Chapter 1

Space History

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> *Control of space means control of the world, far more certainly, far more totally than any control that has been achieved by weapons or troops of occupation. Space is the ultimate position, the position of total control over Earth.*
>
> —Pres. Lyndon Johnson

Few events in our history have been more significant than the dawn of the space age. This chapter will discuss early space pioneers, the space race, manned space programs, the formation of the National Aeronautics and Space Administration (NASA), and a brief history of the US military in space.

Early Developments in Rocketry

Although we do not know for certain, most historians agree that the Chinese were the first to produce a rocket around 1212 AD, essentially a solid fuel arrow powered by gunpowder. These very early rockets contained black powder or something similar as the propellant (fuel). According to legend, a man named Wan Hu made the first attempt to build a rocket-powered vehicle in the early 1500s. He attached 47 rockets to a cart, and at a given signal, 47 workers simultaneously lit all of the rockets. In the ensuing explosion, the entire vehicle and Wan Hu disappeared in a cloud of smoke.[1]

The principles by which rockets operated were not understood until the late 1800s, when some men began thinking about using rockets for the transportation of people. Up to this point, the use of rockets in warfare had been very limited. For example, the British used Congreve rockets during the shelling of Fort McHenry in the War of 1812 (thus, "the rockets' red glare" in what became the US national anthem).[2] Yet even in warfare, the rocket's potential went unrecognized. Major advances in rocket technology did not occur until the early 1900s.

Events in America

Dr. Robert Goddard, commonly referred to as "the father of modern rocketry," is responsible for the advent of space exploration in the United States. He achieved most of the American accomplishments in rocket science in a somewhat autonomous effort. In 1909 he began his study of liquid-propellant rockets, and in 1912 he proved that rockets would work in a vacuum such as exists in space. The year 1919 brought an end to World War I as well as the publication of Dr. Goddard's book *A Method of Attaining Extreme Altitude*. This text laid the theoretical foundation for future American rocket developments such as staging that would be critical for the quest to land on the moon.[3]

On 16 March 1926 in Auburn, Massachusetts, Dr. Goddard made history as the first person to launch a liquid-fueled rocket. The strange-looking vehicle covered a ground distance of 184 feet in 2.5 seconds and rose to an altitude of 41 feet while achieving a speed of 60 miles per hour (mph).[4] In 1929 Goddard launched an improved version that was the first rocket to contain weather instruments. This vehicle rose to an altitude of 90 feet and provided some of the earliest weather readings from "on-board" sensors.[5]

Goddard and Rocket Technology in New Mexico

In 1930, with financial backing from Charles Lindbergh and the Guggenheim Foundation, Dr. Goddard moved his operation to New Mexico, where he continued his work until his death in 1945. His work centered on a number of improvements to his rockets, which resulted in a number of "firsts" in rocket science and technology. For example, Dr. Goddard was the first to develop a gyro-control guidance system, gimbaled nozzles, small high-speed centrifugal pumps, and variable-thrust rocket engines.[6] Today's modern rockets use all of these technologies.

Dr. Goddard's rocket project was a privately funded effort with absolutely no government funding, aid of any sort, or interest in his work. Notwithstanding, his accomplishments in rocketry were truly extraordinary. Meanwhile, a team of German scientists also interested in rocket development proved that rocket technology could have a devastating effect upon the world.

Events in Germany

The German rocket-development effort occurred in two phases. Phase one, 1923–31, involved Herman Oberth, Walter Hohmann, Johannes Winkler, and the Society for Space Travel. Phase two, 1932–45, involved the accomplishments of only one man—Wernher von Braun.

Phase One. Although he never actually built any rockets, Herman Oberth inspired others in Germany and other countries to do so (e.g., Dr. Goddard). He accomplished this through his 1923 publication on space and upper-atmosphere exploration. His book *The Rocket into Planetary Space* laid the foundation for the German rocket-development effort.[7] Oberth suggested that if a rocket could develop enough thrust, it could deliver a payload into orbit. Many people thought this impossible. However, Oberth's work inspired Johannes Winkler in 1927 to form the Society for Space Travel, of which Oberth later became president.[8] This society became the spawning ground for the most significant breakthroughs in space technology. Members of the organization would later include rocket pioneers such as Dr. von Braun.

In 1925 Walter Hohmann published his book *The Attainability of Celestial Bodies*, in which he defined the principles of rocket travel in space, including how to get into geosynchronous orbit.[9] In recognition of Hohmann and his work in rocketry, the orbital transfer technique used to move payloads between two coplanar circular orbits is called the Hohmann Transfer.

Johannes Winkler invented the first liquid-propellant rocket in Europe, the HW-1. The first launch attempt was a failure, but the second launch was successful in 1931, earning him the distinction of being the first person in Europe to launch a liquid-fueled rocket.[10]

Phase Two. In 1932 the National Socialist dictator Adolf Hitler rose to power in Germany and directed the German army to pressure Dr. von Braun to develop rockets for use in warfare. Hitler used the resulting rocket technology to terrorize London during World War II. Ironically, the rocket technology that resulted from Dr. von Braun's early work would eventually enable the United States to send a man to the moon.

Under direction of the German army, Dr. von Braun began experimenting with liquid-fuel rockets, leading to the development of the aggregate or "A" series. The Germans abandoned the A-1 after a number of launch failures, and development turned to the A-2. The A-2 achieved two successful launches in two days in December 1934, thus opening the door for the development of even larger rockets.[11]

In 1937 Gen Walter R. Dornberger, the head of the German army's rocket-development effort; Dr. von Braun; and their development team moved to a peninsula in northern Germany called Peenemünde. After two failures, predominately in the guidance systems, the A-4 was successfully launched in October 1942, becoming the first man-made object to reach the edge of space.[12] Research and development continued until 8 September 1944, when the first Vengeance weapon, the V-2 rocket (fig. 1-1), boosted a 2,000-pound (lb.) warhead to 3,500 mph and burned out, with the warhead continuing on a ballistic trajectory to a range of 200 miles, literally "falling" on Paris.[13]

Figure 1-1. V-2 rocket. (National Oceanic and Atmospheric Administration photo)

Events in the Soviet Union

Many historians say that the space age was born in the home of Russian schoolmaster Konstantin Eduardovich Tsiolkovsky. In 1883 he was one of the first to explain how it would be possible for a rocket to fly in space. Keep in mind that at this time most people did not believe man would ever fly. Consequently, Russians simply considered Tsiolkovsky eccentric. In 1898 he wrote the article "Investigating Space with Rocket Devices" for the Russian magazine *Science Review*. When it was finally published in 1903, it laid the framework for orbital spaceflight using rockets based on years of his calculations.[14]

Tsiolkovsky had a unique depth of understanding. He was the first to recommend the use of liquid propellants because they performed better and were easier to control than solid propellants. His notebooks contain many ideas and concepts that rocket engineers use today. His works also include detailed sketches of spaceship fuel tanks containing liquid oxygen and hydrogen (the same fuel used in the *Saturn V* rocket). Tsiolkovsky further recommended controlling a rocket's flight by inserting rudders in the exhaust or by tilting the exhaust nozzle, just as Dr. Goddard would suggest some 30 years later.

