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Thesis

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ARCHITECTS OF AIR SUPREMACY:

General Hap Arnold and Dr. Theodore von Kármán

by

Major Dik A. Daso

25 January 1994

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Introduction

The partnership of technology and the military pre-dates written history. Long before airplanes became a reality in 1903, inventions such as the stirrup (circa 700 A.D. in Western Europe) and gunpowder (circa 1300 A.D. in Western Europe) had "evolutionized" warfare as well as civil life. The stirrup, which allowed men the means to steady themselves in the saddle, was largely responsible for the preeminence of cavalry on the battlefield for many centuries. Later, the stirrup also allowed the aristocratic gentry class the means to mount and monitor their holdings in a far more dignified manner than had been possible before its introduction. Gunpowder, and gunpowder weapons, eventually sealed the fate of previously unstoppable cavalry charges, which had been made possible by the stirrup, and contributed to the entrenched quagmire known to history as World War I. Metallurgical skills developed during the gunpowder "evolution" were instrumental to the creation of engines and very strong steel which Britain utilized with effect during the industrialization period. It was on 17 December 1903, on Kill Devil Hill, that Orville and Wilbur Wright demonstrated that powered heavier than air flight was possible. Only forty years later, Henry Harley "Hap" Arnold, then a seventeen year old 'plebe' (freshman) at West Point, would command the largest military air force ever assembled in history while, in the same moment, commercial air liners began criss-crossing the free skies of the world. The American journey from fledgling air service to air weapon supreme must include back road travel through personalities and institutions. The detours include the lives of a civilian scientist, a military general officer, and the institutions they created. These men and their institutions were responsible for America's blueprint for post-World War II air supremacy.

CHAPTER 1

Henry Harley Arnold: The Early Years

I am of the opinion that no matter how Buck Rogerish things may seem to us now, with the terrific advances made in the art and science of air operations, they should not be overlooked as a possibility for the future.¹

General Hap Arnold, 6 December 1945

Henry Arnold was not supposed to enter the Army. His older brother, Thomas, was to attend West Point to continue the Arnold family tradition of wartime service. Henry's grandfather, Thomas G. Arnold, fought at Gettysburg during the Civil War. Henry's father, Herbert, had served as a doctor in Puerto Rico in 1898 during the Spanish-American War. But Thomas refused to accept his father's persistent requests to attend West Point so the opportunity instead fell to Henry. The proposition was likely a huge relief to the young man. Until Thomas's refusal, Henry was considering a religious career probably at the insistence of his father. Yet the elder Arnold apparently fell strongly behind Henry's new career for he wrote his son on the eve of his 1903 enrollment:

My Dear Boy,

Always live as in sight of God and your mother. Fully comprehend what is required of you and act with promptness and fidelity. Self-control is essential to success...²

Henry's West Point career did not reflect "fear" of God, mother or of anyone else for that matter. The rest of his father's advice, however, impacted the development of one of the youngest appointees ever to the Long Grey Line.

Though young, Cadet Arnold found a comfortable niche at the tradition-laden institution. He was a member and eventual leader of the "Black Hand." This covert corruption squad was responsible for many of the greatest student spirit pranks ever carried out at West Point. His future wife, Eleanor Pool, recalled that her first meeting with Henry was through the window of his solitary confinement room where he had been placed for some disciplinary indiscretion.³ He played varsity football, second string, and saw moderate playing time during his cadet days. But he had academic drive as well. Arnold "specked" (memorized) 37 pages of logarithm tables, earning him recognition in the West Point Howitzer publication in 1907.⁴ Although he had a clear memory, Henry was a slightly below average cadet by all measurable standards. Yet by other standards he was anything but average. The spirit which Henry imparted in leading the West Point pranksters and in openly defying normally unquestioned authority motivated other cadets (and perhaps even some officers) while setting the tone for a remarkable Army and Air Force career.

Cadet Arnold ended his West Point tenure much as he had lived it as a student. Less than one week before graduating, he earned demerits for chewing tobacco during a cavalry formation: strictly forbidden.⁵ Not only did this infraction keep him from most graduation festivities, suspicion was that it earned him an assignment in the *infantry*--a final stab by the authorities at the impetuous young lieutenant. Arnold had always yearned for a cavalry assignment. "It was the last romantic thing left on earth," he later wrote.⁶ There were other assignments besides infantry, but Henry was not qualified for them. He had not graduated high enough academically, for example, to go to engineering school. Eleanor Pool recognized this: "...Those with brains got the engineers, but I don't think that Hap was the engineering

type at all."⁷ Henry was never accused of being school smart. After graduation in 1907, Lt. Arnold volunteered for duty in the Philippine Islands and made maps of the mountainous island for the Army. After several unsuccessful attempts to gain an assignment to a cavalry unit, he posted near New York City. One day in 1911, Arnold received a letter inviting him to move to Dayton, Ohio, and take flying lessons from the Wright Brothers. Against the advice of his commander, he accepted orders for military flight school. By the summer of 1911 Arnold was on his way to earning military pilot wings (license number 29).⁸

Arnold wasted no time in establishing in house notoriety. On 9 October 1912, Arnold was awarded the first Mackay trophy, still bestowed for the most outstanding flight by a military aircrew during the year. Arnold's flight entailed the successful negotiation of a triangular aerial reconnaissance course and reporting his findings to a panel of judges. This trophy associated Arnold permanently with the Air Service and also afforded him unique opportunities to meet influential civil aviation enthusiasts as well as eminent civilian scientists. Yet Arnold did not take himself or his new status too seriously. After receipt of the actual Mackay Trophy cup, Arnold wrote his bride-to-be that, "It [the trophy] certainly is handsome. I figure that it will hold about four gallons so I cannot see how you can fill it with anything but beer."⁹ That zest for life was certainly influenced just then by a near fatal airplane flight shortly after the Mackay Trophy mission at Fort Riley, Kansas. Henry and a passenger, Lt. A.L.P. Sands, were suddenly thrown into a dive toward the ground. Arnold righted the craft and missed a violent crash by only a few seconds. Such unpredictable incidents were the reason why flying casualty rates were horrendously high: one death for each 105 flying hours. Arnold was so rattled that he requested three weeks leave.¹⁰ Henry

and Eleanor were to marry in December that year. Certainly Arnold was thinking about his fiancée that day. He did not fly again for several years.

After the wedding, a second tour in the Philippine Islands and the addition of two children, the Arnolds returned to America just as the United States entered World War I.¹¹ By August 1917, [Brevet] Colonel Henry "Hap" Arnold (temporary grade) was back in Washington, D.C., as Assistant Director of the Office of Military Aeronautics. He had wanted to join the fighting more directly, but accepted his fate after several requests for overseas transfer were refused. Although aviation played no decisive role in the Great War, operational lessons were learned by many of the American flyers who had participated in air combat. The most vocal advocate was William "Billy" Mitchell.¹²

After World War I, Mitchell demonstrated that the airplane was more than just an observation platform. It was an accurate, destructive weapon. Unfortunately, Mitchell was too outspoken on the subject. His accusation of "treasonable behavior" by Navy officials in aviation matters found him beyond accepted bounds for a military officer. The court martial served as a public forum for aviation advocates, including Henry Arnold, who testified on Mitchell's behalf. For his testimony, Arnold was awarded a permanent duty change: "exile" to Fort Riley, Kansas. For the second time on the open plains of Kansas, Arnold thought his career was spiraling uncontrollably toward the ground--this time figuratively.¹³ But the assignment turned out to be the most significant of his twenty year career.

It was at Fort Riley, in 1927, that Hap came close to retiring from military service. He had been exiled for speaking truthfully, but respectfully, at Mitchell's trial. He had never entered the cavalry, even after repeated requests (to add insult to injury, Fort Riley was a

cavalry post). He was denied any opportunity to participate directly in the American war effort in Europe. Additionally, the national economic picture was very good. The New York Stock Exchange was higher than it had been on the same date for the previous five years. Cotton and coffee hit all time highs in the market and General Motors reported record profits during the week of 23-30 July 1927.¹⁴ More persuasively in July 1927, John K. Montgomery, then president of American International Airways (a branch of Pan Am), had offered Hap a lucrative civil aviation position as the first president of Pan Am Airlines.¹⁵ Remarkably, Major Henry Arnold (permanent grade), remained in the Army.

