America's Spaceport

John F. Kennedy Space Center

"...this generation does not intend to founder in the backwash of the coming age of space. We mean to be a part of it - we mean to lead it."

President John Fitzgerald Kennedy
September 12, 1962

Paintings courtesy of NASA Art Program

Opposite page

Andreas Nottebohm
First Night Launch STS-8
Acrylic

America's Spaceport

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Origins

The John F. Kennedy Space Center . . . America's Spaceport . . . is the doorway to outer space. From its unique facilities, humans and machines have begun the exploration of the solar system, reaching out to the Sun, the Moon, the planets - and beyond. While these spectacular achievements have fired the imagination of people throughout the world and enriched the lives of millions, they represent only a beginning. At America's Spaceport, humanity's long cherished dream of establishing permanent outposts on the new space frontier is becoming a reality.

Yet, our leap toward the stars is also an epilogue to a rich and colorful past . . . an almost forgotten legacy replete with Indian lore, stalwart adventurers, sunken treasure and hardy pioneers. (For the sands of America's Spaceport bear the imprint of New World history from its earliest beginnings.)

Long before people in modern times erected steel and concrete sentinels, the Spaceport was inhabited by dusky-skinned hunters - the Paleo peoples - who crossed the continent from Asia by way of the frozen Bering Sea some 12,000 to 20,000 years ago. When Columbus landed at San Salvador (Bahamas) in the fifteenth century, the Cape area was home to the fierce and often cannibalistic Ais and Timucuan Indians. By the middle 1800's, these aboriginal tribes had virtually disappeared. They had become the victims of internal strife, conflict with the Europeans moving into the area, and worst of all, new and deadly diseases - some of them unwittingly brought by the recent arrivals and spread to an Indian population with no built-up immunities.

The early European explorers came in search of territory, wealth, religious freedom, and even a Fountain of Eternal Youth - first, the Spanish, then the French and later the English. Among these adventurers were such notables as Juan Ponce de Leon, Hernando de Soto, Pedro Menendez de Aviles, Jean Ribault and Amerigo Vespucci, discoverer of Cape Canaveral and after whom America was named.

During the centuries that followed, Florida, which sat astride the main sea route between Europe and the Gulf of Mexico, was bitterly contested by the European powers. Throughout this swashbuckling era, America's Spaceport remained a virtual wilderness. But its coastal waters reverberated to the sounds of musket and cannon as pirates and privateers preyed upon Spanish treasure ships laden with riches from the mines of Mexico and Peru. Shoals, reefs and storms also exacted their toll on the treasure fleets, leaving behind a sunken bonanza now being reaped by modern-day treasure hunters.

By the early eighteenth century, America's Spaceport echoed to the footsteps of other intruders - English settlers and their Indian allies (the latter to become known as the Seminoles) from colonies in Georgia and South Carolina. Thus began a new era of conflict and expansion which would continue until the end of the Second U.S. - Seminole Indian War in 1842.

Against this backdrop, permanent settlement of the Spaceport area began. And in the years following the American Civil War, small rural towns and communities sprang up along a 70-mile-long stretch of mainland, rivers and beaches later to become known as Brevard County. The principal industries were agriculture, fishing and tourism.

After World War II, however, another kind of industry took root in the area, one destined to bring explosive growth and international stature. Brevard County, by virtue of its most prominent geographical feature - Cape Canaveral - became the focal point of a new era of exploration, the Space Age.

The first step in the transformation began in October 1949, when President Harry S. Truman established the Joint Long Range Proving Ground (currently known as the Eastern Range), a vast overwater military rocket test range that now extends 5,000 miles down the Atlantic from Cape Canaveral to Ascension Island.

The Cape was ideal for testing missiles. Virtually uninhabited, it enabled personnel to inspect, fuel and launch missiles without danger to nearby communities. The area's climate also permitted year-round operations, and rockets could be launched over water instead of populated areas. The first launch from the Cape was conducted by a military-civilian team on July 24, 1950. The rocket, a modified German V-2 with an attached upper stage, attained an altitude of 10 miles.

The first launch from Cape Canaveral — July 24, 1950. The modified German V-2 rocket attained an altitude of 10 miles. Note the primitive facilities. A tarpaper shack served as a blockhouse. The pad service structure was made from painters scaffolding.

By the late 1950's, the military services had elevated their sights from missile testing to launching artificial satellites. On January 31, 1958, America's (and the free-world's) first satellite - Explorer I - was launched from Complex 26 at Cape Canaveral by a military-civilian team of the Army's Missile Firing Laboratory. This group, under the direction of Kurt H. Debus, a key member of the famed Wernher von Braun rocket team, later formed the nucleus of the Kennedy Space Center.

Perched atop a Juno I rocket, America's first satellite, Explorer I, awaits launch on January 31, 1958. The Army-civilian launch team would form the nucleus of the Kennedy Space Center.

Rocket pioneers Wernher von Braun and Kurt Debus at rollout of first Apollo/Saturn V from Vehicle Assembly Building. Von Braun, then Director of the Marshall Space Flight Center, was responsible for design and development of the Saturn V. Debus, first Director of the Kennedy Space Center, created the mobile concept of launch operations used at the Spaceport.

With the creation of the National Aeronautics and Space Administration (NASA) in October 1958, the nation turned its attention to the peaceful exploration of space. Cape Canaveral thundered with the sound of rockets carrying sophisticated instruments and payloads to explore mankind's newest frontier. And soon, a new breed of pioneers - American astronauts - were soaring skyward from the Cape to take their first halting steps beyond the Earth.

But even as the first Americans ventured into space, more ambitious undertakings were planned. In May 1961, President John F. Kennedy announced that the U.S. would send men to the Moon and back by the end of the decade. The program, called Apollo, would require the largest rocket ever built - the 363-foot-tall Saturn V.

The Cape, which had served so well up to now, was inadequate as a launch site for the monstrous vehicle, and an adjacent location was selected. Shortly afterwards, the first steel and concrete structures of America's Spaceport sprouted from the marsh and scrublands of northern Merritt Island.

Concurrently, NASA's Launch Operations Directorate at Cape Canaveral, an element of the newly formed Marshall Space Flight Center, was elevated to independent status in July 1962 and renamed the Launch Operations Center. It was renamed the John F. Kennedy Space Center in November 1963, in honor of the slain president.

Five and a half years later, in July 1969, the first humans departed from the Spaceport's Launch Complex 39 to walk on the moon. Following completion of the Apollo-Soyuz Test Project in 1975, the facilities of the Spaceport were modified to support the nation's newest launch vehicle - the reusable Space Shuttle.

And so it is today. Kennedy Space Center . . . America's Spaceport . . . has become the "gateway to the universe," home port for voyages of exploration undreamed of centuries ago - manned by men and women who, like their forebears, still dream of discovering and settling new worlds.

The steel framework of the Vehicle Assembly Building rises on Merritt Island during construction of America's Spaceport. The structure at right is the Launch Control Center

Construction of Pad A at Spaceport's Launch Complex 39. The pad hardstand contains 68,000 cubic yards of concrete.

Mission

From Redstone to Saturn to Space Shuttle, from the time of the earliest scientific and applications satellites to the threshold of the Space Station era, the Kennedy Space Center has been the primary launch base for the nation's manned and unmanned civilian space programs.

It is here, at America's Spaceport, that the dreams and aspirations of space planners reach fruition - where the individual parts of a space mission come together for the first time, to be melded into a single, cohesive element and boosted into space.

At Launch Complex 39, where Moon rockets were once readied for flight, engineers and technicians prepare the reusable Space Shuttle for manned Earth-orbital missions. Unmanned military and commercial rockets are processed and launched at complexes on nearby Cape Canaveral, under the oversight of the U. S. Air Force.

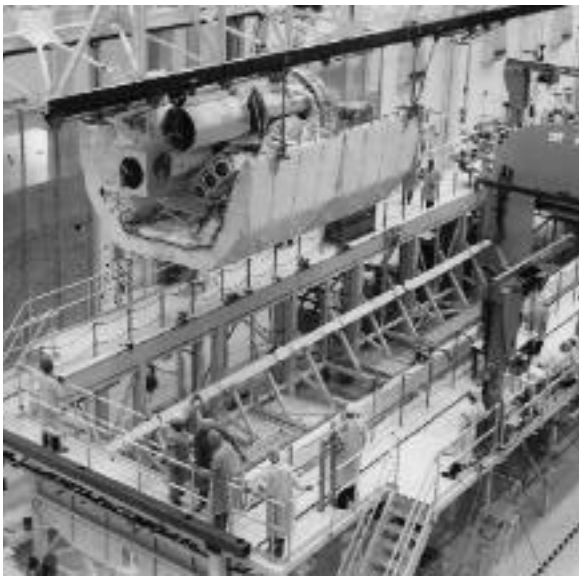
Cargoes destined for space - whether a planetary explorer to survey Jupiter and Saturn, a communications satellite, or a military payload for the Department of Defense - are assembled and tested in specially designed and equipped laboratories.

Elements of the Spaceport team have also conducted launch operations for unmanned polar-orbiting missions from NASA facilities at Vandenberg AFB at the Western Range in California.

