in Air Force Regulation 80-4 which appeared about a year after the March 1948 AF R&D master plan. This regulation states that the Air Force policy for basic research was:

> To engage in and support fundamental studies in order to remove existing limitations faced by the development and operations programs which appear to be intrinsic, but may be removed by new discoveries and to provide new factual knowledge which gives promise of contributing to new concepts, techniques, and materiel of value to the Air Force.[106]

Although the Ridenour Report gave a definition of fundamental research that tended to emphasize the unpredictable nature of such research, it praised AFR 80-4 highly and recommended that the Air Force

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[104]For a discussion of this practical orientation of the Congress see: Baucom, Thesis, pp. 82-85, 93-94, 103-05. By practical I mean, in this case, that the research should produce equipment or weapons. I refer to this view of research as "hardware orientation" on p. 82. See also Alan T. Waterman, "Government Support of Research," Science, CX, No. 2870 (30 December 1949), 703, 704.

[105]"AF Master Plan for R&D," 1948, p. 5.

[106]U.S. Department of the Air Force, Air Force Regulation 80-4, "Research and Development: Research Policies," Washington, D.C., 1 March 1949, p. 2 (hereafter cited as AFR 80-4, 1 March 49).

"put a major effort into implementing the policies for research" that were spelled out in that regulation.[107]

In practice, "applied basic research" made sense if one regarded research as something like a horse race. Since Air Force R&D experts would keep abreast of events in the R&D program of the Air Force and in the various fields of basic research, their knowledge of both areas would enable them to place basic research "bets" for the Air Force. The capital for the wagers would come from appropriations for the Air Force research and development program. Here was a rationalization for the support of basic research even though it was an activity that could not be directed, controlled, or have its outcome predicted. The Air Force would not interject itself or its management structure into the horse race itself (the actual basic research process). It would merely stand apart and observe what was going on and seek to alter the betting odds in its favor by the strategic infusion of money. Critics, of course, could argue that this metaphor simply camouflaged a subterfuge and that, in point of fact, when the Air Force "placed its bets," it was spending money on basic research and infringing upon a function which properly should be carried out by a civilian agency, such as the proposed National Science Foundation.

In the meantime, the Air Force was placing bets through its Office of Air Research. OAR was established in 1949 "to work with those scientific organizations engaged in basic research, when that basic

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[107] Ridenour Report, pp. II-2, IV-2.

research bears directly on Air Force problems."[108] The functions of the OAR staff were

> (a) keeping OAR's own personnel abreast of things, and (b) covering research bets which are considered important to the AF, but which can't be handled by NACA or contract. Its main purpose will be to serve as monitor and shepherd of a very loosely knit group of scientists engaged in very loosely defined explorations. It will have the assignment--a most responsible one--of determining what broad fields the Air Force is particularly weak in, and sprinkle the funds at its disposal among civilians and civilian institutions which are expert in those areas.[109]

The operations of the Office of Air Research reflect a decision by Air Force leaders that basic research was to be a part of the Air Force R&D program. For practical purposes, OAR was the Air Force's answer to the question, where on the science end of the science-and-technology spectrum does research and development end? That point was the pure-research end of the spectrum.

There was at least one official statement of this view of research and development. It appears in the 25 March 1949 version of Air Force Regulation 80-5. This issue of the directive states that R&D activities "extend from the inception of ideas to their final embodiement in all types of materiel or techniques, methods and processes."[110] We shall also see that the Air Force had some difficulty in refining its image of activities in the development area of the science and

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[108] U.S., Department of the Air Force, Secretary of the Air Force, Semiannual Report of the Secretary of the Air Force: July 1-December 31, 1949 (Washington, D.C.: U.S. Government Printing Office, 1950), p. 205.

[109] "Basic Research," Air Force, Jun 50, p. 19.

[110] AFR 80-5, 25 Mar 49, p. 1.

technology spectrum.

So far, the dialogue on research and development in which the Air Force had been engaged since 1945 had resulted in some clarification of just what was involved in the R&D process, for it had focused attention on what would be involved in the Air Force research and development program, and it had evoked some preliminary determinations. At the same time, various international events and organizational crises of the 1945 to 1950 period had tended to draw attention away from the R&D program of the Air Force.

Then, in the fall of 1949 the United States was confronted by a crisis that would focus attention on the Air Force R&D program rather than divert it to some other aspect of Air Force activities. For some time the nation's leaders had known that it was only a matter of time before the Soviet Union achieved the ability to produce atomic bombs. As a January 1948 document described the situation:

> If present official estimates are right we have not yet reached the point where other nations have atomic weapons in quantity. On the other hand, according to these same estimates we must make our military plans on the assumption that they will reach this point soon. No one can forecast definitely the date, and therefore we must arrive at a time, for planning purposes, beyond which it would not be safe to assume that the United States will be immune from atomic attack.[111]

Other nations were known to be working diligently to develop an atomic bomb, and "it would be an unreasonable risk . . . to rely on other nations not having atomic weapons in quantity by the end of 1952." So this document established what it referred to as "A-day," the day by

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[111]President's Air Policy Commission, Survival in the Air Age, p. 13.

which the United States had to have an air arm in being that could defend against an atomic attack. This date was 1 January 1953.[112]

Toward the end of 1948 the different situations that would arise, once the Soviet Union achieved a nuclear capability, were among the major subjects discussed in a lengthy, serialized magazine article which appeared in the last four issues of the 1948 volume of Air Force. The author of the article was Bernard Brodie, then an Associate Professor of International Relations at Yale University.[113]

In April 1949 an article bemoaning the slow progress made in improving the quality of the Air Force appeared in the journal of the Air Force Association. Apparently referring to the 1953 date given above, the article stated:

> We are now 12 months closer to A-Day--twelve months nearer the date when we must assume "possibly hostile" nations will have the atomic bomb in quantity. Already a third of the time we were given to prepare for this date has passed.[114]

It is hard to believe that the Nation's leaders were surprised when the Russians exploded their first atomic bomb in the fall of 1949.[115] As General Carl Spaatz, retired Air Force Chief of Staff, remarked:

> The moment anticipated since Aug. 6, 1945, has arrived. The announcement that an atomic explosion has occured in Russia

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[112]Ibid., pp. 14, 19.

[113]Bernard Brodie, "A-Bombs and Air strategy," Four Parts, Air Force: The Official Journal of the Air Force Association: Part I, XXI, No. 9 (September 1948), 44-46, 64; Part II, XXXI, No. 10 (October 1948), 33-34, 46; Part III, XXXI, No. 11 (November 1948), 50, 52, 54-56; Part IV, XXXI, No. 12 (December 1948), 32-33.

[114]Root, "Finletter Report," p. 27.

[115]"The Atom," Newsweek, XXXIV, No. 14 (3 October 1949), 17.

> can hardly be a complete surprise to our military leaders. That it comes earlier than publicly expected may jar into unpleasant awakening those who have continued to long for isolation from reality. It is a signal to all that the "cold" war moves onward into a crucial state.[116]

Here was a crisis of a different nature as far as the Air Force was concerned. It was not something that the Air Force-in-being could be expected to solve. This crisis raised questions about the Air Force of the future. And as General Donald L. Putt told the officers attending the Air War College in November 1949, "the Air Force of tomorrow is today's job of Research and Development."[117]

When remarking upon the explosion of the Russian atomic bomb, Spaatz called for the end of delays in providing the nation with the seventy-group Air Force that had previously been sought by Air Force leaders. Indeed, it might now be necessary to create an Air Force that was larger than seventy groups. "An additional 'must,'" he said, "is the accelerated development of a radar network covering the approaches to this continent, along with the most modern fighters, anti-aircraft equipment, and guided missile weapons, to meet any attack through the air."[118]

The Soviet explosion of a nuclear device did have an impact on the USAF R&D program. As a result of this event, the USAF Scientific Advisory Board (SAB) added to its numbers people who were knowledgeable of atomic weapons.[119] It was also in response to the Russian A-bomb

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[116]Carl Spaatz, "Atomic Monopoly Ends," Newsweek, XXXIV, No. 14 (3 October 1949), 22 (hereafter as Spaatz, "Atomic Monopoly Ends").

[117]Putt, "USAF R&D," p. 42.

[118]Spaatz, "Atomic Monopoly Ends," p. 22.

[119]Sturm, USAF SAB, p. 39.

that General Muir Fairchild, Vice Chief of Staff, USAF, involved the Scientific Advisory Board in the problem of air defense.[120]

Fairchild asked the SAB to help draft a sound plan for national air defense. The initial report of the Board on this matter was presented to the Air Force on 29 November 1949. Following approval of the report by Generals Vandenberg and Fairchild, the Scientific Advisory Board formed the Air Defense System Engineering Committee (ADSEC) and assigned it the task of "developing 'equipment and techniques--on an air defense basis--so as to produce maximum effective air defense for a minimum dollar investment.'"[121]

The Committee was headed by Dr. George Valley and included Drs. Allen F. Donovan, Charles S. Draper, Henry G. Houghton, H. Guyford Stever, John Marchetti, and George C. Comstock.[122] The ADSEC held its first meeting in December 1949 and continued its work for two years, meeting every Friday with federal and Massachusetts Institute of Technology officials during the peak of its activities. Based upon the recommendations of the SAB and ADSEC, Lincoln Laboratory was established by the Air Force and MIT. This laboratory ended the need for the ADSEC, and it was disbanded in January 1952.[123]

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[120]Ibid.

[121]Ibid.

[122]Ibid., pp. 39, 138.

[123]Ibid., p. 40. For another indication of Soviet atomic developments affecting Air Force R&D, see: I[van] A. Getting, "Recollections of USAF in 1950-1951," Oral History Interview, dated "10-8-73," p. 1 (hereafter cited as Getting, "Recollections of USAF"). Here Getting stated: "There is no question that both General Saville and I were stimulated by the pressure being exerted at that time by the Russians in their development of their A-bomb and the build-up of Russian bomber

The Russian explosion of an A-bomb posed an international crisis that had clear technological ramifications for the Air Force. It also happened to occur within a month of the submission of the Ridenour Report. Since the end of World War II, technical personnel within and without the Army Air Forces and the Air Force had been agitating for reforms in the air arm's R&D program. With the Ridenour Report, their efforts reached a milestone similar to that represented by Science: The Key to Air Supremacy. But, unlike the earlier von Kármán study, the Ridenour Report was to have a lasting and significant impact on the Air Force R&D program. The chance confluence of two different chains of events, the Soviet A-bomb program and agitation for reform in the Air Force R&D program, helps to account for the more favorable institutional response to the Ridenour Report. We shall examine this Report in more detail and observe the response to it in the next chapter.

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forces." At this time, Getting was Chairman of the Radar Panel of the Research and Development Board. As we shall see later, about this time (1949) Saville was Director of Requirements in the office of the Deputy Chief of Staff, Operations, and would become the first Deputy Chief of Staff for Development in 1950. For an additional perspective on the ADSEC, see: History of the Air Force Cambridge Research Center: 1 July-31 December 1953, Vol. XIX, Part I, pp. 247-52.

## CHAPTER IV

## A NEW DEPARTURE: ESTABLISHMENT OF THE DEPUTY CHIEF OF STAFF, DEVELOPMENT, AND THE AIR RESEARCH AND DEVELOPMENT COMMAND, 1948-1950

In spite of crises and traditionalist resistance to change--or perhaps because of them, in some measure--by 1950 there was growing recognition that something was wrong with the Air Force R&D program. Dissatisfaction was expressed in many ways during 1948, 1949, and 1950.

In November 1948 the Scientific Advisory Board met on three occasions. Dr. von Kármán reported the results of the meetings to General Hoyt S. Vandenberg in January 1949.[1] The Board was concerned about several problems. First of all, responsibility for the direction of the Air Force research and development program was divided; there were several staff agencies at Headquarters USAF involved with R&D, but none of them occupied "a position commensurate with the urgent mission of research and development in times of comparative peace."[2] Secondly, the Board thought "the continuity of research and fundamental development work is too much exposed to the impact of current

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[1]Von Kármán to Vandenberg, 15 Jan 49.

[2]Ibid., p. 1.

procurement needs."[3] And finally, the Air Force R&D program seemed to be too conservative: the program appeared to have been failing to capitalize on some of the "most farlooking projects and technically superior developments."[4]

During a July 1949 conference of the Scientific Advisory Board General David M. Schlatter, who at this time was responsible for Air Force atomic energy activities, criticized the Air Force R&D structure for its diffuse character. According to Schlatter, this structure hampered coordination between different types of experts, such as those who were familiar with the capabilities of aircraft and those who were working on bomb developments.[5] Colonel Arthur A. Fickel, also of the Air Force office for atomic energy, voiced a similar criticism during the same meeting. He stated that there was "no synthesis, no over-all direction" to the Air Force R&D function "because it has been diffused throughout the Air Staff and the Air Force." It was this "lack of formal organization" that caused the "strategic or operational planner [to be] miles apart from our research program planner."[6]

The Air University Study, issued toward the end of 1949, strongly criticized the research and development program of the Air Force. According to the Study, the Air Force "is now dangerously deficient in the capacity to insure the long term development and superiority of

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[3]Ibid., p. 2.

[4]Ibid.

[5]SAB Transcript, 12 Jul 49, pp. 6-7.

[6]Ibid., pp. 22-23.

American air power." The Air Force was lagging in "exploitation of scientific possibilities and in the development of new techniques to meet future military situations." The application of technology to military purposes was not adequate. In short, there was not an adequate foundation within the Air Force for productive operation and healthy growth of R&D.[7]

It was also near the end of 1949 that General George Kenney wrote to the Chief of Staff of the Air Force, General Vandenberg, that he had been "gravely concerned" for some time "about the unsatisfactory state of Air Force Research and Development." Continuing, Kenney noted: "There has been evidence from many sources that the Air Force is seriously deficient in providing for its own future strength, . . ."[8]

And finally, in June 1950 we find another expression of dissatisfaction with the Air Force R&D program. An article in Air Force noted that until recently the applied scientists had "only a weak voice in recommending modification of the Air Force arsenal." Even that weak voice was further muffled by having the applied scientists "spread over half the area of the Air Forces [sic] organization chart." Since there were so many offices involved in R&D it was impossible to mount a coordinated effort in the R&D area.[9]

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[7]Air University Study, p. 1.

[8]Kenney to Vandenberg, 19 Nov 49, p. 1.

[9]"Applied Research," Air Force, Jun 50, p. 22. See also Transcript of Proceedings of Air Staff Meeting Held 3 January 1950, Room 4C-1052, The Pentagon Building, Washington, D.C., from 10:10 AM to 11:30 AM, General Muir S. Fairchild, Chairman, Presiding, pp. 2-3, in ARDC Office of Command Historian, History of ARDC: 23 Jan 50-30 Jun 51, II (hereafter cited as Transcript of 3 Jan 50 Air Staff Proceedings).

In theory, the way the Air Force research and development process operated was as follows: the requirements division of the operations staff agency was to inform the R&D division under the Matériel staff agency what instruments were needed to fight a war; R&D would then produce the desired equipment. It did not work.[10]

> Both Operations and Materiel fell into the trap of concentrating on overhauling and adding a little more horsepower to the force-in-being instead of conducting a vigilant and relentless search for entirely new weapons. The AF stood in danger of being overtaken by the fallacy of "military rigidity" . . ..[11]

By the end of 1949 the situation had become so bad that even the traditionalists recognized the need for change. In the briefing given General Schlatter before the 3 January 1950 staff meeting which was cited above as an example of traditionalism,[12] the briefer noted that the Air Matériel Command (AMC) agreed with the need for "better formulated and managed R&D," although the Command opposed the recommendations of the Ridenour Report. AMC recognized and decried the fact that the Engineering Division spent eighty percent of its effort on in-service engineering.[13] To understand what it meant to the Air Force R&D program to have the Engineering Division devoting eighty percent of its efforts to in-service engineering, one need only read an official description of the function of this organization. "The

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[10]"Applied Research," Air Force, Jun 50, p. 22.

[11]Ibid., pp. 22-23.

[12]Supra, p. 75.

[13]Text of Briefing for General Schlatter, pp. 1-2. Although I could find no formal definition of in-service engineering, I assume this term means the modification of equipment already in use by the Air Force.

primary mission of the Engineering Division of AMC is to accomplish scientific research, development, and engineering pertaining to Air Force matériel."[14]

With such a general recognition of deficiencies in the Air Force R&D program and with the importance so many Air Force leaders assigned to research and development, one would expect there to be an extensive dialogue on what needed to be done to get the program operating properly. Such a dialogue did take place, and three of the most important documents in it were the Ridenour Report, the Air University Study, and Survival in the Air Age (Finletter Report).

The Finletter Report was the first and most general of the three. It recommended more funds for aeronautical R&D and listed areas in which research and development should be emphasized. It also presented ideas on how government R&D in the area of aeronautics should be managed.[15]

The second major report to appear during this period was the Ridenour Report of September 1949. This document provided the Air Force with a plan for the improvement of its R&D program that was as extensive as the earlier von Kármán work, Science: The Key to Air Supremacy.

The efforts that produced the Ridenour Report grew out of the November 1948 meetings of the Scientific Advisory Board (SAB) which had dealt with the need to improve the R&D facilities and practices of

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[14]Secretary of the Air Force, Report for FY 1948, p. 190.

[15]President's Air Policy Commission, Survival in the Air Age, pp. 73, 77, 80-92, 94.

the Air Force. General Vandenberg read the report and then met with Dr. von Kármán and General Putt to discuss the Air Force's R&D problems. As a result of these events Vandenberg decided to call upon the SAB in the Spring of 1949 for a comprehensive review of USAF research and development.[16]

Vandenberg had planned to address personally the regular spring meeting of the USAF SAB, but at the last minute he was called to an urgent meeting of the Joint Chiefs of Staff. General Muir S. Fairchild delivered Vandenberg's address for him. Vandenberg's address asked the Scientific Advisory Board for advice on how to govern the functioning of USAF research and development facilities.[17]

Von Kármán and Putt decided to establish a special committee to produce the requested recommendations. It was composed of two members of the SAB, Dr. Louis N. Ridenour, Chairman, and Dr. Frank L. Wattendorf. The remainder of the committee was composed of James H. Doolittle, George P. Baker, James B. Fisk, Carl F. J. Overhage, Ralph A. Sawyer, John M. Wild, and Raymond J. Woodrow.[18]

The first meeting of the Committee took place on 11 July 1949 and opened with an address by General Vandenberg. The General told the Committee that it was to receive the full cooperation of the Air Staff. He then described the post-World War II Air Force situation.

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[16]Sturm, USAF SAB, pp. 30-31.

[17]Ibid., pp. 31-32.

[18]Sturm, USAF SAB, p. 32, and von Kármán to Vandenberg, 21 Sept 49, p. Letter 6. Von Kármán's letter is included in the Ridenour Report, and its pages are numbered Letter 1 through Letter 6.

After that war, he said, the air service deteriorated to the point where it had become difficult for the Air Force to meet its obligations. The Air Force had done well in meeting such world crises as the Berlin blockade and had managed to create a force-in-being in spite of personnel and fund limitations. But now it was time to decide what the Air Force should be doing in the future. The Ridenour Committee should give the Air Force a picture of what it was not doing that it should be doing.[19]

In the following six weeks the Committee met about twenty times at a dozen different Air Force, other military, and government facilities across the nation.[20] The report that resulted from their efforts was submitted to General Vandenberg in September 1949.[21]

The Ridenour Committee made specific recommendations for changes in the organizational structure of the Air Force. At the Air Staff level there should be created a single staff office--the Deputy Chief of Staff for Research and Development (DCS/R&D)--that would be responsible for the overall Air Force R&D program. This staff agency would be established on a co-equal basis with other major elements of the staff.[22] At the operating command level there should be established a Research and Development Command. This Command would be composed

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[19]Sturm, USAF SAB, pp. 32-33. Sturm quoted Vandenberg as saying of the post-World War II situation: "everything went down hill so fast that the first thing we had to pay attention to was to get a sort of fire-bucket brigade ready in case something should break."

[20]Ibid., p. 33.

[21]Von Kármán to Vandenberg, 21 Sept 49.