The reason for his decision was family concerns. On 24 July, Major Arnold sent John Montgomery a final response to the Pan Am job offer. "As much as I would like to tell you that I will resign and take up work with the company, I hesitate doing it on account of the obligations which I have with my family." Arnold did suggest that he might work on "getting a leave for four months and work with the company and then make up my mind."¹⁶ This leave was apparently never taken even though Montgomery had called Jack Jouett, a mutual military friend of Arnold's, who was stationed in Washington to expedite the leave request.¹⁷ Apparently, besides concerns for his family's economic security, an army career still offered several challenges. Arnold had many ideas for the Air Service which he wanted to test.¹⁸ Additionally, his personal pride was damaged by the malice of his superiors. "I couldn't very well quit the service under fire," he said.¹⁹

CHAPTER 2

Theodore von Karman: The Early Years

It is tragic that over and over the enemy must always prove the virtue of scientific investigation.²⁰

Theodore von Kármán

Near Budapest, Hungary, in the spring of 1881 von Sköllöskislaki Kármán Todor was born to Helen and Maurice von Kármán. Todor, "gift of God," was the couple's third healthy son and soon demonstrated remarkable mental skills marking him as the brightest of their offspring. Helen, who carried the bloodline of many gifted scientists, and Maurice, friendly and gregarious, offered a socially active backdrop during Todor's formative years. At age six, Todor showed off for visitors by multiplying six digit numbers in his head with the speed of present day calculators. At sixteen, Todor was awarded the Eötvös Prize as the finest mathematics and science student in all of Hungary.²¹ Thus began an academic, scientific, and engineering career unequaled in the twentieth century. In the early 1900's, after a very successful secondary school career, von Kármán took up studies with Professor Ludwig Prandtl, noted expert in fluid mechanics and all around bore, at the Göttingen Mathematical Institute.

Göttingen University, for all its reputation, stifled Todor's social and mental spirit. He had become accustomed to the cafe lifestyle of Budapest and in 1908, bereft of motivation, he travelled to Paris--a journey which transformed his life in many ways. In March of 1908, a

close friend dragged the young professor to an aerial demonstration at a Paris air strip. The flight of the "box kite made of sticks, wood and paper" intrigued him. From that moment, Todor dedicated himself to the science of aeronautics, a different kind of fluid dynamics.²² Following his new found interest in the wind, Theodore von Kármán moved to Aachen, Germany, where he became the director of the Aachen Aeronautical Institute.

The Polytechnic Institute at Aachen was a perfect place for the future regent of American aeronautics to begin his aviation science career. Not only did Aachen offer gainful employment, the festive atmosphere revitalized the young professor's morale (Recall that in the ninth century, Charlemagne pronounced the region surrounding Aachen his home and was eventually buried there).²³

After only three years at Aachen, Professor von Kármán found himself in the midst of a horrible, modern European siege. In the summer of 1915, while German armies enjoyed success on the Eastern front, Kármán assumed the post of Research Director at an Aircraft factory near Vienna for the Austro-Hungarian Aviation Corps. This was his first real contact with military officials and air operations.²⁴ Ironically, the professor was much closer to The Great War than Henry "Hap" Arnold ever got.

As Arnold agonized over this decision in Kansas, Prof. Theodore von Kármán was contemplating a move to America. The reason was the availability of a Guggenheim fellowship to pursue the study of aeronautical sciences.

The Guggenheim Foundation was organized in 1926 with the express purpose of furthering the prestige of aeronautics in the United States. When grants were made to Eastern schools for the establishment of aeronautical programs, one in the amount of \$500,000, other

colleges began inquiring about the possibility of acquiring money for their own aeronautical programs. The California Institute of Technology (Cal Tech), under the guidance of Prof. Robert A. Millikan, soon requested Guggenheim money to expand its fledgling aeronautics facilities.²⁵

During World War I, Robert Millikan had been commissioned into the Army Signal Corps and made Chief of the Science and Research Division. During this period, Millikan met Hap Arnold who was serving as Assistant Director of the Office of Military Aeronautics in Washington.²⁶ His acquaintance with Arnold would be significant to both Arnold and Cal Tech over the next twenty-five years. After the war, Millikan accepted the chairmanship of the Cal Tech Executive Council in 1921 (making him in effect, University President). His goals for the institution were to thrust Cal Tech science programs to national pre-eminence and to bring aviation interest, and industry, to Southern California. Millikan traveled a long way toward achieving his first goal in 1923, when he earned the Nobel Prize for physics.²⁷ Millikan believed that science, "knowledge of the facts, the laws, and the process of nature," was vital to American destiny. Although officials at other universities held similar beliefs it was Millikan, with help from the Guggenheim Foundation, who made Cal Tech the leader.²⁸ Daniel Guggenheim himself took an interest in Cal Tech, Millikan, and the possibility of luring Theodore von Kármán away from Aachen. By 1926, Millikan had convinced Kármán to visit Cal Tech after paying an introductory visit to the Guggenheim Mansion in New York. During his first visit to America, the Jewish, Hungarian professor was wined and dined by Guggenheim personally, offered a significant pay increase to join the Cal Tech staff, and promised the directorship of the aeronautics laboratory at that school as well as authority to

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run the laboratory any way he felt would make it most productive.²⁹

Although impressed by Guggenheim and Millikan's generosity, Kármán did not commit to a move. With the rise of anti-Semitism and Naziism in Germany in 1928 and 1929 the professor concluded that America offered better scientific, as well as social, opportunities. By December 1929, Kármán had decided to move his home, mother, and sister to the United States. He had several job offers available, both in Germany and in America, but he finally settled on the directorship of the Guggenheim Aeronautical Laboratory at the California Institute of Technology (GALCIT). He learned that Albert Einstein was to be a research associate at Cal Tech in 1930, which may have also influenced his final decision.³⁰ The acquisition of Professor von Kármán, Millikan's Nobel Prize winning reputation, the newest possible facilities, as well as the notoriety of other academic staff members was making Cal Tech the most vital and most renowned of the Guggenheim funded schools.³¹ Karman's presence was perhaps the key factor. For over a decade, Cal Tech claimed the services of the leading figure in aeronautics in America.

The men in charge of the future Air Forces should always remember that problems never have final or universal solutions, and only a constant inquisitive attitude toward science and a ceaseless and swift adaptation to new developments can maintain the security of this nation through world air supremacy.³²

Theodore von Kármán
AAF Scientific Advisory Group

Theodore von Kármán had always admired Sir Isaac Newton. Newton was the quintessential theoretical scientist as well as a practical engineer. Not only had Newton postulated the Universal Law of Gravity but had been a man of practical work, designing, for

example, a footbridge over a river near his alma mater, King's College, in Cambridge, England.³³ Kármán emulated Newton's wisdom and practicality and, throughout his career in aerodynamic theory, maintained a strong interest in the actual engineering of his formulations as well as applications of his work to real-world problems.

Practical applications of his theories were reflected in a variety of traditionally non-aeronautic projects. Not including the professor's landmark work in theoretical fluid dynamics, he helped redesign the Tacoma Narrows Bridge which had been destroyed by gusty Northwestern winds. Kármán also used wind tunnels to study soil erosion, and he proposed methods of controlling these effects. While still in Europe, Todor had even taken a flying lesson which, perhaps fortunately, ended with a crash landing in a potato field.³⁴ Like Arnold in 1912, it was a long time before he ever flew again. Unlike Arnold, he never became a pilot.

Kármán's varied interests were part of his universal appeal. While well known physicists and scientists, such as Jerome Hunsaker of MIT, and Vannevar Bush at the National Defense Research Committee (NDRC), had shunned jet and rocket engine research and development (R&D), Kármán was encouraging the study of such "unconventional ideas."³⁵ Although solving theoretical problems was Kármán's strength, he was not afraid to challenge accepted theory or, when necessary, get his hands dirty doing experiments. On at least one occasion, the professor climbed into his wind tunnel with a handful of modeling clay, and modified an airplane wing root which he suspected of causing high speed turbulence. The modification became known throughout the world as "Kármán's"--small wing fillets which minimized turbulence at high speeds. This discovery would be critical in the

successful penetration of the sound barrier, a barrier many then believed would never be broken.³⁶

Never one to believe what others believed without logical evaluation, Kármán also felt that, "to be always logical is horrible."³⁷ His thinking process set him apart from others who supported large working groups as the method to problem solution. Although he found use for study groups, he believed that individual creativity was often suppressed, sometimes because of the reputations of more respected members of the groups.³⁸ Essentially, younger members of groups were afraid to speak up for fear of having their own prestige crushed by a more experienced, more highly respected member. "In the long run," Kármán said, "I still think that the finest thoughts come **not** out of organized teams but out of the quiet of **one's own world**."³⁹ Yet the professor was not a stereotypical, introverted scientist. He was also a gifted teacher.

