BROOKS AIR FORCE BASE
2507 Kennedy Circle
San Antonio
Bexar County
Texas

HABS TX-3521
HABS TX-3521

PHOTOGRAPHS

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

HISTORIC AMERICAN BUILDINGS SURVEY
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National Park Service
U.S. Department of the Interior
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Santa Fe, New Mexico

HISTORIC AMERICAN BUILDINGS SURVEY
BROOKS AIR FORCE BASE

HABS No. TX- 3521

Location: 2507 Kennedy Circle
San Antonio
Bexar County
Texas

~~USGS, Southton, Texas Quadrangle (7.5')~~
~~Universal Transverse Mercator Coordinates: 14.552948.3246714~~
Google Earth Lat/Long 29.350504, -98.454464

Present Owner: Brooks Development Authority (BDA)

Present Occupant: U.S. Air Force School of Aerospace Medicine (USAFSAM)

Present Use: Aerospace research and education

Significance: The U.S. Air Force School of Aerospace Medicine (USAFSAM) at Brooks Air Force Base (AFB) is significant for its contributions to aviation and aerospace medicine. By pursuing research relating to the medical aspects of flight, USAFSAM has provided pilots and astronauts with the necessary equipment and support to ensure their overall safety and health. In 1926, Brooks Field began its first association with the School of Aviation Medicine (SAM) when it moved from New York in order to support the Primary Flying School at Brooks Field. While stationed there from 1926 to 1931, the school trained flight surgeons as well as performed cadet physical examinations. SAM's brief but important tenure at Brooks Field served as a vital step in the development of aviation medicine and its contributions to pilot safety and training. In 1959, SAM again was relocated to Brooks AFB as part of an Air Force plan to concentrate its aerospace medical research facilities at one location. Construction of the USAFSAM campus began in 1957, with additional laboratories constructed sporadically until 1973. During the 1960s, USAFSAM, as part of the Aerospace Medical Division (AMD) headquartered at Brooks AFB, proved vital to the nation's efforts in space exploration, as well as the military effectiveness of the Air Force. USAFSAM scientists and researchers provided the Air Force and the National Aeronautic and Space Administration (NASA) with groundbreaking research relating to the medical effects of weightlessness, pressure, altitude, temperature, acceleration, and numerous other areas. Research at USAFSAM resulted in breakthroughs in pure science, as well as applied technology that was directly adopted by the Air Force and NASA. One important example of USAFSAM's contributions to NASA included the development of spacesuits used by astronauts in the Gemini and Apollo programs. Scientists at USAFSAM also provided valuable medical research relating to the Vietnam War, especially in the field of flight evacuation. In addition to research, USAFSAM's mission included education and clinical studies, both of which contributed greatly to the Air Forces' ability to protect its personnel. USAFSAM continues to serve as an aerospace medical research facility and remains an integral

component of the Air Force.

PART I. HISTORICAL INFORMATION

A. Physical History:

1. Date(s) of erection: 1917-45, 1959, 1963-64, 1966-73.

2. Architect: Buildings and laboratories at the USAFSAM campus were designed by multiple architects: Charles H. Page, Jr. of Texas Architect-Engineers Associates, Smith, Hinchman & Grylls, Bullock, Wright & Miller, Inc., Phelps & Simmons & Associates, George Pierce and Abel B. Pierce, and Bernard Johnson Engineers, Inc.

3. Original and subsequent owners: Air Force

4. Builder, contractor, suppliers: Unknown

5. Original plans and construction: Original plans are on file with BDA, 8030 Challenger Drive, Brooks City-Base, Texas.

B. Historical Context:

Introduction

Established in 1917 as Kelly Field No. 5, Brooks Field served as a Signal Corps Aviation School and was used to instruct cadets for service in World War I. Named for San Antonio native Sidney J. Brooks, who died on a training flight, Brooks Field achieved fame for its initial use of the British Gosport system of flight training, which was eventually adopted by all flight schools in the country. With the war's cessation in 1918, Brooks Field underwent a change in mission when it was chosen as the location for a Balloon and Airship School in 1919.

One of five schools across the country, the school housed several balloons used to instruct personnel in aerial observation, a task believed by contemporary military planners to be the primary use of aircraft. Several accidents involving explosions forced the school to close in 1922 leaving Brooks Field again in search of a mission. Shortly after, the facility was selected as the primary flying school for the Army Air Corps, a role it performed from 1922-31. The school included notable instructors and aviators in its nine-year existence, including Charles Lindbergh, Claire Chennault, and Jimmy Doolittle.

While the primary flying school was active, the SAM at Hazlehurst Field, New York, was transferred to Brooks Field in 1926, in an effort to unite flight medicine and flight training in one location. In 1928, Brooks Field was host to innovative paratrooper experiments demonstrating the potential use of paratroop drops in warfare. Flight medicine research and primary flight training continued at Brooks Field until 1931 when both were transferred to the newly created Randolph Field in San Antonio.

Brooks Field in the 1930s continued its earlier emphasis on aerial observation by serving as a center for observation training. Several observation squadrons were stationed there as the Army Air Corps continued to place great emphasis upon the role of aerial observation in warfare. Escalating tensions in Europe led to the establishment of an Air Corps Advanced Flying School in early 1941. The school trained pilots in observation skills using single-engine aircraft. The Army Air Corps quickly realized during World War II, however, that aerial observation was a secondary priority to more important uses of aircraft, like bombing and pursuit aircraft. As a result, observation training was canceled in 1943, and in its place a training program for the new B-25 bomber was established.

Pilot training at Brooks Field ended in 1945 after which it served primarily as a reserve flight training center in the postwar period. In 1948, Brooks Field became Brooks Air Force Base after a separate Air Force was created from the Army. Several reserve squadrons operated at the base until 1960 when all flight activities ceased.

In 1959, Brooks AFB began serving as the home of SAM, which coincided with the nation's vigorous Space Race efforts. As a result, from 1959-69, Brooks AFB, as part of the AMD, played a key role in providing the NASA and the Air Force with innovative and important space medicine research, ensuring that astronauts faced the harsh environment of space with the full protections medicine could offer. In addition to the base's contributions to NASA's Mercury, Gemini, and Apollo programs, a main focus of its space medicine efforts was the Air Force's military space program, the Manned Orbiting Laboratory (MOL).

By the mid-1960s, Brooks AFB became increasingly involved in the Vietnam War by sending flight surgeons to Southeast Asia, overseeing the flight evacuation program, and designing appropriate coursework at the School of Aerospace Medicine. In addition, Brooks AFB and the AMD were closely involved in technological advancements that aided efforts in Vietnam.

In the early 1970s, research related to space declined as a result of new priorities. Brooks AFB shifted their focus from theoretical research to applied research resulting in new technological products for the Air Force. Despite budget cutting, Brooks AFB managed to add new divisions and responsibilities during the 1980s and 1990s. In 1995, military planners, as a part of the Base Realignment and Closure (BRAC), approved the gradual transition in ownership of the base from the Air Force to the City of San Antonio. In 2002, BDA assumed control of the newly named Brooks City-Base, with plans to transform the installation into a business and technology park with USAFSAM remaining as the primary tenant. Future plans include leasing buildings at Brooks City-Base to educational and business enterprises that have complimentary missions to Air Force tenants.

Establishment of Brooks Field, 1917-18

The 1916 Congressional passage of an appropriations bill for aeronautics signaled a strong commitment by the United States to create a military aviation program. The U.S. Army identified San Antonio as a site for future airfields by the end of 1916 in large part due to San Antonio's warm climate, a condition favored by military planners that allowed for year-round flight training. Two air facilities, Kelly Field No. 1 and No. 2, were completed in early 1917 and began primary flight training of new recruits on August 6. The emerging need for additional cadets and trainers prompted the War Department in 1917 to search for additional land to construct a new aviation field.[1] In November 1917, Colonel C.G. Edgar, a Signal Corps

construction officer, selected an 873-acre tract of land suitable for expansion.

To construct the new installation (referred to as Kelly Field No. 5), the War Department selected Thomas, Harmon & Co. of St. Louis. The site and building plans were designed by Albert Kahn of Detroit, Michigan. Kahn, in addition to providing plans for Kelly Fields No. 1 and 2, was involved in almost all of the designs for World War I military flying fields. The site plan for Kelly Field No. 5 included a curved hangar line with buildings situated behind the line to the north.[2] The Kelly Field No. 5 included road plans and buildings which resembled another Signal Corps installation in California that consisted of 65 structures, including 16 hangars.

With construction at Kelly Field No. 5 being mostly completed, the Army Signal Corps on January 18, 1918, appointed Major Henry Conger Pratt as commandant of the installation's training efforts. On February 4, 1918, Kelly Field No. 5 was officially renamed Brooks Field in honor of Cadet Sidney Johnson Brooks, Jr., a San Antonio native who died in a plane crash at Kelly Field No. 2 in 1917. By February, Brooks Field, capable of handling the training of 5,000 airmen, witnessed the arrival of multiple squadrons of cadets ready for training.

Gosport Training, 1918-1919

Arriving at Brooks Field on February 16, 1918, Major Pratt oversaw the arrival of cadets from Kelly Field. Pratt's mission Brooks Field was distinct from Kelly Field in that aside from training the large number of cadets needed for the war effort, the airfield would also train flight officers as teachers of a new British training regimen known as the Gosport System. In late 1917, Captain R. Smith-Barry, an instructor at the Gosport Flying School in Hampshire, England, devised an innovative system of training new pilots in hopes of minimizing fatalities among fliers. His system enabled instructors to communicate directly with pilots while in the air by using airplanes fitted with dual controls and speaking tubes (Figure 1). Such innovations greatly improved the quality of flight training and reduced the potential for deadly mistakes made by inexperienced cadets. Other components of the Gosport System included the correcting of mistakes while in the air and the use of one instructor throughout the entire course of training.[3]

Selected to adapt the Gosport System into the American flight training method, instructors at Brooks Field took on the dual mission of training cadets and instructors in the new system. A special board of officers examined the effects of the new system and convinced the War Department in October 1918 to incorporate Brooks Field's experimental system into all U.S. Army airfields. The end of the war in November 1918 signaled the end for a heightened need for military fliers. Brooks Field's program of training continued on a minimal scale in the early months of 1919, until May when the Gosport school was closed. Nevertheless, the innovative adaptation of the Gosport system into the American system of training at Brooks Field proved to be a major contribution to the war effort.[4]

Balloon and Airship School, 1919-22

The end of the war resulted in a temporary loss of mission for Brooks Field. In May 1919, the Observation School at Camp Ben Wise in San Antonio, which trained cadets in the use of aerial observation, moved to Brooks Field, thus giving the base a new purpose. Aerial observation was an important component of the Army's conception of the airplane in warfare. Balloons, used in the Civil War and especially in World War I, demonstrated the effectiveness of aerial observation in providing

ground troops with important tactical information regarding enemy troop movements. The main use of the airplane before 1930 according to military theorists was to provide protection for large, slow-moving and defenseless aerial observation balloons.[5] Colonel Frank P. Lahm, an Army Air Corps pilot summed up the common belief among early military aviation theorists: "the main function of aviation is observation."[6]

To develop aerial observation capacities, the Army Air Corps established five national sites, including Brooks Field, for balloon observation schools. A major focus of the school at Brooks Field was to provide surveillance along the U.S.-Mexico border, an area of concern for the Army. The new school served the 16th Airship Company (85 men), and the 4th and 5th Balloon companies (200 men).[7] To house the massive dirigibles, a huge balloon hangar measuring 1,000 feet long and with a 125-foot clear span was built in 1919.

The balloon and airship program, despite the initial investment of manpower and expense, proved to be a short-lived experiment for the San Antonio region. The Italian airship Roma, for which the dirigible hangar at Brooks Field was constructed, was on its way to San Antonio from Langley Field, Virginia, when it exploded in transit. In addition, the dual explosions of a C-2 airship and a C-43 airship convinced the Army to cease its balloon operations at Brooks Field and instead transfer the units to Scott Field in Illinois on June 22, 1922.[8]

Primary Flying School, 1922-31

Fortunately for Brooks Field, the decision to remove the Balloon and Airship Observation School was part of a 1920 Army Reorganization Bill which stipulated that all flight training for the country would be centered in San Antonio air fields, including Brooks Field. In December 1920, the War Department demonstrated its commitment to Brooks Field by pursuing formal ownership of the land that had formerly been leased to the government by the San Antonio Chamber of Commerce. By June 1922, Brooks Field was classified as the only Primary Flying School in the country as a result of the consolidation of two former flying schools, Carlstrom Field, Florida, and March Field, California.[9] From 1922-31, Brooks Field earned the reputation of being one of the premier aviation training sites in the country and was responsible for developing the young Army Air Service at a crucial period of its growth.

Brook's role as the Primary Flying School grew out of the Army Air Service's attempts to streamline and consolidate its training efforts. The system established in 1922 required all military aviators to begin their basic flying training at Brooks Field, with the graduating class moving on to the Air Service Advanced Flying School at Kelly Field. Brook's inaugural class included 183 students; groups of six students were assigned to a single instructor and remained with that individual for the remaining time of their basic flight training.[10] Over the ensuing months, the intensive training resulted in a small, selective group of aviators ready for advanced training (Figure 2). In its nine years, the Primary Flying School graduated 2,237 students out of 5,573 who had arrived for training. Much of this class of highly trained aviators formed the basic structure of the Air Corps for decades to come. In addition, Brooks Field graduated aviators who in later years transformed and revolutionized the traditions of flight; perhaps most notable among these esteemed graduates was the young Charles Lindbergh (Figure 3), a determined pilot who overnight became a source of inspiration and heroism for much of the world as a result of his non-stop solo flight across the Atlantic Ocean in 1927.

In an early memoir, Lindbergh gives an intimate portrayal of the life of a new cadet at Brooks Field in the

1920s. At the age of twenty-two, Lindbergh arrived at Brooks Field on March 15, 1924, having already amassed 325 hours of flying time, an unusual accomplishment for new cadets arriving for basic flight training.[11] With 104 cadets in his class, Lindbergh described the barracks as "overflowing," with "a carefree lot, looking forward to a year of wonderful experiences before we were graduated as second lieutenants and given our wings."[12] After undergoing five examinations covering aviation topics, the cadets began flight training with their instructors in World War I Curtiss Jennies, an older model of aircraft that although difficult to fly enabled a cadet to "fly anything on wings with a reasonable degree of safety." Required to accumulate ten hours of flight training with an instructor, Lindbergh describes how cadets were constantly under pressure to achieve a high level of flying aptitude or face a board of officers who determined whether a cadet was a "washout" and had to cease their training. The next and most exciting phase for cadets was solo flight training which required students to perform simple and complex aerial maneuvers without the aid of instructors. After this phase of training had been completed and additional cadets had failed out of the program, the remaining students were required to make cross country flights in T.W.3s, practice formation flying in Voughts, and begin training in De Havilands, the plane used at Kelly Field for advanced training. Out of Lindbergh's original class of 104 students, thirty-three graduated from the Primary Flight School; eighteen of the thirty-three graduated from the advanced program at Kelly, thus illustrating the rigor and thoroughness of the San Antonio flight schools.[13]

Brooks Field also graduated many other important aviators, including Frank M. Hawks, Nathan Twining, Jimmy Doolittle, and Barney Giles. Graduates at Brooks were taught by the most experienced and talented aviators in the country. Claire Chennault, leader of the "Flying Tigers," was an important member of the instruction staff at Brooks; he wrote early texts on flying instruction as well as set the record for open cockpit flying at 40,800 feet. Russell Maughan and Elwood Quesada were also both instructors at Brooks; Maughan was the first to fly across the U.S. in a day, and Quesada helped pioneer mid-flight refueling.[14]

In addition to its celebrated graduates and instructors, Brooks Field was also the site of important advances in aviation. In April and September 1929, Brooks Field held public demonstrations of one of the earliest paratroop warfare experiments. Interested in the additional possibilities of flight, Master Sergeant Erwin H. Nickles and Alfonso A. Orozco developed the first experiments in paratrooper warfare by inventing specialized parachutes and padded containers for arms and ammunition.[15] Their experiments involved men, parachutes strapped to their backs, laying prone on the wings of the aircraft as they became airborne (Figure 4). On a given signal, the men leapt from the wings, falling to the ground before releasing their parachutes. In September 1929, an experiment involved eighteen men who landed together at Brooks Field with Lewis machine guns; in four minutes, the men managed to fire the machine guns from fixed positions, impressing a large audience in attendance, including foreign dignitaries interested in paratrooper experiments.[16] These early experiments demonstrated the possibilities aircraft afforded military planners; indeed, paratrooper warfare became an essential tactic by World War II.