Tsiolkovsky determined a way of controlling the flow of liquid propellants with mixing valves and advocated cooling the combustion chamber by flowing one of the liquids around it in a double-walled jacket, as seen in the space shuttle engines of today. His spaceship cabin designs included life-support systems for absorption of carbon dioxide and proposed reclining the crew with their backs to the engines throughout the acceleration phase, as is currently done. Tsiolkovsky further suggested building the outer wall of spaceships with a double layer to provide better protection against meteors and increased temperature. Tsiolkovsky foresaw the use of an airlock for space-suited men to leave their ship and suggested that gyro-stabilization as well as multiple-stage boosters were the only way to attain the velocities required for space flight. Finally, he anticipated the assembly of space stations in orbit with food and oxygen supplied by vegetation growing within.[15]

Tsiolkovsky designed extensive calculations to ensure all his proposals were mathematically possible, but without funding, he was unable to perform any meaningful experimentation. Because of his considerable technical foresight and realistic approach to space problems, Tsiolkovsky is widely acknowledged as the father of space travel.

Rocket Development after World War II

This section will address booster and missile development in the Soviet Union (USSR) and the United States between 1945 and the early 1960s. The space race was a crucial component of the Cold War, as both nations strived to gain an advantage in rocket development, nuclear weapons delivery, and satellite technology.

Soviet Efforts

Immediately after World War II the Soviets and Americans raced to recover German rocket scientists and hardware. When the Red Army captured the major rocketry center of Peenemünde in May 1945, they found that most of the important personnel and documents were gone, already en route to America. The Soviets ended up with a majority of the hardware but only a few remaining scientists and technicians.[16]

In 1946 Stalin was not satisfied with the progress of the Soviet rocket effort at Peenemünde, so he ordered it moved to the Soviet Union. There, like in America, the expatriated German scientists and technicians worked with Soviet rocket scientists in an effort to improve the basic V-2 design. However, the Soviet team decided to take over primary control of the program and relegated the German team to a support role.[17] By the end of 1953, the USSR returned all the expatriated German rocket team to Germany.

Intercontinental Ballistic Missile. The United States was well ahead of the Soviet Union in nuclear technology and possessed the most powerful bomber force in the world. This unnerved the Russians and caused them to probe for an equalizer. In their search for this weapon, the Soviets began to realize the potential of the intercontinental ballistic missile (ICBM) for striking over long distances. The Soviets envisioned a missile capable of striking the United States from the Soviet Union. This thinking dominated all of Soviet rocket research, and by the end of 1947, the consensus in the Soviet Union was to build an ICBM with this capability. In their quest to build an ICBM, the Soviets developed a whole family of short- and medium-range ballistic missiles, the most important of which was the Shyster medium-range ballistic missile (MRBM), which became the world's first operational nuclear-tipped MRBM in 1956.[18]

In 1951 biological experiments with dogs convinced Soviet scientists that manned rocket flights were possible.[19] They were also convinced that they would soon have the capability to place large payloads into orbit. Thus, along with the development of the ICBM emerged the idea of space flight, which included the beginning of research into space suits, life support systems, and emergency escape systems for manned flights.

While Soviet scientists contemplated putting things into space, the vehicles required to accomplish this were being developed at an astonishing rate. The Soviet missile program was well on its way to becoming reality. In 1953 two more missiles entered the development phase: the SS-4 Sandal and the SS-6 Sapwood.

SS-4 (R-12) Sandal. The SS-4 was required to carry a one-megaton (MT) warhead across more than 1,118 miles. It used storable propellants that improved its launch rate capability and had an autonomous guidance system.[20] The SS-4 became operational in 1959 and remained in use for two decades. The SS-4 was the weapon at the heart of the Cuban missile crisis, when the Soviet Union deployed ICBM missiles to the island of Cuba in 1962.[21]

SS-6 (R-7) Sapwood. The SS-6 was still under development in 1956, but the Soviets were so sure of its success that they began discussing its use as a launcher for an artificial satellite. The Soviets announced to the world that they would launch a satellite into Earth orbit as part of International Geophysical Year (IGY) activities. The Western world did not take this proclamation seriously, oblivious to the great strides that the Soviets had made in rocketry.

The SS-6 (fig. 1-2) was ready for its first test launch in May 1957.[22] The Soviets traded stylish design for brute strength. They had not yet built powerful rocket engines, so they used more engines to compensate for the lack of powerful engines. The SS-6 was a single-stage missile with clustered engines and had twice the power of the US Atlas or Titan ICBMs. To avoid making the missile in several stages, the Soviets opted to go with a centralized cluster of motors. Ejection of these clusters occurred after they had used up their fuel, while the central core motor continued to burn.[23] By October 1957, the Soviets were ready to prove to the West that their missile capabilities were more than just a proclamation.

Figure 1-2. SS-6 Sapwood. (NASA photo)

Sputnik. On 4 October 1957, the Soviets used their SS-6 Sapwood ICBM to launch the world's first artificial satellite—*Sputnik 1* (fig. 1-3).[24] On 3 November 1957, *Sputnik 2* entered space with Layka, a Soviet research dog, on board.[25] At this point, the Soviet Union had become the first nation to enter outer space with a biological life form.

US Efforts

While the Soviets had a well-coordinated rocket program, the United States did not. After the Soviets exploded their first hydrogen bomb (H-bomb) on 12 August 1953, the US armed services began to concentrate on missile development.[26] Around this time, the Air Force began work on its Atlas ICBM.

Air Force ICBM Program. Due to the Soviet's H-bomb capability, in 1955 President Eisenhower

Figure 1-3. ***Sputnik 1***. (NASA History Office photo)

directed that the Atlas ICBM project become the nation's number one priority.[27] The Atlas was a 1.5-stage missile with external boosters that separated after burnout. Powered by liquid oxygen and kerosene, it required fueling prior to launch. Test launches had taken place by mid-1955, and by August 1959, the system had gained approval for use.[28] During the development of the Atlas, the Air Force was also working on another ICBM called the Titan.

The Titan I was a two-stage missile powered by oxygen and kerosene, also requiring fueling prior to launch. This fueling operation did not allow for a quick response if the United States were to come under attack.[29] This deficiency led to the development of the Titan II.

The Titan II was much more powerful than the Titan I and could stand alert fully fueled and ready to launch. Although the Titan II stayed in the inventory until 1987, these liquid giants were expensive to build and maintain, leading to the development of the Minuteman solid-fuel ICBM.

Work on the solid-fueled Minuteman ICBM began in 1957.[30] These missiles were lighter, smaller, and more easily stored. The fact that these systems could be built in larger numbers and their warheads improved accuracy offset their reduced payload capacity. The Minuteman met all test objectives by 1961 and entered service in 1962.[31]

Army Missile Program. Near the end of World War II, the US Seventh Army captured many intact German V-2 rockets along with Dr. von Braun and his rocket team.[32] This team was brought to the United States as part of Operation Paperclip, an Air Force program to bring German scientists to America after the war.[33] In 1945, the Army began moving the scientists to Fort Bliss, Texas, to establish a guided-missile program that began with the test firing of the captured V-2s (A-4). When asked about the design of their V-2, the Germans said they replicated the rocket Dr. Goddard flew in 1939. In January 1947 the A-4 Upper Atmosphere Research Panel stood up to coordinate tests of converted captured V-2s being used to carry various scientific instruments. This panel became the Upper Atmosphere Rocket Research Panel in 1948 and the Satellite Research Panel in 1957.[34]

Figure 1-4. Redstone missile. (US Army photo)

In 1950 the Army moved its missile development group to Redstone Arsenal in Huntsville, Alabama. After the Korean War, the Army was looking for a missile with a range of about 500 miles, leading to the development of the Redstone missile (fig. 1-4). First fired on 20 August 1953, with many additional test firings through 1958, the Redstone entered service with Army units stationed in Germany in 1958.[35]

The Redstone was designed and developed between 1952 and 1954. This proved critical to the history of the entire US missile program, as this missile became the foundation for all future US missiles. The Army also ventured into a joint missile project with the Navy, referred to as the Jupiter missile program.

