

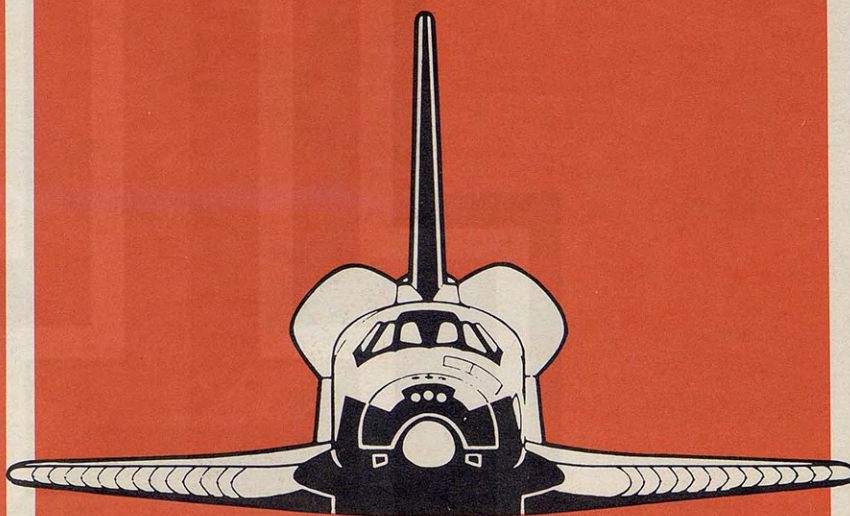
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Information Kit

NASA

National Aeronautics and
Space Administration

John F. Kennedy Space Center



NASA Facts

National Aeronautics and
Space Administration

John F. Kennedy Space Center
Kennedy Space Center, Florida 32899
AC 407 867-2468



KSC Release No. 61-94
June 1994

STS-65 International Microgravity Laboratory-2 (IML-2)

The more than 80 microgravity and life sciences experiments that will be conducted during the STS-65/International Microgravity Laboratory-2 (IML-2) mission will provide new insights into physical and biological processes that could help scientists and medical research personnel develop new materials and treatments for use on Earth and in space. The Orbiter Columbia will begin the STS-65 mission with a liftoff from Launch Pad 39A and climb to an altitude of 184 statute miles (296 kilometers) above the Earth with an inclination of 28.45 degrees to the planet's equator.

Once in orbit, the seven-person flight crew will activate the IML-2 Spacelab laboratory module and its experiments. Then the crew, working in two shifts, will begin the hectic, around-the-clock schedule of experiments throughout the 14-day flight that includes the operation and monitoring of test equipment and participation in medical investigations. A team of more than 210 scientists representing five international space research organizations and NASA will work together with the crew to coordinate the operation of the IML-2 experiments from the Spacelab Mission Operations Control Center at Marshall Space Flight Center in Huntsville, Ala.

The two-week-long, extended-duration mission is scheduled to end when Columbia touches down at Kennedy Space Center's Shuttle Landing Facility.

Commander for the STS-65 crew is Robert D. Cabana., (Col., USMC). He has previously flown on the Space Shuttle as pilot of both STS-41 in 1990 and STS-53 in 1992. The pilot is James Donald Halsell, Jr. (Major, USAF), who will be making his first spaceflight. Richard J. Hieb is the IML-2 payload commander. He has traveled into space as a mission specialist on STS-39 in 1991 and STS-49 in 1992. Mission Specialists Leroy Chiao (Ph.D.) and Donald A. Thomas (Ph.D.) are space rookies, while Carl. E. Walz (Major, USAF) flew as a mission specialist on STS-51 in 1993. Payload Specialist Chiaki Mukai (Ph.D./M.D.) will be the second NASDA astronaut and the first Japanese woman to fly into space.



The IML Program

The STS-42/IML-1 mission in January 1992 marked the first of a planned series of NASA-sponsored comprehensive international missions dedicated to the study of life and materials sciences in microgravity. The research organizations involved in IML-1, The European Space Agency (ESA), Canadian Space Agency (CSA), The French Space Agency (CNES), the German Space Agency (DARA) and the National Space Development Agency of Japan (NASDA), provided experiments and research personnel for that mission and will do so again for IML-2. Some IML-1 equipment and experiments will fly again on the STS-65 mission, while others have flown on previous Spacelab missions.

Spacelab

The 23,000-pound (10,350-kilogram) pressurized Spacelab module is located in Columbia's payload bay, connected to the crew cabin area by an access tunnel. Most of the experiments have been integrated into racks mounted along the inside walls of the module. At least two

crew members will be in the module at all times throughout the on-orbit phase of the mission.

IML-2 Experiments

Life Sciences — The NASA Life and Biomedical Sciences and Applications Division is responsible for the 50 life sciences experiments that will fly on IML-2. The near-absence of gravity in orbit provides scientists with a unique means of learning how this force has shaped and continues to influence fundamental biological processes on Earth. By studying these biological processes in orbit, researchers are able to gather data in a way that could provide insight for treatments of medical disorders. For example, a Canadian experiment, Spinal Change in Microgravity, will investigate the back pain reported by two-thirds of the astronauts on previous missions. Information from this study could give insights into new ways to treat this condition in patients on Earth.

Advances in human medicine and other biological research could also be made once data from the 19 experiments on the Biorack System developed by ESA are analyzed. The subject for these experiments include human and animal tissue, bacteria, fruit flies, sea urchins, jellyfish and plant seedlings. These experiments are expected to provide valuable information that can help understand the causes and treatment of autoimmune diseases, osteoporosis and birth defects, as well as data on crop growth and development. The Aquatic Animal Experiment Unit (AAEU) is an aquarium for studying the development and observing the behavior of live fish and small amphibians in microgravity.

Other life sciences experiments include five that will be conducted in the NIZEMI facility, which contains a slow rotating centrifuge and microscope developed by DARA to help understand the role of gravity in the behavior and developmental processes of various organisms on Earth. Also onboard is the Performance Assessment Workstation (PAWS) in which the orbiter crew will measure their cognitive skills throughout the duration of the flight.

The Extended-Duration Orbiter Medical Project (EDOMP) is a series of investigations for maintaining the health and safety of the crew and their environments during 13-to-16-day missions planned in the future. The Lower Body Negative Pressure (LBNP) experiment is designed as a countermeasure to the dizziness astronauts feel when they return to Earth because of reduced blood flow to the brain. This research could lead to treatment of a similar condition in the elderly and long-term bed rest patients. Experimentation with the Microbial Air Sampler (MAS) may lead to more effective air filtration systems in buildings.

Microgravity Science Experiments — The STS-65 crew will conduct nearly 30 experiments with nine different types of science facilities throughout the spaceflight. These experiments will take advantage of the reduced gravity found in orbit to gain a better understanding of basic phenomena of physical science including mechanisms involved in the production of materials and the behavior of fluids. Enhanced knowledge of these mechanisms may help in the development of next-generation materials and systems for spacecraft and high-technology applications on Earth.

The Electromagnetic Containerless Processing Facility (TEMPUS) will electromagnetically levitate metal samples so they can be melted and solidified without contamination from containers. Experiments conducted with this DARA-

developed equipment will study the solidification of materials from the liquid, or molten, state. This basic research will help scientists better understand key processes critical for improving production methods on Earth.

The Critical Point Facility (CPF) is so named because it will study the behavior of substances under conditions where the liquid and gaseous states are indistinguishable. Research of this unusual but basic physical phenomenon is important to providing advances in the field of fluid physics. This research is well suited to the microgravity environment, since researchers can perform measurements in space that cannot be made on Earth.

Fluids science advances are also expected to be made through experiments conducted with the ESA Bubble, Drop and Particle Unit (BDPU). Gravity at the Earth's surface makes the subtle aspects of bubble growth, evaporation and condensation difficult to study. Scientists feel that experiments in microgravity will increase understanding of these elements of fluid physics and provide a foundation for predicting, controlling and improving a vast range of technological processes.

The Large Isothermal Furnace (LIF) was developed by NASDA to study the relationships between the structure, processing and properties of materials. The LIF will produce sample materials, and it is hoped that analyses of these samples on Earth will help scientists better understand and improve material production techniques for alloys and composites.

The Advanced Protein Crystallization Facility (APCF) will be used to produce biologically important protein crystals for analysis and to study mechanisms that govern crystal growth. X-ray data from these crystals is one of the most promising avenues for developing advanced pharmaceutical drugs.

The French Space Agency's RAMSES facility and the NASDA Free Flow Electrophoresis Unit (FFEU) will study that process, which is a means of separating biological components by using an electrical field. This process is widely used in the production and purification of drugs and medicines. The Space Acceleration and Measurement System (SAMS) and the Orbital Acceleration Research Experiment (OARE) will study Space Shuttle orbiter acceleration and movement to see what affect they might have on experiments carried onboard.

Middeck Payloads

Additional payload activities will be conducted by the flight crew in the orbiter middeck area. They are the Air Force Maui Optical Site (AMOS) Calibration Test, the Military Application of Ship Trails (MAST) experiment and the Shuttle Amateur Radio Experiment-II (SAREX-II). A linear compressor/refrigerator/freezer will also be flown in the middeck area. Its main purpose is to demonstrate this critical technology in microgravity.

KSC Payload Processing

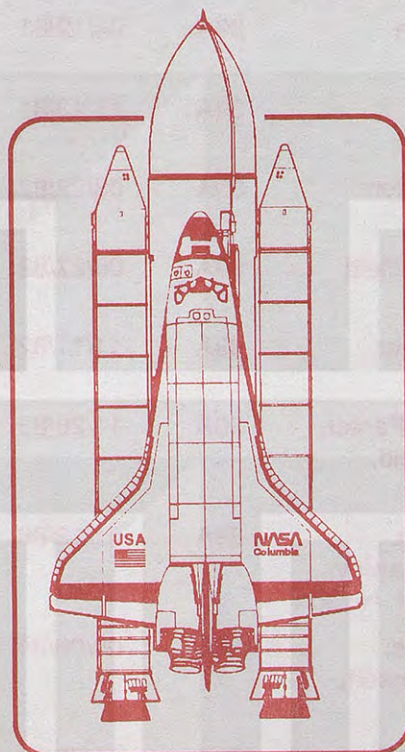
Integration of the IML-2 equipment and experiments into the Spacelab module was conducted in the Operations and Checkout (O&C) Building at KSC. This work began May 4, 1993, with final checkout completed May 9, 1994. The IML-2 was transported to the Orbiter Processing Facility (OPF) high bay 2 that day and installed in Columbia's payload bay. The vehicle was scheduled to be moved to Launch Pad 39A in June for a launch targeted for July.

Columbia (OV-102)

America's fleet of Space Shuttle orbiters are named after pioneering sea vessels which established new frontiers in research and exploration.

NASA delved through the history books to find ships which achieved historical significance through discoveries about the world's oceans or the Earth itself. Another important criterion in the selection process was consideration for the international nature of the Space Shuttle program.

Columbia, the oldest orbiter in the Shuttle fleet, is named after the Boston, Massachusetts-based sloop captained by American Robert Gray. On May 11, 1792, Gray and his crew maneuvered the Columbia past the dangerous sandbar at the mouth of a river extending more than 1,000 miles through what is today southeastern British Columbia, Canada, and the Washington-Oregon border. The river was later named after the ship. Gray also led Columbia and its crew on the first American circumnavigation of the globe, carrying a cargo of otter skins to Canton,



China, and then returning to Boston.

Other sailing ships have further enhanced the luster of the name Columbia. The first U.S. Navy ship to circle the globe bore that title, as did the command module for Apollo 11, the first lunar landing mission.

On a more directly patriotic note, "Columbia" is considered

to be the feminine personification of the United States. The name is derived from that of another famous explorer, Christopher Columbus.

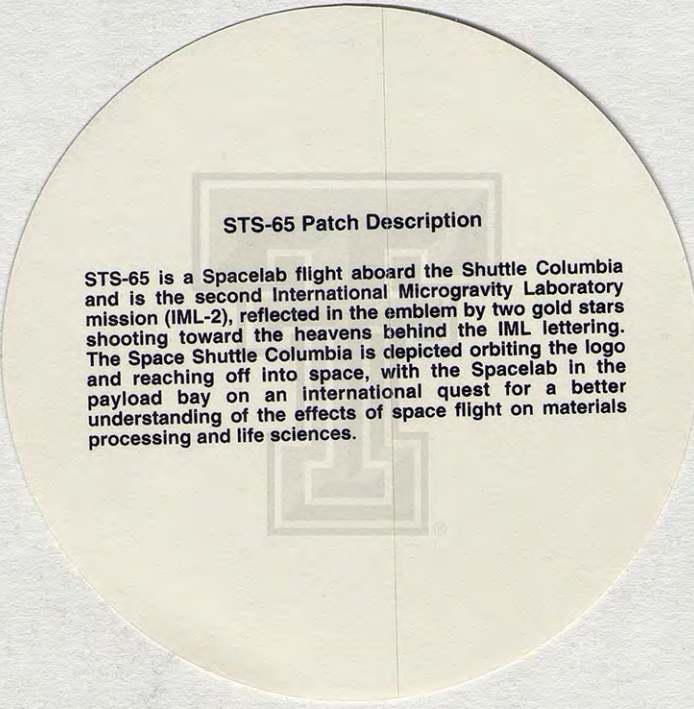
The spaceship Columbia has continued the pioneering legacy of its forebears, becoming the first Space Shuttle to fly into Earth orbit in 1981. Four sister ships joined the fleet over the next 10 years: Challenger, arriving in 1982 but destroyed four years later; Discovery, 1983; Atlantis, 1985; and Endeavour, built as a replacement for Challenger, 1991. A test vehicle, the Enterprise, was used for suborbital approach and landing tests and did not fly in space. The names of Columbia's sister ships each boast their own illustrious pedigree.

In the day-to-day world of Shuttle operations and processing, Space Shuttle orbiters go by a more prosaic designation. Columbia is commonly referred to as OV-102, for Orbiter Vehicle-102. Discovery, Atlantis and Endeavour are, respectively, OV-103, OV-104, and OV-105.

Flights of Columbia (OV-102) (1981 to date)

Times OV-102 Flown	Mission Name	Crew	Launch Pad	Launch Date	Landing Date & Site	Primary Payload
1	STS-1	Young, Crippen	39A	04/12/81	04/14/81 At Edwards	—
2	STS-2	Engle, Truly	39A	11/12/81	11/14/81 At Edwards	OSTA-1
3	STS-3	Lousma, Fullerton	39A	03/22/82	03/30/82 At White Sands	OSS-1
4	STS-4	Mattingly, Hartsfield	39A	06/27/82	07/04/82 At Edwards	DOD 82-1
5	STS-5	Brand, Overmyer, Lenoir, Allen	39A	11/11/82	11/16/82 At Edwards	SBS-C Anik C-3
6	STS-9	Young, Shaw, Parker, Garriott, Merbold, Lichtenberg	39A	11/28/83	12/08/83 At Edwards	Spacelab-1
7	61-C	Gibson, Bolden, Chang-Diaz, Hawley, Nelson, Cenker, Nelson	39A	01/12/86	01/18/86 At Edwards	SATCOM Ku-1
8	STS-28	Shaw, Richards, Leestma, Adamson, Brown	39B	08/08/89	08/13/89 At Edwards	DOD
9	STS-32	Brandenstein, Wetherbee, Dunbar, Ivins, Low	39A	01/09/90	01/20/90 At Edwards	SYNCOM IV-5 LDEF retrieval
10	STS-35	Brand, Gardner, Lounge, Hoffman, Parker, Parise, Durrance	39B	12/02/90	12/10/90 At Edwards	Astro-1
11	STS-40	O'Connor, Gutierrez, Jernigan, Seddon, Bagian, Gaffney, Hughes-Fulford	39B	06/05/91	06/14/91 At Edwards	SLS-1
12	STS-50	Richards, Bowersox, Dunbar, Baker, Meade, DeLucas, Trinh	39A	06/25/92	07/09/92 At KSC	USML-1
13	STS-52	Wetherbee, Baker, Veach, Jernigan, Shepherd, MacLean	39B	10/22/92	11/1/92 At KSC	LAGEOS II USMP-1
14	STS-55	Nagel, Hendricks, Ross, Precourt, Harris, Walter, Schlegel	39A	4/26/93	5/6/93 At KSC	Spacelab-D2
15	STS-58	Blaha, Searfoss, Seddon, McArthur, Wolf, Lucid, Fettman	39B	10/18/93	11/1/93 At Edwards	SLS-2
16	STS-62	Casper, Allen, Thuot, Gemar, Ivins	39B	3/4/94	3/18/94 At KSC	OAST-2 USMP-2





STS-65 Patch Description

STS-65 is a Spacelab flight aboard the Shuttle Columbia and is the second International Microgravity Laboratory mission (IML-2), reflected in the emblem by two gold stars shooting toward the heavens behind the IML lettering. The Space Shuttle Columbia is depicted orbiting the logo and reaching off into space, with the Spacelab in the payload bay on an international quest for a better understanding of the effects of space flight on materials processing and life sciences.



National Aeronautics and
Space Administration

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PMS 018-B (KSC)
October 1991

Countdown! NASA Launch Vehicles and Facilities

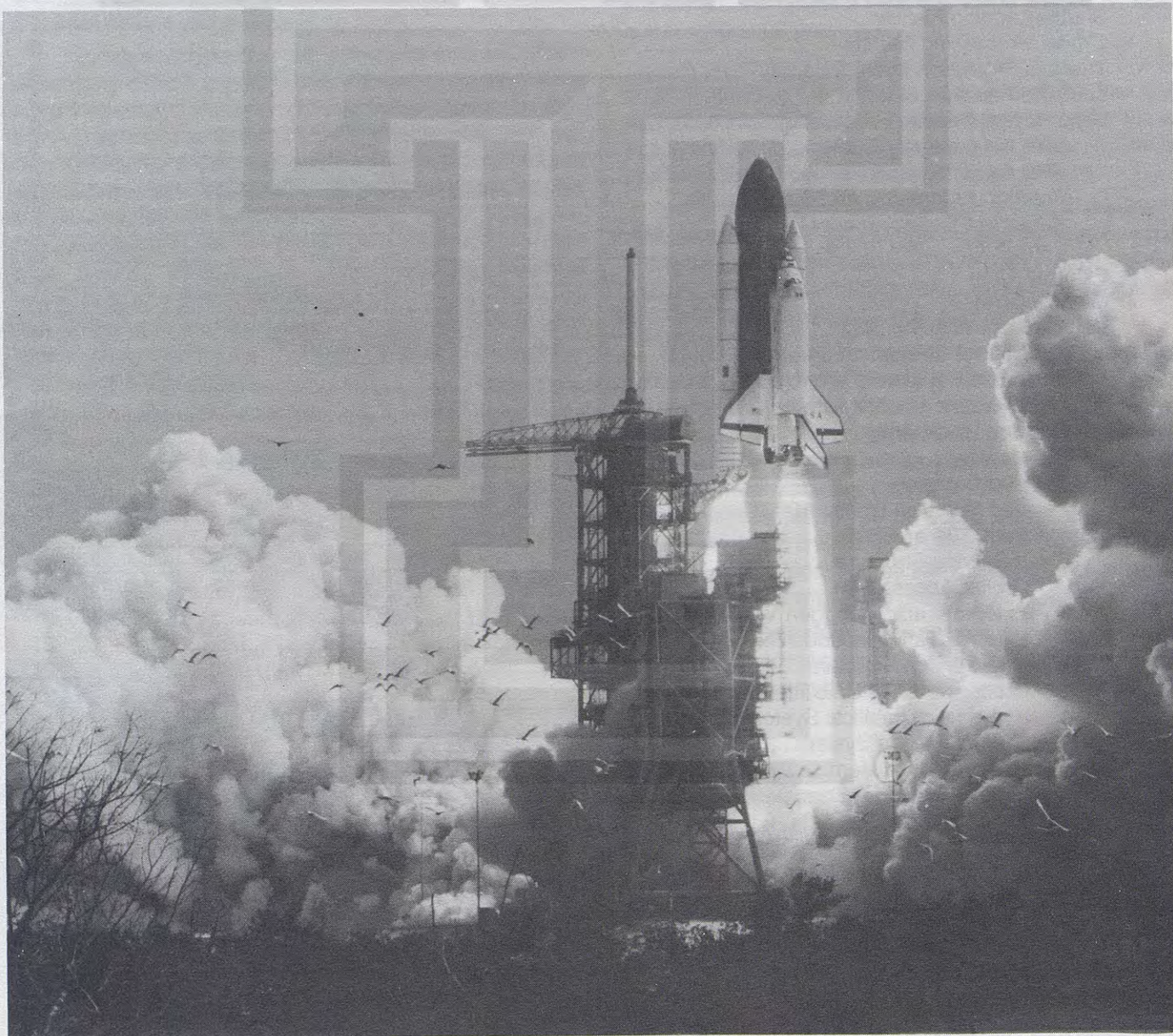


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Space Launch Vehicles

In 1989 NASA implemented a mixed fleet concept, under which the agency launches manned Space Shuttles and unmanned expendable Scouts, and contracts for launch services on other expendable launch vehicles (ELVs). This has encouraged the growth of the U.S. commercial launch industry. It also ended a tradition that began with the birth of the agency — assuming the primary responsibility for the launch of all unmanned space vehicles under contract to NASA. Except for some Scout vehicles to be launched from the West Coast over the next few years, NASA has turned launch operations over to the manufacturers of the vehicles and the U.S. Air Force.

