America's Greatest Projects and Their Engineers IV

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America's Greatest Projects - IV

Engineers in Space

Table of Contents

Introduction

A. Activities Leading to the Space Race

1. The Cold War

Following the end of World War II, during which the United States and Russia had become unlikely allies against German aggression, the two nations entered into an often bitter confrontation that became known even to this day as the **Cold War**. Led by brutal dictator Josef Stalin, Russia had unilaterally annexed most of the Eastern European nations, including the eastern half of Germany, which completely surrounded Berlin. Furthermore, the Russians had managed to infiltrate key segments of the Manhattan Project, the development by the United States of the first atomic bomb, including having a spy network at the Los Alamos, New Mexico laboratories. Their espionage efforts were so effective that they, subsequently becoming the Union of Soviet Socialist Republics (USSR), had tested and begun accumulating their nuclear arsenal by 1949.

Because most Americans had developed a deep distrust of the Russians and the spread of their communist propaganda, President Harry Truman and Congress had adopted a philosophy of "containment" toward the USSR. When North Korea, inspired and motivated by the USSR, invaded the democracy of South Korea in 1950, most Americans believed that the U.S. should intervene. During the Korean conflict, which involved the United States defending South Korea against communist North Korea as well as the Chinese Red Army between 1950 and 1953, the USSR stayed out of the war. However, they used that period to solidify their hold on the nations of Eastern Europe and to enhance their nuclear capabilities. In July of 1953 a somewhat uneasy truce was reached between North and South Korea to end the Korean conflict, with the line of demarcation being the imaginary 38th Parallel.

President Dwight David Eisenhower had been a staunch opponent of the USSR under Josef Stalin ever since Ike had been the leader of the American Expeditionary Forces during World War II. Eisenhower had witnessed first-hand the atrocities that Stalin had perpetrated on the German population, the people of the Baltic nations that his troops had overrun, and the hundreds of thousands of his own citizens and political opponents in Russia. Despite Stalin's death and the nearly simultaneous end of fighting in Korea in 1953, the U. S. Congress became more concerned than ever about the further spread of Communism around the world as well as within the United States. They adopted an intense, far-reaching anti-communist policy which included Congressional hearings and affected thousands of Americans whose careers were jeopardized. During this period of turmoil in the United States in the mid-1950's, the Soviet leaders, led by their new premier Nikita Kruschev, continued to expand their communist agenda around the world.

Meanwhile the French, recognizing that the nuclear "Arms Race" between the United States and the USSR might be spinning out of control, had proposed an International Geophysical Year. The IGY would be an effort by engineers and scientists from around the world to collaborate on some of the latest technological achievements in the fields of space travel, radar, and computerization. The IGY was to be held beginning on 01 July 1957, and was to last through 1958. Sixty-eight nations were invited to participate and to sponsor relevant projects. Only one nation (Mainland China) refused to participate, their reasoning being that the island nation of Taiwan had also been invited.

2. Rocket Pioneers

Dr. Robert H. Goddard

Robert H. Goddard was born in Worcester, Massachusetts in 1882, the only surviving child of a family with over two hundred years of New England heritage. He grew up in an era of exciting new technology such as the implementation of electric generation in the cities, the beginnings of telephone coverage throughout the Northeast, and the invention of the "horseless carriage". He showed an early interest in astronomy, and even began to pursue his dream of space flight before the Wright Brothers flew their first plane at Kitty Hawk.

Although he suffered in his early life from pleurisy and other childhood diseases, Goddard's health improved sufficiently in his latter teen years, and he was able to graduate from Worcester Polytechnic Institute with a B.S. degree in physics. He eventually enrolled at Clark University, also in Worcester, where he focused his studies on aerodynamics and mechanics, and received his Ph.D. in physics in 1911. As an instructor at WPI, Goddard began his lifelong career of developing new and more efficient rocket designs, believing that one day man would travel into outer space. All rockets for the previous several centuries had been solid-fuel rockets, using gunpowder as the primary fuel whereby even the most modern solid-fuel rockets performed in a similar manner: the rocket motor consisted of an igniter near the top of the rocket, a dry propellant charge, and a sealable nozzle at the bottom. The charge was, of course, contained within a heavy duty casing, and the thrust from the rocket's gas discharge was controlled through the fixed or adjustable nozzle.

Goddard realized that there were significant limitations and inefficiencies with solid-fuel rockets. He countered this centuries-old design by proposing the concept of liquid-fuel rockets, whereby the fuel would be liquid hydrogen and the oxidizer would be liquid oxygen. After three years at WPI Goddard filed his first patent in 1914, citing the liquid-fuel rocket for its much higher efficiency and its much greater opportunity to send objects into outer space. His belief that rockets would someday propel instruments and other devices high enough into the earth's atmosphere to escape its gravitational field was met with skepticism by most of the world's engineers and physicists. HIs detractors were of the opinion, later disproved by Goddard, that rockets could neither be adequately controlled nor would they provide thrust when they escaped the earth's atmosphere.

His further supposition that these objects would then be able to orbit the earth subjected Dr. Goddard to significant ridicule. Nevertheless, Goddard continued to pursue his passion for rocket development over the next two decades, meeting with both failure and success. In 1935 his team produced the first rocket to travel faster than the speed of sound, and two years later they sent a rocket into the atmosphere that reached an altitude of more than nine thousand feet. Along the way Dr. Goddard provided written reports of his numerous liquid-fuel rocket trials and tests, but died an unfortunate and early death in 1945 after having received more than ninety patents during his career. In his later years prior to his death Dr. Goddard had spent most of his time working with the U. S. Army, while developing rocket-based military weapons such as the bazooka and other armor-piercing devices.

Hermann Oberth

A contemporary of Dr. Goddard but thousands of miles away, Hermann Oberth was born in 1894 in the part of Austria- Hungary which is today Romania. At the age of eighteen he began the study of medicine, but a few years later he was drafted into the Imperial German Army, and was assigned to the infantry division on the Eastern Front against Russia. By the end of World War I, he had abandoned his study of medicine and focused his studies on physics. Oberth was an early advocate of space flight, and had written a lengthy book on liquid-fueled rockets and space flight. However, Oberth's work had met the same ridicule as Goddard's writings. His dissertation on the subject to receive his doctorate at the University of Berlin was completely rejected as being delusional and too "Utopian" and, thus, he never received his doctorate.

Nevertheless, Oberth continued to espouse space travel and was recognized for his expertise with liquid-fueled rockets, becoming a founding member of the amateur rocket society known as the Spaceflight Society in the late 1920's. One of the young members of the society that he tutored with his design of liquid-fueled rockets and his numerous sketches and designs of two-stage rockets was Wernher von Braun, who was then just eighteen years old. Because of the worldwide depression during this period, Oberth placed his further rocket activities on hold and became a high school physics and mathematics teacher to support his family over the next several years.

During his teaching career Oberth never lost his desire or his dream to eventually see a man land on the moon, and occasionally was hired by movie producers as a consultant to form design concepts of space age rocket ships that eventually became reality. Oberth was finally summoned in 1941 to Peenemunde, the Nazi-Germany designated rocket preparedness base in northern Germany. There he worked alongside von Braun to develop the Aggregate (A-series) rocket program. Following the implementation of the V-2 rocket program in late 1943, Oberth was assigned to the solid-fuel rocket division to design anti-aircraft rockets for the German military. At war's end he and his family were given asylum in a small town near Nuremberg, which became part of the safe zone of post-war occupied Germany.

Oberth was permitted by the U. S. government to travel between the safe zone in Germany and the USA for the next fifteen years. He was assigned to von Braun at the Redstone Army Arsenal in Huntsville, Alabama in the early 1950's where he assisted in the development of rockets and space technology. He returned to Germany after five years, but returned to the U. S. in 1960, working as a technical consultant to the Convair Corporation on the Atlas Rocket Program. In his later years he espoused alternative energy sources such as wind turbines, believed in UFO's and the existence of life in other solar systems, and published books on these subjects prior to his death in December, 1989 at the age of 95.

Dr. Wernher Von Braun

Dr. Wernher Von Braun was born in Germany in 1912, the second of three sons of a German nobleman and an aristocratic mother. Growing up in Post-World War I Germany, he was the equivalent of a child prodigy, being able to play both the viola and classical piano. However, as a teenager he developed a love for astronomy and all but abandoned his musical career. Instead, he focused his studies on physics and mathematics, two areas of study in which he had initially struggled.

In 1930 he was invited to join the Spaceflight Society, an amateur rocket club just a few miles south of his home in Berlin. The club had been in operation for a few years, and had developed several different styles and types of rockets which the members had fired off into the atmosphere. The members, including von Braun, were greatly influenced by the physicist Hermann Oberth. In von Braun's second year as a member of the club, club members had managed to fire off more than eighty rockets of varying types, but none of them reached altitudes of greater than 200 feet. Although they had knowledge of Oberth's research and some familiarity with the experimental work that was being done in the U. S. by Dr. Goddard, the club was never able to achieve the high standards that Goddard had achieved in the U. S.

Regardless, the club was visited in the spring of 1932 by then-Captain Walter Dornberger, a military representative of the Weimar Republic. As part of Germany's surrender following World War I, the Germans had been restricted by the Treaty of Versailles in their ability to manufacture military-grade weapons. Drawing the somewhat abstract conclusion that rockets were not considered to be military-grade weapons and, therefore, were not subject to the Treaty, the Weimar Republic established an army rocket base at Kummersdorf, about twenty-five miles south of Berlin. Dornberger, a mechanical engineer who was also later brought to the United States and was instrumental in the U. S. space program, hired von Braun, at the tender age of twenty-one, to head up their rocket division. Acting in a stealthy manner, the German army weapons base at Kummersdorf encouraged von Braun to bring in engineers and technicians, few of whom believed at the time that they were designing and experimenting for warfare. Von Braun, who had a mechanical engineering degree from a technical school in Berlin, was encouraged by Dornberger to seek his doctorate degree at the University of Berlin, which von Braun completed in the spring of 1934.

The situation changed dramatically over the next several months following Dornberger's arrival at Kummersdorf. First the Chancellor of Germany failed to establish a coalition in the government of the Weimar Republic, and decided to resign in early 1933. Then the Nationalist Socialist Party of Germany, with barely more than thirty percent of the votes of the Weimar Republic, seized control of the entire German Government in April of 1933, and Adolph Hitler was quickly elevated as its leader and dictator. Whereas von Braun and his team had been operating in a somewhat secretive and clandestine manner prior to the Nazi takeover, they were now being urged to produce rockets and rocket designs which didn't necessarily fit with von Braun's desires to put men in space. In the summer of 1937 the entire rocket division was relocated to Peenemunde, a small coastal town on the Baltic Sea in the extreme northeast corner of Germany. There they developed larger and longer-range ballistic rockets, which they were able to recover by firing into the Baltic.

Dornberger and von Braun were approached by Himmler and other SS officials to work on the production of liquid-fueled rockets that could conceivably carry military-grade weapons. Realizing that his rocket work could have devastating consequences for the Nazi enemies, von Braun adopted a personally disappointing and somewhat reluctant philosophy that, although this had never been his goal, he must do whatever he could to help his nation win their war.

The Luftwaffe had become one of the most sophisticated, technologically advanced, and battle-experienced air forces in the world under the command of Hermann Goering starting in 1935. Second in German authority only to Hitler during World War II, Goering led the Luftwaffe to many early successes when the war broke out. His main targets in 1940 were the Royal Air Force (RAF) of the United Kingdom as well as London and several other key English cities. From the summer of 1940 through the spring of 1941 the Luftwaffe, in what became known as the **Battle of Britain,** pounded the United Kingdom with an almost daily bombardment. Despite inflicting severe damage to the RAF's infrastructure and devastating many British cities, the German air force failed to batter the beleaguered British into submission. One of the primary reasons that the death toll and destruction was minimized was because the British had set up a series of radar towers along the English Channel, which gave them early warning of the Luftwaffe's pending strikes.

Von Braun was ordered by Goering to markedly improve their aircraft by designing engines with advanced turbojet and rocket propelled capabilities to provide them with more responsive takeoffs and greater airspeeds. The Allied bombing campaigns was gradually destroying the Luftwaffe's fighter arm, and Hitler was blaming Goering for the military losses that were occurring. Then in December of 1942 Hitler signed an order urging the German rocket agency in Peenemunde to develop a weapons-grade liquid fueled rocket that could carry a payload of explosives more than 1000 km (625 miles), far enough to reach London, England. Almost simultaneously Goering had agreed to build a series of stealth bombers that would travel at the speed of sound and also have a range of 1,000 km. The stealth bomber (named the Horten 229) was being designed by the Horten Brothers, and would be built mostly out of wood in order to absorb the British radar rather than to reflect it. Von Braun, still a youthful and somewhat naive aeronautical engineer and rocket scientist with a non-military vision for the future, bowed to the pressure to produce what he could for his Homeland.

Based on the "A" series of rockets that the agency had been developing since 1937, the rocket designation was changed to "V", a symbol for the German word "vengeance". This was done in deference to Hitler's desire to drop these explosives on London as payback for the RAF and USAF dropping hundreds of bombs on numerous German cities. Despite the fact that the city of Peenemunde was bombed by the RAF and some of his key personnel were killed, von Braun and the rest of his team were able to test launch several rockets that would meet those specifications as they continued to increase the dummy payloads. Finally, in September of 1944 they had tested a rocket that met their requirements, which was named the V-2 rocket. Over the years of development, they had added wings to the rocket that improved stability, and a gyroscope provision that allowed them to more consistently control the rocket's trajectory.

Before the Germans finally surrendered on 06 May 1945, they had managed to launch nearly three thousand V-2 rockets with varying payloads, which were able to kill more than ten thousand Allied military and civilian personnel. Needless to say, the death toll would have been much higher if the V-2 guidance systems had been more precise. Many rockets missed their mark by several miles, some fell into open waters, and others fortunately never exploded. The Luftwaffe gradually fell into a state of disrepair by war's end, while only a prototype of the stealth bomber was ever built, and the rumor that the Third Reich was close to having a nuclear weapon proved to be untrue.