The Jupiter missile made use of Redstone missile technology, thereby saving time and money. In fact, Redstone missiles were used to test Jupiter nose cones. As the project progressed, the Navy lost interest because it wanted a small solid-fuel missile for submarine use, and the Jupiter was shaping up to be a large liquid-fueled missile. The Navy thus broke away to develop the Polaris missile.

The first Jupiter launch occurred in 1957, but the range was only 60 miles. By the third flight, developments improved the missile, and its range had increased to 1,600 miles, making it the first successful American intermediate-range ballistic missile (IRBM).[36] The Army Ballistic Missile Agency delivered its first Jupiter to the Air Force in 1958, and more than 60 missiles saw active service with Air Force units based in Italy and Turkey.

Navy Efforts. The Navy's rocket-development project revolved around three different missiles: the Aerobee sounding rocket, the Viking sounding rocket, and the Polaris submarine-launched ballistic missile (SLBM). The Aerobee project was initially designed to develop a missile capable of carrying a 100 lb. payload to an altitude of 75 miles. It consisted of two levels, the lower being solid fuel and the upper using liquid fuel. The first flight of the Aerobee took place in November 1947; since then it has served all three branches of the military.[37]

Seeking the ability to take accurate measurements, the Navy began looking into a missile program to assure a stable launch to extreme altitudes. This resulted in the development of the Viking sounding rocket, primarily based upon the V-2 design. Engine tests began in 1947, with the first Viking delivered for testing in 1949. In May 1949 the Viking had its successful maiden flight.[38] To evaluate the concept of launching rockets and missiles from ships at sea, the USS *Norton Sound* launched a test Viking.[39]

In September 1958, the Navy began to seriously consider launching missiles from ships. The Polaris project resulted. The first Polarises had a range of 1,500 miles, but that figure increased as the system reached maturity in 1963.[40] At the start of the project, it became apparent that a special vessel would be required to handle this missile, leading to the development of the Polaris submarine (fig. 1-5). By 1958, approval for the first three Polaris submarines was granted and construction began.

The first Polaris submarine was the USS *George Washington*—completed in June 1959 and commissioned in December 1959.[41] The USS *George Washington* participated in actual test firings of the Polaris missile in July 1960 (fig. 1-6), and in November of that same year, the new weapon system became operational.[42]

Figure 1-5. US Polaris nuclear-capable submarine. (US Navy photo)

Figure 1-6. Polaris missile test. (US Navy photo)

Rocket development was not limited to military aspects. To support President Eisenhower's "Space for Peace" policy, the government was also investigating booster development to send satellites into orbit.

US Booster Development and the IGY. The original US military services' appraisals concerning the possibility of developing an effective ICBM were rather discouraging, as nuclear weapons of the day were large and bulky. At the time, the US nuclear deterrence capability rested on the back of the bomber force, since bomber aircraft were the only delivery systems that could carry these large weapons. However, the situation soon changed because:

- The Soviets demonstrated that they were serious about missile development.
- The Atomic Energy Commission announced the development of the hydrogen bomb.
- Nuclear weapons were getting smaller.
- The Soviets obtained a hydrogen bomb of their own.
- The Sputnik satellites were launched.

This series of events was enough to alert the US government to turn its efforts towards large-scale rocket development. The hope of closing the gap in the missile race lay in the development of military missiles. However, President Eisenhower was determined to separate the military programs from the IGY program in order to support his peaceful intentions for space policy.[43] The Redstone, Jupiter C, and Atlas missiles were ready to launch as early as September 1956, but a different decision was made. Our nonmilitary satellite program for IGY would be the Vanguard project.

Vanguard Project. Vanguard was designed to have as few links to the military as possible. Although an honorable idea, it was not practical because the military had the money, scientists, and hardware to get the job done. Funding for the project came from the National Science Foundation. The program was plagued with problems from the start, such as inexperienced contractors, tensions of the space race, and trying to get a configuration that worked. Nevertheless, President Eisenhower insisted that Vanguard become the space launch vehicle for US satellites.

Three Vanguard launches were conducted at the end of 1956 and into 1957 to test different aspects of the launch mission. However, in response to the Sputnik launch the decision was made to launch a satellite on the next scheduled Vanguard mission. On 6 December 1957, the United States attempted to launch its first satellite, which resulted in disaster.[44] After lifting several feet off the ground, the booster lost power and fell back, bursting into flames. Five days later, President Eisenhower approved a satellite launch using a modified Jupiter rocket, now called the Juno (Project Orbiter).

The Juno booster/lift vehicle was launched, and the first US satellite, *Explorer I* (fig. 1-7), a 30 lb. cylinder, went into orbit on 31 January 1958.[45] Although the United States did not launch the world's first artificial satellite, the nation did discover the Van Allen radiation belts, which may have been the most important discovery of the IGY.[46] *Explorer I* transmitted until 23 May 1958.

Figure 1-7. *Explorer I* satellite. (NASA History Office photo)

Vanguard finally did succeed in getting off the ground on 17 March 1958, but this success was short-lived, as only two of the 11 total launch attempts between December 1957 and September 1959 were successful.[47]

Early US booster types emulated IRBM first stages rather than ICBM first stages. These new boosters were known as the Juno 2, Thor Able, Thor Delta, Thor Epsilon, and Thor Agena. The Thor boosters later evolved into the successful Delta boosters. For the larger payloads, development began from boosters developed from the larger successful ICBMs; these boosters were based upon the first stages of Atlas and Titan II development. The Atlas- and Titan II-derived boosters have launched many US satellites. With all of this space activity, the government decided it needed a civilian agency to coordinate and give direction to the US space effort.

NASA. President Eisenhower's administration came up with the concept of a coherent space effort. To help support this concept, Eisenhower appointed James R. Killian, president of the Massachusetts Institute of Technology, to be his scientific advisor. The military lobbied to maintain control of managing the national space effort. However, President Eisenhower was committed to his "Space for Peace" policy, and civilian control of the space program was essential to that concept. This civilian agency would handle all aspects of research and development, with scientists playing the leading role in guiding the space program.

While red tape tied up plans for this new agency, the president could not let time and events override our space program. He established the Advanced Research Projects Agency (ARPA) and quickly approved its plans for space exploration.[48] Although short-lived, ARPA was essentially the first official US space agency.

At this time, much maneuvering was occurring in Congress by various agencies who aspired to take control of the space program. One of these agencies, and the leading contender, was the National Advisory Committee on Aeronautics (NACA). At the time, no other agency could rival NACA's expertise in the field of aeronautics, and NACA felt that space would be a logical extension of its duties. However, Eisenhower was against this idea because he felt that NACA was, at times, too autonomous. Dr. Killian came to the rescue by proposing the National Aeronautics and Space Act, which was adopted on 1 October 1958, officially creating the National Aeronautics and Space Administration (NASA).[49] This plan created a broad charter for *civilian* aeronautical and space research, allowing the administration to absorb NACA. The core of NASA's facilities came from NACA. Within a few years, NASA obtained the organization and equipment to carry out the nation's space program.

Satellite Programs

This section will address some of the early satellite programs, of which there are four types: communication, weather, data collection, and exploration.

