INTRODUCTION
The Dawn of the Space Age

> In making the decision as to whether or not to undertake construction of such a [space]craft now [1946], it is not inappropriate to view our present situation as similar to that in airplanes prior to the flight of the Wright brothers. We can see no more clearly all the utility and implications of spaceships than the Wright brothers could see fleets of B-29s bombing Japan and air transports circling the globe.[1]

In 1946, the authors of the first Air Force-sponsored Project Rand (Research and Development) study on the feasibility of artificial earth satellites aptly characterized the challenge and uncertainty surrounding the country's initial foray into the space age. Postwar skeptics dismissed proposed satellite and missile projects as excessively costly, technologically unsound, militarily unnecessary, or simply too "fantastic," while space advocates themselves remained hard pressed to convince opponents and stifle their own self-doubts. Space represented a "new ocean," a vast uncharted sea yet to be explored. The dawn of the space age brought many questions but offered few answers. Could satellites be successfully produced, launched, and orbited? If technically feasible, what military—or civilian scientific—functions should they perform? How should space functions be organized? What space policy would best integrate space into the national security agenda? What should be the Air Force role in space?

In view of the uncertainties involved, the period from the close of the Second World War to the launching of the first Sputnik in the fall of 1957 proved to be the conceptual phase of the nation's space program. Only by the mid-1950s, a full decade after the 1946 Rand study, could observers identify two sides of a national space policy that would characterize the American space program from the Eisenhower presidency to the present day. One side comprised a civilian satellite effort, termed Project Vanguard, designed to launch a scientific satellite by the end of 1958 as part of the International Geophysical Year. The other, an Air Force-led military initiative, sought to place into earth orbit a strategic reconnaissance satellite capable of providing vital intelligence about Soviet offensive forces.[2]

The Air Force played a central role during the formative era before Sputnik and afterward when the nation's leaders established space policy and organized to confront the Sputnik challenge. The National Space Act of 1958 created the civilian agency, the National Air and Space Administration (NASA), to operate the civilian space effort, while the Air Force and other military services and agencies jockeyed for position within the Defense Department and the overall national space program. Although the Air Force won the contest for military "supremacy" among the services, it seemed to many Air Force leaders that the policy of promoting the "peaceful uses of space" meant a diminished role for Air Force space interests and a threat to the nation's security. Nevertheless, by the end of the Eisenhower administration, the Air Force space program revealed the basic defense support mission characteristics it would retain for the remainder of the century.

Arnold and von Kármán Form a Partnership

The Air Force space saga began with the partnership of General Henry H. "Hap" Arnold, Commanding General of the Army Air Forces (AAF), and the brilliant scientist, Dr. Theodore von Kármán, Director of the Guggenheim Aeronautical Laboratory at the California Institute of Technology (GALCIT). Together they provided the emerging Air Force with a strong research and development focus and championed Air Force interests in the new missile and satellite fields. Their legacy would endure.

Hap Arnold and Dr. von Kármán first met in 1935, when Arnold visited his friend, Dr. Robert Millikan, head of the California Institute of Technology (Cal Tech) in Pasadena, California, while serving as commander of the First Wing, General Headquarters Air Force, at neighboring March Field. The two men could hardly have appeared more different. Arnold radiated physical energy and heartiness from his large frame, while the short, slender intellectual Hungarian émigré exuded a quieter, less forceful presence. Yet the two men took to each other immediately. The Air Corps brigadier general's long-standing interest in aviation technology and association with the National Advisory Committee for Aeronautics (NACA) helped spark an immediate personal and professional friendship. Back in the First World

War Arnold had participated in primitive pilotless aircraft tests, and later served as a military representative to the NACA. For his part, renowned aerodynamicist von Kármán later recalled that while Arnold had no significant technical background or training, he possessed an appreciation for what science could contribute to aviation and the "vision" to persevere against long odds.[3]