All ELVs use the same basic technology to get into space — two or more rocket-powered stages which are discarded when their engine burns are completed. The only U.S. manned space vehicle is the Space Shuttle, which is a unique design and in a class by itself.

The payload weight, destination and purpose determine what vehicle capabilities are required for each mission. A low-weight spacecraft designed to operate in near-Earth orbit might be flown aboard the comparatively small Scout. Sending a manned Apollo spacecraft to the Moon required the massive Saturn V. The powerful Titan-Centaur combination carried large and complex unmanned scientific explorers such as the Vikings and Voyagers to examine other planets. Atlas/Agenas sent several spacecraft to photograph and then impact on the Moon. Atlas/Centaurs and Deltas have launched more than 260 spacecraft for a wide variety of purposes, covering the broad range of the national space program.

NASA Space Vehicles

NASA has used eight major space vehicles over the years. See page four, where they are drawn to scale, for a size comparison; page eleven for views of the Space Shuttle solid rocket booster and external tank; and pages 12-13 for a cut-a-way view of the Space Shuttle orbiter.

Space Shuttle

The Space Shuttle will likely remain the only manned space vehicle available to NASA for the remainder of the century. In addition to its normal workload of scientific satellites and space science missions, the Shuttle fleet of four vehicles will start launching the ground-assembled segments of Space Station Freedom about the middle of the decade. As of 1991, plans called for 17 missions to take up segments and assemble them in orbit, with full-time human occupancy by 1999.

The first Space Shuttle lifted off from Pad A on Launch Complex 39, Kennedy Space Center, on April 12, 1981.

After a two-day, test-flight mission that verified the ability of the Orbiter Columbia to function in space, it landed at Edwards AFB in California. The vehicle was piloted by John Young and Robert Crippen. The STS-1 mission marked the first time that a new space vehicle carried a crew on its initial flight.

A Space Shuttle consists of a reusable delta-winged spaceplane, called an orbiter; two solid-propellant booster rockets, which are recovered and also reused; and an expendable tank containing liquid propellant for the orbiter's three main engines. Only the orbiters have names, and an orbiter alone is not a full Space Shuttle.

An assembled Space Shuttle is approximately 184 feet (56 meters) long, 76 feet (23 meters) high to the tip of the orbiter's vertical tail, and 78 feet (24 meters) wide, measuring across the orbiter's wingtips. Liftoff weight is usually about 4,500,000 pounds (2,041,200 kilograms).

An orbiter's three liquid fueled engines — drawing propellants from the external tank — and the two solid-propellant rocket boosters burn simultaneously for the first two minutes. Together, they produce about 7.3 million pounds (32.4 million newtons) of thrust at liftoff.

After two minutes of flight a Space Shuttle reaches an altitude of 32 miles (48 kilometers) and the boosters have burned all their propellant. They then detach and parachute into the ocean. Two waiting ships recover them, for refurbishment and reuse on later missions.

The orbiter and external tank continue on toward Earth orbit. When the orbiter's main engines cut off, just before achieving orbit, the external tank is jettisoned, to re-enter the atmosphere and break up over a remote ocean area. On most missions the orbiter continues to coast until it reaches the other side of the Earth from where the external tank was discarded. The on-board orbital maneuvering engines are then fired to place the vehicle in a near-circular low-Earth orbit. Most operational missions last from four to seven days, though longer ones are sometimes required.

When the mission has been completed, the orbiter re-enters the atmosphere and returns to Earth, gliding to an unpowered landing at either KSC or Edwards AFB.

Scout

The Scout launch vehicle, which became operational in 1960, has undergone systematic upgrading since 1976. The current Scout is a solid-propellant, four-stage booster system, approximately 75 feet (23 meters) in length, with a launch weight of 46,620 pounds (21,147 kilograms) and a liftoff thrust of 132,240 pounds (588,203 newtons). It can boost an average payload of 400 to 465 pounds (181 to 211 kilograms) into low Earth orbit.

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A total of 113 Scouts were launched through 1990. They were used to place a variety of U.S. and international payloads into inclined, equatorial and polar orbit, for orbital, probe and re-entry missions.

LTV Aerospace and Defense Missiles Division currently produces the Scout vehicle for NASA. LTV also provides systems management and support for launches. Scouts can lift off from Vandenberg AFB in California; the NASA Wallops Flight Facility at Wallops Island, Virginia; and the Italian San Marco launch platform off the east coast of Kenya, Africa. The only firm launches NASA has scheduled at present are from Vandenberg.

Manufacturer-Launched Vehicles

Time-proven launch vehicles formerly purchased and put into space by NASA are now launched by the vehicle manufacturers. NASA contracts with either the U.S. Air Force or the individual company to procure both vehicles and launch services. These vehicles are the Delta II (McDonnell Douglas Space Systems Co.); Atlas I and Atlas II (General Dynamics Space Systems Division); and Titan 34D and Titan IV (Martin Marietta Space Launch Systems). KSC/NASA retains oversight responsibilities for those vehicles which carry NASA payloads.

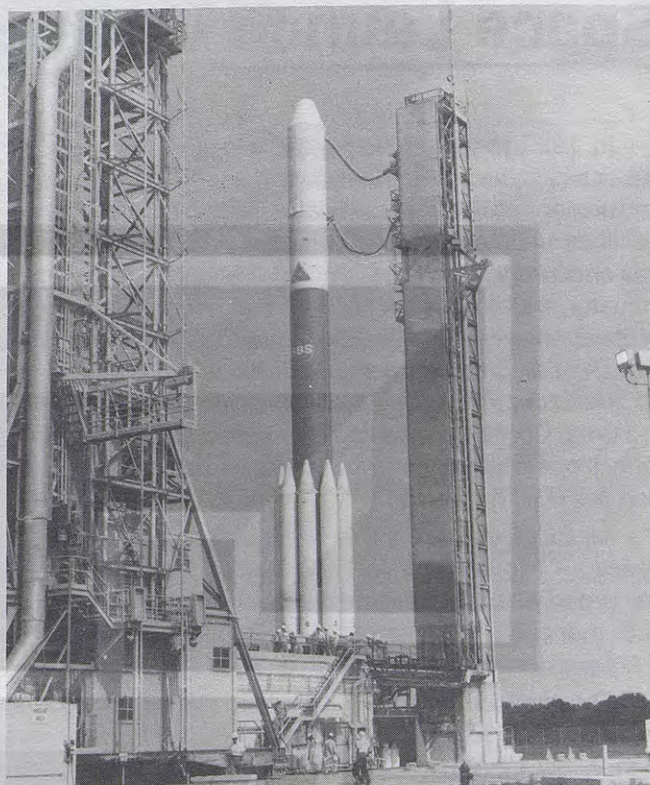
Delta

The Delta rocket has been called the workhorse of the space program. Since 1960, NASA has been the responsible agency in the launch of more than 180 scientific, weather, and communications spacecraft, along with some military satellites. These spacecraft include the TIROS, Nimbus,ITOS, LANDSAT, and Westar series, and over 30 scientific Explorers.

The Delta II is the newest version of this rocket. The U.S. Air Force and McDonnell Douglas first launched this vehicle from Complex 17 at Cape Canaveral Air Force Station in February 1989, carrying the first of 21 upgraded Navstar Global Positioning Satellites into orbit. NASA relinquished control of this launch area to the Air Force in 1988. Delta commercial launches also take place here.

The Delta family of vehicles has been upgraded several times over the years. Currently, the most powerful version is the Delta II, which stands 128 feet (39 meters) tall. Nine Castor IV-A strap-on solid rocket boosters augment its first stage. Six of them ignite at liftoff. The remaining three Castors ignite after the first six burn out. All of them burn for approximately 1 minute.

The average first-stage thrust with the main engines and the six solid-propellant boosters is 873,400 pounds (3.9 million newtons). The Delta has liquid-fueled first and second stages and a solid-propellant third stage. For most launches today, the third stage has been replaced by a more powerful Payload Assist Module (PAM) solid-propellant stage attached to the spacecraft.



Delta poised for liftoff from Complex 17, Cape Canaveral Air Force Station.

The newest version of the PAM upper stage, the PAM-DII, also has been used on Shuttle launches. It can boost spacecraft from the low Earth orbit achieved by the Shuttle orbiter into higher ones. Many spacecraft, especially communications satellites, operate in a geosynchronous orbit some 22,240 miles (35,792 kilometers) above the equator. The Delta II and the PAM-DII together can lift some 3,190 pounds (1,447 kilograms) into a highly elliptical orbit for eventual transfer into geosynchronous orbit by a motor built into the payload spacecraft. This is more than double the 1,500 pounds (680 kilograms) that a Delta built in 1980 could manage.

Atlas/Centaur

The Atlas I and Atlas II are the latest versions of the Atlas/Centaur vehicle that first became operational in 1966. General Dynamics uses these two vehicles to launch military, commercial, and scientific payloads into space from Launch Complex 36 on Cape Canaveral.

The Atlas I can place a 13,000-pound (5,897-kilogram) payload into low Earth orbit. It can also propel 5,150 pounds (2,336 kilograms) into a geosynchronous transfer orbit, or 3,350 pounds (1,520 kilograms) into an Earth escape trajectory.

The Atlas II is 150 feet (45.6 meters) high. The first stage produces 468,500 pounds (2,084,000 newtons) of thrust at liftoff. The Centaur stage has the same thrust as

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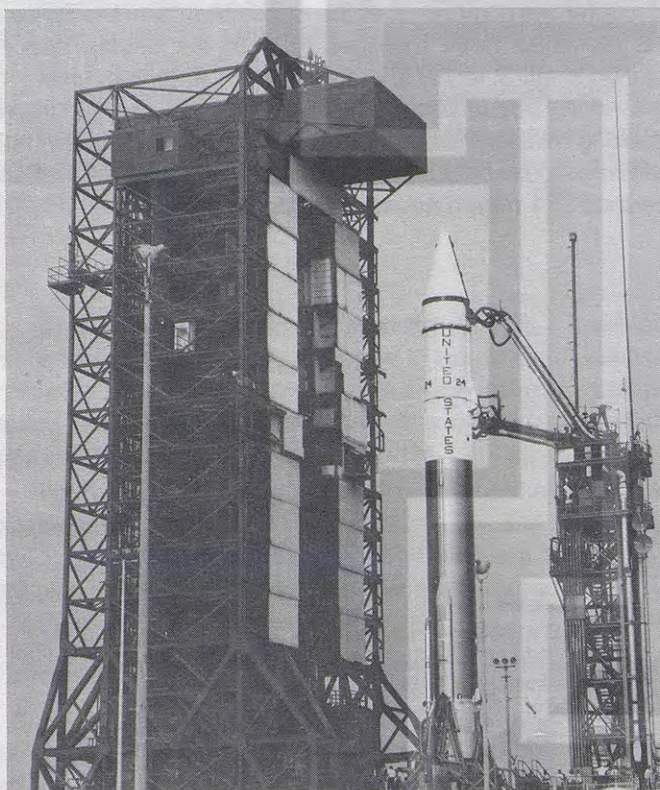
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on the Atlas I, but carries 6,600 pounds more propellant, and so can burn longer for more total power. An Atlas II can place a 14,950-pound (6,780-kilogram) payload into low Earth orbit. The amounts for geosynchronous transfer orbit and Earth escape trajectory are 6,100 pounds (2,770 kilograms) and 4,270 pounds (1,940 kilograms).

While launched by NASA, the Atlas/Centaur was the standard vehicle for intermediate payloads. The Centaur was the nation's first high-energy, liquid-hydrogen/liquid-oxygen launch vehicle stage.

The Atlas/Centaur was the launch vehicle for Surveyor 1, the first U.S. spacecraft to soft-land on the Moon. Some of the other spacecraft launched by NASA Atlas/Centaurs include the Orbiting Astronomical Observatories; Applications Technology Satellites; the Intelsat IV, IV-A and V series of communications satellites; Mariner Mars orbiters; a Mariner spacecraft which made a flyby of Venus and three of Mercury; Pioneers which accomplished flybys of Jupiter and Saturn; and Pioneers that orbited Venus and plunged through its atmosphere to the surface.



Atlas/Centaur stands ready for flight at Complex 36, Cape Canaveral Air Force Station.

Titan

Martin Marietta, builder of the Titan family of vehicles, now launches the Titan IV from pads 40 and 41 on Cape Canaveral, and from Vandenberg AFB in California. Pad 40 also has the capability to launch the smaller Titan 34D. The U.S. Air Force is the primary customer for these launch

vehicles, but Titans are also used for NASA scientific missions — usually planetary launches — and for commercial payloads.

In 1974 NASA launched the first of seven vehicles that combined the Titan III-E, a two-stage liquid-propellant rocket with two large solid-propellant boosters attached, with a Centaur from the Atlas-Centaur vehicle replacing the original third stage. At liftoff the two solids, burning alone, produced 2.4 million pounds (10.7 newtons) of thrust; the first liquid propellants stage ignited when the solids burned out, followed by the second stage. Then the Centaur, which produced 30,000 pounds (133,440 newtons) of thrust from two main engines, ignited and burned for up to 7-1/2 minutes, an unusually long burn time for an upper stage.

The Titan-Centaur combination vehicle, which had a new and wider fairing, had an overall height of 160 feet (48.8 meters). It was used in the interval between the last launches in the Saturn family and the first flight of the Space Shuttle. Titan-Centaur gave the United States an extremely powerful and versatile rocket which successfully launched six large spacecraft on interplanetary missions.

The seven Titan-Centaur flights were of a test vehicle, two Helios spacecraft to the Sun, two Vikings to Mars, and two Voyager spacecraft to Jupiter and Saturn. The Vikings were two-part spacecraft; each first orbited Mars, and then sent a lander to its surface. The second Voyager went on past Saturn to Uranus and Neptune. All provided remarkable new scientific data on our solar system. The Vikings and Voyagers also produced spectacular color photographs of the planets they explored.

Today the Titan IV is the primary launch vehicle for Martin Marietta. It has longer and more powerful solid rocket boosters, longer first and second liquid propellant stages, and an upgraded version of the Centaur. When used with an 86-foot (26.2-meter) fairing over the Centaur and payload, this vehicle is 204 feet (62 meters) in height. It is capable of placing 39,000 pounds (17,690 kilograms) into an east-west orbit — a payload approaching that of the Space Shuttle. It can also place a 32,000 pound (14,515 kilogram) payload into a low polar orbit from Vandenberg AFB in California, where the Shuttle has no launch facilities.

Inactive NASA Launch Vehicles

Atlas/Agena

The Atlas/Agena was a multipurpose two-stage liquid-propellant rocket. It placed unmanned spacecraft in Earth orbit, or inserted them into the proper trajectories for planetary or deep space probes.

Several programs used the versatile Atlas/Agena. They included early Mariner probes to Mars and Venus, Ranger photographic missions to the Moon, the Orbiting Astronomical Observatory, and early Applications Technology Satellites. The Agena upper stage also was the rendezvous target vehicle for the Gemini spacecraft during this series of two-man missions in 1965-1966. In preparation

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for the manned lunar landings, Atlas/Agena launched Lunar Orbiter spacecraft which went into orbit around the Moon and took photographs of most of the lunar surface.

The Atlas/Agena D stood about 100.4 feet (30.6 meters) high and developed a total thrust at liftoff of approximately 376,000 pounds (1.67 million newtons). It carried an Orbiting Geophysical Observatory (OGO) for its last launch in 1968.

Saturn V

The Saturn V, America's most powerful staged rocket, carried out the ambitious task of sending astronauts to the Moon. The first Saturn V vehicle, Apollo 4, lifted off on November 9, 1967. Apollo 8, the first manned flight of the Saturn V, was also the first manned flight to the Moon. Launched in December 1968, Apollo 8 orbited the Moon but did not land. Apollo 11, launched on a Saturn V on July 16, 1969, achieved the first lunar landing.

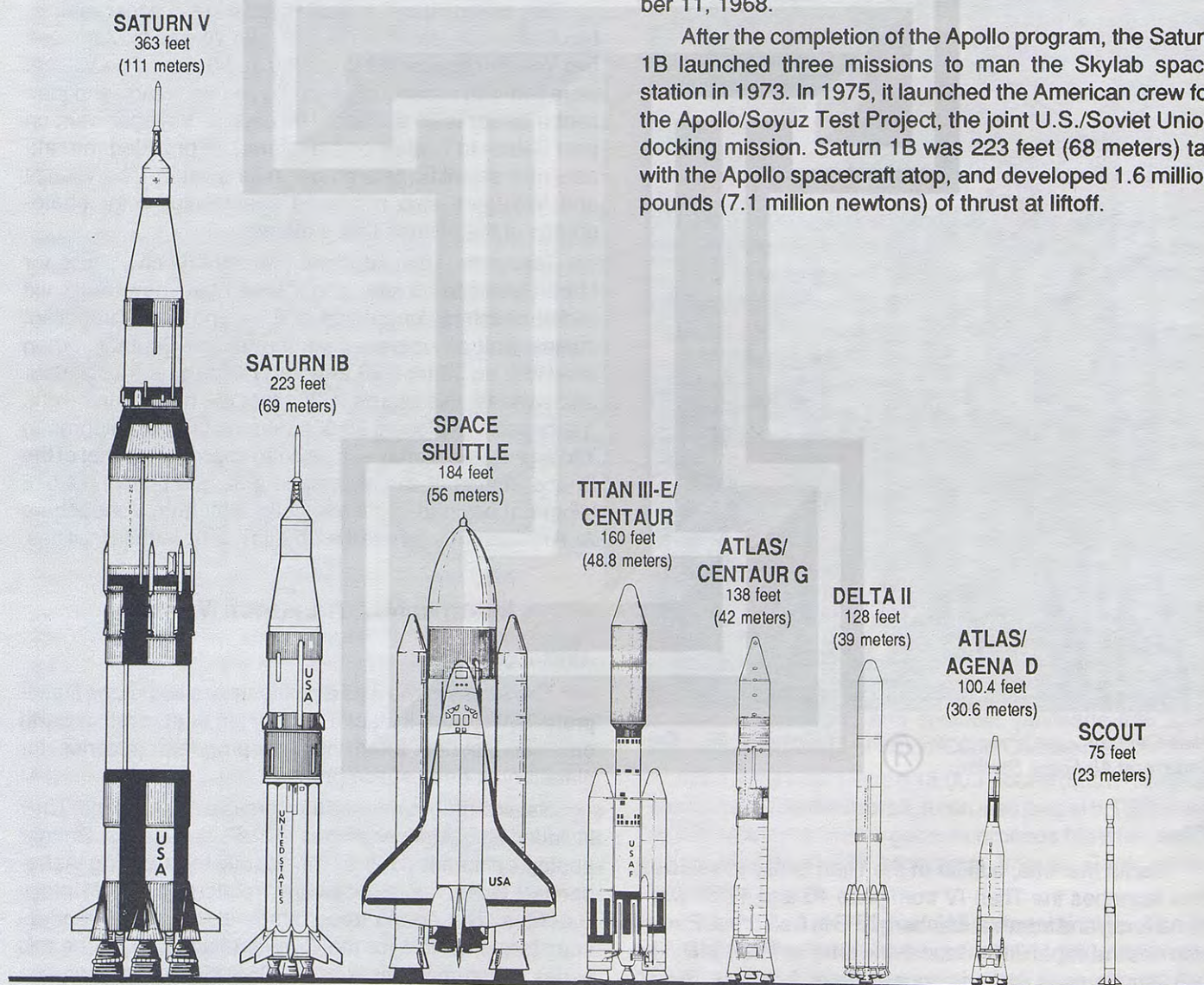
Saturn V began its last manned mission on December 7, 1972, when it sent Apollo 17 on a final lunar exploration flight. For its last mission, on May 14, 1973, it lifted the unmanned Skylab Space Station into Earth orbit, where it was later occupied by three crews for a total period of 171 days.

All three stages of the Saturn V used liquid oxygen as the oxidizer. The first stage burned kerosene with the oxygen, while the fuel for the two upper stages was liquid hydrogen. Saturn V, with the Apollo spacecraft and its small emergency escape rocket on top, stood 363 feet (111 meters) tall and developed 7.75 million pounds (34.5 million newtons) of thrust at liftoff.