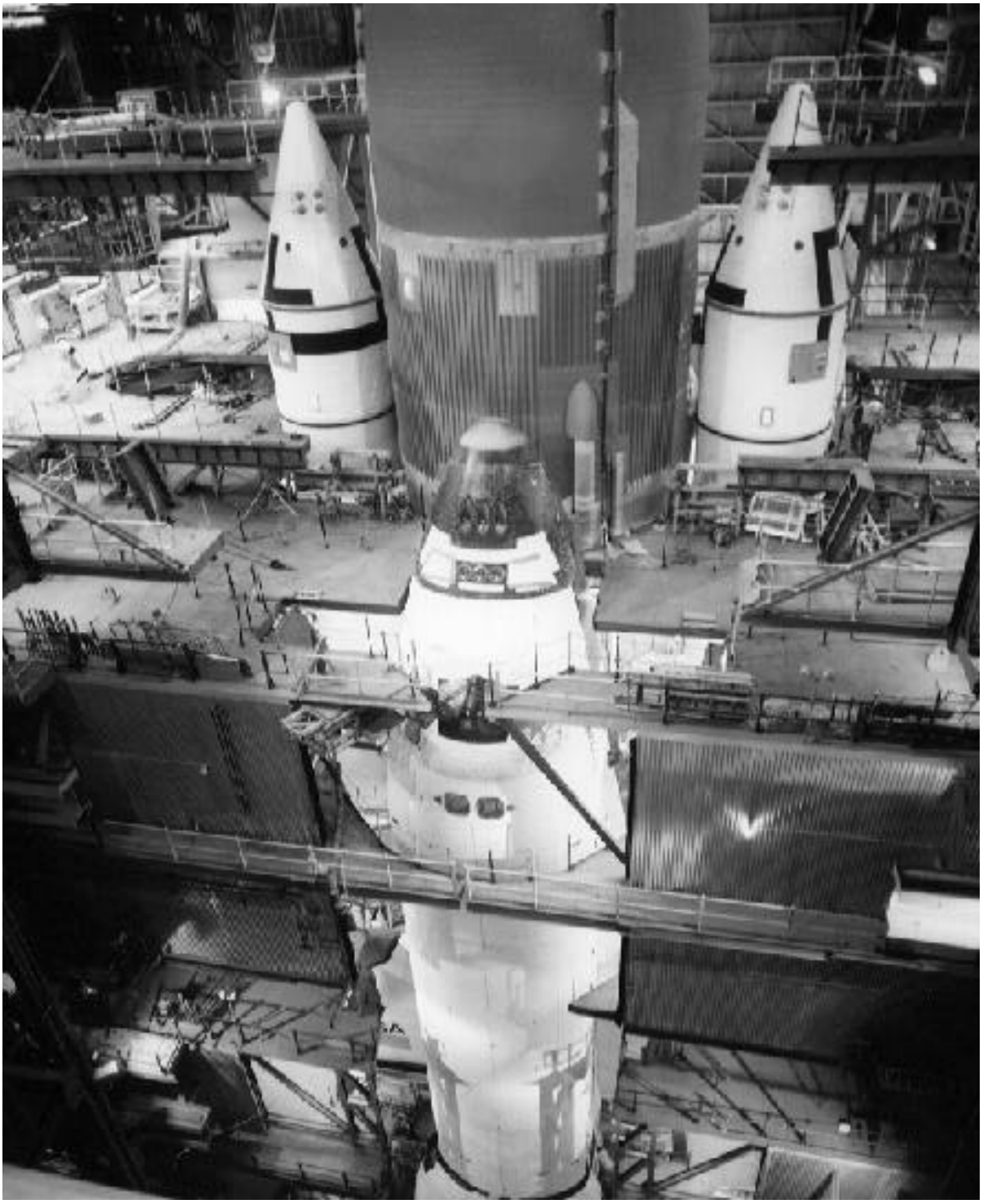
A Delta rocket lifts off from Complex 17, Cape Canaveral. The workhorse of the nation's space program, Delta has orbited more scientific, weather and communications satellites than all other vehicles of its class combined.

The history of the Kennedy Space Center is a chronicle of the Space Age, written in the blinding glare and thunder of rockets and space vehicles. Its distinguished record of achievement in the development and conduct of space vehicle checkout and launch operations is unmatched.

As the future unravels, the people and resources of America's Spaceport will continue to be a major force in our nation's effort to explore and utilize space for the benefit of all humanity.



Payloads, such as this automated scientific pallet to be carried into orbit by the Space Shuttle, are assembled and checked out in specially designed and equipped facilities at the Spaceport.



The elements of a Space Shuttle vehicle are integrated in one of the cavernous high bays of the Vehicle Assembly Building at Complex 39. The platforms slide in and out, allowing workers to reach all levels of the vehicle. The orbiter is in the foreground. Seen at the rear is the huge external tank, bracketed by solid rocket boosters.

People and Facilities

The men and women of the Kennedy Space Center's NASA/industry team are a very special resource of the United States and the world. Their skills and capabilities, many of which are found only at America's Spaceport, have been utilized for every American manned space flight to date.

Over the years, beginning in 1958, the Spaceport team has launched more than 300 unmanned space vehicles. These were primarily Deltas, Atlas-Centaurs, Atlas-Agenas, and Titan-Centaurs. All these lifted off from NASA-operated facilities on Cape Canaveral Air Station and Vandenberg Air Force Base in California.

Every person who works at the Spaceport is a member of the team, even if their jobs are not directly involved with launch operations. Most of the hands-on work is performed by contractors. The Center has a government workforce (in round numbers) of about 1,800 KSC Civil Service employees, plus more than 35 resident NASA personnel from other Centers. There are about 12,000 contractor employees. (These numbers can fluctuate, depending on the programs and responsibilities assigned to the Center.) The largest contractor organization handles Shuttle processing and launch operations, as well as astronaut training and mission operations at the Johnson Space Center. At KSC this includes everything from repairing Shuttle orbiter tiles to recovering the solid rocket boosters at sea to refurbishing the Space Shuttle Main Engines for their next flight.

The second largest contractor at KSC supports the facility itself, providing upkeep and maintenance for the buildings and grounds, and operating the support computers and electrical, mechanical, painting, rigging, and other shops. The thirdmajor

contractor is involved with the complicated process of preparing their spacecraft and other payloads for launch. Several other firms provide various operational, support and housekeeping functions.

Some of the more unusual facilities in which people work are the giant Vehicle Assembly Building, one of the largest enclosed structures in the world; the Orbiter Processing Facility, filled with complicated equipment used to prepare Shuttle orbiters for flight; Pads 39A and 39B, from which Shuttles lift off; NASA-operated Space Shuttle support and spacecraft checkout facilities on both KSC and Cape Canaveral; and a host of other processing and support facilities. Some of the buildings on both the Cape and KSC are especially designed for spacecraft assembly and checkout, and others for hazardous work such as installing explosive ordnance and loading propellants.

The heart of the Kennedy Space Center is its engineering work force, both contractor and NASA. People with electrical, mechanical, electronic and computer engineering degrees have the necessary background to begin work here. After that, it may take years to learn some of the more unusual functions of their jobs.

Members of the NASA-industry launch team conducting countdown operations in the blockhouse at Complex 36, Cape Canaveral. This was an Atlas-Centaur launch, which placed a military communications satellite into orbit.

Spaceport workers are dwarfed by the massive tracks of a crawler-transporter as it carries a mobile launcher platform and a Space Shuttle vehicle (not visible atop the platform) from the Vehicle Assembly Building to the launch pad. Space Shuttle launch operations require experience and skills found nowhere else in the world.

Many Spaceport professionals deal with more routine matters, such as designing and overseeing the construction of office or supply buildings, setting up and operating computer systems, or performing materials and structures tests.

The engineering departments do their work along with other groups that might be found at any industrial facility. Logistics personnel order supplies and keep them available in warehouses. Another organization operates a facility-wide bus system and supplies vehicles for local use. Writing and graphics departments produce a variety of publications, which are printed on site. A janitorial force keeps the facilities clean. A guard force provides security.

The diversity of occupations and the pioneering thrust of America's Spaceport make it a special place to work. Watching a rocket blaze a fiery trail into the sky, hearing the thunder of its passage, is a fringe benefit not available to many elsewhere.

A Shuttle remote manipulator arm undergoes testing by engineers and technicians inside one of the Spaceport's clean rooms before being installed in the cargo bay of an orbiter. The mechanism, built in Canada, helps astronaut crews handle payloads in space.

Readying a Space Shuttle orbiter for flight is an exacting job. Here, workers inspect the tiled underside of the orbiter Discovery during checkout and refurbishment operations inside the Orbiter Processing Facility.