Of course, the Soviets were well aware by this time through their espionage efforts that the United States was planning to test nuclear explosives. Since von Braun and his team had actually developed the first ICBM (Inter-Continental Ballistic Missile), the Soviets were extremely anxious to grab von Braun and his team and bring them to Russia. However, von Braun, along with his rocket team and hundreds of family and friends, had first been moved from Peenemunde to Austria, then later to a small town in central Germany. The story is that they had managed to make their way through war-torn Germany by train to an American outpost, where they surrendered their entire contingency to an American private. They had weighed their prospects of whether they should surrender to the Russians, the French or the British, and had settled on the United States as their best option.

Thus, the United States was able to nab von Braun and many of his engineers as well as more than three hundred railcars of V-2 rockets and parts that the German engineers had stored in an abandoned mineshaft, and had transported everyone and everything back to the U. S. Once in the United States von Braun and his specialists did some advisory work for the military, first at Fort Strong in Boston Harbor, and then at Fort Bliss, an army outpost near El Paso, Texas. He spent most of his time for the next five years training U. S. military and academic personnel in the intricacies of rocket science, when he was not defending his role under Hitler during World War II against the U. S. politicians and the American press. Von Braun and his fellow engineers remained as "Prisoners of Peace" until 1950 and the start of the Korean War, before beginning any meaningful work with the U. S. government.

In 1950 Von Braun and most of his team were transferred to the ABMA (Army Ballistic Missile Agency) in Huntsville, Alabama, his home for the next twenty years. He led the U. S. Army's rocket development team at the Redstone Arsenal, conducting the first live tests of U. S. nuclear ballistic missiles. Also during this period of the 1950's, von Braun and his team developed a modified version of the Redstone rocket which they named the Jupiter-C. The success of this rocket finally enabled the United States to launch its first satellite, which we will describe later, and which propelled the United States into its space program.

3. <u>Sputnik 1</u>

With the advent of the International Geophysical Year (IGY) approaching in July of 1957, and with the agreement among the sixty-seven nations to explore space travel, President Eisenhower issued a press release in July of 1955 which stated that the U. S. would be pursuing a project to place a group of satellites into orbit around the earth. Less than four days later a prominent Soviet scientist was quoted as saying that the USSR would be working on a similar project. The Soviets, however, did not reveal that some members of the USSR's technology ministry had been already planning the procedures necessary to put a satellite into orbit around the earth. This effort was under the direction of Sergei Korolev, a prominent Russian aircraft designer by training. Korolev had been attempting to develop rocket designs similar to those of German's engineers and scientists as far back as 1938. However, he had tried and failed with several rocket designs in the past, and was subsequently accused by the Soviets of squandering valuable defense funds and deliberately sabotaging the research work in which he was involved. He had been sentenced to death in Siberia in 1938 for his supposed carelessness and failures, but somehow Korolev managed to escape execution.

Nevertheless, Korolev served at mostly hard labor for more than six years, even as the Germans invaded Russia in World War II. During this period development of rockets, primarily as a weapons tool, was severely restricted in the Soviet Union due to financial restrictions. Recognizing this stagnation in their rocket program, and hearing of Germany's development of the A-series and V-2 rockets, Premier Josef Stalin finally had Korolev released from prison prior to the end of World War II. After the end of the War Korolev was encouraged to resume his work on the development of rockets, primarily as they pertained to the quicker takeoff and higher airspeed of Soviet aircraft. Once the Soviets had gained control of East Germany and several other Eastern European nations behind their Iron Curtain, their national wealth had grown substantially. In addition to the increased funding, Korolev and his team were greatly fortified by the knowledge and presence of scientists and engineers from East Germany whom the Soviets had managed to capture from the grasp of America's Army and bring to Moscow following the end of the war.

Rising to the ranks as Chief Rocket Scientist for the USSR a few years after the end of World War II, Korolev had assembled a team who placed most of their renewed focus on ICBM's and their uses for carrying nuclear warheads. While most of the USSR's military activities were kept secret during development of the Soviet rocket and space programs, Soviet intelligence felt that they could no longer rely on those German engineers and scientists who might jeopardize the integrity of their programs. In order to avoid any possibility of exposure, nearly all of the German engineers and their families were repatriated to their German Homeland between 1951 and 1953. However, Korolev and his Soviet team continued to rely on some German engineers and seek improvements on the few German rocket designs that they had managed to capture. They also utilized the old patents and drawings of American engineer and scientist Dr. Robert Goddard. Even though Goddard had died just a week before the Japanese surrender to end World War II, his technical papers and numerous patents were still well known and widely published and very familiar to nearly all engineers and scientists in the rocket and space industries.

As early as December of 1954, Korolev had approached the Minister of Defense of the USSR with a proposal to launch an artificial satellite, utilizing the rocket design that he and his team were planning to produce. Following the Soviet announcement in July of 1955, the United States acknowledged the viability of this project by the USSR, but did not consider it as either a serious endeavor by the Soviets nor a credible threat to the United States. However, this announcement by the Soviets was the very beginning of their overall plan that was actually later credited with successfully sending the first satellite into an orbit around the earth's surface. At that time counter-intelligence through the use of high-flying U-2 airplanes was not nearly as sophisticated as it is today with satellites, and many of the Soviet technology advancements in telemetry and radio control systems, gyroscopes, and the preparation of launch sites went completely unnoticed or were simply ignored.

The rocket chosen by the Soviets to carry the first payload into space was the R-7, somewhat of a clone of the V-2 rocket that the German engineers had developed and their Nazi military had been firing just prior to the end of the War. The R-7 was 112 feet long and about ten feet in diameter, was a two-stage rocket, and was being developed by the USSR under the direction of Korolev in the mid-1950's as the world's first sophisticated ICBM. The first stage, equipped with six Vernier rocket engines, was capable of being jettisoned, while the second stage was equipped with four Vernier rocket engines. Each of the Vernier thrusters was radio-controlled, could be fired individually to control yaw and pitch, and used a high-grade of kerosene plus liquid oxygen as its fuel source and oxidizer respectively.

After several dry-run launches, the Soviets surprised the world (and maybe even themselves, to some extent) by successfully launching the **Sputnik I** on **04 October 1957**. The satellite itself was considerably smaller than the satellite that had been originally planned, being a polished metal sphere slightly less than two feet in diameter and weighing about 185 pounds. Sputnik I had four metal antennas, each about six feet in length, mounted equally around the sphere's circumference. The satellite settled into an elliptical Low Earth Orbit (LEO) of between 100 and 1,200 miles above the earth's surface and traveled at about 18,000 miles per hour. It was barely visible from the earth's surface, although the second stage of the rocket with a length of about 86 feet which trailed the satellite could easily be seen. Sputnik 1 transmitted radio signals to many receivers on earth at a pre-designated frequency for three weeks until its batteries died, and it continued its LEO for about ten more weeks before burning up at re-entry.

The revelation of this effort by the USSR quickly found its way to major news organizations around the world and throughout the United States, and considerably altered the thinking and the time line of the Eisenhower administration. Although the USSR had not initially intended to use this launch as propaganda, the reaction by politicians in the United States gave the Soviet political cause a great boost worldwide. This singular incident had the greatest impact on the strategies of the two nations during the ensuing three decades regarding the Cold War, and was actually credited with the beginning of the **Space Race** between the two nations.

Americans feared, maybe somewhat prematurely, that the Soviets now possessed the ability to carry a large nuclear warhead into the stratosphere and drop it anywhere in the world. The simple fact was that the 8K7V1 rocket, which carried the satellite into orbit, had a distinct limitation in its ability to be controlled. Furthermore, although the Soviets had the technology to calculate the rocket's parabolic and elliptical courses with a high degree of accuracy, they recognized that anything that returned back to the Earth's atmosphere would be burned up upon re-entry. With that understanding Kruschev convinced

Korolev to send up a second satellite, which was again carried by a modified 8K7V1 ICBM rocket, and launched on **07 November 1957**.to commemorate the 40th anniversary of the October Russian Revolution,

B. America's Engineering Response to Sputnik

1. America Closes the Gap

Surprised certainly, but not unprepared for the events of the Soviet Union, the United States tried its very best to respond quickly. One of the U. S. problems up to this point was that there was a great reluctance to use any type of rocket design that might be construed as a military device. This factor had resulted in several agencies being involved in various projects for developing different parts of the space program, but none were being given any specific direction, nor were they being held accountable for their performance.

The USAF (United States Air Force) had been working on the Atlas program and had made some progress, but the Atlas rocket was not ready for flight at the time of Sputnik 1. Designed and manufactured by the Convair Division of General Dynamics, it was intended for ICBM use. Although considered as a military device for this reason, its unique staging features eventually made the Atlas Series extremely beneficial to the U. S. space program. Its liquid propellant engines burned liquid oxygen and a high grade of kerosene called RP-1, which was more stable than hydrogen and much less toxic than the ammonia-based hydrazine. Its three rocket engines were configured in such a way that its two outboard (booster) engines would be jettisoned during ascent, while its center (sustainer) engine would be retained until orbit insertion occurred. In fact, as we shall see later, the Atlas rockets were used to launch the first four American astronauts into an LEO.

Concurrently the Naval Research Laboratory (NRL) was chosen by the Department of Defense to launch the first satellite for the United States. The NRL was considered by the DOD to have the best chance to launch a satellite, since they seemed to have the three basic aspects necessary for a successful launch:

1. The NRL was in charge of the manufacture of the Vanguard rockets, which had tested well.

2. The NRL had developed a guidance system that had been proven in rocket tests.

3. The NRL had been working with the Jet Propulsion Laboratory (JPL) in Canoga Park, California, which had furnished a satellite that could be monitored for several months and had instruments that would provide considerable information.

In the meantime, Chrysler was designing and manufacturing the Redstone rocket (known as the Jupiter) for the ABMA (Army Ballistic Missile Agency) under the direction of Dr. von Braun at the Redstone Arsenal. It was 70 feet high and consisted of four stages, but it had only a small (24 lb.) payload capacity. In addition, the Redstone rocket being developed in Huntsville, Alabama by Dr. von Braun's team was considered to be too military in nature, and thus would be unacceptable for an IGY launch. Once the

Soviet Union launched both Sputnik 1 and 2, whose Soviet launch vehicles were both manufactured as ballistic missiles, this became a moot point to the Department of Defense.

This scattered approach continued to deter the American efforts to place a satellite into orbit, as competition occurred among the military groups amid bitterness and anger. On 23 October 1957 the NRL launched a successful rocket with a very small payload, but the second and third stages were dummies (no fuel) and thus never quite reached close to LEO. One of the goals was to test the retrorocket (reverse thrust) system that would control the altitude of the rocket at release of the satellite, and a super high frequency radio band which ground radar could use to track the rocket's trajectory as well as its propulsion. Both systems worked well, proving to at least the American engineers that they were ahead of the Soviets in much of the space technology.

America's First Satellite Attempt Fails

The first actual attempt to launch an American satellite into orbit was with the Vanguard TV-3 (Test Vehicle Three) on 06 December 1957. Manufactured by the Martin-Mariette Corporation and operated by the Naval Research Laboratory, this three-stage rocket carried a small satellite (Vanguard 1-A). The launch site was also Cape Canaveral and the Vanguard 1-A, which had been designed by JPL, was to test the launch capabilities of the Vanguard TV-3 as well as to determine the effects of the space environment on the satellite. However, the rocket lost thrust just four seconds into its launch and settled back onto the launch pad. As it descended, it ruptured its fuel and oxygen tanks, causing a massive explosion which severely damaged the launch pad. The cause of the Vanguard TV-3 failure was investigated, with some claiming that the rocket lost thrust because of low fuel tank pressure which allowed burning fuel to infiltrate the combustion chamber through a leaking fuel injector. Another claim was that the cause of the failure was due to a leaking fuel connection, and each claim may have had some merit. Unfortunately, instrumentation to monitor all aspects of the rocket were not yet developed, and the actual causes of the failure were inconclusive. Many improvements were made in the Vanguard systems over the next few years, and no failures occurred again in either firing tests or subsequent launches.

Regardless, not only was the launch pad severely damaged, but also the technological reputation of the United States took a big hit. Newspapers in the U. S. and around the world questioned America's technical capabilities, and a Soviet Union delegate made an inquiry in a United Nations session as to whether the United States would be interested in receiving any kind of financial assistance designated for "underdeveloped countries". Of course, the USSR's propaganda techniques were totally disproven during the next twelve years, as the United States proceeded in its monumental effort to place the first man on the moon.

America's First Successful Satellite - Explorer 1

The Eisenhower administration wanted the first U.S. satellite to be launched by a civilian-developed rocket instead of a by means of a military-based missile, but the Vanguard which was being developed for this purpose was just not ready. Had the ABMA been allowed to attempt a satellite launch as early as

August 1956, the U.S. possibly could have put a satellite into orbit before the Soviet Union. When the Vanguard rocket settled back on its pad and exploded on the first attempt to launch its Vanguard satellite in December 1957, the Eisenhower administration and its Department of Energy quickly turned to the ABMA. With not only the Soviet Union but also most of the civilized world now mocking American knowhow, the administration called on the Redstone Arsenal in Huntsville, Alabama. As ABMA's research director, Dr. von Braun had been warned previously not to attempt any satellite launches.