[22]Ridenour Report, pp. Conclusion-1, V-2 - V-3.

of "systems groups" with the responsibility for the development of complete weapons systems. Additionally, the R&D Command would absorb the Office of Air Research which the Air Force had established earlier "to conduct research of a preliminary nature, and to review research and development contracts, programs, and budget estimates."[23] The head of the new Research and Development Command should be the DCS/R&D according to the Ridenour Report.[24]

The Air University Committee worked in conjunction with the Ridenour Committee. Some members of the Air University working group attended each of the hearings conducted by the Ridenour Committee, and all documents available to the Ridenour Committee were available to the Air University Committee. Additionally, working committee members conferred at Santa Monica, California, with the Ridenour Committee and Headquarters USAF research and development personnel.[25]

The recommendations contained in the Air University Study closely parallel those of the Ridenour Report. The former report recommended the immediate establishment of a Deputy Chief of Staff for Development (DCS/D) and the "phased consolidation of all Air Staff Research and Development activities under this Deputy."[26] Furthermore, the AU Committee suggested that the Air Force immediately create a Research and Development Command and initiate "a phased assignment of

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[23]Ibid., pp. Conclusion-1, V-3, V-7.

[24]Ibid., p. V-4.

[25]Air University Study, TAB E, p. 1. The working committee was composed of representatives of the USAF Headquarters Staff, the Air University Headquarters Staff, and the Air War College Staff.

activities and functions to this Command."[27] As for the relationship between the commander of the new R&D Command and the Deputy Chief of Staff for Development, the Air University Committee made no recommendation such as that contained in the Ridenour Report, that the DCS/R&D and the commander of the R&D Command be the same person. But neither did the Air University Study take exception to this recommendation in TAB D of the Study which supposedly listed those areas where there were disagreements.[28]

In addition to recommending organizational changes, the Ridenour Report and the Air University Study suggested additional steps the Air Force could take to improve its R&D program. These suggestions, along with those contained in other documents of 1949, advised the Air Force on what it must do to create an environment in which R&D could flourish. As Colonel Fickel stated: "We must recognize that the processes of research and development demand certain peculiar conditions to be effective."[29]

The Ridenour Committee expressed similar views. This group remarked that the traditional military organization did not provide the "proper environment" for the research and initial development portion of R&D to prosper. "Experience has shown," the Committee recorded, that these two undertakings "flourish where freedom of inquiry and

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[26] Ibid., p. 5.

[27] Ibid.

[28] Ibid., TAB D, p. 5.

[29] SAB Transcript, 12 Jul 49, p. 24.

flexibility of program are provided." These conditions were not available in the Air Matériel Command, which had responsibility for Air Force research and development when the Ridenour Report appeared.[30]

To some of those advising the Air Force on how to improve its R&D program in 1949, the university seemed to be a model that the Air Force should seek to imitate. At least one component of research and development, basic research, seemed to succeed best in the university environment. The Ridenour Committee stated: "Traditionally, and in fact today, the universities of the country are the great centers of fundamental research."[31] And if the Air Force were to have an effective research and development program, it must develop strong ties with the universities. As the Report put it: "Air Force research and development cannot be maintained at the highest level of competence without being closely associated with the general research effort of the nation's universities."[32]

The Ridenour Committee was not alone in this belief. In his memoirs Theodore von Kármán recorded his efforts to secure a close tie between the University of Tennessee and the Arnold Engineering Development Center that was established near Tullahoma, Tennessee. The construction of this Center was authorized by Congress in October 1949, and construction was completed in 1951.[33] Von Kármán discussed the

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[30]Ridenour Report, p. V-5.

[31]Ibid., p. X-2.

[32]Ibid., p. X-1.

[33]Arthur K. Marmor, "The Tools: Weapons," in Goldberg, History of the USAF, pp. 199-200 (hereafter cited as Marmor, "Weapons").

various advantages and disadvantages of the Tullahoma site. An advantage was the availability of an excellent power source in the form of the Tennessee Valley Authority. Dr. von Kármán listed two disadvantages: the lack of a sufficient height to provide for direct hydraulic drive for the powerful motors associated with the Center and the absence of a university close to the site. Von Kármán thought the close proximity of a university was "vital to create the atmosphere needed for good research."[34] He noted that he made several trips to the University of Tennessee to enlist its support for the Center.[35]

The Ridenour Committee also recommended the establishment of a fellowship program, in addition to the program of supporting basic research by contract.[36] "The Air Force should seek legislation empowering it to award a modest number of predoctoral and postdoctoral fellowships to highly qualified students."[37] This program would help satisfy the "recurring requirement for staffing Air Force research and development facilities with technically qualified young men" by creating a number of fellowship holders "whose willingness to consider a career with the Air Force would inevitably be greater than that of other graduate students and postdoctoral workers."[38]

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[34]Von Kármán, The Wind and Beyond, pp. 299-300.

[35]Ibid., p. 300.

[36]Ridenour Report, p. V-7.

[37]Ibid., p. X-3.

[38]Ibid. For some other comments on an Air Force fellowship program, see: O. G. Haywood, Jr., "Basic Research in the Air Force," Air University Quarterly Review, VI, No. 4 (Winter 1953-54), 93-94. Haywood noted that the Air Force had no authority to carry out a

Another aspect of the R&D environment that the Air Force should seek to establish involved exploiting the relationship between teaching and good research. We have seen in an earlier chapter that the Air Force was interested in establishing an effective school in its Air Force Institute of Technology. The Ridenour Report wished to see this school turned into a top-ranking graduate engineering school and noted that one of the principal factors in achieving this goal would be assembling a competent staff. The key to assembling a competent staff was to allow its members "to conduct their own research and to guide the research of graduate students. Most of the physical tools for research by the staff and by graduate students are already present at Wright-Patterson Field."[39]

The Ridenour Report raised and answered the rhetorical question of why the Air Force needed a top-ranking engineering graduate school of its own. First of all, the Air Force was interested in many research topics, such as terminal ballistics, which are not the proper business of a civilian institution. Secondly, the Report noted that the Air Force at Wright-Patterson Field, for example, had extensive research facilities unavailable in civilian institutions and expensive and wasteful to duplicate. "These facilities should be used for research, and the proposed development of the Air Institute of

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fellowship program, nor was it seeking such authority. But in a sense its support of basic research in universities gave it a fellowship program administered by those who were performing research under contract to the Air Force. These people selected graduate students to work with them on the projects covered by the contracts, and this was in fact expected by the Air Force.

[39]Ridenour Report, p. X-4.

Technology is the most direct and immediate way of insuring that they are so used."[40]

The Air University Committee agreed that the Air Force should provide "high-caliber graduate-level instruction at the Air Force Institute of Technology." But this instruction should be limited only to those areas of special interest to the Air Force. The Institute should not become a general graduate-level school, for general graduate education could best be acquired by sending officers to civilian institutions. The offering of graduate-level education in special areas would satisfy Air Force requirements for people qualified in those areas and provide technical personnel with the "opportunity to do a small amount of teaching." Such an opportunity was "an important factor in attracting technical personnel of the type and caliber needed to administer effectively Air Force research contracts with universities and various other research organizations."[41]

General Donald Putt, a member of the Air University Committee, brought up the matter of the interrelationship between teaching and R&D during an Air Staff meeting on 3 January 1950. Putt observed:

> a lot of the types of people we would like to attract into the organization [R&D Command] like to do a little teaching on the side also, and also professors like to get their hands dirty

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[40] Ibid.

[41] Air University Study, TAB D, pp. 1-2. Root, "Finletter Report," p. 26, discussed the possibility that the AFIT program, in conjunction with educating officers at civilian schools, might provide a solution to the problem of the shortage of manpower in the Air Force R&D program. Louis Ridenour later confirmed that the AU Study interpretation of the Ridenour Report recommendations on AFIT was correct; AFIT should be a specialized graduate school (Transcript of 3 Jan 50 Air Staff Proceedings, p. 44).

> with a little research; so between that combination plus the enormous facilities that are available in the Air Force, you can compete favorably with any university technically on facilities.[42]

During the same Air Staff meeting General Fairchild asked if giving the Air University administrative control over AFIT would cause any problems. Dr. Ridenour called upon his university experience in assuring Fairchild that it would not, provided the Air University did not "put any obstacle in the way of the senior technical people in the Research and Development Command becoming part of the faculty of the Institute of Technology, because the point General Putt mentioned was really very real in our minds."[43] Doolittle echoed Ridenour, saying such an arrangement must not be allowed to interfere with the flexibility of these "senior Air University people to do research or to instruct."[44]

One final indication of the belief in the beneficial relationship between research and teaching is found in a memorandum that Colonel Arthur Fickel prepared about three weeks after the 3 January 1950 Air Staff meeting. Fickel believed that AFIT would be "one of the first field activities" the new Research and Development Command would absorb. Once the new command acquired AFIT, it should be "physically allied" to the Office of Air Research, the Air Force organization that was responsible for AF basic research.[45] Based upon

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[42]Transcript of 3 Jan 50 Air Staff Proceedings, p. 47.

[43]Ibid., p. 48. When Ridenour spoke of "our minds," he was apparently referring to the members of the Ridenour Committee.

[44]Ibid., p. 49.

[45]Fickel, Memorandum for Record, 23 Jan 50, p. 2.

views that seem to have been widely held in the Air Force (as we shall see shortly), Fickel concluded that both OAR and AFIT should be located in the vicinity of Washington, D.C., for "there is far greater attraction for high caliber staff" in this location.[46]

In addition to the relationship between teaching and R&D and the need for flexibility and freedom in the R&D program, several other special conditions for effective R&D were mentioned in various documents. For one thing, the R&D program needed policies and procedures designed specifically for research and development activities. "USAF management policies and procedures . . . throttle effective and economical Research and Development," argued the Air University Committee. Specifically criticized were Air Force regulations. These were "designed for the management and operation of tactical, administrative, or procurement organizations," but they "seriously interfere with the efficient management and operation of Research and Development activities."[47] To correct this problem, "management procedures appropriate to the specialized nature of Research and Development activities should be initiated at once."[48]

Much the same thing had been stated somewhat earlier in the Ridenour Report. After noting that special policies are needed for R&D, the Report complimented the Air Force on the March 1949 publication of Air Force Regulation 80-4 which "enunciated . . . most of the

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[46] Ibid.

[47] Air University Study, p. 2.

[48] Ibid., p. 6.

basic policies which those experienced in research and development consider to be essential for making effective progress." But, the Committee continued, "actual practices in the Air Force differ substantially from those which are recommended in AFR 80-4." Moreover, a statement similar to that contained in AFR 80-4 was needed for development.[49]

The Ridenour Committee was aware that the Air Force had just published AFR 80-4, but did not seem to think that the newness of the regulation was the complete reason for the degree of difference between stated policy (the regulation) and practice. Accordingly, they commented:

> Unless a fully determined effort is made to put it into effect, . . . it is likely to take its place with numerous past expressions of intent by the Air Force with regard to research and development, which have been sound in conception and principle, but have never been carried through.[50]

An earlier letter from General Fairchild to the Commanding General of the Air Matériel Command reflects one official effort to bridge this gap between policy and procedure. Fairchild told the AMC Commander that Air Force Headquarters attached "unusual significance" to the policies outlined in AFR 80-4.

> Proper implementation of the policies will round out the intellectual capabilities of the Air Force by attracting and holding highly trained scientists. These scientists are

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[49]Ridenour Report, p. IV-1. There are indications that AFR 80-4 may have been published as a result of the efforts of the SAB. Von Kármán to Vandenberg, 15 Jan 49, p. 2, endorsed a draft regulation that was being considered for adoption by the Air Staff at that time. This draft contained "many recommendations" of the SAB.

[50]Ridenour Report, p. IV-1. For a discussion of procedures for research and development, see Chapter IX.

> required to recognize the implication of new fundamental discoveries and applications insofar as they apply to the technological advancement of the Air Force.[51]

Fairchild called on the Commander of AMC to give his personal attention to seeing that the policies of the Regulation were implemented.[52]

Another special need of the AF R&D program was stability of its manning and its funding practices. Colonel Fickel was critical of the funding system that only allocated funds for one year. R&D is a continuous activity; it required the obligation of funds for at least a four year period.[53] And both the Air University Study and the Ridenour Report recommended a stable budget for R&D. The latter was somewhat stronger on this point than the former. The Ridenour Committee stated:

> An effective program of research and development can be achieved only when its budgetary support is relatively stable from year to year, since most important projects take years to bring to successful completion. It is likely that total Air Force appropriations will fluctuate from year to year, so that stability in the research and development budget can be obtained only by causing other activities to absorb the fluctuations and deficiencies in funds.[54]

Both the Air University Study and the Ridenour Report

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[51]General Muir S. Fairchild, Vice Chief of Staff, USAF, to Commanding General, Air Matériel Command, Subject: "Air Force Regulation 80-4," 14 March 1949, p. 1, in History of Separation of R&D from AMC, III.

[52]Ibid., p. 2.

[53]SAB Transcript, 12 Jul 49, p. 22. Fickel also criticized the Air Force R&D management structure and the attitudes of Air Force leaders toward R&D as other sources of instability in the R&D program (pp. 22-24).

[54]Ridenour Report, pp. IV-2 - IV-3. For the comments of the Air University Committee, see: Air University Study, pp. 5, 7, and TAB C, p. 1.

considered personnel to be one of the keys to a successful R&D program. According to the Air University Study: "The quality of Air Force Research and Development is dependent on the individual scientific and technical competence of the personnel performing or supervising the function."[55] The Ridenour Report made the point just as strongly:

> At the very heart of the problem of improving Air Force research and development and placing it on a firm basis for the future is the urgent need for enlightened policies for recruiting and managing military and civilian technical personnel of high competence. An organization can be effective only when it has competent personnel who are given able, inspiring, and dynamic leadership.[56]

The Ridenour Report and the Air University Study were not alone in making this point. At the 12 July 1949 SAB meeting where he brought up the need for stability in R&D funding and manning, Colonel Fickel had also said that the "essence of research progress depends on individual creativeness, and . . . this is engendered best through personal satisfaction and interest of the individual."[57]

People were not only the heart of the R&D process, but also one of the major problems encountered by a military R&D program. Survival in the Air Age called the shortage of qualified men the most serious bottleneck in the military aviation research and development program. The cause of this problem was World War II, which produced a serious decline in the output of engineers and scientists from the nation's

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[55]Air University Study, TAB B, p. 1.

[56]Ridenour Report, p. VII-1.

[57]SAB Transcript, 12 Jul 49, p. 17. For other similar statements by Fickel, see: pp. 16, 24.

schools.[58] A year later, in a report made on the progress achieved in the implementation of the policy outlined in the Finletter Report, an Air Force article related the personnel shortage problem to the Air Force R&D program specifically. According to this article, the shortage of personnel was still probably "the most acute of any [problem] in the R&D program." The Air Force had made strides toward attracting civilian technicians and engineers to jobs with the Air Force, but there was still much to be done. The Air Force simply could not entice enough of the right kinds of people to work in its R&D program.[59]

This situation posed a major challenge for those who would improve the Air Force research and development program. They must establish a personnel situation that would attract sufficient numbers of qualified people. Accomplishment of this goal would involve efforts along two lines: insuring that living and working conditions were adequate, and implementing appropriate personnel policies.

Concerning the policies that should be implemented to assure an adequate personnel supply, the Finletter Report made several recommendations. For one thing, a national program for education in the aeronautical sciences should be set up under "a National Science Foundation." Additionally, the salary limitation of $10,000 per year established by the Classification Act that was then in effect should be lifted; with industry bidding for the services of scientists, it

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[58] President's Air Policy Commission, Survival in the Air Age, p. 94.

[59] Root, "The Finletter Report," p. 26.

would be impossible to attract top-quality people at that salary. Also, the services should allow specialization in research and not transfer its R&D officers to operations after a tour in the R&D career area. Such practices as this produced instability at the policy-making level of an R&D organization. Furthermore, officers should be encouraged to make research and development a career. Part of this effort would be to give them graduate training in their specialty at leading civilian schools at the expense of the government.[60]

The Ridenour Report echoed many of the personnel recommendations made in the Finletter Report. Thus, an individual's R&D expertise should not be dissipated by assignments outside of his career specialty. The Air Force must make room in its general officer ranks for competent officers without requiring participation in unrelated fields of activity as a prerequisite for achieving general officer rank.[61]

Another major piece of advice given in this report was that the Air Force should make an immediate inventory of technical officers to identify and catalogue them. As soon as possible after this it should institute a career guidance plan for them.

> The plan should be drawn up with the help of the best professional advice, and should provide that technical officers be given assignments which use their special skills, as well as

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[60]President's Air Policy Commission, Survival in the Air Age, pp. 95-96. This report also mentioned the importance of good working conditions and adequate housing for families of the workers (p. 95).

[61]Ridenour Report, p. VII-7.

> insuring that such officers have a properly controlled rotation to broaden their experience and to acquaint them with an adequate range of Air Force activities and operations. The plan should also secure for technical officers an equality of opportunity with other officers, both for assignments and for promotion.[62]

Another of the Report's recommendations proposed the institution of a medal for "distinguished technical achievement." This decoration would be awarded not for accomplishment in administration of R&D activities, but only for "the actual achievement of ideas and discoveries. . . . The new award would go to the worker who has a primary part in an important development." This medal would be the equivalent of the Distinguished Flying Cross, which had been instituted to recognize individual performance of Air Force flying personnel. The decoration recommended by the Ridenour Committee would constitute recognition by the Air Force that its effectiveness depended upon the achievements of its technical personnel as well as upon those of its operational crewmembers.[63]

The Air University Study concluded that the Air Force needed to overhaul thoroughly its personnel system in order to improve the situation for technical and scientific personnel. Air Force personnel policies had not provided sufficient numbers of qualified scientific and technical workers. To overcome this shortcoming, the Air Force should establish a catalogue of qualified officers on active and inactive duty and make the technical qualifications of officers the

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[62]Ibid., pp. VII-7 - VII-8.

[63]Ibid., pp. VII-6 - VII-7. For other recommendations on personnel, see Chapter VII of the Ridenour Report, pp. VII-1 - VII-11.

overriding consideration in their assignment so that their skills were properly used. These assignments would be subject to the approval of the Deputy Chief of Staff for Development which the Air University Study would have the Air Force create.[64]

In addition to these recommendations, the Air University Committee advised that positions of responsibility in the R&D field should be filled by officers who were technically and administratively qualified. Civilians should also be considered for these positions. To assure sufficient numbers of qualified people were available, the Air Force should begin an educational program for officers; this program would rely on the Air Force Institute of Technology to provide training where civilian institutions were inadequate. As an added measure, regular commissions in attractive grades should be offered to selected technically qualified research officers and civilians. Advancement opportunities for both officers and civilians in the R&D field should be good; for officers it should be as good as for general duty officers.[65]

Actions on these recommendations were not slow in coming, as the proceedings of the 3 January 1950 Air Staff meeting show. During the meeting Lieutenant General Idwal H. Edwards remarked that as a result of the advice of the Ridenour Committee the personnel staff had established a control office for military personnel with technical specialties. This office controlled the "assignments, movements, and everything else" of people who were identified as technical specialists,

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[64]Air University Study, p. 5; TAB B, pp. 1-2.

[65]Ibid., TAB B, pp. 3-4.

and their activities would be monitored by the new Deputy Chief of Staff for Development.[66] Additionally, a catalogue of technical personnel was being made. Once an individual acquired a technical qualification, he was identified and became a "controlled individual." These efforts, said General Edwards, should correct the deficiencies the Air Force personnel system had exhibited in the past, as far as the management of R&D people was concerned.[67]

General Edwards also noted that the Air Force had established a "survey group" that was to visit the Cambridge and Watson Laboratories to conduct an "on-the-ground study" to find out what made people quit their work with the Air Force. It was hoped that the information gained from this survey would enable the Air Force to recommend to the Civil Service Commission what might be done to improve the situation. Another group was surveying people who had already left the employment of the Air Force to see what their reasons for quitting had been.[68]

General Edwards reported one final official action the Air Force had taken in the area of R&D personnel management. Letters to major commanders had informed them of the difference between managing R&D personnel and handling military members of their commands.[69]

Proper working and living conditions for R&D personnel also required attention. Colonel Fickel had this to say:

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[66]Transcript of 3 Jan 50 Air Staff Proceedings, p. 29.

[67]Ibid., pp. 29-30.

[68]Ibid., p. 30.

[69]Ibid., p. 32.