Communication Satellites

One of the most important and profound aspects of space utilization has been in the area of communication satellites. The use of communication satellites has brought the world's nations closer together. In May 1945 Arthur C. Clarke proposed that three satellites placed above the earth's equator at a distance of approximately 22,000 miles would maintain a constant position over that point and give total communication coverage.[50] This position is called a geosynchronous, geostationary, or Clarke's orbit. Today, most of the world's communication satellites reside in this type of orbit.

Project Score. The first voice returned from space was President Eisenhower's in 1958 under Project Score.[51] An Atlas ICBM with a tape-recorded Christmas message from the president to the world placed the satellite in orbit. It was the first prototype military communications satellite.

Echo. Echo was a 1960 NASA project consisting of a 100-foot-diameter plastic balloon with an aluminum coating, which passively reflected radio signals transmitted from a huge Earth antenna. A number of projects were attempted using balloons, but this proved to be somewhat impractical, and by 1963 civilian communications satellites with active transmitters were in orbit.[52]

Telstar. Telstar was the free world's first commercially funded communication satellite. AT&T financed the project, which launched on 10 July 1962.[53] Telstar's orbit was low Earth, but when in sight of its ground station, it did provide communications among the United States, the United Kingdom, and France. Telstar proved that the use of satellites as communications devices across vast distances was possible.

Syncom. Syncom, another NASA project launched in 1963, was the first communications satellite in geosynchronous orbit.[54] Used for many experiments, it also transmitted television broadcasts of the Tokyo Olympic Games in 1964.

Molniya. Launched in 1968, the Molniya was the first of many Soviet communication satellites using high-altitude, elliptical orbits that positioned the satellite over the entire Soviet Union during the day.[55]

International Telecommunications Satellite. The International Telecommunications Satellite (INTELSAT) Organization provided nations with a way of sharing the cost of satellite communications, based on the amount of use.

INTELSAT 1, or *Early Bird*, was the first of the series and became operational on 28 June 1965 with 240 telephone circuits. Designed to last 1.5 years, it provided service for four years.[56] *INTELSAT 2*, launched in 1967, provided an additional 240 circuits with a design life of three years.[57]

INTELSAT 3, launched in 1968, increased service by 1,500 circuits and improved its design life to five years.[58] Launched in 1971, *INTELSAT 4* contained 4,000 circuits plus two color TV channels and spot beams to increase broadcast efficiency. Its design life increased to seven years.[59] *INTELSAT 5* was launched in 1980 and is three-axis stabilized versus spin stabilized. It has 12,000 circuits and two TV channels.[60]

Westar. Launched in April 1974, Westar was a Western Union project and the United States' first domestic satellite. The first set, made up of *Westar I*, *II*, and *III*, was comprised of 12-transponder satellites with a capacity of 7,000 two-way voice circuits or 12 simultaneous color TV channels.[61] Design lifetime in orbit for the satellite was seven years.

Weather Satellites

Weather satellites show weather patterns that are obscured from the ground. There are two types of weather satellites: polar orbiting satellites and geostationary satellites. Each satellite is equipped with light and heat sensors, recorders, radio receivers and transmitters, and other recording instruments to create a picture of Earth weather. This section discusses some of the satellite systems that originate these pictures.

Television Infrared Operational Satellite. The television infrared operational satellite (TIROS) (fig. 1-8) was the first weather satellite program undertaken by the United States. Its objective was to test the feasibility of obtaining weather observations from space. Launched in April 1960 into a polar orbit, *TIROS-1* achieved all of its objectives.[62] It was operational for only 78 days but proved that satellites could be a useful tool for surveying global weather conditions from space. Nine additional TIROSs were launched.

Environmental Science Service Administration. Based on the success of the TIROS program, a fully operational version of the same satellite, called the TIROS

Figure 1-8. TIROS weather satellite. (NASA image)

Operational System (TOS), was introduced in 1966.[63] The system used a pair of Environmental Science Service Administration (ESSA) satellites and provided uninterrupted worldwide observations.

Nimbus. Given the success of the TIROS program, the primary objective of the Nimbus program was to develop a satellite system capable of meeting the needs of the world's atmospheric science research community.[64] The Nimbus system, originally designed as a replacement for TIROS, became the means to test new remote sensing techniques as well as a means to sense the radiative properties of the earth's landmasses, oceans, and atmosphere. Other goals of the program included the development of new Earth surface-mapping techniques, new ground data-processing techniques, and the capability to sense atmospheric variables in the vertical (soundings).

Improved TIROS Operational Satellite. With the launch of the Improved TIROS Operational Satellite (*ITOS-1*) in 1970, a second generation of meteorological satellites came into being. The primary objective of the ITOS program was to combine the capabilities of ESSA's operational satellites and the knowledge gained from the ongoing Nimbus program into one operational program. The ITOS program served as the second generation of US operational weather satellites, eventually becoming the series we now know as the National Oceanic and Atmospheric Administration (NOAA) satellites.[65]

TIROS-N. Following the ITOS series of weather satellites, a third-generation series came into service and provided global observation service from 1978 through 1985.[66] These satellites employed advanced data-collection instruments. Included on the payload package was a very high-resolution radiometer that improved sea surface temperature mapping, for locating snow and sea ice as well as conducting night and day imaging.

Data Collection Satellites

Since the TIROS weather satellites proved their worth by collecting data on weather patterns, after the first astronauts made detailed observations of the earth, scientists began to consider using satellites to collect data on the earth's land and water resources.

Land Satellites. In the early 1970's, the land satellite (LANDSAT) series (fig. 1-9) of data-collection satellites were employed. This series, because of its infrared microwave and imagery capability, opened up new areas of research never before explored in such detail. The first LANDSAT, originally called the Earth Resources Technology Satellite (ERTS), was developed and launched by NASA on 23 July 1972, on a Delta rocket from Vandenberg AFB, California.[67]

Figure 1-9. LANDSAT. (NASA image)

The satellite carried a television camera and an experimental sensor called the multispectral scanner. The utility of the synoptic, digital, multispectral scanner images was recognized rapidly and proved so valuable that a version of the sensor was flown on each of the subsequent four LANDSAT satellites (NASA changed the name of ERTS to *LANDSAT 1* in 1975). By the time *LANDSAT 1* was retired in 1978, its multispectral scanner had acquired over 300,000 images, providing repeated coverage of the global land surfaces.[68] The quality and impact of the resulting information exceeded all expectations.

SEASAT 1. Based on the LANDSAT series, NASA launched *SEASAT 1* in 1978. Using microwave instruments, *SEASAT 1* measured surface temperatures to within two degrees centigrade, wind speed, and direction and provided all-weather pictures of waves, ice phenomena, cloud patterns, storm surges, and temperature patterns of the ocean currents.[69]

Terrestrial and Extraterrestrial Exploration Satellites

The final type of early satellites includes the exploration satellites, designed to observe phenomenon in space and probe planets and other bodies in our solar system.

Explorer. The largest and oldest US exploration satellite program was the Explorer series. This particular group of satellites studied a wide range of space activities from Earth radiation to solar wind. Approximately 74 satellites in this series were launched, the first of which, *Explorer 1*, discovered the Van Allen radiation belts in 1958.[70]

US Planetary Probes. The United States has launched more than 24 planetary probe satellites, visiting most of the planets in our solar system. Numerous probes have launched to Venus, Mars, Jupiter, and Saturn. These probes were of the Mariner, Pioneer, Viking, and Voyager types. Remarkably, the two Voyager spacecraft, both launched in 1977, are still operational and continue to send back valuable information from the edge of the solar system. *Voyager 2* is the farthest manmade object from Earth (10.16 billion miles as of January 2009).[71] More recent launches include *Galileo* in 1984 to Jupiter, *Mars Climate Orbiter*, *Mars Global Surveyor*, *Mars Odyssey*, *Mars Pathfinder*, and a recently launched first-ever probe (*New Horizons*) dedicated to the study of Pluto.