The ABMA and von Braun were now being asked to forego their backup plan, and to find a way to get a satellite into orbit as quickly as possible. The Jupiter was a three-stage rocket that had been developed by the von Braun team at the Redstone Arsenal during the previous two years. Manufactured by the Chrysler Corporation, it was considered to be the closest and most reliable system available. Von Braun, a devout Christian and a new U. S. citizen who overcame the stigma of being branded by the news media and both political parties as a Holocaust proponent, was about to become a space age household name in the United States for many years. A fourth booster stage was mounted in a "tub" on top of Jupiter's stage three nose cone, and it was designed to fire after stage three burnout. Although this modified Jupiter-C launch vehicle (see figure at right), which was renamed the Juno 1, would be able to put a satellite into orbit, there was no guidance system to project the satellite's position into a precise orbit.

Juno -1 with Explorer 1

Finally, the United States launched its first Earth satellite on **31 January 1958** from Cape Canaveral, Florida, and it carried Explorer 1 with a total weight of less than thirty-two pounds. Built by the JPL and carrying nearly twenty pounds of instrumentation, Explorer 1 allowed Americans to breathe a sigh of relief as it orbited the earth with a perigee of 224 miles and an apogee of about 1575 miles. It was considerably more sophisticated than either of the Sputniks, and transmitted much space data, including the existence of radiation zones encircling the Earth. Shaped by the Earth's magnetic field in what came to be called the Van Allen Radiation Belt, these zones partially dictate the electrical charges in the atmosphere and the solar radiation that reaches Earth. Explorer 1 continued its transmission for nearly four months after entering into orbit until its batteries finally died on 23 May 1958. Explorer 1 continued to orbit the Earth for more than twelve years before making a fiery re-entry over the Pacific Ocean in March of 1970. Although scientific missions to the Moon and planets were getting some attention in the latter 1950's, most Americans still considered those missions to be decades into the future.

America's Second Satellite - Vanguard Finally Lifts Off

Although the Vanguard had been the rocket of choice to launch the first American satellite into earth's orbit, its dismal failure before a worldwide television audience had set its program beck by several weeks. While other military branches were developing rockets that were to be used for ballistic missiles, the NRL (Naval Research Laboratory) was pursuing the launch of a peaceful civilian satellite, with the backing of the United States NSC (National Security Council). In fact, the NSC was interested in orbiting a reconnaissance satellite, for which there were no ethical universal standards. The satellite chosen for the Vanguard mission was an approximately 3 pound solar-powered aluminum sphere, also containing a small transmitter powered by a mercury battery.

Following the failure of TV-3, a second Vanguard satellite launch got under way two months later on 05 February 1958, but it also failed after only 57 seconds due to a faulty guidance system. The hue and cry from the von Braun team in Huntsville was loud, because they knew what the Soviets had used to send Sputniks 1 and 2 into orbit, and that their so-called military style rockets could launch more than enough satellites to keep up with the Soviets. Nevertheless, the Vanguard rocket program proceeded and finally prevailed, and the three-stage TV-4 Vanguard rocket successfully placed the Vanguard 1 satellite into a very high orbit on **05 March 1958**. The satellite (named Vanguard 1) provided scientific data for more than seven years before its batteries died, is still in orbit to this day, and is expected to continue in orbit for more than 200 years. Explorer 2 was launched from Cape Canaveral Space Station in Florida, also by a Juno-1 rocket (launch vehicle), and was expected to be a repeat of the Explorer 1 mission. However, due to the failure of the fourth-stage rocket to fire during launch, the satellite did not reach orbit.

2. Civilian Agencies Are Created

ARPA Is Established

After the end of World War II, the National Advisory Committee for Aeronautics (NACA) had been experimenting with rocket planes such as the supersonic Bell X-1. In the mid-1950s, the United States had accepted the challenge by the French to launch an artificial satellite for the International Geophysical Year (1957–58). After the Soviet launch of Sputnik 1 on **04 October 1957**, the attention of the United States turned toward its own fledgling space efforts. Despite the seeming nonchalance of the administration under President Dwight D. Eisenhower, the launch of a second Sputnik by the Soviets just one month later set off a panic mode throughout the United States. Known as the "Sputnik Crisis", the United States Congress was alarmed by the perceived threat to national security and technological leadership by the USSR. They urged immediate and swift action, which resulted in President Eisenhower and his advisers offering some deliberate and concrete measures.

Recognizing that there was much infighting among the military branches and that a non-military solution was needed for research and development in space technology, the Eisenhower administration first established the Defense Advanced Research Projects Agency (DARPA), which was created in February 1958 to develop space technology for military applications. Not surprisingly because of the perceived lagging behind the Soviet Union of space technology, the Eisenhower administration created DARPA in part to ward off criticism from the Democrat Party and in part to combine the space technologies of the three competing military branches. The agency was given independence from the three military R&D departments, and reported directly to the Department of Defense management. Their work at the time was to stem the flow of thought that the Western World had lost its technical edge to the Soviets regarding such abstracts as strategy and tactics, education, basic research, and missile production. But DARPA) has since been instrumental in the creation and development of computer networking (No Virginia, Al Gore did not really invent the Internet!) and numerous other data links and information technologies.

NASA Is Established

A full-scale crisis had resulted on 04 October 1957 when the Soviets launched ***Sputnik1,*** the world's first artificial satellite, as its IGY entry. This had a "Pearl Harbor" effect on American public opinion, creating an illusion of a technological gap that provided the impetus for increased spending for aerospace endeavors, technical and scientific educational programs, and the chartering of new federal agencies to manage air and space research and development. This led to an agreement that a new federal agency, mainly based on the National Advisory Committee for Aeronautics (NACA), would be needed to conduct all non-military activity in space.

"An Act to provide for research into the problems of flight within and outside the Earth's atmosphere, and for other purposes." With this simple preamble, the Congress and the President of the United States enacted the National Aeronautics and Space Act on **28 July 1958**, which created the National Aeronautics and Space Administration (NASA), and established NASA as the sole developer of space programs for the United States NASA was intended to be an independent agency of the executive branch of the United States federal government responsible for the distinctly civilian (rather than military) orientation toward space exploration as well as aeronautics and aerospace research. NASA's objective was to encourage peaceful applications in space science, and resulted in President Eisenhower's approval to dissolve NASA's predecessor (NACA).

A direct result of the Sputnik crisis, NASA began operations on **01 October 1958**, absorbing into its organization the earlier NACA intact, its 8,000 employees, and an annual budget of $100 million. It also absorbed three major research laboratories (Langley Aeronautical Laboratory, Ames Aeronautical Laboratory, and Lewis Flight Propulsion Laboratory) as well as two smaller test facilities. It quickly incorporated other organizations into the new agency, notably the space science group of the Naval Research Laboratory in Maryland, and the Jet Propulsion Laboratory managed by the California Institute of Technology for the Army. NASA also became the administrator for the Army Ballistic Missile Agency, a significant contributor to NASA's entry into the Space Race with the Soviet Union. NASA took advantage of the technology from the Redstone rocket program led by Dr. von Braun in Huntsville, Alabama, where von Braun and his team of engineers were engaged in the development of large rockets, and had incorporated the technology of American scientist Dr. Robert Goddard's earlier works. Eventually NASA created other Centers and, since 1958 nearly all of the U. S. space exploration efforts have been under the management of NASA, including all manned space flights. Today NASA has ten space centers located around the United States, including the aforementioned as well as one each named after former presidents Kennedy and Johnson, former astronauts Glenn and Armstrong, U. S. Army General George Marshall, Dr. Robert Goddard, and Mississippi Senator John Stennis.

T. Keith Glennan

A native of North Dakota and a graduate of Yale University with a BS degree in electrical engineering in 1927, T. Keith Glennan was selected as director of the new NASA when it began operations in October of 1958. For the next two years he worked with the Eisenhower administration to secure sufficient funding and to bring all auxiliary agencies under the NASA umbrella. Nevertheless, progress to launch an American into outer space, which became known as Project Mercury, was slow and very deliberate. The project's main objective under Glennan was to launch a man into space and, preferably, into orbit before the Soviets.

After more than two years of trying to meet NASA's objective, and especially to beat the Soviet Union by putting a man in space first, Glennan felt that the U. S. was still several months away from this achievement. John F. Kennedy had won the U. S. presidential election in a close race in November of 1960 against Richard M. Nixon. While NASA was a civilian agency whose director would be appointed by the new president, the handwriting was on the wall for Glennan. Shortly after the inauguration of the new president in January of 1961, Glennan tendered his resignation from NASA and moved back into academia at Case Institute of Technology in Cleveland, Ohio.

James E. Webb

Glennan was succeeded by Hugh Dryden, his assistant director, for a short period of time until President Kennedy found a permanent replacement. On February 14, 1961, James E. Webb accepted President

Kennedy's appointment as the new Administrator of NASA. Dryden stayed on as Webb's assistant, and was credited by many as being the one who suggested to Kennedy that, because of the superiority of U. S. technology, America should commit to landing a man on the moon by the end of the decade. Webb was a career politician and a Democrat who was tied closely to Lyndon B. Johnson, Vice President of the United States. For seven years after Kennedy's May 25, 1961 announcement of the goal of a manned lunar landing, through October 1968, Webb lobbied for support for NASA in Congress. As a longtime Washington insider, and with the backing of President Johnson, he was able to produce continued support and resources for America's Space Program.

Webb had a key role in creating the Manned Spaceflight Center just south of Houston, Texas, later named the Johnson Space Center. Webb's focus and ambition was not only to put a man in space, and to place an American on the moon before the Soviets, but also to ensure that NASA would carry out a program of planetary exploration with subsequent space programs. However, with Johnson choosing not to run for reelection in 1968, due in large part to the angst in the United States over the Vietnam War, he decided to step down as administrator to allow the next president, which turned out to be Richard M. Nixon, to choose his own NASA Administrator.

Walter C. Williams

Williams was a graduate of Louisiana State University with a Bachelor of Science degree in Aeronautical Engineering. After graduation he joined the staff at Langley Research Center in DC, and at the end of World War II he joined NACA (The National Advisory for Aeronautics) as a Project Engineer. During this period at NACA he authored numerous technical papers on aircraft flight research, and was considered one of the highest-ranking experts on "High-Speed Airplane Stability and Control Characteristics."

Following the formation of NASA, which absorbed NACA into its organization in October 1958, Williams left the High-Speed Flight Station and was assigned responsibility for overall launch operations in Project Mercury at Cape Canaveral. He directed the Worldwide Tracking Network and recovery operations for manned space flight missions. As Operations Director in Mercury Control Center at Cape Canaveral, Florida, Williams utilized the combined know-how of approximately 20 scientists and engineers on the site. Each of these men was responsible for a specific facet of space flight and reported directly to Williams during flight operations, which enabled him to assess the flight and make necessary decisions. As Flight Operations Director, Williams was responsible for America's earliest manned space flights, including suborbital and orbital flights. He held the position of Chief Engineer at NASA Headquarters, from which he retired in 1982.

C. Project Mercury

1. <u>Planning and Design for Space Travel</u>

Limits and Challenges

The limit of outer space as defined by the members of the IGY in 1955 was a minimum altitude of 62 mi (100 km). With the increasing number of satellites that were entering outer space above the earth's atmosphere between 1957 and 1961, the obvious (and quite likely the only) way to reach that altitude for manned flight with a much heavier payload (a manned space capsule) was by using rocket-powered boosters. While this may have been a foregone conclusion among engineers and scientists, the IGY had also declared that "...only if a man returned to earth while in his spacecraft would that journey be considered official." This stated criterion not only created numerous risks for the pilot of the spacecraft but also presented a myriad of challenges for NASA.

NASA's Design Considerations - Launch and Flight

The mission of **Project Mercury** from the very beginning was to have the United States put a man into an orbit of the Earth and return him safely, ideally before the USSR did. After a slow start riddled with humiliating mistakes, the Mercury Project gained a measure of popularity, and its missions were followed by millions on radio and TV around the world. During the first two years of the project, NASA was successful in putting into space only animals, but no men - women did not enter the NASA Space Program until 1978. The project ran for five years, beginning informally at the inception of NASA in 1958, and ending after the sixth manned space flight in 1963.

Between October of 1958 and April of 1961 NASA conducted twenty unmanned developmental flights (three using chimpanzees). Of those twenty flights, only slightly more than half of them were rated as very successful by NASA administrators. Leading up to the first manned space flight by the U. S. on **05 May 1961**, there was a considerable amount of anxiety and concern by everyone who was associated with the project. Project Mercury, which took its name from the Roman god of speed, cost about $400 million in 1965 US dollars, and involved the work of more than 2 million people, including about a dozen prime contractors and over seventy-five major sub-contractors.

Review of the first twenty unmanned flights gives unmistakable proof that the extreme caution and conservatism of the NASA engineers allowed the Soviet Union to beat the United States by putting the first man into space. The United States was simply unaware of the pending successful launch of Vostok 1 with Cosmonaut Yuri Gagarin on board. Although manned spaceflight was an immediate goal of the U. S. space program, there didn't seem to be a NASA policy of urgency. The attitude among the engineers and scientists associated with NASA was that they would not sacrifice their principles for the sake of expediency.

For the next two years, between the fourth quarter of 1958 and the first quarter of 1961, NASA dedicated itself to moving forward as the premier space technology center in the world. John F. Kennedy had been successful in being elected to succeed Dwight D. Eisenhower as President of the United States. Meanwhile the U. S. Congress had budgeted more than one hundred million dollars to fund NASA and its affiliated agencies, and calm regarding the space program seemed to have prevailed nationally under the new administration in Washington.

Launch Vehicle Requirements

Project Mercury was instituted within a week of NASA's actual beginning on 01 October 1958, and some of the risk factors associated with the launch vehicles included the following:

1. Reliability of the rockets and boosters - more than one-half of the launches through 1958 had failed, and several explosions had occurred.

2. Subjecting the pilot (not yet given the title of astronaut) to high g-forces (possibly eight or greater) due to excessive vibrations during lift off and while ascending through the dense atmosphere of the Earth.