Saturn 1B

The Saturn 1B originally launched Apollo lunar spacecraft into Earth orbit to train for manned flights to the Moon. The first launch of a Saturn 1B with an unmanned Apollo spacecraft took place in February 1966. A Saturn 1B launched the first manned Apollo flight, Apollo 7, on October 11, 1968.

After the completion of the Apollo program, the Saturn 1B launched three missions to man the Skylab space station in 1973. In 1975, it launched the American crew for the Apollo/Soyuz Test Project, the joint U.S./Soviet Union docking mission. Saturn 1B was 223 feet (68 meters) tall with the Apollo spacecraft atop, and developed 1.6 million pounds (7.1 million newtons) of thrust at liftoff.



Propellants

Sir Isaac Newton stated in his Third Law of Motion that "every action is accompanied by an equal and opposite reaction." A rocket operates on this principle. The continuous ejection of a stream of hot gases in one direction causes a steady motion of the rocket in the opposite direction.

A jet aircraft operates on the same principle, using oxygen in the atmosphere to support combustion for its fuel. The rocket engine has to operate outside the atmosphere, and so must carry its own oxidizer.

The gauge of efficiency for rocket propellants is specific impulse, stated in seconds. The higher the number, the "hotter" the propellant.

Specific impulse is the period in seconds for which a 1-pound (0.45-kilogram) mass of propellant (total of fuel and oxidizer) will produce a thrust of 1 pound (0.45-kilogram) of force. Although specific impulse is a characteristic of the propellant system, its exact value will vary to some extent with the operating conditions and design of the rocket engine. It is for this reason that different numbers are often quoted for a given propellant or combination of propellants.

NASA and commercial launch vehicles use four types of propellants: (1) petroleum; (2) cryogenics; (3) hypergolics; and (4) solids.

Petroleum

The petroleum used as a rocket fuel is a type of kerosene similar to the sort burned in heaters and lamps. However, the rocket petroleum is highly refined, and is called RP-1 (Refined Petroleum). It is burned with liquid oxygen (the oxidizer) to provide thrust.

RP-1 is a fuel in the first-stage boosters of the Delta and Atlas-Centaur rockets. It also powered the first stages of the Saturn 1B and Saturn V. RP-1 delivers a specific impulse considerably less than that of cryogenic fuels.

Cryogenic

Cryogenic propellants are liquid oxygen (LOX), which serves as an oxidizer, and liquid hydrogen (LH2), which is a fuel. The word cryogenic is a derivative of the Greek *kyros*, meaning "ice cold." LOX remains in a liquid state at temperatures of minus 298 degrees Fahrenheit (minus 183 degrees Celsius). LH2 remains liquid at temperatures of minus 423 degrees Fahrenheit (minus 253 degrees Celsius).

In gaseous form, oxygen and hydrogen have such low densities that extremely large tanks would be required to store them aboard a rocket. But cooling and compressing them into liquids vastly increases their density, making it possible to store them in large quantities in smaller tanks.

The distressing tendency of cryogenics to return to gaseous form unless kept supercool makes them difficult to store over long periods of time, and hence less satisfactory as propellants for military rockets, which must be kept launch-ready for months at a time.

But the high efficiency of the liquid hydrogen/liquid oxygen combination makes the low-temperature problem worth coping with when reaction time and storability are not too critical. Hydrogen has about 40 percent more "bounce to the ounce" than other rocket fuels, and is very light, weighing about one-half pound (0.45 kilogram) per gallon (3.8 liters). Oxygen is much heavier, weighing about 10 pounds (4.5 kilograms) per gallon (3.8 liters).

The RL-10 engines on the Centaur, the United States' first liquid-hydrogen/liquid-oxygen rocket stage, have a specific impulse of 444 seconds. The J-2 engines used on the Saturn V second and third stages, and on the second stage of the Saturn 1B, also burned the LOX/LH2 combination. They had specific impulse ratings of 425 seconds.

For comparison purposes, the liquid oxygen/kerosene combination used in the cluster of five F-1 engines in the Saturn V first stage had specific impulse ratings of 260 seconds. The same propellant combination used by the booster stages of the Atlas/Centaur rocket yielded 258 seconds in the booster engine and 220 seconds in the sustainer.

The high efficiency engines aboard the Space Shuttle orbiter use liquid hydrogen and oxygen and have a specific impulse rating of 455 seconds. The fuel cells in an orbiter use these two liquids to produce electrical power through a process best described as electrolysis in reverse. Liquid hydrogen and oxygen burn clean, leaving a by-product of water vapor.

The rewards for mastering LH2 are substantial. The ability to use hydrogen means that a given mission can be accomplished with a smaller quantity of propellants (and a smaller vehicle), or alternately, that the mission can be accomplished with a larger payload than is possible with the same mass of conventional propellants. In short, hydrogen yields more power per gallon.

Hypergolic

Hypergolic propellants are fuels and oxidizers which ignite on contact with each other and need no ignition source. This easy start and restart capability makes them attractive for both manned and unmanned spacecraft maneuvering systems. Another plus is their storability — they do not have the extreme temperature requirements of cryogenics.

The fuel is monomethyl hydrazine (MMH) and the oxidizer is nitrogen tetroxide (N2O4).

Information Summaries

Hydrazine is a clear, nitrogen/hydrogen compound with a "fishy" smell. It is similar to ammonia. Nitrogen tetroxide is a reddish fluid. It has a pungent, sweetish smell. Both fluids are highly toxic, and are handled under the most stringent safety conditions. Hypergolic propellants are used in the core liquid propellant stages of the Titan family of launch vehicles, and on the second stage of the Delta.

The Space Shuttle orbiter uses hypergols in its Orbital Maneuvering Subsystem (OMS) for orbital insertion, major orbital maneuvers and deorbit. The Reaction Control System (RCS) uses hypergols for attitude control.

The efficiency of the MMH/N₂O₄ combination in the Space Shuttle orbiter ranges from 260 to 280 seconds in the RCS, to 313 seconds in the OMS. The higher efficiency of the OMS system is attributed to higher expansion ratios in the nozzles and higher pressures in the combustion chambers.

Solid

The solid-propellant motor is the oldest and simplest of all forms of rocketry, dating back to the ancient Chinese. It's simply a casing, usually steel, filled with a mixture of solid-form chemicals (fuel and oxidizer) which burn at a rapid rate, expelling hot gases from a nozzle to achieve thrust.

Solids require no turbopumps or complex propellant-feed systems. A simple squib device at the top of the motor directs a high-temperature flame along the surface of the propellant grain, igniting it instantaneously.

Solid propellants are stable and easily storable. Unlike liquid-propellant engines, though, a solid-propellant motor cannot be shut down. Once ignited, it will burn until all the propellant is exhausted.

Solids have a variety of uses for space operations. Small solids often power the final stage of a launch vehicle, or attach to payload elements to boost satellites and spacecraft to higher orbits.

Medium solids such as the Payload Assist Module (PAM) and the Inertial Upper Stage (IUS) provide the added boost to place satellites into geosynchronous orbit or on planetary trajectories.

The PAM-DII provides a boost for Delta and Space Shuttle payloads. The IUS goes on the Space Shuttle and the Titan III and Titan IV class of launch vehicles.

Only one of the nation's launch vehicles, the Scout, uses solids exclusively. This four-stage rocket launches small satellites to orbit.

Titan, Delta and Space Shuttle vehicles depend on solid rockets to provide added thrust at liftoff.

The Space Shuttle uses the largest solid rocket motors ever built and flown. Each reusable booster contains 1.1 million pounds (453,600 kilograms) of propellant, in the form of a hard, rubbery substance with a consistency like that of the eraser on a pencil. The four center segments are the ones containing propellant. The uppermost one has a star-shaped, hollow channel in the center, extending from the top to about two thirds of the way down, where it gradually rounds out until the channel assumes the form of a cylinder. This opening connects to a similar cylindrical hole through the center of the second through fourth segments. When ignited, the propellant burns on all exposed surfaces, from top to bottom of all four segments. Since the star-shaped channel provides more exposed surface than the simple cylinder in the lower three segments, the total thrust is greatest at liftoff, and gradually decreases as the points of the star burn away, until that channel also becomes cylindrical in shape. The propellant in the star-shaped segment is also thicker than that in the other three.

A solid propellant always contains its own oxygen supply. The oxidizer in the Shuttle solids is ammonium perchlorate, which forms 69.93 percent of the mixture. The fuel is a form of powdered aluminum (16 percent), with an iron oxidizer powder (0.07) as a catalyst. The binder that holds the mixture together is polybutadiene acrylic acid acrylonitrile (12.04 percent). In addition, the mixture contains an epoxy-curing agent (1.96 percent). The binder and epoxy also burn as fuel, adding thrust.

The specific impulse of the Space Shuttle solid rocket booster propellant is 242 seconds at sea level and 268.6 seconds in a vacuum.

Facilities and Operations

Kennedy Space Center is the primary NASA center for the test, checkout and launch of Space Shuttle vehicles and their payloads, as well as the turnaround of orbiters between missions. It is one of the major landing sites for the Shuttle.

Manned Space Shuttles launch from KSC's Launch Complex 39, located on Merritt Island, FL, just north of Cape Canaveral. The Launch Complex 39 facilities originally supported the Apollo lunar landing program. From 1967 to 1975, 12 Saturn V/Apollo vehicles, one Saturn V/Skylab workshop, three Saturn 1B/Apollo vehicles for Skylab crews, and one Saturn 1B/Apollo for the joint U.S.-Soviet Apollo-Soyuz mission, flew into space from Launch Complex 39.

These facilities underwent modifications to process and launch the Space Shuttle. Modifying existing facilities was far less expensive than building all new structures. There were two major new additions — a special runway to land returning orbiters and an orbiter checkout hangar called the Orbiter Processing Facility. During the 1980s, a number of new facilities were added for solid rocket booster processing, Shuttle logistics, orbiter modification and refurbishment, and repair and final manufacture of Thermal Protection System materials.

Shuttle Landing Facility

When an orbiter lands at the Kennedy Space Center, it touches down on one of the world's longest runways. The concrete facility is located about two miles northwest of the Vehicle Assembly Building on a northwest/southeast alignment.

The Shuttle Landing Facility is about twice the length and width of the average commercial airport runway. It is approximately 15,000 feet (4,572 meters) long, 300 feet (91.4 meters) wide and 16 inches (40.6 centimeters) thick at the center. There is a 1,000-foot (305-meter) safety overrun at each end. Small grooves, each 0.25 inch (0.63 centimeter) wide and deep, run across most of the concrete from side to side.

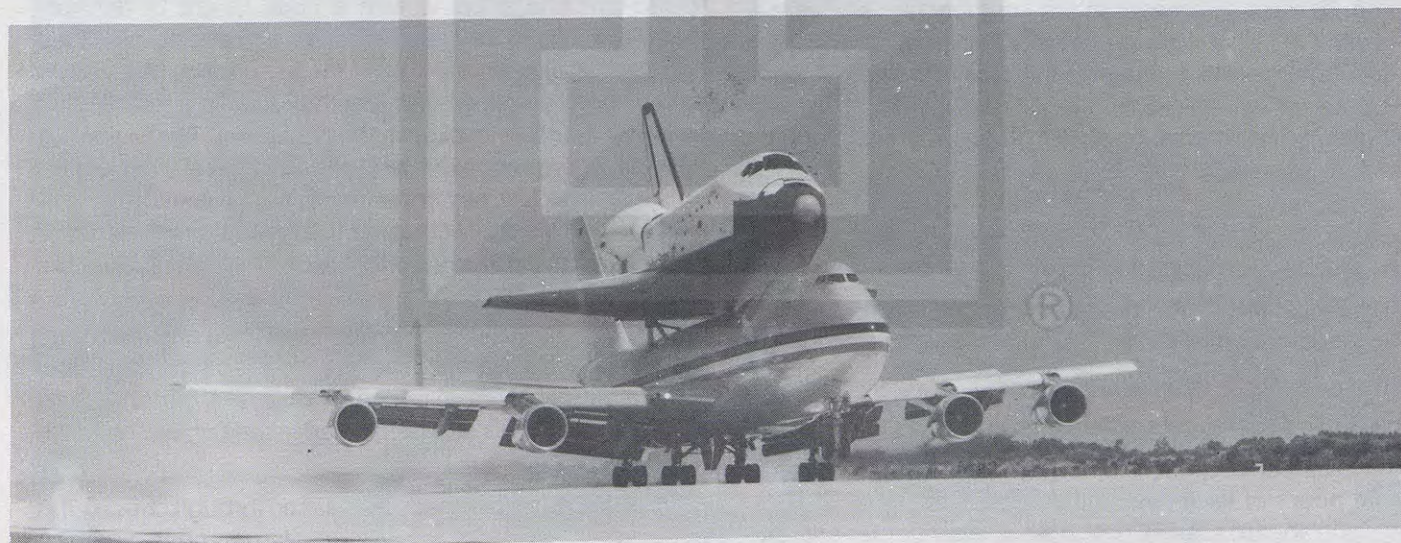
Unlike conventional aircraft, the orbiter lacks propulsion during the landing phase. Its high-speed glide must bring it in for a landing perfectly the first time — there is no circle-and-try-again capability. The landing speed of the orbiter ranges from 213 to 226 miles (343 to 364 kilometers) per hour.

Navigational aids on the ground and on board the orbiter help to direct the Space Shuttle to a smooth landing. A Microwave Scanning Beam Landing System guides the final approach and brings the orbiter to the designated point on the runway.

Landings may be made from the northwest to southeast (Runway 15) or from the southeast to northwest (Runway 33).

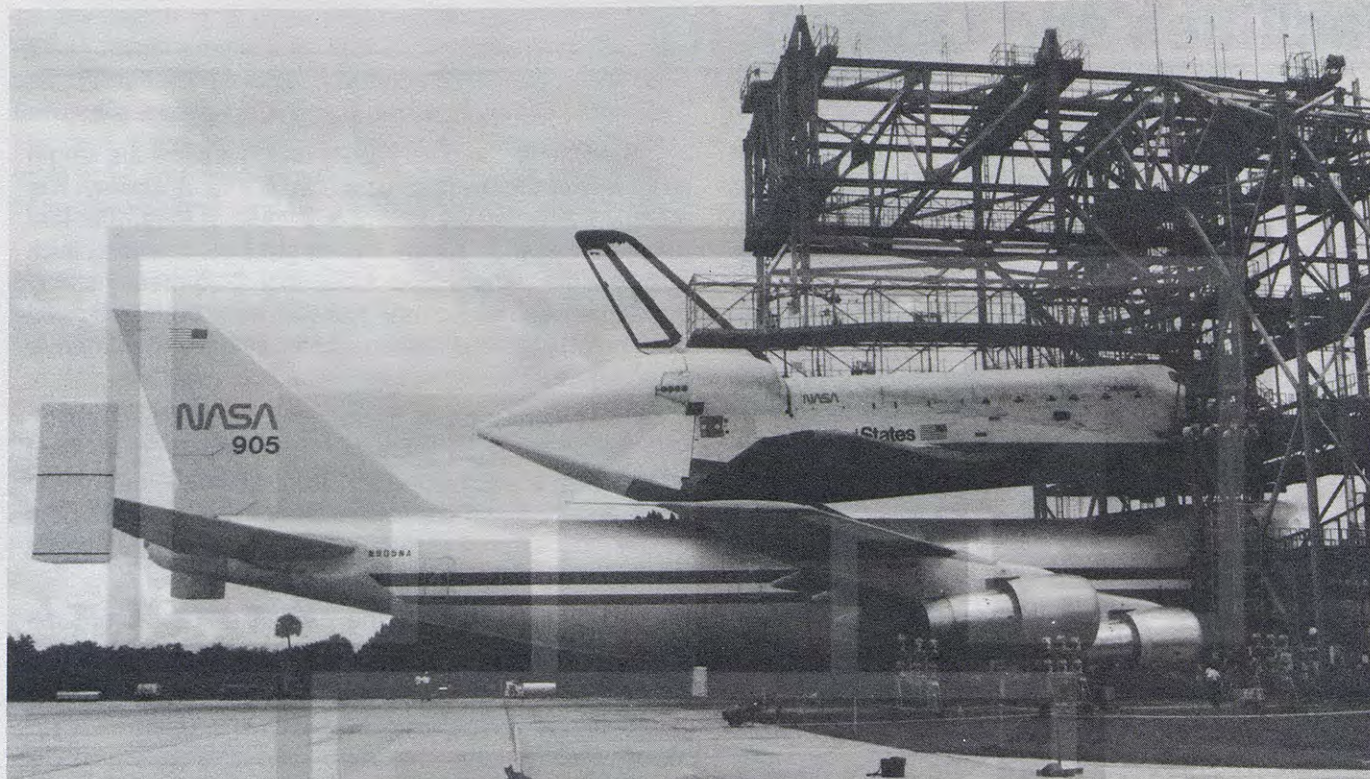
The runway is not perfectly flat; it has a slope of 24 inches (61 centimeters) from the centerline to the edge. The slope of the runway, as well as the small grooves, provide a very effective way to shed water, helping to prevent hydroplaning in wet weather. The grooves also provide a more skid-resistant surface.

More recent runway modifications enhance safety and reduce orbiter tire wear during landing. At each end, where the orbiter main gear normally touches down, a section



An Orbiter/Shuttle Carrier Aircraft combination touches down on the extra-long runway at the Shuttle Landing Facility.

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The mate/demate device at the Shuttle Landing Facility lifts an orbiter from the Shuttle Carrier Aircraft used in ferry operations. Movable platforms provide access to orbiter components.

3,500 feet (1,067 meters) long has been ground down to create a smoother surface, one without cross grooves. The overruns on each end have been upgraded to be equivalent to the runway itself; in effect, providing a runway that is 17,000 feet (5,182 meters) long. The ground along both sides of the runway has been strengthened to support more weight. And improvements have been made to the landing zone light fixtures.

A 550-by-490-foot (168-by-149-meter) aircraft parking apron, or ramp, is located at the southeastern end of the runway. On the northeast corner of the ramp is the mate/demate device which attaches the orbiter to or lifts it from the Shuttle Carrier Aircraft during ferry operations. There are movable platforms for access to some orbiter components.

The mate/demate device can lift up to 230,000 pounds (104,328 kilograms) and withstand winds of up to 125 miles (201 kilometers) per hour.

A diesel-driven towing tractor brings the orbiter to its next stop after landing, the Orbiter Processing Facility.

Orbiter Processing Facility

An orbiter is towed to the Orbiter Processing Facility within hours of its arrival, either after landing at KSC or returning aboard a ferry flight on the Shuttle Carrier Aircraft. The facility has three almost identical high bays, each of

which is 197 feet (60 meters) long, 150 feet (46 meters) wide, 95 feet (29 meters) high, and encompasses a 29,000-square-foot (2,694-meter) area. A low bay connects high bays 1 and 2. It is 233 feet (71 meters) long, 97 feet (30 meters) wide and nearly 25 feet (eight meters) high. High bay 3, built last, is located to the north and east of the first two; it also has an adjacent low bay. Annexes and portable buildings provide additional shop and office space.

Each high bay comes equipped with a 30-ton (27-metric-ton) bridge crane with a hook height of approximately 66 feet (20 meters). Platforms, a main access bridge and two rolling bridges with trucks provide access to various parts of the orbiter. The trucks have a telescoping arm with rotatable buckets to hold workers. The high bays have an emergency exhaust system in case of a hypergolic fuel spill. The low bay contains areas for electronic, mechanical and electrical equipment, a communications room, offices and supervisory control rooms. All bays have fire protection systems.

In addition to routine postflight servicing and checkout, many of the vehicle modifications needed for future flight requirements, or to enhance vehicle performance and correct deficiencies, are performed in the Orbiter Processing Facility.

Spacecraft or payloads processed through checkout in a horizontal position, usually the larger ones such as Spacelab, are installed in the orbiter in this facility. Space-

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craft handled in a vertical position normally are installed at the launch pad.

After processing, the orbiter is usually towed into the Vehicle Assembly Building transfer aisle through the large door at the north end of the high bay.

Thermal Protection System Facility

A Thermal Protection System, composed of a network of tiles, gap fillers and insulation blankets, protects the exterior of each orbiter from the searing heat of launch and re-entry, and the cold soak of space. These materials can sustain damage during a flight, and must be inspected, repaired, or sometimes replaced for the next mission.

Repair and final manufacture of the Thermal Protection System materials takes place in the two-story, 44,000-square-foot (4,088-square-meter) Thermal Protection System Facility. It is located across the street from the Orbiter Processing Facility.