Hubble Space Telescope. The idea for the Hubble Space Telescope (HST) was conceived back in the 1940s, but work on the telescope did not start until the 1970s and 1980s.[72] The telescope did not become operational until the 1990s. The HST program is a cooperative program between NASA and the European Space Agency (ESA). The program objective is to operate a long-lived space-based observatory for astronomical observation. The HST is the largest on-orbit observatory ever built and is capable of imaging objects up to 14 billion light years away. The resolution of the HST is seven to 10 times greater than Earth-based telescopes. Ground-based telescopes can seldom provide resolution better than 1.0 arc-seconds, except momentarily under the very best observing conditions. The HST's resolution is, depending on conditions, 0.1 arc-seconds, which is 10 times better than ground-based telescopes.[73]

Originally planned for 1979, the Large Space Telescope program called for the satellite to return to Earth every five years for refurbishment and on-orbit servicing every 2.5 years. Contamination as well as structural concerns negated the concept of ground return for the project. NASA then decided that a three-year cycle of on-orbit servicing would work out just as well as the first plan. The three HST servicing missions in December 1993, February 1997, and mid-1999 were enormous successes.

USSR Space Probes. The Soviets, while launching more planetary probes than any other country, have confined themselves to Mars, Venus, the moon, and the sun. Most of their initial attempts to send probes to Venus and Mars failed. These probes were of the Venera, Mars, Cosmos, Zond, and Vega series. An ambitious probe named *Mars-96* was launched in 1996 but failed to escape Earth orbit.[74]

Both the United States and the Russians are planning future probe missions back to Mars, Venus, the moons of Jupiter, and other interesting places within the solar system. As time has passed, more countries have entered the space exploration business (China, Japan, Germany, France, etc.) by sending probes into the cosmos.

Manned Space Exploration by the United States and USSR since 1960

Pres. George W. Bush said, "To leave behind Earth and air and gravity is an ancient dream of humanity. . . . This cause of exploration and discovery is not an option we choose; it is a desire written in the human heart. We are that part of creation which seeks to understand all creation. We find the best among us, send them forth into unmapped darkness, and pray they will return. They go in peace for all mankind, and all mankind is in their debt."[75]

Space Race

The United States had placed its prospects for getting into space first in Project Vanguard. However, the Russians entered orbit first, resulting in a public outcry among Americans. Sen. Lyndon Johnson (later to become president) of the Armed Forces Subcommittee recommended that a national space program be established. The consensus was that the United States needed a consolidated national space program to coordinate and guide its space efforts. Thus, NASA was formed in 1958. The space program would consist of two parts: the military functions under the control of the Department of Defense and the civilian functions under the control of NASA.

With the USSR's launch of Sputnik in 1957, the United States and the Soviet Union were firmly entrenched in the space race, which was an extension of the Cold War. The Soviet Union had beaten the United States in the unmanned space race, and the same would occur in the manned race. On 12 April 1961, the Soviets shocked the world again when Yuri Gagarin became the first person to orbit the earth.[76] Public outcry was not as strong as when Sputnik went up, but presidential concern was. President Kennedy addressed Congress and committed the nation to a project that by the end of the decade would land a man on the moon and return him safely. The president's decision to undertake this task was endorsed virtually without dissent.

The space race led to a number of programs, both American and Soviet, which greatly advanced our understanding of space and our capacities for manned space exploration.

Mercury (US): 1961–1963

In addition to sending a man into space, Mercury was designed to further our knowledge of man's capabilities in space. The Soviets had already proven that man could survive reentry. Mercury had a number of objectives, the most important of which were putting a man in orbit and devising a stepping-stone for an eventual journey to the moon. In the Mercury capsule, all systems were redundant, control was manual or automatic, and the control system technology was new.

The main objective of the Mercury project was to investigate man's ability to function in the space environment.[77] Mercury gained valuable information for the building and flying of more complex spacecraft, such as the Gemini and Apollo. The milestones began with the chimpanzee "Ham" flying in a capsule on 31 January 1961, followed by Alan Shepard's suborbital flight on 5 May 1961. Then on 20 February 1962, John Glenn became the first American to achieve Earth orbit, completing three revolutions.[78]

Vostok (USSR)

Unlike the Mercury capsule, the Vostok capsule was composed of two parts: the round-shaped manned section and the lower equipment bay located underneath the manned section. Vostok crew recovery was also different. With Mercury, the astronaut and capsule parachuted into the ocean, while the Soviet cosmonaut ejected from the capsule and was recovered on land. Vostok led the space race by carrying the first man into space in 1961 (Yuri Gagarin), putting the first woman in orbit in 1963 (Valentine Tereshkova), supporting the first dual-flight mission, and setting flight endurance records.[79]

Gemini (US): 1962–1966

The Gemini capsule was designed to carry two astronauts and had two sections—the upper or manned section and a lower equipment section. Because of the greater lift needed, the Titan II ICBM was used instead of the Atlas. The objectives of the Gemini program included developing procedures for practicing maneuvers critical to a moon landing: rendezvous, docking, and extravehicular activity (EVA).[80] Gemini also allowed astronauts to gain experience in longer missions and perform complicated maneuvers.

All the objectives set by NASA for Gemini were met. However, some tasks, such as spacewalks, turned out to be more difficult than anticipated. Gene Cernan's exertion during the spacewalk portion of the *Gemini IX* mission overtaxed his suit system and fogged his helmet visor.[81] Cernan had to terminate his EVA early due to fatigue. The problem was not solved until the last flight, *Gemini XII*, in November 1966. Edwin "Buzz" Aldrin used footholds, Velcro-covered tools, and hand grabs to work in space with ease.[82]

The Gemini milestones were vast and diverse and included the first orbital plane change, the first US dual flight, and the first hard docking and one-orbit rendezvous. Gemini's success gave the United States confidence to press ahead with the Apollo program and in effect placed the United States ahead of the Russians in the race to the moon.

Voskhod (USSR)

The Voskhod capsule was a Vostok modified to accept three cosmonauts.[83] A terminal-thrust braking system was added to achieve a soft landing. The Voskhod program was a stopgap measure instituted by the Soviet Union to make up for the stalled Soyuz program. The objectives of the Voskhod program were the same as those of Gemini and resulted in some notable accomplishments, including the first three-man craft orbit, the first spacewalk, and the first emergency manual reentry.[84]

Apollo (US)

The Apollo program was the final step to the moon. The objective of the program was twofold. First, the program was to gather information needed for a lunar landing. Secondly, Apollo was to actually land on the moon.

Figure 1-10. Apollo system. (NASA image)

A new "tear drop" capsule was used, thus departing from the traditional "bell" shape of the Mercury/Gemini capsules. The Apollo system consisted of three parts: the command module, the service module, and the lunar module (fig. 1-10).[85]

The booster for this program started from scratch. With the help of Dr. von Braun, the Saturn boosters emerged, which included the *Saturn 1B* and the *Saturn 5* (fig. 1-11).

Figure 1-11. *Saturn 5*. (NASA photo)

The advent of Apollo, as in the tradition of Mercury and Gemini, was a step-by-step process. However, the United States suffered a tragic event on 27 January 1967 when Apollo I developed a fire in the capsule that cost the lives of three astronauts: "Gus" Grissom, Ed White, and Roger Chaffee.[86] The space program was halted while NASA investigated the accident. Within 19 months, the manned portion of the Apollo program was back on track with an altered Apollo capsule.