After their first meeting, Arnold often visited Cal Tech to observe wind tunnel experiments and discuss with von Kármán various aeronautical and, especially, rocket propulsion initiatives Cal Tech had just undertaken. Von Kármán, who had established his reputation in structures and fluid dynamics as well as aerodynamics, showed the foresight to support a research project first proposed in 1936 by his bright graduate student, Frank Malina. Malina and his four-man team, known as the "suicide squad," had formed the GALCIT Rocket Research Group to develop both high-altitude sounding rockets and rocket-powered airplanes along the lines described by Austrian theorist, Dr. Eugen Saenger. With Cal Tech's move into rocketry, von Kármán's research placed him squarely at the center of the two areas of propulsion that would take the Air Force to "the fringes of space." One was the aerodynamic approach, represented by the NACA, which involved jet-propelled airbreathing "cruise" missiles; the other, astronautical approach, encompassed rocket-powered "ballistic" missiles.[4]

NACA and the Rocketeers Lay the Groundwork

Since its founding in 1915, the National Advisory Committee for Aeronautics had served as the major government agency performing experiments in basic aviation technology and advanced flight research. During the 1920s and 1930s its research engineers worked closely with the Army, Navy, the Bureau of Standards, and the infant aircraft industry to improve aircraft design and performance. Relying primarily on wind tunnels at its Langley research laboratory in Virginia, its research led to use of retractable landing gear, engine cowlings, laminar flow airfoils, and low-winged all-metal monoplanes. It developed an outstanding reputation for its work in aerodynamics and with aerodynamic loads. Chartered to benefit both civil and military aviation, the NACA generally performed the research and left to the military services and industry the practical development of aircraft design and production. During the 1930s, the country's focus on Depression issues and budget retrenchment convinced the NACA to remain a small agency with interests primarily in aerodynamics. On the eve of World War II, Chairman Vannevar Bush's organization employed only 523 people and operated one research laboratory at Langley Field.[5]

Wartime, however, brought major expansion in the number of personnel, broader responsibilities in the area of structural materials and powerplants, and the addition of two new laboratories, one adjacent to Cleveland's municipal airport, and the other next door to the naval air station at Moffett Field forty miles southwest of San Francisco. During the war the NACA served as the "silent partner of US airpower," and solved a host of aeronautical problems. Alarmed by reports of German turbojet developments in 1940, for example, the NACA established a Special Committee on Jet Propulsion, and followed in 1944 with a Special Committee on Self-Propelled Guided Missiles. Although the NACA intended to work diligently with the Navy and Army Air Forces on these threats, the need to provide "quick fixes" throughout the conflict meant that basic research became secondary. At war's end the NACA proved eager to learn from the war by continuing its cooperative research efforts with the military. In an agreement signed between the NACA and the services in 1946, the parties agreed that "the effects of accelerated enemy research and development in preparation for war helped to create an opportunity for aggression which was promptly exploited. This lesson is the most expensive we ever had to learn. We must make certain that we do not forget it."[6]

The NACA's postwar vision embraced support of American supersonic flight probes by means of small solid-propellant sounding rockets, and the "X" series of high-altitude, rocket-propelled research aircraft. The first rocket-powered aircraft, Bell Laboratory's X-1, broke the sound barrier on 14 October 1947 with Captain Charles "Chuck" Yaeger at the controls. His historic flight became the first of many increasingly higher and faster experimental aircraft flights toward the fringes of space. The last, the single-place X-20A Dyna-Soar (named for dynamic soaring), would be the Air Force's best hope to launch a manned boost-glide rocket aircraft to the border of space. Although it did not become operational after initial development in the late 1950s, the Dyna-Soar served as a precursor of the Space Shuttle of the 1980s. Although the NACA expressed interest in rocket propulsion, its focus remained centered on aerodynamic experiments and manned flight within the earth's atmosphere. Space research seemed wholly outside its experience and interests.[7]