Accepted as the most brilliant aerodynamicists of his time, Kármán also had the ability to turn every encounter with students into an occasion for intellectual excitement. It was not uncommon for Kármán to invite students and faculty members to his Pasadena home for mid-week gatherings consisting of Hungarian food and "shop talk". During the gathering, he mingled with guests, Jack Daniels and a cigar in hand, spreading his enthusiasm for science and life as a hungry child spreads peanut butter and jelly on mushy white bread. His home was his spiritual source of strength. His mother and sister were constant companions and confidants as well as his link to a rich European heritage. The festive atmosphere was reminiscent of the cafe scene from which he emerged almost thirty years before and often included famous Hollywood guests and high ranking military officers but rarely including

German beer, which he missed a great deal.⁴⁰ The casual relaxation of the situation was ideal for learning.

The professor's teaching method centered around a belief in comprehensive, "broad based" education; that is, scientists should learn some engineering and engineers should learn some science. Additionally, he believed that a familiarity with the humanities served to broaden one's ability to understand complex scientific concepts. He had a unique ability to explain complex solutions in rather simple terms.⁴¹ Moreover he was insistent on open exchange of ideas, even if a solution appeared flawed. He was able to point out absurdity or inconsistencies without destroying a relationship or squelching enthusiasm.⁴² He resented, for example, the secrecy which Robert Goddard insisted on during his early rocketry experiments in the 1930's because it resulted in duplication of effort and a time delay in eventual experimental success. His teaching ability was undoubtedly one reason why Hap Arnold, a man of somewhat basic academic ability, came to like and respect Kármán so much.

Yet, despite his notoriety as a scientist and a teacher, Kármán remained a man of deep humility. During his lifetime, he shared the company of Albert Einstein, Henry Ford, Daniel Guggenheim, Jane Mansfield, Orville Wright, Pope Pius XII, Joseph Stalin, and President John F. Kennedy--to name only a few. The ease with which he moved through exalted social and political circles demonstrated that, although he was aware of his personal standing as a renowned scientist, he sought no status or reward for it. Further, he showed remarkable interest in those who were experts in unfamiliar fields of study.⁴³ In reality, Kármán was interested in everything surrounding him. To him, true understanding was only achieved with

an open mind. "The greatest progress in my lifetime," he once observed, "has consisted of the elimination of what I call the scientific prejudices."⁴⁴ During his life he successfully breached barriers between engineers and scientists, work and leisure, art and science, students and teachers, home and class room, thinkers and laborers, as well as "long hairs" and military men. While at Cal Tech, Kármán developed a similar vision to Hap Arnold's: the United States needed an aeronautics establishment with civilians and military men directly involved.⁴⁵

CHAPTER 3

National Advisory Committee on Aeronautics

At about the same time Henry and Todor were beginning their careers, the United States authorized the formation of the National Advisory Committee for Aeronautics (NACA).⁴⁶ This committee became the sounding board for fundamental aeronautical research in the United States up through the early years of the Second World War. On 3 March, NACA became a functioning government agency as a result of a "rider" to the Naval Appropriations Act of 1915. The committee budget was five thousand dollars.⁴⁷ The founding of NACA marked the beginning of the second major phase of aeronautical development: turning infant theory into tangible function. Although joint Army-Navy committees had existed before NACA, they had no official status and even less authority over the progress of aeronautical science. The need for a committee with legitimate power became apparent the following year during the disastrous attempt at providing air support for Brig. Gen. John J. Pershing's punitive expedition into Mexico.⁴⁸

Apparently learning little from the Mexico debacle, it was not until the 1920's that NACA made headway in the area of pure research. Another student of Professor Prandtl, Max Munk, became a NACA consultant at Langley Field, Virginia, NACA's primary research facility at that time. Munk designed the first variable density wind tunnel in the United States and was also responsible for the zeal with which the Langley facility utilized its wind tunnel resources. This invention allowed testing of scale model airplanes rather than full size

mock-ups of the craft.⁴⁹ The Washington bureaucracy overwhelmed the committee and, by 1926, NACA had slipped away from theoretical aeronautics altogether. Essentially, the committee was serving an "advisory function to other agencies [which] hampered its research efforts."⁵⁰ It is inaccurate to say that the United States was doing nothing in preparation for war. Since 1927 Wright Field near Dayton, Ohio, had been the center of Air Corps Research and Development (R&D). NACA, the National Bureau of Standards, civil industry, and many universities were hard at work solving aeronautical problems. By 1939, the majority of tasks which NACA was tackling were primarily routine requests from the aviation branches of the Army and Navy. Studies to determine R&D priorities for the Air Service were initiated in 1939 and 1940. A new organization, the National Defense Research Committee (NDRC), was formed as the NACA equivalent for weapons and devices.⁵¹

CHAPTER 4

The Architects Meet

One military man whose career was bringing him ever-closer to Karman was Henry Arnold. Major Arnold survived his "exile" to Kansas and by the early 1930s had assumed command at March Field in Southern California, forty miles from Cal Tech. While in that assignment, which earned him a brigadier generalship, Arnold continued building upon the many civilian acquaintances he had already made in his career. He frequently entertained celebrities, some whom he probably met when he flew as a stunt double during Hollywood production earlier in his flying career. He kept close contacts with his World War I friend Millikan, who was preparing cosmic ray experiments (for which he needed Arnold's airplanes). In 1935, Arnold restructured his command to accommodate the new General Headquarters (GHQ) Air Force concept. GHQ Air Force was an attempt to streamline the Army Air Corps and consolidate administrative and training functions. This was the first legitimate step toward an independent Air Force. Essentially, Arnold was responsible for all air assets at the field: pursuit, bomber, and attack/observation. Since March Field had been home to all types of aircraft prior to the official reshuffle, little actually changed in day-to-day operations.⁵²

That same spring, Brigadier General Arnold met Professor von Kármán for the first time while visiting Robert Millikan at GALCIT.⁵³ Although the general and the professor crossed paths occasionally after that encounter, it was not until 29 September 1938, after

Arnold was made the Commanding General Army Air Corps (CGAAC) and had been reassigned to Washington, that their official association began in the gathering clouds of yet another conflict.

With crisis looming again in Europe, Arnold and his staff closely monitored the events surrounding the Spanish Civil War. Of critical interest was German airpower and its practical application in that theater. Many military projects were under development or under consideration in anticipation of a widening conflict. Two of these were improvement to bomber aircraft windshields for cold, high altitude flight, and the development of a Jet Assisted Takeoff System (JATO) to improve short field operations for heavy aircraft. In September 1938, Arnold called a meeting of the "long hairs" to solve these problems.⁵⁴

GALCIT and the Massachusetts Institute of Technology (MIT), another Guggenheim school, sent representatives to the gathering. Jerome Hunsaker of MIT, requested the windshield problem for his institution and openly dismissed JATO as a fantasy. Millikan and Kármán, representing GALCIT, eagerly accepted the JATO challenge. By Christmas, Arnold had given them a small stipend for preliminary research. In July 1939, a progress report written by Frank Malina, one of Kármán's assistants, earned an additional ten-thousand dollars for the research team (dubbed the 'Suicide Club' a name earned by a few different accidental attempts to destroy the GALCIT with rocket experiments).⁵⁵ Kármán's own words summarized the significance of Arnold's vision and the JATO the project. "Really, without Arnold I think jet propulsion would have come much later."⁵⁶

CHAPTER 5

The War and The General

...My observation of the leaders I have known, do not indicate that a high I.Q. is the certain hallmark of the leader.⁵⁷

**Lt. Gen. Ira C. Eaker
Commander, 8th Bomber Command
(under Arnold in W.W.II)**

Hap Arnold realized that airpower was not dependent upon massive numbers of airplanes. Certainly planes were important, but so were pilots, mechanics, and air bases. The requirement for continued "experimentation" with "gadgets" was also significant.⁵⁸ These views were held by many members of the Army Air Corps; and had been for many years. Just before he died in 1936, Brig. Gen. Billy Mitchell had predicted that Arnold's convictions and courage might even be enough to ensure the Air Service would actually be prepared before the next war began.⁵⁹ Unfortunately, American forces at Pearl Harbor in 1941, including the Air Corps, were not prepared to make any immediate decisive contribution to the war effort. Arnold's task was clear in 1941: He was to build a fighting American Air Force immediately. But if preparations were progressing, it was as accurate to say that they were occurring far too slowly. The first priority in building the Army Air Corps, necessarily, was to speed up the production of planes, pilots, mechanics, and bases. That is exactly what Hap Arnold did.