> The facility must . . . be attractive, not only as a laboratory but as a community. We are not now dealing merely with the stoicism of the field soldier to whom any assignment is still within his professional scope. The ability to attract and hold professional talent in the Air Force is dependent on providing it with an agreeable professional--not necessarily military--atmosphere.[70]

The importance of good working and living conditions in attracting quality R&D personnel was also discussed in the Ridenour Report. Competent civilian technical personnel could be attracted to government services in peacetime, said the Report, only by

> employment practices which yield working conditions, including intellectual freedom, personal dignity and rewards, and cultural opportunities that are not inferior to those freely available in the research laboratories of industry and the universities.[71]

Similar comments can be found in the Air University Study.[72]

An article on basic research in Air Force also emphasized the importance of good living conditions in attracting capable people to the Air Force research and development program. The location of employment should be "where there is comfortable housing, good schools, a reasonably cosmopolitan atmosphere, and the opportunity for the individuals of the staff to go to a concert or a play occasionally if the mood strikes them." This must not be considered pampering the technician or scientist; it is merely a matter of giving him what he can obtain elsewhere. "It is a simple case of attracting the brains with sugar instead of the vinegar he has been fed in the past."[73]

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[70] SAB Transcript, 12 Jul 49, p. 17.

[71] Ridenour Report, p. VII-10.

[72] Air University Study, TAB C, p. 2.

[73] "Basic Research," Air Force, Jun 50, p. 19.

The actions undertaken to improve the personnel situation for R&D workers, whether trivial or significant, whether pedestrian or insightful, were all less important than two major changes recommended to improve the organization of R&D for the long haul. These were the establishment of a Deputy Chief of Staff for Development and the creation of the Air Research and Development Command.[74] Both recommendations were implemented, and R&D management achieved unprecedented recognition in the Air Force, but these changes were not accomplished without difficulty.

The recognition of a problem does not guarantee that all who recognize it will propose the same solution. We have previously observed the creation of the Deputy Chief of the Air Staff for Research and Development, an office similar in some ways to the Deputy Chief of Staff for Development, and seen that this earlier office succumbed to a resurgence of the traditional Air Force view of R&D management which held that R&D was an aspect of the matériel function in a combat organization. We have also seen that this view still had its proponents in the Air Force of 1949 and 1950.[75]

There was opposition to the reforms proposed. In 1949 the center of opposition seems to have been the Air Matériel Command. In December of that year Brigadier General N. B. Harbold, Inspector General, Headquarters Air Matériel Command, addressed a memorandum on the Ridenour Report to General St. Clair Streett, Commanding General of the Air Matériel Command. Speaking of the problem of scattered

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[74]Fairchild, Memorandum, "Organization for R&D," 23 Jan 50, p.1.

[75]Supra, pp. 62-70.

responsibility for R&D in the current AF organization which the Ridenour Report criticized, Harbold stated that this "is certainly correctible by means other than the major reorganization recommended."[76] Moreover, Harbold contended that the idea of a separate command in the Ridenour reorganization scheme raises the question, "'Is Research and Development of such importance as to require a segregation of function or is it only part of a larger, more important function?'"[77] Harbold concluded that the Air Force effort in response to the Ridenour Report "should be to modify or correct its existing organization."[78]

In addition to Harbold's memorandum to Streett, which gives some indication of the thinking behind AMC's opposition to the Ridenour Report, there was the view expressed in a briefing for General Schlatter, who became the first Commander of ARDC in February 1950,[79] prior to the 3 January 1950 Air Staff meeting. Speaking of the Ridenour Committee recommendation for the establishment of a separate R&D command, the briefer said:

> The Air Materiel Command does not agree that this recommendation will be of over-all benefit to the Air Force. AMC thoroughly agrees with the need for better formulated and managed R&D, . . .. AMC believes, however, that the necessary structure can be developed within the AMC framework, and that it should be developed within that framework in order to prevent a difficult

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[76] N. B. Harbold, Memorandum to General Streett, Subject: "Report of the Special Committee of the SAB," 5 December 1949, p. 1, in History of Separation of R&D from AMC, III.

[77] Ibid.

[78] Ibid., p. 2.

[79] Sturm, USAF SAB, p. 135.

break in continuity between the development, production, and maintenance of materiel.[80]

To overcome resistance such as that posed by AMC and bring about desired changes, those who sought to begin a new approach to R&D within the Air Force seem to have used two techniques. In the first place, they articulated a set of images to explain why the Air Force needed to make changes in its R&D program. These images proved to be persuasive in their effect upon top Air Force leadership. Secondly, there were some unique men among the proponents of change who were either in key positions or who possessed access to top Air Force leadership. These men themselves provided the leadership for the effort to change the Air Force R&D program. As we shall see, James H. Doolittle and Gordon F. Saville were perhaps the two most important men as far as bringing about changes in the research and development activities of the Air Force was concerned.

One image that was developed must be set against the background of the battle over which military service would control strategic missiles. In 1946 this matter did not seem too controversial. General Spaatz, who became the Commanding General of the Army Air Forces in 1946 and the first Chief of Staff of the Air Force in 1947,[81] believed

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[80]Text of Briefing for General Schlatter, p. 2. The philosophy behind AMC's opposition to the change is more fully developed on pp. 9-10. Here concern is expressed that separating the components of R&D would be "fatal" to the R&D enterprise. Dr. von Kármán, The Wind and Beyond, p. 304, claimed the idea of a separate major command for R&D "on a par with operational commands" "crystallized the opposition in the Air Force" to elevation of the importance of R&D.

[81]Ira C. Eaker, "Gen. Carl A. Spaatz, USAF: June 28, 1891-July 14, 1974," Air Force Magazine, LVII, No. 9 (September 1974), 47-48.

the dividing line should be based on the technical characteristics of the missile. In that year Spaatz told Congress: "In general terms, the Air Force develops those forms of guided missiles and rockets that depend on the aerodynamic principles, and Ordnance develops those in the projectile field."[82] And even as late as 1949 no less a figure than Vannevar Bush was to contend that intercontinental missiles would be of little consequence "for the near future."[83]

But by 1949 there were those who had begun to take the missile more seriously. In October of that year an article entitled "Who Will Guide the Missiles?" appeared in the journal of the Air Force Association; its author was Ned Root, managing editor of the magazine. Root's article raised the question of whether the Army, Navy, or Air Force would control the nation's missile program:

> Should any one service cop the program for its very own, that branch would stand to put its two sister services in all but total eclipse. For it is apparent that the end refinement of the guided missile as an instrument to carry destruction to the enemy--the guided missile that has "grown" to full maturity, will be of such a nature as to revolutionize (and in most cases antiquate) the carriers we now use on land, sea, and in the air.[84]

Root strongly criticized the efforts of the Navy to secure control of the missile program. He reported: "For at least three

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[82]U.S., Congress, House, Committee on Appropriations, Military Establishment Appropriation Bill for 1947, Hearings before the subcommittee of the Committee on Appropriations, 79th Cong., 2d sess., 1946, p. 425.

[83]Bush, Modern Arms and Free Men, pp. 84-87.

[84]Ned Root, "Who Will Guide the Missiles?" Air Force: The Official Journal of the Air Force Association, XXXII, No. 10 (October 1949), 15.

years now, the Navy has endeavored with every device at its disposal to establish itself in the public mind as pre-eminent in the missile field." This publicity effort seemed to have been achieving results, for fifty-seven percent of all R&D money for missiles in 1949 went to the Navy, while the Air Force received twenty-two percent and the Army twenty-one percent, based upon figures released by the Joint Guided Missiles Committee.[85]

A warning similar to that expressed by Root appears in the Ridenour Report, only this time the threat was the Army.

> The Committee understands that the Army has recently proposed to the Joint Chiefs of Staff that development and operational cognizance over ground-to-ground and ground-to-air guided missiles be given to the Army. If this were to be done, it would transfer to the Army a large share of the future mission of the Air Force.[86]

Faced with this competition between the service branches, how would Department of Defense agencies such as the Research and Development Board decide to assign program or mission responsibility? According to Colonel Fickel, this would be done on the basis of three criteria: "The first of these is on the basis of which Department has primary operational mission interest; the second, which has the best technical capability; and third, which has an assigned procurement responsibility."[87] These criteria were similar to those described in the Air University Study:

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[85]Ibid., p. 17. Root's article contains much of the acrimony of inter-service rivalry, including a rehearsal of the wrongs the Navy perpetrated during the earlier B-36 bomber controversy (pp. 18-19). The Joint Guided Missiles Committee was an agency under the Research and Development Board of the Department of Defense (p. 19).

[86]Ridenour Report, pp. IV-1 - IV-2.

[87]SAB Transcript, 12 Jul 49, p. 14.

> Any current agreement reached between the services on roles and missions, and on the location of operational responsibilities with respect to new weapons, has no real or lasting significance. Evolutionary processes and logic will ultimately dictate that the service possessing the combination of technical competence and strategic understanding within a particular field will be the service which controls and operates within that field.[88]

As early as May 1949 warnings were sounded that the weakness of the Air Force R&D program endangered the position of the Air Force within the Department of Defense. In a 24 May memorandum, General Putt compared the Air Force R&D program with that of the Army and the Navy. In this comparison the Air Force emerged the weakest, while the Navy had what appeared to be the best research and development program. Putt emphasized the interest that high-ranking Naval officers displayed in research and development and noted that the Air Force compared unfavorably with the Navy in this respect. The shortage of high-ranking USAF R&D personnel "compromises the effectiveness with which USAF R&D needs are presented to outside organizations such as the Congress, Research and Development Board, National Advisory Committee for Aeronautics, etc."[89] The Navy "apparently realizes that its future depends primarily on research and development," Putt continued. "The Navy's position will become increasingly stronger since availability of R&D personnel and facilities is an important factor in the allocation of

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[88]Air University Study, p. 4.

[89]Donald L. Putt, Memorandum for the Chief of Staff, USAF, Subject: "Need for More Emphasis on USAF Research and Development Activities," 24 May 1949, p. 1, in ARDC Office of Command Historian, History of ARDC: 23 Jan 50-30 Jun 51, II (hereafter cited as Putt, Memorandum, "Need for Emphasis on R&D," 24 May 49).

R&D responsibilities among the three services."[90]

Colonel Fickel sounded another warning in July 1949. He pointed out that the Air Force R&D program was weak compared to those of the Army and the Navy. "Through many decades" the Army and the Navy had "developed research and development structures which not only contract for research and development but do it themselves." On the other hand, the Air Force had until recently been dependent on the Army, the Navy, or the aircraft industry for its R&D. Assignment of R&D responsibility based upon the three criteria listed above[91] was going badly for the Air Force. Fickel described the situation in these words:

> Because of this inheritance, we find in the daily decisions being made in atomic energy projects, that assignment of R&D responsibility, on the basis of the second R&D Board criterion of competency, has a strong tendency to be made in favor of the more traditionally developed structures of the Army and Navy, in spite of the first criterion which is generally disregarded or undefined, and in spite of the lack of previous atomic energy experience all around.[92]

In November 1949 General Putt again sounded the alarm, discussing the weakness of the Air Force in the Pentagon's internal technology race. He told students of the Air War College that in nearly "every significant issue before joint consideration, we are on the defensive, and defeated or else impeded to a degree amounting to defeat." The source of this problem was Air Force neglect of the

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[90]Ibid., p. 2. For another comparison that highlights the weakness of the Air Force R&D program relative to that of the Navy see: Ridenour Report, p. III-3.

[91]Supra, p. 144.

[92]SAB Transcript, 12 Jul 49, p. 15.

"planning and technological process." The Air Force was not providing the technical leadership that would "cause others to turn to us for the necessary technology that must be evolved."[93]

What could the Air Force do to protect its mission and indeed itself under such circumstances? The answer was almost obvious. To secure a role in the development of nuclear weapons Colonel Fickel stated that the Air Force "must reflect the work and the projects in its program and budget, it must constantly demonstrate a growing capability as a competent and comprehensive research and development unit in our national technological structure."[94]

Somewhat later, the Ridenour Report recommended a similar course of action. The Air Force "will scarcely be in a position to claim for itself cognizance in such matters [as missiles]," the Report advised, "unless its developmental achievements and its operational proficiency rank with or are superior to those of the other Services." Superiority in a new field could not be had merely for the wishing; it must be earned and can only be earned "by sound achievement in research and development."[95]

In this case the advocates of change in the Air Force R&D program seem to have articulated an image in which their efforts to improve the Air Force R&D activity became an extension of the Air Force fight for independence from the Army. The Air Force had to give greater

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[93]Putt, "USAF R&D," pp. 20-21. For another warning, see: Air University Study, pp. 3-4.

[94]SAB Transcript, 12 Jul 49, p. 15.

[95]Ridenour Report, p. IV-2.

emphasis to research and development if it were to become a full partner of the Army and Navy under the Department of Defense.

In addition to the concern expressed about the Air Force position in the Department of Defense relative to her sister services, some anxiety existed with respect to civilian control of Air Force research and development.

In February 1949 Dr. Karl T. Compton, Chairman of the Research and Development Board, asked Dr. von Kármán to comment on a proposal to create a new civilian R&D organization that would be activated within the National Military Establishment in times of emergencies.[96] Von Kármán indicated that he did not agree with the concept and that he thought the idea for the organization was based on the belief that the military would be as unprepared for the next war from the standpoint of R&D as they had been for World War II.[97] Dr. von Kármán also observed that the recommendation seemed to "assume tacitly that nothing can be done to increase even further the efficiency and effectiveness" with which military funds are used.[98] He believed that rather than complicate the Department of Defense further by the addition of still another R&D agency,

> the main effort should be directed toward enabling the military Departments to appreciate their scientific problems, to organize the cooperation of science in peacetime, and to reorganize

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[96]Theodore von Kármán to Karl T. Compton, 28 February 1949, p. 1, in ARDC Office of Command Historian, History of ARDC: 23 Jan 50-30 Jun 1951, II (hereafter cited as von Kármán to Compton, 29 Feb 49), and Walkowicz, Memorandum, "Civilian Control of Military Research," p. 1.

[97]Von Kármán to Compton, 28 Feb 49, p. 1.

[98]Ibid., pp. 1-2.

> their own structure so that civilian and military scientists have sufficient influence on decisions and are afforded the possibility of doing undisturbed, systematic scientific work.[99]

In drafting a memorandum for the signature of General Putt, Major Teddy Walkowicz seized upon von Kármán's phraseology and noted that "every conclusion" in the report that recommended the establishment of the new civilian R&D organization was "based on an assumption that nothing has been done or can be done to improve the efficiency and effectiveness of research done by the military Departments." Walkowicz then penned these paragraphs for Putt's memorandum:

> I believe that there are grave implications in any movement which will gradually place military research under civilian control. Certainly the margin of USAF technical superiority might be seriously compromised, probably with fatal results in the event of another conflict.
>
> I feel that the growing tendency to weaken and probably eventually deprive the USAF of its research function must be vigorously countered. This can be done by continual strengthening of our research and development activities, and especially their administration.[100]

On two different occasions later in 1940, General Putt expressed views similar to those that appeared in the Walkowicz memorandum. In May Putt informed the Chief of Staff of the Air Force:

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[99] Ibid., p. 2.

[100] Walkowicz, Memorandum, "Civilian Control of Military Research," p. 1. This memorandum is an unsigned copy marked for coordination with Colonel Glantzberg and signing by General Putt. It is apparently directed to the Office of the Vice Chief of Staff, General Fairchild, for the last paragraph of the memorandum reads: "This matter is considered sufficiently urgent to be brought to the attention of the Vice Chief of Staff prior to the luncheon meeting with Dr. von Karman on Tuesday 1 March 1949." I could find no evidence that the memorandum had been signed by General Putt, but in later pronouncements on civilian control of military R&D General Putt used language which we have already seen in von Kármán's letter to Compton and in the Walkowicz memorandum of 28 February 1949.

> There is increasing pressure for civilian control of military research. The USAF must vigorously counter this pressure by giving full support to R&D activities. Otherwise, the growing tendency to weaken and probably eventually deprive the USAF of its R&D function may well prove disastrous. The Air Force would be unable to keep its striking power up-to-date if forced to beg an outside organization for new aircraft, missile, armament, and electronic developments.[101]

Six months later, while addressing the students of the Air War College, Putt indicated his opposition and that of the Air Force to the proposal for the establishment of the new civilian R&D agency within the Department of Defense. One reason for this opposition "lies in the tacit assumption which is evident throughout the report that nothing has been done or can be done to improve the efficiency and effectiveness of research done by the military Services."[102] Putt continued his remarks with these words:

> Over the past several years, this pressure for civilian control of military research has materially increased. To date, little or no action has been taken within the Air Force which, in the minds of those scientists proposing civilian control, would indicate the competency of the military to engage in military research and development activities.
>
> I feel that the growing tendency to weaken and probably eventually deprive the USAF of its research and development function must be vigorously countered.[103]

The message behind these two images, a threat to the future of the Air Force both from her sister services and the spreading influence of civilians, was clear. The Air Force must improve its R&D

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[101] Putt, Memorandum, "Need for Emphasis on R&D," 24 May 49, p. 2. Compare this wording with that contained in the quotations just above from the Walkowicz memorandum.

[102] Putt, "USAF R&D," p. 12. Compare the quotation given here with those given just above from von Kármán's letter to Compton and the Walkowicz memorandum.

[103] Ibid., p. 15. Again, compare this wording with that contained in the quotations from the Walkowicz memorandum given above.

program or face a bleak future in which its role in the defense of the nation would be steadily eroded.

Although Air Force leaders feared the effects of a controlling civilian influence, they did not desire to eliminate civilian participation in their R&D program. Indeed, a genuine concern seems to have existed that civilian scientists might cease to be associated with the research and development program of the Air Force.

In the Air University Study it was noted that the Air Force was not "establishing that partnership with science necessary to the exploitation of scientific frontiers," but instead was "alienating or ignoring vital segments of our national technical resources."[104] A similar statement appears in a 2 December 1949 staff study on the implementation of the Ridenour Report and the Air University Study. According to this document the Air Force had gone far toward alienating science. And if "no visible and positive action" were taken to follow up on the Ridenour Report, "we will undoubtedly complete the alienation of science from the United States Air Force."[105]

Although fairly popular, this image of an Air Force needing to improve its R&D program to protect its position within the Department of Defense was not the most commonly used image. The image that seems to have been used most often in the effort to bring about change in the Air Force R&D program was one that pitted the Air Force of

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[104]Air University Study, p. 1.

[105]U.S., Department of the Air Force, "Implementation of the Ridenour and Air University Reports on Research and Development," Staff Study, Headquarters USAF, 2 December 1949, p. 2 (hereafter cited as USAF, "Implementation of Ridenour and Air University Reports," Staff Study, 2 Dec 49).

today against the Air Force of tomorrow. In an environment where resources are limited, according to this image, the needs of the present compete with the anticipated needs of the future for the resources that are available; research and development is the future's representative in the present.

Many statements of this competition appear in 1949 documents; some are more specific and explicit than others. One of the first appears in the Army Information Digest in July 1949 and suggests the source of the popularity of this image with those who were seeking to gain support for their efforts to change the Air Force management of R&D. The words are those of the Chief of Staff of the Air Force, General Hoyt S. Vandenberg:

> There are many balances which we must achieve within the Air Force itself. We must balance our investment against the possibilities of war today and the possibilities of war five or ten years from today. We must not fatally weaken ourselves today in order to be strong tomorrow. On the other hand, we must not mortgage our future by neglecting research and development in order to gain the temporary advantage of a great number of today's weapons.[106]

General Doolittle used this image more than once. During the 12 July 1949 meeting of the Scientific Advisory Board, he announced that he favored sacrificing the quality of the current inventory of Air Force aircraft so that nuclear powered aircraft development could be advanced.[107] A few months later, at the November SAB meeting, Doolittle said that a technological advantage was all that would keep

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[106]Hoyt S. Vandenberg, "Building a Balanced Air Force," Army Information Digest, IV, No. 7 (July 1949), 4. This passage is quoted on p. II-1 of the Ridenour Report.

[107]SAB Transcript, 12 Jul 49, p. 31.

the United States out of war.[108] He then continued in these words:

> It is far better to keep out of war than to win a war. . . . [To] permit a potential enemy to get ahead of us technologically . . . is the surest way to start a war. I feel that the time has come to make some sacrifice from today's continuing emergencies in order to prepare for tomorrow's eventualities--to jar loose some funds, some competent personnel from the daily requirements in order to prepare for tomorrow's requirements.[109]

The Air University Study appeared about two weeks after the 3 November meeting of the Scientific Advisory Board. In this report we find another example of the image of the competition between the Air Force of today and the Air Force of tomorrow. It occurred in the Committee's conclusion that the Air Force had placed such a great emphasis on "day-to-day operational and materiel problems" that the long-term development of the Air Force had been adversely affected.[110] A little later in the Study this explicit statement of the competition appears:

> We are confronted constantly with two requirements:
> A. To maintain a force-in-being capable of immediate and powerful action, and
> B. To provide for a future force and capability fully abreast of scientific and technological potential.
> These two requirements are necessarily competing, and only the most judicious balance of effort will adequately provide for both contemporary and future security.[111]

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[108] Sturm, USAF SAB, pp. 33-34.