Logistics Facility

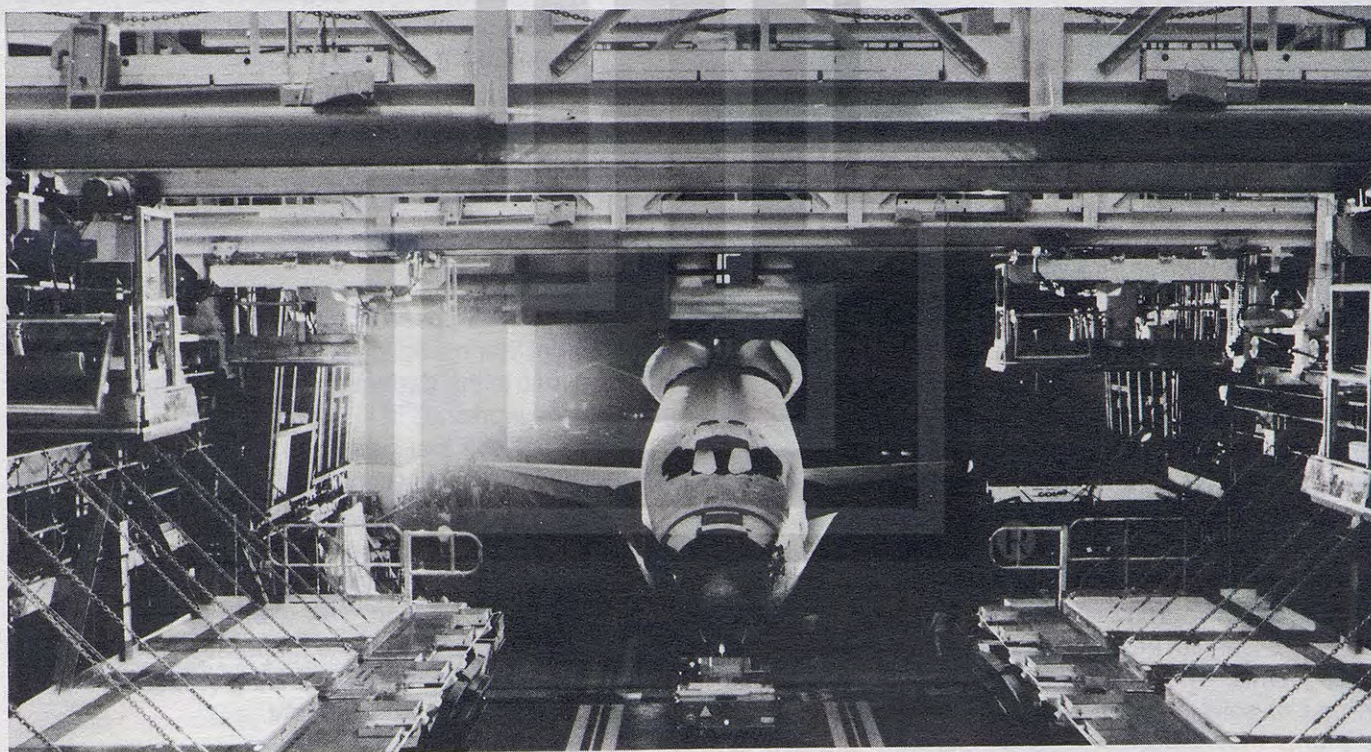
The modern 324,640-square-foot (30,159-square-meter) Logistics Facility is located south of the Vehicle Assembly Building. It contains some 160,000 Space Shuttle hardware parts and more than 500 NASA and contractor workers. An unusual feature of the Logistics Facility is the state-of-the-art parts retrieval system, which has automated handling equipment to find and retrieve specific parts.

Solid Rocket Booster Processing Facilities

After the Space Shuttle launches, the two solid rocket boosters burn out and jettison about 2 minutes into the flight. Huge parachutes lower them into the Atlantic Ocean where special recovery vessels retrieve and tow them back to a dock at Cape Canaveral Air Force Station.

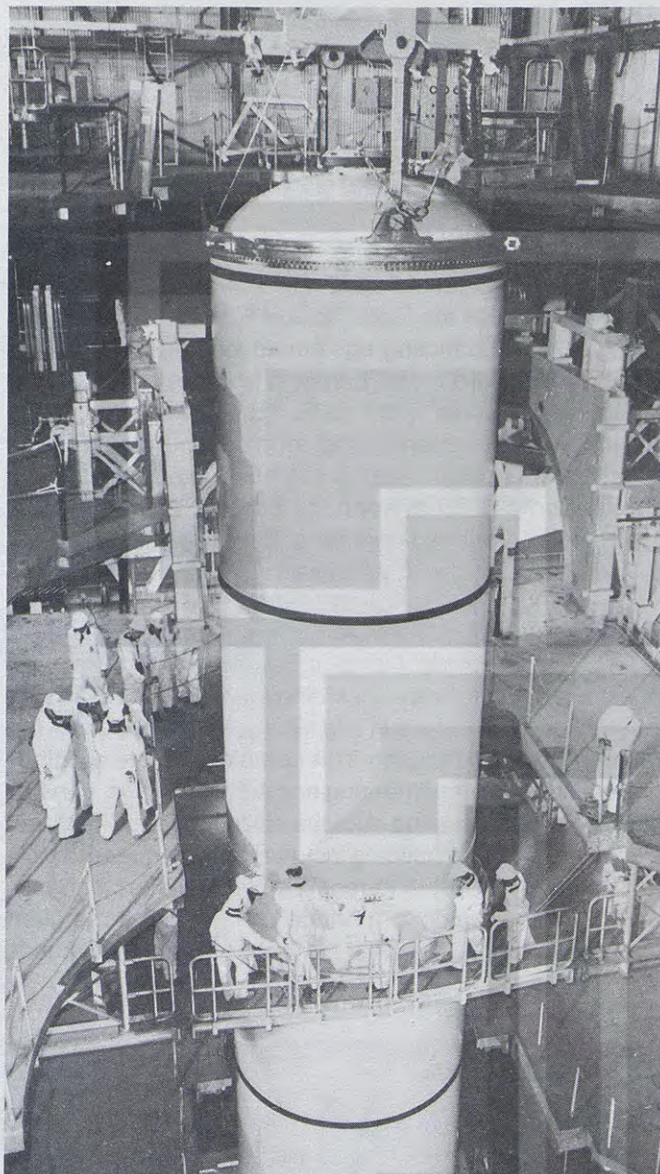
Solid Rocket Booster Disassembly Facility: The area in and around Hangar AF and the hanger building itself together comprise the Solid Rocket Booster Disassembly Facility. Special handling equipment located behind Hangar AF lifts the solid rocket boosters from the water. There, they undergo an initial washing. Each booster disassembles into four main segments, and aft skirt and forward skirt assemblies. The main casing segments are taken back to Launch Complex 39 at Kennedy Space Center, cleaned, and placed on railroad cars for shipment to the manufacturer and reloading with propellant.

Solid Rocket Booster Assembly and Refurbishment Facility: Refurbishment and subassembly of inert solid rocket booster hardware, including the forward and aft skirt assemblies, takes place in this facility, located south of the Vehicle Assembly Building. This complex has five buildings — manufacturing, engineering and administration, service, aft skirt or hot fire testing, and the chiller facility. The three-level manufacturing building includes an automated check-out system, an 80-by-200-foot (24-by-61-meter) high bay, two 15-ton (14-metric-ton) bridge cranes, and three overhead gantry robots; the latter are among the world's largest.



Processing for a mission begins when an orbiter is towed into the Orbiter Processing Facility.

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Assembly of the Space Shuttle flight components such as this solid rocket booster takes place in High Bays 1 or 3 of the Vehicle Assembly Building. The two boosters are stacked on the Mobile Launcher Platform. The external tank is then mated to the boosters, and the orbiter is the final component added.

Rotation Processing and Surge Facility: Located just north of the Vehicle Assembly Building, this facility receives new and reloaded solid rocket booster segments shipped by rail from the manufacturer. The complex includes a processing building and two surge buildings. Inspection, rotation and aft booster buildup occur in the processing building. Completed aft skirt assemblies from the Assembly and Refurbishment Facility integrate here with the booster aft segments. The two nearby surge buildings are for storage of solid rocket booster segments. They remain here until moved to the Vehicle Assembly Building for integration with other flight-ready booster components.

Parachute Refurbishment Facility: Originally built to process parachutes used in the Gemini manned space program, this facility in the Industrial Area has been modified for the Space Shuttle. The two vessels which recover the solid rocket boosters also retrieve the parachutes from the ocean, hauling them in on large reels. These reels are taken to this facility, where the parachutes are washed, dried, and stored in canisters for eventual reuse.

Vehicle Assembly Building: The solid rocket booster segments are integrated here into complete flight sets and mated with the orbiter and external tank before being moved to the launch pad.

External Tank

The external tank arrives by barge from its manufacturing site in Louisiana. Off-loaded at the Complex 39 turn basin, it travels horizontally to the nearby Vehicle Assembly Building. There, it is processed and stored in a vertical storage or checkout cell until mated with the other Space Shuttle flight elements.

The external tank is the largest and heaviest — when loaded — element of the Space Shuttle. Besides containing and delivering propellants to the main engines, it serves as the structural backbone of the Shuttle by absorbing the thrust loads during launch. It has three major components: the forward liquid oxygen tank, an unpressurized intertank that contains most of the electrical components and joins the two propellant-filled tanks, and the aft liquid hydrogen tank. The entire external tank is approximately 154 feet long (47 meters) and 28 feet (8.5 meters) in diameter. The liquid oxygen and hydrogen feed into the tank at the launch pad. These cryogenic propellants fuel the orbiter's three main engines during liftoff and ascent.

After the Shuttle main engines shut down, the external tank separates from the orbiter and follows a ballistic trajectory into the Indian ocean. It is the only major Space Shuttle component that it is not recovered and reused.

Main Engines

Newly arrived Space Shuttle main engines, delivered by truck from Stennis Space Center in Mississippi after test firing, off-load in the Vehicle Assembly Building where the main engine workshop is located. The workshop is a low bay checkout cell that has been converted into an enclosed, environmentally controlled area.

The workshop has three engine workstands and can support main engine disassembly and reassembly, checkout and leak testing. The engines go to the Orbiter Processing Facility for installation. The workshop also supports engine removal operations and preparation of engines for shipment back to Stennis for test firing or to the manufacturer in California for refurbishment.

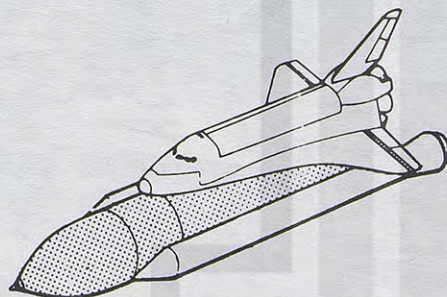
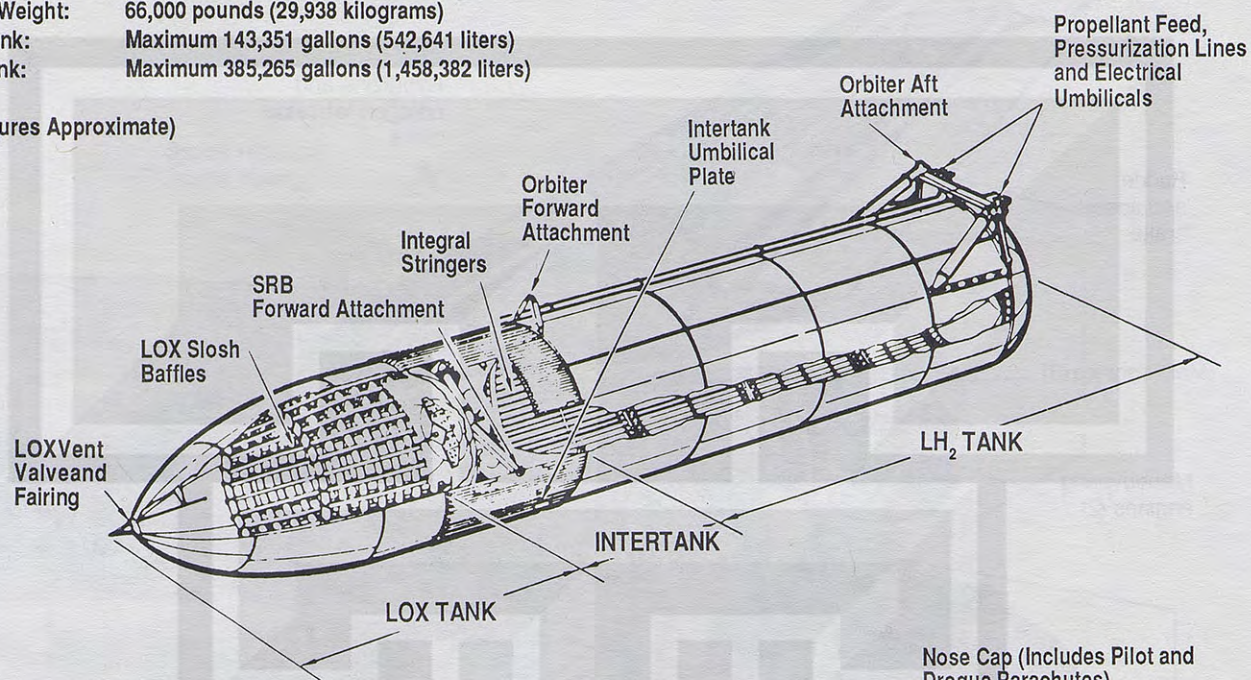
A cluster of three main engines provides the primary propulsion for the orbiter and helps to steer the Shuttle. The

Information Summaries

External Tank

Length:	154 feet (47 meters)
Diameter:	27.6 feet (8.4 meters)
Loaded Weight:	1,676,000 pounds (760,234 kilograms)
Empty Weight:	66,000 pounds (29,938 kilograms)
LOX Tank:	Maximum 143,351 gallons (542,641 liters)
LH ₂ Tank:	Maximum 385,265 gallons (1,458,382 liters)

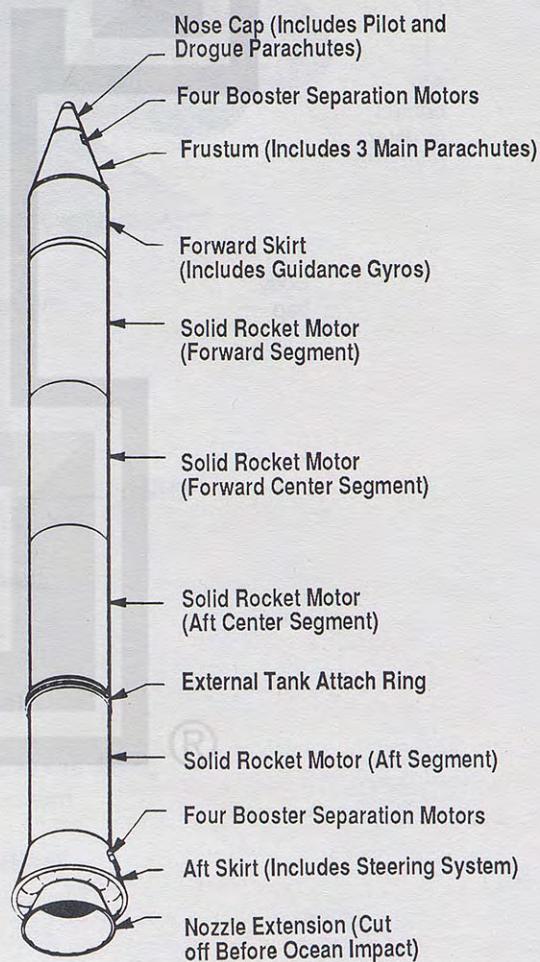
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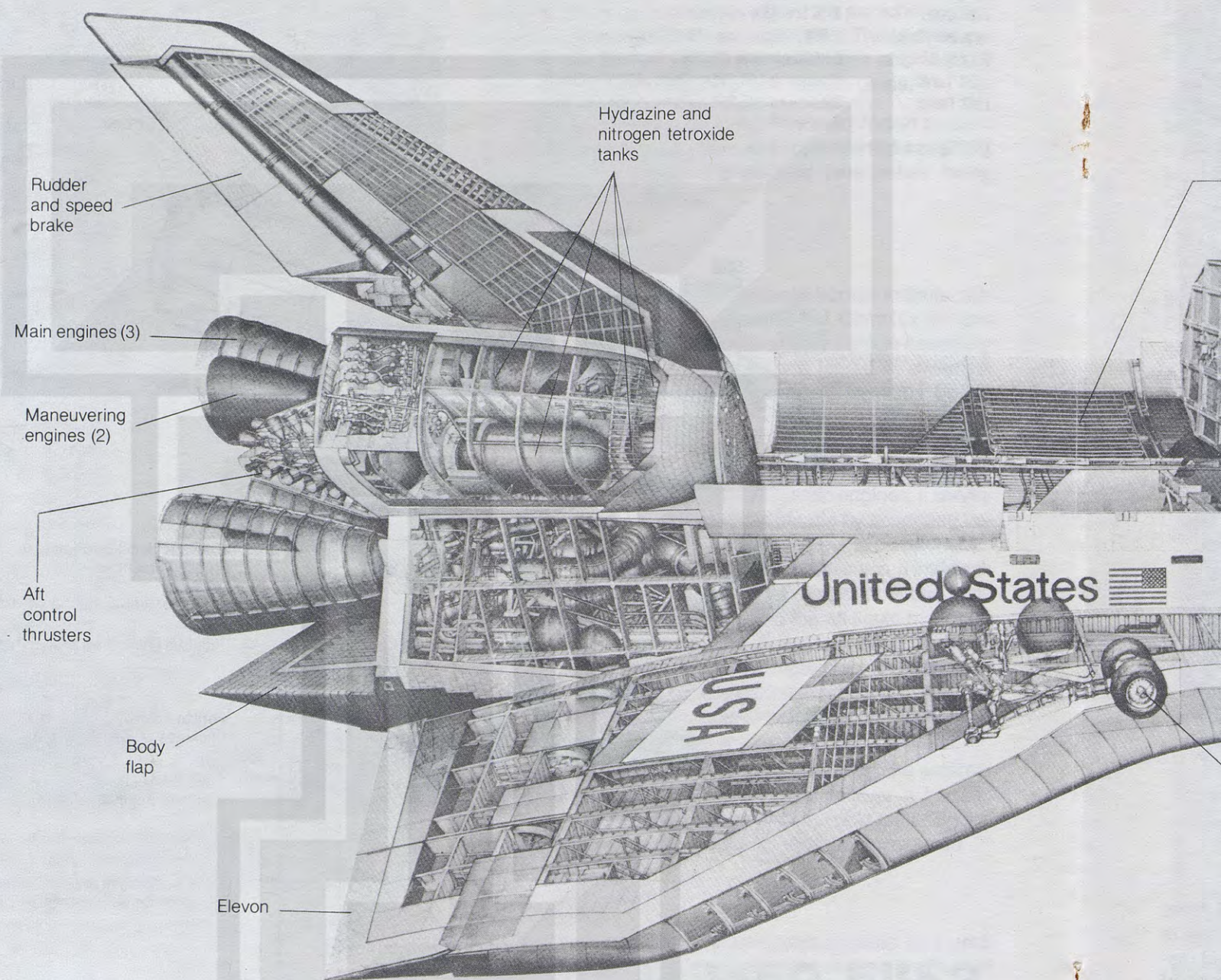
Solid Rocket Booster

Length:	149.2 feet (45.5 meters)
Diameter:	12.2 feet (3.7 meters)
Weight:	1,300,000 pounds (589,680 kilograms)
Liftoff Thrust:	Each 3.06 million pounds (13.6 million newtons)