Brooks Field was witness to another great contribution to aviation with the development of instrument flying. In 1929, Colonel William C. Ocker, joined the Primary Flying School's staff as an experienced flyer; his greatest contribution, however, was the invention of the Ocker box, a device allowing pilots to fly "blind" with the use of instruments inside the cockpit. Prior to Ocker's device, pilots relied on their natural senses to determine the orientation of the plane in relation to the ground below. However, in cloudy or night conditions, pilots were unable to adequately gauge the position of their plane, resulting in numerous pilot fatalities. Ocker's solution was a box that contained a bank and turn indicator, a compass

and a flashlight, all of which aided the pilot in determining his correct orientation regardless of outside conditions. Ocker, along with Lt. Carl J. Crane, began to train Brook's cadets in the art of instrument flying. To demonstrate the effectiveness of "instrument flying," Ocker flew 900 miles from Brooks Field to Scott Field in 1930 while only using instruments. In 1932, he and Crane published the world's first book on instrument flying. Shortly after, the military began experimenting with Ocker's instrument box and by World War II instrument flying was a solid element of aircraft design and pilot training.[17]

In 1926, four years after the Primary Flying School was initiated at Brooks Field, Brigadier General Frank P. Lahm ordered that one component of basic training be moved from Kelly Field to March Field in California. As a result, training for an aviator occurred at three bases—primary training at Brooks Field, basic training at March Field, and advanced training at Kelly Field. Lahm's vision was to consolidate all levels of flight training and related facilities into one field. Construction for a new field to house all aspects of flight training began shortly after; by 1931, the newly completed Randolph Field in San Antonio became the Air Corps center for its entire flight training system.[18]

School of Aviation Medicine (SAM), 1926-31

Four years after Brooks Field received the Primary Flying School in 1922, SAM was relocated from Mitchell Field, New York to Brooks Field in an effort to improve pilot performance. SAM grew out of concerns during World War I about pilot fatalities and the relatively unfamiliar practice of flight and its effects on fliers. Early experiments by the Europeans on the effects of flight on blood pressure, and ways to fight airsickness marked the first attempts to understand the important intersection of flight and medicine. Influenced in particular by the British Army's investigations into flight medicine, Lieutenant Colonel Theodore Charles Lyster, Chief Surgeon of the Aviation Section, Army Signal Corps appointed an Aviation Medical Research Board to "investigate all conditions affecting the physical efficiency of pilots to carry out experiments and tests at different flying schools, to provide suitable apparatus for the supply of oxygen."[19] Lyster also advocated the teaching of physicians, known as "flight surgeons," in the new field of aviation medicine. In 1918, the Air Service Medical Research Laboratory was established at Hazelhurst Field, New York. The laboratory, under the command of Colonel William H. Wilmer consisted of six concentrations of medical research: psychology, physiology, otology, ophthalmology, neuropsychiatry, and cardiovascular.[20] The diversity of departments illustrated the unique and holistic nature of aviation medicine—flight surgeons had to consider the atmosphere's effects upon the entire body. The Hazelhurst facility conducted early experiments including altitude classification pilot tests, low-pressure chamber tests, and psychology profile tests, all of which furthered the laboratory's goal of isolating the medical factors that contributed or detracted from the overall effectiveness of new pilots.

The Medical Research Laboratory moved to Mitchel Field, New York in 1919 at a time when the war's end signaled a decline in medical research related to aviation. However, commercial and military interest in aviation medical research gradually increased as both depended heavily on a pilot's physical performance. In 1922, the laboratory changed its title to the SAM, a change that reflected its new emphasis: the education of physicians in the area of flight medicine.[21]

Flight training occurring at Brooks Field and Kelly Field in the 1920s began to demonstrate to Air Service leaders the high level of cadets who could not meet the requirements of the rigorous training programs. As a result, discussion within the military began to shift the pursuit of aviation medicine in a "more practical and less theoretical" direction in order to decrease the number of students unable to

progress in flight training.[22] Such insight resulted in the transfer of SAM to Brooks Field in August 1926; flight surgeons, it was argued, were of greater service when stationed at an active base of training, as a close relationship between physician and pilot produced more results than a strictly academic environment.

Despite the arrival of SAM, Brooks Field lacked appropriate facilities to house the school; instead, they resided in the balloon and dirigible hangar, which was vacant after the cessation of the Balloon and Airship School. Shortly after its arrival, the school proceeded with plans to build its first permanent facility and in 1927 a two-story, Mediterranean style building with offices, lecture halls, a library, and examination rooms was completed. The building (Building 538) is still used by the base and houses administrative offices. From 1926-31, flight surgeons at SAM primarily acted as physicians first and teachers second; their main responsibility was to direct physical examinations to determine the condition of cadets for flying (Figure 5). In addition to this role, department heads at SAM carried out experiments in two key areas of aviation research: instrument flying and the development of a Complex Coordinator.[23]

Colonel Ocker's development of instrument flying was aided in large part by the efforts of two SAM department heads, Captain Frederick H. Thorne, director of Ophthalmology-Otology, and Captain Robert K. Simpson, director of Aviation Medicine. Because of studies conducted by Thorne and Simpson at SAM, the innovations developed by Ocker were confirmed, which led to a recommendation by the two men for Ocker to organize training in instrument flying at Kelly Field. These efforts led to the Army Air Corps' adoption of instrument flying in 1934. Another important contribution developed at SAM was the Complex Coordinator, a machine capable of measuring reflex aptitude by measuring a pilot's reaction time. Both Captain Thorne and Captain Neely C. Mashburn, of the Department of Psychology, provided important contributions to the device that by 1931, enabled physicians to better gauge the chances of a student in becoming a pilot. The results from these and other tests conducted by SAM were published in articles by the school, which greatly contributed to the field of aviation medicine.[24]

The decision to move the Primary Flying School to Randolph Field in 1931 resulted in SAM's relocation to Randolph as well. In its five years at Brooks Field, SAM graduated 340 flight surgeons and flight surgeon assistants; these graduates went on to further the research and investigations that enabled man to conquer the harsh conditions of the atmosphere. The contributions of SAM at Brooks Field were critical in establishing the long-term viability and success of the school in its later years at Randolph Field and Brooks AFB in 1959.[25]

Aerial Observation Center, 1931-39

After the departure of the Primary Flying School and SAM, Brooks Field once again entered a period of uncertainty regarding a cohesive mission. To replace the departed organizations, the Air Corps transferred the 12th Observation Group from Fort Sam Houston to Brooks Field in October 1931. The group consisted of 36 officers and 600 enlisted men and included the 12th Observation Squadron, 12th Observation Headquarters Squadron, 88th Observation Squadron, 22nd Observation Squadron, 62nd Service Squadron, and a medical detachment. Flying two-man O-43s, the observation groups performed observation missions in conjunction with Fort Sam Houston; each plane utilized a pilot and observer who trained as a gunner as well.[26]

Within the Army Air Corps at this time, a debate concerning the relative importance of observation,

pursuit, and bombardment was well under way. For much of the decade following World War I, observation or reconnaissance capabilities were viewed as the primary role of aviation. By the 1930s, arguments favoring the use of aircraft for bombardment and pursuit were gaining favor among Air Corps planners, thereby diminishing the importance of observation squadrons. By the mid-1930s, these shifts in military aviation altered once again the mission of Brooks Field when the 88th Observation Squadron and the 12th Observation Squadron were transferred to other bases, leaving only the 22nd Observation Squadron.[27]

In the years leading up to World War II, Brooks Field lacked a major objective within the larger vision of the Army Air Corps. With the exception of the 1927 construction of SAM and the 1930s construction of two runways, Brooks Field witnessed no new construction up to World War II. The World War I design and temporary construction of Brooks Field remained remarkably intact; rising tensions on the European continent, however, suggested significant change was on the horizon.

Brooks Field in World War II, 1939-45

The relative inactivity at Brooks Field during the 1930s was reversed during World War II due to the arrival of numerous training commands set up to meet the increased demand for wartime pilots. By 1938, events overseas prompted President Roosevelt and other government leaders to expand its defense capabilities; to invigorate the Air Corps, $300,000,000 was set aside to train new personnel, construct new bases and provide construction at old facilities.[28] In September 1939, Brooks Field was designated as the future home of an advanced flight training program, part of a plan to relieve a crowded program at Kelly Field, as well as serve as the home of an observation training program. Such dramatic changes required massive construction efforts, and by the end of the war Brooks Field had undergone tremendous physical change (Figure 6).

From 1940-43, Brooks Field served as the main site for aerial observation training, much as it had done from 1919-22 and in the 1930s. With classes in flight instruction, piloting, and ground instruction, the observation training school focused on training non-pilot military observers and pilot-observers in combat aerial reconnaissance and in support of ground troops. After graduating 50 Combat Observers in 1941, the school was reorganized under the command of the Advanced Flying School (Observation) in an attempt to further delineate the roles of pilots and observers in a combat role. Captain Richard C. Lindsay of the 22nd Observation Squadron at Brooks Field was the main force behind the redevelopment of the observation program, which tried to incorporate criticisms of the earlier program into the new school. Chief among the criticisms was the outdated curriculum of the school, as it depended heavily upon combat lessons from World War I. Earlier debates among military planners over the effectiveness of aerial observation and its role in combat reemerged with the new combat realities that World War II presented. Lindsay's efforts towards promoting aerial observation in combat roles, however, came to an end in August 1943, when the Army Air Forces decided to end the country's efforts at developing a World War II observation role.[29]

In addition to the Observation Training program, Brooks Field was host to several advanced military pilot training programs beginning in February 1940, when it was designated an official subpost of Kelly Field. Roughly a year later in 1941, Brooks Field separated from Kelly's command and was designated an Air Corps Advanced Flying School. Cadets were instructed in acrobatic, formation, cross-country, instrument, and night flying as well as ground-related courses, such as signal communications, military

organization, combat orders, air navigation, and squadron duties. Training focused on advanced single-engine flying until August 31, 1943, when the Air Corps Advanced Flying School became the Army Air Forces Pilot School (Advanced Twin Engine). The change was significant; pilots were now trained to fly the new twin-engine B-25, a medium bomber that was a departure from the earlier school focusing on single-engine planes (Figure 7). Over 1,000 pilots graduated from the school and played an important part in both the Atlantic and Pacific theaters of the war.[30]

Brooks Field also aided the war effort by training civilians to act as instructors in pilot training as part of the Student Instructors' Pilot Training School. Students were taught Army pilot procedures and techniques with the intention of teaching at Army Primary Contract Schools. The program was very successful, graduating 1,578 civilian instructors who helped to alleviate shortages in Air Corps instruction.

Overall, Brooks Field's contributions towards preparing pilots for the war were vital. As it had done following World War I, Brooks Field rose from secondary to primary status as a training facility, allowing the nation to quickly meet the rising need for trained combat pilots. The war years transformed Brooks Field; changes included numerous construction projects from utilitarian buildings to runways, as well as a huge influx of new personnel including Women Air Corps (WAC) members, all of whom made the operation of the base during wartime possible. In January 1945, the Army Air Forces Pilot School (Advanced Twin Engine) was discontinued. The end of the war presented the airfield with a familiar problem from its past: the lack of a mission. For months following the war's end, Brooks Field suffered a loss of morale due to a difficult postwar transition.

Air Reserve Activities at Brooks AFB, 1945-60

For several months after war's end, Brooks Field was in a state of inactivity as Army Air Force leaders attempted to determine the structure of the postwar service. In November 1945, units and personnel previously at Brooks Field moved to new facilities across the country leaving the base with a minimal presence. At the end of the month, however, it was assigned tactical units of the Third Air Force, which included the 69th Reconnaissance Group, five tactical reconnaissance squadrons, and other units. In March 1946, the Third Air Force at Brooks Field was replaced by the Ninth Air Force, stationed at Biggs Field, Texas. A few months later, Brooks Field became the headquarters of the Tenth Air Force, which began a mission of overseeing air defense for the southwestern United States. The next three years saw the Tenth, Fourteenth and Twelfth Air Force occupy the base in succession.[31]

In 1948, Brooks Field was renamed Brooks AFB after the Department of Defense separated the Air Force from the Army. A year later, the base shifted its mission to reserve training, hosting the 259th Air Base, 2577th Air Force Reserve Flying Training Center, the 2577th Air Base Group, and the 3790th Air Base Group from 1949-58. Brooks AFB continued reserve activities until June 23, 1960, when the last plane flew from the base, ending a decades-long commitment to flight.[32] The mission of the base changed significantly with the return of SAM in 1959; with its arrival, Brooks AFB became the center of the Air Force's efforts in aerospace medical research.

The Air Force and Early Achievements in Aerospace Medicine, 1948-59

Finally gaining status as a separate branch of the military on September 18, 1947, the Air Force assumed

control of all military aircraft not assigned to the Army or Navy. With the Air Force's new independence, many pushed for SAM and other aviation medical units to fall under control of the Air Force. They were supported by the American Medical Association who argued: "...so long as three co-equal military services exist, it is necessary that each exercise 'command responsibility' for its supporting medical service..."[33] Unfortunately for the supporters of the Air Force, the Army retained control of the Air Force's medical needs for reasons that were more political than medical. The Army and Navy were still upset over the creation of an independent Air Force and the possible loss of government funds that its creation represented. Over the next two years, however, the work of Major General David N.W. Grant and Major General Malcolm C. Grow laid the foundation for the establishment of the Air Force Medical Service on July 1, 1949, with Grow serving as the first Air Force Surgeon General.

As the debate over the Air Force's control of its medical units continued, General Harry Armstrong, commandant of SAM, led the Air Force in achieving dramatic breakthroughs in aerospace medicine. While heading the Aerospace Medical Research Laboratory (AMRL) at Wright Field in Dayton, Ohio, Armstrong was instrumental both before and during the war in pushing forward aviation medical research and engineering applications, including the development of the pressurized cabin.[34]

At war's end, Armstrong was a key player in the United States' attempts at securing the medical secrets and personnel of Germany's wartime aviation research program, especially scientists associated with the Berlin Aeromedical Research Institute. Headed by Dr. Hubertus Strughold, an influential aviation physician, the institute at Berlin both before and during the war was widely known as the premier research center in aviation medicine; however, components of its wartime research were widely condemned for its utilization of concentration camp victims in cold water and pressurization experiments. Intent on obtaining the scientific knowledge of Strughold and others at the institute, Armstrong, as part of the clandestine venture known as Project Paperclip, made it possible for many aviation physicians, including Strughold, to work for the Air Force. Armstrong's efforts were a small part of Project Paperclip; the main motivating factor for both the U.S. and the Soviet Union was gaining the secrets of the V-2 rocket program and the military applications it promised. Despite President Truman's statement disallowing individuals affiliated with the Nazi Party or German militarism from entering the country, Project Paperclip was successful in obtaining key German scientists after the war, many of whom made important contributions to the United States' efforts in space flight.[35]

While many of the German aviation scientists were located at the AMRL at Wright-Patterson AFB, Armstrong managed to assign six prominent scientists under his command to SAM at Randolph AFB: Hubertus Strughold, Hans-Georg Clamann, Konrad Buettner, Siegfried J. Gerathewohl, and the brothers Fritz and Heinz Haber (Figure 8).[36] Armstrong and his team of German scientists wasted little time in pursuing a course of innovative medical research regarding space exploration.

Armstrong, in November 1948, brought military and university scientists to Randolph AFB to hold a panel discussion on the "Aeromedical Problems of Space Travel." Both Hubertus Strughold and Heinz Haber of SAM gave papers detailing for the first time the medical challenges associated with "extra-atmospheric flight." This newly created medical field was aptly called "space medicine" by Strughold. Shortly after, in February 1949, Armstrong established the world's first Department of Space Medicine, led by Strughold, and assisted by Heinz and Fritz Habers and Konrad Buettner.[37]

Due to the capture of German rocket technology from the war, U.S. military planners quickly realized that

flight beyond the known atmosphere was only a matter of years. Despite this, substantial questions remained unanswered; most prominent was at what point would constraints of the atmosphere prohibit or alter biological functions. Aside from early Soviet and U.S. experiments involving the launch of fruit flies and mice into the upper atmosphere, little substantive scientific research was being performed in the realm of space biology. Thus, the new and innovative developments associated with Armstrong and Strughold at SAM represented one of the first institutions dedicated to understanding the relationship between space and medicine; as a result, it captured the attention of the medical community, as well as military planners and the public alike.