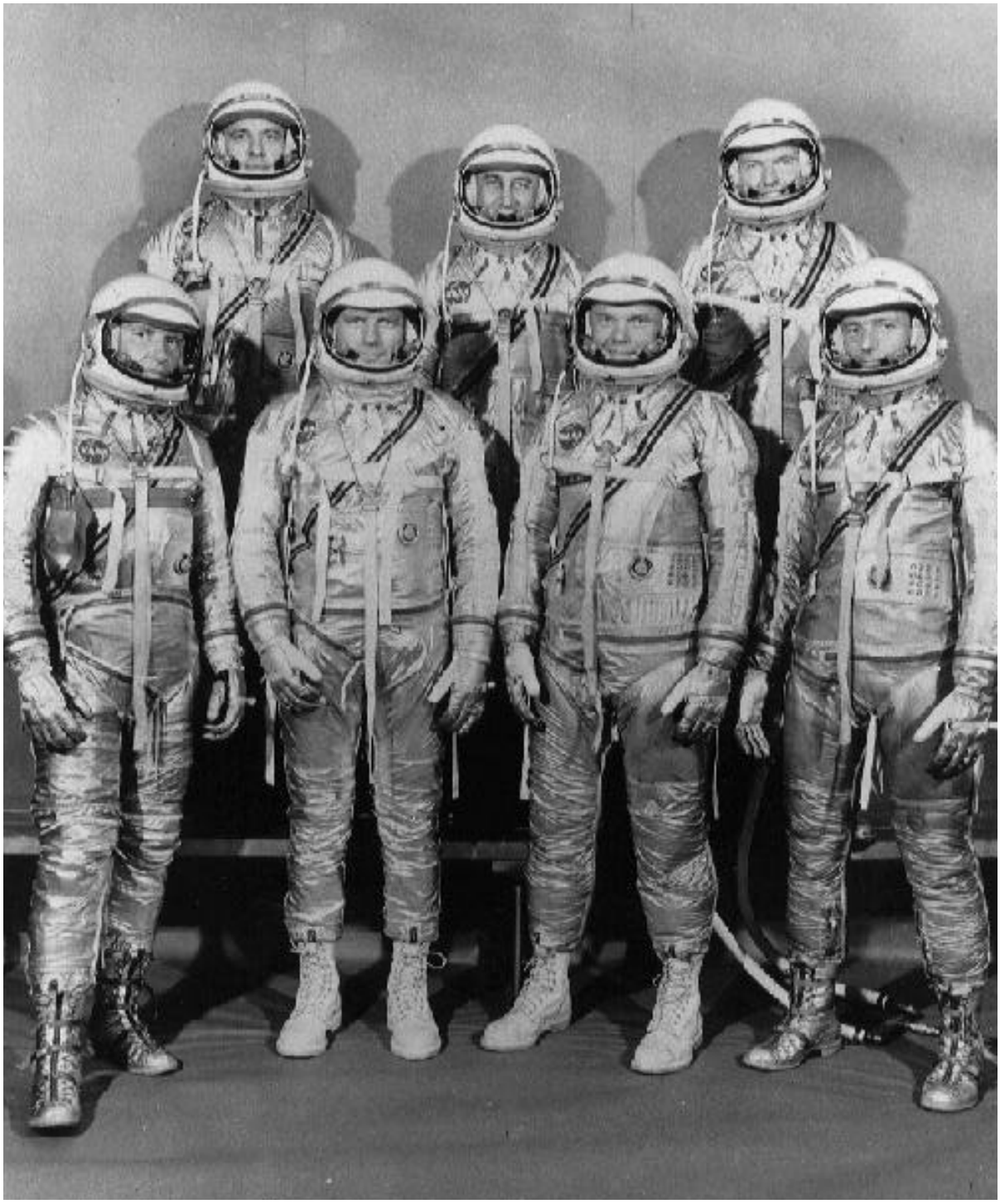
Human Space Flight - The First Era

On October 7, 1958, just six days after NASA was formally organized out of the old National Advisory Committee for Aeronautics, the infant agency initiated Project Mercury, the first American human space flight program.

Considering that only four American satellite launch attempts out of thirteen had been successful at the time, this was an undertaking of high ambition. The task of making the launch systems, rockets and spacecraft safe enough to risk a human life was a daunting challenge.

One of the most reliable vehicles then available, the Redstone, was chosen first for “man-rating” - upgrading in reliability to be as safe as human talent and ingenuity could make it. This meant the pad, the checkout and launch procedures, and the tracking systems all had to be reexamined. Astronaut escape and rescue systems had to be designed and installed, and Kennedy personnel trained in their use.

On May 5, 1961, after extensive preparations and several frustrating and nerve-wracking launch attempts, Alan Shepard became the first American to make a suborbital flight. His Mercury-Redstone vehicle reached an altitude of 116 miles, and splashed down about 304 miles out into the Atlantic. Gus Grissom, on July 21, followed on an almost identical flight. The Kennedy team had adapted to the tough new requirements of human space flight and America had entered a new era. Space would never again be restricted to automated machines.



The seven Mercury astronauts, the first Americans chosen to venture into the dangerous new frontier of space, pose for a group photograph. They are from left to right (front): Walter M. Schirra, Jr.; Donald K. Slayton; John H. Glenn, Jr.; and Scott Carpenter; (back): Alan B. Shepard, Jr.; Virgil I. "Gus" Grissom; and L. Gordon Cooper.

For Mercury orbital flights, NASA selected the larger and more powerful Atlas, until then only used as an intercontinental ballistic missile by the U.S. Air Force. After two successful missions, the second of which carried the chimpanzee Enos into space for two orbits, John Glenn was launched aboard a Mercury-Atlas, on February 20, 1962. He became the first American to complete three circles of the Earth. Glenn was followed by Scott Carpenter, Wally Schirra, and Gordon Cooper, the latter staying up a full day after his launch on May 15, 1963.

After Alan Shepard and Gus Grissom had completed two suborbital flights, an Atlas vehicle roared off Complex 14 on February 20, 1962, carrying John Glenn. After three trips around the world, the Mercury spacecraft he had named Friendship 7 re-entered the atmosphere and parachuted to a safe landing in the Atlantic Ocean. Glenn became the first American to orbit the Earth.

A Titan II vehicle carrying the Gemini 11 spacecraft heads for space from Launch Complex 19, where all 10 manned Gemini flights began. Charles Conrad, Jr. and Richard F. Gordon, Jr., made four practice rendezvous with a target vehicle, reached an altitude of 851 miles, and flew with the hatch open for over two hours.

The next step in the nation's human space program was Project Gemini, which served as a bridge between the Mercury flights and the more difficult Apollo missions to come. For the larger two-man Gemini spacecraft, the Air Force Titan missile was chosen and "man-rated."

The first manned Gemini vehicle was launched on March 23, 1965, and the tenth and final one on November 11, 1966. During the brief span of 20 months, an equal number of astronauts

were sent into orbit. Seven unmanned target vehicles were launched in the same time period for rendezvous practice and other associated functions. When the program was completed, enough had been learned about launching and operating manned vehicles in space to make fulfilling President Kennedy's commitment to a Moon landing a real possibility.

Apollo 17 heads for Pad A atop its giant Saturn V rocket for the last manned flight to the Moon. Riding a mobile launcher that towered well over 400 feet into the air, with a total weight on the crawler-transporter treads of over 18 million pounds, an Apollo/Saturn V vehicle in motion on the crawlerway was an awesome and unforgettable sight.

For the Apollo lunar landing program, an entirely new family of launch vehicles was required - the massive and powerful Saturns. Eleven Saturn I launches were followed by several of the more powerful Saturn 1B's. Both vehicles were initially used to test unmanned elements of the three-man Apollo spacecraft. They were launched from new complexes constructed by NASA on Cape Canaveral.

On November 9, 1967, the first Saturn V - 363 feet tall, and still the largest vehicle ever flown - was launched on a test flight from Complex 39 at the Spaceport. This powerful three-stage vehicle produced more than seven-and-one-half million pounds of thrust, equal to about 180 million horsepower - enough to place almost a quarter of a million pounds of payload into Earth orbit.

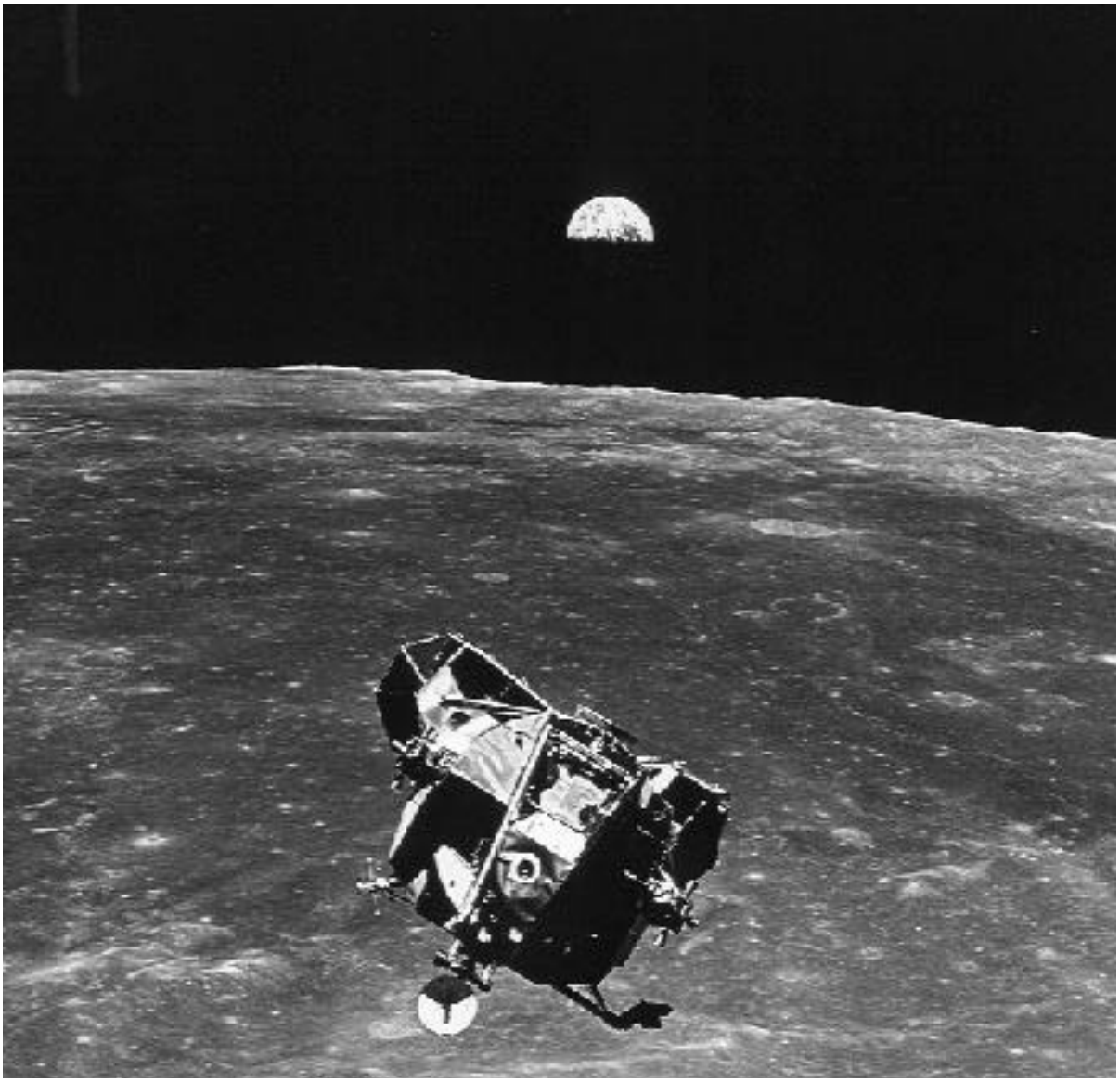
Apollo 7, the first manned Apollo mission, lifted off into Earth orbit on October 11, 1968, on a Saturn 1B vehicle. And just over two months later, on December 21 - on the third flight of the Saturn V and the second manned launch of an Apollo spacecraft - Frank Borman, James Lovell and William Anders flew to the Moon, and into orbit around it. Considering the short test history of both the launch vehicle and the spacecraft, this was a feat of incredible courage and daring.