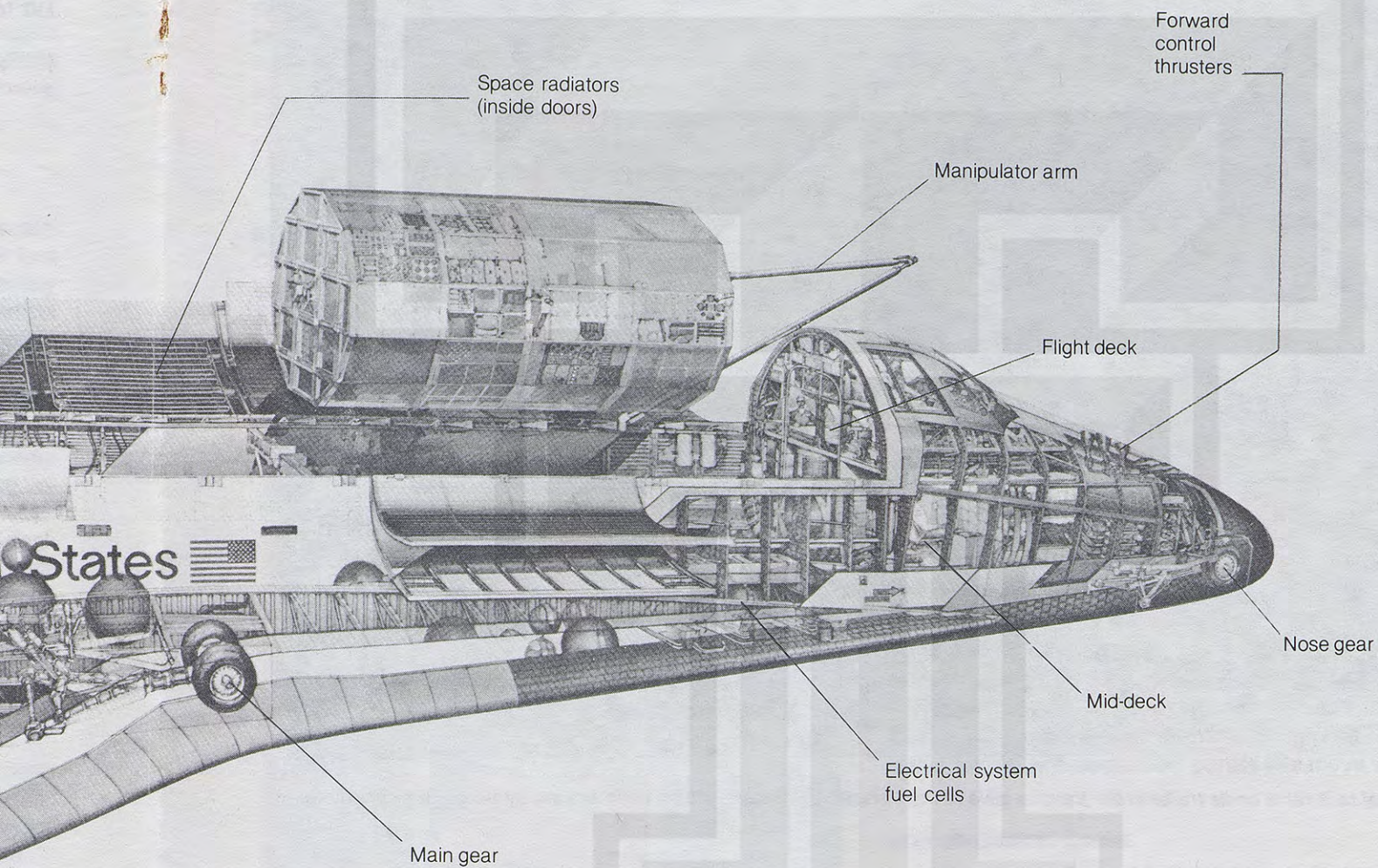
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Information Summaries



The Orbiter



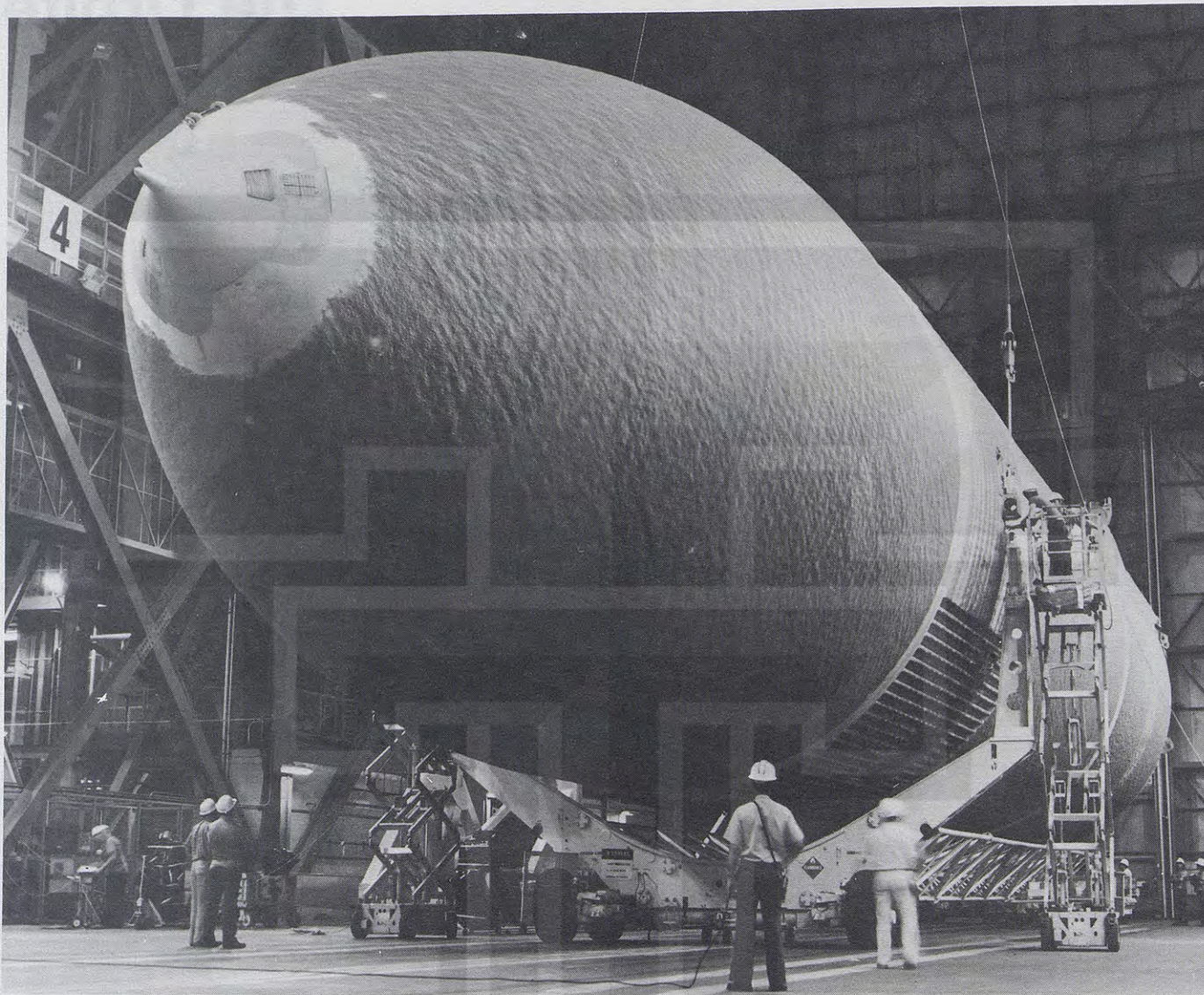
Length: 122 feet (37 meters)
Taxi Height: 57 feet (17.4 meters)
Wingspan: 78 feet (24 meters)
Landing Weight: Variable - About 200,000 pounds (90,718 kilograms)

MAIN ENGINE THRUST: 375,000 pounds each (1,668,000 newtons) at sea level,
470,000 pounds (2,090,560 newtons) in vacuum

Cargo Bay: 60 feet long (18.3 meters) 15 feet diameter (4.6 meters)
Payload Weight: About 50,000 pounds (22,680 kilograms)

(All Figures Approximate)

Information Summaries



The external tank rests on its trailer in the transfer aisle of the Vehicle Assembly Building after arriving by barge at Kennedy Space Center.

liquid-hydrogen/liquid-oxygen propellant engines ignite on the ground, and work in parallel with the solid rocket boosters during the initial ascent. After booster separation, the engines continue to operate for several minutes. They are reusable.

Vehicle Assembly Building

At the heart of Launch Complex 39 is the huge Vehicle Assembly Building, one of the largest buildings in the world and the last stop for the Shuttle before the launch pad. It covers a ground area of about eight acres (3.24 hectares) and has a volume of approximately 129,482,000 cubic feet (3,884,460 cubic meters). The Vehicle Assembly Building is 525 feet (160 meters) tall, 716 feet (218 meters) long, and 518 feet (158 meters) wide.

The structure can withstand winds of up to 125 miles (201 kilometers) per hour. The foundation rests on more than 4,200 steel pipe pilings, each 16 inches (40.6 centimeters) in diameter and driven down to bedrock at a depth of 160 feet (49 meters).

The high bay area is 525 feet tall (160 meters) and the low bay area is 210 feet (64 meters) tall. A north-south transfer aisle connects and transects the two bay areas. Shuttle main engine maintenance takes place in the low bay, which also serves as a holding area for solid rocket booster forward assemblies and aft skirts.

Facing east are High Bays 1 and 3 where integration and stacking of the complete Space Shuttle occurs in a vertical position on the Mobile Launcher Platform. Facing west are High Bays 2 and 4 where external tank checkout and storage takes place.

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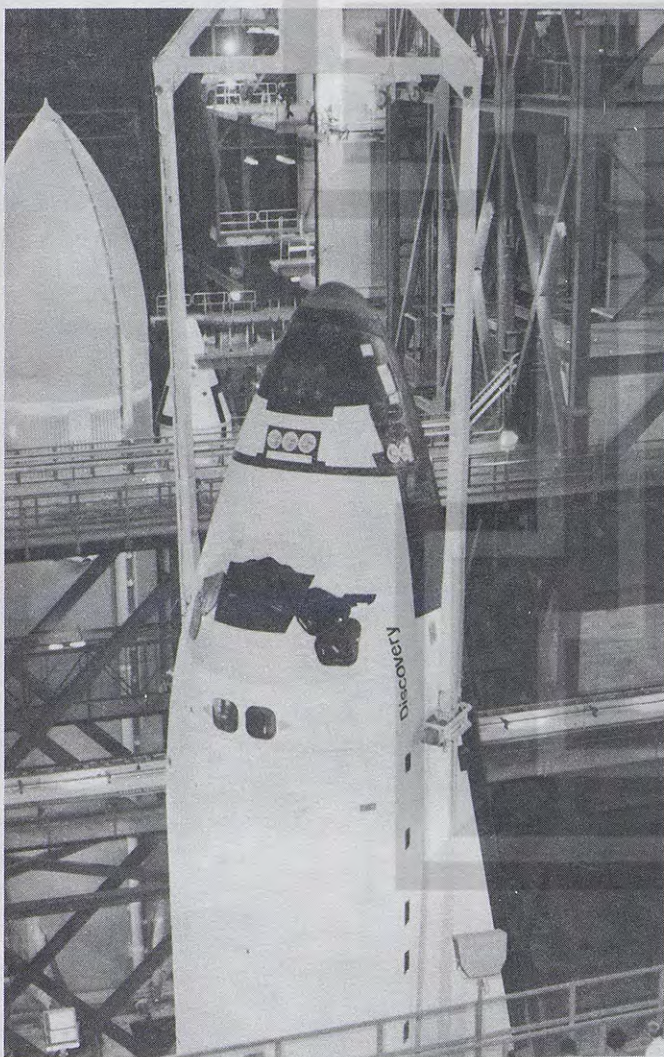
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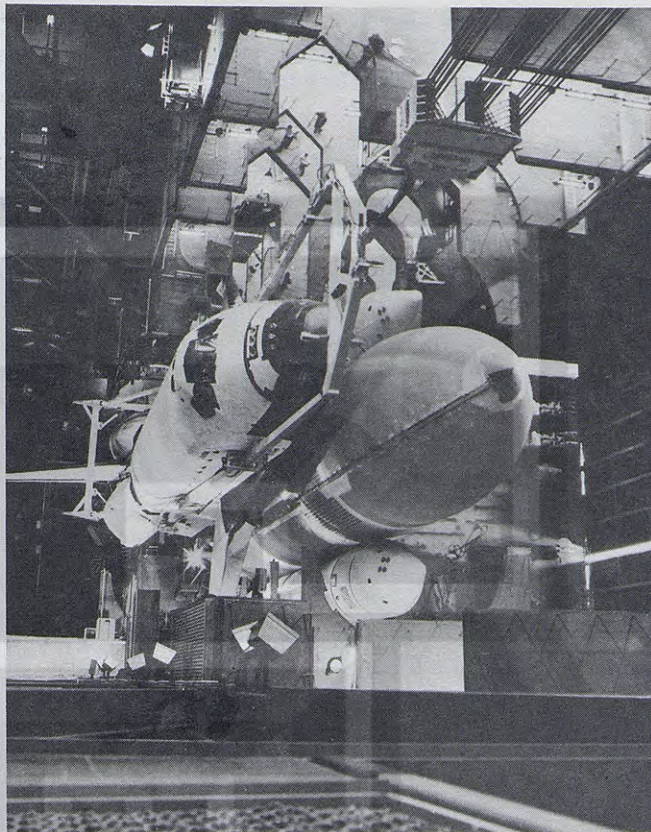
The Vehicle Assembly Building has more than 70 lifting devices, including two 250-ton (227-metric-ton) cranes.

During Space Shuttle buildup operations inside the Vehicle Assembly Building, solid rocket booster segments are transferred from nearby assembly and checkout facilities, hoisted onto a Mobile Launcher Platform in High Bays 1 or 3, and mated to form two complete boosters. After checkout and inspection in High Bays 2 or 4, the external tank transfers to High Bays 1 or 3 to be attached to the solid rocket boosters. The orbiter, the final element, gets towed from the Orbiter Processing Facility to the Vehicle Assembly Building transfer aisle, raised to a vertical position by overhead cranes, lowered onto the Mobile Launcher Platform, and mated to the other components.

With the assembly and checkout operations complete, the huge outer doors of the high bay open to permit the Crawler-Transporter to enter and move under the Mobile Launcher Platform holding the assembled Shuttle. The



An orbiter is raised to a vertical position and lifted for mating to the external tank and solid rocket boosters in the Vehicle Assembly Building.



A huge crane lowers the orbiter into position to be attached to the external tank in the Vehicle Assembly Building.

high bay doors are 456 feet (139 meters) high. The lower section is 152 feet (46 meters) wide and 114 feet (35 meters) high, with four door panels that move horizontally. The upper door is 342 feet (104 meters) high and 76 feet (23 meters) wide, with seven door panels that move vertically.

Launch Control Center

If the Vehicle Assembly Building is the heart of Launch Complex 39, then the Launch Control Center is its brain. The Center is a four-story building connected to the east side of the Vehicle Assembly Building by an elevated, enclosed bridge.

The Launch Control Center contains two primary and two backup firing rooms. Each is equipped with the Launch Processing System — an automated computer-operated system — which monitors and controls Shuttle assembly, checkout and launch operations.

Largely because of the Launch Processing System, the countdown for a Space Shuttle launch (excluding built-in holds) takes only about 43 hours, compared to more than 80 hours needed for the earlier Apollo/Saturn flights.

Also, use of the Launch Processing System requires only approximately 225-230 persons in the firing room as compared to some 450 people needed for Apollo manned missions.

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Mission responsibility transfers to Mission Control Center at Johnson Space Center, Houston, TX, when the solid rocket boosters ignite at liftoff.

Transportable Equipment and Facilities

The *Mobile Launcher Platform* is a two-story steel structure which provides a transportable launch base for the Space Shuttle. First used in the Apollo/Saturn program, the Platforms underwent modifications for the Shuttle.

The main body of each Platform is 25 feet (7.6 meters) high, 160 feet (49 meters) long, and 135 feet (41 meters) wide. At their parking sites north of the Vehicle Assembly Building, in the Vehicle Assembly Building high bays and at the launch pads, the Mobile Launcher Platforms rest on six pedestals 22 feet (6.7 meters) high.

Unloaded, a Platform weighs about 8.23 million pounds (3.73 million kilograms). With an unfueled Shuttle aboard, it weighs about 11 million pounds (5 million kilograms).

The main body of the Platform provides three openings — two for the exhaust of the solid rocket boosters and one for the main engines exhaust.

There are two large devices called Tail Service Masts, one on each side of the main engines exhaust hole. The masts provide several umbilical connections to the orbiter, including a liquid-oxygen line through one and a liquid-hydrogen line through another. These cryogenic propellants feed into the external tank from the pad tanks via these connections. At launch, the umbilicals pull away from the orbiter and retract into the Masts, where protective hoods rotate closed to shield them from the exhaust flames. Each Tail Service Mast assembly is 15 feet (4.6 meters) long, 9 feet (2.7 meters) wide, and rises 31 feet (9.4 meters) above the Platform deck.

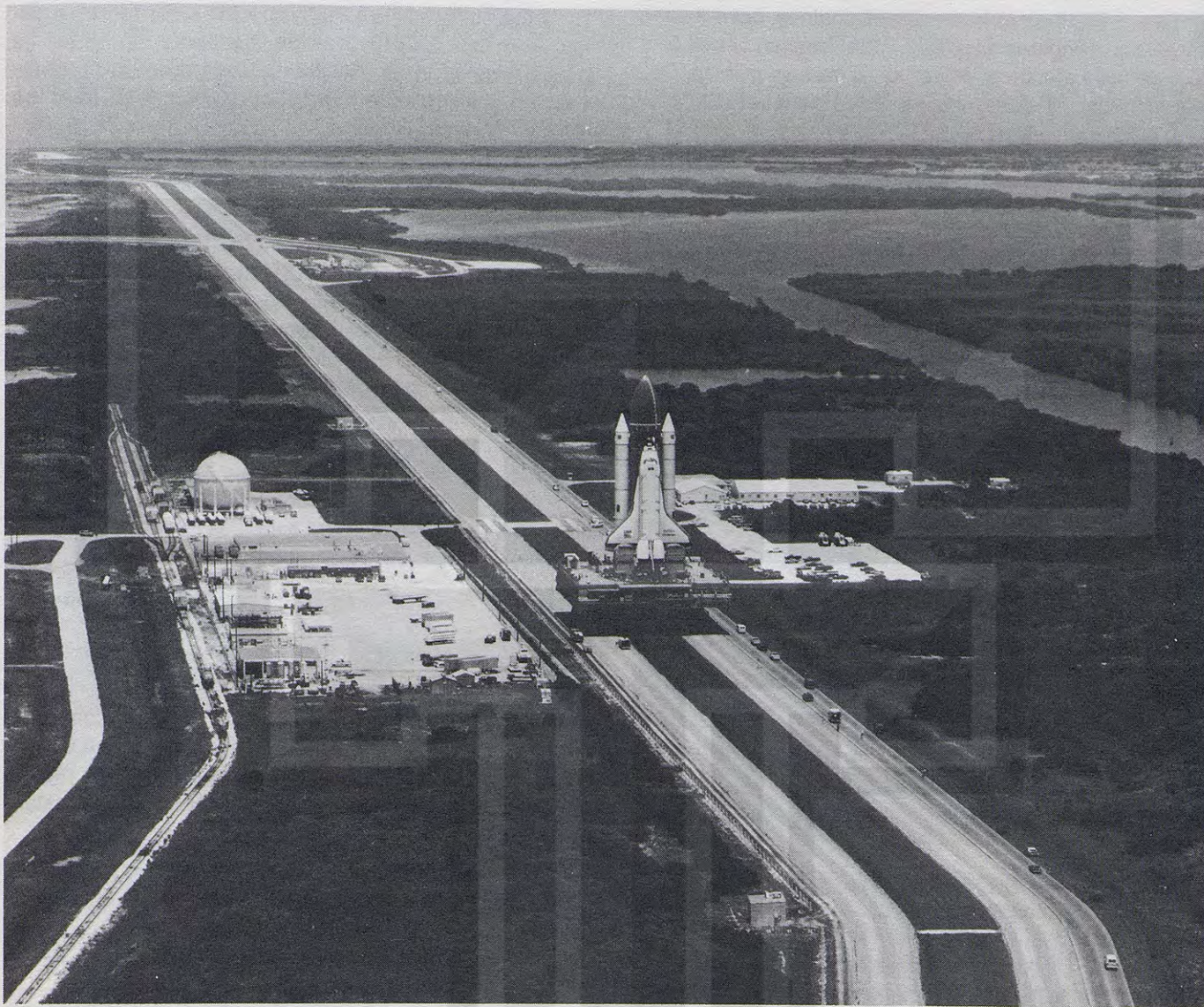
Other umbilicals carry helium and nitrogen, as well as ground electrical power and communications links.

Eight attach posts, four on the aft skirt of each SRB, support and hold the Space Shuttle on the Mobile Launcher



Firing Room 1 of the Launch Control Center contains consoles for monitoring and controlling Space Shuttle assembly, checkout and launch operations.

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The Space Shuttle assembled on the Mobile Launcher Platform moves slowly on the Crawlerway between the Vehicle Assembly Building and the launch pad.

Platform. These posts fit on counterpart posts located in the Platform's two solid rocket booster support wells. The space vehicle disconnects from the Platform by explosive nuts which release the giant studs linking the solid rocket attach posts with the Platform support posts.

Each Mobile Launcher Platform has two inner levels containing electrical, test and propellant-loading equipment.

A *Crawler-Transporter* moves a fully assembled Space Shuttle, mounted on a Mobile Launcher Platform, from the Vehicle Assembly Building to the launch pad. The huge tracked vehicles, originally used during the Apollo era, underwent modifications for the Shuttle.