As a colleague recalled, Arnold achieved the necessary speed-up by "management methods far removed from orderly staff procedures."⁶⁰ Arnold realized that organization was

one of the most crucial tools in successful mission accomplishment. But it had to be his own method of organization. He had spent nearly a decade dealing with the managerial melee in Washington, two of those years during wartime. His familiarity with the inner workings of the "system" had become essential to his ability to outwit the bureaucracy and make things happen.⁶¹

The ability to hoodwink, although vital, was not Arnold's only forte. Nathan Twining, who worked on Arnold's staff from 1940-42, said, "There was some lost motion in those early days, but Arnold straightened that out before the war was over."⁶² He did this, in large degree, by strength of his own will and certainty in his decisions. As his father had hoped he would do in 1903, Hap fully comprehended requirements and acted swiftly and faithfully. Others, such as the Wright Brothers, reinforced in Arnold that strong will can "make the impossible, possible."⁶³ Laurence Kuter, a member of Arnold's trusted Advisory Council, once wrote that it was very unwise to utter the words, "It can't be done," around the general. Those were fighting words.⁶⁴ His contemporaries called him many things: "Go'er," "Do'er," "An S.O.B.," "Strong and Courageous," "Tough and Rough," "Turbo-Supercharged," "A Steam Engine," and "leading at a very fast pace."⁶⁵ They all marked a man who had 'moxie' as well as impatience and remarkable vision. All combined to make Gen. Hap Arnold an airpower pacesetter.

...I have been impatient all my life and will probably be impatient to get the caisson rolling faster when I go through the gates of Arlington but that's my make-up, and that's that.⁶⁶

Arnold to Spaatz, 19 Aug 1942

There is no question that Hap Arnold was an impatient man. He was unable to tolerate delay and was restless. He was unable to sit in one place for much more than fifteen minutes and was always in the middle of something.⁶⁷ He was unable to endure opposition and was intolerant. His disdain for "can't do" attitudes was well known.⁶⁸ He was, above all else, restively eager for "things" to happen. Hap wanted any task to have happened yesterday--he was all business.

Occasionally, his enthusiasm to accomplish tasks resulted in duplication of effort by staff officers who had been "tagged" or "Hey, you'd" in the hall by Arnold himself.⁶⁹ Every once in a while, when dissatisfied or just to make a point, Arnold resorted to verbal eruptions which were not soon forgotten by the recipient of the barrage.⁷⁰ To admit that Hap was impatient is one thing, to suggest that his impatience was deleterious would certainly be incorrect. The United States military, now facing a war on two fronts separated by six-thousand miles, could not have been in a more precarious position. Airplanes, pilots, and mechanics could not have appeared fast enough to diminish the immediate threat of catastrophe. Gen. Hap Arnold's "impatience" was exactly what the Army Air Corps needed during the early years of American involvement in World War II.⁷¹

Arnold had this intellectual curiosity and the fanatic belief that air power is most important for the nation and for the future of Mankind.⁷²

Prof. Theodore von Kármán

By 1944, Arnold, convinced of Allied victory, quickly demonstrated that his vision for the future was as important to the Air Corps as his impatience had been in 1941. General Arnold held the same vision of an independent Air Force as Billy Mitchell had twenty years

earlier. By now, however, Arnold realized that it was only a matter of time before the dream of independence for his branch of the service would be realized.⁷³ Arnold's prescience went beyond the thinkably inovative; it was clearly visionary. Aided by long association with the civilian scientific community, Hap had an open-minded view of the relationship of technology to military forces. Men who served with Arnold during the war said that Arnold was the only prominent military officer to have possessed a broad enough view or a clear enough understanding of the potential capability of science to alter the complexion of the air service.⁷⁴ Arnold realized that the technical genius needed to fulfill his vision was beyond bureaucracy--beyond the military. The expertise required could only be found at universities and in civilian industry.⁷⁵ It was only logical that Arnold sought out his long time acquaintance, Nobel Laureate Robert Millikan, to discuss his vision for the future.

Although Hap had already decided on Kármán as the civilian, university scientist he needed for the Air Corps, he probably felt an obligation to inform Millikan of his choice and then ask for his blessing upon their union. The prospect of losing the world's leading aeronautics professor to the Pentagon must have disappointed Millikan, despite his friendship with Hap and his realization that the American military was in a scientific bind. Arnold had sent a telegram to Lake George, New York, where Kármán was recuperating from a rather nasty intestinal cancer operation earlier that summer. Arnold was unaware that the problem had been very serious as he sent the telegram on 4 August and asked the professor to visit him in Washington within two weeks.⁷⁶ Apparently, Arnold did not contact Millikan until sometime after this telegram had been sent. By mid-September, Kármán was able to travel short distances and a meeting with Arnold was arranged at LaGuardia Airport, a stop-over for

Arnold on his way to Europe. The meeting was brief and honest. When it was over, the Army Air Forces had a new long-range designer while GALCIT had a job opening to fill.⁷⁷

CHAPTER 6

The Problem with NACA and Others...

Such decisions appear very short sighted indeed.⁷⁸

Prof. Theodore von Kármán

"NACA continued to be the most important government agency engaged in fundamental research for the advancement of aeronautical science." After 1939, NACA expanded its staff and, "contributed significantly to most of the technical achievements of the war period."⁷⁹ Since inception in 1915, the role of NACA was specifically tied to "fundamental research," which had been re-emphasized throughout its existence. Entering World War II, NACA functioned as a clearing house for solving the problems of existing weapons and planes. Basic research was limited to whatever might be garnered on the way to fixing the problems of the present day.⁸⁰ Even though NACA held a rather impressive record of aeronautical triumphs, there were two significant reasons why Hap Arnold decided to form an independent group responsible for drafting the long-range forecast for the Army Air Forces.

First, in 1930, while Kármán was testing the GALCIT wind tunnel efficiency rating, Eastman Jacobs, sent by NACA Research Director Dr. George Lewis, monitored the project closely. The 5.6 to 1 efficiency rating was roughly equal to the best wind tunnels available in Europe. Kármán, keeping true to his belief that all information should be openly shared,

allowed Jacobs complete access to the results for his report to Lewis.⁸¹ In 1933, Clark B. Millikan, son of the Nobel Laureate and now a colleague of Kármán at GALCIT, had requested data from a NACA experiment on Boundary Layer Control (BLC); that is, flow of air very close to the surface of an object moving through air. His request was refused and the excuse offered was that the data was too preliminary. It had long been NACA policy to withhold preliminary test results from civil industry but the scientific community, until this instance, had been immune.⁸² Because of incidents like these, long before the professor met the General Arnold, he had a disparaging impression of NACA, its policies, and its leadership.

Throughout the 1930s, these early impressions did not improve. Twice during the period Kármán had proposed the construction of a supersonic velocity wind tunnel. Twice he had been turned down by Dr. G. Lewis. Lewis' rationale in the case of the wind tunnel refusal is an illuminating one. Since the limiting airspeed of an aircraft propeller was approximately 500 miles per hour, to design a wind tunnel which produced wind much faster than that was a futile endeavor. Of course the planes which Kármán had in mind were not to be powered by propellers. Again in 1938, Clark Millikan re-submitted his request for Freeman's boundary layer data. Again, Lewis refused to release the results. Coupling these unreasonable and non-visionary refusals with the fact that Lewis had replaced a fellow Prandtl-ite (Max Munk) at NACA in 1926, Kármán's picture of a managed research team, void of a spirit of cooperation, was evidently accurate.⁸³ Arnold, either through Millikan or Kármán himself, was aware of the ill feelings which were sheltered within the professor's congenial nature.

Second, and more importantly, was General Arnold's own experience with NACA which was similar to that of the GALCIT staff. Even as late as 1939, Hap was a supporter of NACA as the primary hub of aeronautic activity for the Air Corps. He did, however, support Cal Tech as far as wind tunnel research was concerned, a result of his assignment at March Field in the early 1930s where he was personally kept abreast of Kármán's wind tunnel experiments and other activities.⁸⁴ During this period, he was undoubtedly aware of NACA's inhospitability toward GALCIT and Kármán's disappointment in the bureaucracy which it represented. When Arnold arrived in Washington in the late 1930s, he encountered the NACA on a much more personal level.