The next Apollo/Saturn V launched by the Kennedy Space Center team, on March 3, 1969, sent three astronauts into Earth orbit, to flight-test the Lunar Module in microgravity. This new vehicle was the lightly built, insect-shaped craft designed to actually descend to the lunar surface.

On May 18, a second Apollo/Saturn V was sent toward the Moon. Another Lunar Module was flight-tested, this one while actually in lunar orbit. And on July 16, 1969, all the parts, planning, care and labor came together for the launch of Apollo 11. Neil Armstrong and Edwin Aldrin subsequently became the first human beings to set foot on the surface of another planetary body, while their crewmate Michael Collins kept a lonely vigil in the orbiting Command Module.

Through December 1972, the Kennedy team processed and launched six more of the giant Apollo/Saturn V vehicles, maintaining a hectic pace that never evolved into a repetitive and routine job.

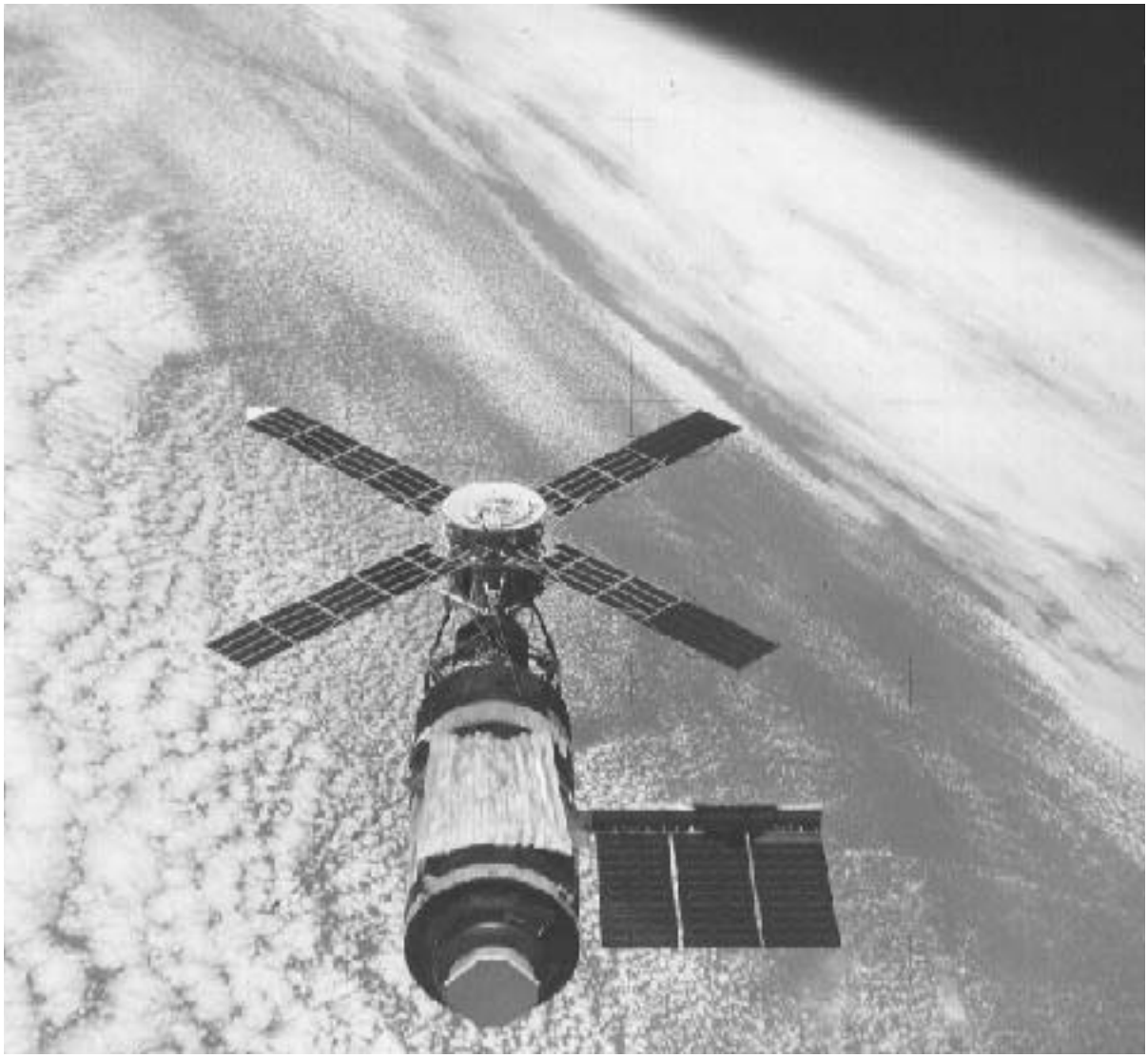
A wealth of scientific data and physical artifacts were brought back from the Moon; these are



still under study today. And Apollo entered history books as the greatest and most far-reaching feat of scientific exploration of humankind.

The Apollo Program was over. But the Kennedy team had to process and launch still one more of the huge Saturn V vehicles. On May 14, 1973, it hurled the world's first orbital workshop, Skylab 1, into space. Skylab was actually an inert Saturn V third stage which had been internally modified to function as a manned scientific laboratory, with three other scientific and operational modules added.

The ascent stage of the Apollo 11 Lunar Module floats over the eerie, crater-scarred landscape of the Moon, after Neil Armstrong and Edwin Aldrin, Jr., successfully lifted off using the descent stage as a stable launch platform. This photo was taken through the orbiting Apollo spacecraft window by Michael Collins. After the rendezvous in lunar orbit the astronauts headed for Earth, seen here, half shadowed in darkness, above the bleak lunar horizon.



Skylab, the orbital workshop that was a precursor to the Space Station, floats above a heavily clouded Earth. The solar array on the left side of the workshop is missing, and an improvised sunshade protects the main body from excessive heat accumulation. Skylab was repaired in orbit after suffering damage during ascent, and went on to complete a highly successful mission. It remains one of the largest habitable structures ever placed in orbit.

Skylab was launched without an astronaut crew. The Kennedy team later sent up three separate crews of astronauts to occupy it. They were transported by Apollo/Saturn IB vehicles launched from modified facilities at the Spaceport's Launch Complex 39. Skylab produced a bonanza of scientific information and proved that humans could work in space for extended periods of time The final crew, launched on November 16, 1973, stayed in space for 84 days. This length of time in microgravity remained the record for American astronauts until 1995, when Norman Thagard exceeded it while working on board the Russian Space Station MIR.

One last mission remained to be flown before America entered a long hiatus from human space flight. On July 15, 1975, the last Apollo/Saturn 1B lifted off from Complex 39. It carried three American astronauts into space, to rendezvous with a Russian Soyuz spacecraft and its crew of two cosmonauts. The Apollo-Soyuz Project remained the only such international meeting until the Space Shuttle Atlantis rendezvoused and docked with MIR in June 1995.

The Apollo-Soyuz flight also was the last for American manned space vehicles that could fly only once. NASA needed a more economical way to get into orbit and safely back to Earth. The era of the reusable Space Shuttle was at hand.

Astronaut Thomas Stafford (center left) and Cosmonaut Aleksey Leonov meet in the module temporarily connecting their spacecraft in orbit. The Apollo-Soyuz mission was the first international meeting in space. The two vehicles remained docked together for several days, and astronauts and cosmonauts visited each other's spacecraft.

A New Approach - The Space Shuttle

NASA had blazed new trails across the heavens with expendable vehicles and spacecraft, but the cost had been high. To continue the exploration and utilization of space on a permanent basis, a more economical way to reach orbit was urgently needed. This had become apparent well before the end of the Apollo era, and work had started on a new type of space vehicle. This became the Space Shuttle, where the reusable orbiter resembled an airplane and, like one, could fly again and again - for a planned life of at least 100 missions.

The Space Shuttle required a new philosophy of operations. No longer would a vehicle be prepared for a single flight. In the future, the same vehicle would return again and again to the Kennedy Space Center, to be processed and launched once more.

The Space Shuttle was very different from the Apollos and Saturns, and it was far more sophisticated and technically complex. It was designed, tested and built with limited funds. To help keep costs down, Kennedy engineers adapted the Apollo launch facilities, rather than building all new ones. The huge Vehicle Assembly Building was converted to handle Shuttle components. The three mobile launchers used for the Saturns were modified to stack and carry the new vehicle, and Pads A and B were given new above-ground configurations.

Some new facilities were mandatory. A three-mile-long landing strip was one of the first constructed. The orbiter would land at Kennedy after enough landing experience had been gained on the extra-long dry lake beds at Edwards AFB, California. A large, highly specialized two-bay building called the Orbiter Processing Facility was constructed near the Vehicle Assembly Building. A few years later, a similar building used as a refurbishment facility was upgraded to become OPF Bay 3. Spacecraft checkout and assembly facilities were modified to process and integrate a large number of payloads each year. Many other modifications were required throughout the Center. This rebuilding and conversion process became the main activity at Kennedy during the years following the Apollo-Soyuz flight.