3. Developing reliable guidance systems that would place the pilot into a precise orbit.

Space Capsule Design

The Mercury space capsule, which was manufactured by the McDonnell Aircraft Corporation, was designed to carry supplies of water, food and oxygen for about one day in a pressurized cabin. Other pertinent features of the space capsule, some of which proved to be unnecessary, included these items:

1. The capsule was fitted with a launch escape enclosure to carry the astronaut safely away from the launch vehicle in case of a failure.

2. The flight was designed to be controlled from the ground via a special system of tracking and communications stations. Redundant back-up controls were outfitted on board the capsule.

3. The capsule included a bank of smaller retrorockets to bring the spacecraft out of its orbit.

4. A special ablative heat shield was developed at the Ames Space Center to create a special vapor barrier and to lift the hot gases away from the capsule upon re-entry.

5. A huge parachute would be employed shortly after re-entry to slow the spacecraft down for a water landing. Both the astronaut and the space capsule were to be recovered by helicopters deployed from a nearby U.S. Navy ship.

In order to maintain a high degree of consistency and maintainability, all flights were to be launched from pads at the Cape Canaveral Air Force Station along the Atlantic Ocean in Florida. Furthermore, the combination of the Mercury Redstone missiles for the initial phase and the Mercury Atlas-D missiles for the second phase of the project had been chosen by NASA back in 1959 as the launch vehicles of choice for the manned space flight program. Through the ensuing period of 1959 and 1960, the first five test launches had failed, including one in which all seven chosen astronauts were observing the launch at Cape Canaveral. Despite this record of significant failures and exploded missiles, the manufacturer

(Convair Corporation) continued to assure NASA management that the Mercury Atlas-D system would be 75% reliable by the beginning of 1961.

Pilot Safety

The challenges for the NASA engineers regarding the pilots themselves also included the following:

1. For the length of time that they were in space, pilots would require pressurized chambers or special suits to supply fresh air.

2. While in space the pilots would most assuredly experience an acute sense of weightlessness, which would likely cause some period of disorientation, necessitating that all spacecraft controls be duplicated from the ground.

3. The pilots would likely be exposed to solar radiation, which would normally be absorbed and dissipated into the earth's atmosphere.

4. Finally, re-entry was studied using the nuclear warheads of ICBM's (ballistic missiles). This study demonstrated that a blunt, forward-facing heat shield should solve the problem of shielding the pilot and spacecraft from extremely high temperatures of more than 10,000 °F resulting from air compression during re-entry.

Micrometeoroid strikes were also initially considered to be potential hazards, but experience from orbiting satellites suggested micrometeoroid risk was negligible. Experiments in the early 1950s with simulated weightlessness and high g-forces on humans had been extensively studied. All challenges and potential problems seemed possible to overcome by known technologies, and putting a man in space before the Soviet Union was a distinct probability.

2. <u>Astronaut Selections</u>

Although NASA planned an open competition for its first astronauts, President Dwight Eisenhower insisted that they all be test pilots. In addition, because of the restricted area in the proposed Mercury space capsule, which had yet to be finitely designed, all potential astronauts could be no taller than 180 cm (5' 11"), nor could they weigh more than 82 kg (180 lbs). Other requirements included:

1. being under the age of 40,

2. having a Bachelor of Science degree (or equivalent) in engineering,

3. having a minimum of 1,500 hours of flying time,

4. being qualified to fly a jet aircraft.

After an advertisement among military test pilots drew more than 500 applications, NASA identified 110 pilots as potential candidates. Several dozen candidates were brought to Washington, DC, to participate in a further round of extensive physical and psychological exams between January and March 1959. Some candidates were rejected as being too tall for the planned spacecraft, while others dropped out due to the rigors of the exams. By the end of March there were only eighteen candidates remaining, and the first seven pilots (now called astronauts) were chosen from this list. Each of the seven was considered to be in superb physical condition, and to have an IQ of 130 or above. Furthermore, their psychological exams illustrated that they could each function as either a leader or as part of a team.

All seven had attended college or military academies in the 1940s, and all except Scott Carpenter and John Glenn, the lone Marine Corps pilot, had Bachelor's degrees in engineering. Virgil Grissom, Gordon Cooper, and "Deke" Slayton were U. S. Air Force pilots, while Alan Shepard, Scott Carpenter and Wally Schirra were all pilots in the U. S. Navy. Although Carpenter and Glenn did not technically meet all of their universities' degree requirements, they were later awarded Bachelor of Science degrees after their 1962 space flights. The seven men were introduced to the Washington press corps in April of 1959, and were accorded "Rock Star" and national hero status almost immediately. Americans were interested in their personal lives rather than their military records, and considered them to be the U. S. vanguard that was preparing to combat worldwide Communism.

3. Mercury-Redstone Program

Mercury-Redstone Missiles

While the Atlas-D continued to be the launch vehicle of choice for NASA, the Redstone Arsenal continued to test fire their ICBM missiles with almost complete success. Irrespective of Redstone's successes and the fact that they had launched the first satellite, NASA only considered the Mercury-Redstone vehicle as a backup plan for the first manned spaceflight. The most important change in making the Mercury-Redstone a suitable vehicle for an astronaut was the addition of an automatic in-flight abort sensing system. In an emergency situation where the rocket was about to suffer a catastrophic failure, an abort would activate an automatic abort system attached to the Mercury capsule, which would rapidly eject it from the rocket. Either the astronaut or the ground controllers could initiate an abort command manually, but the danger to the astronaut was that some potential failures during manned flight could lead to disaster before an abort signal could be manually initiated.

The Mercury-Redstone designers originally planned for the rocket to be recovered by parachute after its separation from the Mercury capsule. This was the first significant effort to develop a recoverable launch vehicle and the first to reach the testing phase. The space between the pressurized instrument compartment and the capsule was originally intended to hold a parachute recovery system for the rocket, but it had been left empty after this system was abandoned.

The recovery system at the top of the rocket would have used two stages of parachutes. In the first stage, a single parachute, 17 feet in diameter, would stabilize the rocket's fall and slow its descent. This parachute would then draw out a set of three main parachutes, each 67 feet across. The rocket would come down in the Atlantic Ocean, to be recovered by ship. To determine the feasibility of this system, several tests were performed on full-sized Redstone rockets, including water impact and flotation tests, and an exercise at sea in which a floating Redstone was picked up by a Navy recovery ship. All these tests showed recovery of the rocket to be workable, but further development was halted, however, due to lack of funding, and the rocket recovery system was abandoned.

The Mercury-Redstone's automatic in-flight abort sensing system potentially solved this problem by monitoring the rocket's performance during flight. If the system detected an anomaly which might threaten the astronaut, such as losses of flight control, engine thrust, or electrical power, it would automatically abort, shutting down the engine and activating the capsule's escape system. The abort system could not shut off the engine until at least 30 seconds after liftoff in order to prevent a malfunctioning launch vehicle from coming down on or near the launch site. During the initial 30 seconds of the flight, only the Range Safety Officer had the ultimate authority to terminate the flight. Review of flight data from the more than 60 Redstone and Jupiter C launches since 1953 was used to analyze the most likely failure modes of this launch vehicle family. As a precaution for the safety of the pilot, the abort sensing system had to be kept as basic as possible and was designed to monitor parameters that were vital to booster operation.

An automatic launch abort system (LAS) could be triggered by any of the following conditions, all of which could be indicative of a catastrophic launch vehicle malfunction:

1. Pitch, yaw, or roll angle deviating too far from the programmed flight profile, or changing too rapidly,

2. Pressure in the engine's combustion chamber falling below a critical level,

3. Loss of electrical power for the flight control system,

4. Loss of general electrical power (including power for the abort sensing system itself), which could indicate a catastrophic failure.

Instant abort capability was important because certain failure modes such as loss of thrust upon liftoff, which had occurred in a previous test flight in May 1954, could result in an immediate catastrophic situation. Other failure modes such as deviation from the proper flight path or a drop in engine chamber pressure during ascent did not necessarily present an immediate risk to the astronaut's safety, and he could either initiate a manual abort by pulling a lever in the capsule to activate the Launch Escape System or ground control could send a command to activate it. Mercury-Redstone flights were designated with the prefix "MR-". The Mercury-Redstone boosters used for these flights were designated in the same way, usually with different numbers at the tail end. Because NASA's original intentions for Project Mercury from the outset were to launch each astronaut on a suborbital mission before beginning orbital Atlas flights, they only purchased eight Mercury-Redstone rockets.

Mercury-Redstone Schedule

The original Project Mercury schedule for Redstone was one unmanned Mercury-Redstone dummy flight, one chimpanzee flight, and six manned suborbital flights. In total, some 800 modifications were made to the Redstone design in the process of adapting it for the Mercury program. The process of man-rating Redstone was so extensive that NASA quickly found themselves not using an off-the-shelf rocket, but what was in effect a completely new one and thus negating all of the hardware and flight test data from previous Redstone and Jupiter-C launches. This created a series of disputes between Von Braun's team at ABMA and NASA, as the former preferred simply making the abort system as foolproof as possible so as to guarantee that the astronaut would be bailed out of a malfunctioning launch vehicle, while the latter favored maximum booster reliability to minimize the chance of aborts happening at all.

The most visible difference between the Jupiter-C first stage and the Mercury-Redstone was in the section just below the Mercury capsule and above the propellant tanks. This section was known as the aft (or tail) section, a term which was inherited from the military Redstone. The tail section held most of Mercury-Redstone's electronics and instrumentation, including the guidance system, as well as the adapter for the Mercury capsule. In the military Redstone and the Jupiter-C first stage, its lower portion containing the rocket engine and propellant tanks would separate from the aft section and be discarded. After the rocket had burned out, the aft section with its guidance system would direct the top half of the rocket during its unpowered ballistic flight. However, in the Mercury-Redstone the aft section was permanently attached to the lower portion of the rocket, so that when the rocket had burned out, the Mercury capsule would separate from the aft section and would rely on its own guidance.

To improve the Mercury-Redstone's reliability, the inertial guidance system was replaced with the simpler LEV-3 autopilot that dated back to the German V-2 rocket. A special pressurized instrument compartment was built in the "aft section" to hold the most important instrumentation and electronics, including the guidance system, the abort and destruct systems, the telemetry instrumentation, and the electrical power supplies.

The fuel pre-valves were deleted from the Mercury-Redstone in the interest of improved reliability, since if they closed during a launch, an abort condition could be triggered. On the first three (four counting MR-BD) Mercury-Redstone flights, which developed as unmanned flights, the ABMA discovered that the Mercury-Redstone exhibited a roll transient of 8° per second versus 4° for the Redstone missile. Although this was below the 12° per second roll transient required to trigger an abort, the roll rate sensor was later removed from the two actual Mercury-Redstone manned flights to reduce the chances of an accidental abort (the booster still retained the roll attitude angle sensor which would be triggered at 10°).

Following these numerous modifications, and in preparation for the first manned space flight by the United States, NASA ordered the ABMA to conduct a short series of test flights by the virtually newly designed Mercury-Redstone rockets:

Mercury-Redstone Flights Nos. MR-1, MR-1A, MR-2, and MR-BD (Unmanned)

MR-1 was launched from Cape Canaveral on **21 November 1960** in the first attempt to qualify the Mercury-Redstone for manned spaceflight, and it carried a dummy space capsule. It failed to launch only about four seconds into flight, was seriously damaged and could not be reused, although the abort system did function.

MR-1A was launched four weeks later from Cape Canaveral on **19 December 1960** using Redstone launch vehicle MRLV-3. The mission objectives of this unmanned suborbital flight were intended to qualify the system for an upcoming primate suborbital flight as well as to qualify the spacecraft for space flight. The mission, which lasted about sixteen minutes and was termed by NASA as completely successful, tested the spacecraft's instrumentation, posigrade rockets, retrorockets, and recovery system. The Mercury capsule reached an altitude of 130 miles and a range of 235 miles, although the launch vehicle reached a slightly higher velocity than expected of over 4,900 miles per hour. The Mercury spacecraft was recovered in the Atlantic by helicopters about 15 minutes after landing.

MR-2 was also launched from Cape Canaveral on **31 January 1961** with the chimpanzee HAM (an acronym for Holloman Air Force Base Medical Center) aboard. This flight was intended to be the final sub-orbital unmanned flight prior to the first manned flight, and lasted only about seventeen minutes. The spacecraft landed in the Atlantic Ocean approximately sixty miles from the nearest recovery ship. When the rescue helicopters found the spacecraft bobbing in the ocean, it had taken on several hundred pounds of seawater. However, they were able to lift it out of the water and place it aboard the rescue ship. HAM emerged from the spacecraft in good condition. Because of some of the flight inconsistencies, NASA was of the strong opinion that the Mercury Redstone needed further development before it could be trusted to carry a human passenger on the first manned sub-orbital flight.

Mercury-Redstone 1A and Mercury-Redstone 2 had both experienced over acceleration in flight, the former due to a problem with an accelerometer, the latter due to a problem with the LOX regulator which oversupplied the engine with oxidizer and caused thrust termination to occur 1.2 seconds early. Dr. von Braun and his Redstone team added an unscheduled flight, Mercury-Redstone BD (*Booster Development*) to the launch schedule between the MR-2 and MR-3 missions. Mercury-Redstone flight **MR-BD** was an unscheduled and unmanned booster development flight in the program, and was designed as an engineering test to correct these problems. **MR-BD** launched on **24 March 1961** from Cape Canaveral, using a mockup spacecraft and Redstone MRLV-5 launch vehicle. The MR-BD mission used an inert escape rocket, and the spacecraft had no retrorocket package or posigrade rockets. The mission lasted eight and a half minutes, reached an apogee of 113.5 miles, and the spacecraft traveled down range slightly over three hundred miles. The spacecraft recorded a peak load of 11 *g*'s, and there was no intention to separate the Redstone rocket from its mock Mercury spacecraft.