Having received reports of a German plane capable of speeds in excess of 400 m.p.h., Arnold approached George Lewis, director of research, to find out why "in the name of God we [Army Air Corps] hadn't got one."⁸⁵ Lewis replied, "Because you haven't ordered one." After a rather lengthy conversation, Arnold discovered that Lewis was well aware that the capability had existed for some time to build a faster airplane. He had not suggested that it be built because it was not his function to dictate to the military what they should or should not build. The events that followed re-enforced Arnold's suspicion that the NACA was self-centered and bogged down in bureaucracy.⁸⁶ Hap, having lost trust in the workings and leadership of NACA, resorted to other civilian agencies in an effort to capitalize on new jet engine information made available in 1941 by Great Britain.

In April that year, General Arnold visited England where he was introduced to the Gloster E 28/29 turbojet airplane. Through "reverse Lend-Lease," Arnold obtained the plans for the Whittle Engine which powered the craft. After his return to Washington, Hap gave

the plans to three separate civilian engine companies and instructed them, under strict orders of secrecy, to reproduce the engine for manufacturing. The internal "cloak of secrecy" was so effective that NACA had heard only rumors of the technology exchange, which even included an actual Whittle Engine. And when Chuck Yeager broke the sound barrier in 1947, NACA did not know that the Bell X-1 aircraft even existed.⁸⁷ NACA policies of information exchange under George Lewis left Arnold feeling let down in the area of aircraft development. By the end of the war the general felt no obligation to share information with an agency which, for the previous ten years, had maintained a closed lip approach to technology transfer within the United States scientific community.⁸⁸ The same lack of faith in NACA sent Arnold looking for Kármán in the fall of 1944 to realize what was now Hap's most important objective: The Army Air Force Long Range Development Program.

CHAPTER 7

The Blueprint

...The free thinking of the director, AAF Scientific Advisory Group, should not be hampered by a layer of staff officers who are too busy solving current problems to project themselves into the future.⁸⁹

Gen. Hap Arnold

I cannot say that we did not see things.⁹⁰

Prof. Theodore von Kármán

On 9 November 1944, in a speech to the new NACA Aeronautics Engineering Lab, Arnold told the gathering of scientists and engineers that when the AAF got stuck in a development problem or when looking toward the future of aeronautics, "**normally** we go to the NACA and ask you people to do that work for us."⁹¹ "Normally," may be translated as: having to do with routine or low priority tasks. In 1941, Arnold gave the jet engine problem to civil industry so that the AAF might "catch up" with her European counter-parts. In 1944, Hap gave the important task of looking toward the future of the Air Forces to Kármán and his Scientific Advisory Group (SAG).

After the LaGuardia meeting in mid-September 1944, Kármán was "more impressed than ever with Arnold's vision."⁹² Symbolically, the film, "Wing and a Prayer," starring Don Ameche and Dana Andrews, was a box office smash in September 1944.⁹³ Arnold had directed the professor not to be concerned with current projects which were already being executed. He insisted that the SAG ignore nothing and that they project themselves ten or

twenty years into the future letting their "imagination run wild, and see what kind of Air Force we might have at that time."⁹⁴ To ensure that the SAG could accomplish this crucial task as thoroughly as possible, Arnold imposed no completion deadline, he insisted the SAG travel to all foreign countries and assess their aeronautics programs and then make bold, viable predictions.⁹⁵

To accomplish this, Kármán moved to Washington assuming his post as AAF Consultant on Scientific Matters, officially effective 23 October 1944. The first report Kármán made was organizational in nature naming Hugh Dryden as Deputy on the SAG.⁹⁶ On 1 December 1944, Headquarters Office Instruction (HOI) 20-76, officially established the AAF Scientific Advisory Group and attached it directly to the Commanding General AAF, Hap Arnold.⁹⁷

Eventually "thirty-one giant brains" assembled in Washington and prepared to execute the monumental task at hand. Monthly meetings consisted of Arnold's admonitions to throw conservatism to the wind while Kármán, "The Boss," reminded scientists that they had to deliver on their promises. Frank Wattendorf, a former student and admirer of Kármán, discussed The Boss's unusual work habits and prepared the newcomers, as best he could, for the "von Kármán experience." Not unexpectedly, the younger members of the team found working in the SAG the "equivalent of a semester of grad school each day."⁹⁸ In May 1945, the SAG departed for Europe on "Operation Lusty," a name which The Boss called, "unlikely but pleasant." Arnold's instructions to "Tooe" Spaatz, the European air commander at the time were: "Give them what they want, Get them where they are going. Make it a personal concern."⁹⁹ He did.

After six weeks travelling throughout the devastated countryside of Europe, The Boss met Arnold in Paris for a debriefing on the team's initial findings. Hap was travelling with President Truman to the Potsdam Conference, scheduled for the last week in July, and was pressed for time. He asked the professor to prepare a report for him summarizing the team's findings. On 22 August Kármán submitted, Where We Stand, in fulfillment of Arnold's request. The report included predictions of supersonic flight, practical inter-continental ballistic missiles, nuclear warheads, and the successful development of surface-to-air anti-aircraft missiles.¹⁰⁰ During the fall, The Boss began assembling and compiling the work of the SAG members. It was an arduous, time consuming task. In October 1945, the previously relaxed mood in the SAG work rooms changed. Suddenly there was a great sense of urgency to complete the project.

General Arnold had suffered the first of a series of heart attacks. He was well enough to ask Kármán if the report might be finalized by 15 December 1945. After many sleepless nights by many members of the group, the final report, Toward New Horizons, was delivered to the general right on time.¹⁰¹ Kármán wrote the opening book, Science: The Key to Air Supremacy, as the introduction to the thirty three volume completed, "classified" report. Recommendations included: administrative reorganization, future engine design considerations, technical schooling for air officers, weapons possibilities, and a plea for government authority to "foster," not "dictate," basic research, to name only a few.¹⁰² This study was the first of its kind ever accomplished in American military history. Although future attempts were made to repeat the feat of the SAG, none were as effective nor had the monumental impact on the structure of the Air Force.¹⁰³ While preparing to relinquish

command to Gen. Carl "Tooe" Spaatz, Arnold offered his perceptions of the SAG and its importance.

Hap reminded Spaatz that the Air Forces had no great scientists in their ranks. The military R&D labs had stagnated during the war, largely due to increased production requirements and short-sighted leadership. Outside civilian help had been required during the war to meet development of power plants for aircraft and aircraft structural design problems. Through them, scientific potential became obvious. "These men did things that the average Army officer could never have accomplished. We must not lose these contacts."¹⁰⁴ Arnold's deteriorating physical condition forced him to slow his "fast-paced" leadership after the war ended in August 1945.

Realizing that the war was won, his dream of preparing a blueprint for the Air Forces completed, and his health deteriorating, Arnold retired from service in February 1946, the same month that the original charter for the SAG expired. The last formal meeting of the AAF Scientific Advisory Group was held 6 February 1946, where Arnold addressed the gathering and thanked them for their super-human efforts during the past year. On 1 March 1945, Kármán resigned his government position as AAF Scientific Advisor ending one of the most intellectually active chapters ever written in Pentagon history.¹⁰⁵

CHAPTER 8

The Legacy

General Arnold was unique in his ability to anticipate and to prepare for the future, and when he got together with Theodore von Kármán it was a very fortunate thing indeed, because while General Arnold was not a highly technical man he did understand the importance of science and technology, and while Dr. von Kármán was not strictly a military man he realized the importance to the military of the mobilization of science.¹⁰⁶

Lt. Gen. James H. Doolittle

To Dr. von Kármán and to his close friend, Gen. H.H. "Hap" Arnold, goes the prime credit for the research-and-development orientation of today's Air Force.¹⁰⁷

Dr. Hugh L. Dryden
Deputy Administrator, NASA
SAG Deputy to Karman, 1945

Hap and The Boss held similar beliefs for the future of the Air Forces while complimenting the other's shortcomings on a regular basis. Both men saw the necessity to weld science to the military R&D scheme which included a combination of military men and civilian scientists working together. Both men expected a "can do" approach from their staff members and viewed slow-downs with disgust. Both men appreciated blunt, acute questions. Both were remarkably open minded compared to others in their professions.¹⁰⁸ Both men were dashing in their youth and maintained a certain magnetic quality as they matured. Both enjoyed a good glass of beer.

Aside from the similarities, Kármán had a great respect for Arnold and felt that the

general was the greatest example of a United States military man. The Boss admired his superb dedication and complete logic. Arnold also offered the professor one of his greatest career challenges as chairman of the SAG, and he was extremely flattered that Arnold depended upon him as much as he obviously did. When there was a dispute between the scientists and a military colleague, Hap normally picked the "brown derby" over the uniform. Perhaps this was because of Kármán's ability to explain complicated problems using everyday terms or word pictures. This gift was invaluable to Arnold, who never claimed to have a deep knowledge of science or its principles. The professor had always insisted that university men of highest stature should teach the most elementary classes. Arnold was the recipient of the knowledge that resulted from this belief.¹⁰⁹ Arnold's retirement and Kármán's resignation ended one of the most unique and productive relationships in American military history.