The two Crawlers are about 20 feet (6.1 meters) high, 131 feet (40 meters) long, and 114 feet (34.7 meters) wide

— about the size of a baseball diamond. Each one weighs about 6 million pounds (2.7 million kilograms) unloaded. A Crawler has eight tracks, each of which has 57 shoes or cleats. Each shoe weighs approximately one ton (907 kilograms).

With the Space Shuttle aboard, the Crawler can creep at a maximum speed of about 1 mile (1.6 kilometers) per hour; unloaded, it can manage about 2 miles (3.2 kilometers) per hour.

The Crawler has a leveling system designed to keep the top of the Space Shuttle vertical while negotiating the 5 percent grade leading to the top of the launch pad. Also, a laser docking system provides almost pinpoint accuracy when the Crawler and Mobile Launcher Platform are positioned at the launch pad or in the Vehicle Assembly Building.

Information Summaries

Two 2,750-horsepower diesel engines power each Crawler. The engines drive four 1,000-kilowatt generators which provide electrical power to 16 traction motors. Operators in cabs on either end steer the giant vehicle.



The Payload Canister Transporter can transport payloads in the Canister either vertically or horizontally.

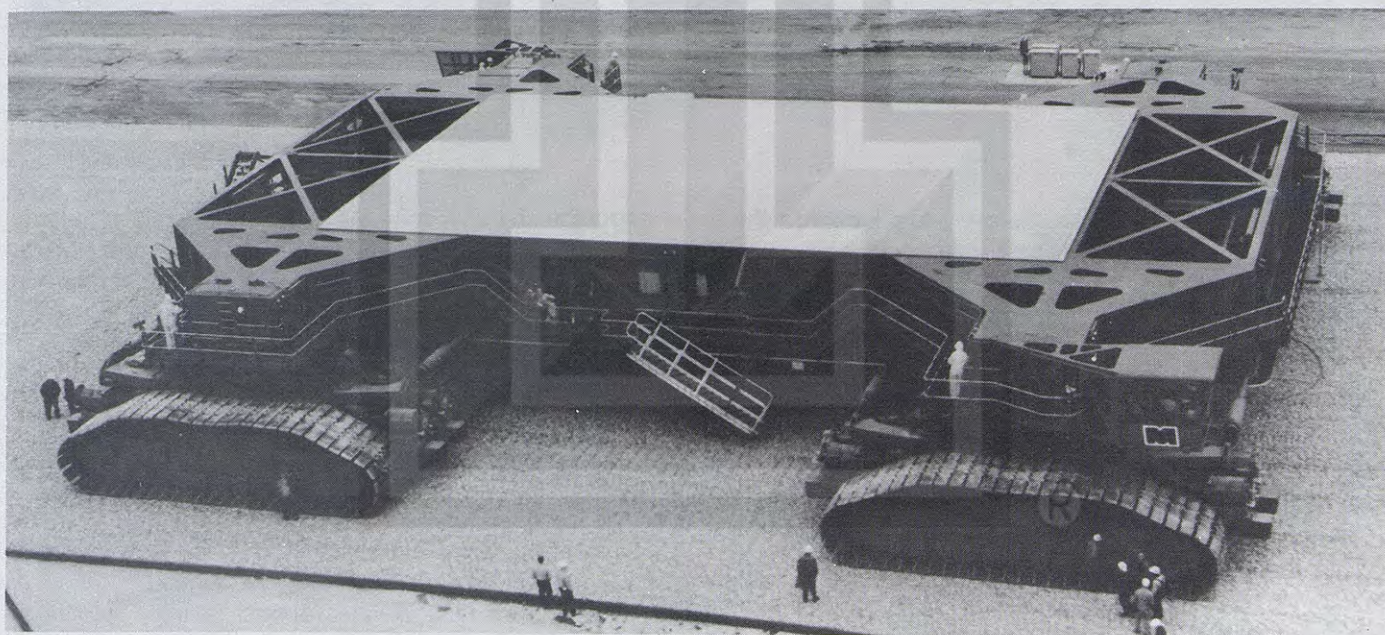
The *Crawlerway* is a 130-foot-wide (39.6-meter) roadway — almost as broad as an eight-lane freeway. The Crawler-Transporters use this for their more than 3-mile (4.8-kilometer) trek to one of the launch pads from the Vehicle Assembly Building.

The Crawlerway consists of two 40-foot (12-meter) wide lanes, separated by a 50-foot (15-meter) wide median strip. The Crawlerway has four layers to support the huge weight. The Crawler, Mobile Launcher Platform and Space Shuttle with empty external tank weigh about 17 million pounds (7.7 million kilograms). The top layer of the Crawlerway is river gravel about 8 inches (20.3 centimeters) thick on curves and 4 inches (10.2 centimeters) thick on straightaway sections. The other layers in descending order are: 4 feet (1.2 meters) of graded, crushed stone; 2.5 feet (0.76 meter) of select fill; and 1 foot (0.30 meter) of compact fill. It takes several hours for the journey from the Vehicle Assembly Building to one of the launch pads. The distance to Pad 39A is about 3.4 miles (5.5 kilometers); to Pad 39B, it is approximately 4.2 miles (6.8 kilometers).

The *Payload Canister* holds payloads in transit from various processing or assembly facilities to the launch pad (for vertically installed payloads) or to the Orbiter Processing Facility (for horizontally installed payloads).

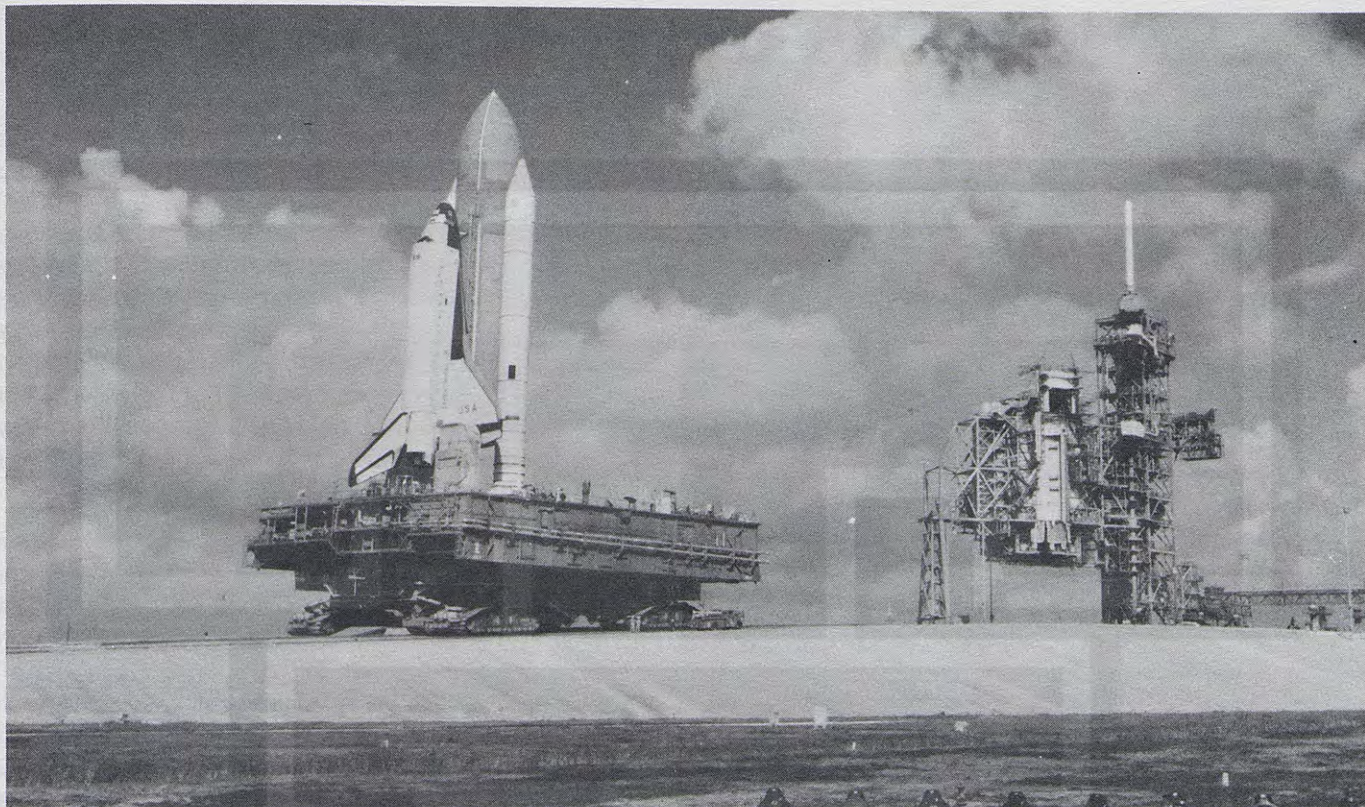
Each environmentally controlled Canister can carry payloads up to 15 feet (4.6 meters) in diameter and 60 feet (18.3 meters) long, matching the capacity of the orbiter payload bay. Maximum payload weight is approximately 50,000 pounds (22,680 kilograms).

The *Payload Canister Transporter* is a 48-wheel, self-propelled truck which can transport the Canister and its



The Crawler-Transporter can lift the Space Shuttle on its Mobile Launcher Platform and move it from the Vehicle Assembly Building to the launch pad.

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The launch pad, with its Rotating Service Structure in the retracted position, prepares to accept the Space Shuttle on its Mobile Launcher Platform.

hardware either in a vertical or a horizontal position. It is 65 feet (19.8 meters) long and 23 feet (7 meters) wide, with a flatbed that can be lowered and raised from about 5 feet (1.5 meters) to 7 feet (2.1 meters), if required.

Independently steerable wheels permit the Transporter to move forward, backward, sideways, and diagonally, or turn on its own axis like a carousel. Diagonally opposed operator cabs are located on each end of the truck.

A diesel engine powers the Transporter. Inside a spacecraft facility, it runs on an electric motor.

Fully loaded, its top speed is about 5 miles (8 kilometers) per hour. But it can creep as slowly as a 0.25 inch (0.635 centimeter) per second, or approximately 0.014 miles (0.022 kilometers) per hour, for payloads which require precise handling.

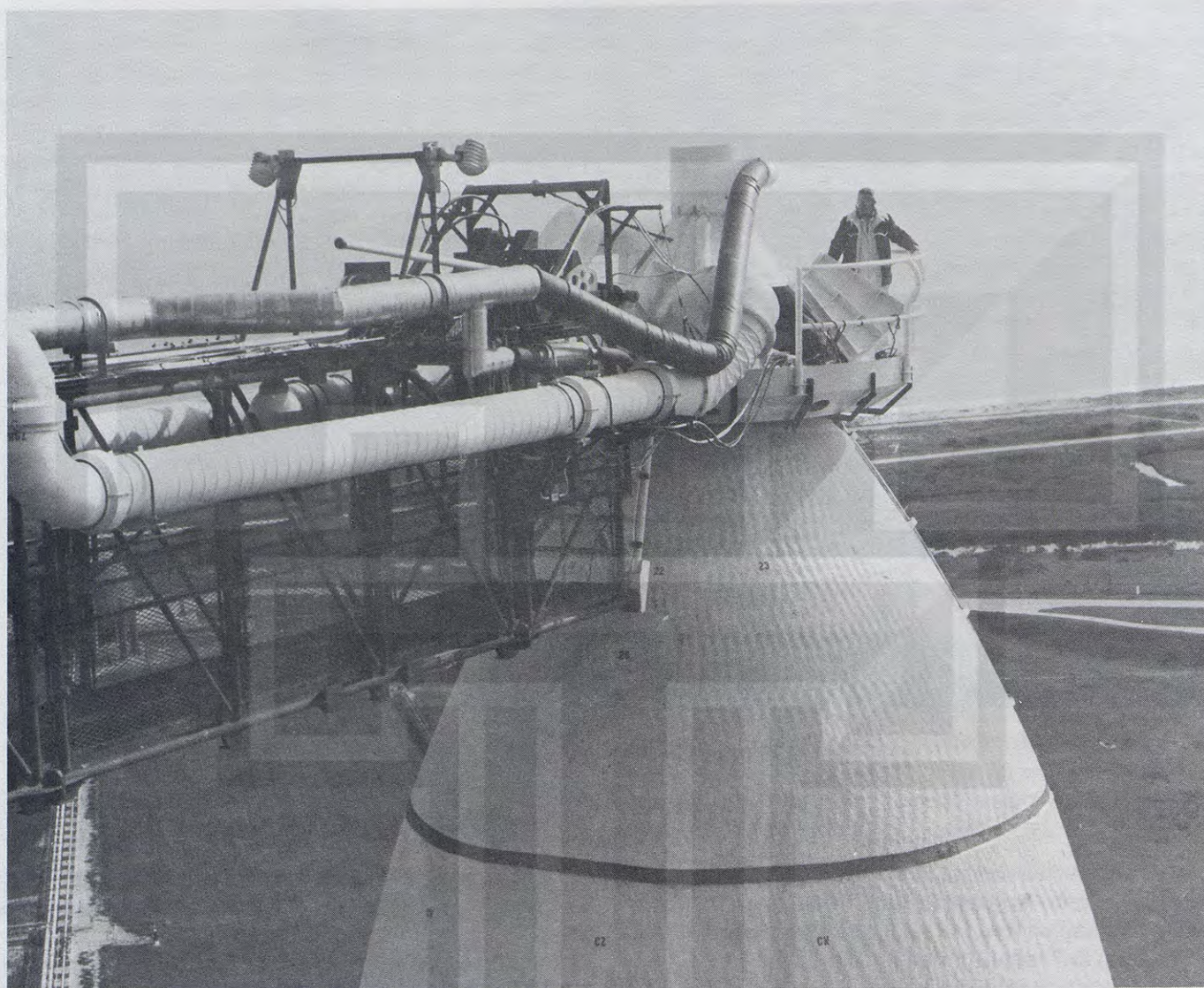
Launch Pads 39A and 39B

The Launch Complex 39 Pads A and B are roughly octagonal in shape. Each covers about 0.25-square-mile (0.65-square-kilometer) of land, contained within a high chain link fence. Space Shuttles launch from the top of the concrete hardstand in the center of the pad. The Pad A stand is 48 feet (14.6 meters) above sea level at its top, while the upper surface at Pad B is at an elevation of 55 feet (16.8 meters).

Approximately 105 Space Transportation System (STS) 51-L accident-related pad modifications were made before the STS-26 return-to-flight mission in September 1988. Although pad equipment was not found to be a contributing factor in the accident, the modifications improved flight safety margins and corrected possible problems in emergency escape hardware and procedures.

Some of the modifications include extensive changes to the Crew Emergency Egress System. The personnel escape route from the Shuttle, beginning with the orbiter access arm, has been covered with solid panels for fire protection. A water spray system also has been incorporated. Two slidewire baskets have been added to the slidewire system for a total of seven, along with devices to decelerate the baskets and to improve exit from them. The old emergency shelter bunker near the end of the slidewires, which the crew would enter to wait out the emergency, has been replaced by a new version.

Other modifications include the addition of a solid rocket booster joint heater umbilical to keep booster field joints at or about 75 degrees Fahrenheit (24 degrees Celsius), and a system to recirculate launch pad water services to prevent them from freezing. Still other modifications are improvements to the environmental controls in the Payload Changeout Room, the addition of a cryogenic liquid-propellant filter device, and the inclusion of an auto-



The gaseous oxygen vent hood is located on the end of the highest swingarm attached to the Fixed Service Structure.

matic secondary release system for the Shuttle external tank hydrogen vent umbilical.

The top of each pad measures 390 feet by 325 feet (119 meters by 99 meters). The two major items of equipment on each pad are the Fixed Service Structure and the Rotating Service Structure.

The **Fixed Service Structure** is located on the north side of each pad's hardstand. It is an open framework structure about 40 feet (12.2 meters) square. A hammerhead crane on top provides hoisting services as required in pad operations. There are 12 work levels at 20-foot (6.1-meter) intervals. The height of the structure to the top of the tower is 247 feet (75 meters), while the distance to the top of the hammerhead crane is 265 feet (81 meters). The 80-foot (24-meter) fiberglass lightning mast tops off the Fixed Service Structure at 347 feet (106 meters).

The Fixed Service Structure has three service arms. They are the Orbiter Access Arm, the External Tank Hydrogen Vent Line Access Arm and the External Tank Gaseous Oxygen Vent Arm.

Orbiter Access Arm: This arm swings out to the crew compartment to provide access for personnel. The outer end of this arm supports a small room, commonly called the "white room." This room can hold up to six persons. The arm mates with the crew hatch to allow the astronauts to be assisted in entering the Space Shuttle. The Orbiter Access Arm remains in the extended position until 7 minutes and 24 seconds prior to launch, to provide an emergency exit for the crew should one be needed. It is 65 feet (19.8 meters) long, 5 feet (1.5 meters) wide, and 8 feet (2.4 meters) high. The Orbiter Access Arm is attached to the Fixed Service Structure at the 147-foot (44.8-meter) level.

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In an emergency, this arm can be mechanically or manually repositioned in about 15 seconds.

External Tank Hydrogen Vent Line Access Arm: This arm allows the mating of the external tank umbilicals to the pad facilities, and provides work access to the tank area. The arm retracts several hours before launch, leaving the umbilicals attached. At the moment the solid rocket boosters ignite, these umbilicals release from the Shuttle and fall back against the tower, where a curtain of sprayed water protects them from engine flame. The External Tank Hydrogen Vent Line Access Arm is 48 feet (14.6 meters) long, and attaches at the 167-foot (51-meter) level. The arm itself rotates 120 degrees to its stowed position in approximately 3 minutes.

External Tank Gaseous Oxygen Vent Arm: This arm swings into position over the Space Shuttle's external tank and lowers a hood, called the beanie cap, over the top of the tank. Heated gaseous nitrogen flows into the hood to warm the liquid oxygen vent system at the top of the external tank. This heating action prevents vapors at the vent opening from condensing into ice that could dislodge and damage the orbiter during launch. The vent system arm is 80 feet (24.4 meters) long, 5 feet (1.5 meters) wide, and 8 feet (2.4 meters) high. The vent hood is 13 feet (4 meters) in diameter. The arm attaches to the Fixed Service Structure between the 207-foot (63-meter) and 227-foot (69-meter) levels. At 2 minutes and 30 seconds before launch, the hood lifts to clear the external tank and the arm retracts into a "latchback" position against the Fixed Service Structure. It can be re-extended in the event of a countdown hold and retracted again at the same point in the countdown.

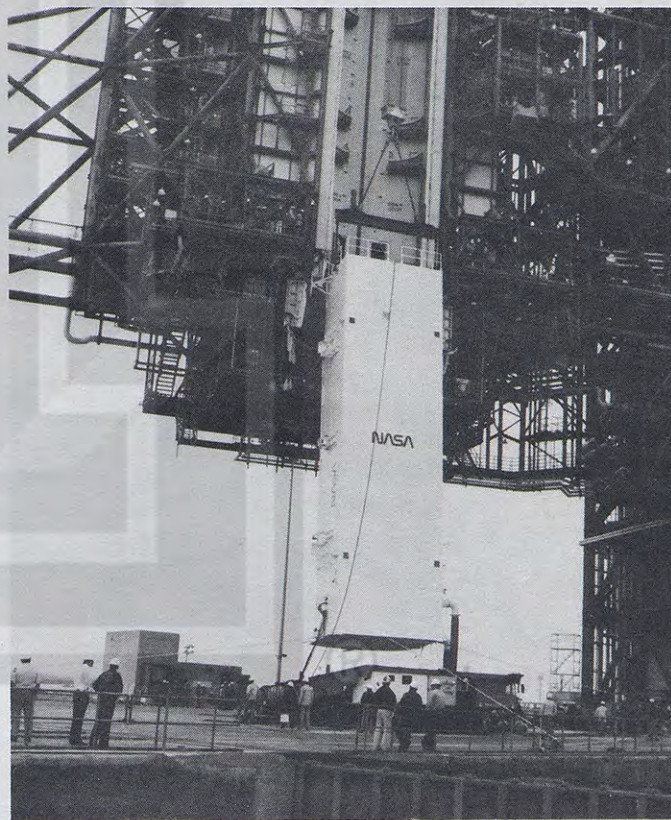
The **Rotating Service Structure** provides protection for the orbiter and access to the cargo bay for installation and servicing of payloads at the pad. It pivots through one-third of a circle, to 120 degrees, from a retracted position well away from the Shuttle to where its payload changeout room doors meet and match the orbiter cargo bay doors. This structure rotates around a vertical hinge attached to one corner of the Fixed Service Structure. The body of the Rotating Service Structure begins at the 59-foot (18-meter) level and extends to 189 feet (57.6 meters) above the pad floor, providing orbiter access platforms at five levels. The hinge and a structural framework on the opposite end support the structure. This framework rests on two eight-wheel, motor-driven trucks, which ride on rails installed within the pad surface. The rotating body is 102 feet (31 meters) long, 50 feet (15 meters) wide, and 130 feet (40 meters) high.