Rocketeers Lead the Way

Spaceflight represented a challenge far more daunting than traditional aviation. Although future Air Force leaders would lay claim to spaceflight as a logical extension of Air Force operations in the atmosphere, aviation technology offered only limited solutions on the road to outer space. Although the technical advances that led from reciprocating to jet turbine engines powered aircraft higher into the upper atmosphere, the oxygen-dependent airplane remained confined to the atmosphere. Rockets, on the other hand, operate independent of the atmosphere by relying on their own internal propellants: fuel and oxidizer. In their flight through increasingly thinner atmosphere on the way to airless space, rockets become progressively more efficient. Although the post-World War II American rocket research airplanes could provide useful information on the guidance and control challenges facing vehicles in the upper atmosphere, their small rockets could never break the bonds of gravity, and they remained primarily aerodynamic vehicles. To operate either manned spacecraft or instrumented satellites in outer space, rockets needed sufficient thrust to boost their payloads into orbit where centrifugal force balanced the earth's gravitational field.[8]

The challenge of manned spaceflight had captivated the imaginations of dreamers for centuries. Yet their ideas remained only idle musings until technological progress in the late 19th century led serious enthusiasts to consider liquid-propellant rockets as "boosters" of spacecraft. Among the pioneers of liquid-propellant rocket research linked to visions of manned spaceflight, three men—Russian Konstantin Tsiolkovsky, German-Romanian Hermann Oberth, and American Robert Goddard—paved the way for the successful military and civilian space programs of the second half of the 20th century. While their research initially led to production of bombardment rockets for use by their respective military forces in the Second World War, they all remained committed to visions of spaceflight.[9]

The earliest of the space triumvirate, mathematics teacher Konstantin Eduardovich Tsiolkovsky, in 1895 published the first technical essays on artificial earth satellites. By the end of the century, he had worked out the theory of a liquid-fueled rocket dependent on kerosene to achieve sufficient exhaust velocity. For the next 20 years he immersed himself in theoretical studies but remained largely unknown to the world outside Russia. Yet, by the time of his death in 1935, his pioneering work had helped the Soviets establish a strong prewar rocket and jet-powered aircraft development program which led to the space program of the postwar era.

Although Hermann Oberth also taught mathematics and produced important theoretical studies on spaceflight, he assumed the role of publicist for rocketry and space exploration to enthusiastic European audiences after World War I. In 1923 he established his reputation in the new field of astronautics with the seminal publication, "The Rocket into Interplanetary Space," in which he described the technical requirements for propelling satellites into earth orbit. In 1927 he helped found the German Society for Space Flight, which became the most influential of the numerous rocket societies in Europe. By 1931, Oberth's work with the Society came to the attention of the German Army, which saw in sponsorship of the young rocket scientists a means of obtaining bombardment rockets for an army sorely constrained by the Versailles Treaty. Among the Society members who joined the Army project in 1932 was a 20-year old engineer named Wernher von Braun. After 1933, the Nazi regime expanded the Wehrmacht program and in 1937 began developing the Peenemuende experimental site on the Baltic coast under supervision of Captain Walter Dornberger. Although von Braun and his colleagues had now to focus on long-range rockets to help fuel Germany's military expansion, they continued to dream of manned spaceflight. During the Second World War, while the Luftwaffe produced the V-1 aerodynamic pulse-jet "cruise" missile, the Wehrmacht's Peenemünde rocketeers developed the far more impressive "big rocket," the V-2. Known as the A-4 to the rocket specialists, the V-2 measured 46 feet in length, weighed 34,000 pounds, and approached a range of 200 miles under 69,100 pounds of thrust produced by its liquid-propellant engine. To the Allies the V-2 presented a frightening weapon that could not be thwarted with any known defense. After the war Americans discovered that German plans had called for an intercontinental ballistic missile to strike New York by 1946. To the German rocketeers, however, the A-4 always represented the first rung on the ladder to space. After the war, the American Army's Operation Paperclip brought Dornberger, von Braun, and a host of other German rocket experts to the United States, where they joined the Army's rocket program—with their visions of spaceflight still alive.[10]