Strughold seized upon the increased attention by publishing a seminal paper in *The Journal of Aviation Medicine* in 1950, in which he proposed a dramatic thesis concerning the human potential for space exploration. Strughold addressed the central problem of where space began; he argued that rather than existing in the remote regions of the atmosphere, space was present in small gradations as altitude levels increased. In other words, some of the effects associated with space, such as changes in pressure and oxygen levels, occurred at the relatively low height of ten miles. As a result, space was not marked by a definite boundary; in fact, experimental aircraft such as the X-1 and D-558-II had already flown at altitudes that fell under Strughold's definition of space conditions. In a second important aspect of his paper, Strughold delineated the key medical problems fliers would face as they rose higher and higher into the atmosphere, making space medicine a workable field and not one relegated to science fiction. Strughold's breaking down of the traditional theory of a space "boundary" hastened the Air Force's use of the term "aerospace" rather than "aeronautics" or "aviation", as evidenced by the School of Aviation Medicine changing its name to the School of Aerospace Medicine by the end of the decade. [38] As a result of his efforts, Strughold earned the title of "Father of Aerospace Medicine" (Figure 9).

To further highlight the Air Force's contributions to space medicine, the commandant of SAM, Brigadier General Otis Benson, initiated a gathering of important scientific and medical minds to discuss the emerging field of space medicine. Held on November 6, 1951, in San Antonio, Texas, the meeting included 38 speakers, some of whom included Strughold, Herman Muller (zoologist), Dr. Marcel Nicolet (authority on solar physics), Titus Carr Evans (radiation research), and Fred Whipple (chairman of Harvard Department of Astronomy). Also present were numerous government researchers, many of whom would become leading figures in space medicine research. The meeting, like Strughold's seminal 1950 paper, was a crucial step in the early evolution of space medicine; Strughold later called the meeting "an important step toward clarifying the medical problems involved in flight in the highest strata of the atmosphere, where the various benefits derived from the presence of air fall short."[39] Because the idea of space exploration was new, the event attracted national press—reporters from *Collier's* and *The Saturday Evening Post* provided SAM with widespread public attention. The school was unique in that, of the few institutions involved with space research, it was the only one presenting its work to a public audience in the form of scientific journals; other space agencies pursued military-related work and therefore classified all research. For much of the 1950s, SAM "came to be regarded as a prime authority on the exploration of the cosmos."[40]

SAM and other Air Force institutions established this authority by pursuing multiple experiments in the realm of space medicine research. At SAM, Hubertus Strughold led efforts at understanding the effects of space on man. Eager to develop the arguments made in his 1950 paper, Strughold invented a working space cabin in 1952, which was built and delivered to the school in 1954. The space cabin was similar in design to the early pressure chambers used before World War II, except for the fact that the cabin interior

modeled an earthlike environment rather than a highly pressurized one. Such a modification came about because of the interest of Strughold and others in sending a man into space, thus the need to create a stable, earthlike environment to ensure survival. The device allowed Strughold and his team of scientists at SAM to perform a variety of important experiments ranging from the effects of isolation, ways to organize work, rest, and sleep, and developing proper air environments for space travel.

One of the most important and famous of Strughold's space cabin experiments was the seven day space cabin simulation by Airman Donald G. Farrell in February 1958. The experiment for the first time placed a man in conditions similar to space flight and enabled researchers to test life-support systems and physiological effects of extended isolation. The experiment excited a nation wounded by the humiliation of the Soviet Union's launch of an artificial satellite, Sputnik I, several months before. Press from across the country hailed the young Airman from the Bronx as the first "space traveler." The significance of the test to the national psyche was evident by the presence of Senate Majority Leader Lyndon B. Johnson, who greeted Farrell as he exited the space cabin following 168 hours of confinement. The 1958 space cabin experiment as well as those that preceded and followed it, allowed SAM researchers to test cabin environments and their effect upon fliers, allowing the Air Force to understand the dangers of space without launching unnecessary and costly test flights.[41]

Researchers at SAM were also involved in research examining the possibility of using plants to provide oxygen in a closed environment such as a space cabin. Due to the engineering expenses needed to provide oxygen in space, scientists like Dr. Jack Myers experimented with much cheaper systems involving photosynthesis, in other words using the ability of plants to recycle carbon dioxide into breathable oxygen. These early experiments with plants translated later into valuable environmental systems for future space flights.[42]

The effects of weightlessness and zero-gravity (zero-g) were also tested in the 1950s at SAM. While researchers could recreate the equivalent pressures of space, they could not simulate the experience of zero-g. The brothers Heinz and Fritz Haber solved the problem by developing a system using planes to create a short period of zero-g (achieved by planes flying a parabolic or roller-coaster flight pattern). In 1955, SAM received T-33A jet trainers for the sole purpose of zero-g experiments (Figure 10). Dr. Siegfried J. Gerathewohl led the zero-g flight experiments, which involved monkeys and men experiencing weightless environments up to a minute and a half at a time. Gerathewohl, using cameras in the cockpit, recorded the effects of weightlessness on the psychomotor performance of pilots as well as animals, resulting in the publishing of his findings in scientific journals. Ultimately, the zero-g experiments were of limited value as longer exposures to weightlessness were needed to understand the long-term effects of space on astronauts.[43] Nevertheless, SAM's wide-ranging experiments in space medicine established it as one of the early leaders in the nation's newfound interest in space.

In addition to SAM, the Air Force pursued space-related research in the 1950s at two facilities, AMRL at Wright-Patterson AFB in Ohio and the Aeromedical Research Laboratory (ARL) at Holloman AFB in New Mexico. Established in 1935 by the aviation medicine pioneer Harry Armstrong, AMRL in Ohio was created to translate aeromedical research into design and engineering solutions for pilots. In addition to wartime research, the laboratory in 1947 developed the T-1 partial-pressure suit, an extremely important invention which allowed test pilots like Charles Yeager to survive the dangers of high altitude flight and paved the way for future manned space exploration. In addition, scientists at the institute devised foods specifically for space as well as created technology used to track the medical health of an

astronaut throughout orbital flights. The laboratory was also critical in pursuing early centrifuge studies to gauge man's ability to withstand the effects of acceleration.[44]

At Holloman AFB in New Mexico, the Air Force early on demonstrated its interest in space flight. In 1948, scientists at ARL began "space biology" experiments; in four separate attempts, rhesus monkeys in pressurized cabins were vaulted into the upper reaches of the atmosphere on V-2 rockets. While surviving the actual flight, each monkey perished when their parachutes failed upon return to earth. The Air Force followed these flights with the Aerobee series from 1949-52, in which in four successive flights, monkeys and mice were launched to altitudes above 231,000 feet. In these flights, the animals returned safely, showing no adverse effects from weightlessness or acceleration.[45] In 1952, the space biology experiments gave way to experiments studying the effects of linear acceleration and high-speed impact, both of which were dangers facing astronauts. To test such factors, Colonel John Stapp, a flight surgeon at ARL, underwent a series of extraordinary experiments in the early 1950s that earned him the nickname of the "Fastest Man on Earth." Strapped to a rocket sled, Stapp accelerated to a speed of 638 miles an hour along a seven mile track and decelerating to a full stop in a matter of seconds. The forces exerted upon Stapp's body during deceleration equaled 40 times the force of gravity. Remarkably, Stapp suffered only a broken arm, proving that astronauts could survive the collision forces resulting from a capsule's reentry with the atmosphere from space.[46]

In addition to acceleration and deceleration experiments, ARL at Holloman AFB was the site of the Air Force's Man High series of high altitude balloon flights. In 1957, Major David G. Simons achieved a balloon flight that set a world altitude record of 101,516 feet. For 32 hours, Simon sat in a cramped, pressurized cabin at a high altitude to test life-support systems and to determine the effects of cosmic radiation. The Man High series also helped perfect the monitoring of life-support systems from remote areas of the earth using radio-telemetry.[47]

The combined efforts and activities during the late 1940s and 1950s of SAM, AMRL at Wright-Patterson AFB, and ARL at Holloman AFB established the Air Force as the prime authority on the U.S.'s early attempts to conquer space and understand its effects on man. The coming decade would transform the nation's efforts in space, in particular SAM.

Establishment of the Aerospace Medical Center (AMC) at Brooks AFB, 1949-59

The diverse efforts in space research within the Air Force demonstrated the institution's firm commitment to space; a consistent problem, however, arising from this arrangement was that of duplication. When the AMRL was created in 1935, scientists at the center pursued applied research, creating design solutions for aviation purposes, while SAM limited its research efforts to basic or pure science. During the 1940s and 1950s, however, the two institutions often overlapped in their research efforts, both developing departments that mirrored the functions of the other.

Concerns over research duplication had frustrated the Air Force since the end of World War II. The rising complexity of medical issues surrounding the aviator and the need to devise a single institution to meet those needs also posed problems for the Air Force. The arrival of the jet engine at the end of World War II dramatically enhanced the sophistication and capabilities of aircraft, placing new and undiscovered stresses upon pilots. With the additional promise of space exploration provided by rocket technology, the human factor became the single greatest detriment to future development of a sophisticated Air Force.[48]

To elevate the physical capabilities of the pilot, a cross-disciplinary medical and engineering effort centralized into a single center was required to discover and explore the potential hazards of high-speed, high-altitude flight, as well as design aircraft components to aid pilots. An early proponent of such a center was the aviation medicine pioneer General Harry Armstrong. The center, he argued, must pursue an academic course, much like a medical school, incorporating multiple fields of biological science as well as working closely with military scientific and engineering facilities. In addition to research, the center would consolidate efforts in aviation medicine education and training with a clinical facility. As a result, sick and injured pilots would be centrally located rather than spread out across the country, allowing for flight surgeons at the center to better understand problems affecting pilots. Many forward-thinking Air Force leaders, including Major General E.N. Powers, Major General Curtis LeMay, and Major General F.L. Anderson, realized the need for a aeromedical center and lent their support to Armstrong's efforts. The need for the center was obvious, Armstrong argued:

> These requirements and principles of operation may perhaps be considered revolutionary in concept. To the extent that it is a recommended for inclusion in a military service, this is true. However, in civil life, it is centuries old. All that is being recommended is that the United States Air Force adopt a tried and proven method of reaching a desired objective....the Air Force, as the first line of defense of the United States, cannot afford the luxury of a medical service which offers less. Not only will an inadequate aeromedical service result in an unnecessary wastage of men and material, with an economic loss to the United States Government, but it will lessen the efficiency of the Air Force and in no small degree, jeopardizing the safety of the country.[49]

On June 21, 1949, an Aeromedical Center Planning Board was established to move forward Armstrong's ideas for a permanent center. The board's objective was to devise and recommend solutions for the center's mission, activities, and location. In January 1951, it presented its findings for the new center to General Vandenberg, Chief of Staff of the Air Force. Vandenberg approved the board's recommendations, which formally selected Brooks AFB as the site for the future AMC.[50] Brooks AFB was chosen over such sites as Miami, Pasadena, and Denver for several key reasons. Brooks AFB's former relationship with SAM from 1926-31 was a small part of the decision, as was its close proximity to the current location of SAM at Randolph AFB. Aside from reserve flight training, Brooks AFB was relatively devoid of a mission; in addition, it retained 375 acres of vacant land on the northwest corner of the base. More importantly, Brooks AFB had important allies in Congress—Representative Paul J. Kilday, Texas and the soon to be Senate Majority Leader, Lyndon B. Johnson of Texas. Kilday, representing the district for the base, was a ranking member of the House Armed Services Committee, a position that assured Congressional funding for the new center.

Early in the planning stages, officers of the Air Force Headquarters in Washington, D.C., had a clear notion of the type of facilities they wanted, distinguishing it from other Air Force installations: "Consideration should be given to permanence and preeminence of this facility as an academic institution . . . The quality of construction should be comparable to that of the leading medical institutions in the United States."[51]

To accomplish such a vision, the AMC planning board in 1951, chose Ellerbe & Associates, an architectural design firm from St. Paul, Minnesota, to create a master plan for the new center. Officers of

the Headquarters of the Dept of the Air Force made an unqualified recommendation of Ellerbe & Co.:

> Because of their special qualifications, their experience with this type of construction, and the detailed knowledge they have already acquired through working on this project during the past two years, it is requested that prime consideration in letting this contract be given to the firm of: Ellerbe & Co. The Ellerbe Company, because of the design over the past twenty-five years of the varied and highly specialized diagnostic research and hospital facilities for the Mayo Clinic at Rochester, Minnesota, is considered eminently qualified to continue this project. In addition this firm has just completed a large multi-story specialized Mayo Clinic building, similar in some program requirements to the nine and one-half million dollar clinic for the Air Force needs.[52]

The campus plan Ellerbe & Associates were chosen to create, grew out of a distinction that the center's original founder Harry Armstrong had in mind.[53] To achieve the complex and interrelated aviation medicine research tasks Armstrong envisioned, the center's laboratories, offices and classrooms needed a closely integrated layout which encouraged collaboration and communication. Ellerbe & Associates, with instructions from the planning board, completed a master plan in 1952 that resembled a medical school campus. By September 1954, Ellerbe & Associates was unwilling or unable to finish work on the design of USAFSAM. Work on the contract had been halted for almost a year, while the Air Force transferred responsibility for the project to Air University, headquartered at Maxwell AFB in Alabama, from the Air Force's Washington headquarters. After a meeting between Air Force and Ellerbe representatives, the architects apparently indicated that other work responsibilities might impede their ability to complete the building designs. It is likely that Ellerbe at this point called in Charles H. Page, Jr. of C.H. Page and Son as a subcontractor to perform detailed design work.

Initial funds for the first wave of construction were set at $8,000,000 and passed by Congress in an appropriation bill in July 1952. Unfortunately, rising construction costs, war in Korea, and budget cutters within the executive branch all played a part in delaying the start of construction until 1957.[54]

During the interim years, aerospace medicine research continued at Randolph AFB. Finally, in October 1956, the Air Force granted $8,800,000 of appropriated money towards construction of AMC. The Galveston District of Army Engineers advertised bids in December and by March 1957 had awarded a contract. In May 1957, construction for the new center began, marked by a groundbreaking ceremony attended by Air Force dignitaries (Figure 11).