"Tooeey" Spaatz, Arnold's successor, held his glass high at the Stratford, Philadelphia, and toasted General Arnold as a monument to the service because of his imagination, military diplomacy, and "contagious vitality."¹¹⁰ For forty years Arnold had served his country, entering West Point five months before the first airplane flew, and retiring as Commander of the mightiest Air Force in the world. Meanwhile, Hap had seen a global depression and two World Wars. President Harry S. Truman summarized his friend Hap's career in a letter commemorating his retirement:

In the more than forty years you have devoted to the service of your country, you have watched and helped the Army Air Forces grow from a fledgling corps of two airplanes to the mightiest aerial force the world has ever seen--an unbeatable air arm which has contributed so much to the victory we have won and the peace we are determined to keep.¹¹¹

Harry S. Truman

Arnold's Distinguished Service Medal citation emphasized "driving spirit" and "professional genius" in leading the Air Forces to their dominant world position. Perhaps the greatest honor of all came in May 1949, when Hap was awarded the rank of General of the Air Force, the only five star Air Force General rank ever bestowed. On 15 January 1950, Hap died from a heart attack.¹¹²

As for Kármán, he still had several years in the limelight. For the next decade he continued collaboration with the military as chairman of the Scientific Advisory Board which replaced the SAG following one of the recommendations from Toward New Horizons. He was also actively involved in industrial consulting, guiding the European scientific community, and a member of a host host of different aeronautical and astronomical organizations. Donald Douglas, airplane manufacturing mogul, dubbed the professor: "The Elder Statesman of Aviation." On 18 February 1963, his grey bushy hair glistening on a sunny Washington day, he received the first National Medal of Science from President John F. Kennedy. Then the reigning monarch of aeronautical science returned to Europe and his intellectual home: Aachen, Germany. On 6 May 1963, Theodore von Kármán died.¹¹³

APPENDIX

Army Air Corps	AAC
Army Air Forces	AAF
California Institute of Technology	Cal Tech
Commanding General AAC	CGAAC
Commanding General AAF	CGAAF
Guggenheim Aeronautics Laboratory, California Institute of Technology	GALCIT
Jet Assisted Take-off	JATO
Jet Propulsion Laboratory	JPL
Massachusetts Institute of Technology	MIT
National Advisory Committee on Aeronautics	NACA
National Aeronautics and Space Administration	NASA
National Defense Research Committee	NDRC
Research and Development	R&D
Scientific Advisory Board	SAB
Scientific Advisory Group (1944-45)	SAG

ENDNOTES

¹H.H. Arnold to Carl Spaatz, 6 Dec 1945. "Hap Arnold" The Murray Green Collection, Special Collections, United States Air Force Academy, Colorado. (hereafter, Murray Green Collection).

²Henry H. Arnold, Global Mission (New York: Harper and Brothers, 1949), 2-10; and Edgar F. Puryear, Jr., Stars in Flight: A Study in Air Force Character and Leadership (Novato, California: Presidio Press, 1981), 3; and Murray Green Collection, reference to inscription on picture at the Arnold Ranch.

³General H.H. Arnold: Reminiscences of Friends and Acquaintances, United States Air Force Academy, Special Collections, Colorado. (hereafter: Friends of Arnold). Mrs. H.H. Arnold.

⁴Murray Green Collection, ref. L/C box 262A; and Howitzer, 1907.

⁵Murray Green Collection, notes from the Columbia University Oral History Review (hereafter: CUOHR).

⁶Arnold, Global Mission, 7-8; and see Henry H. Arnold and Ira C. Eaker, Army Flyer(New York: Harper and Brothers, 1942), 40-41.

⁷Murray Green Collection, M. Green interview Mrs. H.H. Arnold.

⁸Arnold, Global Mission, 10-15; and Puryear, Stars in Flight, 8. Orville Wright was one of Arnold's instructor pilots.

⁹Puryear, Stars in Flight, 11; and Murray Green Collection, Arnold to Bee, 20 June 1913. Arnold loved to have fun and a drink was never out of the question. His father had been rather strict about the use of alcohol and did not even permit it at Henry and Bee's wedding, a decision he later wished he had modified to allow champaign. Tommy Milling, Arnold's best man for the affair and a fellow pilot, smuggled some liquor up from the Arnold cellar during the reception anyway.

¹⁰Murray Green Collection, ref. L/C box 222, National Archives, Arnold 201, p. 94, Stack W-3; and the CUOHR of B. Foulis. The safety statistics during the 1990-91 flying year for the Air Force showed that less than two major accidents (not necessarily even a fatality) occurred every **100,000 flying hours**. This included **combat operations in the Persian Gulf War**. In 1913 the safety rate equivalent would have been 950 DEATHS per 100,000 flying hours not including major accidents were planes could not be repaired.

¹¹Forrest C. Pogue, "George C. Marshall: Global Commander" in The Harmon Memorial Lectures in Military History, 1959-1987, ed., Harry R. Borowski (Washington D.C.: Office of Air Force History, 1988), 177-183. Arnold met Marshall during this tour and, after watching him dictate field orders directly off of a map, perhaps one Arnold had drafted during his first

Philippine Island tour, Arnold predicted that Marshall would one day be Chief of Staff. He was right.

¹²Alfred Hurley's, Billy Mitchell: Crusader for Air Power, is the best summary of the subject's life. For a more detailed and more recent version, consult the unpublished dissertation on Billy Mitchell by Capt Michael Grumelli, Department of History, USAFA.

¹³Puryear, Stars in Flight, 19. Mitchell was diligent in thanking those who had testified for him during his court martial. Of import to this story are John Montgomery, president of a branch of Pan Am Airlines, and Hap Arnold.

¹⁴New York Times, 23-30 July 1927.

¹⁵Major H.H. Arnold to John K. Montgomery, 15 and 24 July 1927, John K. Montgomery Papers, TMs, Caroliniana Library, University of South Carolina, Columbia (hereafter: J.K. Montgomery Papers); also Arnold, Global Mission, 123-128.

¹⁶Arnold to Montgomery, 24 July 1927. J.K. Montgomery Papers.

¹⁷Montgomery to Arnold, 27 July 1927. J.K. Montgomery Papers. Included in this letter are the specifics of the salary and "perks" offer to Arnold. 1. The presidency of Pan Am; 2. \$8000 per year salary; 3. 300 shares B Stock (voting shares) and 1200 more if he stayed on with the company. I cannot verify that the 300 shares offered were intended to be delivered had Arnold decided NOT to stay on, but he never went.

¹⁸Thomas M. Coffey, Hap: The Story of the U.S. Air Force and the Man Who Built It, General Henry H. "Hap" Arnold (New York: Viking Press, 1982), 126.

¹⁹Arnold, Global Mission, 122.

²⁰Theodore von Karman with Lee Edson, The Wind and Beyond: Pioneer in Aviation and Pathfinder in Space (Boston: Little, Brown and Company, 1967), 304-05.

²¹Michael H. Gorn, The Universal Man: Theodore von Karman's Life in Aeronautics (Washington and London: Smithsonian Institution Press, 1992), 3-5.

²²Ibid., 19-22.

²³Lee Edson, "He Tamed the Wind," Saturday Evening Post, 3 August 1957, 78; and Gorn, Universal Man, 26-7; Hanle, Bringing Aerodynamics to America, 54; One of Charlemagne's greatest military achievements was the revival of the Roman siege train. Although these long trains slowed the main army's ability to react rapidly to exterior threats, the King's cavalry was equipped as a "rapid deployment force" to counter any immediate menace. These supply trains guaranteed that the King's armies were never unprepared to lay siege to an enemy fortress. The young professor hoped that his work might leave a similar legacy.

²⁴Gorn, Universal Man, 29-30.

²⁵Hallion, Legacy of Flight, 46-53; and Doolittle Oral Interview, 26 Sep 1971, #68/68A, United States Air Force Academy Oral History Interviews, USAF Academy, Colorado.

²⁶Robert H. Kargon, The Rise of Robert Millikan: Portrait of a Life in American Science (Ithaca, New York: Cornell University Press, 1982), 87-92; and Gorn, Universal Man, 81-82.

²⁷Gorn, Universal Man, 39-40, 56; and Kármán, Wind and Beyond, 124.