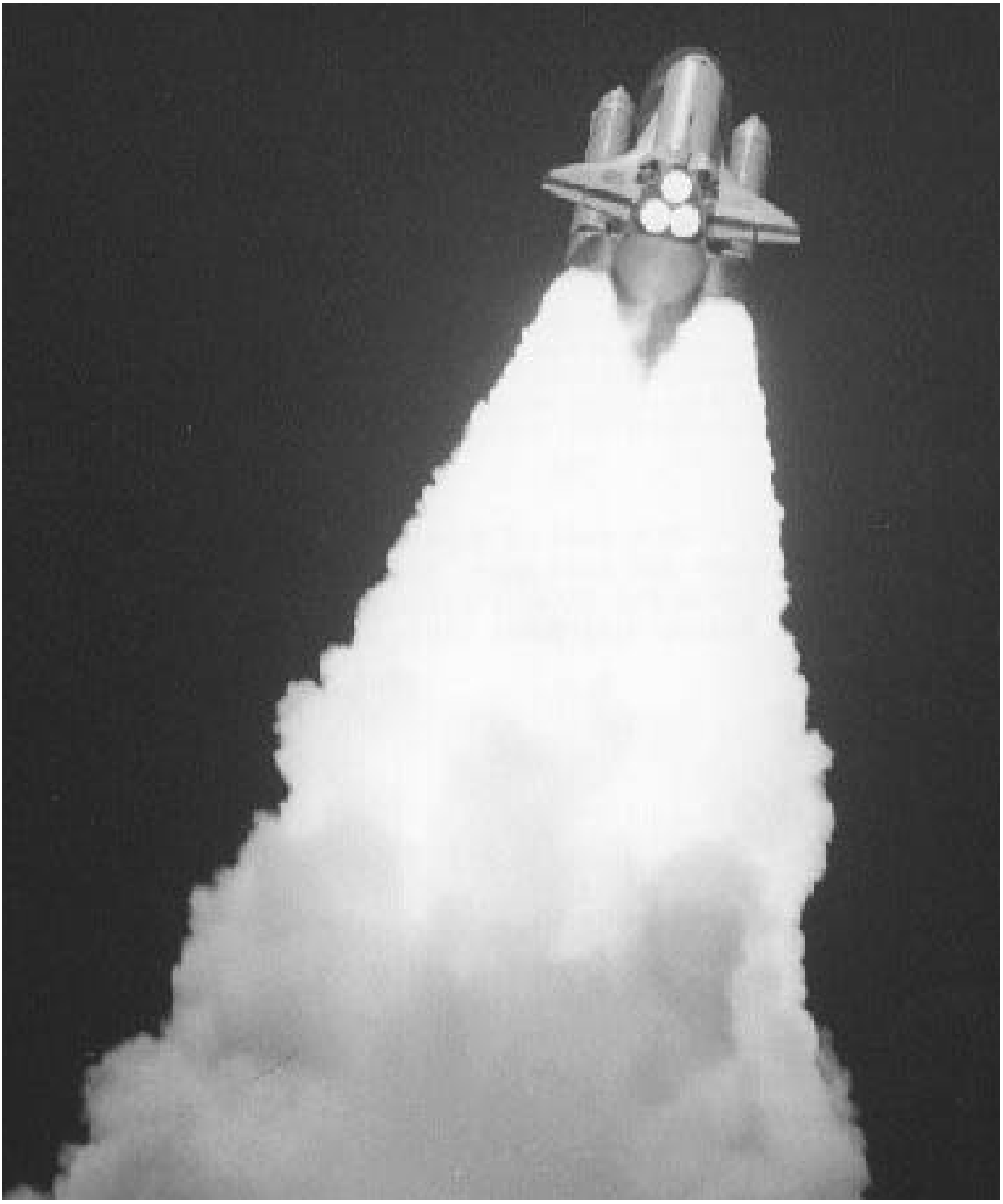
The first orbiter intended for space flight, Columbia, arrived at the Spaceport in March 1979. A great deal of work remained to be done. Both Kennedy and Johnson Space Center (the lead design agency) were very busy for the next 610 days in the Orbiter Processing Facility. They had to perform the remaining assembly work and a series of major modifications. The orbiter then spent another 35 days in the Vehicle Assembly Building and 105 days on Pad A, before finally lifting off on April 12, 1981. John Young and Robert Crippen became the first two astronauts to enter orbit in a reusable spacecraft, and to land it like an airplane at the end of the mission.

The Launch of the first Space Shuttle was a true milestone for the people of Kennedy. The launch team had learned new checkout and launch procedures. Two entirely new sets of computers, called the Launch Processing System, had been installed in two of the old Apollo/Saturn V firing rooms in the Launch Control Center, and crews trained in their use.

The orbiter Columbia is slowly backed out of the Orbiter Processing Facility, after a stay of 42 days in preparation for its fourth journey into space.

An assembled and ready Space Shuttle heads for Pad A as the shadows of twilight creep over the Space Center.

A New Approach - The Space Shuttle



With a roll of thunder and riding a pillar of flame that made the Florida morning Sun seem pale in comparison, an orbiter heads for orbit and a first in space — the capture, repair, and redeployment of an ailing spacecraft. The new life given to the Solar Maximum Mission scientific satellite saved millions of dollars, compared to building and launching a new spacecraft.

This view of an orbiter, floating some 180 miles above the white clouds and blue oceans of Earth, was taken by the free-flying German spacecraft SPAS-01. It had been deployed from the orbiter's cargo bay earlier. At the rear of the open bay, half in shadow, are the sunshields that protected two communications satellites before deployment.

Once the first Space Shuttle mission was over, and the orbiter Columbia back at Kennedy, the Center again went into high gear. One more Space Shuttle was launched in 1981, three in 1982, four in 1983, five in 1984, and nine in 1985 - the latter a total that had seemed unobtainable back in 1981.

As 1986 began, NASA was close to having the ability to launch a Space Shuttle every month, or 12 a year. There were four orbiters in the fleet - (in order of first flight) Columbia, Challenger, Discovery and Atlantis. Then, on January 28, tragedy struck. The Orbiter Challenger and its crew were lost during the launch of STS-51L, the 25th Space Shuttle mission.

The Space Shuttle had just started to fulfill its promise of frequent and economical access to orbit. A large variety of scientific and commercial spacecraft had been launched. One expensive scientific spacecraft had been repaired in orbit, and two large commercial satellites were recovered from improper orbits and returned to the ground. Both were later re-launched and entered active service, saving their owners many millions of dollars compared to buying new spacecraft.

On a Hubble Servicing Mission (STS-103) in 1999, astronaut Claude Nicollier, mission specialist from the European Space Agency (ESA), works at a storage enclosure, using one of the Hubble power tools, during the second of three extravehicular activities (EVA).

The Space Shuttle was becoming a true national and international asset, carrying into space student experiments, small business payloads, and foreign payload specialists who accompanied their scientific experiments to perform them in orbit. The next major task for the Space Shuttle fleet, the assembly of a permanent manned Space Station, had already been authorized by President Reagan and the Congress, in January 1984. But the problems that caused the loss of Challenger and its crew had to be found and corrected before Space Shuttles could fly again.

The longest and most intensive investigation ever conducted by NASA indicated that the primary culprit in the Challenger accident was an inadequate design of the field joints between the solid rocket booster segments. These were re-designed and re-tested. Many other critical flight systems were also re-examined and re-certified at the same time. The unique checkout and launch facilities at the Spaceport, and the detailed procedures and software that determined their operation, were all thoroughly reviewed, and improved where necessary. It took 32 months before everyone was satisfied that the vehicle and its crew were now as safe as it was humanly possible to make them.

STS-26 lifted off on September 27, 1988, with Discovery as the orbiter. The flight was completely successful. By the Spring of 2001, Space Shuttles had flown 104 missions, more than four times the 24 safe flights that preceded Challenger's last flight, and had settled into a steady launch rate of about six times a year. On Nov. 20, 1998, the Zarya Control Module, the first International Space Station (ISS) component, was launched. In the following 2-plus years, the ISS grew to include the Russian-built service module, Zvezda; the U.S.-built Unity Node 1; the U.S. Laboratory Destiny; and a Canadian-built robotic arm to aid in construction. In addition, Italian-built Multi-Purpose Logistics Modules began regular service as cargo modules, especially for experiments. Oct. 31, 2000, marked the first human presence on the Space Station with the three-person crew Commander Bill Shepherd, Soyuz Commander Yuri Gidzenko and Flight Engineer Sergei Krikalev. Thus, NASA's goal of steady progress toward living and working on the new frontier of space was begun. Since the October 2000 launch, there has been permanent human presence on the ISS.

Unmanned Space Missions

For more than 30 years, NASA's unmanned space programs compiled an enviable record of achievement in space science and applications.

During this span, more than 300 launches were conducted for programs ranging from solar system exploration to improved weather forecasting, global communications and Earth resources studies. These projects, which have more than repaid the nation's investment in time, money and technical talent, depended on the development and evolution of a varied fleet of unmanned rockets.

The origins of this fleet were primarily military. When NASA was created in October 1958, it lacked the launch vehicles and facilities to carry out its mandate to explore space, and drew heavily on rocket systems under development by the armed services.

During its first year of operation, for instance, NASA awarded a contract to McDonnell Douglas to upgrade the Thor-Able missile, developed under Air Force management, to become the Thor-Able-Delta launch vehicle–later known simply as the Delta.

A group of employees from the Naval Research Laboratory had been at the Cape for some time, launching the early Vanguard vehicles that placed America's second satellite into orbit. With the establishment of NASA, this group became the Launch Operations Branch of the Goddard Space Flight Center, and later formed the nucleus of the "Unmanned Launch Operations" directorate of the Kennedy Space Center. Another early launch team, from Goddard, was responsible for the engineering management and configuration control of the Delta vehicle. In 1965, this team also was phased over into Kennedy.

The upgraded Thor-Able vehicle soon acquired the reputation of being "Dependable Delta." By the end of 1989 more than 180 had been launched by NASA, from facilities on Cape Canaveral and Vandenberg AFB. This was more than all other vehicles of an equivalent size combined. The Delta has been continuously upgraded over the years. It can now place a spacecraft weighing up to 4,010 pounds into a geosynchronous transfer orbit–a weight 15 times that of its early payloads.