They impacted together just over 307 miles downrange, 5 miles short of their planned landing site, and they sank to the bottom of the Atlantic Ocean. The problems that had been encountered in previous Redstone flights, such as over acceleration and excessive harmonic vibrations, were seemingly resolved, and the success of the MR-BD test flight gave NASA Project Managers the confidence to launch America's first manned space flight with MR-3

Vostok 1

While the United States was making plans to put their first astronaut into space, they were about to be upstaged again in the space program by the Soviet Union. Americans were embarrassed by the seeming technological superiority of the USSR, and all political eyes were on NASA for a quick and meaningful response. However, the Soviets under the direction of Sergei Korolev and Soviet Space Administrator Nikolai Kaminin were secretly in pursuit of, not only placing the first man into space, but also having him orbit the Earth. They had planned to show the world which of the two Cold War superpowers had the superior space technology. Both countries wanted to develop spaceflight technology quickly, particularly by launching the first successful spaceflight by a human. The Soviet Union secretly pursued a project in competition with Project Mercury, and the name chosen by the Soviets was Vostok. Between May 1960 and March 1961, the U. S. and the Soviets were able to launch several precursor unmanned missions, and to test and develop their rocket families with dummy space capsules. These Soviet missions, part of the Vostok Program, had varied degrees of success, but when the final two—named Sputnik 4 and Sputnik 5—were so completely successful, the Soviets felt that they were ready to launch the first manned flight.

Kaminin, an air force commander was chosen in 1960 as the military chief of the manned orbital flight agency for the Soviet Space Program. In his position with the orbital flight agency, Kaminin made the final decision to determine who would fly the mission, although he relied heavily on the opinion of the other cosmonauts in training, Kaminin was undecided between Yuri Gagarin and Gherman Titov until four days before the flight. Even before the first flight took place, which would be a relatively short single orbit flight, Kaminin was planning for the second mission. He believed that he would need the stronger cosmonaut (Titov) for the full one day flight. Vostok 2 in his mind would be a much longer, all-day flight that might encompass at least four orbits. Gagarin, nevertheless, was very happy and gave an acceptance speech.

Vostok 1 (Launch)

The Space Race between the U. S. and the Soviet Union took a nearly unimaginable turn when the Soviet Union's 8K72K rocket (later known as Vostok), lifted off on **12 April 1961** with Yuri Gagarin on board. The rocket had been derived and developed from an earlier three-stage launch vehicle, and had been tested more than a dozen times. The total launch mass of the rocket with the Vostok spacecraft, Gagarin and a ten-day supply of food on board reached 287 tons. A backup retrorocket had been left off the space vehicle to lighten the overall load, and Kaminin's staff had calculated that, in the unlikely event that the retrorocket failed to slow Gagarin's craft down to re-entry speed after one orbit, the vehicle would naturally slow itself down - somewhere in the world - within ten days.

Vostok 1 was launched from the Russian Cosmodrome, the first and largest space center in the world. The launch and first two stages leading to the orbital insertion were similar to the previous two launch vehicles based on the R-7 missile. The Vostok spacecraft with the single retrorocket was split away soon after the separation of the first and second stages. The BK72K rocket had an upgraded engine that featured better reliability and specifications, thanks to more efficient and lighter combustion chambers. Upon reaching the velocity necessary to insert the Vostok spacecraft into orbit, the flight control system shut down the engine of the third stage. The spacecraft design had an abort system similar to America's to enable Gagarin to eject from the cabin in case of an emergency either on the launch pad or in the early phase of the launch. This was the 24th Soviet space launch since Sputnik 1, the 16th of the type of booster rockets used to launch Vostok, and 12 had failed. Gagarin's bravery cannot be over emphasized.

Vostok 1 (Orbit)

Launched from the Cosmodrome in Kazakhstan, Gagarin's flight took him across Russia and southern Siberia, then southeast in a diagonal pattern over the Pacific Ocean to the tip of South America. There his spacecraft passed over the Strait of Magellan and turned northeast, crossing over the South Atlantic and the entire continent of Africa in a diagonal pattern, reaching Egypt and the eastern edge of the Mediterranean Sea, where his orbit was about to end.

Vostok 1 (Re-entry)

Over Egypt and about seventy-eight minutes into the flight, the guide path was verified, and the liquid-fueled retrorocket engine was fired by ground control. Ten seconds after retrofire, commands were sent to separate the service module from the re-entry module, but the equipment module unexpectedly remained attached to the re-entry module by a bundle of wires. Both modules separated when the wires broke as the spacecraft began re-entry, and the descent module settled into the proper re-entry attitude. As Gagarin continued his descent, he remained conscious, was automatically ejected approximately five miles above the ground, and he parachuted the rest of the way.

The main parachute was deployed from the Vostok spacecraft at about 2 miles, and it landed with a hard couple of bounces. Both the cosmonaut and the capsule landed via parachute about 200 miles west of the planned landing site. Had the fact been known at the time that both landed by parachute, Gagarin's trip into space might not have been considered the first official manned space flight. Nevertheless, Gagarin had become the hero of the Soviet space program and the Russians still commemorate Gagarin's exploits in space every **12 April**, a day which is still annually celebrated in Russia as a national holiday.

America's First Man in Space

The U.S. prepared to launch its first astronaut into space on a suborbital flight little more than three weeks after Vostok 1. The previous unmanned Mercury-Redstone flights, of which three were launched and one never left the launch pad, were still exhibiting higher than tolerable vibration levels and structural bending in the adapter area, so this first manned flight included 340 pounds of lead-infused plastic in the adapter section along with additional bracing and stiffeners.

Robert R. Gilruth, the director of NASA's Space Task Group, had informed the seven astronauts in January of 1961 that Alan B. Shepard had been chosen for the first American manned mission into space. Gilruth was born and raised in Minnesota, and graduated from Duluth High School in 1931. He received his B.S. in Aeronautical Engineering from the University of Minnesota in 1935, and his MS one year later. Following graduation, he joined NACA (National Advisory Committee for Aeronautics). Gilruth pioneered research in both newly conventional aircraft as well as pilotless missiles and rockets, and his publications became standard operating procedures for military aircraft.

He and his NACA team had pushed their superiors to pursue a program to launch satellites into space when the French first proposed the IGY in 1955, but he was rebuffed by administrators. When the Soviets succeeded in launching Sputnik, the dynamic quickly changed and Gilruth became one of the key players in the transition of NACA into NASA. At NASA's creation, Gilruth became head of the Space Task Group, which was charged with putting a man in space before the Soviet Union did. In addition to being the lead Engineer for Project Mercury, he was also deeply involved in the later Project Gemini and the Apollo Program. He was a principal advocate for planning and designing a means for NASA to learn more about operating in space before attempting a lunar landing. As head of the Johnson Space Center he oversaw a total of 25 manned space flights, from Mercury-Redstone 3 through Apollo 15.

Alan B. Shepard, Jr. was born and raised in Derry, New Hampshire and graduated from the Pinkerton Academy in 1940. Because World War II was already raging in Europe, Shepard applied to the U. S. Naval Academy at Annapolis. He easily passed the entrance exam, but at sixteen was too young to enter that year, so he was sent by the Navy to prep school at Admiral Farragut Academy for one year. At Annapolis he became a keen and competitive sailor, learned to sail all the types of boats at Annapolis, and participated in swimming and rowing. Owing to World War II, the usual four-year course at Annapolis was cut short by a year, and he graduated with a Bachelor of Science in Aeronautical Engineering and was commissioned as an ensign in June of 1944.

Although interested in aviation, Shepard was first required by the U. S. Navy to have service at sea. He served with distinction aboard the destroyer U. S. S. Cogswell in the Pacific theater for the rest of the war. His ship participated in the Allied naval bombardment of Japan and was present in Tokyo Bay for the official surrender of Japan in September 1945. He began basic flight training after the war, and continued his training at the Naval Air Station in Pensacola, Florida, where he received his naval aviator wings.

In 1950 Shepard was selected to attend the U. S. Naval Test Pilot School in Patuxent, Maryland. As a test pilot he conducted high-altitude tests to obtain information about the light and air masses at different altitudes over North America, and received carrier suitability certification of the newest jet fighters. He also performed experiments with the Navy's new in-flight refueling system, and was personally involved in numerous other tests. After serving on various fighter squadrons for the next several years, Shepard returned to Patuxent, where he flight-tested such new jet aircraft as the Banshee, Crusader and F-11 Tiger. He was an instructor at the Test Pilot School, attended and graduated from the Naval War College in Newport, Rhode Island, and was commissioned as an Aircraft Readiness Officer. By the time he enrolled as a candidate for Project Mercury, Shepard had logged more than 1,700 hours in jet aircraft.

Launch of Freedom 7

MR- 3, named Freedom 7 by its pilot, Astronaut Allen Shepard, was the first manned American spaceflight on **05 May 1961**, and was obviously the first Project Mercury flight piloted by a human. Freedom 7 spacecraft reached an altitude of 110 miles above the Earth's surface. By naming his space capsule Freedom 7, Shepard set a precedent for the remaining six Mercury astronauts to follow by each naming his spacecraft. The number 7 was included in all the manned Mercury spacecraft names to honor the first seven astronauts chosen for the American space program. The MR-3 flight was suborbital, which achieved the first phase of NASA's scheduled objective to put an astronaut into orbit around the Earth and return him safely. Shepard's mission, which lasted only about 15 minutes, did demonstrate a major objective of an astronaut's ability to withstand the high g forces of both launch and re-entry. Shepard was subjected to a maximum acceleration of 6.3g just before the Redstone engine shut down, two minutes and 22 seconds after launch. Freedom 7's velocity was 5,134 miles per hour, close to the planned value. Within ten seconds after the engine shut down, the emergency escape tower was automatically jettisoned.

Flight of Freedom 7

During the flight, Shepard observed the Earth and he was now able to take manual control of the spacecraft. He began testing whether he was able to adjust its orientation, and he tested manual control of yaw motion from left to right and roll, actually turning the capsule around to face its blunt heat shield forward for atmospheric re-entry. He also tested the retrorockets which would return later missions from orbit, though his capsule did not have enough energy to remain in orbit. When he took control of all three axes, he found that the spacecraft's response was about the same as that of the Mercury simulator; however, he could not hear the jets firing, as he could on the ground, due to the high levels of background noise.

Shepard used a controller to order the automatic system to fire the rockets for the desired positioning, rather than manually controlling the individual jets. Adjusting roll and yaw, he found the pitch position was approximately ten degrees too shallow for re-entry, but as he began to correct it, the timed retrorockets automatically fired to send him into re-entry. The retrorocket pack was strapped atop the heat shield, thus requiring release before re-entry. Although not necessary for this suborbital flight, the retrorocket pack wad successfully jettisoned.

Re-entry and Recovery of Freedom 7

Shepard kept control until the g-forces peaked at 11.6g during re-entry; he held the capsule until it had stabilized and then relinquished control to the automated system. The descent was faster than anticipated, but the parachutes deployed as planned, the drogue at four miles and the main parachute at two miles. Splashdown occurred about 300 miles down range in the north Atlantic Ocean off the coast of the Bahamas with an impact comparable to landing a jet on an aircraft carrier. Freedom 7 tilted over on its right side briefly before returning to an upright position, but did not show any signs of leaking. Shepard was able to report to the circling aircraft that he had landed safely and was ready to be recovered. A recovery helicopter arrived after a few minutes, and after a brief problem with the spacecraft antenna, the capsule was lifted partly out of the water in order to allow Shepard to leave by the main hatch. He squeezed out of the door and into a sling hoist, and was pulled into the helicopter, which flew both the astronaut and his spacecraft to a waiting aircraft carrier, the USS Lake Champlain. The whole recovery process had taken less than twelve minutes, from splashdown to arriving aboard the carrier.

NASA Continues Its Original Schedule

Following Shepard's successful flight and recovery, public criticism had died down and confidence reigned supreme throughout the country, including at the White House and in Congress. On 25 May 1961 President John F. Kennedy made an impassioned speech before a joint session of the United States Congress. Among his remarks was a request that Congress budget over $500 million for space exploration in fiscal 1962, and an additional $7 to 9 billion over the ensuing five years. While **he did not go so far as to predict that America would have a man on the moon by the end of that decade,** Kennedy asked Americans to make this commitment. He also stated his desire to see worldwide satellite weather communications as well as an American astronaut being the first man to walk on the moon, and exploration by the United States "... beyond the moon and even to the edge of our solar system." Kennedy challenged Congress and the American people that either we would be first to develop the technology to lead the other nations in the exciting adventure into outer space, or by not pursuing this space technology, we would surely finish last. While his speech created much enthusiasm around the United States, there was much angst among the members of the space agencies as to how and when this would get done.

Next American Astronaut Up

The next scheduled manned flight by NASA was another suborbital flight, and **Virgil "Gus" Grissom** was chosen for the second manned flight. His flight was to again use the launch vehicle from the Redstone series, which had three more rockets under contract to NASA. However, after Shepard still reported noticeable vibration during his launch, even more ballast was added to the booster for Grissom's subsequent flight.

"Gus" Grissom was born in 1926 and raised in Mitchell, Indiana, the second child of a family of modest means. A lifelong member of the Church of Christ, he was a star scout in the Boy Scouts. While in high school he delivered newspapers in both the morning and the evening, which enabled him to take private flying lessons from a local attorney. Upon graduation he was anxious to join the war effort, and enlisted in the U. S. Army Air Force as an aviation cadet. Following his discharge from the Army at the end of the war, he enrolled at Purdue University on the G. I. Bill, and earned a Bachelor of Science degree in Mechanical Engineering in 1950.

After graduating from Purdue, he enlisted in the U. S. Air Force, where he received twenty months of flight training. Grissom's squadron was dispatched to the Korean War zone in February 1952, and he flew over 100 combat missions, mostly in F-86 Sabre jets. He received the Distinguished Flying Cross as well as other air medals for his outstanding service. After the Korean truce Grissom returned to the United States, serving as a flight instructor at the Air Force Base in Bryan, Texas. He was then reassigned to the Air Force Institute of Technology in Dayton, where he earned a Bachelor of Science in Aeromechanics in 1956. He entered USAF Test Pilot School at Edwards Air Force Base in California, and returned to Wright-Patterson in Dayton as a test pilot assigned to the fighter branch of the USAF.