[109] Minutes of Scientific Advisory Board Meeting, 3 November 1949, quoted in Sturm, USAF SAB, p. 34.

[110] Air University Study, p. 3.

[111] Ibid., TAB A, p. 1. For other examples of the use of this image, see: Putt, "USAF R&D," pp. 41-42; Ridenour Report, pp. IV-3, VII-3 - VII-4.

In conjunction with their pronouncements of the conflict between the Air Force of today and that of tomorrow, the advocates of R&D reform frequently related research and development to the creation of an effective Air Force for tomorrow. One instance of this appears in the Ridenour Report where the reader is informed that the investment of funds in R&D brings great dividends in the future.[112] R&D was also related to the future development of the Air Force by the Air University Committee. The stated purpose of the study was to "review the entire Research and Development structure of the Air Force to determine whether or not it is adequate to provide for the long term development and superiority of American air power."[113] General Donald Putt specifically stated that the Air Force of tomorrow is today's job for R&D.[114]

R&D's impact on the Air Force was in the future, yet current crises seemed to demand more money, more people, and more attention. Consequently, research and development was one of those areas that was constantly tapped for the additional resources needed to meet present demands. Concise statements of this practice appear in two letters, written nine months apart, from Dr. von Kármán to General Vandenberg.

In January 1949 von Kármán told the Chief of Staff of the Air Force that the Scientific Advisory Board was "gravely concerned" about the excessive exposure of R&D projects to the "impact of current procurement needs." Research and development efforts "which probably will

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[112] Ridenour Report, p. IV-1.

[113] Air University Study, p. 1.

[114] Supra, p. 113.

have high priority in years to come seem to be the first ones which are pushed overboard because of current budgetary problems and procurement objectives."[115] And in his 21 September 1949 letter which transmitted the Ridenour Report to General Vandenberg, von Kármán summarized the situation of R&D with respect to current Air Force needs.

> Research and development activities cannot be brought to full effectiveness without making corresponding sacrifices elsewhere in the Air Force. A decision to correct some of the deficiencies in the present research and development situation will be valueless unless it is implemented in terms of competent men, money, and effort; and such men, money, and effort must come from a fixed, possibly even a declining, total Air Force allocation. It is my feeling, and that of the Committee, that the effectiveness of research and development is so uniquely important to the continued supremacy of the Air Force and the continued security of the nation that the necessary sacrifices must be made. Steps should be taken to insure that the process of successive cuts and economy measures within the Air Force do not form a growing avalanche which hits research and development with its maximum impulse, destroying essential agencies and projects of this vital part of the Air Force Organization.[116]

The major problem for research and development in the Air Force was that too many regarded R&D as a resource reservoir to be drained each time an emergency arose that called for more resources than were available in the operating and support forces. A reasonable way to overcome this problem was to raise the priority of R&D and isolate it from the tremors that crises produced throughout the Air Force.

Colonel Fickel told the 12 July 1949 meeting of the Scientific Advisory Board that the Air Force's "first emphasis in peacetime must

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[115] Von Kármán to Vandenberg, 15 Jan 49, p. 2.

[116] Von Kármán to Vandenberg, 21 Sept 49, pp. Letter 5 - Letter 6.

be the maintenance of the best Air Force development process which the nation can support."[117] Since every quantitative reduction or instability in an R&D program produces a deterioration in the quality of the research product, variations in the support of the Air Force must be absorbed by "changes in the quantity of our Air Force in-being."[118]

That it was time to increase the priority of reserach and development was the major theme of the Ridenour Report. According to Doolittle, who was a member of the Committee that wrote the report:

> The fundamental thought behind the Ridenour Report was that a time had come for a change in emphasis. Of necessity, in the past, our principal emphasis in all of our Air Force thinking and activities was on the present because of the tremendous problems with which you were faced; but the time has now come to give more emphasis to the future.[119]

Doolittle believed it was necessary to overemphasize the future if you are to get anything done, in view of the pressure of today's problems. "If you have a toothache today, you want to correct it right now. You don't think about taking remedial steps to see that you don't get smallpox ten years from now."[120] Doolittle's idea of how to take care of the future was to separate responsibility for the future from responsibility for the present. "I am inclined to go along with the idea of separating the future from the present and putting it in one single staff function."[121] And Doolittle was not the only one who thought this way.

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[117] SAB Transcript, 12 Jul 49, p. 20.

[118] Ibid., pp. 20-21.

[119] Transcript of 3 Jan 50 Air Staff Proceedings, p 34.

[120] Ibid., p. 35. See also Air University Study, TAB A, pp. 3, 6.

[121] Transcript of 3 Jan 50 Air Staff Proceedings, p. 39.

The Air University Study noted that there was no one "general staff agency in the USAF today responsible to the Chief of Staff for thinking about the future." This made it impossible to fix responsibility for this function when the task of looking out for the future of the Air Force was not performed. Provided one accepted the ideal that there were two major tasks associated with the accomplishment of the Air Force mission--"the one to operate an Air Force in-being, and the other to provide an effective Air Force for the future"--then one could not believe that it was correct to "bury the responsibility for the Air Force of the future under the logististic responsibility for the Air Force of the present."[122]

The 2 December staff study on the implementation of the Ridenour Report and the Air University Study expressed a similar view of the situation of R&D in the Air Force prior to 1950. "In effect, the Chief of Staff has four Deputies responsible to him for the Air Force of today. He has no Deputy responsible to him for the Air Force of the Future."[123] After noting that there was "an urgent need for a functional, organizational structure to direct, administer, and operate research and development activities within the Air Force and correlate" AF R&D with outside agencies, the staff study concluded that a Deputy Chief of Staff for Development and an Air Force Research and

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[122]Air University Study, TAB A, p. 2.

[123]USAF, "Staff Study--Implementation of Ridenour and Air University Studies," 2 Dec 49, p. 2. For another statement on this situation in virtually identical words see: Peter Schenk, Interview, 16 October 1952, in ARDC Office of Command Historian, History of ARDC: 23 Jan 50-30 Jun 51, II, p. 2 (pagination refers to the interview).

Development Command should be established.[124]

Frequently, when the future Air Force was discussed, the need to assure the proper interaction between R&D, strategy, and tactics was also mentioned. The role that the new R&D structure of the Air Force would play in bringing about this interaction was given as another reason the Air Force should make the changes advocated in the Ridenour Report and the Air University Study.

A belief in the importance of this interaction was expressed frequently in 1949 and 1950. One example of this appears in General Putt's November 1949 Air War College lecture. In addition to making the point that the future Air Force is the responsibility of research and development, General Putt told the Air War College that the "evolution of a sound R&D program requires interaction between strategy and technology."[125] General Gordon P. Saville, who shortly was to become the first Deputy Chief of Staff for Development, remarked during the 3 January 1950 Air Staff proceedings that the determination of future Air Force requirements should come from an interaction of technical and tactical experts.[126]

Another example of this view of the importance of the interaction between R&D, strategy, and tactics appears in a June 1950 article in Air Force. Speaking of the applied scientist, the article states:

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[124]USAF, "Staff Study--Implementation of Ridenour and Air University Studies," 2 Dec 49, p. 1. For a similar expression of this image see: "Applied Research," Air Force, Jun 50, p. 23.

[125]Putt, "USAF R&D," p. 20.

[126]Transcript of 3 Jan 50 Air Staff Proceedings, pp. 39,43.

> In a broad sense he is part military philosopher and strategist as well as scientist. For given a general outline of the Air Force's task, he must not only strive to develop a better turbo-prop engine, but keep constantly alert to the possibilities of doing away with the turbo-prop by the invention of something better--something that will give greater facility to the accomplishment of the Air Force's grand objective.[127]

How to achieve the desired interaction was seen by some as being a major problem for the Air Force. Thus we see General Schlatter stating that one of the two major questions confronting the Air Force was "how can the Air Force achieve an effective interaction between technical developments and the science and art of applied military air power?"[128] This view was echoed by the Air University Committee in their report: "Interaction between strategy and science is a primary requirement for an effective Air Force of the future. This interaction is not now being achieved."[129]

The Air Force had tried in various ways to achieve a connection between strategy, tactics, and R&D. In 1949 General Putt told the House Appropriations Committee:

> It is intended that selected leaders in research and technology be kept familiar with the Air Force strategic plans and policies in order to maintain close relationship between our strategic planners and those engaged in the research and development program. The Air Force Scientific Advisory Board composed of some 20 of the Nation's outstanding scientists, headed by Dr. Theodore von Karman, is an important element in this relationship.
>
> Research and development plans and programs are closely integrated on the staff level with those of strategic and tactical planning organizations.[130]

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[127]"Applied Research," Air Force, Jun 50, pp. 21-22.

[128]SAB Transcript, 12 Jul 49, pp. 1-2.

[129]Air University Study, TAB A, p. 3.

[130]House Appropriations Committee, Hearings on Military Appropriations for 1950, Part 2, p. 503.

For Colonel Fickel, the RAND Corporation helped the Air Force integrate strategy, tactics, and R&D. During the 12 July 1949 meeting of the Scientific Advisory Board, Fickel spoke to the members about "our desired inter-dependency between strategic planning and technical research and development" and remarked that the "evaluation services provided by RAND" was the "necessary catalyst which will give us a proper reaction so that we can truly carry out our function of developing the Air Force in the light of our technical age."[131]

In spite of such ways in which the interaction was supposed to be brought about, the Air Force was apparently failing to accomplish its goal in this matter. At least one person, General Putt, stated bluntly that the Air Force did not understand what the proper relationship between strategy, tactics, and R&D was.[132] He further stated that the Air Force had "not yet established that partnership between the strategist and the scientist which is mandatory to insure that superior strategy and technology which is essential to future success against our potential enemies."[133]

The cause of this problem as Colonel Arthur Fickel saw it was organizational. Fickel decried the lack of a formal organization for development in the Air Force and said this deficiency "is precisely the reason why we find the so-called strategic or operational planner miles apart from our research program planner."[134] He continued as follows:

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[131]SAB Transcript, 12 Jul 49, p. 21.

[132]Putt, USAF R&D," p. 22.

[133]Ibid.

[134]SAB Transcript, 12 Jul 49, p. 23.

> We have a theory that out of strategic plans comes guidance direct to the Research and Development organization. It certainly does not, and it never will. There is an extensive translation to be made, and in peacetime you will find that the translation is more often in the other direction--from the researcher to the planner. I wish to lay great emphasis on that point because everything that we have ever done has indicated that the planner must turn to the researcher to find out what he thinks he ought to think
>
> A solution may be the provision of a Deputy Chief of Staff for Air Force Development; having cognizance for the Chief of Staff over the Air university, over the Proving Ground Command, and over a Research and Development Command that is not part of the Air Materiel Command.[135]

Such an establishment would assure "a continuous top side correlation between professional military planning and professional technical planning."[136] Fickel emphasized that the development staff must not simply be composed of ex-warriors, but must be manned by people with experience in developmental work. Neither should they be strictly ex-laboratory workers, but people who have worked with military technical problems.[137]

The Ridenour Committee also considered reorganization a solution to the interaction problem. According to the Committee's report, a Deputy Chief of Staff for R&D would serve to end the confusion caused by "scattered responsibility" for research and development. This Deputy would also be one way in which the Air Force might assure itself of "sufficient impact of research and development on long-term planning for the Air Force as a whole." It would provide "adequate

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[135] Ibid.

[136] Ibid.

[137] Ibid.

staff support for Air Force research and development activities."[138]

Summarizing the thinking of those who considered it essential for the future well-being of the Air Force to have an R&D organization that was co-equal with the other components of the Air Force, the Ridenour Report declared:

> Long-term, over-all planning for the Air Force as a whole can be carried on effectively only by the combined efforts of the major staff elements concerned on a co-equal basis. Such planning by top-level staff elements must of necessity be based upon the employment of newly conceived equipment, since the development of just one new weapon can completely alter a given concept of waging war. The representation of research and development at top staff levels is essential to the accomplishment of the Air Force mission in National Defense. It will insure on the one hand the best technical opinion on development possibilities and prospects in the determination of war plans and operating policies, and will facilitate on the other hand the effective programming and planning of research and development activities and facilities to meet the requirements of the Air Force of the future. Only by this reciprocal interaction of research and development on plans and of plans on research and development can the Air Force attain the progress in weapons and strategy essential to the national security.[139]

Virtually the same view is found in the Air University Study. TAB A of this report listed eight reasons the Air Force should make the organizational changes the Study was recommending. Number eight stated that interaction between strategy and science is a primary requirement for an effective future Air Force, and this was not currently being achieved. A means of accomplishing this interaction other than through voluntary means must be realized; a Deputy Chief of Staff for Development at Headquarters USAF would be one way of

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[138] Ridenour Report, p. Conclusion-1.

[139] Ibid., pp. V-3 - V-4, It will be recalled that traditionalists opposed a co-equal status for an R&D staff office.

doing this.[140]

The drafters of the Air University Study seemed to recognize that their advice would arouse the opposition of traditionalists, and they took pains to see that traditionalist arguments would not be allowed to prevent implementation of their recommendations. In anticipation that the traditionalists would use the failure of the former Deputy Chief of Air Staff for R&D as an argument against their own suggestion of the establishment of a Deputy Chief of Staff for Development, the Air University Committee presented their own version of the reason for the failure of the former DCAS/R&D.

The Committee recognized that the previous experience with General LeMay's air staff office for R&D might be "used as the basis for argument contrary to the recommendations contained in this report." After exploring the "relationships and functioning" of the previous office, the members of the Committee concluded that there was no similarity between the office they now proposed to establish and the LeMay office. LeMay's office had not been a part of a "homogeneous staff structure at Deputy Level. It was a special office or a carbuncle."[141] Additional problems with LeMay's former office included a shortage of personnel and the failure of the AAF to concentrate R&D functions in the office.[142]

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[140]Air University Study, TAB A, pp. 2-3.

[141]Ibid., TAB A, p. 5.

[142]Ibid. Another problem for LeMay's office may have been that there was no organization at the command level to do its bidding. Some directives from LeMay's office would probably have had to be carried out by the Air Matériel Command which was organizationally under the Deputy Chief of Air Staff for Matériel. It might also be

On can hardly read the objections given in the briefing to General Schlatter prior to the 3 January 1950 Air Staff meeting without concluding that this defense of the new DCS/D was perceptive and politically shrewd. In presenting AMC's opposition to the establishment of an Air Staff position for R&D, the briefer had this to say:

> There is admission that there should be some unity [in] top-level judgment on questions of technological change in the Air Force. However, previous attempts are pointed out as being failures (such as General LeMay's position in 1945-46; and the Aircraft and Weapons Board of 1946-47).[143]

Exactly how the "reciprocal interaction of research and development on plans and of plans on research and development" (as the Ridenour Report had expressed it) was to be achieved was a matter of some concern to top Air Force leaders. The problem was discussed extensively during the 3 January 1950 meeting of the Air Staff.[144] The crux of the question was the military requirement which, according to General Gordon P. Saville, was itself the answer at any given time to two questions: "What have you got? and what do you want?"[145] A requirement can be established only by an agreement between "what you might call the consumer people and the producer people, one of whom tends to represent what you want and the other tends to represent what you can have."[146]

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noted that Dr. von Kármán considered General LeMay too conservative in R&D matters (The Wind and Beyond, p. 302).

[143] Text of Briefing for General Schlatter, p. 3.

[144] Transcript of 3 Jan 50 Air Staff Proceedings, pp. 34-44.

[145] Ibid., p. 39.

[146] Ibid., p. 39-40.

Saville did not think that the current way in which the Air Force established its requirements was effective. Requirements could not be "generated by a group of technical specialists coming in and saying that this is what we do, do you want it?" Neither could the Air Force establish its needs by means of having "a group of tactical people who go to the technicians . . . saying, 'This is what we want; you guys produce it.'" Saville thought this matter "a continuing business, just like all of my Indians spend all of their time talking to all of Putt's Indians today."[147] So the correct approach to assure the proper integration of R&D, strategy, and tactics was to combine the Directorate of Requirements that was under the Deputy Chief of Staff for Operations with the Directorate of Research and Development that was under the Deputy Chief of Staff for Matériel.[148]

And this was the way in which the Air Force formed the Deputy Chief of Staff for Development (DCS/D). The two major subdivisions of the DCS/D were the Directorate of Operations Requirements, which used to be in the Office of the Deputy Chief of Staff for Operations, and the Directorate of Research and Development, which had formerly been a part of the Office of the Deputy Chief of Staff for Matériel.[149]

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[147]Ibid., p. 40. At the time of this meeting Saville was the Director of Requirements in the Office of the Deputy Chief of Staff, Operations, and Putt was the Director of Research and Development in the Office of the Deputy Chief of Staff, Matériel (Schenk, Interview, p. 2).

[148]Transcript of 3 Jan 50 Air Staff Proceedings, p. 43.

[149]"Key to the Future," p. 17, and U.S., Department of the Air Force, General Orders Number 9, Washington, D.C., 23 January 1950, p. 1 (hereafter cited as General Orders Number 9, 23 Jan 50). See also: Sturm, USAF SAB, p. 35.

The concept of operation for this new office of Deputy Chief of Staff for Development was described as follows in Air Force:

> In close liaison with the War Plans people, the Director of Operational Requirements will make a constant study of requirements in Air Offense, Air Defense, Tactical Air, and Air Transport.
>
> At the same time, the Director of R&D will study means of improving Equipment, Electronics, Armament, and Aircraft and Guided Missiles. By putting both offices under the same roof to live together day by day it is hoped that henceforth neither one will get ahead of, nor fall behind, the other organization.[150]

Thus, it would seem that although the broad concept of having a deputy chief of staff responsible for research and development took form in the thinking and writing of members of the Scientific Advisory Board, concrete details of how the office would be organized and function came from within the military ranks of the Air Force, specifically from General Gordon P. Saville.

The similarity between the actual organization of the new Deputy Chief of Staff for Development and Saville's thoughts as expressed in the 3 January 1950 Air Staff meeting indicates that he was the articulate military spokesman and perhaps the military thinker behind its organization. It is not surprising that Saville was selected to be the first DCS/D.[151]

Lieutenant Colonel Peter Schenk has provided an interesting account of the role of leadership in bringing about the Air Force

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[150]"Key to the Future," p. 17.

[151]Ibid., and U.S., Department of the Air Force, Special Orders Number 16, Washington, D.C., 24 January 1950. Paragraph two of these orders confirmed verbal orders of the Secretary of the Air Force relieving General Saville from his duties as Director of Requirements, DCS/O, and assigning him to the position of Deputy Chief of Staff, Research and Development (Development).

reorganization that included the establishment of the Deputy Chief of Staff, Development.[152] Schenk appears to have been one of those figures who, like Walkowicz, exerted more influence on affairs than his rank would indicate. He has been referred to as one of Saville's "henchmen" and as a member of a "kitchen cabinet" in the Air Force R&D hierarchy. He served as a member of the Radar Panel of the Research and Development Board and as executive officer to the Chief Scientist of the Air Force.[153]

According to Schenk, change in the Air Force R&D structure was sought by four different types of people: the dissatisfied field operator who thought a better means of establishing requirements would mean better equipment; "the dissatisfied technical officer who sought to improve the internal management of R&D in the Air Force"; the scientist who saw the weaknesses of the Air Force R&D program from the outside (Dr. Ridenour for example); and General Muir S. Fairchild (USAF Vice Chief of Staff) who saw the problem from above, understood the problem, and "had the courage and authority to put across unpopular but vitally needed reforms."[154]

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[152]Schenk, Interview.

[153]Getting, "Recollections of USAF," pp. 1-2. Getting also referred to Walkowicz as a member of this "kitchen cabinet." Schenk also became President of the Air Force Association (Ralph H. Hardin, "How Real Is Our Shortage of Scientific Manpower?" Air Force: The Magazine of American Airpower, XLI, No. 9 [September 1958], 52).