The program pressed ahead, testing docking maneuvers, lunar landing procedures, and a slew of other experiments designed to get us to the eventual landing. Then on 20 July 1969, *Apollo 11* was the first of the Apollo series to land on the moon.[87] Six more missions to the moon followed, culminating with *Apollo 17*. The only subsequent mission that did not land on the moon was *Apollo 13*, which aborted some 205,000 miles from Earth when an oxygen tank exploded.[88] An anxious world watched as NASA worked feverishly through one problem after another to bring the crew back alive. Their success in doing so was one of the agency's finer moments and inspired a 1995 feature film that ignited the interest of a new generation in the Apollo program.

The United States met President Kennedy's goal and proved man could react to and solve in-flight emergencies (*Apollo 13*). Although the Apollo moon program was concluded, an abundance of valuable scientific information had been obtained.

Soyuz (USSR)

Like the Apollo program, the Soviet Soyuz program began on a tragic note when the *Soyuz 1* reentry parachute failed to deploy properly and the capsule slammed into the ground, killing Col Vladimir Komarov in April 1967.[89] As a result of this crash, the Soyuz program was halted for 19 months while changes in design were made. On 29 October 1968, Soyuz made its first successful safe flight and began achieving its major objectives of maneuvering in group flights, docking, prolonged space flight, and development of new navigation and spacecraft control systems.[90]

After a series of launch and in-flight problems led to them being beaten to the moon in July 1969, the Soviets turned their emphasis towards manned space stations. The Soyuz was used as a ferry to the Salyut and Mir space stations and now ferries personnel to the International Space Station.

Follow-On Manned Programs

Space technology has continued to advance through several follow-on manned programs. Among them are the US space shuttle, the Russian Mir space station, and the International Space Station, the largest and most complex international scientific project in history.

Skylab. A *Saturn 5* launched from Kennedy Space Center on 14 May 1973 and placed Skylab (fig. 1-12) into orbit.[91] Skylab was partially made from a third-stage section of the *Saturn 5* and was to be used for a variety of experiments, such as the effects of long-term weightlessness and human adaptation to zero gravity. Skylab proved to be a successful program—information was learned about these areas as well as others. In all, 46,000 images were taken of the earth and 127,000 pictures of solar activity in addition to a list of other achievements.[92]

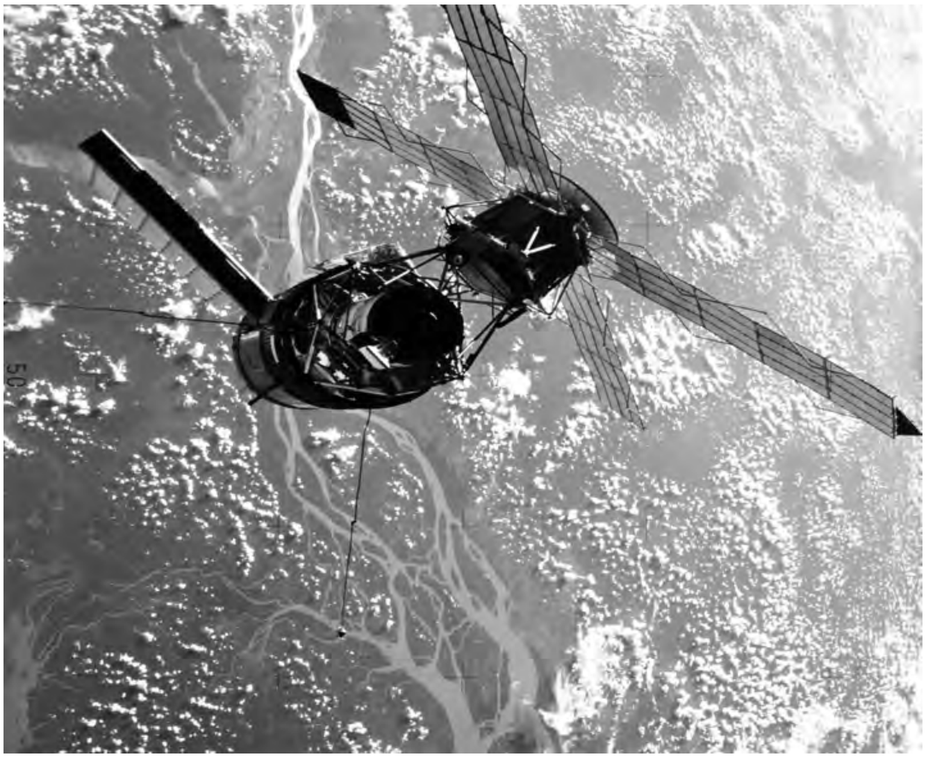

Figure 1-12. Skylab. (NASA artist's drawing)

Due to a number of factors, such as increased solar activity and delays in getting the shuttle off the ground (the shuttle was to boost the satellite into a higher orbit), Skylab's orbit continued to decay until it made its final plunge on 11 July 1979.[93]

Salyut. The Soviet space station program began in 1971 with the launch of *Salyut 1*, which gave the USSR another first in space.[94] *Soyuz 10* had difficulty docking with the station, but *Soyuz 11* was able to successfully dock in June. Tragically, the crew was killed while returning to Earth, and again the Soviet space program was plagued with setbacks.[95] The experience gained from Salyut would help the Soviets achieve a highlight in their exploration on space—Mir.

Apollo-Soyuz (July 1975). The primary objectives of the Apollo-Soyuz program were the development of a rescue system, docking procedures, and crew transfer between US and Soviet spacecraft. Additional objectives dealt with conducting astronomy, Earth studies, radiation, and biological experiments. NASA used its last remaining Apollo spacecraft for this mission, and the crew consisted of Apollo veteran Tom Stafford, Vance Brand, and astronaut office chief and original *Mercury 7* astronaut Deke Slayton.[96] Although there were not many gains in technology, this program was viewed as a political success.

Space Transportation System. The primary motivation for NASA's perseverance with the Space Transportation System (STS) was to find a cost-effective manned system. The current STS can trace its roots back to the lifting body research conducted at Edwards AFB. On 5 August 1975, an X-24B made a textbook landing after a powered flight to 60,000 feet.[97] The X-24B was America's last rocket research aircraft and concluded the manned lifting body program. The X-series research developed many concepts that would eventually be incorporated into the space shuttle, such as dead stick landings, flat bottoms, and others.

The actual conceptual design for the STS began in 1969 when President Nixon directed top Department of Defense and NASA scientists to devise a post-Apollo manned program.[98] The Space Shuttle Task Group was formed to study the problem, and they recommended the STS.

Due to its design philosophy, the STS looked promising and was approved by President Nixon. The system concept included the use of reusable components, autonomous operations, large payload, relatively simple on-board operation, a cargo compartment designed for a benign launch environment, throttleable engines, and on-orbit retrieval and repair of satellites.[99] This design scheme (fig. 1-13) would provide the United States with routine access to space.

Figure 1-13. STS. (NASA History Office photo)

Components of the STS include the orbiter, an external fuel tank, and two reusable solid-rocket motors. The first STS launch occurred on 12 April 1981, with landing on 14 April.[100] The astronauts for the mission were Robert Crippen and Gemini and Apollo veteran John Young.