Launch of Liberty Bell 7

The second suborbital Project Mercury fight (**MR-4)** was launched from Cape Canaveral on **21 July 1961** with Virgil "Gus" Grissom aboard. Grissom had named his space capsule Liberty Bell 7, and it was launched by Mercury-Redstone launch vehicle MRLV-8. Grissom's cabin pressure sealed off at the proper altitude of 27,000 feet and, watching his instruments, the pitch rate of the Redstone rocket followed the directions as programmed, tilting over at about one degree per second. Grissom felt the abort system separate and watched the tower through the window as it drifted off, trailing smoke. The Redstone's Rocketdyne engine built up a speed of just over 6,500 feet per second before cutting off at about two and a half minutes into the launch.

Flight of Liberty Bell 7

The Redstone coasted for 10 seconds after its engine cut off, reached an altitude of more than 110 miles, then the posigrade rockets fired and broke the spacecraft loose from the booster. Although Grissom peered out his window throughout his ship's turnaround maneuver, he never caught sight of his launch location. The suborbital flight went almost exactly as expected, lasting a short duration of just over fifteen and a half minutes. Grissom was so enamored with the horizon and the recognition of the sights below that he almost missed the re-entry point. He did manage the yaw and pitch maneuvers, but never did have time to obtain the proper roll. With Liberty Bell 7 at an altitude of approximately 118 miles, Grissom was authorized to position the spacecraft in its re-entry attitude. Grissom had initiated the retrorocket sequence and the spacecraft began arcing downward.

Re-entry and Recovery of Liberty Bell 7

Re-entry presented no problem. Condensation and smoke trailed off the heat shield at about 65,000 feet as Liberty Bell 7 plunged back into the atmosphere. The drogue parachute deployed on schedule at 21,000 feet Grissom said he saw the deployment and felt some resulting pulsating motion, but not enough to worry him. The main parachute deployed at about 12,300 feet, and Liberty Bell7 splashed down with an impact that was milder than expected in the north Atlantic Ocean, some 300 miles downrange, and less than three miles from its targeted landing site. The spacecraft heeled over in the water before gradually righting itself.

After splashdown emergency explosive bolts unexpectedly fired and blew the hatch off, causing water to flood into the spacecraft. Quickly exiting through the open hatch and into the ocean, Grissom nearly drowned as water began filling his spacesuit. A recovery helicopter tried to lift and retrieve the spacecraft, but the flooding spacecraft became too heavy, and it was ultimately cut loose before sinking. The capsule sank into the Atlantic and was not recovered until 1999. Grissom was airlifted back to the USS Randolph, where he faced a battery of questions by Robert F. Thompson, Director of Mercury Operations. NASA officials concluded Grissom had not necessarily initiated the firing of the explosive hatch, which would have required pressing a plunger that required five pounds of force to activate, and he was absolved of any blame.

Vostok 2

Kaminin and Korolev had been working out the flight plan for the next mission, as they and flight doctors argued about the considerable risks over the duration of the mission traveling more than three orbits. On previous flights with dogs in orbit, the animals began to suffer convulsions after three orbits. In addition, the aspect of spacecraft recovery for the Soviets would prove to be difficult if not nearly impossible:

1. By traveling exactly three orbits, reentry and landing would take place in the wide open area of southern Russia.

2. With more than three orbits, the landing site would move further west with each orbit back toward the Pacific Ocean.

3. With less than three flights, landing would be in Russia, but much further north into the remote, frozen wastelands of Siberia

Thus the three orbit limit would not only make landing easier, but would also minimize risks to the cosmonaut posed by prolonged weightlessness and potentially difficult recovery. Several enhancements were made to Vostok 2, including an improved TV transmission system and better climate control systems.

Liftoff took place the morning of **06 August 1961** from the Cosmodrome and carried Cosmonaut Gherman Titov into orbit for a full day. Booster performance was almost flawless, placing the spacecraft into a perigee of 115 miles and an apogee of 153 miles. Once again, the Soviet Union unleashed its propaganda machine on the world. The objective of the flight was to study the effects of a more prolonged period of weightlessness on the human body. Titov's flight lasted more than twenty-four hours, and he actually orbited the Earth over seventeen times, far more orbits than had originally been planned. Not only did his flight exceed the single orbit of Yuri Gagarin on Vostok 1, but Titov's number of orbits and flight time would not be surpassed by an American astronaut until the spaceflight of Gordon Cooper on Mercury-Atlas 9 nearly two years later. After his day-long flight Titov was given a rigorous examination and was found to be in excellent health.

Vostok Epilogue

Following the day-long, multiple orbit flight by the Soviet Union, NASA management made the decision that there was no need to continue with the Redstone suborbital missions. Since Alan Shepard's flight in MR-3 and Gus Grissom's flight in MR-4 had proved to be successful, and since the Soviet Union had already flown two manned orbital space flights by the late summer of 1961, Gilruth canceled the Redstone contracts, and the last two rockets, MR-5 and MR-6, were never flown.

4. Mercury-Atlas Program

Atlas-D Missiles

From 1947 until early 1951 there were no American projects for an intercontinental ballistic missile. However, following the Soviet Union detonating its first atomic device in 1949, the perceived United States' postwar monopoly on nuclear weapons came to an abrupt end. President Harry S. Truman quickly ordered the development of hydrogen-fusion warheads on a priority basis. The onset of the war in Korea in 1950 further deteriorated America's self-confidence as the world's super power. The limited economic military programs instituted by the Truman administration were abandoned, and the military budget was dramatically increased.

Since there was no central space and missile agency until October of 1958, the ballistic missile development program proceeded as a military program under the highest national priority. Owing to the pressure of the Soviet Union's overt development of military missilery, other agencies and military branches had begun their own versions of ICBM's. At the beginning of 1956 the job of contriving one ICBM, the Atlas, was complicated by the decision to begin work on other missile programs.

Included in this expanded list was the Thor missile, also being designed and developed by the U. S. Air Force. It became the first IRBM (Intermediate Range Ballistic Missile) in the U. S. arsenal to be deployed. With a down range capacity of up to 2300 miles, it was deployed to the United Kingdom and had the capability to reach Moscow. Although it was the first ballistic missile to be deployed, it was meant strictly as a deterrent to the Soviet Union's nuclear proliferation program. Also being developed concurrently with the Atlas was the Titan 1, which was ordered by the Air Material Command, and became the first official ICBM of the United States. In reality these parallel programs consumed duplicate funding for research, design, testing, and manufacture of launch vehicles and components, as well as the design and construction of test facilities. The Thor was deployed in the UK between 1959 and 1963 while the Titan I, a longer-range, higher-thrust, multi-stage ICBM was in service between 1959 and 1965.

Appropriations for weapons research became a priority, and the Army missile program, under the direction of Dr. von Braun, began its developmental work on the Redstone rocket. Concurrently, the U. S. Air Force resumed its efforts to develop an intercontinental military rocket, awarding a new contract to the Convair Division of General Dynamics Corporation for America's first truly ICBM, which the Convair engineering group named "**Project Atlas**." **Atlas** was a family of American missiles and space launch vehicles that was designed in the late 1950s and produced by Convair for Project Mercury. They were initially designed to be used as ICBM's (intercontinental ballistic missiles). The missile was a liquid propellant rocket that combined liquid oxygen with a special fuel named RP-1. The Atlas was configured with three engines in an unusual "stage-and-a-half" or "Parallel Staging" design. Its two outboard booster engines were jettisoned during ascent, while its center sustainer engine, propellant tanks and other structural elements were retained through orbital insertion for orbital flights. Nevertheless, after the Korean War reached a truce in 1953, funding by Congress was greatly reduced and the pace of the military rocket program became conservative and deliberate.

Though never used for its original purpose as a weapon, Atlas was suggested for use by the United States Air Force to launch the first American satellite as a significant part of the International Geophysical Year celebration. This suggestion was ultimately turned down by NASA for two reasons:

1. Atlas would not be operational in time for the IGY.
2. Atlas was seen by the administration as being too heavily connected to the military.

Atlas saw the beginnings of its "workhorse" status during the Mercury-Atlas orbital missions, which were essentially the second phase of Project Mercury. During the period of 1962-1963, Atlas provided expendable launch systems for the Mariner space probes, which were used to explore the planets of Mars, Venus, and Mercury. Nevertheless, the primary purpose of the Atlas rockets was to be the launch vehicle for the ten scheduled Project Mercury orbital missions in that same period. General Dynamics later sold off various divisions of Convair to McDonnell and Lockheed, but Convair continued to manufacture missiles for the space program after Project Mercury, many of which are still in use today.

Description and Testing of the Atlas Rocket

The first Atlas D missiles were launched from Cape Canaveral in April through June of 1959, but all three of these missiles exploded less than three minutes into their flights. A fourth Atlas D launched from Cape Canaveral in July of 1959 completed a successful test flight. After the SAC (Strategic Air Command) conducted a west coast launch of an Atlas configuration missile from Vandenberg AFB to a target near Wake Island on **<u>09 September 1959</u>**, NASA declared the Atlas system to be operational. This marked the attainment of <u>operational status</u> for the Atlas one year earlier than the six years of the original projection. One of NASA's main objectives was for the Atlas to prove itself to be a reliable and versatile launch vehicle. Eventually the Atlas D missile became the core booster for Atlas space launch vehicles which would follow. In general terms, Atlas D-based space launch vehicles were classified as Space Launch Vehicle-3 (SLV-3).

The stage was now set for a prototype of the Mercury-Atlas rocket for NASA's Project Mercury to be launched from Cape Canaveral. The first Atlas D model flight test missile was launched on **29 July 1960**, but had to be destroyed less than half way into the ascent due to a severe engine malfunction and explosions. MA-1 had been launched with a dummy Mercury capsule, but did not carry a launch escape system (LES). The missile carried posigrade rockets to separate the boosters, but the retrorockets were also dummies. Several other systems were missing, including the cabin pressurization system and the astronaut couch. The launch abort system (LAS) was flown for the first time on MA-1, but was essentially non-functional. The mission was to conduct a suborbital test flight and re-entry of the spacecraft.

The MA-1 suffered a structural failure 58 seconds after launch, as it reached an altitude of about five miles and two miles down range. A number of Mercury engineers had voiced their objection to the **July 29** launch because of the weather precluding visual coverage of the flight. The capsule continued transmitting until it impacted the ocean, approximately 6 miles downrange. The automatic abort system appeared to have functioned correctly and issued a shutdown command to the Atlas's engines the moment that it detected an abnormal situation. However, the parachute system did not deploy because the abort had taken place too early in the launch, so that not all of the damaged rocket was salvaged. The Atlas booster used for later orbital Mercury flights also experienced this issue, but not with the catastrophic results that had destroyed Mercury-Atlas 1 in-flight, which was due to structural failure caused by excessive flexing at the point where the booster mated with the capsule adapter.

Owen Maynard, an aeronautical engineer from Canada who was involved in Mercury systems engineering, led the recovery of the MA-1 capsule from the sea-floor. His initial suspicion was that the fiberglass fairing placed on top of the capsule to sit in place of the absent LES (Launch Escape System) had broken loose and punctured the Atlas's LOX (liquid oxygen) tank. He also calculated that the skin of the launch vehicle just below the spacecraft would have buckled due to the combined drag, acceleration, and bending loads which exceeded the resisting tensile stress in the skin provided by internal pressure. Based on his findings, NASA specified that future Mercury-Atlas launch vehicles double the skin structure in that area, and that future launch trajectories be lessened to reduce pitch angle rate to minimize the bending stress on the launch vehicle. There were also suspicions that the lack of an LES had negatively affected the booster's aerodynamic profile. Convair engineers had argued for the necessity to include the LES for damping purposes, but Project Mercury program officials ultimately ruled against their recommendation. This particular failure mode did not recur on any subsequent Mercury-Atlas launches.

The basic problem areas in the development of the Atlas included structure, propulsion, guidance, and thermodynamics. Convair attacked the structural problem by coming up with an entirely different kind of airframe. The Atlas airframe principle, nicknamed the "gas bag," entailed using stainless steel sections thinner than paper as the structural material, with rigidity achieved through helium pressurization to a differential of between 25 and 60 pounds per square inch. The pressurized tank innovation led to a substantial reduction in the ratio between structure and total weight; the empty weight of the Atlas airframe was less than two percent of the propellant weight. Yet the Atlas, like an automobile tire or a football, could absorb very heavy structural loads.

In addition to other changes, the D series replaced the MA-1 (Mercury Atlas -1) engine package with a larger power plant for MA-2. For the revised Atlas power plant, the Air Force contracted with the Rocketdyne Division of North American Aviation. The booster engines in the MA-2 produced 309,000 pounds of thrust versus 300,000 pounds for the MA-1. Sustainer engine thrust remained 57,000 pounds. Including the verniers, total thrust for the MA-2 was 368,000 pounds compared to 357,000 for the MA-1 engine package.

This resulted in the original five-engine configuration planned for the Atlas being scrapped in favor of a smaller, three-engine design. Thus the new Rocketdyne engines would alter the configuration so that Convair could design a unique side-by-side arrangement for the two booster engines and one sustainer engine. Furthermore, this simpler design allowed Launch Command to fire simultaneously all three engines, plus the small Vernier engines mounted on the airframe, at liftoff. The technique of igniting the boosters and sustainer on the ground gave the Atlas two distinct advantages:

1. Ignition of the second stage in the upper atmosphere was avoided.
2. Firing the sustainer at takeoff meant that smaller engines could be used.