[154]Schenk, Interview, pp. 2-3. For an adverse, if not bitterly cynical, view of Fairchild's actions in bringing about change in the AF R&D structure, see: Ethel M. De Haven, History of Separation of Research and Development from the Air Materiel Command (Wright-Patterson Air Force Base, Ohio: Historical Division, Office of Information Services, Air Matériel Command, December 1954), pp. 74-91 (hereafter cited as De Haven, Separation of R&D from AMC). De Haven claimed that

Putt was the "dissatisfied technical office," and Saville was the unhappy field operator. Schenk claimed that Saville desired closer working relations between the R&D Directorate in the Office of Deputy Chief of Staff, Matériel, and the Directorate of Requirements in the Office of Deputy Chief of Staff, Operations. Saville established close relations with General Putt, the Director of Research and Development.

> When Putt disclosed his campaign of reorganizing the management of R&D within the Air Force, Saville enthusiastically concurred, because Putt's aims coincided with Saville's, although they were independently arrived at from rather different points of view. Both saw that joining forces would be to mutual advantage.[155]

Saville was more firmly entrenched in the operational part of the Air Force than was Putt, and Saville's personal friendship with the Vice Chief of Staff, General Fairchild, was a valuable entrée to the highest level of authority in the Air Force.

> The combination of temperament and personality--Putt, the careful thinker (scientist in uniform), and Saville, the flamboyant and erratic--at times brilliant--operator was ideal for the purpose of putting across the establishment of DCS/D and ARDC

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whatever plan for the separation Fairchild had died with him on 17 March 1950 (p. 91). De Haven stated that her work was an effort to give the Air Matériel side of the controversy that surrounded this separation (p. V).

[155]Schenk, Interview, p. 2. Donald L. Putt to Donald R. Baucom, 2 October 1974, p. 1 (hereafter cited as Putt to Baucom), confirms the alliance between Putt and Saville. Putt pointed out that there was some disagreement over the organization of DCS/D and that Saville won the point. Saville's organizational desires were the ones that were followed in this matter. Putt noted that in the end he was happy that Saville's ideas had prevailed, for the organization turned out well.

against the almost unanimous opposition of the Air Staff.[156]

Saville's comradery with operational officers in the Air Force was not the only entrée to top-level Air Force leaders that was available to those who sought to change the Air Force approach to R&D. Perhaps even more important in this respect were the services of James H. Doolittle. Here was a man whose many accomplishments allowed him to speak to the Air Force as General Doolittle, to the nation's scientific community as Dr. Doolittle, and receive a hearing from both parties.[157]

Doolittle had taken a doctoral degree in aeronautical engineering at Massachusetts Institute of Technology prior to World War II. He was a famous combat leader, having led the first aerial attack on Tokyo, for which he was awarded the Congressional Medal of Honor. He also had commanded various combat units during the war, including the Twelfth Air Force. He eventually rose to the rank of lieutenant general. Additionally, in the late 1940's and early 1950's, when he served on the Ridenour Committee and worked on the implementation of that Committee's report, he was an executive of the Shell Oil Company. He was a man with outstanding credentials and reputation in Air Force operations, in industry, and in the research and development community.[158]

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[156]Schenk, Interview, p. 2. It should be noted that Putt had studied at California Institute of Technology under von Kármán in the late 1930's. A close relationship existed between these men until von Kármán's death (Putt to Baucom, pp. 1-2, and von Kármán, The Wind and Beyond, p. 294).

[157]T[eddy] F. Walkowicz, "USAF Scientific Advisory Board," Air Force: The Magazine of American Airpower, XXXVIII, No. 6 (June 1955), 54.

[158]Doolittle has been called a pioneer of air power. For information on his exploits and accomplishments, see: Carroll V. Glines, [Jr.], Jimmy Doolittle: Daredevil Aviator and Scientist, Air

In a 1965 interview Doolittle discussed his role in the reorganization activity associated with the Ridenour Report. Doolittle remarked that Generals Spaatz and Vandenberg were inclined to ask his advice on technical matters because he had had some technical experience. Because of his academic training, he could communicate with the scientists. As Doolittle put it:

> . . . I think I was useful as a link between the military and the academic people. I could talk to them because I had had some academic training; I could talk to the military and I think I was useful in bridging that gap, so my greatest activity in connection with the Ridenour Report was to participate actively in its sale to the Chief of the Air Staff.[159]

General Doolittle also made the same point in an earlier letter to General Earle Partridge. Of his role in getting the Air Research and Development Command started, Doolittle wrote: "All of this was largely the result of my personal needling of Van [General Hoyt Vandenberg] and the recommendation of the Ridenour Board, of which I was a member."[160]

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Force Academy Series, ed. by Carroll V. Glines, [Jr.] (New York: The Macmillan Company, 1972); Carroll V. Glines, Jr., The Compact History of the United States Air Force, revised ed. (New York: Hawthorn Books, Inc., 1973), pp. 100-01, 104, 131, 133, 166-69, 211, 214, 228-29, 237. For information on Doolittle's education see: Oral History Interview Number 625 with James H. Doolittle, Lieutenant General, USAF (Retired), 21 April 1969, p. 11, Air Force Archives, Maxwell Air Force Base, Alabama; and Glines, Jimmy Doolittle, pp. 54-59. See also: "USAF Almanac: United States Air Force--Facts and Figures," Annual Air Force Almanac Issue, Air Force Magazine, LVI, No. 5 (May 1973), 154.

[159]Oral History Interview Number 623 with James H. Doolittle, Lieutenant General, USAF (Retired), p. 27, Air Force Archives, Maxwell Air Force Base, Alabama.

[160]James H. Doolittle to Major General E. E. Partridge, 5 March 1951, in Partridge Correspondence, Air Force Archives, Maxwell Air Force Base, Alabama. For a similar view of Doolittle's role in changing the Air Force R&D program, see: De Haven, Separation of R&D from AMC, p. 57.

Vandenberg appears to have thought highly of Doolittle's advice in R&D matters. During the 3 January 1950 Air Staff meeting, he had asked that Doolittle and Ridenour be available to assist in getting the Ridenour plan implemented. To be sure that things went according to plan, Vandenberg said, "technical guidance of a very high quality" had to be available.[161]

Perhaps this need for high quality technical guidance explains why Vandenberg appointed Doolittle as his special adviser to assist in resolving conflicts between the Air Matériel Command and the Air Research and Development Command during the reorganization associated with the implementation of the Ridenour plan.[162] Such matters which could not be settled by the two commanders were to be forwarded, along with the conflicting views, through General Doolittle to Vandenberg. Doolittle would study the situation and make a recommendation to Vandenberg. A similar procedure was to be followed in matters of conflict between the Deputy Chiefs of Staff for Development and Matériel.[163]

The Air Force officially established its new Air Research and

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[161]Transcript of 3 Jan 50 Air Staff Proceedings, p. 38.

[162]Hoyt S. Vandenberg to Commanding General, Air Matériel Command, and Commanding General, Air Research and Development Command, Subject: "Appointment of Lieut. General Doolittle as Special Assistant to the Chief of Staff," 28 March 1951, p. 1, in ARDC Office of Command Historian, History of ARDC: 23 Jan 50-30 Jun 51, II (hereafter cited as Vandenberg to Commanding Generals, AMC and ARDC, 28 Mar 51). Getting, "Recollections of USAF," p. 2, reported that Ridenour and Vandenberg had a "disagreement" over what Getting believed was an article Ridenour published in Life.

[163] Vandenberg to Commanding Generals, AMC and ARDC, 28 Mar 51, p. 1.

Development Command and the Deputy Chief of Staff for Development on 23 January 1950.[164] This reorganization was the culmination of five years of efforts by such men as von Kármán, Ridenour, Putt, Saville, and Doolittle. It had not been a simple matter of laying out and implementing in a receptive organization a management plan for R&D. The Air Force already had an operating R&D structure with its own policy and procedures. The advocates of change had to convince Air Force decision makers like Vandenberg and Fairchild that the then current way of managing research and development was inadequate and that their method offered a chance of significant improvement.

The articulation of images that related R&D to the strength of the Air Force and its ability to accomplish its mission was important in "selling the top." By phrasing their images in terms that related to operational effectiveness, the advocates of change were able to communicate with the non-technical officers who had to make the policy and organizational decisions that determined how the Air Force would manage R&D. The power of these images to persuade was strengthened by the fortuitous timing of the Soviet explosion of an atomic bomb. The technological and military implications of the Russian bomb were inescapable.

Finally, credit is due those men who had a foot in each camp--the operational and the R&D--for playing a major role in bringing about change in the Air Force R&D program. Specifically, in the officer corps, Doolittle and Saville played key roles through their

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[164]General Orders, No. 9, 23 Jan 50, p. 1; Fairchild, Memorandum: "Organization for R&D in the USAF," 23 Jan 50, p. 1.

operational contacts with key Air Force leaders, while in the technical and scientific community, von Kármán and Ridenour played equally important roles.

The establishment of the new organizational structure was not a total victory, however, nor did the scales fall in a trice from the previously blind eyes of the conservative traditionalists. While the advocates of change had seen to it that the Air Force gave R&D a higher priority in its organizational hierarchy, there were still non-believers. They were still in positions of power and influence, and there was much unfinished work to be done.

# CHAPTER V

## END OF THE BEGINNING: 1950 AND AFTER

This study has identified certain threads that emerge from the welter of events surrounding Air Force efforts to establish an effective research and development program between 1945 and 1950. These threads include the existence of a traditionalist strain of thought that would subordinate R&D to the matériel function of the Air Force, the role of leadership in bringing about changes in Air Force management of research and development, and the problem of the appropriate conduct and supervision of basic research as it related to and nourished the research and development process which produced the advanced weapons.

The threads include, further, the articulation of images that would justify changes in Air Force management of R&D and a discussion of policies that the Air Force should implement to assure itself of an effective R&D program. But since history is a continuum, if it is anything, these threads do not end neatly with the organizational changes the Air Force made in 1950.

Traditionalist thinking continued to exert influence on Air Force management of research and development well into the 1950's. In April 1951, General Doolittle, in his capacity as special assistant to

the Chief of Staff for technical matters, reported formally to General Vandenberg that progress on the implementation of the Ridenour Report was being slowed due to the resistance of people inside and outside the Air Force who "are primarily concerned with today's problems, [and who] question the advisability of giving substantially increased emphasis to research and development at this time."[1] That certain policy makers in the Air Matériel Command still opposed the separation of research and development from AMC was clear to Doolittle, for he attacked what he called the Air Matériel philosophy of R&D, the view that there was nothing wrong with research and development under AMC control that more people would not cure. As General Doolittle saw it, the separation of R&D from AMC which he favored would weaken the self-sufficiency of AMC; he realized this explained the resistance to

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[1] J[ames] H. Doolittle, Memorandum for General Hoyt S. Vandenberg, Subject: "Report on the Status of Air Force Research and Development," [20 April 1951], p. 1 (hereafter cited as Doolittle to Vandenberg, Memorandum, [20 Apr 51]). This document may be found in the Air Force Archives, Maxwell Air Force Base, Alabama. I have seen a second version of this memorandum which appears in U.S., Department of the Air Force, History of Separation of Research and Development from the Air Materiel Command, Vol. IV, Air Force Archives, Maxwell Air Force Base, Alabama (hereafter cited as History of Separation of R&D from AMC, IV). The version of Doolittle's memorandum that is found in volume IV is hereafter cited as Doolittle to Vandenberg, Memorandum, 20 Apr 51. The pagination of these two documents is different, and they do not contain exactly the same information. But there are extensive identical passages that appear in both documents. Although it is undated, the first version cited in this footnote is probably the final version, while the second version cited is perhaps an early draft. The first version cited is more diplomatic than the second, for the second version contains comments that might be considered disparaging to the Air Matériel Command. Presumably, it was considered unwise for an official who was mediating between ARDC and AMC to appear to exhibit animosity toward one of the parties involved in the mediation.

change being exhibited by the Air Matériel Command.[2]

Perhaps the most convincing evidence of the continued existence of traditionalist thinking about Air Force R&D is a 6 October 1953 letter from General Thomas D. White, Vice Chief of Staff of the Air Force, to the ARDC Commander. In this letter General White stated:

> In order to secure improved balance and economy within the materiel area, including Research and Development, it has become apparent that realignment of Research and Development functions and organization within the Air Force is essential. After careful study and consideration of the problem of better integration of the efforts of the Air Force to secure weapons and supporting equipment and services of the highest possible quality at the least cost in money and time, it has been decided to assign responsibility for administration of Research and Development matters in Headquarters USAF to the DCS/M, in addition to the materiel functions for which he now has responsibility. The DCS/D will continue to have responsibility for research and initial phases of development in the Air Force. He will report to and be responsible to the DCS/M for those functions.[3]

Under this policy, the Deputy Chief of Staff for Matériel essentially became the R&D czar for the Air Force, for in addition to authority over the DCS/D he was given authority to do the following:

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[2]Doolittle to Vandenberg, Memorandum, 20 Apr 51, pp. 3-4. For other statements about AMC resistance to the establishment of ARDC, see: Leighton I. Davis, Lieutenant General, USAF (Retired), Burbank, Cal., 26 April 1973, Interview Number 668 in the United States Air Force Oral History Program, Interview Conducted by Major Lyn R. Officer and Hugh Ahmann, pp. 39-40 (hereafter cited as Davis, Interview 668); Bernard A. Schriever, General, USAF (Retired), Washington, D.C., 20 June 1973, Interview Number 676 in the United States Air Force Oral history Program, Interview Conducted by Major Lyn R. Officer and Dr. James C. Hasdorff, pp. 22-23 (hereafter cited as Schriever, Interview 676); and infra, p. 179.

[3]General Thomas D. White, Vice Chief of Staff USAF, to Commander Air Research and Development Command, Subject: "Realignment of Research and Development Functions and Organization in the USAF," 6 October 1953, (Copy), p. 1.

A. Resolve conflicts involving function, missions, and organization within the materiel field, including Research and Development.

B. Direct the movement, assignment, or reassignment of personnel through normal command and staff channels, when and where he may deem such action essential to the discharge of his responsibilities.

C. Direct elimination, consolidation, or reassignment of functions and missions within the materiel field, including Research and Development, as required.

D. Review the adequacy of installations and facilities within ARDC and AMC, and initiate action to activate, deactivate, consolidate, or eliminate where considered necessary.[4]

In the face of this continuing traditionalism, leadership continued to play an important role in the process of change in the Air Force R&D program. In this case, the role was to provide as much protection as possible for the infant R&D organization.

An example of this effort to protect the research and development organization is the manner in which the second commander of the Air Research and Development Command was selected. The commander's name was Earle E. Partridge, and the man who played the most important role in his selection for the commander's job was James H. Doolittle.

Partridge and Doolittle were good friends who had served together in World War II, and they corresponded frequently.[5] In 1951,

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[4]Ibid. These policies remained in effect until August 1955 when General White, then Chief of Staff of the Air Force, restored the office of the Deputy Chief of Staff, Development, to its previous status as a separate Deputy Chief of Staff (U.S., Department of the Air Force, Analysis Division, Assistant for R&D Programming, DSC/ Research and Develoment, "Organizational Evolution of DCS/Research and Development: [1945-1964]," n.d., p. 5).

[5]Correspondence of General Earle E. Partridge, Air Force Archives, Maxwell Air Force Base, Alabama.

while Doolittle was serving as special assistant to General Vandenberg, Partridge was serving in the Far East as the Commander of the Fifth Air Force, the tactical element of the Air Force then engaged in the Korean War.[6]

In an April 1951 letter Doolittle informed General Partridge about his own duties as special adviser to General Vandenberg. He then asked Partridge when he was coming home and what job in the Air Force Partridge would like when he completed the tour he was serving at the time. Doolittle wrote, "This is all unofficial, but it might be possible for me to assist you in achieving your desires--provided I knew what they were."[7]

Partridge replied to Doolittle that his situation was such that he did not wish to return to the United States at that time. He did indicate to Doolittle that he disliked service in Washington and would "much prefer a command in preference to a staff job."[8]

About a week later Doolittle told Partridge that Major General "Slats" Schlatter who had played a key role in organizing the Air Research and Development Command and served as ARDC's first commander, had "been asked for another command job."

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[6]E[arle] E. Partridge to J[ames] H. Doolittle, 24 May 1951, Correspondence of General Earle E. Partridge, Air Force Archives, Maxwell Air Force Base, Alabama, p. 1 (hereafter cited as Partridge to Doolittle, 24 May 51), and R. Frank Futrell, "The Deeds: The Korean War," in Goldberg, History of the USAF, pp. 243-57.

[7]J[ames] H. Doolittle to E[arle] E. Partridge, 2 April 1951, Correspondence of General Earle E. Partridge, Air Force Archives, Maxwell Air Force Base, Alabama.

[8]Partridge to Doolittle, 24 May 51, p. 1.

> You, a smart cookie and the guy who has been using our equipment in actual combat for the past year, are in a better position than anyone else, from the point of view of actual experience, to speak for our quality requirements and therefore to replace Slats. Bill Craigie[9]--with his excellent technical background--will complement you perfectly.
>
> The going will not be smooth. A.M.C. is, naturally, opposed to losing part of their self-sufficiency and does not believe in the A.R.D.C. as set up. The aircraft industry looks, unfortunately and erroneously, at the new command as the first step in government taking over the aircraft industry, as an agency that will get research funds which could more effectively be spent by industry, and as an added and unnecessary complication in their contacts with government.
>
> Most of the A.R.D.C. people come from the A.M.C. and many retain their A.M.C. affiliations and are prejudiced against the whole plan.[10]
>
> You are going to have a fight on your hands. The C.G., A.R.D.C. does not have to be a profound technologist--though, of course, it would be ideal if he had technical knowledge along with the other necessary attributes--provided he has proper technical support. He must believe in research and development as a means to improve A.F. equipment. He must be an organizer, builder, administrator, and he must be a fighter. That is you.[11]

Partridge became the second commander of Air Research and Development Command on 24 June 1951 and served in that capacity until 20 June 1953.[12]

Doolittle's mention of Bill Craigie in his 29 May 1951 letter

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[9]Major General Laurence C. Craigie.

[10]For an example of what this meant, see: Davis, Interview 668, p. 40. Here Davis claimed Major General "Freddie" Dent who was in charge of the ARDC Engineering Division at Wright Field was fired for "playing footsie under the table" with AMC friends. Fred R. Dent, Jr., to E[arle] E. Partridge, 3 December 1951, Correspondence of General Earle E. Partridge, Air Force Archives, Maxwell Air Force Base, Alabama, 3 pp., pertains to this episode.

[11]J[ames] H. Doolittle to E[arle] E. Partridge, 29 May 1951, Correspondence of General Earle E. Partridge, Air Force Archives, Maxwell Air Force Base, Alabama, pp. 1-2.

[12]"AFSC's Leaders through the Years," Air Force Magazine, Annual Air Force Almanac Issue, LVII, No. 5 (May 1974), 69.

to Partridge brings to mind another Air Force leader who played an important role in the Air Force R&D program. Like Partridge, Major General Laurence C. Craigie possessed outstanding operational credentials. In October 1942 he became the first American military pilot to fly a jet plane.[13] During the Korean War he served as Vice Commander of the Far East Air Force and, along with Admiral C. Turner Joy, was a delegate to the Panmunjom armistice conference.[14] Upon completion of his duties in the Far East, Craigie became the Deputy Chief of Staff for Development near the beginning of 1952.[15]

Partridge and Craigie, with their ties to the operational Air Force, were strong leaders at a time when strong leadership was needed for the fledgling Air Research and Development Command and the Deputy Chief of Staff for Development. Although the boundaries of ARDC responsibilities on the research end of the R&D spectrum were reasonably well defined by the articulation of the "applied basic research image," the dividing line between production and development was unsettled, and it caused considerable contention between AMC and ARDC.

The nature of the conflict over this dividing line can be glimpsed in documents generated during the period following the

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[13]John C. Warren, "World War II, 1939-45: The War At Home," in Goldberg, History of the USAF, p. 93; Craigie, Interview 637, p. 26. Craigie's discussion of the flying of America's first jet aircraft extends from p. 26 to p. 30.

[14]U.S., Congress, House, Committee on Appropriations, Department of the Air Force Appropriations for 1953, Hearings before a subcommittee of the Committee on Appropriations. 82d Cong., 2d sess., 1952, p. 300 (heareafter cited as House Appropriations Committee, Hearings on DAF Appropriations for 1953).