After many successful missions, tragedy struck STS 33 on 22 January 1986 when the *Challenger* exploded after lift-off because of a faulty solid-rocket motor pressure seal design that was "unacceptably sensitive to a number of factors."[101] As in 1967 with *Apollo 1*, NASA investigated the cause and made corrections, but this time the manned space program was halted for 32 months. It was not until 29 September 1988 that America reentered space with the launch of the *Discovery*.[102]

On 1 February 2003, tragedy again struck the shuttle program.[103] The space shuttle *Columbia* broke apart during reentry, and seven astronauts were lost. The cause of the accident occurred during liftoff when a piece of foam insulation broke free from the external fuel tank and punctured the leading edge of the left wing. During reentry superheated air was able to enter the internal compartments of the wing, leading to structural failure.

After this loss, the investigation board and NASA questioned the continued usefulness of the STS. In January 2004, President Bush announced that the STS would continue to be used to service and complete the International Space Station (ISS) but would be retired in 2010 when the ISS is completed.[104]

Mir. The Mir (loosely translated "peace," "world," or "commune") complex was described as a third-generation space station by the Russian space program. The Mir (fig. 1-14) was modular in design, which allowed different modules to be added and subtracted or moved from place to place, making the Mir very versatile. One of the most important features of Mir was that it was permanently manned, which was a giant step toward breaking earthly ties.[105] Mir was probably the most durable single achievement of the Russian/Soviet space program.

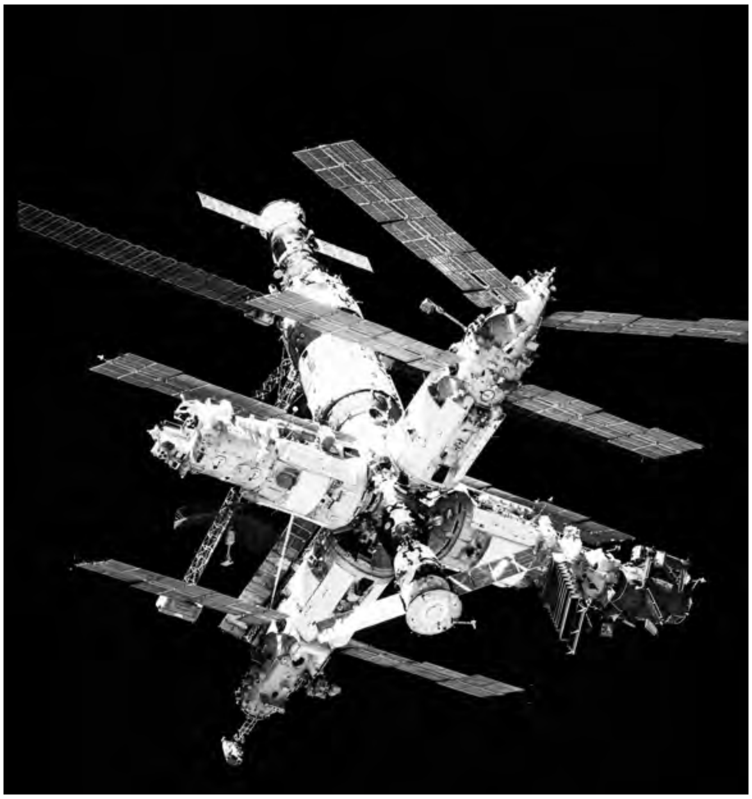

Figure 1-14. Mir space station. (NASA photo)

The Mir was the central portion of the space station and was the core module for the entire complex. Four other compartments completed the Mir complex: the transfer, working, intermediate, and assembly compartments. All compartments were pressurized except for the assembly compartment.

The usual missions began with a launch of either two or three crew members. It usually took about two days for the spacecraft to reach and dock with Mir. Docking always took place on an axial port. As a precautionary measure during docking, the crew that was occupying Mir put on activity suits and retreated to the resident *Soyuz-TM*, which was the capsule the cosmonauts rode to and from the Mir. The *Soyuz-TM* stayed attached so the crew could escape if necessary. When hatches were opened, both crews removed their suits and began changeover procedures, which took differing amounts of time depending on what needed to be accomplished. After changeover was complete, the crews put their suits back on and returned to the *Soyuz-TM*. The crew that had been there the longest got in the older of the two capsules, leaving the newer one for the new crew.

The Mir had its share of problems. Originally designed to last only five years, the Russian space station was continuously occupied from 1987 to 2000 (with the exception of two short periods).[106] NASA astronauts were a part of the crews aboard Mir. In 1997, two life-threatening incidents almost forced abandonment of the station. In February, a fire broke out, triggered by a chemical oxygen generator that filled the station with choking smoke and blocked one of the escape routes to a docked *Soyuz* capsule.[107] Although no major damage ensued, it was a frightening 14 minutes for the six men on board. In June, an unmanned *Progress* cargo ship collided with the *Spektr* module, and the ruptured module began to decompress.[108] The three-man crew sealed off the damaged module, but the power on the station was reduced by half.

Mir's 15-year life span was a monumental achievement. Mir circled the earth 86,331 times, and 104 individuals spent time on the station (42 were Russian and 44 were American).[109] Mir received 70 unmanned dockings and the space shuttle nine times.[110] The seven longest-flying Americans achieved their records on Mir—Shannon Lucid stayed in space for 188 days.[111] The Russians on Mir set incredible duration records: Sergei Avdeev, 742 days in space; Valeri Poliakov, 678 days in space; and the list goes on.[112] The volume of science carried out on Mir was enormous. Its remains crashed into the South Pacific on 23 March 2001.[113]

International Space Station. When the International Space Station (fig. 1-15) is complete, it will represent a move of unprecedented scale off of the home planet. Led by the United States, the International Space Station draws upon the scientific and technological resources of 16 nations: Canada, Japan, Russia, 11 nations of the European Space Agency, and Brazil.

More than four times as large as the Russian Mir space station, the completed International Space Station will have a mass of about 1,040,000 pounds.[114] It will measure 356 feet across and 290 feet in length, with almost an acre of solar panels to provide electrical power to six state-of-the-art laboratories.[115] The station is in an orbit with an altitude of 250 statute miles with an inclination of 51.6 degrees.[116] This orbit allows the station to be reached by the launch vehicles of all the international partners to provide a robust capability for the delivery of crews and supplies. The orbit also provides excellent observations of Earth with coverage of 85 percent of the globe and overflight of 95 percent of the population.

The ISS program began in 1994 and moved into the first stage in 1995.[117] Phase 1 was the joint Mir/shuttle rendezvous program. The main objective of this program was