The propellant for the boosters, sustainer, and verniers consisted of liquid oxygen and a hydrocarbon mixture of RP-1. The basic fuel and oxidizer were brought together by an intricate network of lines, valves, and sometimes troublesome turbo pumps, which fed the propellant into the Atlas combustion chambers at a rate of about 1,500 pounds per second. The Atlases "B" through "D" employed a radio-inertial guidance system, wherein transmitters on the rocket sensed aerodynamic forces acting on the missile and sent radio readings to a computer on the ground, which calculated the Atlas' position, speed, and direction.

Radio signals were then sent to the rocket and fed through its inertial autopilot to control the booster and sustainer engines and establish the Atlas' correct trajectory. After the jettisoning of the outboard booster engines, the sustainer carried the Atlas to the desired velocity before cutting off, while the Vernier engines continued in operation to maintain precise direction and velocity. At Vernier cutoff the missile began its unguided ballistic trajectory. A few moments later the nose cone separated from the rest of the rocket and continued on a high arc before plunging back into the atmosphere. Radio-inertial guidance, which was the system used on the Atlas D and in Project Mercury, had the advantage of employing a computer on the ground instead of in the rocket.

On **23 January 1961** flight testing of the Series D Atlas missiles was completed with the successful launch and flight of Atlas D (MA-1) from Cape Canaveral. This was the 32nd Atlas D to be launched in the research and development series and the 55th Atlas missile overall to be flown since the first attempted launch in June 1957. During this flight test series, 35 missiles were flown successfully to a target down the Atlantic Missile Range. Of the total 49 test launchings for the D missile of which 35 were successes, 8 had some degree of success, and 6 others were categorized as total failures.

On **21 February 1961** Mercury-Atlas 2 (MA-2) was launched from Cape Canaveral in a test to check maximum heating and its effects during the worst re-entry design conditions. The flight test objectives were met, and the structure and heat protection elements appeared to be in excellent condition. However, a similar launch with Mercury-Atlas 3 (MA-3) on **25 April 1961** failed after just 40 seconds**,** although the spacecraft was able to deploy its parachutes, and was recovered in the Atlantic Ocean with only very minor damage.

Two More Test Flights

There were two more test flights for the Atlas D, Mercury-Atlas 4 (MA-4) on **13 September 1961** and Mercury-Atlas **5** (MA-5) on **29 November 1961. B**oth were rated by NASA as successful, and NASA was confident enough to consider placing an astronaut on board. The **13 September 1961** Mercury-Atlas 4 (MA-4) had been launched from Cape Canaveral with special vibration and noise instrumentation and a mechanical crewman simulator aboard in addition to the normal spacecraft equipment. This was the first Mercury spacecraft to attain an earth orbit. The orbital apogee was 154 miles and the perigee was 96 miles. After one orbit, the spacecraft's orbital timing device triggered the retrograde rockets, and the spacecraft splashed in the Atlantic Ocean 161 miles east of Bermuda. Recovery was made by the USS Decatur. During the flight, only three slight deviations were noted - a small leak in the oxygen system; loss of voice contact over Australia; and the failure of an inverter in the environmental control system. Overall, the flight was highly successful, the Atlas booster performed well, and the Atlas D demonstrated that it was ready for the actual manned flight. The spacecraft systems had operated well, and the Mercury global tracking network and telemetry had also operated in an excellent manner, with NASA engineers concluding that the Atlas-D was ready to support manned orbital flight.

On **29 November 1961** Mercury-Atlas 5 (MA-5) was the second and final orbital qualification of the spacecraft prior to orbital flight with an astronaut on board. It was launched from Cape Canaveral with Enos, a 37.5 pound chimpanzee, aboard. Scheduled for three orbits, the spacecraft was returned to earth after two orbits due to the failure of a roll reaction jet and to the overheating of an inverter in the electrical system. Both of these difficulties could have been corrected had an astronaut been aboard. The spacecraft was recovered 255 miles southeast of Bermuda by the USS Stormes. During the flight, the chimpanzee performed psychomotor duties and, upon recovery, was found to be in excellent physical condition. The flight was termed highly successful and the Mercury spacecraft declared well qualified to support manned orbital flight, thus setting the stage for America's first manned orbital flight by a human.

First American to Orbit the Earth- Friendship 7

Lt. Colonel **John Glenn** was chosen by NASA's Space Task Group to pilot the first manned orbital flight around the Earth. Very well qualified for this assignment, he finally put America in orbit with this flight.

Glenn was born in Cambridge, Ohio and raised in nearby New Concord, Ohio. The son of the owner of a plumbing company, he graduated from New Concord High School in 1939 and enrolled in engineering at Muskingum College in New Concord. He enlisted in the U. S. Army Air Corps after the Japanese attack on Pearl Harbor, and did not complete his senior year in residence or take a proficiency exam, both required by the school for its Bachelor of Science degree. Note: Muskingum awarded his degree in 1962, after Glenn's space flight.

Never called to duty by the U. S. Army, he then enlisted in the U. S. Navy as an aviation cadet, and received primary flight training at naval air stations in Iowa and Kansas. During advanced training at Naval Air Station Corpus Christi in Texas, he accepted an offer to transfer to the United States Marine Corps. Having completed his training in March 1943, Glenn was assigned to a Marine Squadron that flew transport planes. He was promoted to First Lieutenant in October 1943, and shipped out to Hawaii in January 1944.

His squadron moved to the Midway Atoll from where he flew 57 combat missions in the Pacific, receiving two Distinguished Flying Crosses and ten Air Medals. After the war he was commissioned a captain and stayed in the Marine Corps, eventually being promoted to major at the outset of the Korean War. Ordered to South Korea in 1952 as a Marine fighter squadron operations officer, Glenn flew 63 combat missions in Korea, mostly on a Panther Jet Fighter Bomber. Toward the end of the war he flew an F-86 Sabre Jet on 27 more combat missions. Glenn managed to shoot down three MiG's in July of 1953, the last one just a few days before the Korean truce. For his Korean service, Glenn received two more Distinguished Flying Crosses and ten more Air Medals.

With combat experience as a fighter pilot, Glenn applied for training as a test pilot while he was still in Korea, reported to the U. S. Naval Test Pilot School at Patuxent River, Maryland in January 1954, and graduated six months later. At Pax River he tested jet fighter planes as well as aircraft armament, and was assigned to the Fighter Design Branch of the Navy's Bureau of Aeronautics in DC. In July 1957, he made the first supersonic transcontinental flight from Los Alamitos, CA to New York City in an F8U Crusader in under three and a half hours. Glenn's on-board camera took the first continuous, transcontinental panoramic photograph of the United States. For this mission Glenn received his fifth Distinguished Flying Cross and was promoted to lieutenant colonel in April 1959. By this time Glenn had logged nearly 9,000 hours of flying time, including about 3,000 hours in jets.

While on duty at Patuxent and in Washington, Glenn was sent to Langley Air Force Base in Virginia to make runs on a spaceflight simulator, as part of research by NASA into the design of re-entry vehicle shapes. He was also sent to the Naval Air Development Center in Johnsville, PA, and was subjected to high g-forces in a centrifuge. Before Glenn's appointment as an astronaut, he was sent as a military-service member to the McDonnell Plant in St. Louis to participate in spacecraft design as a NASA representative. To say the least, Glenn was very well prepared for his Mercury Seven astronaut program despite not having his BS degree.

Launch of Friendship 7

After nearly a month's scheduling delays, the U.S. reached its orbital goal on **20 February 1962** with the flight of **Lt. Colonel John Glenn** aboard Friendship 7. The first Project Mercury manned orbital flight (MA-6) was launched from Cape Canaveral using a modified Mercury Atlas D rocket. Friendship 7 was the name given to the capsule by Lt. Colonel Glenn, and it ascended to a perigee of 98 miles and an apogee of about 150 miles. The trajectory was controlled by computers but, as part of the preflight checklist, Glenn had made a request in a news conference that was famously highlighted in the movie entitled "Hidden Figures". He asked the Flight Control Group to have NASA research mathematician Katherine Johnson check the orbital equations by hand on her desktop mechanical calculating machine. While some of the movie was just for good theater, that scenario was absolutely true. Her manual calculations confirmed that the computerized equations were accurate, thus putting Glenn's mind at ease. The automatic guidance system took over at launch, and the booster engines cut off and dropped away exactly as scheduled. A few seconds later the escape tower was jettisoned, and Friendship 7 was put into orbit.

Flight of Friendship 7

During the flight only two major problems were encountered: (1) a yaw attitude control jet apparently clogged at the end of the first orbit, forcing the astronaut to abandon the automatic control system for the manual electrical fly-by-wire system; and (2) a faulty switch in the heat shield circuit indicated that the clamp holding the shield had been prematurely released - a signal later found to be false. During re-entry, however, the retropack was not jettisoned but retained as a safety measure to hold the heat shield in place in the event it had loosened.
The Friendship Seven capsule completed three orbits, but because of failure of one of the automatic systems, Glenn was required to take over manual control of the spacecraft during parts of the last two orbits.

Re-entry and Recovery of Friendship 7

The false landing bag deploy indicator light led to re-entry being started with the retropack being left in place on the heat shield. Per Glenn's statement, a spectacular re-entry ensued, with glowing chunks of the retropack whizzing by the observation window. After four hours and 43 minutes the spacecraft re-entered the atmosphere, the drogue and main parachutes deployed perfectly, and Friendship 7 landed in the planned recovery area in the Atlantic Ocean just east of Grand Turk Island in the Bahamas. The spacecraft splashed down in the North Atlantic 40 miles) short of the planned landing zone. Retrofire calculations had not taken into account spacecraft weight loss due to use of onboard consumables. The destroyer USS Noa had spotted the spacecraft when it was descending on its parachute. The destroyer was about 6 miles away and was able to reach the Friendship 7 seventeen minutes later. Once Friendship 7 was hoisted aboard, Glenn blew off the side hatch and climbed out of the spacecraft, with both the astronaut and spacecraft reported to be in excellent condition.

Second American to Orbit the Earth- Aurora 7

The basic objectives of Project Mercury had been achieved with the flight of Friendship 7, and NASA management and the entire Project Mercury team were exuding confidence. Next up for America's second orbital flight on **24 May 1962** was U. S. Navy Commander **M. Scott Carpenter** in his spacecraft named Aurora 7. Carpenter was born in Boulder, Colorado and mostly raised by his grandparents. Following graduation from Boulder High School in 1943 he enrolled as an aviation cadet at Colorado College in Colorado Springs. He spent a year there, then spent ten months in preflight training and primary flight training. World War II ended before he was able to finish training and receive an overseas assignment, so the U. S. Navy released Carpenter from active duty.

Carpenter returned to Boulder in November 1945 to study Aeronautical Engineering at the University of Colorado in Boulder. At the end of his senior year, Carpenter missed the final examination in heat transfer, leaving him three credits short of a degree. After his Mercury flight, the university granted him a Bachelor of Science degree with the statement that, "His subsequent training as an Astronaut has more than made up for the deficiency in the subject of heat transfer."

Carpenter was recruited by the U. S. Navy just before the start of the Korean War, and he earned his aviator wings in April 1951. He was assigned to a patrol squadron in Hawaii, flying reconnaissance and surveillance missions along the coasts of the Soviet Union and mainland China. After the end of the Korean War Carpenter was appointed to the U. S. Naval Test Pilot School at Patuxent River, staying there until 1957, working as a test pilot in the Electronics Testing Division. His assignment included the testing of all types of prop and jet aircraft, both single- and multi-engine. He was attending the Naval Air Intelligence School in DC, and had just been named Air Intelligence Officer for the aircraft carrier USS Hornet, when the call came from NASA for astronaut candidates.

Launch of Aurora 7

The original prime crew member for Mercury Atlas-7 (MA-7) was to have been "Deke" Slayton, but Slayton had been removed from all flight crew availability after the discovery of cardiac arrhythmia during a *g*-loading test in the training centrifuge. Slayton had chosen the name Delta 7 for the spacecraft, as this would have been the fourth manned flight and Delta (Δ) is the fourth letter in the Greek alphabet. Carpenter had trained with John Glenn, was considered the next-best prepared astronaut, and was chosen to fly Mercury Atlas 6. When Carpenter was given the mission, he renamed it *Aurora 7* for the open sky and the dawn, symbolizing the dawn of the new age

Launch of MA 7 with Scott Carpenter aboard occurred on **24 May 1962** from Cape Canaveral. The Atlas launch vehicle performance was very good overall with one small glitch that did not affect the flight in any way. One of the sustainer engine hydraulic sensors moved to the abort position due to a faulty pressure transducer showing a loss of hydraulic pressure. However, a redundant transducer indicated correct pressure levels until after the sustainer engine cut off. The Atlas's flight path was so accurate that Aurora 7 reached almost the exact orbital parameters planned for the mission at capsule separation.

Flight of Aurora 7

Carpenter had been given solid food items for the flight, but the high cabin temperatures (up to 102 °F) and improper packaging made the food messy, so he avoided any food after the first orbit. With each orbit sunrise, Carpenter also discovered that the "fireflies" seen by Glenn were actually ice crystals shaken loose from the exterior of the capsule. Like Glenn, Carpenter circled the Earth three times. The performance of the Mercury spacecraft and Atlas launch vehicle were almost perfect in nearly every respect. All primary mission objectives were achieved. The single mission-critical malfunction which occurred involved a failure in the spacecraft pitch horizon scanner, a component of the automatic control system. This situation was adequately addressed by giving this control to the pilot in subsequent in-flight operations, so that the success of the mission was not compromised. Cabin and pressure-suit temperatures were high but not intolerable to the well-being of the astronaut. The flight further qualified the Mercury spacecraft systems for manned orbital operations and provided evidence for progressing into missions of extended duration and consequently more demanding systems requirements.