The overall construction of the center occurred in three groups, the first of which included five buildings: Building 100 (Flight Medicine Laboratory); Building 125 (Research Institute); Building 130 (Research Laboratory Shop); Building 160 (Altitude Laboratory); and Building 180 (the Academic Building). The architect for these buildings was Texas Architect-Engineers Associates from Austin, Texas; the total cost being $9,750,000. The five new buildings, while only representing the first phase of construction, represented a welcome change from the comparatively spartan conditions at Randolph AFB. Designed by Charles H. Page, Jr., the buildings were modern, brick, functional designs located on a hill on the northwest corner of the base. The tallest building, the four-story Building 125, was designed for laboratory space. Building 180 would serve the teaching functions of the school and included sixteen classrooms, an assembly hall for lectures, and examining rooms. Building 160 was designed to hold the pressure chambers, a centrifuge and to house the physiology department. Finally, Building 100 provided

clinical facilities for examination, research and treatment while Building 130 provided space for fabrication shops.[55]

By August 1959, the move from Randolph AFB to Brooks AFB was complete. Because of a lack of housing and support facilities, many scientists, including the commandant of SAM, General Otis Benson, continued to live at Randolph AFB and commute to Brooks AFB each day. The years leading up to 1959 had diminished somewhat Harry Armstrong's grand vision for a medical center. Because of restructuring and budget problems, the new center would lack a clinical facility—a factor Armstrong and others thought vitally important, as it allowed for a concentration of medical cases to be used in research. As a result, the new center was now viewed by some to be merely the new home for SAM. Eager to restore the larger vision of the center, General Benson began a campaign to enlarge the scope of the new center by shifting its command structure. Instead of continuing to be placed under the Air University Command, Benson arranged for the new center to be placed under the Air Training Command. As part of this transition, Benson arranged for the new 1,000-bed hospital at Lackland AFB in San Antonio to fall under the command of the new AMC at Brooks AFB. Thus, on August 20, 1959, the center became a unit of the Air Training Command signaling a new and exciting period for the scientists and researchers at the AMC.[56]

On November 14, 1959, Senate Majority Leader Lyndon B. Johnson, Senator Ralph Yarborough (Texas), and Representative Paul J. Kilday (Texas) formally dedicated the AMC. In attendance were the Secretary of the Air Force, the Surgeon General of the Air Force, Chief of Staff of the Air Force and General Benson, the new commander of SAM and AMC. Senator Johnson, in his speech, viewed the completion of the center as a success for Congress, which was dedicated to creating a national medical institution that worked in tandem with military and space-related agencies.[57]

Creation of the Aerospace Medical Division (AMD), 1961

After functioning for only two years under the leadership of General Benson, the Aerospace Medical Center on November 1, 1961, changed its name to the Aerospace Medical Division, a change that placed an even greater responsibility upon the center at Brooks. With the Air Force sponsoring numerous medical research laboratories across the country, certain Air Force officials had long been wary of research duplication. Lieutenant General Bernard A. Schriever, commander of the Air Research and Development Command, believed that an institution like the AMC at Brooks could serve as the central agency that coordinated all of the research efforts at laboratories across the country. As a result, aerospace research could achieve a new focus and efficiency that would greatly aid the country's attempts at space exploration. Though some flight surgeons opposed the move to the much more engineering and weapons development focused Air Research and Development Command, General Schriever was successful in bringing the center under his command. The new AMD at Brooks became one of seven divisions under the newly organized Air Force Systems Command. The new commander of AMD, Brigadier General Theodore C. Bedwell was now in charge of SAM, the Air Force Hospital at Lackland AFB, AMRL at Wright-Patterson AFB in Ohio, ARL at Holloman AFB, New Mexico, the Personnel Research Laboratory at Lackland AFB, and the Arctic Aeromedical Laboratory near Fairbanks, Alaska. AMD found its mission greatly expanded as a result; it now commanded all of the Air Force's research and development in aerospace medicine. In addition, the division was responsible for all postgraduate training of flight surgeons, nurses and technicians in aviation medicine as well as treatment and diagnosis of fliers.[58]

To alleviate crowded conditions and meet its new responsibilities, the young division at Brooks added additional buildings in a second phase of construction in 1963. The new buildings included the Building 150 (Professional Building), Building 155 (Research Library), and Building 185 (Vivarium Support). To dedicate the new buildings and recognize the early achievements of the AMD, President Kennedy visited Brooks on November 21, 1963. With a large crowd in attendance, Kennedy spoke in front of Building 150 and emphasized the importance of Brooks AFB and its contributions to aerospace medicine, the benefits of which would spill over into the civilian world (Figure 12). Most importantly, Kennedy, in his speech, linked the scientists at SAM with the noble and expansive national efforts at conquering space:

> Frank O'Connor, the Irish writer, tells in one of his books how, as a boy, he and his friends would make their way across the countryside, and when they came to an orchard wall that seemed too high, and too doubtful to try, and too difficult to permit their voyage to continue, they took off their hats and tossed them over the wall—and then they had no choice but to follow them.
>
> This nation has tossed its cap over the wall of space—and we have no choice but to follow it. Whatever the difficulties, they will be overcome; whatever the hazards, they must be guarded against. With the vital help of this Aerospace Medical Center, with the help of all those who labor in the space endeavor, with the help and support of all Americans, we will climb this wall with safety and with speed—and we shall then explore the wonders on the other side.[59]

Following the speech, Kennedy toured the facilities at Brooks, even speaking with airmen inside a pressure chamber as they conducted a month-long experiment. For scientists and personnel at the base, Kennedy's visit was a tremendous confirmation of their hard work towards the advancement of space research. Sadly, the visit marked Kennedy's last official act as President; the following day, November 22, Kennedy began his fateful trip to Dallas, Texas.

The Space Race – The Air Force and NASA, 1957-59

Kennedy's 1963 speech heralding early aerospace medicine achievements at Brooks AFB illustrated just how far the country had come since the U.S. and the Soviet Union began their political race for the conquest of space. The launching of Sputnik I, an unmanned orbital satellite, by the Soviet Union on October 4, 1957, served as the catalyst for the race that would consume countless hours of effort between the two superpowers. The Soviet display of booster and satellite technology painfully demonstrated to the U.S. that its space program had fallen behind. Suddenly, early space experiments by scientists such as Strughold at SAM were viewed with a heightened sense of urgency and importance. No longer would space experiments rise out of the "desire to discover the undiscovered"; instead, they would preserve and maintain "international prestige" and promote "technological supremacy."[60]

Prior to 1957, the Air Force, Navy and Army were the only institutions undertaking the pursuit of space, unlike the Soviet Union, which poured all of its resources into the Soviet Air Force. Among the three U.S. military branches, the Air Force was the unquestioned leader, largely due to the similar nature of spaceflight to its overall mission. Committing itself to a three-phase development process for space exploration, the Air Force was first involved with the continuation of designing high-speed, high altitude aircraft, which could push the boundaries of flight. The X-15 rocket-powered research airplane was an

Air Force high performance aircraft designed to fly in the outer regions of the atmosphere. The data gained from the X-15, the Air Force argued, represented its first steps in putting a man into space. The next phase of the Air Force program was the X-20 (Dyna-Soar), a much enhanced version of the X-15; the aircraft would be launched by a booster rocket, achieving a velocity of mach 17.5 and a maximum altitude of 75 miles. During its flight, the X-20 would orbit the earth briefly before reentering the atmosphere.

The third and most ambitious component of the Air Force's designs for space exploration was devised early in 1958 and became known as "Man-in-Space-Soonest" (MISS). The program grew out of the Air Force's abandonment of winged space aircraft, such as the X-20, and acceptance of rocket booster technology, which could lift a manned capsule into space (the concept was referred to as "a man in a can on an ICBM.") Comprised of four phases, MISS would first begin with placing a manned capsule into orbit followed by a longer 14-day flight, a lunar reconnaissance flight, and finally a lunar landing and return flight. The last phase was to be completed by the end of 1965, with the entire MISS campaign totaling $1.5 billion, (an amazingly low amount when compared to the actual expense required to send a man to the moon).[61] The Air Force's overall plans for space exploration were closely tied to Cold War tensions with the Soviet Union and the necessity, as General Bernard Schriever of the Air Force argued, that new weapon systems evolve with the advance of technology:

> Since the days of the cave man, much of military history has been a history of technological advance. Scientific and technical superiority is a key element in preserving our national security. In order to work effectively toward maintaining this superiority, we must consider realistically the potential military uses of space.
>
> The Soviets have made it clear that they regard space as a possible realm for military operations. Mr. Krushchev has spoken publicly of a global rocket that could fly around the world in any direction and strike a blow at any set target.[62]

Unfortunately for the Air Force, President Eisenhower and leading experts in aerospace technology favored the shifting of space research and technology from a military to a civilian platform. In the months following the October 1957 Sputnik I launch, the President, Congress and scientists nationwide held hearings and conferences in order to determine the next course of action for the country's space program. Though the Air Force up until this time had been the noted expert in space research and technology, Eisenhower and key members of Congress were wary of delivering to the military the immense responsibility of managing the country's efforts in space, especially in lieu of Eisenhower's concerns about a military-industrial complex.[63] Instead, Eisenhower chose to create an entirely new civilian agency which could "plan, direct, and conduct aeronautical and space activities," in sharp contrast to the Soviet Union's military space program. On July 29, 1958, Eisenhower signed the National Aeronautics and Space Act into law, thus creating the National Aeronautics and Space Administration (NASA).

In October 1958, NASA gained formal authority of the manned orbiting satellite program (renamed Project Mercury), which had been the first phase of the Air Force's MISS program. To ensure the sharing of space research between civilian and military institutions, members of Congress added a Civilian-Military Liaison Committee. Nonetheless, the creation of NASA in 1958 marked a significant change of direction for the country as it headed into the Space Age; no longer would the Air Force, under a military focus, guide the nation's research priorities, goals and experiments relating to the manned space

program.[64]

SAM and NASA – Early Space Research, 1959-63

The sudden shift in control over manned space flight management in 1958 left SAM and the AMD uncertain of their future role. With NASA selected as the primary institution for space exploration, SAM lost its prior designation as the center for space research (a change welcomed by many SAM scientists weary of media attention). Some in the Air Force worried that the school would fall under the control of NASA, as it had done with the Army's missile development facilities at Huntsville, Alabama. However, with the recent appropriations of funds towards the creation of the AMD at Brooks and SAM's important medical contributions to the Air Force, it was in little danger of being lost to NASA.[65]

AMD cooperation with NASA in developing the Mercury Project was a likely outcome given that it was formerly an Air Force mission. With such an ambitious mandate set before it, NASA was greatly in need of medical expertise relating to the effects of space on man. During its first year of service at Brooks, however, the AMD was virtually ignored by NASA, despite its obvious experience in space medicine.

In 1959, with its arrival at Brooks, SAM was divided into five operating departments: the Aviation Medicine Department; the Clinical Medicine Department; the Dental Sciences Department; the Medical Sciences Department; and the Space Medicine and Astrobiology Department.[66] It was this last department, under the leadership of Hubertus Strughold, which established the school as a leader in aerospace medicine. At the time of NASA's creation, the Department of Space Medicine focused on a set of ambitious research goals relating to the protection of astronauts from the harsh space environment. As outlined in a 1958 proposal for the AMC, the Department of Space Medicine and Astrobiology focused its efforts on manned space flight:

> ...manned space flight is feasible within the present state of biologic and physical knowledge. At present, however, such flights would be of limited duration.
>
> Problem areas where prolongation of time is definitely involved in establishing tolerance limits in space flight are: the atmosphere of sealed cabins, acceleration patterns during boost and re-entry, weightlessness, thermal effects, water, nutrition, waste disposal, isolation, confinement, and forced association. In order to extend the time limits of man's capability for flight into space, these and many related areas must be studied extensively.[67]

During the course of NASA's first year, managers focused on the engineering and technology issues surrounding the task of putting a man into space. NASA soon realized it had little capability in the life sciences; true to the original intentions of Congress and the President, NASA in 1959 turned to the AMD at Brooks AFB to aid its efforts in Project Mercury. On a contract basis, NASA hired the division to perform research or experiments relating to medical issues for manned spaceflight. Early on, the AMD performed three projects for NASA at under $200,000 a year; by 1963 that number had risen to seventeen projects at $913,000, illustrating the increasing importance NASA assigned to the center.[68] Aside from SAM's reputation, a key factor in the formation of a working relationship with NASA was its intention to develop a Manned Spacecraft Center just outside of Houston, Texas. With such a short distance between them, NASA and Brooks AFB easily developed a working partnership, including the use of AMD's Air

Force hospital at Lackland AFB in San Antonio. Nonetheless, by 1960, Air Force leaders were forced to realize that their control of America's manned space program was over.

The earliest contractual relationship between NASA and the SAM occurred in April 1959, when Air Force Headquarters directed the school to provide biomedical support for three Project Mercury missile launches. Before NASA scientists could launch a man into space as part of Project Mercury, serious uncertainties regarding man's survival in space remained, such as how the effects of weightlessness, radiation, heat, and acceleration would affect the human body. To better understand the risks to man, NASA planned to undertake a series of test launches utilizing primates. Just before its move to Brooks AFB, SAM was contracted by NASA to create a life-support system for the rhesus monkeys used in the test flights. The launches tested NASA's escape system as well as life-support systems that could accurately gauge an astronaut's health at all stages of flight.

Dr. Hans-Georg Clamann, the new head of the Department of Space Medicine, along with Lieutenant Colonel David G. Simons, headed SAM's efforts at creating a life-support system which would monitor health functions as well as provide oxygen. Working closely with engineers at SAM, Clamann's team of scientists worked for a year on the design and construction of a Bio-Pak capsule. While many engineering components were designed and built at the AMRL at Wright-Patterson AFB, Ohio, SAM also had the capacity to build components for space flight. Roy and Bill Sparkman were part of the engineering team at SAM that devised a fiberglass and aluminum alloy cylinder weighing 100 pounds; the capsule was capable of holding a rhesus monkey and equipment used to provide oxygen and adequate pressurization (Figure 13).[69] Raised and trained at the school, the monkey "SAM" was outfitted with a complex suit designed to measure physiological reactions and conditions within the capsule environment. Inside the cockpit, a small lever was built for the monkey, which would enable scientists to monitor his ability to maneuver controls while under the stress of space flight.[70]

On December 4, 1959, after a year of preparation, NASA, using SAM's trained monkey and Bio-Pak container, launched the capsule from the Wallops Island Test Center on the Virginia shore using a Little Joe research rocket. Flying fifty-three miles into the atmosphere, the monkey faced skyward, in order to withstand acceleration forces; during the flight, scientists measured vital information such as eye movement, heart activity, and respiratory rates. To test their new escape system, NASA ejected the capsule from the rocket booster. Six hours later, the monkey was picked up by a Navy destroyer safe and unharmed. As a result of the test, NASA gathered valuable information concerning the stresses involved with spaceflight and learned that no apparent health problems occurred. A second rocket test using a similar Bio-Pak and a rhesus monkey "Miss SAM" launched on January 21, 1960, and provided scientists with additional information. SAM was involved in further animal and biological missile tests involving mice, embryonic chicken hearts, algae and bread mold, all of which helped NASA understand the stresses Mercury astronauts might face. From the tests, NASA witnessed firsthand SAM's expertise in space medicine and the able leadership of the head of the Space Medicine Department, Dr. Clamann—factors which no doubt helped to foster a closer working relationship between NASA and SAM.[71]

In July and August 1960, SAM performed a second contract experiment for NASA involving high-altitude balloon flights over Bemidji, Minnesota. Lieutenant Colonel David G. Simons, who had been placed inside high altitude balloons during the 1957 Man High experiments, monitored the balloon flights from the ground. Instead of men, each balloon carried mice and samples of living tissue in a life-support capsule to an altitude of twenty-seven and one-half miles. The experiment proved to NASA that the upper

reaches of the atmosphere and the high levels of cosmic radiation present there did not pose a threat to man. Though small in scale, the experiment illustrates the medical complexities NASA and SAM faced; scientists and doctors were forced to consider the smallest of details regarding the possible medical effects of space travel. With this reality, the relationship between NASA and SAM was vital as the country attempted to place a man into space ahead of the Russians.[72]

SAM also performed for NASA a set of experiments involving man's extended exposure to a pure oxygen environment at high altitude. Using the limited power of Atlas boosters for the Mercury launches, NASA was constrained in the type of gaseous environment it could use in the space capsule because of the additional weight caused by sea-level pressure. The only feasible combination of pressure and oxygen was a mixture "providing only one-third the pressure at sea level, equivalent to an altitude about five miles above the earth, but with oxygen as its sole component."[73] Such an environment posed little risk to Mercury astronauts who would be in space from just a few minutes to a little over a day. NASA's plans for the Gemini program, however, involved pairs of astronauts performing experiments in space for two weeks at a time—a period that posed unknown health risks for astronauts in a pure oxygen environment.

To test such an environment, NASA turned to SAM, who since the early 1950s under the leadership of Hubertus Strughold, had performed the first space cabin tests. In October 1959, SAM had acquired a two-man space cabin allowing it to perform more advanced and extended simulated flight conditions. Led by the talented young Dr. Billy E. Welch, head of the Space Ecology Branch, SAM continued the Strughold tradition of using space cabins to test space conditions. In February and September 1960, successful tests of the two-man space cabin were completed, totaling fourteen days and thirty days respectively (Figure 14). The latter represented the longest test carried out until that time. The tests measured human reactions to high altitude pressures as well as psychological factors related to extended confinement. In January and February 1961, SAM carried out a flight simulation for NASA testing the specific high-oxygen, high-pressure environment required for Gemini flights. Captain William D. Habluetzel and Captain John J. Hargreaves stayed in the space cabin for seventeen days in an atmosphere composed of 98 percent oxygen plus small parts carbon dioxide and water vapor with atmospheric pressure equivalent to over six miles above the earth.[74] In addition to testing the cabin environment, Dr. Welch and his team studied techniques for food preparation and human waste removal. Overall, the test revealed no harmful effects on the participants, thus allowing NASA to plan accordingly for its Gemini missions.