NASA also adopted another Air Force developed stage, the Agena, and combined it with a Thor first stage. This was the first NASA vehicle launched from Vandenberg, and the first to have solid motors strapped to the outside of the first stage for extra power. NASA launched a total of 12 Thor-Agenas from the west coast.

The Agena was also adapted to fly on top of an Atlas booster, creating a larger and more powerful combination than either of the other two. This vehicle performed well for many missions, but was eventually phased out in favor of a still more powerful combination, the Atlas booster and a new stage called Centaur.

Developed under NASA contract by General Dynamics, builder of the Atlas, Centaur was the first stage to use liquid hydrogen for its fuel. Liquid oxygen remained the choice for the oxidizer. The Centaur is still the most powerful stage, in proportion to its weight, of any yet successfully operated.

The overhead crane in the gantry on Pad B, Launch Complex 36, lifts a Centaur nose fairing toward the opening to the interior. Inside the fairing was a FLTSAT-COM military satellite spacecraft. Once inside the gantry the nose fairing was mated with the Atlas/Centaur.

Technicians install a solar panel on Mariner 8, launched on May 8, 1971. It was half of a twin launch of scientific spacecraft, planned to survey Mars from orbit. Mariner 9 reached the "Red Planet" next November 13, in the middle of a planet-wide dust-storm. It waited it out in orbit, then provided the first complete photographic record of the spectacular Martian surface.

After the last Atlas-Agena was launched in March1968, the Delta and the Atlas-Centaur became the standard unmanned launch vehicles for NASA. One test flight and six operational launches were conducted of a new, more powerful vehicle, a combination of Titan and Centaur. The latter was needed to launch two Helios spacecraft to the Sun, two unusually heavy Vikings to Mars, and two Voyagers to the outer giant gas planets.

Unmanned Launch Operations continued to place the large majority of spacecraft in orbit until the Space Shuttle became operational.

As the new system matured, many payloads were shifted from unmanned launch vehicles to the Space Shuttle. But after the loss of Challenger and its crew, the decision was made to reserve the

Shuttle primarily for scientific spacecraft. Responsibility for the launch of the Delta, Titan, and Atlas-Centaur vehicles was assumed extensively by their manufacturers and the U.S. Air Force. All three vehicles now launch payloads for the Air Force, NASA, and commercial customers on a contract basis.

Automated spacecraft have performed some of the most spectacular feats of the American space program. Surveyors landed softly on the Moon, helping pave the way for later Apollo missions. Mariners provided detailed photographs of the cloudtops of Venus and the surfaces of Mars and Mercury. Two Viking Landers descended to the surface of Mars and searched for evidence of life, while two orbiters mapped almost the entire planet from overhead. Two Pioneers went to Jupiter, and one flew onward to Saturn. Two much larger Voyager spacecraft followed them to both planets - and one of these has now visited Uranus and Neptune as well.

The Hubble Space Telescope, a joint program of NASA and the European Space Agency, made many contributions. The large telescope was launched in April 1990 aboard Discovery on the STS-31 mission. Hubble made the deepest-ever look into the universe revealing thousands of galaxies, supporting the fact that the universe made most of its stars long ago (when the universe was one-tenth its present age), and that the vast majority of stars are only one-fifth the mass of our Sun. Hubble also made the first surface map of the planet Pluto and discovered that massive black holes are common throughout the universe.

NASA's ambitious plan to send spacecraft to Mars was realized with the November 1996 Mars Global Surveyor project, which studied the planet's surface, atmosphere, and gravitational and magnetic fields. Then one month later, the Mars Pathfinder delivered the Rover, named Sojourner, to Mars' surface to study and record data about

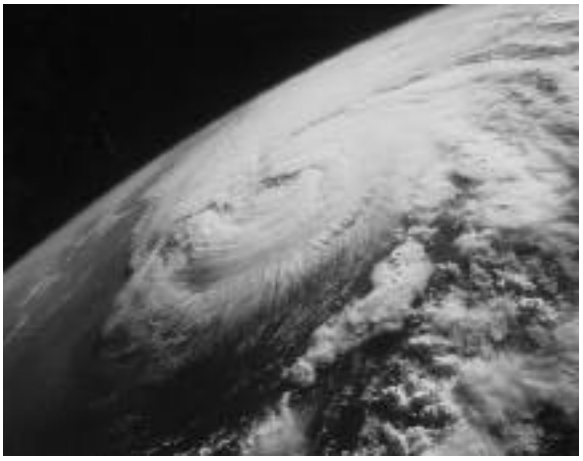
The salmon sky and red, boulder-strewn expanse of Mars' Utopian Plain as seen by the camera of NASA's Viking 2 lander shortly after setting down on the planet's surface September 3, 1976. Portions of the lander are in the foreground. Unmanned exploration of the solar system is one of the most exciting and scientifically rewarding aspects of the nation's space program.

Protected by its gantry, a Delta rocket awaits launch under leaden skies at Complex 17. It later hurled a GOES weather satellite into a geostationary orbit. Five of the Delta's nine strap-on solid booster rockets are visible in this photo.

NASA's Tracking and Data Relay Satellite (TDRS-H) sits bathed in spotlights before liftoff atop an Atlas IIA/ Centaur rocket from Launch Complex 36A, Cape Canaveral Air Force Station.

ancient rocks. The Cassini satellite is set to arrive at Saturn in July 2004. Since Cassini's 1997 launch, the satellite has been conducting gravity-assisted flybys of the planets Venus and Jupiter.

But by far the largest number of unmanned spacecraft have remained in orbit around the Earth. So many communications, weather, and other types of satellites have crowded into geosynchronous orbit - that region above the equator at about 22,240 miles altitude, where a velocity of 6,878 miles an hour toward the east will keep a satellite apparently motionless in the sky - that international agreements have had to be worked out on assigning spaces. Weather and other Earth observation satellites patrol our planet steadily in north-south polar orbits. Scientific explorers in many types of orbits have returned a wealth of information that could not have been obtained in any other way.



The unmistakable swirl of a monster hurricane straddles the Gulf of Mexico, bound for the Mississippi and Louisiana coastlines. Photographs taken from space help meteorologists track dangerous storms and add a new dimension to accurate weather forecasting.

The two gantries of Launch Complex 36 (foreground), where Atlas rockets are launched, still stand on the eastermost point of Cape Canaveral. But the line of gantries extending north from the right-hand pad in this 1964 photograph have mostly been dismantled. Corrosion from the salt air had weakened the steel structures until they were no longer safe.

Unmanned Space Missions

The following table lists some of the more notable spacecraft launched by the Kennedy teams, with brief descriptions of the results.

Launch Spacecraft	Date	Mission Description/Results
TIROS 1	4/1/60	Relayed thousands of cloud pictures, demonstrating thefeasibility of satellite observations in weather forecasting.
Telstar 1	7/10/62	First commercial communications satellite, launched for the American Telephone & Telegraph Company.
Mariner 2	8/27/62	First U.S. interplanetary probe to reach the planet Venus.
Syncom 2	7/26/63	First communications satellite in geosyn-chronous orbit; proved out the concept widely used today.
Ranger 7	7/28/64	First U.S. spacecraft to impact on the Moon; returned a series of photos and other data.
Intelsat 1 (Early Bird)	4/6/65	First international communications satellite. Intelsat grew to become largest international carrier in history.
Surveyor 1	5/30/66	Performed first U.S. soft landing on the Moon, sending back thousands of excellent surface photographs.
Mariner Mars 6	2/24/69	Passed within 3,220 km (2,000 miles) of Mars' equatorial region, returning the first good photographs for the U.S.
Pioneer 10	3/2/72	Performed flyby of Jupiter, returning first close-up photographs and measuring radiation emissions.
LANDSAT 1	7/23/72	First satellite to perform major assess-ment of Earth resources from outer space.
Anik 1 (Telesat 1)	11/9/72	First geosynchronous orbit domestic communications satellite; owned by Canada.
Pioneer 11	4/5/73	Performed flyby of Jupiter and first flyby of Saturn.
Mariner Venus/ Mercury	11/3/73	Performed a flyby of Venus,then continued on to Mercury and completed the first three flybys of that planet.
Westar 1	4/13/74	First U.S. geosynchronous orbit domestic communications satellite; owned by Western Union.
Helios 1	12/10/74	Approached the Sun to within outer solar corona and took density, temperature, velocity,and magnetic field measurements.
Viking 1	8/20/75	Placed an orbiter in orbit around Mars and a lander on the surface; obtained voluminous data in a search for life.
GOES 1	10/16/75	First weather satellite to photograph complete disk of the Earth every 30 minutes from geosynchronous orbit.
PALAPA 1	7/8/76	First geosynchronous orbit domestic communications satellite in Southeast Asia. PALAPAs now also serve Thailand, Singapore, and Malaysia.
Voyager 2	9/5/77	Performed flybys of Jupiter, Saturn,Uranus and Neptune,and some of their moons.
Pioneer Venus Orbiter	5/20/78	Placed in orbit around Venus to study the atmosphere and surface; compiled radar maps of surface features.