R-entry of Aurora 7

Passing over Hawaii at the final orbit Mission Control notified Carpenter to begin his retrofire countdown and to shift from manual control to the automatic attitude control. Due to a series of miscues and other pilot errors, Aurora 7 had a near-disastrous landing. When Carpenter (1) tried to correct the spacecraft for re-entry, he fell behind in his check of other critical items; (2) when he hurriedly switched to the automatic control mode, he forgot to switch off the manual system, resulting in both systems being used redundantly for 10 minutes and wasting large amounts of fuel; and (3) Carpenter also activated the retrorockets three seconds late, adding another 15 miles or so to the trajectory error. Due to lack of fuel and late firing of the retrorockets, Carpenter overshot his planned reentry mark and splashed down **250 miles** from the intended target.

After several hours of frantic searching, the U. S. Navy located Carpenter in the Atlantic Ocean in an area northeast of Puerto Rico and he was taken aboard the aircraft carrier USS Intrepid. Other than slight exhaustion, he was in good health and spirits, and post flight medical exams did not find any significant physical changes. However, NASA management was dissatisfied with Carpenter's performance due to his many miscues which resulted in re-entry and landing taking place well off-course, and so Carpenter was sidelined for future missions. He left the space program two years later.

Third American to Orbit the Earth - Sigma 7

NASA’s Project Mercury orbital operations plan of July 1961 had been to have four spacecraft equipped for three-orbit flights each. Mercury Atlas-8 (MA-8) would be the project's fifth American manned space mission All equipment for this flight was delivered to Cape Canaveral in March of 1962, but the decision was made by NASA to forego the remaining short-duration missions and move directly to a multiple-orbit mission. Planning began for the third U.S. orbital mission in February 1962, aiming for a six-or-seven-orbit flight to build on the previous three-orbit missions. NASA officially announced the mission in June, and the flight plan was finalized in late July. The mission focused on engineering tests rather than on scientific experimentation. However, by the time that NASA scheduled the flight, Soviet Cosmonaut Andriyan Nikolayev had orbited the Earth 64 times for four days in Vostok 3 between 11-15 August 1962, a feat which would not be matched by U. S. astronauts until NASA's 1965 Gemini program.

NASA selected **U. S. Navy Captain Walter Marty "Wally" Schirra Jr.** to be the fifth American to go into space, and the third American to go into orbit**.** Schirra was an American naval officer and was qualified as an aviator, aeronautical engineer, and test pilot. Schirra was born in Hackensack, New Jersey to an aviation family. Schirra' s father served with the Royal Canadian Air Force in World War I, and he and Schirra' s mother went on barnstorming tours around New Jersey after the war. By the time he was 15, Wally was flying his father's airplane.

Schirra graduated from Dwight Morrow High School in Englewood, New Jersey in 1940, and enrolled at the Newark College of Engineering. He later received an appointment to the United States Naval Academy, and graduated with the accelerated Class of 1946 with a Bachelor of Science degree in aeronautical engineering. He served briefly at the end of World War II, trained as an aviator at Pensacola Naval Air Station, and received his wings in 1948 by logging over 1,000 hours in jet aircraft. He flew 90 missions, mostly on F-84 Thunderjets during the Korean War, receiving the Distinguished Flying Cross and air medal with oak leaf cluster.

As with most of the other six original astronauts, Schirra attended U. S. Test Pilot School at Patuxent River, testing weapons systems such as the Sidewinder missile and the F7 Cutlass jet fighter. After graduating from Jet Pilot School in 1957, Schirra spent time as a flight instructor, continuing to train other pilots and testing the F-4 Phantom jet and the F3H Demon from McDonnell Aircraft before becoming a prime candidate for NASA"s Project Mercury space program.

Launch of Sigma 7

The Mercury Atlas-8 (MA-8) mission was finally launched on **03 October 1962** from Cape Canaveral, having been delayed two weeks because of an Atlas booster problem, with American astronaut **Walter M. Schirra, Jr.** aboard. The booster did experience some minor technical problems during launch, but liftoff proceeded smoothly. There was a momentary clockwise roll transient at liftoff, which approached 80% of the required threshold to trigger the abort system. This was later identified as being due to a slight misalignment of the main engines and was kept under control by the booster's Vernier thrusters. Because the Atlas was flying on a slightly lofted trajectory, the booster engines cut off 2 seconds earlier than planned, but the sustainer engine burned for about 10 seconds longer than intended, giving the spacecraft an extra velocity and putting it in a slightly higher orbit than planned. However, initial analysis of the trajectory confirmed that the capsule could have remained in a stable orbit for at least seven orbits.

Flight of Sigma 7

Schirra orbited the Earth six times in the Sigma 7 spacecraft, in a nine-hour flight focused mainly on technical evaluation rather than on any scientific experimentation. This was the longest U.S. manned orbital flight achieved to date in the Space Race with the Soviets, although well behind the four-day record set by the Vostok 3 just a month and a half prior. This mission did confirm the Mercury spacecraft's durability in preparation for the one-day mission of Mercury Atlas-9 that was to follow. During the first five orbits, Schirra switched over to manual control, which he found to be a little loose and unresponsive. He also ate a light meal and began to relax, not feeling any negative effects from his prolonged period of weightlessness. He dropped into manual attitude control, where he reported an over steering condition as well as a sudden burst of high fuel use.

The sixth orbit was dominated by preparations for re-entry, though Schirra was able to take a last set of photographs of South America and try another set of pilot spatial-orientation tests. He armed the retrorockets while passing over the western Pacific, and fired the first one just before his ninth hour in space. The automatic control system held the capsule "steady as a rock" during this period, though Schirra noted, after the retrorockets had stopped firing, that the system had burned only a quarter of its fuel.

Re-entry of Sigma 7

As the spacecraft continued toward re-entry after the de-orbit burn, Schirra used the high-power thrusters to put the capsule in the correct orientation. He then enabled the rate stabilization control system, an automatic control method which used up fuel at a very high rate, to maintain control during re-entry. This was a specific engineering request, and it dismayed Schirra because he had done his best to conserve fuel during his flight. In the most successful American manned space flight to date, Schirra traveled nearly six orbits, returning to earth in the Pacific Ocean 9 hours, 13 minutes after liftoff. At 40,000 feet Schirra deployed the drogue parachute, and then the main parachute at 15,000 feet. The landing was surprisingly precise, only 4.5 miles from the target point and 0.5 miles from the aircraft carrier U.S.S. Kearsarge. The capsule hit the water, sank and bobbed to the surface again, righting itself after about 30 seconds. Schirra radioed that he would prefer to be towed to the carrier.

Because the capsule had so nearly landed at a predetermined point and so close to the recovery ship after six orbits, this confirmed the capabilities of the Mercury spacecraft. The flight of MA-8 allowed NASA to plan with confidence for a day-long flight with MA-9, which had been an early goal of the Mercury program. Schirra continued in the U. S. space program, participating in the two-man Gemini program in which he achieved the very first space rendezvous. He later commanded the Apollo 7 mission, which was an eleven-day LEO (Low Earth Orbit) prior to the first moon landing, He was the first person to go into space three times, and the only one of the original seven astronauts to have flown in the Mercury, Gemini, and Apollo programs.

Final American in Project Mercury to Orbit the Earth - Faith 7

There was more than a six-month time period between the MA-8 flight and the **Mercury Atlas- 9** (MA-9), which proved to be the final manned space flight of Project Mercury. This was due to several reasons:

1. The Soviets had already launched Vostok 3, which accomplished sixty-four orbits.

2. Many in NASA believed that MA-8 was as good as they could do in Project Mercury and were anxious to develop the two-man missions of Project Gemini.

3. When NASA did decide on an MA-9 flight, they had to negotiate with McDonnell for several capsule modifications to accommodate the longer flight.

Chosen for the MA-9 assignment was **U. S. Air Force Colonel L. Gordon Cooper, Jr**., an American aerospace engineer, U. S. Air Force pilot, test pilot, and the youngest of the original seven astronauts chosen for Project Mercury. Cooper was born and raised in Shawnee, Oklahoma, but when his father, a retired U. S. Army Air Force Colonel, was called to active duty just before the end of World War II, the family moved to Murray, Kentucky, and he graduated from Murray High School in 1945. He enlisted in the U. S. Marine Corps, but failed to receive an appointment to the U. S. Naval Academy, and was eventually discharged from the Marine Corps. He moved to Hawaii with his family and attended the University of Hawaii for three years. While in Hawaii he met his wife, who was quite active in flying, and she convinced him to have his Marine commission transferred to the U. S. Air Force.

He received extensive flight training and served for nearly four years in West Germany, before returning to the U. S. Cooper attended the U. S. Air Force Institute of Technology in Dayton for two years, and he received his Bachelor of Science degree in Aeronautical Engineering in 1956. He was assigned to Edwards Air Force Base in California for the next two years, functioning as both a test pilot and a project manager. Cooper logged over seven thousand hours of flying time, including four thousand hours in jet aircraft. As a test pilot he was credited with saving the Air Force several million dollars in aircraft design and operations. When NASA called for volunteers for their space pilot program, Cooper felt that he would be a logical choice, and he was.

Launch of Faith 7

Mercury Atlas 9 (MA-9), known as Faith 7, was launched on **15 May,1963** from Cape Canaveral, and was piloted by astronaut **Gordon Cooper**, then an Air Force major. The launch vehicle was a modified Atlas D rocket and the Mercury spacecraft from McDonnell Corporation in St. Louis was the sixth manned spacecraft in the Project Mercury program. The mission marked the last time an American was launched alone to conduct an entirely solo orbital mission

One minute into the flight the Atlas D started its pitch program, and at two minutes and fifteen seconds the booster engines cut off and were left behind. At the three=minute mark the Launch Escape Tower was jettisoned and cabin pressure was sealed. Two minutes later the sustainer engine cut off, and Faith

7 entered orbit at a speed of slightly over 17,500 miles per hour, at a perigee of 101 miles, with a projected apogee of 165 miles

Orbit of Faith 7

A few minutes after the capsule entered orbit and turned to orbit attitude, Cooper learned that the orbital parameters were good enough for at least 20 orbits. During the thirty-four hour, twenty-two orbit odyssey that ensued, his scheduled rest period was between orbits 9 through 13. Although not particularly sleepy because of the excitement, he did become the first American to sleep in space. During his flight he had a dinner of powdered roast beef mush and some water, reported the spacecraft condition to Ground Control, and took some great pictures of Asia, including shots of the Tibetan highlands and the Himalayas.

Toward the end of the Faith 7 orbit 19, there were mission-threatening technical problems, including a capsule power failure. Carbon dioxide levels began rising, and the cabin temperature jumped to over 100 degrees F. On the 20th orbit, Cooper lost all attitude readings, and on the 21st orbit a short-circuit occurred in the bus bar serving the 250-volt main inverter. This left the automatic stabilization and control system without electric power. Cooper turned to his understanding of star patterns, took manual control of the capsule and successfully estimated the correct pitch for re-entry into the atmosphere. Cooper drew lines on the capsule window to help him check his orientation before firing the re-entry rockets. On the 21st orbit, John Glenn on board the tracking ship Coastal Sentry Quebec off the coast of Japan helped Cooper prepare a revised checklist for retrofire. Due to the system malfunctions, many of the steps had to be done manually. At the end of the 21st orbit, Cooper again contacted Glenn on the Coastal Sentry Quebec, and reported the spacecraft was in retro attitude and holding manually. Understanding that the checklist was complete, Glenn gave a ten-second countdown to retrofire. Cooper kept the spacecraft aligned at a 34° pitch down angle and manually fired the retrorockets on command, using his wristwatch to time the burn.

Re-entry and Recovery of Faith 7

Faith 7 had completed 22 Earth orbits before entering the Earth's atmosphere. Fifteen minutes later Faith 7 landed about 81 miles southeast of Midway Island in the Pacific Ocean. Splashdown came at 34 hours and 20 minutes after liftoff, and was just four miles from the prime recovery ship, the aircraft carrier USS Kearsarge. This was the most accurate landing to date, despite the lack of automatic controls. Cooper's cool-headed performance and piloting skills were paramount to the success of NA-9. The spacecraft did tip over in the water momentarily, then righted itself. Helicopters dropped rescue swimmers and relayed Cooper's request of a U. S. Air Force officer for permission to be hoisted aboard the Navy's carrier. Protocol had been followed and permission was granted. Forty minutes later the explosion hatch blew open on the deck of the Kearsarge, and Cooper stepped out of Faith 7 to a warm greeting.

Project Mercury is Complete

Following Cooper's flight in Faith 7, Alan Shepard and others pushed for a six-day Mercury Atlas- 10 (MA-10) endurance mission. This would give America the manned space endurance record for the first time and also cover the biological objectives of the upcoming Gemini's first two missions. The Mercury capsule had already been modified for long-duration flight and Shepard had the name 'Freedom 7 II' painted on the side. But the risk and work pending on Gemini persuaded NASA managers not to undertake another mission. After the MA-9 mission's electrical mishaps, there was an ongoing debate about whether to fly one more Mercury flight (MA-10). This would have been a three-day, 48-orbit mission to be flown by Alan Shepard in October 1963. In the end, NASA officials decided that the Mercury had fulfilled its goal and most of its objectives, so the time had come to move on to Project Gemini, and MA-10 never flew.

F. Summary

As the Mercury Project achieved increasing success in its missions, it was followed by millions on radio and TV around the world. Its technological achievements laid the groundwork for the next two phases of the U. S. Space Program. Project Gemini carried two astronauts in each capsule, and perfected space docking and other space maneuvers. These were essential components for the manned lunar landings in the subsequent Apollo Program that was encouraged by President Kennedy just a few weeks after the first manned Project Mercury flight. This course does not include the more expansive space programs of Project Gemini or the Apollo Program. When the Mercury Project ended in May 1963, both the United States and the Soviet Union had each sent six people into space, but the Soviets still led the U.S. in total time spent in space. The NASA organization was determined to change that paradigm.