By 1961, SAM's growing involvement with NASA coincided with significant changes at the school. On May 8, 1961, SAM was renamed the U.S. Air Force School of Aerospace Medicine (USAFSAM). The change in name referenced the school's growing space involvement as well as the evolving mission of the Air Force. In large part due to the groundbreaking space theories initiated by Hubertus Strughold in the early 1950s, the Air Force, by 1960, had removed the traditional barrier between air and space and instead spoke of a "continuous aerospace medium" that differed only in density and pressure. The change in mission reflected the Air Force's recognition that the challenges of spaceflight, like aviation, could be overcome.[75] In November, the Aerospace Medical Center became the Aerospace Medical Division, under the command of General Theodore Bedwell. The change gave the division at Brooks AFB extended laboratory space across the country and a greater ability to pursue research for manned space flights.

Despite NASA's hectic efforts to put a man in space first, the Soviets succeeded on April 12, 1961, in putting a young Soviet pilot, Yuri Gagarin, into orbit. Nonetheless, the Mercury project was proceeding on schedule and on May 5 and July 21, 1961, NASA sent Alan B. Shepard and Virgil I. Grissom high into

space. The first orbital flight occurred on February 20, 1962, when John H. Glenn, Jr., circled the earth for five hours.[76]

During the historic Mercury flights, USAFSAM and the AMD played a critical role. NASA, in an effort to prepare for any medical emergencies during each flight, appointed Brigadier General James W. Humphreys, Jr., commander of the Hospital at Lackland, to manage a team of flight surgeons and physicians responsible for pre- and post-flight astronaut examinations. Since Humphreys' post at Lackland was part of the AMD, several members of his medical staff were from USAFSAM. One of the flight surgeons was Dr. Robert McIver, who, aboard the destroyer that picked up Glenn from the ocean, performed the post-flight examination of the first American to orbit the earth. In addition to physical examinations of the astronauts, two USAFSAM physicians served as medical monitors during Glenn's orbital flight. Stationed at remote locations across the earth, these physicians monitored Glenn's health through radio telemetry and updated NASA's flight director as to the astronaut's health at all times of the flight.[77]

In 1962, Brooks AFB was selected by NASA to perform medical evaluations of future potential astronauts. Prior to USAFSAM's appointment, astronaut selection (the original "Mercury Seven") was performed at Lovelace clinic in Albuquerque, New Mexico. Through a series of rigorous medical tests and evaluations, groups of potential astronauts demonstrated to medical staff their qualifications for inclusion in NASA's elite astronaut program. Three critical factors convinced NASA to select USAFSAM for astronaut medical evaluations. First, AMD's vital clinical help during the Mercury flights displayed the school's able staff. Secondly, the school's innovative creation of courses in aerospace medicine demonstrated its expertise and relevant focus—courses included "Lectures in Aerospace Medicine," "Medical Support for Missile Operations," and "Medical Support for Space Flight."[78] Finally, USAFSAM's previous experience in astronaut selection made it an obvious choice; in 1959 the school had been chosen by the Air Force to develop a medical selection program for the Dyna-Soar astronaut program.

The head of the medical selection committee at Brooks, Dr. Lawrence E. Lamb, led the program for astronaut selection at Brooks AFB. Recommendations were based on the rigorous and exhaustive testing candidates underwent. Thus, beginning in 1962, USAFSAM performed all medical evaluations for NASA's future astronaut candidates—men who would later achieve greatness in the Gemini and Apollo programs. In addition, USAFSAM flight surgeons continued to monitor Gemini and Apollo flights from remote locations, as well as perform pre- and post-flight examinations.

By the time of Kennedy's visit to Brooks AFB in November 1963, USAFSAM and the AMD had contributed greatly to the success of the Man-in-Space program. In the last year, the school had performed vital tests on pressure suits, which would be used in the Gemini and Apollo programs. Further research on gaseous environments in space cabins were also performed, giving NASA important information and data in its planning efforts for future missions. The early years of NASA and its success in the Mercury, Gemini, and Apollo programs owed much to the medical breakthroughs and research provided by USAFSAM and AMD. Kennedy's visit also marked a new period of independence for Brooks; for the first time in many years, the Department of Defense planned for a space project to be led by the Air Force—a project that would occupy USAFSAM's scientists for six years.

USAFSAM and the Manned Orbiting Laboratory (MOL), 1963-69

Despite the creation of NASA in 1958 and the subsequent loss of control over manned spaceflight, the Air Force continued to pursue funding for a military-oriented space research mission. In 1957, the Air Force had been chosen to begin research into the X-20 Dyna-Soar aircraft, designed to operate at sub-orbital levels for military reconnaissance and bombing purposes. USAFSAM was given the responsibility of performing medical evaluations and selecting potential astronauts for the Dyna-Soar program, one of whom, Neil Armstrong, would be the first human to set foot on the moon.[79] Progress on the project was slow and limited in scope; the newly sworn-in President Lyndon B. Johnson, a dedicated supporter of the Air Force and space research, expressed his concerns over the project to Secretary of Defense Robert S. McNamara, who announced on December 10, 1963, that the X-20 Dyna-Soar project was to be canceled. To replace the X-20, McNamara revealed that the Air Force would pursue more expansive research into the manned military capabilities of space, chiefly in the form of a manned orbiting laboratory. The project, entitled Manned Orbiting Laboratory (MOL), was a decisive change of course from Eisenhower's and Kennedy's desire to keep manned space exploration under civilian management.[80]

The MOL, designed to be an earth-orbiting space station, utilized a modified Gemini capsule attached to a cylinder-shaped laboratory, and was launched into orbit by a Titan III booster. The MOL was planned for missions up to 30 days where astronauts would engage in experiments ranging from military reconnaissance using cameras and radar; satellite interception and inspection; as well as general manned experiments testing the long-term capabilities of man in space. The environment aboard the MOL was referred to as "shirt sleeve," in other words, a pressure suit-free working environment suitable for extended trips.[81]

General Bernard Schriever, the Air Force official responsible for combining USAFSAM and Air Force space laboratories under AMD, assigned management of the massive MOL project to two individual commands: physical and engineering components to Space Systems Division in Los Angeles, California, and all medical and biological aspects to AMD at Brooks AFB. Under General Bedwell's command, AMD established twenty-two design-area coordinators, each responsible for specific research tasks. A total of four scientists at USAFSAM were designated as coordinators, including Dr. Billy E. Welch and Dr. Lawrence E. Lamb. The areas of AMD's responsibility for the MOL project included developing life-support systems for the laboratory astronauts, supervising the selection and training of astronauts and monitoring astronauts' health status from earth tracking stations, the last two of which AMD already performed for NASA. Another key area of research referred to as "The Black Book," involved a series of ground and orbit-based life science experiments that would investigate the effects on man in a space environment over a three month period. Results from such tests would give the Air Force a better understanding of how man could function for an extended period in space, information that would help it to plan future military missions in space. Over the next six years, AMD pursued an extensive medical research agenda designed to make the MOL a reality.[82]

Fortunately coinciding with the expanded space mission of USAFSAM was the construction of three new buildings in 1964—Building 140 (Biosystems Research Laboratory), Building 170 (Bioastronautics and Biodynamics Laboratory), and Building 175 (Bionucleonics Laboratory). The new buildings allowed USAFSAM researchers to conduct vital experiments in metabolism, food development for space, radiation, acceleration effects, and space cabin atmospheres, all of which related directly to its broad MOL mission.

One of the important research tasks assigned to USAFSAM regarding the development of life-support systems for the MOL was further testing of space cabin atmospheres. Dr. Billy E. Welch supervised these experiments as he had done during the Mercury Project. Welch was greatly aided by the addition in 1964 of a four-man, environmental test cell, or space cabin simulator that was separated into three rooms and allowed for detailed experiments lasting thirty days or more. The new chamber allowed Welch to test different gaseous combinations for space environments involving helium and oxygen. One experiment, which began on October 4, 1965, involved four volunteer airmen undertaking a fifty-six-day test in the MOL simulator to test a 70 percent-oxygen and 30-percent helium atmosphere environment at pressure. Because helium is one of the lighter gases, it interested engineers whose job it was to design booster rockets which could carry the heavy equipment necessary to keep astronauts alive in space. Scientists also favored introducing helium as it reduced the combustible nature of a 100 percent-oxygen rich environment. Such concerns became sadly evident in the month of January 1967 when two incidents involving oxygen-rich space environments killed three NASA astronauts and two Air Force airmen in flash fires. Thus, USAFSAM's experimentation with different gaseous environments aided efforts by NASA and the Air Force to create safer conditions for astronauts.[83] Dr. Welch identified his MOL testing of cabin environments as one of the highlights of his career:

> One of the exciting activities of SAM was the development of the MOL. Project officers were very much interested in the human acceptability of helium as a diluent gas in the MOL atmosphere, because it had some positive engineering benefits. Since the school had recently developed a double-walled chamber designed to control these types of atmospheres, we were asked to conduct experiments as rapidly as we could and provide our recommendations to be used in design decisions for the MOL. This was done in a series of experiments which were quickly briefed to the MOL office.[84]

Related to Welch's space cabin experiments was the problem of how to recycle an atmosphere that would sustain life within the small confines of the MOL capsule. Given the weight limitations involved with carrying the necessary oxygen for extended flights, an alternative system for recycling a breathable atmosphere was investigated at USAFSAM. Building on the original research the school had undertaken in the 1950s, scientists examined the possibilities of using algae and duckweed as sources of oxygen. Within a confined capsule, the plants (assuming they had nutrients and a source of light) could absorb excess carbon dioxide from astronauts and provide oxygen in return (Figure 15). To test these photosynthesis theories, ground and orbital experiments were undertaken—on March 30, 1966, a 200-pound satellite containing algae and duckweed cultures was launched at Vandenberg AFB by an Atlas missile. The thirty-day orbit at an altitude of 200 miles demonstrated to USAFSAM scientists the oxygen-generating characteristics of the two plants in a zero-g environment.[85]

Another cabin atmospheric concern among AMD scientists was possible contamination of the cabin environment. Astronauts performing in a sealed environment with recycled air were vulnerable to any "toxic substance accumulation." In June 1965, USAFSAM conducted a four-week test of atmospheric contaminants in a space cabin simulator to determine how they might affect astronauts. AMD's laboratory in Ohio, AMRL, conducted similar tests in Thomas Domes, simulators which held metals and composite materials from capsule instruments that could produce toxic contaminants. The Thomas Domes were used by AMD to test every piece of hardware and equipment used in the Apollo program to determine if the

equipment was safe for astronauts.[86]

The rigorous demands of a thirty-day MOL mission required the formulation of food that would provide adequate nutrition. The problems inherent in eating food while in-flight were many—researchers at the AMRL at Wright-Patterson AFB studied the problem as early as 1952. In preparation for the Mercury Project, NASA contracted AMRL in 1961 to advise it in procedures for in-flight nutrition in a zero-g environment. Out of these experiments, Mercury astronauts were first exposed to bite-sized cubes and freeze-dehydrated food.

By 1963, both NASA and the Air Force were planning for extended space missions, which included very different nutritional requirements. Long-term spaceflight, with factors such as weightlessness, confinement, reduced pressure and changes in temperature, exposed an astronaut's metabolism to unique stresses. In addition, nutritional scientists were limited in their design of space food given payload weight restrictions. Responsibility for space food and nutritional studies transferred in 1963 from AMRL to USAFSAM under the Physiology Branch of the Biastronautics Laboratory.[87] The head scientist, John E. Vanderveen led a group of forty medical, dietary and biological specialists in the study of human metabolism in space; in 1966, he outlined USAFSAM's responsibilities in nutrition:

> The role of the nutritional program here is two-fold. One is to establish the nutritional requirements and any peculiarities of nutritional requirements for aerospace operations. The second is to evaluate foods which have been developed for the purpose of meeting these aerospace situations.[88]

One aspect of food research involved testing newly-designed foods on volunteers to determine the long-term nutritional benefits or problems. One experiment in May 1966 tested the effects of a milk-based liquid food intended to solve previous problems with astronaut dehydration. Four airmen were given the liquid diet for two weeks—two of them then entered a pressurized space cabin for thirty-day tests simulating space flight, after which all possible effects of the diet were then studied. Other tests involved seventy-two-day freeze-dehydrated food experiments in similar space conditions. Results from USAFSAM experiments enabled dieticians and preparers of food to better understand the body's ability to absorb nutrients in a space environment. In addition to Dr. Vanderveen, the dedicated work of Dr. Richard Kronenberg and Captain May J. O'Hara among others, enabled space food research to improve dramatically; one Apollo mission feasted on a Thanksgiving dinner while orbiting the moon in large part due to the advancements made by the school's researchers (Figure 16).[89]

As part of their mission in providing life-support systems, AMD scientists designed pressure suits in the case of a loss of pressurization, and for extravehicular activities. Flight suits worn by Mercury astronauts were similar to those worn in aircraft, as flexibility was not an issue in the small capsules. The MOL program, however, required the astronaut to perform numerous actions requiring flexibility in the arms, shoulders and legs. The pressure suits designed by AMD provided an "adequate breathing atmosphere, thermal protection and means of thermal regulation, protection against micrometeroid hazards, life-support expendables and adequate mobility." The pressure suits designed by AMD were so effective, NASA used them in both the Gemini and Apollo missions.[90]

Biomechanical environments, or the effects of noise, vibration, rotation and acceleration upon astronauts, continued to be an important source of investigation for aerospace physicians, especially given the

increasing power of rocket boosters. Given the extended stay of astronauts on the MOL, understanding these forces was especially important. Utilizing the school's centrifuge in the Bioastronautics and Biodynamics Laboratory, USAFSAM scientists recreated the multiple G-force effects of lift-off and reentry as well as the rotational effects of orbit. The experiments demonstrated the physiological limitations of astronauts and helped scientists prepare an environment suitable for human performance.[91]

Another MOL responsibility of AMD scientists was the consideration of personal hygiene, waste management and the development of personal health accessories. To promote physical health aboard the tight confines of the MOL, scientists at USAFSAM developed a personal hygiene kit which included chewing gum, a toothbrush, a wet cleansing cloth, a dry cleansing cloth and towels. For dental emergencies, an emergency kit simple enough to be used by astronauts was developed.[92] Air Force engineers working on MOL waste management systems turned to USAFSAM for medical information regarding urination and defecation in a zero-g environment.[93]

Since scientists had begun examining the potential hazards of spaceflight, a consistent concern was radiation exposure. With missions lasting up to a month or longer, MOL astronauts would be exposed to potential radiation hazards from solar flares, the inner Van Allen belt, and galactic particles. AMD helped to determine the maximum allowable radiation dosage for each astronaut and devised protective gear to limit exposure. Two USAFSAM scientists, Dr. Donald Pitts and Dr. Thomas Tredici, performed research concerning the effects of infrared radiation on the eyes. Through animal and human research, the scientists were able to develop a gold visor which would protect the eyes of the wearer from harmful ultraviolet and infrared radiation. NASA used the visor in the face shield of its Apollo astronauts who landed on the moon. Without the visors, astronauts would have been temporarily blinded by infrared radiation and unable to perform their missions.[94]

By 1969, several developments signaled waning interest in the MOL mission. War in Vietnam, NASA's Skylab space station, and advances in unmanned defense systems all contributed to the decision on June 10, 1969, to cancel the MOL program. Work on the launching site at Vandenberg AFB was 90 percent complete; while AMD's medical selection and testing of astronauts had fielded three groups of MOL astronauts.[95] Researchers throughout AMD suffered a significant setback to their research. While MOL never launched a single manned mission, the research conducted by AMD was transferred to numerous projects including Department of Defense unmanned satellite systems working in communications, meteorology, and navigation. Perhaps the MOL's greatest contribution was to NASA. The "Black Book" studies of man in space for extended periods of time greatly aided efforts to create Skylab, NASA's space station.[96] Much of AMD's work in space food, radiation studies, space cabin atmospheres, pressure suits and more were directly adopted by NASA during the Gemini and Apollo missions. Eisenhower's vision of a dual charter encouraging civilian and military participation in space research had become a reality through the close cooperation between NASA and AMD at Brooks AFB. AMD's complex and comprehensive aerospace medical support demonstrated to the world the necessity of aerospace medical research and ensured the success of NASA's historic manned space missions.