Launch Spacecraft	Date	Mission Description/Results
Pioneer Venus Multiprobe	8/8/78	Sent four probes into the Venusian atmosphere five days after the Orbiter arrived; returned much useful data.
International Sun-Earth Explorer (ISEE)	8/12/78	Third International Sun-Earth Explorer; examined solar wind and its interaction with Earth's magnetosphere. Renamed International Cometary Explorer (ICE) and redirected in 1983 to make the first flyby of a comet —Giacobini-Zinner-on Sept.11,1985.
HEAO 2	11/13/78	Examined selected x-ray astronomcal sources in detail with the largest Xray telescope ever made.
Infrared Astronomical Satellite (IRAS)	1/25/83	Made first detailed infrared examination of the universe; discovered new stars being born and possible evolution of new planetary systems.
COBE	11/18/89	Measured the diffuse infrared and micro-wave radiation from the early universe to the limits set by our astrophysical environment.
SOHO	12/3/95	Gathered data on the internal structure and outer atmosphere of the sun, and on the origin of the solar wind.
NEAR	2/17/96	Conducted the first long-term, close-up look of an asteroid's surface. For a year, NEAR studied Eros' physical properties.
Mars Global Surveyor	11/7/96	Conducted a global mapping of Mars by studying the planet's surface, atmosphere, and gravitational and magnetic fields.
Mars Pathfinder	12/4/96	Delivered a lander and small robotic rover, Sojourner, to Mars' surface to study and record data about ancient rocks.
Cassini	10/15/97	Cassini will conduct gravity-assist flybys of the planets Venus and Jupiter, then arrive at Saturn in July 2004.
Lunar Prospector	1/6/98	Provided the first global maps of the Moon's surface elements and its gravitational and magnetic fields.
Stardust	2/7/99	Brought comet material back to earth and collected interstellar dust.
Landsat 7	4/15/99	Gather remotely sensed images of the land surface and surrounding coastal regions of the Earth for global climate change studies.
EOS/TERRA	12/18/99	Consisted of a science component and a data system supporting a coordinated series of polar-orbiting and low-inclination satellites for long-term global observations of the land surface, biosphere, solid Earth, atmosphere,and oceans.
GOES I-M	1994-2001	NASA-developed payload for the National Oceanic and Atmospheric Administration (NOAA); launch vehicle services contract. Launched into geosynchronous Earth orbit.

A Place to Visit

Exciting, educational exhibits. Peaceful nature trails. Pristine seashores. The nation's only manned vehicle spaceport, and one of Central Florida's most popular tourist destinations, Kennedy Space Center offers visitors a wide variety of things to see and do.

Each year, more than 2.2 million guests from around the world explore the past, present and future of America's space program at Kennedy Space Center Visitor Complex. Since 1995, every aspect of this 70-acre facility has been entirely redeveloped and enhanced, offering guests a high-quality, full-day space experience.

The KSC Tour takes guests on a narrated tour with self-paced stops at the LC-39 Observation Gantry, where they view Space Shuttle Launch Pads; the Apollo/Saturn V Center, where they relive the launch of Apollo 8 from mission control, walk beneath a massive Saturn V rocket, touch a moon rock and enjoy a front row seat as human lands on the moon; and to the International Space Station, where they witness NASA technicians preparing actual components for launch. Special interest tours are also available. Cape Canaveral: Then and Now showcases the 50-year history of the Cape, while NASA Up Close highlights space shuttle processing and launch facilities. Wildlife tours are available to groups of 10 or more, when arranged in advance.

In addition to its tours, the KSC Visitor Complex offers a variety of programs, exhibits and films. The live action stage show, Mad Mission to Mars 2025, takes guests on an action-filled adventure to the Red Planet. The Visitor Complex's daily Astronaut Encounter program aims at inspiring children to pursue academic excellence: It is the only place in the world where children and families may come face to face with one of the few who has flown in space every day of the year. New exhibits such as Exploration in the New Millennium, Early Space Exploration and Robot Scouts complement long-time favorites such as the Rocket Garden

Students of all ages take part in aerospace educational activities at the Exploration Station. The hands-on-learning center, located in the Center for Space Education, is staffed by professional educators.

The Canaveral National Seashore is an unspoiled mecca for swimming, bathing and surf-fishing.

The KSC Visitor Complex is accessible to the public and open for business every day of the year except Christmas and certain launch days. A general admission fee provides access to bus tours, IMAX movies and exhibits that take visitors on a journey from early space exploration and re-creation of the first Shuttle launches to the future in space and International Space Station.

and Shuttle Plaza. Visitors are also encouraged to watch five-story-tall space films at the world's only back-to-back IMAX theaters.

KSC Visitor Complex is located 45 minutes east of Orlando on SR 405 (accessible from U.S. Highway 1 and I-95). The Visitor Complex is operated for NASA by Delaware North Parks Services of Spaceport, Inc. For more information, call (321) 449-4444 or visit **www.kennedyspacecenter.com**.

The Educator Resource Center, located in the Center for Space Education at KSC Visitor Complex, provides extensive facilities to aid teachers in the preparation of aerospace-related teaching materials. These include a large number of aerospace publications, videotapes, 35mm slides, text data and computer programs that can be copied on site.

The Exploration Station, also in the Center for Space Education, provides educational programs and hands-on, minds-on activities that illustrate and explain the principles of rocketry and space science. Students often work with actual hardware used for space missions.

A great blue heron prepares to take flight in a lagoon near a Space Shuttle launch pad. All but the operational areas of America's Spaceport are part of a national wildlife refuge, containing over 500 species of birds, animals, reptiles and amphibians.

For more information about the Educator Resource Center or the Exploration Center, or to make reservations, call (321) 867-4090. To find out more about NASA KSC's Education programs, visit www-pao.ksc.nasa.gov/kscpao/educate/edu.htm.

The "other side" of America's Spaceport is less known, perhaps, but an equally treasured national asset. Under agreements between NASA and the Department of Interior, all but the operational areas of the Kennedy Space Center are designated as a wildlife refuge, including 25 miles of undeveloped ocean beach that forms the Canaveral National Seashore.

This gentle but untamed land swarms with wildlife. Over 500 species of birds, mammals, reptiles and amphibians are found here. Some, like the American bald eagle, woodstork, alligator and the ponderous manatee, or sea cow, are on the endangered or threatened species list.

Recreational activities abound: fresh water and surf fishing, waterfowl hunting in season, birdwatching, swimming at the ocean beaches, canoeing and hiking nature trails.

Most of the refuge and all of the seashore are open to visitors during daylight hours, except when space operations require closure. Seashore headquarters are located in nearby Titusville. A wildlife refuge visitors center is located several miles east of Titusville, on State Road 402.

A pair of southern bald eagles look out from the nest they occupy on the Spaceport. The same pair winter at the nest year after year, and have raised several eaglets hatched here.

A Look Back -- A Look Ahead

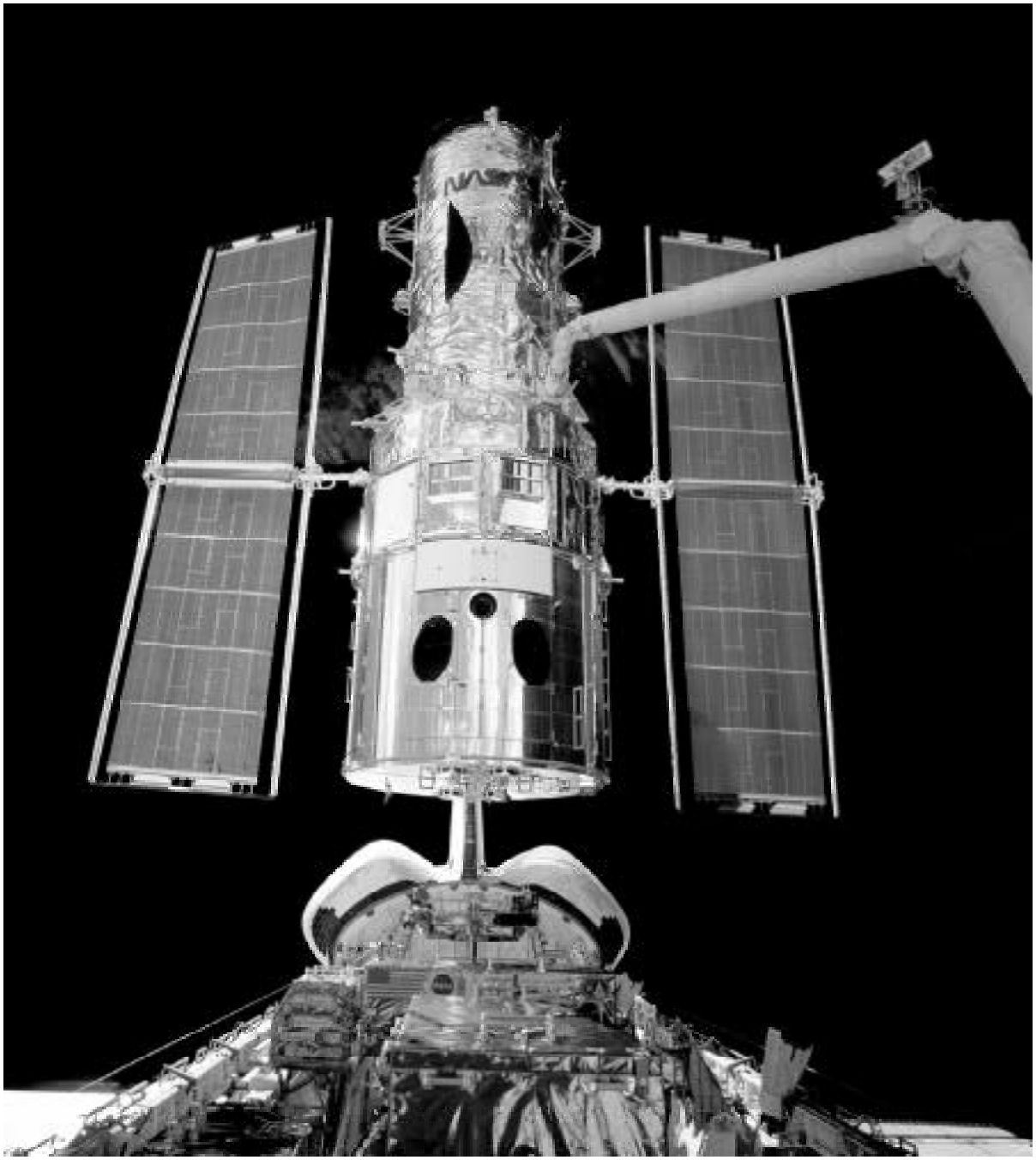
The Kennedy Space Center team can look back on a history of proud accomplishment as it moves toward the challenges of the 21st century. NASA was responsible for launching more than 300 unmanned space vehicles from 1958 to 1989, when the major unmanned vehicles were turned over to their manufacturers to operate, under Air Force oversight. Now NASA flies only Space Shuttles, and buys launch services from manufacturer/operator when it is more economical to launch on an unmanned vehicle.