The primary purpose of the Rotating Service Structure is to receive Space Shuttle payloads while in the retracted position, rotate, and install them in the orbiter cargo bay. With the exception of Spacelab and other large payloads, spacecraft are loaded into the Shuttle at the pad. The largest payloads are installed while the orbiter is in the Orbiter Processing Facility. The Payload Changeout Room

in the center of the structure provides an environmentally clean or "white room" condition in which to receive a payload transferred from a protective Payload Canister. Pad personnel maintain this cleanliness level by never exposing the spacecraft to the open air during the transfer operations. A clean-air purge maintains environmental control during cargo operations.

Personnel operate controls to hoist the Payload Canister to the proper elevation in the retracted Rotating Service Structure and lock it into position. The environmental seals in the structure inflate against the sides of the Canister. Clean, temperature- and humidity-controlled air purges the space between the closed doors of the Rotating Service Structure and the Canister. After the purge, the doors may be opened. The payload then transfers from the Canister into the Payload Changeout Room. The Canister and the Rotating Service Structure doors then close, the environmental seal deflates, and the Canister lowers to the Transporter to be taken off the pad. The Rotating Service Structure rolls into position to enclose the orbiter's payload bay, re-establishing the environmental seals and clean air purge. The Payload Changeout Room and payload bay doors open so that the payload may be installed.

Orbiter Midbody Umbilical Unit: This provides access to and permits servicing of the midfuselage area of the orbiter. It extends from the Rotating Service Structure at

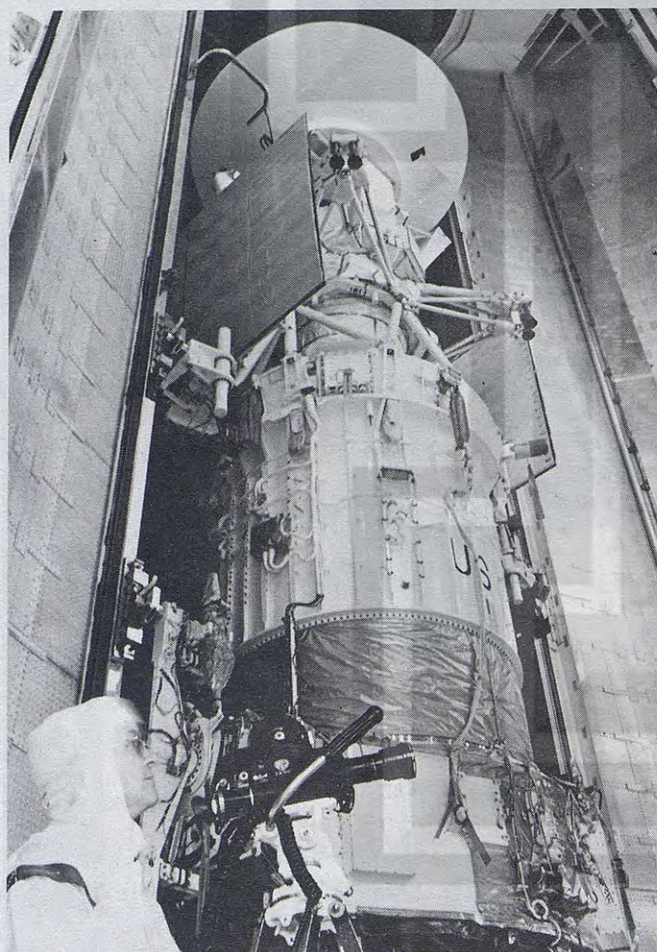


The Payload Canister is lifted from its Transporter into the Rotating Service Structure at the launch pad.

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levels ranging from 158 to 176 feet (48 to 53.6 meters) above the pad surface, and is 22 feet (6.7 meters) long, 13 feet (4 meters) wide, and 20 feet (6 meters) high. A sliding extension platform and a horizontally moving, line-handling mechanism offer access to the midbody umbilical door on the left side of the orbiter. Liquid oxygen and liquid hydrogen for the fuel cells, and gases such as nitrogen and helium, feed through this unit.

Hypergolic Umbilical System: This carries hypergolic fuel and oxidizer, as well as helium and nitrogen service lines, from the Fixed Service Structure to the Space Shuttle. The system also allows rapid connection of the lines to and disconnection of them from the vehicle. Six umbilical handling units, manually operated and controlled at the pad, attach to the Rotating Service Structure. These units are located to the right and left sides of the aft end of the orbiter. They serve the Orbital Maneuvering System and Reaction Control System, as well as the payload bay and the nose area of the orbiter.



Spacecraft are loaded into the Payload Changeout Room at the launch pad after delivery in the Payload Canister. Here, the spacecraft Magellan is prepared for installation at the pad before beginning its journey to Venus.

A Weather Protection System at Pads A and B shields the orbiter from windblown debris, heavy rains and hail that could damage the craft's Thermal Protection System tiles and insulation blankets. The Rotating Service Structure, which closes around the orbiter while on the pad, shields a considerable portion of the vehicle. The Weather Protection System fills the gaps.

Metal doors that slide together between the orbiter's belly and the external tank provide protection for the lower portion of the orbiter. These doors, which measure up to 53 feet (16 meters) long and 38 feet (11.6 meters) tall, weigh up to 46,000 pounds (20,866 kilograms). They connect to the Rotating Service Structure and the Fixed Service Structure. The doors move together from opposite sides on wheeled flanges that ride on steel beams.

An inflatable seal that protects the top of the orbiter extends from the Payload Changeout Room, forming a semicircle covering 90 degrees of arc between the vehicle and the external tank. A series of 20 or more bifold metal doors, about 80 by 4 feet (24.4 by 1.2 meters) in size, fold out from the Payload Changeout Room on the Rotating Service Structure to cover the side areas between the external tank and the orbiter.

The Flame Deflector System protects the vehicle and pad structures from the intense heat of launch. It is located in the ground level flame trench that bisects the hardstand. A flame deflector presents an inverted V-shape to the flames pouring into the trench through the openings in the Mobile Launcher Platform. Both sides of the upside-down V curve out near the bottom until they are almost horizontal. Flames follow these curves and deflect horizontally down the flame trench, rather than bouncing back to envelop the vehicle.

The flame trench divides the hardstand lengthwise from ground level to the pad surface. It is 490 feet (149 meters) long, 58 feet (18 meters) wide, and 40 feet (12 meters) high. At launch, flames shoot out both ends of the trench into the air. The deflector for the Space Shuttle is actually a two-in-one device, where one side of the inverted V receives the flames from the orbiter's main engines, and the opposite side gets the flames from the two solid rocket boosters. It is fixed near the center of the trench and extends completely across it.

The orbiter and booster deflectors are built of steel and covered with an ablative material about 5 inches (12.7 centimeters) thick that flakes off to shed heat. These deflectors weigh over 1 million pounds (453,600 kilograms) each.

In addition to the fixed deflectors, there are two movable ones located at the top of the trench for additional protection from the solid rocket booster flames.

The Slidewire System provides an escape route for the astronauts in the orbiter and closeout crew on the Fixed Service Structure until the final 30 seconds of the countdown. Seven slidewires extend from the Fixed Service

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Structure at the Orbiter Access Arm level, down to the ground. A flat-bottom basket made of steel wire and heat-resistant fiber, surrounded by netting, suspends from the top of each of the seven wires. Each basket can hold up to three persons. The basket slides down a 1,200-foot (366-meter) wire to an emergency shelter bunker located west of the Fixed Service Structure. The descent takes approximately 35 seconds; a braking system using a net and drag chain stops the slowing basket at the bottom.

The **Lightning Mast** extends above the Fixed Service Structure and provides a "cone of protection" over the vehicle and pad structures. A steel cable starts from a ground anchor 1,100 feet (335 meters) south of the Fixed Service Structure, angles up and over the lightning mast, and then extends back down to a second ground anchor the same distance to the north. Lightning strikes run to ground through this cable. The mast functions as an electrical insulator, holding the cable away from the tower. The mast, with its accompanying support structure, lifts the cable 100

feet (30.5 meters) above the steel of the Fixed Service Structure.

A **Sound Suppression Water System** has been installed on the pads to protect the orbiter and its payloads from damage by acoustical energy and rocket exhaust reflected from the flame trench and Mobile Launcher Platform during launch. The Shuttle orbiter, with its payloads in the cargo hold, is much closer to the surface of the Mobile Launcher Platform than the Apollo spacecraft was at the top of a Saturn V or Saturn 1B vehicle.

The Sound Suppression System includes an elevated water tank with a capacity of 300,000 gallons (1,135,620 liters). The tank is 290 feet (88 meters) high and is located adjacent to each pad. The water releases just prior to the ignition of the Shuttle engines, and flows through 7-foot-diameter (2.1-meter) pipes for about 20 seconds. Water pours from 16 nozzles atop the flame defectors and from outlets in the main engines exhaust hole in the Mobile Launcher Platform, starting at T minus 6.6 seconds. By the



Astronauts Robert L. Crippen and John W. Young practice emergency egress procedures in a slidewire basket at the launch pad.



The rainbirds begin to place a cushion of water on the Mobile Launcher Platform to prevent reflection of acoustical energy from the Platform's steel structure. Fresh water stored in an elevated tank flows through a valve network (upper left) to achieve the proper pressure. It flows through the giant pipes to the rainbirds.

time the solid rocket boosters ignite, a torrent of water will be flowing onto the Mobile Launcher Platform from six large quench nozzles, or "rainbirds," mounted on its surface.

The rainbirds are 12 feet (3.7 meters) high. The two in the center are 42 inches (107 centimeters) in diameter; the other four have a 30-inch (76-centimeter) diameter.

The peak rate of flow from all sources is 900,000 gallons (3,406,860 liters) of water per minute at 9 seconds after liftoff.

Acoustical levels reach their peak when the Space Shuttle is about 300 feet (91 meters) above the Platform, and cease to be a problem at an altitude of about 1,000 feet (305 meters).

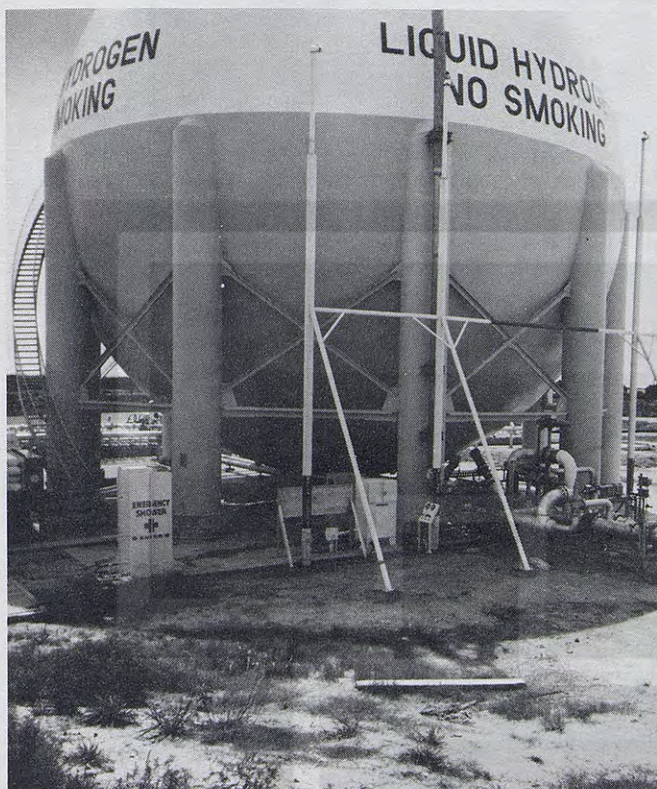
Solid Rocket Booster Overpressure Suppression System: This is part of the Sound Suppression Water System. It alleviates the effect of a reflected pressure pulse which occurs at booster ignition. Without the suppression system, this pressure would exert significant forces on the wings and control surfaces of the orbiter.

There are two primary components to this acoustic energy suppression system. A water spray system provides a cushion of water which is directed into the flame hole directly beneath each booster. A series of water bags

stretched across the flame holes, providing a water mass to dampen the reflected pressure pulse, supplements this effort. Used together, this water barrier blocks the path of the reflected pressure wave from the boosters, greatly decreasing its intensity.

In the event of an aborted mission, a Post-Shutdown Engine Deluge System will cool the aft end of the orbiter. It also controls the burning of residual hydrogen gas after the Shuttle's main engines have been shut down with the vehicle on the pad. There are 22 nozzles around the exhaust hole for the main engines within the Mobile Launcher Platform. Fed by a 6-inch-diameter (15-centimeter) supply line, water flows at a rate up to 2,500 gallons (9,463.5 liters) per minute.

Main Engine Hydrogen Burnoff System: Hydrogen vapors which occur during the main engine start sequence expel into the engine nozzles just before ignition. This action results in a hydrogen-rich atmosphere in the engine bells. To prevent damage to the engines, six hydrogen burnoff pre-igniters have been installed in the Tail Service Mast. Just before main engine ignition, the pre-igniters activate. They then ignite any free hydrogen in the area below the engine bells. This avoids rough combustion at main engine start.



A large round container which is actually a huge vacuum bottle stores the supercold liquid hydrogen at the launch pad. A similar round vessel holds the liquid oxygen. The liquid propellants flow to the orbiter's main engines.

The **Propellant Storage Facilities** are located at both pads. A 900,000-gallon (3,406,860-liter) tank situated at the northwest corner of each launch pad stores the liquid oxygen, which is used as an oxidizer by the orbiter's main engines. These ball-shaped vessels are actually huge vacuum bottles. They maintain the supercold liquid oxygen at temperatures of minus 297 degrees Fahrenheit (minus 183 degrees Celsius). Two pumps which supply 1,200 gallons (4,540 liters) of oxidizer per minute each transfer the liquid oxygen from the storage tank to the orbiter's external tank.

Similar 850,000-gallon (3,217,590-liter) vacuum bottles at the northeast corner of the pads store the liquid hydrogen for the orbiter's main engines. Pumps are not required to move the liquid hydrogen from the storage tank to the orbiter's external tank during fueling operations. First, a small amount of liquid hydrogen vaporizes. This action creates a gas pressure in the top of the tank that moves the extremely light fuel through the transfer lines.

The vacuum-jacketed transfer lines carry the supercold propellants to the Mobile Launcher Platform, where they feed through the orbiter into the external tank through the Tail Service Masts.

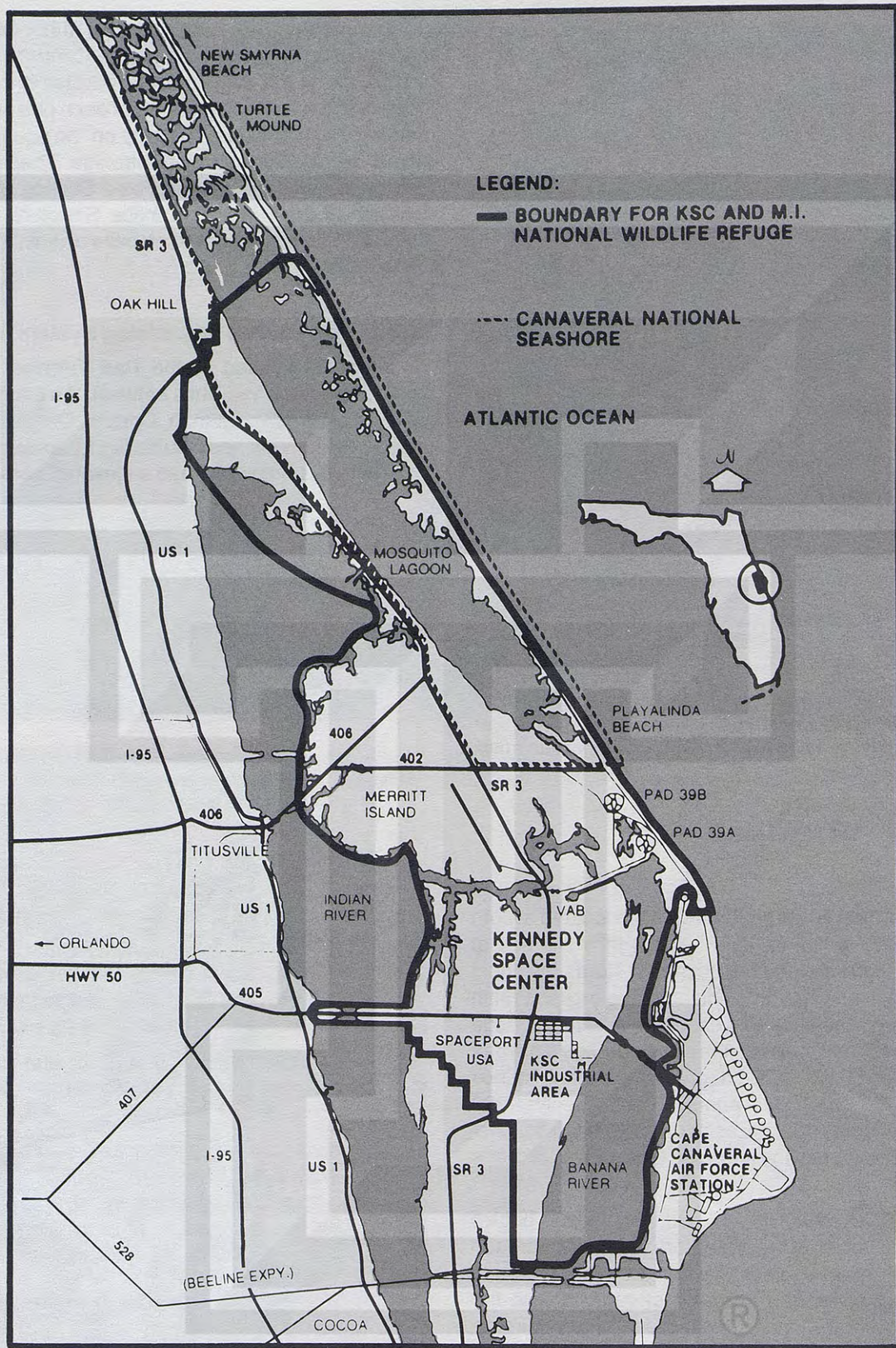
Hypergolic propellants used by the orbiter's Orbital Maneuvering Engines and Attitude Control Thrusters are also stored at the pad in well-separated areas. A facility located on the southeast corner of each pad holds the fuel, monomethyl hydrazine. A facility on the southwest corner stores the oxidizer, nitrogen tetroxide. These propellants feed by transfer lines to the Fixed Service Structure and continue to the Rotating Service Structure's Hypergolic Umbilical System, with its three pairs of umbilicals attached to the orbiter.

Launch Pad/Launch Processing System Interface

Elements located in the Pad Terminal Connection Room provide the vital links between the Launch Processing System in the Launch Control Center, the ground support equipment, and Shuttle flight hardware at the pad. This room lies below the pad's elevated hardstand.



Each side of the orbiter at the launch pad is connected to a Tail Service Mast, center foreground. The Mast provides propellant-loading umbilicals and establishes connections to ground support equipment.



NASA

National Aeronautics and
Space Administration

John F. Kennedy Space Center

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NASA Facts

National Aeronautics and
Space Administration

John F. Kennedy Space Center
Kennedy Space Center, Florida 32899
AC 407 867-2468



KSC Release No. 92-131
February 1993

KSC and Space-Related Area Attractions

The following is a listing of visitor facilities on Kennedy Space Center or nearby that are related to space exploration.

Spaceport USA

Kennedy Space Center, FL 32899
(407) 452-2121

Exploration Station: (407) 867-2959

Educators Resources Laboratory: (407) 867-4090

Spaceport USA is the KSC visitors center, operated for NASA by concessioner TW Recreational Services. It is located on NASA property, on the NASA Parkway West between the KSC Industrial Area and U.S. 1 on the mainland. The origins of a visitors center for KSC date back to the 1960s when public curiosity about the space program mushroomed. At first, only drive-through tours were permitted, but as interest continued to mount, the need for a permanent visitors center became clear. A site was selected in the mid-1960s, and in August 1967 the first official visitors center was opened. Since then it has undergone a number of expansions and upgrades.

Spaceport USA features a wide variety of exhibits and activities related to the space program, including guided bus tours of KSC and Cape Canaveral Air Force Station. Two IMAX movies, shown on a 50-by-70-foot screen in the IMAX theater, incorporate footage shot by Shuttle astronauts. "The Dream is Alive" allows the viewer to experience the sights and sounds of a Shuttle liftoff, while "The Blue Planet" takes a look at Planet Earth. A second IMAX theater is set to open in 1993.