The German rocket specialists freely acknowledged their debt to American rocket pioneer, Robert H. Goddard. Unlike his Russian and German contemporaries, Goddard immediately moved beyond theoretical studies to practical experimentation. He always found applied research more exciting than theoretical studies. From his post as a physics professor at Clark University, Goddard began experimenting with powder rockets, and in 1914 received a patent for his liquid-propellant rocket engine. In 1920 the Smithsonian released his highly technical paper, "A Method of Reaching Extreme Altitudes," which described various rocket-propelled experiments that could be conducted as high as 50 miles in altitude. His paper also included a theoretical argument for rocketing a payload of flash powder to the moon, which drew public censure after a *New York Times* reporter ridiculed the idea in print. The experience left Goddard badly scarred and more than ever inclined to focus on private research. By 1926 he had built and tested the first liquid-propellant rocket, and in 1935 successfully launched a gyroscopic-stabilized rocket to an altitude of 7000 feet. Eventually, the prolific experimenter amassed an amazing 214 patents for his designs and devices. But Goddard preferred working alone and jealously guarded his work from other space enthusiasts like the intrepid members of the fledgling American Rocket Society.

In the 1930s Goddard moved his increasingly complex liquid propellant experiments from Massachusetts to the New Mexico desert, where he worked with his wife and various assistants supported by grants from the Guggenheim Foundation. Guggenheim officials quite naturally sought to bring Goddard and von Kármán's Cal Tech Rocket Research Project team together. Characteristically, Goddard proved reluctant, and von Kármán refused to collaborate without full disclosure of Goddard's research results.[11]

Despite the acknowledged importance of Goddard's work for future rocket development, active collaboration between von Kármán and Goddard might well have placed the postwar American rocket program on better technical footing and created more incentive for the Air Force to promote research in ballistic rather than aerodynamic missiles after the war. Cooperation between the two camps would certainly have helped the neophyte rocket group at Cal Tech, which had developed convincing theories about rocket flight but had no experimental data to work with. Moreover, as Malina recalled, in the 1930s most scientists generally considered rocket experiments a part of science fiction. With so little available practical data, Goddard's assistance would have been welcomed by von Kármán and the young rocketeers, who proceeded largely independently of Goddard.[12]

Wartime Provides the Momentum—Arnold and von Kármán Establish the Foundation

Meanwhile, von Kármán and his Cal Tech rocket team continued their research into high-altitude sounding rockets and jet-assisted takeoff (JATO) devices by examining potential fuel types, rocket nozzle shapes, reaction principles, and thrust measurements. They managed to keep their experiments afloat with very little money until General Arnold came to the rescue in 1938. Late that year, Arnold, now chief of the Army Air Corps, helped convince the National Academy of Sciences to provide initial funding for the Cal Tech project. Shortly thereafter, in January 1939, the Air Corps assumed direction of the program, and in June awarded the researchers a $10,000 contract. Von Kármán explained that the program's label, "Air Corps Jet Propulsion Research, GALCIT #1," included the word "jet" rather than "rocket" because of wide-spread skepticism among his colleagues. As one of them told him, he was welcome to the "Buck Rogers" job.[13]

Malina wisely committed his team to explore both liquid- and solid-propellant rocket engine research. The team made rapid progress once they developed the first relatively long-duration, controlled-explosion solid-propellent engine. In August 1941, the Cal Tech engineers carried out their first flight tests in which Captain Homer Boushey, using four JATO canisters attached to his Ercoupe monoplane, rapidly climbed to an altitude of 20 feet. Malina was ecstatic. Continued test successes brought in a JATO contract from the Navy, and von Kármán and Malina in 1942 decided to capitalize on their growing project by forming a private company, Aerojet Engineering Company, to produce the jet canisters and work on other rocket-related contracts they expected to receive.[14]