Many important scientific and commercial spacecraft have been launched on Space Shuttles since the first flight in 1981, including a number of interplanetary explorers. Among the more notable scientific spacecraft was Magellan, which used radar to map the surface of Venus, providing excellent profiles of this cloud-shrouded planet. The Hubble Space Telescope was launched into Earth orbit with a defect in the main mirror, but that was corrected on the first servicing mission three years later, and Hubble became the most powerful telescope in history. The Compton Gamma Ray Observatory, also in Earth orbit, is the largest telescope to operate in this very high energy range.

Ulysses looped around Jupiter and out of the planetary plane, becoming the first spacecraft to directly examine the south and north poles of the Sun. The Galileo mission sent a probe plunging into Jupiter, while an orbiter analyzed both this giant planet and several of its largest moons from space.

The Earth-orbiting Chandra X-Ray Observatory was designed to make astrophysical observations of celestial objects from normal stars to quasars, allowing scientists to understand the nature of physical processes that take place within astronomical objects, and understand the history and evolution of the universe.

On the commercial side, satellite communications now provide several billion dollars in revenue each year, and continue to grow steadily. These spacecraft flew primarily on unmanned vehicles but Space Shuttle did place several in orbit. The ability of a single transponder (on a satellite often



Discovery's robot arm lifts the Hubble Space Telescope out of the payload bay after a successful servicing mission, STS-103, in December 1999.

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On the commercial side, satellite communications now provide several billion dollars in revenue each year, and continue to grow steadily. These spacecraft flew primarily on unmanned vehicles but Space Shuttle did place several in orbit. The ability of a single transponder (on a satellite often providing 30 or more) to bring television into every home in most entire countries is unique to the space program. Satellite observations and the data they produce, such as from the Geostationary Operational Environmental Satellites (GOES), greatly improve the ability of meteorologists to make more accurate and longer-range weather forecasts. And Earth resources spacecraft provide powerful tools to help to locate new mineral and water resources, as well as measure the effects of human activities on land and sea.

Many other commercial and scientific spacecraft were launched into Earth orbit, by both Shuttles and unmanned vehicles. Hundreds of human-tended experiments have been conducted in the microgravity of orbit, including international crews performing several Spacelab and Shuttle missions.

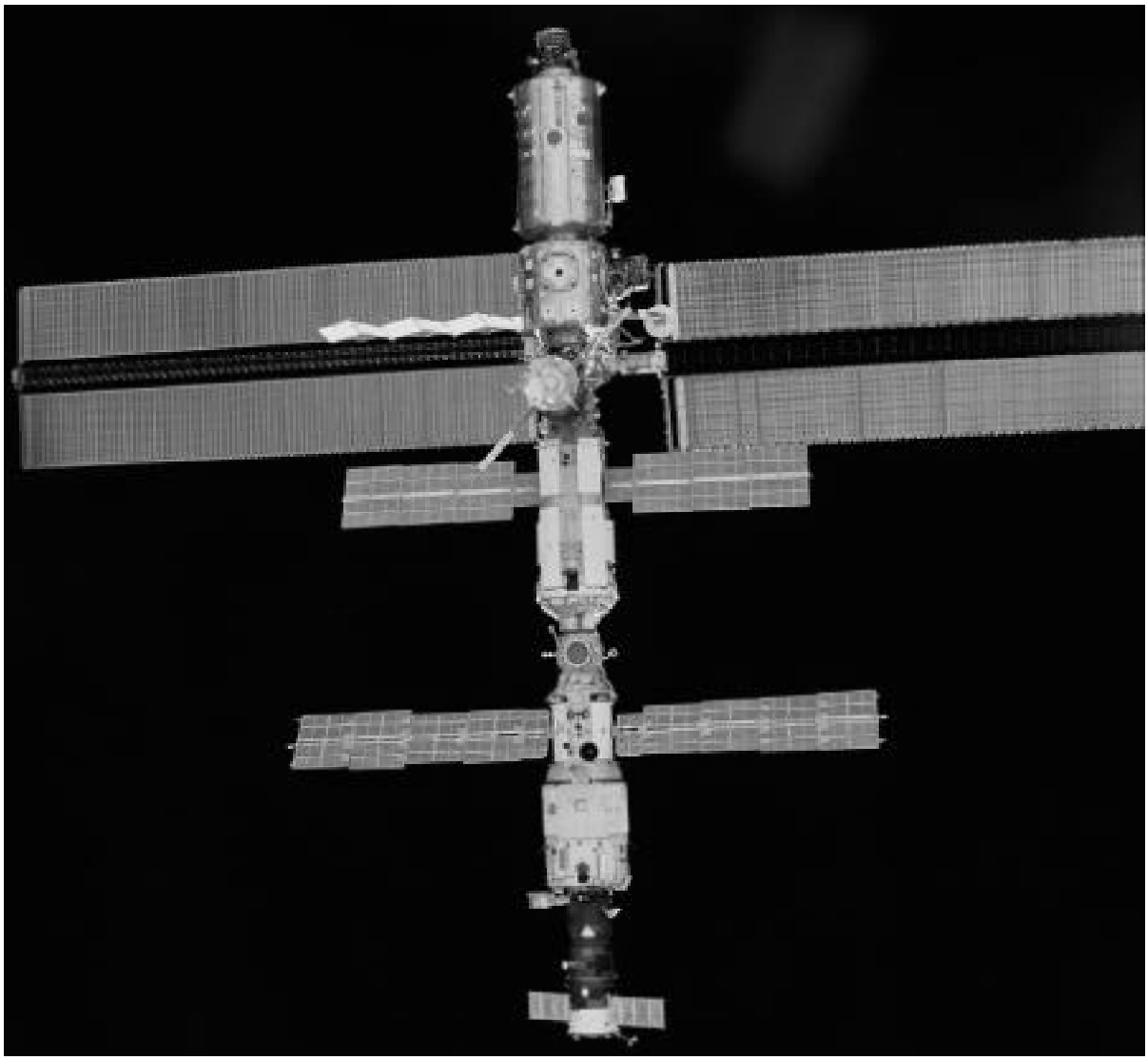
In 1995 NASA astronauts began rotating assignments on the Russian space station Mir, with Shuttles docking with Mir on a regular basis. This continued until the International Space Station was ready for permanent occupancy. A major program, “Mission to Planet Earth,” has operated economical new satellites with greatly improved capabilities to observe, monitor and analyze Earth’s very complex environment. This includes gaining a better understanding of the interrelationships between solar radiation and Earth’s atmosphere, and tracking the ozone layer and the “ozone hole” over Antarctica. The EOS and NOAA satellites have been instrumental in expanding the available data on Earth’s environment.

The largest construction project ever attempted is the International Space Station. The United States and its partners in Europe, Japan, Russia and Canada are assembling this facility in orbit. The Station will greatly improve our ability to utilize the space environment for the benefit of humanity. Shuttle-transported elements brought to KSC for future payloads are first checked out in the 457,000- square-foot Space Station Processing Facility at the KSC Industrial Area. By early 2001, more than nine elements had been processed, launched and assembled in space, including the Unity Node 1, U.S. Lab Destiny, Russian modules Zarya and Zvezda, various truss segments and pressurized mating adapters, plus the Canadian remote manipulator system needed to continue construction. Multi-Purpose Logistics Modules, built by the Italian Space Agency, have enabled transporting experiments to the U.S. Lab plus needed supplies and equipment. The first crews have set up residence of three- to four-month duration. In the new millennium, the Space Station could become a major stepping stone on the way to establishing a permanent base on the Moon, and/or a manned mission to Mars.

Unmanned interplanetary exploration will continue, with highly sophisticated spacecraft launched on expendable vehicles. KSC serves as NASA’s lead center for managing Expendable Launch Vehicle launch services.

Two probes, the Mars Global Surveyor and Mars Pathfinder, were launched in late 1996. Two additional orbiters were launched in late-1998 and early-1999 but were lost after arrival at Mars. The Mars Odyssey spacecraft was successfully launched in 2001 and is designed to map the Martian surface. Cassini was launched in 1997 on a 4-year exploratory mission of Saturn, its rings and moons.

A Space Launch Initiative (SLI) was introduced



Backdropped against the blackness of space on March 18, 2001, the International Space Station is separated from Space Shuttle Discovery after several days of activities and an important crew exchange. One of the astronauts aboard Discovery took this photograph from the aft flight deck.

in 2001 as a research and development effort to substantially improve safety and reduce the high cost of space travel in a second-generation reusable launch vehicle. The studies associated with the contract awards marked the beginning of a process leading to the development of a common set of alternative technologies that NASA will make available to all U.S. companies. The technologies include crew survival systems, advanced tanks and airframe structures, long-life rocket engines and thermal protection systems. The pioneering efforts are expected to make the new reusable launch vehicle at least 10 times safer and crew survivability 100 times greater.

In the interim, the Shuttle fleet, with its upgrades and improvements, will continue to serve the space program.

Since the creation of NASA in October 1958, the Kennedy Space Center has pioneered in developing the launch procedures, facilities, equipment and skills needed to place and keep the United States in space. Whatever path the future takes, the space program will depend in large part on the unique experience and resources of the people of KSC.

Directors of the Kennedy Space Center

Dr. Kurt H. Debus
1961 - 1974

Lt. Gen. Forrest S. McCartney
1986 - 1991

Roy D. Bridges Jr.
1997 -

Lee R. Scherer
1974 - 1979

Robert L. Crippen
1992 - 1995

Richard G. Smith
1979 - 1986

Jay F. Honeycutt
1995 - 1997