USAFSAM and Vietnam, 1965-70

By 1965, the USAFSAM and AMD were forced to divide their mission between two important undertakings, the Space Race and the Vietnam War. With the escalation of the war, key medical personnel of the AMD were pulled from their departments and sent to Southeast Asia as were recent

graduates of USAFSAM. Flight surgeons either served in field hospitals or acted as observers so that the Air Force could learn from techniques practiced in the field. Developments from the field were then transferred to aerospace medicine courses at the school. Overall, AMD and USAFSAM contributed greatly to the war in both personnel and in developments in operational equipment. Remarkably, Brooks managed the two diverse missions simultaneously with efficiency and skill.

Researchers at AMD provided the Air Force with numerous research and technological innovations that aided the war effort. Research goals focused on technologies that would protect or aid pilots in performing their missions. The AMRL in Ohio devised a side-firing technique for gunships that greatly increased the effectiveness of air to ground missions. In addition, a flak jacket was created at AMRL to protect aircrews from ground fire. Another example of operational technology came out of USAFSAM when scientists invented stethoscopes that could reduce jet engine noise when used on flight evacuations of the injured.[97]

AMD's greatest contribution to the Vietnam War, however, was aeromedical evacuation, the use of large airplanes to remove casualties from field hospitals to major hospitals. In 1942, the Army Air Forces created a flight nursing course at Bowman Field, Kentucky. The course trained nurses in the methods used to treat wounded patients while in the air. The concept of aeromedical evacuation, while developed decades before, was only appreciated by military planners after its use in World War II. USAFSAM was assigned responsibility for the course in 1944, and by the 1950s, it was "the hub of aeromedical evacuation."[98] Increased budgets after 1965 allowed USAFSAM physicians and researchers to spend significant time in developing both flight nursing courses and new designs for the C-9 "Nightingale" aeromedical aircraft. The jet powered C-9 was specifically outfitted for patient treatment and included all necessary medical equipment. The evacuation of injured troops made possible by the C-9s saved countless lives, as field hospitals could not provide the level of care of operational hospitals. As a result, a great number of casualties were evacuated by air in Vietnam, allowing military forces to receive the best care possible (Figure 17).[99]

Thus, the Air Force drew upon the talents and specialties of USAFSAM during the Vietnam War, just as it had done during the Space Race. Contributions including the development of operational technology, medical education of flight surgeons, and aeromedical evacuation all greatly enhanced the Air Force's ability to protect its personnel and pursue the war more effectively.

USAFSAM, 1970-Present

Entering the 1970s, USAFSAM faced dramatic budget reductions, as did much of the military after the nation's gradual pullout from Vietnam. Because of military downsizing, the focus of its research shifted from theoretical to applied—subsequent research centered on providing direct benefits to Air Force flyers and personnel.

As a result, space research decreased dramatically at USAFSAM in the 1970s. The death of the MOL program forced the Air Force to recognize a greatly diminished role in manned military space capabilities. Space work did continue on a limited scale; NASA's plans for a space shuttle included support work from the school regarding medical data. In addition, the early 1980s witnessed Brooks' military space biotechnology program, which utilized the space shuttle's capabilities to conduct medical experiments related to possible military performance in space. Overall, space research from the early 1970s to the

present day has included studies on vision in space, the study of space physiology, study of medical treatments for ebullism (exposure to the vacuum of space), and the development of reentry anti-gravity-suits. Nevertheless, Brooks' contribution to space declined from the hectic and exciting pace of the 1960s, a trend experienced by NASA as well given the nation's waning commitment to space since the successful Apollo missions.[100]

Despite budget cuts that diminished its role in space, Brooks AFB added the USAF Occupational and Environmental Health Laboratory in 1976. The mission of the group was to analyze the possible harmful effects of any chemical in use by the Air Force. The laboratory enhanced the school's mission and added to its capabilities in protecting crewmembers from harm. In 1979, the Epidemiology Division at Brooks AFB was selected to conduct a study of the potential harmful effects of Agent Orange on personnel who used it during the Vietnam War. Known as "Operation Ranch Hand," the use of aerial defoliation sprays like Agent Orange had created theories about serious side effects on the crewmembers using the weapon during the war. The Epidemiology Laboratory at Brooks was created to study diseases and how they might impact Air Force personnel. The study was undertaken in a professional and unbiased manner giving all interested parties a better scientific understanding of the issues.[101]

The 1980s ushered in a new era of responsibility for the AMD. In 1983, the Air Force Human Resources Laboratory was assigned to Brooks AFB, greatly enhancing the research capabilities of the base. No longer focused solely on basic research, the laboratories and research centers of AMD adopted engineering and development programs, allowing them to develop their own theoretical research into actual products, a shift known as "technology transition." Examples of projects that utilized this shift involved chemical defense, on-board oxygen-generating systems, crew systems technology, aeromedical system development, and epidemiological studies.[102] The shift in AMD's responsibilities from theoretical to human and weapons systems development resulted in AMD changing its name to Human Systems Division (HSD) in 1987. With the expansion of its research capabilities in the 1980s, the AMD at Brooks AFB became the world's "largest concentration of human, life, and behavioral science personnel."[103]

The collapse of communism in Eastern Europe and of the Soviet Union prompted military planners to diminish the size of the Cold War military. To meet the demands of the post-Cold War environment, the Air Force in 1991 created four super laboratories, each of which consolidated individual laboratories across the country. Fortunately for Brooks AFB, it was selected to house the Armstrong Laboratory, which included the Air Force Human Resources Laboratory, the Air Force Drug Testing Laboratory, the Harry G. Armstrong Aerospace Medical Research Laboratory, the Air Force Occupational and Environmental Health Laboratory, and the laboratory functions of USAFSAM. In addition, the Air Force Center for Environmental Excellence was created and located at Brooks. The center is responsible for managing the restoration of closing bases and ensuring environmental safety at future installations.[104]

In 1992, the Air Force merged the Air Force Systems Command and the Air Force Logistics Command into the new Air Force Materiel Command. As a result, the HSD at Brooks became the Human Systems Center. In 1995, military planners, as a part of the Base Realignment and Closure (BRAC), approved the gradual transition in ownership of Brooks AFB from the Air Force to the City of San Antonio. On July 22, 2002, BDA assumed control of Brooks City-Base—USAFSAM remains a tenant of the base.[105]

PART II. ARCHITECTURAL INFORMATION

A. General Statement:

1. Architectural character: The historic buildings that remain at Brooks AFB vary widely in aesthetic sensibility. Building 538, the first permanent structure constructed at the old Brooks Field in 1927, exhibits a Spanish Colonial style, likely modeled on similar buildings at Fort Sam Houston in northeast San Antonio. However, unlike the Army installation, Brooks never developed in a unified style. The design of a master plan for Brooks AFB began in the early 1950s, when it became clear that the base would receive a new aeromedical center. The USAFSAM buildings, constructed between 1959-74, display a uniform International Style design aesthetic characterized by low, horizontal lines, brick-faced exterior walls, and aluminum-framed storefront units at entries. The most formal of the fifteen historic buildings in the USAFSAM campus are arranged around Kennedy Circle towards the north of the group, while the more utilitarian laboratory and technical support buildings are grouped at the south. The buildings together present the most cohesive, identifiable architectural signature for the Brooks AFB.

2. Condition of fabric: The buildings have been well-maintained by the Air Force and are in good condition.

B. Site:

1. General setting and orientation: Brooks AFB is located in south San Antonio, Texas, southwest of the intersection of U.S. Highway 281 and Loop 410. The site is bounded on the north by Southeast Military Drive, on the east by Goliad Road, and on the west by the Old Corpus Christi Highway. The southern boundary is a line formed by Southton Road and Perimeter Road. The terrain slopes gently downhill from northeast to southwest toward San Juan Ditch.

2. Historic landscape design: Brooks AFB has been developed in a number of stages beginning with the original 1917 layout of the curved hangar line, airfield and support buildings near the center of the base enclosure, completed by the Detroit, Michigan office of architect Albert Kahn. At that time, no consideration of landscape design was indicated in drawings or implemented, aside from the grading required to make a flat, turf-free airfield. The airfield has since been paved, though the curve of the original hangar line is still visible at Inner Circle Road despite the destruction of all but one of the original hangars. The majority of the base was left undeveloped in its natural state of brush groundcover and native south Texas trees including pecan and live oak. Parts of the north and central sections of the base were developed in the 1960s for housing and a golf course, as well as other support facilities.

   Designers of the USAFSAM campus buildings at the northwest corner of the base did consider landscaping in select areas. The natural rise of the land, studied in topographic

models by the firm of C.H. Page and Son, dictated the layout of the first buildings and their relation to one another. Most building face north, towards a wide, circular lawn called Kennedy Circle. The facade of Building 150, on the circle's south side, creates a formal vista from the northern gate (now closed). President John F. Kennedy made his well-known address inaugurating the campus from this lawn. The slope of the land on 'the Hill' also required architectural consideration in the design of individual buildings such as Building 125, whose south service entrance is on the basement level, flanked by brick retaining walls. Building 155 occupies the highest point on the Hill, and is defined by terracing and retaining walls on three sides. Grassy lawns and plentiful sidewalks connect the USAFSAM buildings in a campus-like manner meant to resemble private academic institutions more than military installations. Nonetheless, the final phase of building, completed in the early 1970s, was haphazard, and resulted in some building inserted into the southern edge of the campus with little thought for landscape design. Most buildings in the campus area have been subject to recent landscaping efforts, generally focused at primary entries. These include planting beds and massed shrubbery that, though attractive, are not always in sympathy with the sleek lines of the International Style Buildings. Undeveloped areas remain at the extreme northwest corner of the base and at the southeast corner, which is used for survival training.

PART III. SOURCES OF INFORMATION

A. Original architectural drawings: Most original drawings for the sixteen historic buildings included in this report are archived by the BDA, 8030 Challenger Drive, Brooks City Base, Texas. The original 1927 drawings for Building 538 have not been located, although a variety of later as-built and rehabilitation drawings are also archived by the Brooks Development Authority.

B. Early views: Brooks Heritage Foundation (BHF) maintains an archive of aerial photographs at the Edward H. White II Museum of Aerospace Medicine in Hangar 9 which provide an overall understanding of site development, but minimal information on individual buildings.

C. Interviews: In November and December 2002, HHM Inc. conducted interviews with seven individuals associated with Brooks AFB, USAFSAM, or related institutions. All interviews were digitally recorded, and some provided information used in this documentation. Where used, they have been noted as such in Part III, Section C.

D. Notes:

[1] Martha Freeman, "Appendix L: Historic Context: Brooks Air Force Base, An American Flying Field, 1917-1946." in *Brooks Air Force Base – Historic Preservation Plan* by D.E. Peter, M.B. Cliff, J. Freeman and K.L. Kane. Geo-Marine, Inc., Plano, Texas, L-3.

[2] Brooks Air Force Base, *The First Seventy-Five Years*, (n.p., 1992).

[3] Ibid.

[4] Freeman, "Historic Context: Brooks Air Force Base," L-3.

[5] *The First Seventy-Five Years*, 1992.

[6] Freeman, "Historic Context: Brooks Air Force Base," L-16.

[7] Ibid., p. L-18.

[8] Ibid., p. L-20.

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[28] *The First Seventy-Five Years*, 1992.

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F. Supplemental Materials:

LIST OF ACRONYMS

AFB	Air Force Base
AFRL	Air Force Research Laboratory

AMC	Aerospace Medical Center
AMD	Aerospace Medical Division
AMRL	Aerospace Medical Research Laboratory
ARL	Aeromedical Research Laboratory
BDA	Brooks Development Authority
BHF	Brooks Heritage Foundation
BRAC	Base Realignment and Closure
DOD	Department of Defense
HSD	Human Systems Division
ICBM	Intercontinental Ballistic Missile
MISS	Man in Space Soonest
MOA	Memorandum of Agreement
MOL	Manned Orbiting Laboratory
NASA	National Aeronautics and Space Administration
NHPA	National Historic Preservation Act
NPS	National Park Service
SACS	San Antonio Conservation Society
SAM	School of Aviation (Aerospace) Medicine
SHPO	State Historic Preservation Office
USAFSAM	U.S. Air Force School of Aerospace Medicine
WAC	Women's Air Corps

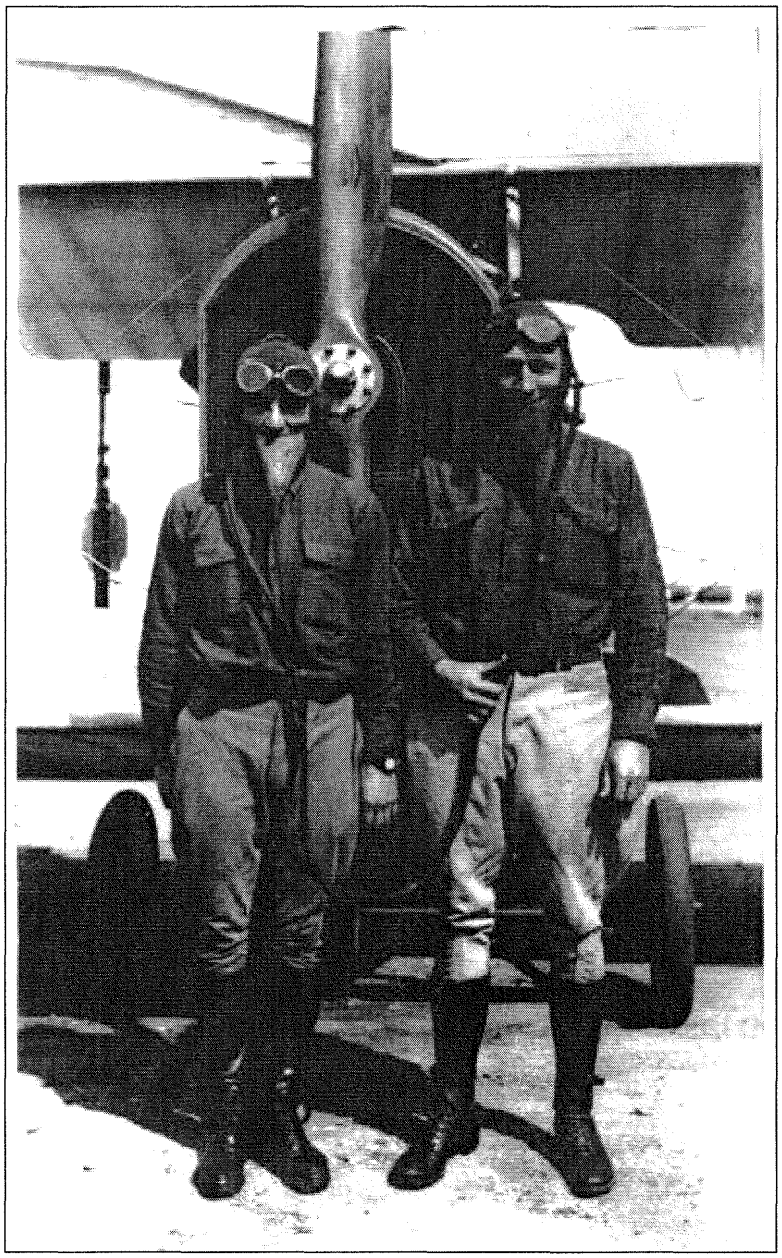

Figure 1. Gosport Training at Brooks Field, 1918.
Source: Edward H. White II Museum of Aerospace Medicine.

Note: This photo and all photos on pages 42 through 59 are property of the U.S. Air Force, and are not subject to copyright restrictions.