²⁸Kargon, Robert Millikan, 119; and ²⁸22Kármán, Wind and Beyond, 151. Daniel Guggenheim also intended that the U.S. would eventually achieve dominance in the aviation industry, which would preserve the country and boost the economy at the same time.

²⁹Hallion, Legacy of Flight, 170-171, 187-188; Paul A. Hanle, Bringing Aerodynamics to America (Cambridge, Mass.: MIT Press, 1982), 139; Bilstein, NACA, 5-6; Gorn, Universal Man, 52-53.

³⁰Gorn, Universal Man, 48-52; and Kargon, Robert Millikan, 115-117.

³¹Hallion, Legacy of Flight, 187. Of the five original schools, Hallion gave a separate consideration to Cal Tech and lumped all the others into one comprehensive chapter. Without a doubt, Cal Tech stood above the other schools in overall impact.

³²Theodore von Kármán, Toward New Horizons: Science, the Key to Air Supremacy ed., Gary R. Akin and Pamela S. Hammons (Washington D.C.: Headquarters Air Force Systems Command History Office, 1992), reprinted in this commemorative edition.

³³Kármán, Wind and Beyond, 295-296.

³⁴Shirley Thomas, Men of Space: Profiles of the Leaders in Space Research, Development, and Exploration (New York: Chilton Co., 1960), 164.

³⁵Theodore von Kármán, Oral Interview, USAFA Oral History Interviews; Gorn, Universal Man, 75, 84; Futrell, Ideas, Concepts, Doctrine, 219-220. Van Bush had said, "I don't understand how a serious engineer or scientist can play around with rockets." During the late 1930's there was a definite view that "Science was very much against rocketry," said von Kármán.

³⁶Gorn, Universal Man, 58; Thomas, Men of Space, 159.

³⁷Kármán, Wind and Beyond, 233.

³⁸Ibid., 307.

³⁹Emphasis added. Kármán, Wind and Beyond, 307, 247; Thomas, Men of Space, 170-171; Gorn, Universal Man, 87, 145; Lee Edson, "He Tamed the Wind," 77.

⁴⁰Gorn, Universal Man, 56, 65.

⁴¹Gorn, Universal Man, 35, 68; and Theodore von Karman, Oral Interview with Shirley Thomas, Jan 1960.

⁴²Gorn, Universal Man, 68, 73, 83, 157.

⁴³Thomas, Men of Space, 162-167, 180; Edson, "He Tamed the Wind," 69; Gorn, Universal Man, 107, 156. It would be interesting to know if Einstein and Kármán ever discussed military issues while together at Cal Tech. An interesting article by Ilse Bry & Janet Doe "War and Men of Science," Science (11 Nov 1955), 912-913, presents Einstein's views on the responsibility of scientists to Mankind. In this view offered in 1950, Einstein suggests that a "lamentable breakdown" in scientific zeal and its possible impact on human life and death had occurred.

⁴⁴Thomas, Men of Space, 159.

⁴⁵Gorn, Universal Man, 116, 158.

⁴⁶Eugene M. Frame. "The American Dimension," in Alfred F. Hurley and Robert C. Ehrhart, Air Power and Warfare: The Proceedings of the 8th Military History Symposium, 18-20 October 1978 (Washington D.C.: Office of Air Force History, 1979), 61.

⁴⁷Roger E. Bilstein, Orders of Magnitude: A History of NACA and NASA, 1915-1980 (Washington D.C.: National Aeronautics and Space Administration, 1981), 3; and Stetson Conn, ed., United States Army in World War II (Washington D.C.: Center of Military History United States Army, 1989), Buying Aircraft: Materiel Procurement for the Army Air Forces, by Irving B. Holley, 23 (hereafter: Holley, Buying Aircraft).

⁴⁸Bilstein, NACA, 1-15; and Howard S. Wolko, In the Cause of Flight: Technologists of Aeronautics and Astronautics (City of Washington: Smithsonian Institution Press, 1981), 18; and Robert F. Futrell, Ideas, Concepts, Doctrine: Basic Thinking in the United States Air Force, 1907-1960 (Maxwell Air Force Base, Alabama: Air University Press, 1989), Vol. 1, 19; and Wesley Frank Craven and James Lea Cate, The Army Air Forces in World War II (Chicago: The University of Chicago Press, 1948) Vol I, 7. The Air Service sent a few ill-prepared planes with Pershing as aerial observers, before long many of them were destroyed, including several casualties, due to crashes.

Nineteen-fifteen was a watershed year. Albert Einstein offered the "theory of relativity" publicly and Alexander Graham Bell made the first trans-continental phone call (New York to San Francisco). The Panama Canal had opened in August 1914, as had the Great War in Europe. Symbolically, the canal closed for much of 1915 because of a landslide of mud, much like Europe had witnessed in the trenches during the first complete year of the war.

⁴⁹Alex Roland, Model Research: The National Advisory Council for Aeronautics, 1915-1958 (Washington D.C.: National Aeronautics and Space Administration, 1985), 91-95; and Gorn,

Universal Man, 39.

⁵⁰Richard P. Hallion, Legacy of Flight: The Guggenheim Contribution to American Aviation (Seattle: The University of Washington Press, 1977), 13-16.

⁵¹Craven and Cate, The Army Air Forces in World War II, Vol. I, 55, Vol. VI, 181, 235-236; and Hallion, Legacy of Flight, 186. Over forty government agencies were dealing directly with the AAF in the late 1930s and early 1940s, not to mention Lend-Lease and American commitments to that project as well. There was some feeling in the Air Corps that the U.S. was hurting its own build-up by giving away all of its "stuff." Negotiations between American and British officials lessened the feelings that too much was being "lost" to Lend-Lease.

⁵²Arnold, Global Mission, 138-139. The origin of the name "Hap" is still a matter of dispute. Arnold's original West Point tag was "Pewt," a popular cartoon character. One account claims that Henry's "perpetual smile" led a Hollywood representative, who probably could not remember his name, to calling him "Happy." This was eventually shortened. Another version was that Henry, when angry, would involuntarily tighten his lips in an insidious smile. This "smile" deceptively portrayed Arnold as "happy" when troubled. In any event, the name "Hap" did not come into common use until around 1930.

⁵³Kármán, Oral Interview, 27 Jan 1960, USAF Academy Oral History Interviews; and Gorn, Universal Man, 81.

⁵⁴Gorn, Universal Man, 84; Ira C. Eaker, Oral Interview, 19 Oct 1978, USAF Academy Oral Interview Series. Eaker verified that Arnold and his staff reviewed intelligence reports on the air battles of the Spanish Civil War.

⁵⁵Hallion, Legacy of Flight, 201; and Gorn, Universal Man, 84.

⁵⁶Kármán, Oral Interview, 27 Jan 1960, USAF Academy Oral History Interviews.

⁵⁷Lt. Gen. Ira C. Eaker, Address to Air University, 17 Mar 1961, Included in correspondence to author.

⁵⁸Arnold, Global Mission, 178-179.

⁵⁹Puryear, Stars in Flight, 18. To actually enter a war prepared would have violated a long standing American military tradition of **unpreparedness** in the face of any possible conflict. This tradition remains unbroken to the present day although a case could be mounted for an improvement to this sad tradition in regards to the Gulf War.

⁶⁰Laurence Kuter, "How Hap Arnold Built the Army Air Force," Air Force Magazine (September 1973), 93.

⁶¹Craven and Cate, The Army Air Force in WW II, Vol. I, 525; and Herman S. Wolk, "Men Who Made the Air Force," 14, in Murray Green Collection, Roll #1.

⁶²Nathan F. Twining, Oral Interview, USAF Academy Oral History Interviews, #206, 40-42.

⁶³Murray Green Collection, ref. Arnold TMs [microfilm], 1925-26, L/C Box 227. From an article, "Sunday with the Wrights."

⁶⁴Laurence S. Kuter, "The General vs. The Establishment: General H.H. Arnold and the Air Staff," Aerospace Historian (September 1973), 186. The Advisory Council was a very interesting organization which Arnold initiated early in his tenure and CGAAF. It included several officers who were assigned directly to Arnold and who had no other function but to organize tasks and help out the "thinking process" for the general. Arnold wrote to "Tooe" Spatz on the occasion of their change of command that it was one of the most valuable tools he ever had. A more detailed study of the Advisory Council is not offered here but would be a valuable examination for the future.