[15]Ibid.; Sturm, USAF SAB, pp. 46, 135.

establishment of the ARDC and the DCS/D in 1950. In April 1951 Lieutenant General Kenneth B. Wolfe, Deputy Chief of Staff for Matériel, complained to General Saville about the manner in which R&D personnel had behaved during a 6 April 1951 meeting dealing with "accelerated service testing" which matériel representatives thought was no concern of R&D staff members. Although General Saville's staff had been informed previously that accelerated service testing was none of their concern, R&D staff members still attended the 6 April conference. Of this meeting General Wolfe wrote, less than a week later:

> . . . R&D personnel attended this meeting and endeavored to confuse the issue by irrelevant discussion of functions and responsibilities of ARDC by quibbling over interpretations of General Twining's letter dated 2 February 1951,[16] which clearly stated both AMC and ARDC responsibilities.[17]

Two months later, Wolfe and Saville retired from the Air Force.[18] According to an article in the Dayton Daily News, Wolfe's departure from the Air Force "was related to an intra-organizational dispute growing out of the recent separation of procurement and research and development."[19]

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[16]General N[athan] F. Twining, Vice Chief of Staff, USAF, to Commanding General Air Matériel Command and Commanding General Air Research and Development Command, Subject: "Organization for Research and Development in the USAF," 2 February 1951 (hereafter cited as Twining to Commanding Generals, AMC and ARDC, 2 Feb 51).

[17]Lieutenant General K[enneth] B. Wolfe, Memorandum to Major General Gordon P. Saville, 11 April 1951, p. 1 (Copy), in History of Separation of R&D from AMC, IV.

[18]Photostatic Copy of "Two Generals Said Retiring; Hint A.F. Row," Dayton Daily News, 11 Jun 1951, no page number, in History of Separation of R&D from AMC, IV.

[19]Ibid. When ARDC became a separate command responsible for R&D, the weapons procurement function remained with AMC. This was a compromise apparently designed to placate AMC (Schriever, Interview 676, pp. 22-23).

While the conflict between Wolfe and Saville is indicative of the difficulties surrounding the separation of R&D from the matériel function at Headquarters USAF level, the debate over responsibility for support engineering illustrates the difficulty of establishing a boundary between the matériel and R&D functions at the operating command level. There was more than one definition of support engineering given during the debate, yet the one that was used by General B. W. Chidlaw, AMC Commander, seems to have been widely accepted. According to Chidlaw, support engineering "is defined as that engineering service rendered to the Maintenance and Procurement Divisions of AMC in connection with the correction of Unsatisfactory Report conditions of in-service and in-production aircraft and equipment."[20]

After the decision was made to establish the Air Research and Development Command there were those who thought that the division between ARDC and AMC should be made in such a way that the research function would go to ARDC and development to AMC.[21] General Chidlaw was one of those who wished to separate the functions of ARDC and AMC

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[20]Lieutenant General B. W. Chidlaw, Commanding General, Air Matériel Command, to General Nathan F. Twining, Vice Chief of Staff, USAF, Subject: "Resources for AMC Support Engineering," 23 October 1950, p. 1 (Copy)(hereafter cited as Chidlaw to Twining, 23 Oct 50), in History of Separation of R&D from AMC, IV. Twining used a similar definition for "AMC Engineering Responsibility" which he said was "all engineering and testing applicable to a production item and other modification of equipment in service use" (Twining to Commanding Generals, AMC and ARDC, 2 Feb 51, p. 1).

[21]Doolittle to Vandenberg, Memorandum, 20 Apr 51, p. 10, and Transcript of "Conference Held in Engineering Division Control Room, 12 January 1951, for Discussion of Relationship between Air Materiel Command and Air Research and Development Command," p. 3 (hereafter cited as Transcript of 12 Jan 51 Conference), in History of Separation of R&D from AMC, IV.

along this line between research and development.[22] If General Vandenberg agreed, Chidlaw "would like to see the line of demarcation drawn at the research end of the spectrum and that the division of assets and responsibilities be made at that point."[23]

This proposal was opposed by Major General David M. Schlatter, Commanding General of ARDC. According to Schlatter: "If we confine it [ARDC] to scientists only, it doesn't warrant the dignity of being a command."[24] General Putt, the Director of Research and Development under the Headquarters Deputy Chief of Staff for Development, supported Schlatter.[25]

Putt would not even accept the counter-proposal of Chidlaw that his command be allowed to establish a support engineering organization with sufficient resources to allow AMC to perform the engineering duties Chidlaw thought belonged to AMC. Putt criticized such terms as "support engineering" and "in-service engineering" as being confusing. For Putt, improvement of an aircraft and design deficiency correction were developmental functions. Putt thought that the cut-off point for research and development should be the point at which an item had been developed sufficiently to render production feasible. All research and all development up to this point belonged under the Air Research and Development Command.[26]

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[22]Transcript of 12 Jan 51 Conference, p. 3.

[23]Ibid., p. 7.

[24]Ibid., p. 3.

[25]Ibid., pp. 4, 8.

[26]Ibid., pp. 4-6, 8.

But in spite of the opposition of Doolittle, Putt, and others, AMC leaders for the moment seemed to carry the day. On 2 February 1951 General Nathan F. Twining, Vice Chief of Staff of the Air Force, directed a letter to the Commanding Generals of AMC and ARDC. According to Twining, the division of functions and responsibilities between the two commands would be established as follows:

> Responsibilities--The following definitions for Research, Development, and AMC Engineering Responsibility will be accepted as a base line of departure.
>
> Research--Theoretical analysis, exploration, and experimentation directed to the increase of knowledge and with it the power to control phenomena, but without completely defined goals.
>
> Development--The Extension of the investigative findings and theories of a scientific or technical nature into practical application for experimental or demonstration purposes including the construction and testing of experimental models or devices, but excluding operation and service tests.
>
> AMC Engineering Responsibility--All engineering and testing applicable to a production item and other modification of equipment in service use.[27]

Twining's letter granted authority to AMC to fund and to man an organization to carry out its engineering responsibilities.[28]

However, Twining's letter was not to be the final word on the matter of the dividing line between AMC and ARDC. Here, obviously, was a point of disagreement between ARDC and AMC; and, as we have seen,[29] in February 1951 James H. Doolittle was appointed special assistant to General Vandenberg to resolve disputes between these two commands.[30]

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[27]Twining to Commanding Generals, AMC and ARDC, 2 Feb 51, p. 1.

[28]Ibid.

[29]Supra, p. 171.

[30]Although the supporting document cited on p. 171 above

In a 5 March 1951 letter to General Partridge, Doolittle wrote the following about his assignment as Vandenberg's special assistant:

> My present job is to supervise the separation of the Siamese twins (Supply, Maintenance and Procurement on the one side, Research and Development on the other, with the cut taking place somewhere in the Engineering area which lies between) and see that neither patient dies. Putting it a little simpler, I am responsible for setting up a sound Research and Development establishment to look into the future and, at the same time, assure minimum interference with the solution of our day to day problems. This is going to require a neat piece of tightrope walking. Can't do it and keep everybody in love with Doolittle.[31]

Doolittle officially stated his views on the matter of the division of responsibilities between ARDC and AMC in his memorandum of 20 April 1951 to General Vandenberg. After noting that an artificial separation between development and engineering had been attempted, Doolittle wrote:

> Actually, research, development, and engineering cannot be wisely or soundly separated. Development is a function which runs continuously from the concept of an idea to the obsoleting and abandoning of the process or product that resulted from the idea. Frequently, as with the B-17 for example, by far the greater part of development takes place after an airplane is in actual service.[32]

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concerning Doolittle's appointment is dated 28 March 1951, I have seen a copy of a personal message from Vandenberg to Chidlaw, dated 15 February 1951, informing Chidlaw of Doolittle's appointment ([Hoyt S.] Vandenberg to [B. W.] Chidlaw, personal telegraphic message, 15 February 1951, (Copy), in History of Separation of R&D from AMC, IV).

[31] J[ames] H. Doolittle to E[arle] E. Partridge, 5 March 1951, Correspondence of General Earle E. Partridge, Air Force Archives, Maxwell Air Force Base, Alabama, p. 1.

[32] Doolittle to Vandenberg, 20 Apr 51, p. 10. The B-17 was a four-engined bomber aircraft used extensively in the European theater during World War II. The aircraft was manufactured by the Boeing Aircraft Corporation.

Concerning the establishment of an engineering organization by AMC, Doolittle remarked:

> With the establishment of ARDC, the creation of a new AMC Directorate of Production and Service Engineering is a step in the wrong direction. It is wasteful of personnel and will serve only to prolong the existence of the present unsatisfactory situation.[33]

Doolittle had agreed with General Twining when he decided to assign AMC responsibility for "'all engineering and testing applicable to a production item and other modification of equipment in service use."[34] But further study had convinced Doolittle that this decision was wrong; all engineering, including AMC's Production and Service Engineering should be turned over to ARDC. AMC should be left with strictly maintenance and procurement responsibilities.[35] The result, according to Doolittle, would be that "ARDC now becomes the one USAF research and development agency, whereas AMC remains the one USAF production and maintenance organization."[36]

AMC's February victory did not last long. By 28 March 1951 the engineering question was beginning to be decided in favor of ARDC. On that day General Vandenberg directed that all "facilities, installations, buildings and personnel under the control of the Director of Research and Development, Air Matériel Command, as of 2 February 1951" be transferred to ARDC. He also directed ARDC to "provide on a

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[33]Ibid.

[34]Ibid. Doolittle has quoted from Twining's 2 February 1951 letter. See p. 184 above.

[35]Doolittle to Vandenberg, 20 Apr 51, pp. 10-11.

[36]Doolittle to Vandenberg, [20 Apr 51], p. 9.

continuing basis such engineering, laboratory, and testing services as are required by Air Materiel Command in support of the AMC programs for materiel in production and in service."[37]

A 16 July 1951 letter from General Twining shows that AMC's efforts to establish an engineering role and organization for itself had failed. Twining stated that the assignment of engineering responsibility to AMC had been a temporary expedient until a thorough study of the situation could be completed. Having finished the study, Headquarters USAF issued Air Force Regulations 23-2 and 23-8, both dated 22 May 1951, which established "the responsibilities of ARDC and AMC. These two documents state the ultimate goal of this Headquarters in connection with the establishment of ARDC." These directives were to be used as a guide for the implementation of the instruction in Twining's letter of 16 July and to resolve "ARDC-AMC organizational problems."[38]

Air Force Regulation 23-8 stated that the mission of the Air Research and Development Command was:

> A. To attain and maintain qualitative superiority of materiel and to conduct or supervise scientific and technical studies required for the accomplishment of the Air Force missions.

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[37]General Hoyt S. Vandenberg, Chief of Staff, USAF, to Commanding General Air Matériel Command and Commanding General Air Research and Development Command, Subject: "Organization for Research and Development in the USAF," 28 March 1951, p. 1 (Copy), in History of Separation of R&D from AMC, IV.

[38]General N[athan] F. Twining, Vice Chief of Staff, USAF, to Commanding General, Air Matériel Command, and Commanding General, Air Research and Development Command, Subject: "Organization for Research and Development in the USAF," 16 July 1951, p. 1 (hereafter cited as Twining to Commanding Generals, AMC and ARDC, 16 Jul 51), in History of Separation of R&D from AMC, IV.

B. To seek new basic knowledge from which improved aeronautical equipment, materiel, weapons, and techniques can be developed.

C. To undertake the development and recommend the adoption of appropriate new and improved devices and systems for the conduct and support of air warfare including aircraft, missiles, weapons, techniques, and procedures applicable to Air Force purposes.[39]

And Air Force Regulation 23-2 established the mission of the Air Matériel Command:

A. To provide adequate and efficient systems of procurement, production, maintenance, and supply for the United States Air Force.

B. To provide general over-all logistical support for all activities and agencies of the United States Air Force.

C. To train specialized units for the accomplishment of specified logistic functions in the oversea areas and theaters.[40]

The "Concepts and Principles" section of both regulations are very similar and in some places contain identical paragraphs. Both regulations contain the same paragraphs describing the logistics and the R&D functions. Of research and development, AFR 23-8 states:

There is a continuing responsibility throughout the Air Force for maintaining and improving the functional quality of materiel during its life, from the inception of design to the phase-out of the resulting item from inventory. The responsibility for implementing this function is assigned to the Air Research and Development command.[41]

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[39]U.S., Department of the Air Force, Air Force Regulation 23-8, "Organization--Air Commands and Air Forces: Air Research and Development Command," Washington, D.C., 22 May 1951, p. 1 (hereafter cited as AFR 23-8, 22 May 51).

[40]U.S., Department of the Air Force, Air Force Regulation 23-2, "Organization--Air Commands and Air Forces: Air Materiel Command," Washington, D.C., 22 May 1951, p. 1 (hereafter cited as AFR 23-2, 22 May 51).

[41]AFR 23-8, 22 May 51, p. 1. See also: AFR 23-2, 22 May 51, p. 1.

Concerning the logistics function, AFR 23-2 states:

> There is a continuing responsibility throughout the Air Force for the logistics function including procurement, production, maintenance, and supply. This function includes checking new designs from the standpoint of producibility and ease of maintenance, producing materiel in accordance with qualitative specifications, and meeting quantitative requirements, routine quality control of materiel in quantity production, and maintenance of materiel in service use. The responsibility for implementing this function is assigned to the Air Materiel Command.[42]

Both regulations also call for "continuous and active collaboration, cooperation, and coordination among representatives of the interdependent development, logistic, and operational agencies" which include ARDC, AMC, the Air Proving Ground, and other major air commands "to insure the maximum effective use of Air Force materiel, equipment, facilities, and services."[43]

In these two regulations, then, we see the institutionalization of the thoughts General Doolittle had expressed in his 20 April 1951 memorandum to Vandenberg. Research and development was to include everything from the original idea, through the technical development of an item of equipment, to the actual production of the equipment. The process of maintaining and improving the quality of the equipment throughout its lifetime would be an R&D function also.

Within this concept of R&D there was no justification for the creation of a support engineering branch in the Air Matériel Command. Such support would be provided by ARDC. As General Twining stated in

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[42]AFR 23-2, 22 May 51, p. 1. See also: AFR 23-8, 22 May 51, p. 1.

[43]AFR 23-2, 22 May 51, p. 1. See also: AFR 23-8, 22 May 51, p. 1.

his 16 July 1951 letter: "ARDC must give first priority to providing AMC with engineering services required to insure continued maximum effectiveness of the force-in-being and maximum flow of equipment now in quantity production."[44]

Twining's letter called for a phased assumption of ARDC responsibility for the quality of Air Force equipment. There was to be no "abrupt change in the responsibilities of the Air Materiel Command" with regard to equipment that was already in the hands of Air Force units, in the quantity-production stage, or in the service test stage.[45] General Twining's description of the results of this phased process seems to have come right out of Doolittle's 20 April 1951 memorandum. Twining's words in this case were:

> Thus, as a new cycle of equipment replaces the materiel now in operational units, ARDC will become the one USAF research and development agency, whereas AMC will remain the one USAF production and maintenance organization.[46]

The result of the years of discussion of what research and development involved seems to have produced an image in which everything from the support of basic research, if not the actual carrying out of basic research, to the modification of a production item was included under the rubric of research and development.

In August 1951 the Air Force published a regulation, AFR 80-13, designed to purge conflicting terms from the language used to discuss

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[44]Twining to Commanding Generals, AMC and ARDC, 16 Jul 51, p. 2.

[45]Ibid., p. 1.

[46]Ibid., p. 2.

R&D.[47] Although this directive provided definitions of basic research, applied research, and development, its general discussion of R&D noted that there were problems in trying to separate and classify the components of research and development. This discussion summarized the point to which Air Force thinking about R&D had come by 1951 and is worth quoting at length.

> Sharply delineated areas which correspond to the commonly understood meanings of the terms research, development, production engineering, maintenance engineering, and service testing cannot be marked out. The development process is a continuous one which extends from the inception of an idea, through its embodiement in a product or process, to the final obsoleting and abandonment of the process or product resulting from the idea. Thus, not only activities identifiable as research but also activities commonly referred to as "engineering" are encompassed in the customary definition of development. It is more convenient for the present purpose to draw a distinction between those activities which have a bearing on the qualitative performance of Air Force materiel and those activities concerned with the quantitative or logistic problems connected with Air Force materiel. The former class of activities will be here defined and hereafter identified as development, even though much of the work involved is commonly referred to as "engineering"; the latter class of technical activities, that is, those which affect logistic problems, will be identified as production engineering and maintenance engineering. The distinction between activities which affect quality of materiel and activities which affect quantity of materiel is important in the present connection, because it is this distinction which determines whether primary responsibility shall rest with research and development agencies or with logistic agencies.[48]

In August 1952 the Air Research and Development Command published a guide for contractors which adhered to the R&D doctrine

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[47] U.S., Department of the Air Force, Air Force Regulation 80-13, "Research and Development: Definitions of Research, Development, Production Engineering, Maintenance Engineering, and Service Testing," Washington, D.C., 7 August 1951, p. 1 (hereafter cited as AFR 80-13, 7 Aug 51). On page two of this regulation one reads: "Terms, phrases, and usages in conflict with those above will be eliminated from Air Force Terminology."

[48] Ibid., p. 1.

pronounced in AFR 80-13. This guide depicted the ARDC mission as being threefold: to seek new basic knowledge, to develop "new and improved devices, processes, and techniques," and to "maintain qualitative superiority of materiel."[49] In carrying out its mission, the "Air Research and Development Command procures Basic Research, Applied Research and Development."[50]

What the procurement of these things meant can be seen by looking at the definitions for basic research, applied research, and development that are contained in the guide. Basic research was defined as:

> Fundamental, theoretical, or experimental investigation to increase man's knowledge and understanding of the natural world. Immediate application is not a direct objective of the investigation.[51]

The ARDC guide for contractors defined applied research as:

> The application of the results of basic research to accomplish specific objectives. It includes the systematic survey of a field of research in order to discern and support application to the design of specific devices.[52]

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[49]U.S., Department of the Air Force, Air Research and Development Command, "Research and Development in the United States Air Force," August 1952, p. 4 (hereafter cited as USAF ARDC, "R&D in the USAF," Aug 52).

[50]Ibid., p. 6.

[51]Ibid., p. 8. U.S., Department of the Air Force, Air Research and Development Command, "Research and Development in the United States Air Force," September 1957, p. 7 (hereafter cited as USAF ARDC, "R&D in the USAF," Sept 57), provides a definition of research that is what I call the applied basic research image. "Fundamental investigation of all activities wherein the discovery of applications of interest to the Air Force may be expected. It includes theoretical analysis, exploration and experimentation directed to the increase of knowledge and with it the ability to utilize that knowledge."

[52]USAF ARDC, "R&D in the USAF," Aug 52, p. 10.

And finally, according to this guide, development was

> The extension of the investigative findings and theories of a scientific nature into practical application, including the construction and testing of prototype models or devices, and such design changes affecting qualitative performance as may be required during the service life of any item.[53]

The guide for contractors was designed to explain the functioning of ARDC so that those contractors interested in participating in the Air Force research and development program would know how to establish contact with the Command.[54] As such it represents one of ARDC's efforts to fulfill its responsibilities to provide the Air Force with what was needed to produce superior equipment--an R&D program that included everything from the basic search for new knowledge to the modification of operating equipment.

Defining the limits of research and development was not the only problem the R&D enterprise posed for Air Force leaders. As was previously noted,[55] the Ridenour and Air University Committees advised the Air Force that special management policies were needed for research and development. This advice offers an interesting contrast with the image of R&D which held that at least the basic research portion of research and development was unmanageable.[56] Would even special policies make it possible to really manage R&D?

The debate over this question extended outside the Air Force and

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[53] Ibid.

[54] Ibid., p. 1.

[55] Supra, pp. 130-31.

[56] Supra, pp. 95-97.

goes beyond the time limits of this study. But at least some Air Force leaders thought they could manage research and development, and in December 1952 they published their rules for managing the unmanageable in Air Research and Development Command Manual (ARDCM) 80-4. Here they stated:

> It is axiomatic that research and development workers must have some authority and freedom, and that the various levels of management must manage. The Manual [80-4] proposes to reconcile this conflict. . . . First, it provides for the organization of research and development work; then it establishes the tools for the coordinated planning, scheduling, and approval of that work and the necessary resources to accomplish it. This approval effects the release of authority to all concerned to act freely and decisively within the limits of the approved plan. Responsible individuals and agencies assume first the responsibility of completing their jobs on time and within the plan; and second, the responsibility of informing and assuring the higher levels that their first responsibility is being discharged. The higher levels will lend the necessary support to all aspects of the plan. They will moreover focus their management interests on deviations from the approved plan; on evaluation; and on developing new plans, policies, and programs.[57]

But saying you are going to do something does not necessarily mean that you will or can do that thing. There are indications that research and development management may not have been as simple as the quotation from ARDCM 80-4 would have one believe.