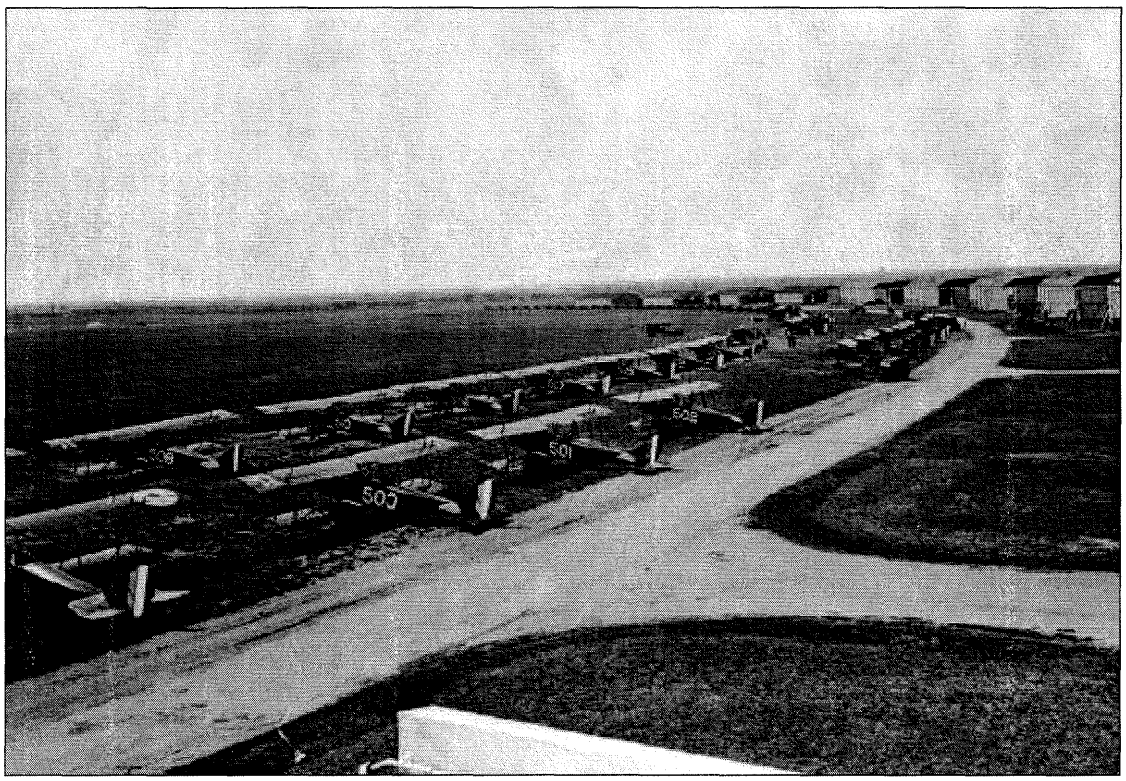

Figure 2. Rows of Curtiss JN-4 Trainers at Brooks Field, 1923.
Source: Edward H. White II Museum of Aerospace Medicine.

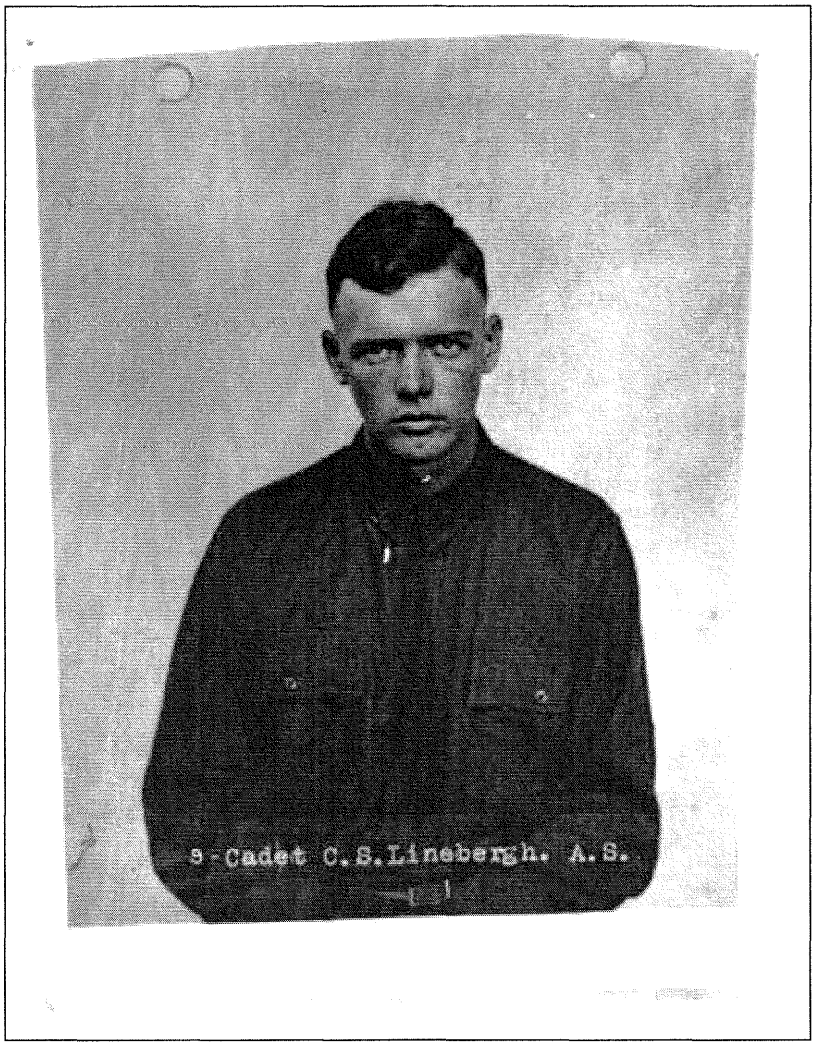

Figure 3. Charles Lindbergh as a cadet at Brooks Field, 1924. (Note misspelled name) Source: Edward H. White II Museum of Aerospace Medicine.

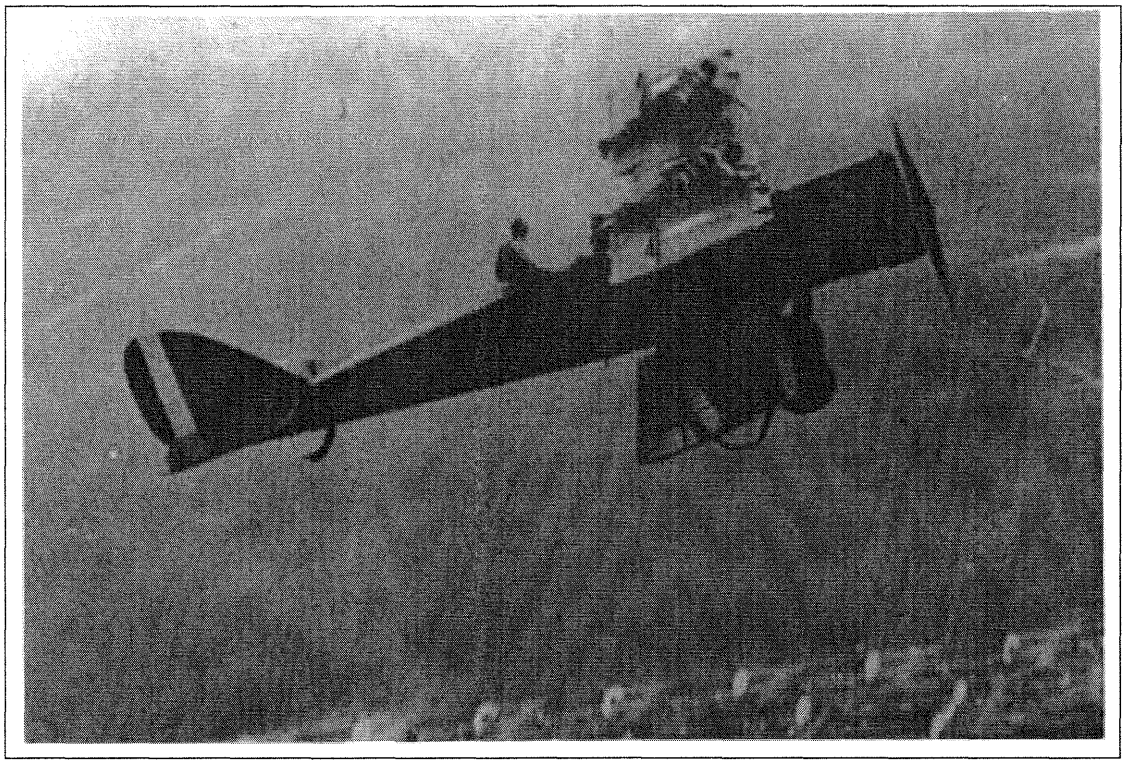

Figure 4. Demonstration of paratrooper warfare at Brooks Field, 1929.
Source: Edward H. White II Museum of Aerospace Medicine.

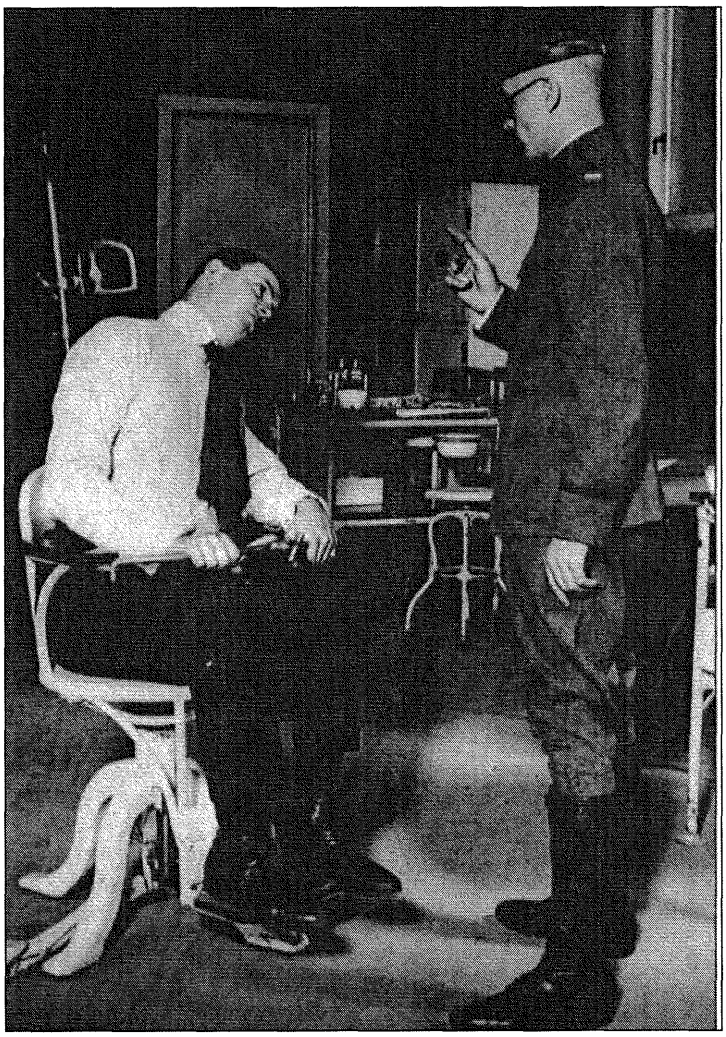

Figure 5. SAM flight surgeon performing pilot orientation tests using a Baramy Chair.
Source: Edward H. White II Museum of Aerospace Medicine.

Figure 6. Aerial photo of Brooks Field, 1942. Source: Edward H. White II Museum of Aerospace Medicine.

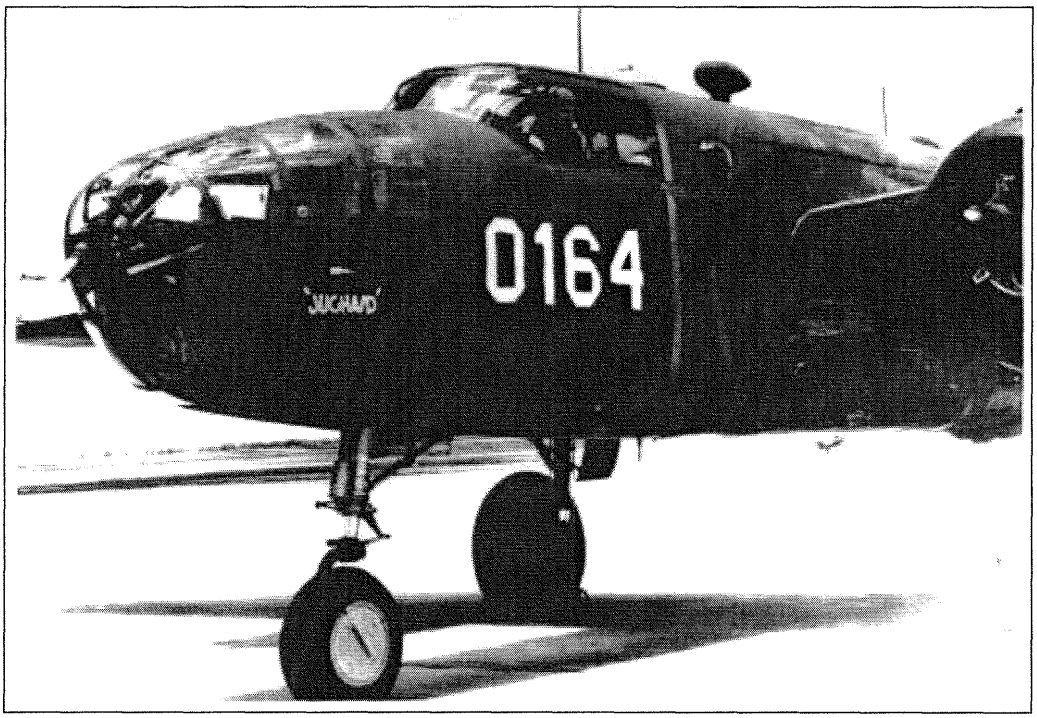

Figure 7. B-25 at Brooks Field, 1944. Source: Edward H. White II Museum of Aerospace Medicine.

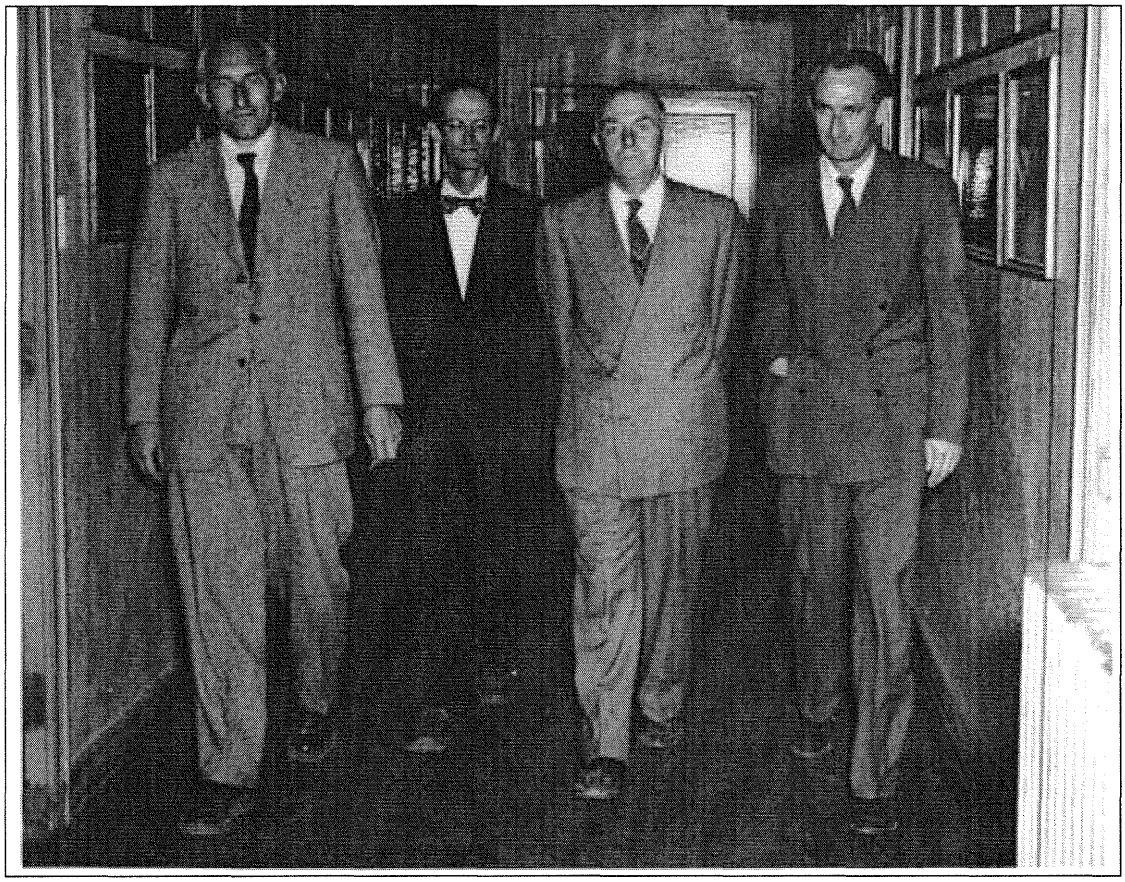

Figure 8. SAM Department of Space Medicine staff, ca. 1949 (left to right: Drs. Fritz Haber, Konrad Buettner, Hubertus Strughold, and Heinz Haber.
Source: Edward H. White II Museum of Aerospace Medicine.