In late 1943, after reviewing intelligence reports on German rocket development, von Kármán wrote a brief paper entitled, "Memorandum on the Possibilities of Long-Range Rocket Projectiles," in which he proposed that the AAF support development of a 10,000-pound air-breathing missile with a seventy-five-mile range as an extension of JATO research. When the AAF demurred, the Army Ordnance Department stepped in and offered von Kármán a far more challenging contract. The scientist readily agreed to the Army's project, which called for producing a 20,000-pound liquid-propellant rocket with a burn time of sixty seconds and a range of nearly forty miles. Organized under Frank Malina, the large project became known as ORDCIT (representing Ordnance, California Institute of Technology), until renamed the Jet Propulsion Laboratory (JPL) in November 1944. Their work would lead to the successful launching of the WAC Corporal series of liquid-propellant sounding rockets after the war. Meanwhile, as the Army's Ordnance Department focused primarily on rockets, the AAF's Air Materiel Command preferred to stress air-breathing missiles.[15]

During much of the war, von Kármán served as an aeronautical troubleshooter for Hap Arnold, the Commanding General of the AAF. By 1944 Arnold had become convinced that the next war, unlike the last, would demand far more technical competence. As Chief of the Army Air Forces, he said, his job was to

> project [himself] into the future; to get the best brains available, have them use as a background the latest scientific developments in the air arms...and determine what steps the United States should take to have the best Air Force in the world twenty years hence.[16]

In September of that year he called on von Kármán to lead a study group comprised of civilian and military experts to chart a course for the Air Force future. Arnold outlined his objectives for the group in a 7 November 1944 memorandum, "AAF Long Range Development Program." In order to place Air Force research and development programs on a "sound and continuing basis," he called for a plan whose farsighted thinking would provide a sound prescription for preparing Air Force research and development programs as well as congressional funding requests. Because "our country will not support a large standing Army" and "personnel casualties are distasteful, we will continue to fight mechanical rather than manpower wars." Given these constraints, he said, how can science be used to provide the Air Force with the best means to ensure the nation's security?[17]

With Arnold's strong support to overcome any bureaucratic impediments, von Kármán began work immediately, and by December had brought together a group of twenty-two renowned scientists and engineers. Calling itself the Army Air Forces Scientific Advisory Group, it would remain in place and continue as the Scientific Advisory Board after the Air Force became a separate service in September 1947. Following field trips to Europe and Russia to assess the current state of research, von Kármán's group on 22 August 1945 issued a preliminary report, *Where We Stand,* which explored the "fundamental realities" of future air power. The report argued that technological advances led by Germany during the war set the stage for an air force that must embrace supersonic flight, long-range guided missiles with highly destructive payloads, and jet propulsion to achieve air superiority. Von Kármán viewed government-supported research centers on the German model as a major element in the postwar national defense structure. *Where We Stand* raised crucial questions about the future of air power, and the Scientific Advisory Group intended to provide answers in its final report to General Arnold due at the end of the year.[18]

Meanwhile, while von Kármán and his team in late 1945 gathered additional field data and prepared their final report to the AAF chief, Arnold took additional steps to shape the future Air Force's scientific focus. Two of the most important involved the creation of Project Rand and a new Air Staff office to establish and direct the Army Air Forces' research and development agenda.