Armed Forces Management is a journal "designed to interchange the latest techniques and developments in the management field between industry and the Armed Forces." As such it examined "all phases of

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[57]U.S., Department of the Air Force, Air Research and Development Command, Air Research and Development Command Manual 80-4, Headquarters Air Research and Development Command, Baltimore, Maryland, 1 December 1952, p. 4 (hereafter cited as ARDCM 80-4, 1 Dec 52).

management" and analyzed "their application to the services."[58]

In December 1956 an article by E. R. Rechel, Director of Chemical Research at the Frankford Arsenal, appeared in Armed Forces Management. Apparently, the matter of whether or not research could be managed was still being debated, for Rechel took as his thesis "management principles do apply to scientific research."[59] The moment of creation which was a highly personal experience formed the basis for the claim that research could not be managed. But Rechel claimed that creation constituted a minor part, time-wise, of the research process and that most of the process could be broken down into six common activities that could be used by managers to check the progress of a research project.[60]

Another article in Armed Forces Management, this one an interview with Clifton T. Foss, an electrical engineer and R&D executive, indicates that the management of research and development was still something new as late as April 1957. Foss stated: "Most of us were inclined to say that research would reach a given point at some accidental time just depending upon luck and success and one thing and another."[61] But, Foss said, "we have gone to pretty rigidly scheduling both the time and cost of research. . . . Today we do schedule

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[58]Advertisement of Armed Forces Management, Armed Forces Management, II, No. 12 (September 1956), 47.

[59]E. C. Rechel, "Why Science Needs Modern Management Principles," Armed Forces Management, III, No. 3 (December 1956), 20 (hereafter cited as Rechel, "Why Science Needs Management").

[60]Ibid., pp. 20-21, 23.

[61]"Research--Alternate Approach," An Interview with Clifton T. Foss, Armed Forces Management, III, No. 7 (April 1957), 24.

research. And, we schedule development."[62]

In an October 1958 article Marvin E. Mundel, Vice Director of the Management Center of Marquette University, argued that the failure to recognize the similarities and differences between management of production and management of research was the cause of the "conflict between managers of the establishment (and their staffs) and the research groups." In those areas where production and research were similar "the usual management engineering techniques could be applied with their usual extreme usefulness and economy." And there were more of these manageable areas than is frequently admitted.[63]

Although much more evidence could be educed to support the argument that the management of research and development and the principles of this management remained unsettled even into the Sixties, we shall examine only one other example illustrating the fluctuating state of Air Force R&D management practices after 1950.[64] It was about the

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[62]Ibid.

[63]Marvin E. Mundel, "Military R&D . . . How to Make It More Effective," Armed Forces Management, V, No. 1 (October 1958), 21.

[64]See, for example, George Davies, "'Inventiveness' Needs Managing," Armed Forces Management, VIII, No. 4 (January 1962), 39-41; "New Controls Planned for R&D," Armed Forces Management, VIII, No. 10 (July 1962), 29, 32, 34; W[illiam] M. Capron, The Klystron Story: A Case Study in Research and Development, U.S. Air Force Project RAND Research Memorandum (Santa Monica, Cal.: The RAND Corporation, 22 May 1956; withdrawn from RAND's active inventory); Burton Klein and William Capron, Suggestions for Maintaining the Technological Superiority of the Air Force: Special Memorandum (Santa Monica, Cal.: The RAND Corporation, 22 February 1957), see especially pp. v, vii (here is a specific criticism of ARDCM 80-4), 51, 56-57; and Stever Report, especially pp. 2-7, 12-14.

time that the DCS/D and ARDC were established that the "systems management" concept began to have a noticeable effect upon how Air Force leaders thought about research and development.

The systems management concept was explained in 1960 by Air Force Regulation 375-1. According to this directive, the existing management structure of the Air Force centered around functional groupings of responsibilities that were based on the type of work an organization performed. The types of work included such things as planning, operational activities, R&D, maintenance and supply, and personnel. Systems management, according to this regulation,

> is the process of organizing and employing functional agencies to accomplish approved systems program objectives. Systems management affords formal recognition of the character of today's complicated and long lead time systems.[65]

The systems management concept sought to accomplish the integration of the various agencies involved in producing a "system." The system itself was composed of the equipment, personnel, techniques, etc., needed to perform a particular task.[66] An example of a system is the

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[65]U.S., Department of the Air Force, Air Force Regulation 375-1, "Systems Management: Weapon/Support Systems Management," Washington, D.C., 31 August 1960, p. 1 (hereafter cited as AFR 375-1, 31 Aug 60).

[66]Ibid., pp. 1, 3. For excellent discussions of what comprises a system, see: D[onald] L. Putt, "The Systems Approach to Air Weapons Development," "Preprint" of Address Prepared for Presentation at the Annual Meeting of the Society of Automotive Engineers, Detroit, Michigan, 12-16 January 1953, p. 2 (hereafter cited as Putt, "Systems Approach"); and T. G. Belden, "R&D Management: Systems Concept," USAF Research and Development Quarterly Review, 4th Quarter FY 1953, 30 June 1953, p. 130 (hereafter cited as Belden, "Systems Concept"). Belden defined system as "an integration of components and techniques to satisfy a military operational requirement." Belden also wrote: "a weapon system is made up of aerodynamic and propulsion systems, an armament system, and so on through all the components and techniques necessary for the particular weapon system to accomplish its military requirement" (p. 131).

MINUTEMAN missile system which is composed of such things as the missile, the ground support equipment, and the trained crews.

Military men began to think about equipment in terms of systems as early as World War II, when the differences between systems and components were first clearly recognized.[67] There is evidence that this mode of thought began to have a significant influence on Air Force thinking about the management of research and development as early as 1951. In April of that year at the direction of the Vice Chief of Staff, USAF, the Deputy Chief of Staff for Development prepared a staff study titled "Combat Ready Aircraft: How Better Management Can Improve the Combat Readiness of the Air Force."[68] The individual who seems to have been most responsible for the preparation of this study was Colonel Bernard Adolph Schriever.[69]

Schriever's report noted that one of the greatest weaknesses in past Air Force efforts to secure combat-ready aircraft was the inability to recognize the operational, technical, and logistical functions and provide for their proper execution in the process of producing the

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[67]Ridenour Report, p. IX-I.

[68]U.S., Department of the Air Force, Deputy Chief of Staff for Development, Headquarters USAF, "Combat Ready Aircraft: How Better Management Can Improve the Combat Readiness of the Air Force," A Special Report Based on an Air Force Study Completed April 1951, Washington, D.C. (hereafter cited as USAF DCS/D, "Combat Ready Aircraft").

[69]J[ames] H. Doolittle to E[arle] E. Partridge, 15 November 1951, Correspondence of General Earle E. Partridge, Air Force Archives, Maxwell Air Force Base, Alabama, p. 1 (Copy) (hereafter cited as Doolittle to Partridge, 15 Nov 51). For a biographical sketch of General Schriever, see: "Pentagon Profile: Lt. Gen. Bernard A. Schriever," Armed Forces Management, VII, No. 5 (February 1961), 31-32.

combat-ready aircraft.[70] There are valid technological, logistical, and operational interests involved in each phase of the production of a combat-ready aircraft; these interests must be protected and balanced constantly throughout the process of creating a weapon system.[71] Among the recommendations of the Schriever study was the following:

> Internal development and procurement organizations within the Air Force must incorporate a management level with responsibility and authority to plan, budget, and control development and procurement activity in terms of complete weapons systems. Such a management component must exist above the operating laboratory and technical division level of activity in order to exert adequate control. This management function must exist at all appropriate levels within the development and procurement families to prevent competition for funds, personnel, and facilities between sub-agencies, particularly within Development, whose concern is with parts rather than with the whole. . . .
>
> Weapons system control--as a management tool--will better gear the development and procurement agencies to fulfill the conditions required for Combat Readiness of weapons systems.[72]

General Doolittle was impressed with Schriever's study and considered the implementation of systems management procedures important for achieving an effective Air Force R&D program. He wrote to General Partridge that he was "most concerned" about several things. One of these was "the rapid implementation of effective procedures for systems management of our R&D program, together with a program to get a suitable number of top-notch project engineers for ARDC." Another item of major concern to Doolittle was "the attainment of the objectives outlined in Colonel B. A. Schriever's study on Development and Procurement of Combat

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[70] USAF DCS/D, "Combat Ready Aircraft," p. 1.

[71] Ibid., pp. 12, 21-22.

[72] Ibid., p. 23.

Ready Aircraft."[73] Toward the end of 1951, Doolittle directed that Colonel Schriever be scheduled to brief two meetings: one was a gathering of personnel from ARDC and the Office of the Deputy Chief of Staff for Development, and the other was a conference of ARDC and AMC personnel.[74]

In early 1953 General Donald L. Putt explained how systems management worked in the Air Force. In an address prepared for the annual meeting of the Society of Automotive Engineers Putt said that the key to the process was the creation of a Development Planning Objective by the Assistant for Development Planning in the office of the Deputy Chief of Staff for Development.[75] This document "expresses in rather broad terms the development objectives for a . . . weapons system" and may cover a ten to twenty year period. After approval by the Chief of Staff, a Development Planning Objective becomes "a guide for the formulation of . . . General Operational Requirements" by the Director of Requirements in USAF Headquarters. The Operational

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[73]Doolittle to Partridge, 15 Nov 51, p. 1. For a glimpse of the activity surrounding adoption of systems management techniques by ARDC, see: Major General L[aurence] C. Craigie, Deputy Chief of Staff for Development to Lieutenant General E[arle] E. Partridge, Commanding General of the Air Research and Development Command, 17 March 1952; and Colonel E. Godfrey, ARDC Deputy for Comptroller, Memorandum for General Partridge, 19 March 1952. Both documents are in the General Partridge Correspondence at Maxwell Air Force Base, Alabama.

[74]Doolittle to Partridge, 15 Nov 51, pp. 1-2; and J[ames] H. Doolittle, Special Assistant to the USAF Chief of Staff, to Commanding General Air Research and Development Command and Commanding General Air Matériel Command, Subject: "Briefings on Various Aspects of ARDC-AMC Relationships," 15 November 1951, Correspondence of General Earle E. Partridge, Air Force Archives, Maxwell Air Force Base, Alabama, p. 2.

[75]Putt, "Systems Approach," p. 3.

Requirements document divides the weapons system into subsystems such as navigational systems, bombing systems, etc., and is sent to the Directorate of R&D, DCS/D. Here the various tasks necessary to meet the requirements are written into development directives which are sent to the Air Research and Development Command. At ARDC the work necessary to perform the various tasks is planned and the work assigned to the various research, development, and test centers of ARDC.[76]

Once the system is broken down into the work required to produce the system, and the work is assigned to all the centers for completion, the creation of the system becomes a management problem to see that "a complete weapons system will be developed and ready for combat at the proper time." This is accomplished in the office of the Deputy Chief of Staff for Development and in the Air Research and Development Command by having agencies in both organizations that are responsible for the development of specific system types such as strategic air systems, tactical air systems, and other major air weapons systems.[77]

From Doolittle's view of Schriever's "Development of Combat Ready Aircraft" and Putt's discussion of systems management in the Air Force, it appears that Schriever was one of the leading Air Force proponents of systems management. Schriever achieved extensive prestige and considerable fame as the "principal military architect" of America's

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[76] Ibid., p. 4.

[77] Ibid., p. 5. For a similar discussion of systems management, see: Donald L. Putt, "Air Weapons Development Systems," Army Information Digest, VIII, No. 8 (August 1953), 8-13, (hereafter cited as Putt, "Air Weapons Development Systems").

ICBM forces during the late Fifties.[78] While the power and prestige of Schriever were rising, so, it appears, was the influence of systems management. Organizational changes are not always convincing evidence of the importance of a particular policy, nor are isolated administrative pronouncements, but taken together they sometimes become straws in the wind. Such was the case with the weapon system concept. In 1955 "development and implementation of the weapon system concept" was "one of the most critical of ARDC functions." And in August of that year a Deputy Command for Weapon Systems was established in ARDC headquarters. This office contained the Directorate of Systems Management.[79] In December there appeared an article by Lieutenant General Thomas S. Power, in Armed Forces Management. Said Power bluntly, "air research and development is built around what is known as the 'weapon system' concept."[80]

Less than three and a half years later, in April 1959, General Schriever was named the Commander of the Air Research and Development

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[78]U.S., Congress, Senate, Senator Henry M. Jackson speaking on the retirement of General Bernard A. Schriever, 89th Cong., 2d sess., 29 August 1966, Congressional Record, CXII, Pt. 16, 21115 (Jackson's comments extend onto p. 21116). See also: U.S., Congress, Senate, Senator John Stennis speaking on the retirement of General Bernard A. Schriever, 89th Cong., 2d sess., 29 August 1966, Congressional Record, CXII, Pt. 16, 21060 (Stennis' remarks extend to p. 21061). Stennis said Schriever had played a "primary and decisive role" in the development of the ICBM.

[79]"Organization: Headquarters ARDC Organizational Adjustments," USAF Research and Development Quarterly Review, 1st Quarter FY 1956, 30 September 1955, p. 36.

[80]Thomas S. Power, "Managing the Air Force Research and Development Program," Armed Forces Management, II, No. 3 (December 1955), 6. Power's article contains an indication of the influence of Schriever's 1951 report; see p. 8.

Command. On 1 April 1961, following a two-year study of systems management by the Air Force, the Air Research and Development Command officially became the Air Force Systems Command; thenceforth, ARDC was to be known as AFSC. General Schriever played a key role in this reorganization.[81] The result of the change was that the Air Force "concentrated all development and procurement of systems--space, aeronautical, electronic, and ballistic--in a single new command, AFSC."[82] The mission of this new command made it responsible for the R&D, testing, production, and procurement that were necessary to produce an operational aerospace system.[83]

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[81]"Air Force Systems Command," Air Force and Space Digest: The Magazine of Aerospace Power, Annual Air Force Almanac Issue--1962, XLV, No. 9 (September 1962), 160 (hereafter cited as "AFSC," Air Force, Sept 62); Schriever, Interview 676, pp. 23-26; and "Air Force Systems Command," Air Force and Space Digest: The Magazine of Aerospace Power, Annual Air Force Almanac Issue--1961, XLIV, No. 9 (September 1961), 158 (hereafter cited as "AFSC," Air Force, Sept 61). In the interview, Schriever claimed the reorganization was inspired by an offer from Under Secretary of Defense Roswell Gilpatric to assign responsibility for missile development to the Air Force if the Air Force would correct the problems that centered around the relationship between AMC and ARDC. Schriever at least implied that his personal contact with Gilpatric was important in bringing about the Department of Defense offer. Since Schriever favored the creation of an AFSC-type organization earlier, but was meeting with stiff opposition from other Air Force leaders, it may be that he "back-doored" them through his contact with Gilpatric. Several other sources relate the changes in the Air Force organization to the rising importance of missiles. See: Bernard A. Schriever, "The Operational Urgency of R&D," Air University Quarterly Review, XII, Nos. 3 & 4 (Winter and Spring, 1960-61), 233 (hereafter cited as Schriever, "Operational Urgency of R&D"); and Claude Witze, "Organizing for the Space Age," Air Force and Space Digest: The Magazine of Aerospace Power, XLIV, No. 4 (April 1961), 39.

[82]"AFSC," Air Force, Sept 61, p. 158.

[83]"AFSC," Air Force, Sept 62, p. 160.

Although responsible for research required to produce aerospace systems, the Air Force Systems Command was no longer in charge of the Air Force basic research program. The applied research, or initial development, portion of the AFSC mission and the advanced technology portion of its mission were still handled by the Air Force Systems Command in its Research and Technology Division.[84] But the "research elements of the ARDC" were taken over in 1961 by a new Office of Aerospace Research (OAR), a separate agency, that reported directly to the Chief of Staff of the Air Force. OAR was to function as a major air command.[85]

This change in Air Force organization was in part inspired by a new view of the relationship between the various stages in the creation, production, and use of a weapons system. There were, according to one account, seven stages in the process of acquiring a weapons system: basic research; applied research; advanced development; system research, development, test, and engineering; system production; operational use; and obsolescence. ARDC had been responsible for the first four of these stages, while AMC had been responsible for the fifth one, and the using commands for the last two. After the 1961 reorganization, the Office of Aerospace Research assumed responsibility for basic research, and the Air Force Systems Command became responsible for: applied research; advanced development; system research, development, test, and engineering; and system production.[86]

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[84] Ibid. p. 165.

[85] "Air Force Functions Shifted," Armed Forces Management, VII, No. 8 (May 1961), 17.

[86] Ibid., p. 18.

This was not the final refinement, of course, of Air Force thought on so appealingly intricate and debatable a subject as the management of research and development. Nearly a decade later, on 1 July 1970, the Office of Aerospace Research was merged back into the Air Force Systems Command. AFSC was once again made responsible "for the full range of Air Force research, development, test, and evaluation" that had once been intended for ARDC (AFSC's predecessor).[87] Under the Systems Command, the Office of Aerospace Research became the Air Force Office of Scientific Research.[88]

Through these vicissitudes of Air Force organization and reorganization of its research and development activity and the debate over suitable management principles for R&D, one feature seems to have remained fairly constant following 1950: the importance attached to research and development by the Air Force. Increasingly, after the Soviet explosion of an atomic bomb in 1949, the United States seemed to have come to visualize itself as engaged in a crucial technological race or "war" with the Soviet Union.

The Soviet nuclear explosion was followed by a sequence of Russian technical achievements that seemed to evoke closer American scrutiny of the quality of the Air Force R&D program. One such achievement was the development of a truly impressive jet fighter, the MIG-15. This airplane challenged American control of the air over Korea, during the early Fifties. Good fortune, rather than shrewd anticipation and

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[87]"A Major Command: AFSC--A Step Ahead of History," Air Force and Space Digest, LV, No. 5 (May 1972), 81.

[88]Ibid.

deliberate providence, was a key element in the process that made available an American fighter aircraft, the North American F-86 "Sabre Jet," which could meet the challenge of the MIG.

As originally designed in May 1945 the F-86 was to be a straight-wing fighter aircraft. Serendipitously, a team of technical personnel sent to Germany in the spring of 1945 returned to the United States with captured German data on the swept-wing airfoil concept. Based largely on the high-speed performance advantage indicated by the German data, the decision was taken to convert the F-86 from a straight-wing configuration to the sweptback-wing configuration the Germans had used on "the full-swept version of the ME-262."[89] At high speeds the swept wing has the unique property of yielding a higher lift-to-drag ratio than does a comparable straight wing. The employment of swept wings was an important factor in achieving high speed in both the MIG-15 and the F-86.[90]

In aerial combat during the Korean War, American F-86's destroyed eleven MIG's for every one F-86 lost.[91] The success of the Sabre was frequently mentioned in discussions of Air Force research and development.[92] Of this episode Theodore von Kármán wrote:

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[89]T[eddy] F. Walkowicz, "Birth of Sweepback," Air Force: The Official Journal of the Air Force Association, XXXV, No. 4 (April 1952), 72. The ME-262 or Messerschmitt-262 was a twin-engined jet fighter plane used by the Germans in World War II.

[90]Ibid., pp. 30-31.

[91]Putt, "Air Weapons Development Systems," p. 8.

[92]Ibid.; Marmor, "Weapons," p. 210; House Appropriations Committee, Hearings on DAF Appropriations for 1953, p. 1076; and "Organizing for the Technological War: An Air Force Magazine Staff Study,"

> The operational groups were amazed at the performance of the Russian MIG, which was introduced into combat for the first time. Only one airplane, the North American F-86 Sabre Jet, equipped with sweptback wings based on captured German Luftwaffe data, could outperform the MIG sufficiently to swing the balance in favor of the United States. That tore into military complacency and resulted in a more receptive atmosphere to research.[93]

The F-86 affair was followed by the advent of thermo-nuclear bombs. On 1 November 1952 the United States exploded the world's first hydrogen bomb on Eniwetok Island.[94] Less than a year later the Russians exploded their first hydrogen bomb on 12 August.[95] Shortly after the explosion of the Russian hydrogen bomb the Von Neumann Committee informed the Air Force that it was possible to put hydrogen bombs with high explosive yields in small containers, thereby convincing Air Force leaders of the feasibility of Intercontinental Ballistic Missiles.[96]

In 1957 Russia placed the first artificial earth satellite in orbit.[97] Here was more evidence of the high quality of the Soviet

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Air Force: The Magazine of American Airpower, XL, No. 12 (December 1957), 45 (hereafter cited as "Organizing for Technological War," Air Force, Dec 57).