⁶⁵Murray Green Collection, ref. Thomas Milling, CUOHR, and int. with Ben S. Kelsey, 9 June 1971; also Nathan F. Twining, Oral Interview, USAF Academy Oral History Interviews, #206, 3 Nov 1967; Puryear, Stars in Flight, 22, 37; and Coffey, Hap, 202.

⁶⁶Arnold to Spatz, 19 Aug 1942, Murray Green Collection.

⁶⁷Kuter, "How Hap Arnold Built the AAF," 89; and Puryear, Stars in Flight, 41, Spatz explains Hap's "impatience".

⁶⁸Friends of Arnold, Carl A. Spatz, CUOHR. "I never had a letter of impatience from Gen. Arnold," he said.

⁶⁹Murray Green Collection, Interview with M/G Franklin Carroll, 1 Sep 1972; James H. Doolittle, Oral Interview, 22 Dec 1977, 20-21; Kuter, "How Hap Arnold Built the AAF," 89; and Kuter, "The General vs. The Establishment." 186.

⁷⁰Murray Green Collection, ref. letter Bowles to M. Green, 18 Mar 1971.

⁷¹Murray Green has suggested that Arnold's impatience was the key to his personality. This is certainly true. What is even more important is that he had the right personality for the given situation.

⁷²Kármán, Oral Interview, USAF Academy Oral History Interviews.

⁷³Doolittle, Oral Interview, 22 Dec 1977, 4.

⁷⁴Murray Green Collection, ref. Interview with Godfrey McHugh, 21 Apr 1970. McHugh was the administrative assistant to the Scientific Advisory Group at its inception in December 1944; and Puryear, Stars in Flight, 31.

⁷⁵Kármán, Wind and Beyond, 268.

⁷⁶Telegram H.H. Arnold to Kármán, 4 Aug 1944. Henry Harley "Hap" Arnold Papers, Library of Congress, Washington D.C.

⁷⁷Kármán, Oral Interview, USAFA, 8; and Roland, Model Research, 665. There is a definite irony in this meeting. LaGuardia had been a supporter of civil aeronautics for a long time and was a huge supporter of NACA, the organization which the newly conceived Scientific Advisory Group (SAG) was specifically designed to circumvent. The story of this historic meeting is well portrayed in Gorn, The Universal Man, and Coffey, Hap: The Story of the Air Force and the Man Who Built it.

⁷⁸Kármán, Wind and Beyond, 224.

⁷⁹Craven and Cate, Army Air Force in World War II, Vol. VI, 235; Futrell, Ideas, Concepts, Doctrine, Vol. 1, 542.

⁸⁰Roland, Model Research, 665; I.B. Holley, Buying Aircraft, 22-23; Emme, "The American Dilemma," 76-78.

⁸¹Kármán, Wind and Beyond, 126-127. The highly technical information which Eastman took with him is not really important, the fact that it was shared in an open atmosphere of scientific curiosity is.

⁸²Roland, Model Research, 538.

⁸³Kármán, Wind and Beyond, 224-225; and Roland, Model Research, 97-98, 548.

⁸⁴Roland, Model Research, 678.

⁸⁵John F. Victory, Oral Interview, #210A, USAF Academy Oral Interviews. Victory was the first employee of the NACA in 1915 and served as secretary throughout the period of this study.

⁸⁶John Victory, Oral Interview, #210, USAF Academy Oral History Interviews. The story is too long to reproduce but, essentially, Lewis sat at his desk in Washington and strictly adhered to the "advisory mission" of NACA. Never once did NACA offer to expedite production or offer data without being asked by the Army Air Corps first. Arnold certainly saw this attitude as an obstacle to rapidly expanding the size of the air arm.

⁸⁷Bilstein, NACA, 31-48; Roland, Model Research, 191-192.

⁸⁸Roland, Model Research, 192. Arnold did not give up on NACA altogether. In 1944 he pressured Donald Marr Nelson to push the construction of the Jet Engine Facility in Cleveland, Ohio. This facility became the test center for the engines that Arnold had kept secret from them in earlier years. Ironically, the facility was named after George Lewis, the research director most directly responsible for the Arnold and Kármán's distrust.

⁸⁹Arnold to Spaatz, 6 Dec 1945. Murray Green Collection.

⁹⁰Kármán, Oral Interview, USAF Academy Oral History Interviews.

⁹¹Murray Green Collection, ref. H.H. Arnold speech to NACA Aeronautics Engineering Research Lab, 9 Nov 1944.

⁹²Kármán, Wind and Beyond, 267-68.

⁹³New York Times, 8, 10, 11 September 1944. Don Ameche died of cancer on 7 December 1993.

⁹⁴Arnold to Spaatz, 6 Dec 1945, and Arnold to Eaker, 22 May 1945, Murray Green Collection; Craven and Cate, The Army Air Forces in WW II, vol. VI, 234; Thomas A. Sturm, USAF Scientific Advisory Board: Its First Twenty Years, 1944-1964 (Washington D.C.: USAF Historical Division Liaison Office, 1967), 37.

⁹⁵Arnold, Global Mission, 532-533; Re-enforced by a cable sent to Spaatz after the war was nearing completion, 15 Apr 1945, Murray Green Collection.

⁹⁶Murray Green Papers, ref. Kármán's first report for the SAG, 23 Nov 1944, L/C box 79; and Gorn, Universal Man, 99.

⁹⁷Murray Green Papers, ref. H.H. Arnold Papers, HOI 20-76, L/C box 40; Arnold to Kármán, 7 Nov 1944, reprinted in, Toward New Horizons, commemorative addition, 1992; Gorn, Universal Man, 100.

⁹⁸Thomas, Men of Space, 176; T. F. Walkowicz, "von Karman's Singular Contributions to Aerospace Power," Air Force Magazine (May 1981), 60-61; Gorn, Universal Man, 47.

⁹⁹Kármán, Wind and Beyond, 272; Gorn, Universal Man, 103-105; and Kármán, Oral Interview, USAF Academy Oral History Interviews.

¹⁰⁰Theodore von Kármán, Where We Stand, 22 August 1945. TMs, Air Force Materiel Command History Office, Wright/Patterson Air Force Base, Ohio, 1-2. Thomas A. Sturm has summarized the early efforts of the SAG in, USAF Scientific Advisory Board, which includes the evolution and decline of the group through 1964.

¹⁰¹Kármán, Wind and Beyond, 290; Gorn, Universal Man, 113-114.

¹⁰²Kármán, Toward New Horizons, reprinted version, 69-84.

¹⁰³Kármán, Wind and Beyond, 294; Michael H. Gorn, Harnessing the Genie: Science and Technology Forecasting for the Air Force, 1944-1986 (Washington D.C.: Office of Air Force History, 1988), 2-17.

¹⁰⁴Arnold to Spaatz, 6 Dec 1945, Murray Green Collection.

¹⁰⁵Sturm, Scientific Advisory Board, 13; Gorn, Universal Man, 118-119.

¹⁰⁶James H. Doolittle, Oral Interview, 21 Apr 1969, USAF Academy Oral History Interviews. Jimmy Doolittle held one of the only military Ph.D.'s in aeronautics during this time. Doolittle also went on to chair the Scientific Advisory Board, the successor to the SAG, from the fall of 1955 through mid-1958. He also led the first American air attack against the Japanese off of an aircraft carrier in 1942 earning him the Congressional Medal of Honor.

¹⁰⁷Hugh Dryden, Theodore von Karman: 1881-1963 (New York and London: Columbia University Press, 1965), 7.

¹⁰⁸John W. Huston, "The Wartime Leadership of Hap Arnold," in Air Power and Warfare, Hurley and Erhart, 181; and Gorn, Universal Man, 114; Hanle, Bringing Aerodynamics to America, 136-137.

¹⁰⁹Murray Green Papers, ref. Interview with General Yates, 9 Jan 1970 and Interview with Lt. Gen Harold Grant, 15 Oct 1970; Kármán, Wind and Beyond, 225, and Oral Interview with Shirley Thomas, Jan 1960; Thomas, Men of Space, 175; Gorn, Universal Man, 70; Hanle, Bringing Aerodynamics to America, 136-137.

¹¹⁰Murray Green Papers, ref. Spaatz toast to Arnold at his retirement party, February 1946.

¹¹¹Truman to Arnold, 14 Feb 1946. Harry S. Truman Presidential Papers, Harry S. Truman Presidential Library, Independence, Missouri.

¹¹²Harry S. Truman Papers, DSM Citation, 357-J; Arnold to Truman, 23 May 1949; also Truman to Mrs H.H. Arnold, 15 Jan 1950.

¹¹³Edson, "He Tamed the Wind," 76; Gorn, Universal Man, 153.

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