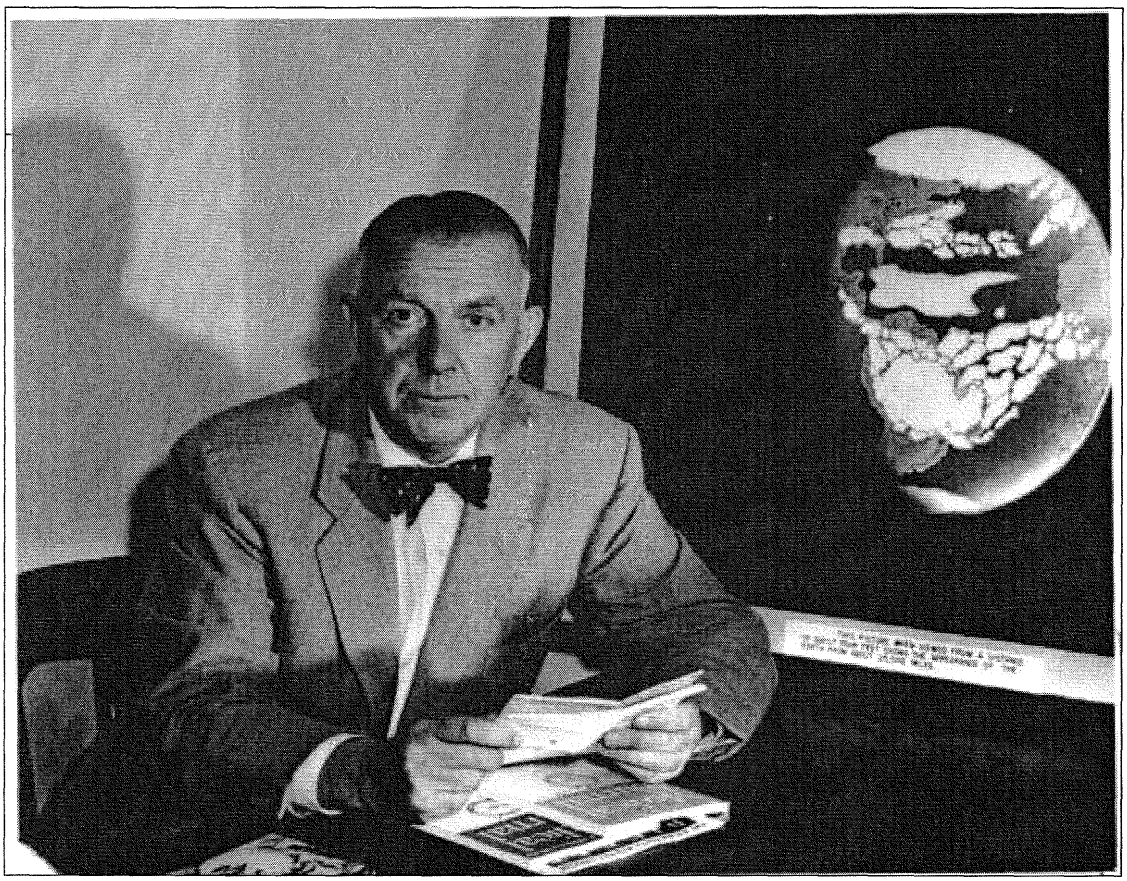

Figure 9. Dr. Hubertus Strughold, "Father of Aerospace Medicine."
Source: Edward H. White II Museum of Aerospace Medicine.

Figure 10. USAFSAM zero-g experiments using jet trainers, 1959.
Source: Edward H. White II Museum of Aerospace Medicine.

Figure 11. Initial construction of Aerospace Medical Center (AMC), 1958.
Source: Edward H. White II Museum of Aerospace Medicine.

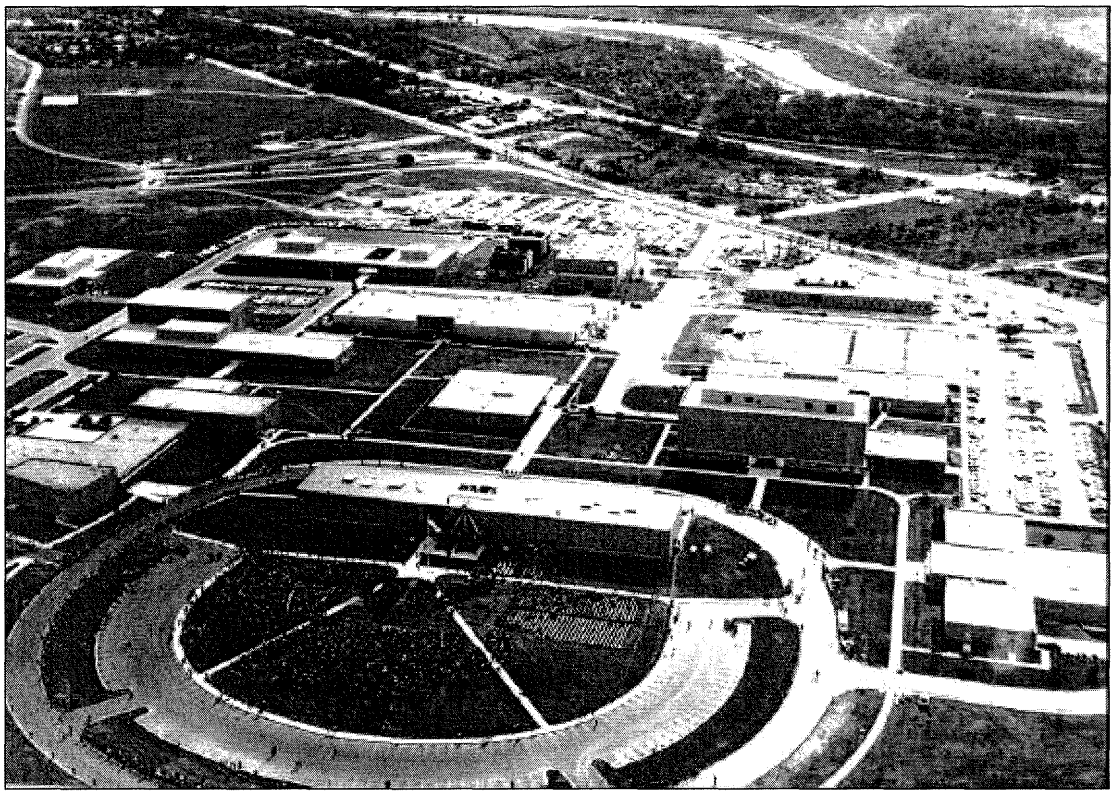

Figure 12. Aerial photo of USAFSAM during President Kennedy's Dedication, November 21, 1963. Source: Edward H. White II Museum of Aerospace Medicine.

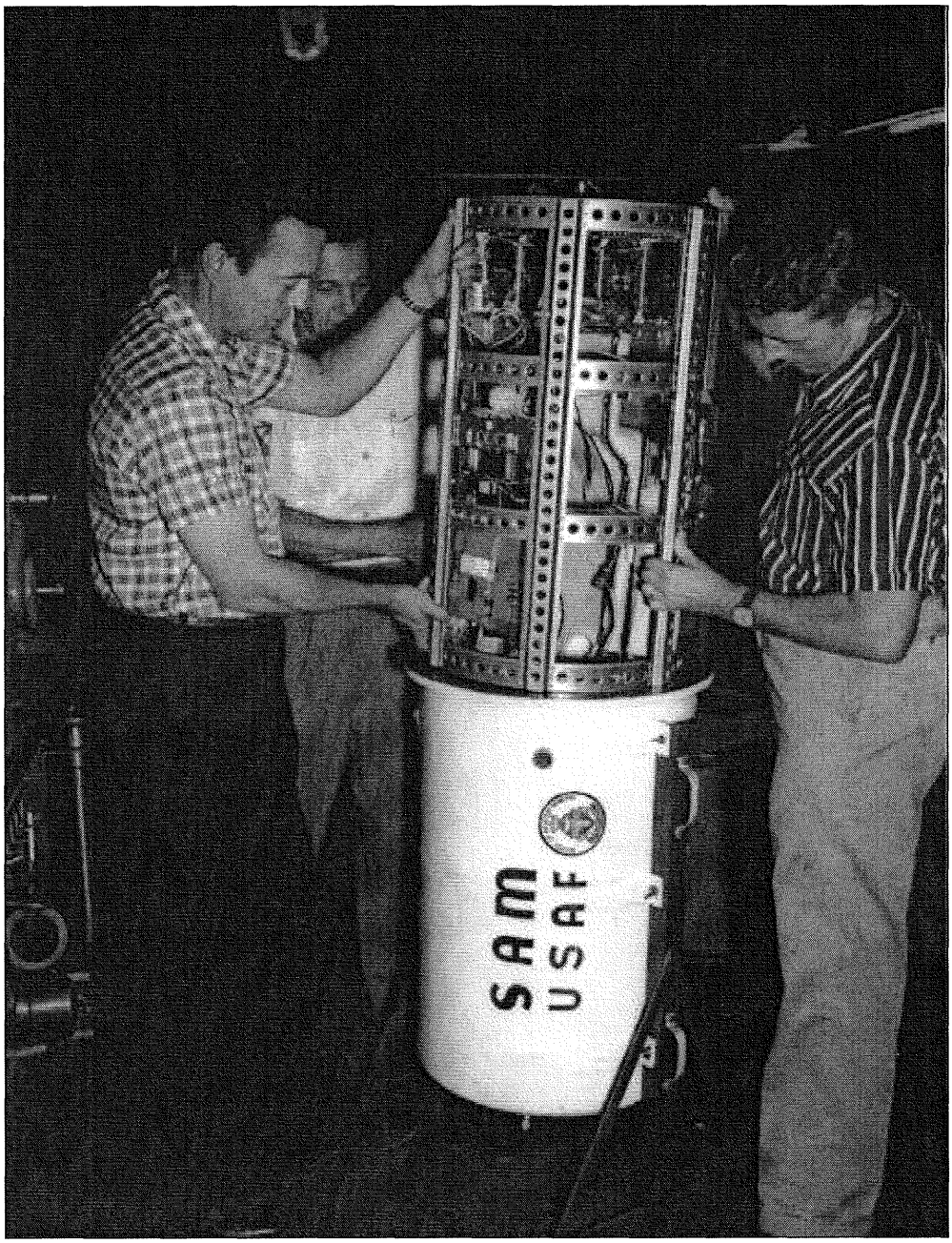

Figure 13. USAFSAM personnel preparing Bio-Pak capsule, 1959.
Source: Edward H. White II Museum of Aerospace Medicine.

Figure 14. Brooks AFB volunteers in the two-man simulator at USAFSAM. Source: Edward H. White II Museum of Aerospace Medicine.

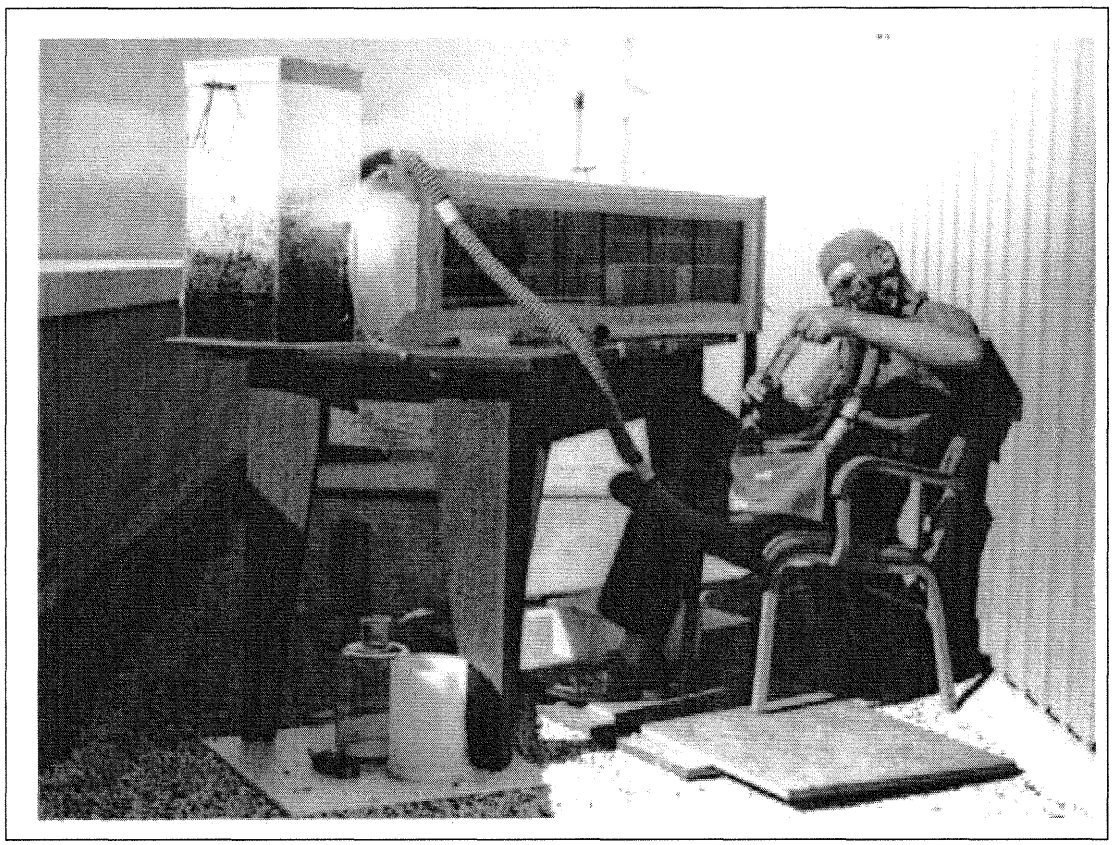

Figure 15. Oxygen generating photosynthesis experiments at USAFSAM, ca. 1966. Source: Edward H. White II Museum of Aerospace Medicine.

Figure 16. Captain May O'Hara (left) exhibits examples of USAFSAM space food. Source: Edward H. White II Museum of Aerospace Medicine.

Figure 17. Air evacuation flight nurses supervising transport of wounded in Southeast Asia, 1968. Source: Edward H. White II Museum of Aerospace Medicine.

PART IV. PROJECT INFORMATION

A. Federal Agency:
Air Force
311th Human Systems Wing
Brooks City-Base
San Antonio, Texas.

B. Project Causing Adverse Effect: The Brooks City-Base project is a cooperative partnership between the Air Force and the non-federal community in which the physical assets of the former Brooks AFB have been transferred from the Air Force to BDA, a local municipality under Texas statute. Under Section 106 of the National Historic Preservation Act (NHPA) of 1966, as amended, and its enabling regulations 36 CFR 800, the transfer of Federal property is an adverse effect that must be mitigated via a Memorandum of Agreement (MOA) between the lead federal agency, the State Historic Preservation Officer (SHPO) and other consulting parties invited to participate in the consultation.

In consultation with the Texas SHPO, the Air Force determined that seventeen buildings at Brooks City-Base were eligible for inclusion in the National Register of Historic Places. The Air Force developed an MOA in consultation with the Texas SHPO, City of San Antonio and BDA to mitigate the adverse impact that transfer would have on the seventeen historic properties at the former Brooks AFB. The MOA was also signed by two concurring parties, the San Antonio Conservation Society (SACS) and the Brooks Heritage Foundation (BHF). The MOA stipulated multiple measures, including preparation of a Historic American Buildings Survey (HABS) Level II documentation report. The Air Force, through the 311th Human Systems Wing, hired Earth Tech, Inc. to oversee the preparation of HABS documentation. Under contract to Earth Tech, HHM Inc. of Austin, Texas, gathered historical and architectural information and prepared a historic context and the HABS forms.

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