In September of 1945, Franklin Collbohm of the Douglas Aircraft Company proposed that the AAF establish a research project to provide it with long-range strategic planning based on ongoing scientific and technological advances. Collbohm's ideas had taken shape during his wartime association with Dr. Edward L. Bowles, who had served as General Arnold's special technical consultant. Late that month, Arnold and Bowles flew to California, where at Hamilton Field, north of San Francisco, they met with Collbohm and Donald Douglas, who strongly supported the proposal. At their meeting, Arnold decided to divert $10 million from the fiscal year 1946 procurement budget for Douglas Aircraft to organize a group of civilian scientists and engineers at Santa Monica, California, which would function independently of the company's existing research and engineering division. It would serve as a technical consultant group charged with operations analysis and long-range planning to examine future warfare and the best way the Air Force could perform its missions. Shortly thereafter, the Air Materiel Command (AMC) and Douglas Aircraft agreed to a three-year, $10 million contract for Project Rand to begin operating in May 1946.[19]

To provide an Air Staff focus for Project Rand and other research activities, General Arnold also created the office of Deputy Chief of Air Staff for Research and Development. The new position, which became effective 5 December 1945, drew criticism from the powerful Air Materiel Command, which heretofore tightly controlled the AAF procurement process from initial requirements to completed system. AMC favored rigid directives establishing specific AAF-determined goals for contractors without involving civilians in the planning process. Critics complained that research fell victim to production priorities at AMC. The new arrangement reflected Arnold's flexible approach to research and development whereby Rand would conduct broad investigations to see what could be accomplished and recommend courses of action and the new Air Staff office would provide central direction. AMC never reconciled itself to the new Air Staff position, while the Air Staff remained unwilling to assign it specific responsibility for the satellite and guided missiles programs. These would remain subjects of intra-Air Force organizational squabbles throughout the pre-Sputnik period. Nevertheless, initial prospects for achieving Arnold's goals appeared bright when he selected as his first Deputy Chief of Staff for Research and Development the hard-driving combat veteran, Major General Curtis E. LeMay.[20]

In November 1945, General Arnold became the first prominent military figure to address future warfare in terms of missile and satellite potential. In a report to Secretary of War Robert Patterson on 12 November, the air chief described the future importance of missiles and satellites as a means of preventing another Pearl Harbor-like surprise attack on the United States, and he outlined his vision for the nation's air arm. Strongly opposing shortsighted focus on present day forces, he cautioned that

> national safety would be endangered by an Air Force whose doctrines and techniques are tied solely to the equipment and processes of the moment. Present equipment is but a step in progress, and any Air Force which does not keep its doctrines ahead of its equipment, and its vision far into the future, can only delude the nation into a false sense of security.[21]

For Arnold, the forces of the future must never be sacrificed for the forces of the present. While the current state of technology convinced him to support manned aircraft, he envisioned a pilotless air force and supported developing intercontinental ballistic missiles (ICBMs) for the future Air Force. Profoundly affected by the German V-2 (A-4) rocket missile, he called for a similar weapon for the American arsenal, one "having greatly improved range and precision, and launched from great distances. [Such a weapon] is ideally suited to deliver atomic explosives, because effective defense against it would prove extremely difficult." In perhaps his most controversial prognostication, he proposed launching such "projectiles" from "true space ships, capable of operating outside the earth's atmosphere. The design of such a ship is all but practicable today; research will unquestionably bring it into being within the foreseeable future." Much of General Arnold's vision for his future Air Force received strong backing from Theodore von Kármán's monumental study on the state of air force technology—past, present, and future.[22]

After General Arnold suffered a massive heart attack in October 1945, von Kármán drove his group hard to conclude their work by the end of the year. In mid-December 1945 von Kármán's team produced the remarkable 33-volume report, *Toward New Horizons*. The first volume, "Science: The Key to Air Supremacy," set the tone by declaring that the Air Force should establish its policy, create new organizational alignments, and lay the "foundation of organized research" so that science would become an integral part of the Air Force. Von Kármán proceeded to discuss many specific means for providing technological training for service personnel and adequate research and development facilities, for disseminating scientific ideas at the staff and field levels, and promoting cooperation between the Air Force and science and industry. Regarding the latter, he noted that the Air Force preferred to sponsor research and development activities outside its own organizations, and this should be continued on a broader scale through extensive contacts with universities, research facilities, and scientists. As a means of providing continued scientific advice to Air Force leaders, he recommended that Arnold continue the Scientific Advisory Group as a permanent institution.[23]