[93]Von Kármán, The Wind and Beyond, p. 304. Millis, Arms and Men, noted that the appearance of quantities of "excellent Soviet jet airplanes" in Korea was evidence of the "power of the Soviet military technology" (p. 340).

[94]Emme, Aeronautics and Astronautics, p. 70.

[95]Ibid., p. 72.

[96]Von Kármán, The Wind and Beyond, p. 301; Sturm, USAF SAB, pp. 75-76. Sturm claimed that the fall of 1953 von Neumann report was followed a year later by another report that concluded: "'yields as high as 1 megaton per ton of weight were possible.'" This finding confirmed "'that a thermonuclear weapon could be incorporated in a ballistic missile.'"

[97]Emme, Aeronautics and Astronautics, p. 91.

military technology, and it led to the disturbing belief that the Russians could have a substantial number of ICBM's operational by 1960.[98]

In January 1958 Trevor Gardner, who had served as Special Assistant for Research and Development to the Secretary of the Air Force (1953-1955),[99] sought to explain historically how the United States and the Air Force lost "the technological leadership of the world in air-missile power."[100] Gardner noted that the "national guided missile program, and particularly that phase of it entrusted to the U.S. Air Force, has become the subject of continued notice and comment in the press and so a matter of daily interest and concern to every John and Jane Doe in the land."[101]

Gardner continued his comments with an appraisal of the political ramifications of events in the guided missile field.

> Awesomely fantastic devices, which seem more properly to belong to the pages of science fiction, are pressing topics of debate in the halls and committee rooms of the Congress. Indeed, it seems certain that the progress and management of the missile development program will rank as a primary issue in the forthcoming contest between the political parties.[102]

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[98]James H. Douglas, Secretary of the Air Force, "The Year Since Sputnik," Air Force: The Magazine of American Airpower, XLI, No. 11 (November 1958), 47.

[99]Dan Kimball, "Trevor Gardner: 1915-1963," Air Force and Space Digest: The Magazine of Aerospace Power, XVLI, No. 11 (November 1963), 101.

[100]Gardner, "How We Fell Behind in Guided Missiles," pp. 3-13. The quoted material may be found on p. 13.

[101]Ibid., p. 3.

[102]Ibid.

This situation was placed in the spotlight of national interest by the successful orbiting of the first Earth satellite, "Sputnik," by Russia. As Gardner expressed it,

> . . . Sputniks I and II found the Air Force essentially without a program capable of meeting the challenge for the control of space, toward which the Soviet rival has chalked up the first success. Perhaps more immediately painful, the Air Force faced the dawn of the space age in the unfortunate position of appearing to the public, to the other services, and to itself, as technologically less-than-best in the race for IRBM's, ICBM's, satellites, and anti-ballistic-missile missiles.[103]

Gardner's assertion that the missile development program would become a major political issue proved to be prophetic. Concern over an alleged missile gap between the United States and the Soviet Union was a major campaign issue during the 1960 race for the Presidency.[104]

A consequence of all these technological events and their consideration by the government and the public was an unusually emphatic

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[103]Ibid., p. 4. Concerning the impact of Sputnik at the national level, Edward A. Kolodziej, has written: "Sputnik forced the issue of national security into the public's consciousness" (The Uncommon Defense and Congress, 1945-1963 [N.p.: Ohio State University Press, 1966], p. 263 [hereafter cited as Kolodziej, Uncommon Defense]).

[104]Theodore C. Sorensen, "Election of 1960" in vol. IV of History of American Presidential Elections: 1789-1968, ed. by Arthur M. Schlesinger, Jr. (New York, Toronto, London, and Sydney: Chelsea House Publishers in association with McGraw-Hill Book Co., 1971), pp. 3451, 3453, 3465; and Kolodziej, Uncommon Defense, p. 334. On 9 January 1958 General Schriever appeared before the Senate Preparedness Investigating Subcommittee to help them "define and evaluate the kind of performance and programs required to give our country undisputed leadership in the field of ballistic missiles and astronautics." The immediate problem, as Schriever saw it, was: "How can we close the gap that now exists between our country and the Soviet Union with respect to the availability of these weapons systems?" (U.S., Congress, Senate, Committee on Armed Services, Inquiry into Satellite and Missile Programs, Hearings before the Preparedness Investigating Subcommittee of the Committee on Armed Services. 85th Cong., 1st and 2d sess., Part 2, p. 1676.)

highlighting of the already-existing image of the relationship between the United States and Russia--an image of two nations engaged in a profoundly grave technological race as a result of the international tensions initiated by the "cold war" of the late Forties. Following the Soviet explosion of an atomic bomb in 1949, references to this technological race appear with increasing regularity in documents dealing with Air Force research and development. Toward the end of the Fifties such references become quite common. A cursory review of literature that discusses Air Force R&D between 1949, when the Air Research and Development Command was being gestated, and 1961, when the Air Force Systems Command was established, reveals over twenty references to this competition between the Soviet Union and the United States. A few examples of these references will serve to indicate something of the nature of this image.

A January 1958 article in Armed Forces Management suggests that the Russian explosion of its first atomic bomb in 1949 may have been the beginning of this race. The article was written by General Samuel E. Anderson who was the Commander of Air Research and Development Command at the time he wrote the article. It is introduced by these headlines: "Soviet scientific competence was already known as early as 1950." In the article itself General Anderson wrote:

> . . . military men realized that, although we were recording rapid research and development progress, so were the Soviets. They knew that the country's technological lead in many scientific areas was dwindling; had, in fact, been dwindling steadily since the world's first A-bomb drop over Hiroshima.
>
> Example?

> Only four years later, the Soviets scored their own technological breakthrough and detonated their own A-bomb.[105]

From his discussion of the Russian atomic bomb, Anderson moved to a review of other Soviet technological achievements, such as the MIG-15 fighter plane, the detonation of a hydrogen bomb a year after our first explosion of such a bomb, and the BISON bomber which was comparable to our own B-52 bomber.[106]

Some two years before the appearance of Anderson's article, Dr. Horton Guyford Stever, Chief Scientist of the Air Force, discussed the Soviet challenge to American technological superiority in Air Force. After citing many of the same examples of Soviet technical achievements that Anderson would later cite, including the atomic bomb and the MIG fighter, Stever wrote that Russian emphasis on science was a "factor which favors Russia in this technical race."[107] For Stever, the "grimmest" aspect of the competition for the United States was Russia's superior training rate for scientific and engineering personnel.[108]

Two months later, Teddy Walkowicz published an article in Air Force in which he stressed the importance of the hydrogen bomb in

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[105] S[amuel] E. Anderson, "Research and Development--Key to Air Supremacy," Armed Forces Management, IV, No. 4 (January 1958), 10-11.

[106] Ibid., p. 11. The B-52 is an eight-engined jet bomber manufactured by Boeing and still in use by the Air Force.

[107] H[orton] Guyford Stever, "Science and the Military," Air Force: The Magazine of American Airpower, XXXVIII, No. 10 (October 1955), 74.

[108] Ibid., p. 75.

American-Russian relations. Walkowicz warned of the consequences if Russia should achieve a technological breakthrough such as the development of an unusual delivery technique for its nuclear weapons. He listed the ICBM as an example of such a delivery system. Of the competition between the Soviet Union and the United States he wrote:

> Clearly the R&D race--and not World War III--is our last stand. If we keep ahead in it, if the major technical surprises are on our side, the Soviets may remain deterred and there may be time to convert the H-bomb and even the super-horror weapons that come after it to mankind's peaceful progress.[109]

Shortly following the orbiting of the Soviet satellite Sputnik I, an article titled "Organizing for the Technological War" appeared in Air Force.[110] In this article the editors invoked an R&D image to describe the world situation of their day:

> The world has now entered upon the scientific age, marked by a technological war between the US and the USSR, in which the Soviets are currently gaining by an inspired pioneering spirit, and by our default. Since the end of World War II, Soviet science has forged ahead unrelentingly. During the same period, American science has been bogged down by a bureaucracy which places major emphasis on economy and red tape and little emphasis on results. . . .
>
> The race for the conquest of space is today's major engagement in the technological war. And we must win it, for the nation which dominates space will be in a position to dominate the world.
>
> Furthermore, we are in a dynamic situation in which science is creating new threats to our security faster than it can develop adequate countermeasures. Thus, at some point, the loss of a significant engagement in this war may prove fatal. In short, either the US promptly goes ahead in the technological war and stays there, or human freedom will eventually succumb to Communist tyranny by default.[111]

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[109] T[eddy] F. Walkowicz, "Waterloo USA?" Air Force: The Magazine of American Airpower, XXXVIII, No. 12 (December 1955), 50.

[110] "Organizing for Technological War," Air Force, Dec 57, pp. 41-45, 48.

[111] Ibid., p. 42.

Following this introduction, the editors proceeded to discuss actions that needed to be taken to assure the U.S. of an effective R&D effort.

Finally, an article appearing in the Winter and Spring, 1960-1961, edition of the Air University Quarterly Review contains still another discussion of the technological competition which had become a national political issue. Its author was Lieutenant General Bernard A. Schriever. Here one reads:

> It may be said that warfare has acquired a new phase--technological war. In the past, research and development were only preparation for the final and decisive testing of new systems in battle. Today the kind and quality of systems which a nation develops can decide the battle in advance and make the final conflict a mere formality--or can bypass conflict altogether.
>
> There can be little doubt that we are now engaged in a technological war. The opponents in this war represent the two most highly developed plans for the organization of human society--one by total absorption into the state, the other by free association between groups and persons. The side that first achieves unquestioned superiority in technical capability as well as numerical strength may well prevail over the other without any overt test in battle.[112]

In such a technological war, "the laboratory, the assembly line, and the test range comprise the combat theater," Schriever declared. Furthermore, R&D had "become almost an operational function, inseparable from the strategic performance of the systems which it produces."[113]

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[112]Schriever, "Operational Urgency of R&D," p. 230.

[113]Ibid., p. 234. For a few other examples of this image, see: Putt, "USAF R&D," p. 12; Donald L. Putt, "The Four Freedoms of the Air Force: I. Freedom from Natural Barriers," Air Force, XXXIV, No. 11 (November 1951), 22; Donald A. Quarles, "Security in the Hydrogen Age: Research and Development," Air Force: The Magazine of American Airpower, XXXVII, No. 10 (October 1954), 56; John F. Loosbrock, "We Are Beating Ourselves--Right in the Pentagon," Air Force: The Magazine of American Airpower, XXXIX, No. 3 (March 1956), 43; Trevor Gardner, "Lagging Research and Development," Air Force: The Magazine of American Airpower, XXXIX, No. 1 (January 1956), 31; Thomas D. White, "At the Dawn of the

Schriever's reference to R&D as becoming "almost an operational function" points to the accomplishment of those who had sought to revise Air Force management of research and development between the end of World War II and the beginning of the Korean War. These men had endeavored to achieve their goal of an effective Air Force R&D program through such measures as establishing educational and personnel programs that would provide the Air Force with an adequate number of competent research and development workers. They had attempted to create an environment within the Air Force that would allow R&D to flourish. These advocates of change thought that the Air Force needed special policies to manage R&D, and they had attempted to formulate such policies.

Finally, they had sought to increase the priority of R&D in the Air Force primarily by means of a reorganization that created, on the one hand, a Deputy Chief of Staff for Development at the top headquarters level and, on the other hand, a major operational command, the Air Research and Development Command. The DCS/D was designed to make R&D equal in importance to the two major elements of the Air Force--operations and logistics--at the planning level. The creation of the Air Research and Development Command was intended to elevate R&D to the status of operations and logistics at the functioning level where the plans and directives of Headquarters USAF were executed.

As we have seen, all of the problems were by no means settled

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Space Age," The Air Power Historian, V, No. 1 (January 1958), 17; and "Are We Using or Abusing Technology?" Air Force and Space Digest: The Magazine of Aerospace Power, XLIV, No. 10 (October 1961), 45-46.

by the reorganization of 1950. The devising of special policies for R&D at that time opened the way to the subsequent development of the Air Force's systems management techniques, and these produced another reorganization in 1961, when ARDC became the Air Force Systems Command. There was also another temporary resurgence of traditionalism that resulted in the subordination of DCS/D to DCS/M between 1953 and 1955.[114]

But in spite of this second resurgence of traditionalism, the most lasting legacy of the 1950 reorganization was a permanent departure from the traditional view of research and development which held that R&D was a subordinate function of matériel or logistics. Over the span of time since early Army Signal Corps days, aviation research and development had been admitted to the top policy-making levels of the Air Force as the third panel of a triptych that included traditional logistics and operations. As Air Force policy makers saw it, if the elements of this triptych were properly combined or interacted properly, an effective military air arm could be maintained in the nation's defense arsenal.

The reorganization of 1950 signified the Air Force's recognition of R&D as a major element of Air Force institutional activity. The 1952 guide for contractors published by ARDC described the situation well:

> The United States Air Force is organized on a functional basis. In the field of materiel which includes weapons, equipment and techniques, the three important functions directly involved are:

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[114] It might also be noted that the special personnel program implemented by the Air Force for R&D personnel by January 1950 (Supra, pp. 137-38) had been abandoned by 1958 (Stever Report, p. 2).

1. The Development Function

2. The Logistics Function

3. The Operational Function

> The Air Force organizations involved in these three functions which are so closely inter-related in providing the Air Force with the proper quality and quantity of materiel are: (1) the Air Research and Development Command--responsible for research and development and the technical quality of materiel and equipment; (2) the Air Materiel Command--responsible for the logistics function which involves quantitative aspects of Air Force materiel and equipment, including procurement, supply and maintenance; and (3) the Air Proving Ground Command in coordination with the Operational Commands which are responsible for Operational Suitability Testing and Combat employment of air weapons and related equipment.[115]

After 1950 the Air Force was to change its research and development organization several times. But the importance of R&D in the eyes of Air Force leaders did not essentially diminish. Rather, the Air

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[115] USAF ARDC, "R&D in the USAF," Aug 52, p. 2. The September 1957 version of this document contains a virtually identical statement (USAF ARDC, "R&D in the USAF," Sep 57, p. 1). See also USAF DCS/D, "Combat Ready Aircraft," pp. 5-7. Here three functions are described as essential to achieving a combat ready aircraft: operations, technology, and logistics. According to "Combat Ready Aircraft," to assure itself of achieving combat ready aircraft, the Air Force should adopt the organizational and procedural recommendations offered. One of these recommendations reads:

> The responsibility for, and the authority over, the Operational, Technical, and Logistical functions must remain in the hands of the specific agencies charged with these functions throughout the life span of an aircraft.

Then follows in italics:

> The establishment of a Deputy Chief of Staff for Development on an equal status with the Deputy Chief of Staff for Operations and the Deputy Chief of Staff for Materiel, together with the establishment of an Air Research and Development Command co-equal with the Air Materiel Command and the operational combat commands of the Air Force will assist, organizationally, in the attainment of this objective (p. 24).

Force came to assign more importance to research and development as a result of an entire series of fresh technological crises that became translated into the image of a technological "war" or race between the United States and the Soviet Union. How best to secure the maximum benefits from R&D continued to be a matter of serious managerial debate within and among the Air Force, the Department of Defense, and the Congress. But the vital necessity of research and development in the effort to attain an effective Air Force was not seriously questioned thereafter.

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## BIBLIOGRAPHIC ESSAY

The major repository for the material used in writing this dissertation is the Air Force Archives located in the Air University Library at Maxwell Air Force Base, Alabama. The correspondence of several General Officers is located there. Of particular importance for the subject of Air Force research and development is the correspondence of General Earle E. Partridge. Only part of General Curtis E. LeMay's correspondence is kept at Maxwell, but some of the letters and documents in these LeMay papers do deal with the early post-World War II period in Air Force R&D. There are also numerous folders of memoranda, letters, etc., that are filed according to which Air Force office or agency generated or received the documents. All of this material is well-indexed in the card files of the Archives.

In addition to the correspondence, a number of oral history interviews with principal Air Force leaders such as James H. Doolittle and Bernard A. Schriever is maintained in the Archives. These interviews often help one gain insights into some of the activities and events that lie in back of official reports, correspondence, and directives.

As far as directives are concerned, one can find many of the important regulations that govern Air Force R&D activities in the Authority Branch of the Air University Library. In addition to

regulations, official letters and some manuals are maintained in the authority section.

The Air University Library itself has many documents that are useful to one interested in Air Force research and development. These include complete runs of such journals as Air Force, which has undergone numerous modifications in its title, Air University Quarterly Review, Armed Forces Management, and Air Power Historian. Speeches delivered to the different schools that make up the Air University and to the Industrial College of the Armed Forces may also be found in either the Archives or in the Air University Library. These addresses were delivered by such men as Vannevar Bush, Alan T. Waterman, and Hugh L. Dryden.

The Archives and the Air University Library also hold a large number of official histories of the Air Force and the Army Air Forces. The official history holdings of the Archives are especially extensive. Here one finds several multi-volume histories which frequently include one or more volumes that contain collections of the documents or copies of the documents used in writing the history. These supporting-documents volumes are rich sources for those interested in studying aspects of Air Force history.

Listed below are all of the major sources used in preparing this dissertation. Additionally, a few documents not cited in footnotes have been listed where they are believed to be of particular interest to those interested in Air Force research and development.

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APPENDICES

APPENDIX I

LIST OF KEY REPORTS

| SHORTENED TITLE OF REPORT | AUTHOR (PERSON OR AGENCY), FULL TITLE, AND DATE OF THE REPORT |
|---|---|
| Air University Study | U.S., Department of the Air Force, Air University Committee, "Air University Study: Research and Development in the United States Air Force," 18 November 1949. |
| Bush Report | Vannevar Bush, Science: The Endless Frontier--A Report to the President, 1945. |
| Finletter Report | See Survival in the Air Age. |
| Ridenour Report | U.S., Department of the Air Force, Scientific Advisory Board, Research and Development in the United States Air Force, 21 September 1949. |
| Science: The Key to Air Supremacy | Theodore von Kármán, Science: The Key to Air Supremacy in Army Air Forces Scientific Advisory Group, Toward New Horizons, December December 1945. |
| Steelman Report | U.S., President, President's Scientific Research Board, Science and Public Policy, 1947. |
| Stever Report | U.S., Department of the Air Force, Scientific Advisory Board, Report of the Ad Hoc Committee on Research and Development, June 1958. |
| Survival in the Air Age | U.S., President, Air Policy Commission, Survival in the Air Age: A Report by the President's Air Policy Commission, 1 January 1948. |

| SHORTENED TITLE OF REPORT | AUTHOR (PERSON OR AGENCY), FULL TITLE, AND DATE OF THE REPORT |
|---|---|
| Toward New Horizons | U.S., War Department, Army Air Forces Scientific Advisory Group, Toward New Horizons: A Report to General of the Army H. H. Arnold, 15 December 1945. |

## APPENDIX II

## GLOSSARY OF ABBREVIATIONS AND TERMS

| | |
|---|---|
| AAF | Army Air Forces. |
| AC/AS | Assistant Chief of Air Staff. |
| AC/AS-4 | Assistant Chief of Air Staff, Matériel and Supply. |
| AFA | Air Force Association. |
| AFB | Air Force Base. |
| AFIT | Air Force Institute of Technology. |
| AFM | Air Force Manual. |
| AFOSR | Air Force Office of Scientific Research. |
| AFR | Air Force Regulation. |
| AFSC | Air Force Systems Command. |
| AMC | Air Matériel Command. |
| ARDC | Air Research and Development Command. |
| ARDCM | Air Research and Development Command Manual. |
| DCAS/R&D | Deputy Chief of Air Staff for R&D. |
| DCS/D | Deputy Chief of Staff for Development. |
| DCS/M | Deputy Chief of Staff for Matériel. |
| DCS/O | Deputy Chief of Staff for Operations. |
| OAR | Office of Air Research; Office of Aerospace Research after March 1961. |

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|---|---|
| Operations | When Used in relation to the Air Force of the 1945-1950 period, this term refers to flying activities, especially those directly related to combat, such as strategic bombing, troop transport, air-to-air combat, and air defense. |
| OSRD | Office of Scientific Research and Development. |
| SAB | Scientific Advisory Board. |
| SAG | Scientific Advisory Group. |