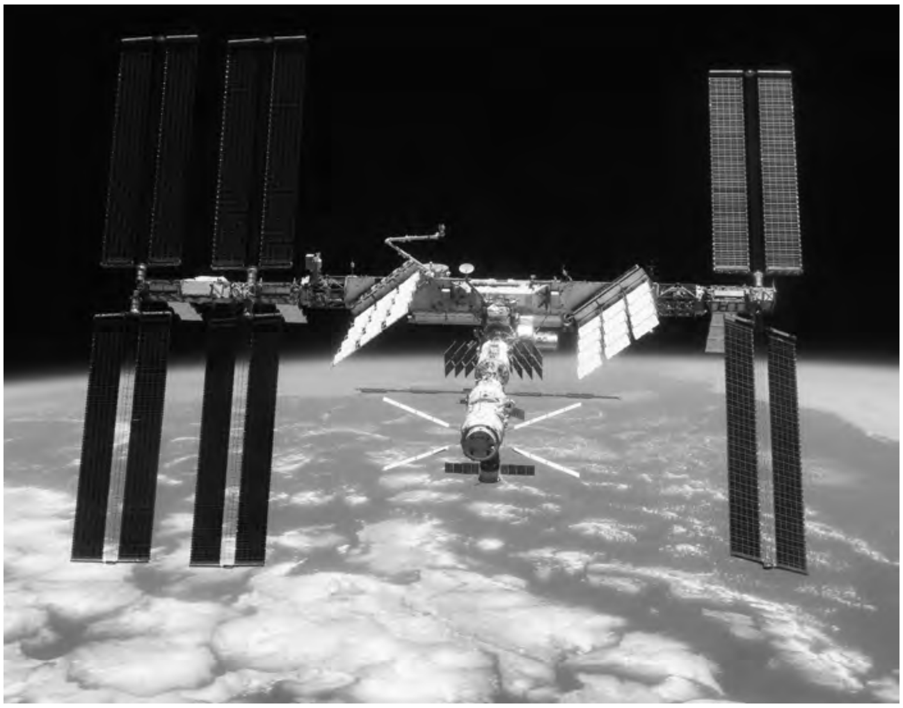

Figure 1-15. International Space Station. (NASA photo)

to provide operations experience to Americans, as the ISS is also using the basic schematics of the Mir space station. Countries all over the world are responsible for different parts of the space station. The United States is responsible for the building of the Unity structure, an 18-foot-long node that will serve as a hub for other nodes to be attached.[118] The United States is also responsible for the nearly 80,000 lb. of hardware that go along with the station. The United States is also contributing solar array panels, rack structures, and hatch assemblies. Canada built the mobile service system (MSS) that provides external station robotics.[119] The European Space Agency (ESA) is developing both a pressurized laboratory called the Columbus Orbital Facility (COF) and the automated transfer vehicle (ATV), which will be used for supplying logistics and propulsion.[120] Hauling the pieces and parts of the space station will require 45 space flights on five types of launch vehicles over a five-year period. The three launch vehicles are the US space shuttle, Russian *Proton* and *Soyuz* rockets, the ESA's *Ariane 5V* rocket, and Japan's *H-2A* rocket.[121] Launch of the space station began on 20 November 1998 (five months behind schedule) with the Russian Zarya control module.[122] Since then, many more modules have been attached including Spacehab, the Zenith-1 truss structure, the laboratory module Destiny, the joint airlock module Quest, the integrated truss structure, the mobile servicing system, and the American propulsion module.[123] The ISS is still being constructed and is scheduled to be complete in 2010.

Current Space Initiatives

In the post–Cold War world, space programs are no longer solely the initiatives of two superpowers in a race to control space. New players such as Iran and India are engaged in their own space research and development, even as the United States and Russia continue to pursue robust space programs.

United States

In January 2004 President Bush announced a new direction for NASA after the STS program draws to a close with the completion of the International Space Station in 2010. President Bush announced that NASA will return to the moon, this time no later than 2020.[124] Through an initiative named the Constellation Program, NASA hopes to return to the moon and establish a permanent colony on its way to manned exploration of Mars. Elements of this program are already in the testing phase, and the *Ares I* crew launch vehicle is scheduled to be test-fired in April 2009.[125]

In addition to government-sponsored efforts to continue space exploration, many private companies in America are trying to make space travel a reality for everyone. In 2004 the Ansari X prize was developed to spur private-company interest in space travel. The prize awarded $10 million to the first private team to build and launch a spacecraft capable of carrying three people 100 kilometers (km) above the earth's surface, twice within two weeks.[126] Aerospace designer Burt Rutan and financier Paul Allen won the prize on 4 October 2004 when *SpaceShipOne* rocketed to an altitude of over 328,000 feet for the second time in less than 10 days.[127] Since that time, several other X prizes have been offered, including a $30 million prize for the first team to design and soft-land a robotic probe on the moon.[128]

China

China is the third nation on Earth capable of independently launching its citizens into orbit. On 15 October 2003, Yang Liwei blasted off from a remote space base in the Gobi Desert atop a *Long March 2F* rocket and entered China into the exclusive club of nations capable of manned space missions.[129] On 27 September 2008, China continued its rapid push into space by completing the country's first spacewalk.

China is currently planning to land a robotic rover on the moon in 2010 or 2012 and follow this with a probe to bring back lunar rock samples by 2015.[130] If these efforts are successful, China hopes to land a man on the moon by 2020—interestingly, the same year by which the United States hopes to send another manned mission to the moon.

Japan

Despite a recent string of failures in the domestically made *H-2A* rocket, the Japan Aerospace Exploration Agency (JAXA) has tentative plans to send a manned spacecraft to the moon by 2025.[131] Over the next 10 years, Japan will try to develop nanotechnology and robots to explore the moon, as well as a rocket and vehicle to get astronauts there. After this 10-year period, JAXA will reevaluate its plans. Other projects under development include a passenger airliner capable of flying Mach 2, or twice the speed of sound.[132]

Russia

Russia regularly sends Soyuz spacecraft to the International Space Station to resupply and support crew change-outs. In addition, Russia continues to put military payloads into space, as well as satellites to complete their Globalnaya Navigatisionnaya

Sputnikovaya Sistema (GLONASS) navigation system.[133] Recently, Russia joined the race to the moon, announcing a joint program with the ESA to develop a rocket and capsule. Although no timeline has been announced, the design may be similar to NASA's Orion spacecraft, currently in development as part of the Constellation project.[134]

Europe

The ESA is one of the world's leading space programs. In 2007 the ESA launched six *Ariane 5* rockets, all delivering their satellite payloads into space.[135] The ESA is working with Russia on a collaborative mission to the moon and has primarily focused its efforts on the moon, Mars, and asteroids. These Aurora programs are designed to explore the universe, stimulate new technology, and inspire the young people of Europe to be interested in science and technology. NASA and the ESA are currently working on a joint program to bring Martian soil samples back to Earth for the first time in history.[136]

Iran

In February 2008 Iran announced the launch of its first research rocket and unveiled its new space center.[137] On 3 February 2009, Iran entered the global space race when it successfully launched its first domestic satellite, *Omid*.

India

The Indian Space Research Organization (ISRO) seeks to develop satellites, launch vehicles, and sounding rockets. These platforms are used primarily for telecommunications, television, meteorology, and disaster warning.[138] The ISRO also has two reliable launch vehicles that place payloads from other countries into orbit as well.

In 2007 an Italian satellite was placed into orbit, and in early 2008 an Israeli satellite was successfully placed in orbit.[139]

Where We Have Been and Where We Are Going

Mankind has been trying to solve the mysteries of the heavens since the beginning of time. With the development of the first rockets, man took the first tentative steps on this journey of discovery. Early pioneers such as Herman Oberth, Konstantin Tsiolkovsky, and Robert Goddard began to make the dream of space exploration a reality, paving the way for Dr. von Braun and other leading scientists.

Undaunted by countless failures on the ground and in flight, mankind continued the relentless pursuit of space. As rockets gave way to missiles and satellites, manned spaceflight slowly became a reality. Since the launch of *Sputnik* in 1957, mankind has come almost full circle in space exploration. Whereas the 1960s saw the Soviet Union and United States race to become the first to the moon, today the world is once again trying to achieve this goal. Now many nations are working to visit the moon by 2020 and hope to see a human being set foot on Mars.

As many historians believe that mankind's first steps on the moon in 1969 were the defining moment of the last century, perhaps we who are living now will be fortunate enough to witness one of the most important achievements in the history of the world—manned exploration to Mars and beyond.

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