Toward New Horizons expanded on issues discussed in von Kármán's "Science: The Key to Air Supremacy." The report's assessments of space issues are particularly interesting. Both jet and rocket propulsion received considerable attention, and von Kármán predicted the eventual operational success of ICBMs and declared the "satellite"..."a definite possibility." In his memoirs, von Kármán recounts that his group "examined the thrust capabilities of rockets and concluded that it was perfectly feasible to send up an artificial satellite, which would orbit the earth. We did not, however, give consideration to the military potential of such a satellite."[24] In fact, neither ICBMs nor satellites received more than passing mention because von Kármán and his colleagues believed that technological barriers would delay successful ballistic missiles for at least a decade. The report proceeded to emphasize what could be achieved within the atmosphere with jet propulsion. Indeed, von Kármán proposed that the Air Force implement a deliberate, step-by-step guided missile development program based on air-breathing missiles rather than ballistic rockets. The Air Force would accept von Kármán's argument and follow the air-breathing approach to missile development. Although von Kármán differed with other prominent scientists who dismissed the ICBM entirely, his recommendations served to chart an Air Force course that would delay development of the long-range ballistic missile.[25]

Nevertheless, *Toward New Horizons* proved to be a landmark because it established the importance of science and long-range forecasting in the Air Force. In staking out a role for military research, von Kármán differed fundamentally with colleagues like highly regarded Dr. Vannevar Bush, who believed that the military services should confine themselves to improving existing weapons and leave new scientific ideas to the civilian experts. *Toward New Horizons* helped ensure that the Air Force would reflect von Kármán's thinking. As his biographer aptly concludes, von Kármán's "detailed, highly technical blueprint set the agenda of research and development [in the Air Force] for decades to come."[26]

Arnold's and von Kármán's comments did not escape the attention of Dr. Bush, then the influential Director of the Office for Scientific Research and Development, and Chairman of the Joint Committee on New Weapons of the Joint Chiefs of Staff. Having sharply differed with von Kármán on military prerogatives in the research field, he turned his attention to the predictions of military officers on matters scientific. Appearing before a special Senate Committee on Atomic Energy in December 1945, Dr. Bush observed that

> We have plenty enough to think about that as [sic] very definite and very realistic-enough so that we don't need to step out into some of these borderlines, which seem to me more or less fantastic. Let me say this: There has been a great deal said about a 3,000-mile high angle rocket. In my opinion such a thing is impossible and will be impossible for many years. The people who have been writing these things that annoy me have been talking about a 3,000-mile high-angle rocket shot from one continent to another carrying an atomic bomb, and so directed as to be a precise weapon which would land on a certain target such as this city. I say technically I don't think anybody in the world knows how to do such a thing, and I feel confident it will not be done for a very long period of time to come. I think we can leave that out of our thinking. I wish the American public would leave that out of their thinking.[27]

When asked whether he was addressing his remarks to anyone in particular, he specifically identified General Arnold, whose report to Secretary of War Patterson had appeared the previous month.

Although Dr. von Kármán could characterize Vannevar Bush as "a good man... limited in vision,"[28] Bush and other prominent civilian scientists who expressed similar criticism had a major influence on the Air Force missile and space development programs. Their pessimism reflected current thinking in many postwar circles that contributed to stifling research by limiting it to the technical problems posed by ICBMs. In the postwar flush of victory and sense of American superiority, the American monopoly of seemingly scarce of fissionable uranium and the great weight of the first atomic bombs produced an air of complacency about the technological future. Atomic bombs of over five tons and relatively poor destructive capacity ("kill-radius") suggested that missiles could never be constructed with sufficient thrust and guidance accuracy to provide a credible operational weapon. Dr. Bush continued until his retirement in 1948 to manage research and development for the Defense Department, where he became known for his parsimonious funding of military programs that could not guarantee progress to his satisfaction.[29]