A Space Station Freedom exhibit is located nearby with a full-scale model depicting living and laboratory quarters aboard Freedom, complete with experiment setups and a crew shower. "Satellites and You" is a 45-minute exhibit that incorporates animatronics and audiovisual effects to show how satellites affect daily life. The Rocket Garden and outdoor exhibits contain authentic rockets and spacecraft. A full-scale model of a Space Shuttle orbiter, featuring a walk-through exhibit of the crew compartment and cargo bay, is under construction and scheduled to open in late 1993. A moon rock and other historical exhibits on human space flight are on display in the Gallery of Space Flight exhibit hall.

On the educational side, the Educators Resources Laboratory at Spaceport USA was established for professional teachers. It has extensive facilities to aid educators in the preparation of aerospace-related teaching materials. For students, there is the Exploration Station, featuring hands-on science demonstrations. These programs will be expanded in a new Center for Space Education being built by the Astronauts Memorial Foundation Inc.

Admission to Spaceport USA is free. There is a nominal charge for the bus tours and the IMAX films. Reservations are required for large groups wishing to take the bus tour, for student visits to the Exploration Station, and for large groups of teachers planning to use the Educators Resources Laboratory.

Hours: Spaceport USA is open every day of the year except Christmas. It opens at 9 a.m.; closing time will vary depending on the time of year; typically it is later in the summer. Launch day opening and closing times vary depending on the mission; visitors should call ahead for information.

Astronauts Memorial (Space Mirror)

Spaceport USA,
Kennedy Space Center

Built and operated by:
Astronauts Memorial Foundation Inc.
Mail Code: AMF
Kennedy Space Center, FL 32899
(407) 268-0272

Also located at Spaceport USA is the Astronauts Memorial, or Space Mirror. The 42.5-foot-high by 50-foot-wide monument was constructed by a non-profit foundation, the Astronauts Memorial Foundation, on 6 acres of land provided by NASA at Spaceport USA. Engraved on the mirror-finished black granite surface of the memorial are the names of those American astronauts who have given their lives to the quest to explore space. A moving base supporting the mirror rotates on track with the sun, allowing sunlight to reflect through the astronauts' names and appearing to

emblazon them against the sky. The Astronauts Memorial Foundation built the memorial primarily with funds raised from the sale of Challenger license plates in Florida. The foundation also plans to build a Center for Space Education adjacent to the visitors center. This is envisioned as a "living memorial" that will expand existing educational programs at KSC into a world-class center for space education.

Hours: Hours for the Space Mirror are the same as for Spaceport USA.

Astronaut Hall of Fame

(407) 269-6100

U.S. SPACE CAMP Florida

(407) 267-3184

Both are located at:
6225 Vectorspace Blvd.
Titusville, FL 32780-8040

Space education programs varying from a few hours' visit, an overnight stay, a weekend trip to a five-day training session are offered in a joint venture of the U.S. Astronaut Hall of Fame and U.S. SPACE CAMP Florida.

The programs are headquartered in the combined facilities at 6225 Vectorspace Blvd., Titusville, off the NASA Causeway (State Road 405), just west of the entrance to Kennedy Space Center.

One of the most well-known SPACE CAMP programs introduces students to space sciences and exploration in a five-day session of mostly hands-on activities, including propulsion exercises and astronaut training on simulators in the Training Center, as well as classroom instruction. The program culminates in a simulated Space Shuttle mission. A tour of NASA's rocket garden in nearby Spaceport USA is part of a segment on assembling and launching model rockets. The Florida program is designed for students in grades 4-7.

SPACE CAMP participants as well as day visitors to the facilities are invited to enter the U.S. Astronaut Hall of Fame which follows the lives of America's first astronauts, the Mercury 7, from their days as astronaut candidates through their historic missions in space. Videotapes of flights and interviews are shown at individual displays which also feature personal memorabilia. The 13 astronauts who flew on Project Gemini, the next phase of the manned space program, are slated for induction into the Astronaut Hall of Fame in 1993. Memorabilia of the Gemini flights also will be on display.

The "Shuttle To Tomorrow" exhibit outside the main building is a full-scale replica of a Space Shuttle orbiter in which visitors experience a multi-screen video show with a 3-D sound system. The astronaut "adventure" includes the rumble of liftoff and a simulated space walk.

The first U.S. SPACE CAMP was established in 1982 in Huntsville, AL. The Florida camp opened in 1988 under the sponsorship of the U.S. Space Camp Foundation and the Mercury Seven Foundation, two non-profit educational organizations which encourage young people to pursue science, math and high-technology studies.

Six of the original Mercury astronauts, and Betty Grissom, widow of the seventh, Virgil "Gus" Grissom, oversee the Mercury Seven Foundation which, in partnership with the Space Camp Foundation, operate the Astronaut Hall of Fame. The Mercury Seven Foundation also provides college scholarships in all areas of science and technology.

Besides the five-day camp for youths, there is a Friday-Sunday camp in Florida for parents and their children ages 7-11. Also, professional educators can attend a five-day space academy specially designed to assist teachers in motivating students toward greater achievements in math and science through the excitement of space exploration. Lodging and meals are provided on-site for the camp or field trip programs.

Special field trip programs available to students in grades 3-12 are:

- SPACE CAMP Action Tour is an approximately three-hour session designed to introduce students to space science.
- The Space Exploration Merit Badge Weekend for Scout troops completes the requirements for the Space Exploration Merit Badge during the two-night stay.
- Blue Sky Below My Feet Weekend participants receive a 4-H Club "Blue Sky" certificate after completion of the weekend program.
- Outerspace Tour is designed to introduce students to space exploration through an overnight stay.
- Final Frontier program, billed as "a complete Space Coast adventure," requires a two-night stay.

Hours: The facilities are open to visitors seven days a week from 9 a.m. to 5 p.m., closing only on Christmas Day. The hours may vary according to the season. The nominal admission charge covers a visit to the U.S. Astronaut Hall of Fame and the show in the Shuttle orbiter replica. The cost varies for the camp programs and field trips.

Merritt Island National Wildlife Refuge & Canaveral National Seashore

Kennedy Space Center

Refuge information:

Refuge Manager, Merritt Island National Wildlife Refuge
P.O. Box 6504
Titusville, FL 32782
(407) 861-0667

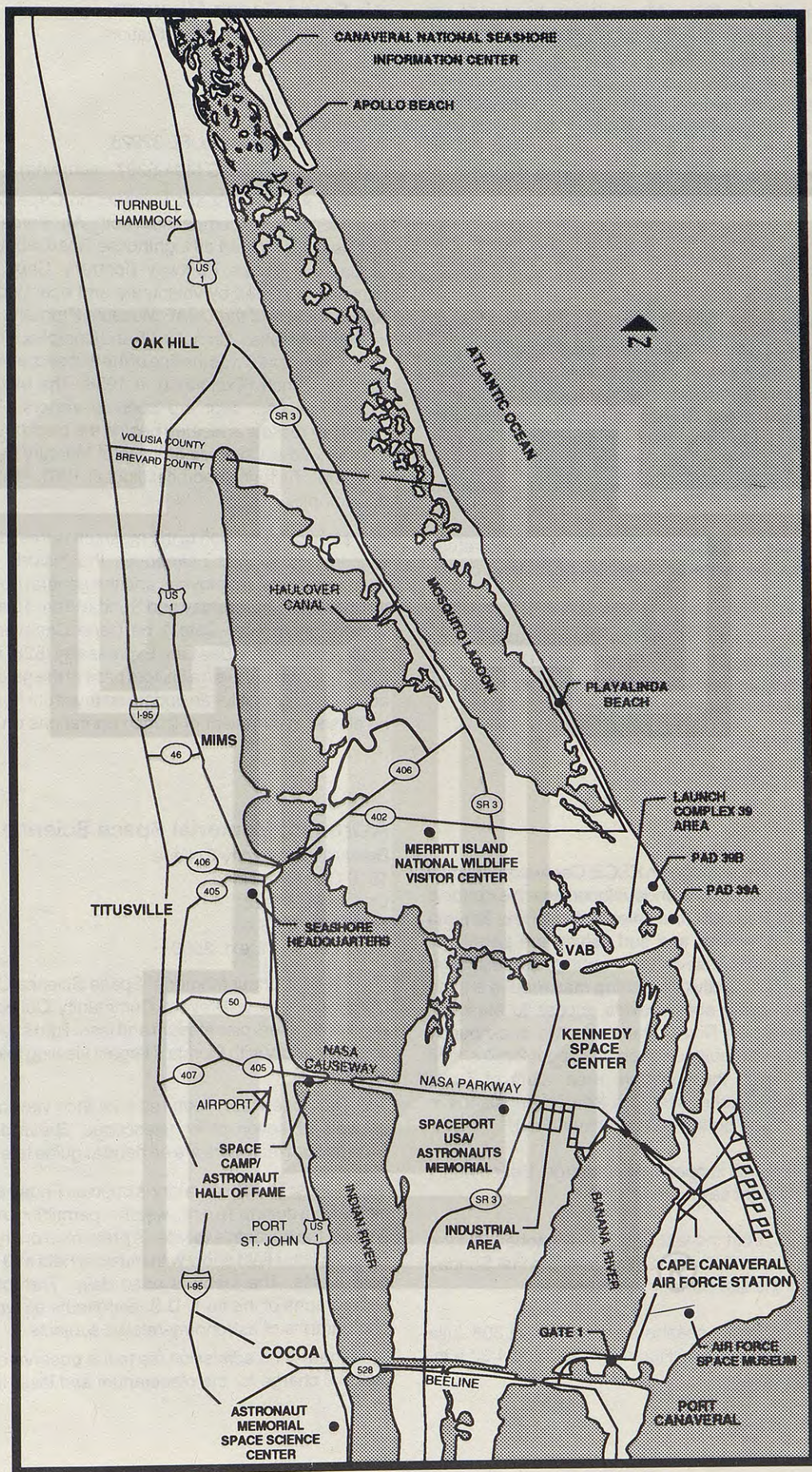
Seashore information:

Canaveral National Seashore Headquarters
308 Julia St.
Titusville, FL 32796-3521

Seashore Headquarters (Titusville): (407) 267-1110

Seashore Visitor Information Center (New Smyrna): (904) 428-3384

Much of the 140,000 acres comprising KSC is a wildlife refuge. Launch pads, as well as facilities where hazardous rocket propellants are processed, must be located well away from inhabited areas. When KSC was first established,



NASA bought all of northern Merritt Island to provide the needed isolation, leaving huge tracts of undeveloped land in their natural condition. In 1963, in cooperation with NASA, the U.S. Fish and Wildlife Service established the Merritt Island National Wildlife Refuge. Canaveral National Seashore was created in 1975 and is managed by the National Park Service. The refuge is one of the finest in the United States, while the seashore boasts the last extended stretch of undeveloped beach on Florida's east coast.

Refuge:

Refuge headquarters and a visitor information center are located on KSC, on SR 402 four miles east of Titusville. Talks, exhibits and walks are offered on a seasonal basis. There are several self-guided walking trails and one driving trail on the refuge. Each Christmas the Audubon Society conducts a count of the abundant bird population, many of which have migrated from points north. Fishing and duck hunting are permitted in season in certain areas; restrictions apply.

Hours: There is no charge for visiting either the refuge or visitor information center. Hours vary depending on the time of year:

- Refuge visitors center: November through April, 8 a.m.-4:30 p.m., Monday through Friday, and 9 a.m.-5 p.m. Saturday and Sunday. May through October, hours are same as above, except closed Sundays.
- Refuge: Open during daylight hours.

Seashore:

Co-located with the refuge on KSC is Canaveral National Seashore, a pristine stretch of undeveloped beach extending from just north of Pad 39B to a little south of New Smyrna Beach. Swimming, surfing and surf fishing are permitted. There are no lifeguards. Elsewhere, crabbing, clamming and shrimping are popular activities; fishing may require a state license. Boat-launching sites provide access to Mosquito Lagoon and the Indian River. There are two backcountry campsites along a self-guided canoe trail about 2 miles long which circles through the seashore area south of Turtle Mound. Other backcountry sites are located on islands in Mosquito Lagoon and on the beach (winter only).

Hours: The beach is open free of charge. Beach hours match up with daylight saving time:

- 8 a.m.-6 p.m., from the last Sunday in October until the first Sunday in April; 6 a.m.-8 p.m. from the first Sunday in April until the last Sunday in October.

Headquarters for the seashore are located at 308 Julia Street in downtown Titusville. Hours are 8 a.m. to 4:30 p.m. Monday through Friday.

Air Force Space Museum

Cape Canaveral Air Force Station

For information:

Museum Curator

45 SPW/PAC

Patrick Air Force Base, FL 32925

Call (407) 494-NEWS (494-6397, recording)

The Air Force Space Museum on Cape Canaveral Air Force Station encompasses both Air Force and NASA facilities. It is located off Lighthouse Road, about 1 mile east of Samuel Phillips Parkway (formerly Cape Road). The museum is staffed by volunteers and operated by the 45th Space Wing and the USAF Museum Program. Two historic launch complexes, Complex 26 and Complex 5/6, are located here. Complex 26 was the site of the first successful American satellite launch (Explorer I) in 1958. The blockhouse and exhibit hall next door are open to visitors. An extensive display of rockets is located behind the blockhouse. South of Complex 26 is Complex 5/6, site of Mercury astronaut Alan Shepard's historic suborbital flight in 1961. NASA oversees this complex.

Hours: Admission to the museum is free; donations are welcome to support upkeep on the historic rockets and launch facilities. Employees and the general public may visit the museum on Saturday and Sunday from 10 a.m. to 4 p.m. Visitors must enter Gate 1 on Cape Canaveral Air Force Station north of the Bee Line Expressway (528) and Highway A1A. They will be given a visitors pass at the gate. Visitors are advised to call first for an update on museum hours, as it may be closed in the event of launch operations on the Cape.

Astronaut Memorial Space Science Center

Brevard Community College

1519 Clearlake Road

Cocoa, FL 32922

(407) 631-7889 or

(407) 632-1111, ext. 3500

The Astronaut Memorial Space Science Center on the Cocoa campus of Brevard Community College (BCC) on weekends offers planetarium and laser light shows as well as an observatory with Florida's largest viewing telescope open to the public.

The observatory features a 24-inch viewing telescope, as well as seven other telescopes. Brevard Community College staff members are on hand to guide telescope users.

Hours: The observatory is open on Friday and Saturday nights from dusk to 10 p.m., weather permitting. A planetarium show in the building's theater is presented on those nights at 8 p.m. A laser light show with music is held at 9 and 10 p.m., both nights. The lobby is open daily. The lobby displays photographs of the early U.S. astronauts as well as original photographs of astronomy-related subjects.

There is no admission fee to the observatory; there is a nominal charge for the planetarium and laser light shows.

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*

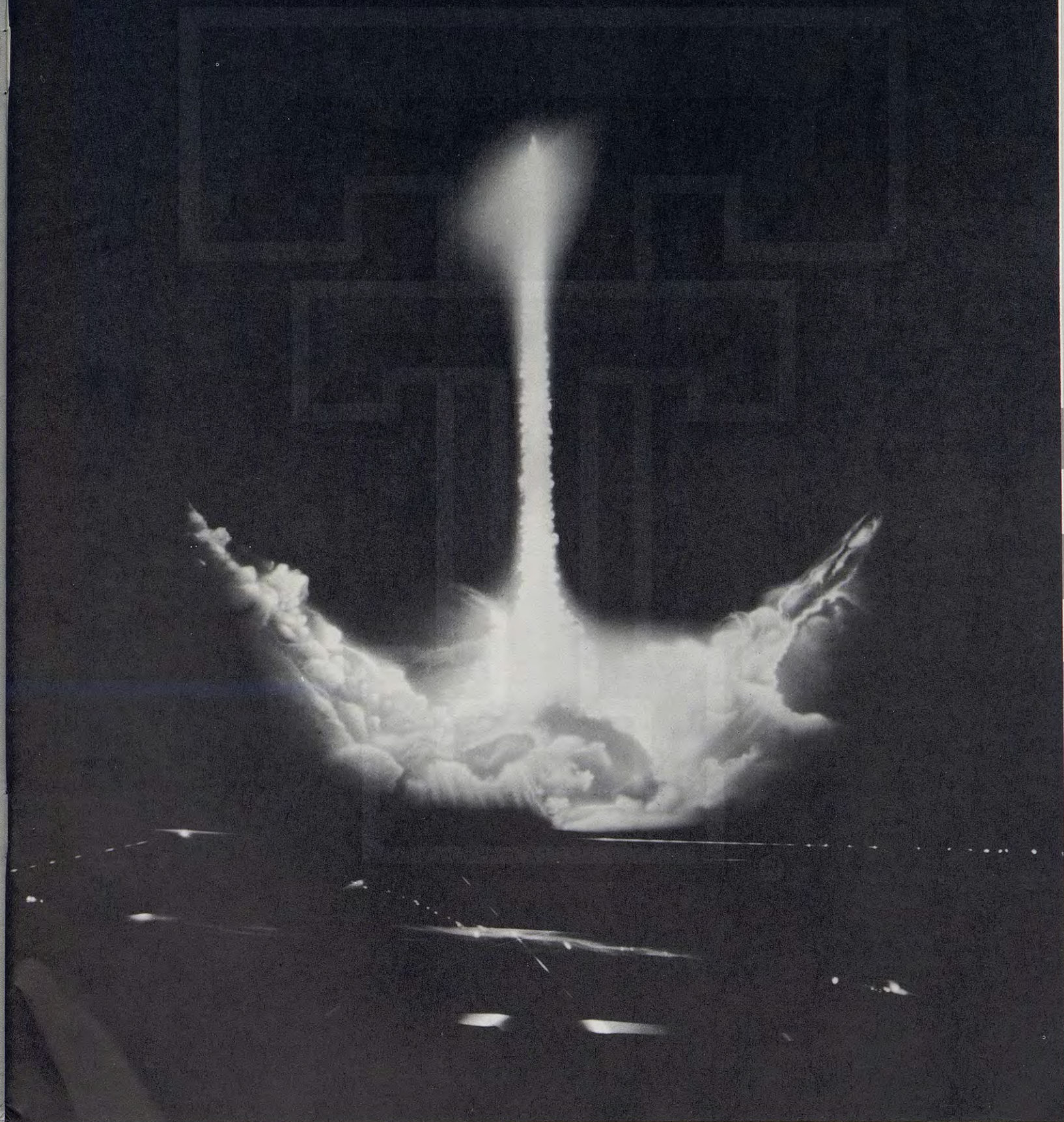
**Paintings courtesy of
Nasa Art Program**

Opposite page

Andreas Nottebohm
First Nighi Launch STS-8
Acrylic

America's Spaceport

John F. Kennedy Space Center



Origins

The John F. Kennedy Space Center . . . America's Spaceport . . . is the doorway to outer space. From its unique facilities, men 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 modern man erected his 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 area was home to the fierce and often cannibalistic Ais and Timucuan Indians. By the middle 1800's, these aboriginal tribes had virtually disappeared, the victims of internal strife, disease and conflict with a new and formidable foe — light-skinned people who came from across the open waters to the east in huge canoes with white wings.

These were the European explorers who came in search of eternal youth, wealth, territory and religious freedom — 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.

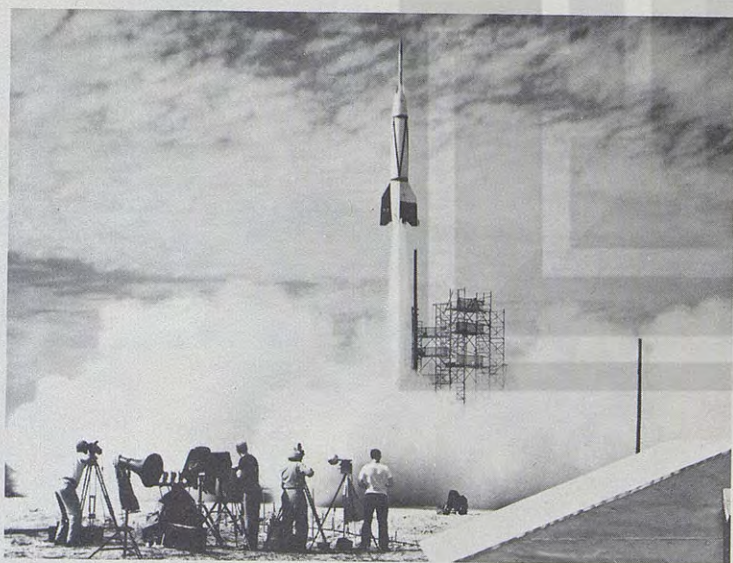
Against this backdrop, permanent settlement of the Spaceport area began. And in the years following the American Civil War, small rural towns and communities sprang up along a 70-mile-long stretch of mainland, rivers and

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 Air Force Eastern Test Range), a vast overwater military rocket test range that now extends 5,000 miles down the Atlantic from Cape Canaveral to Ascension Island.

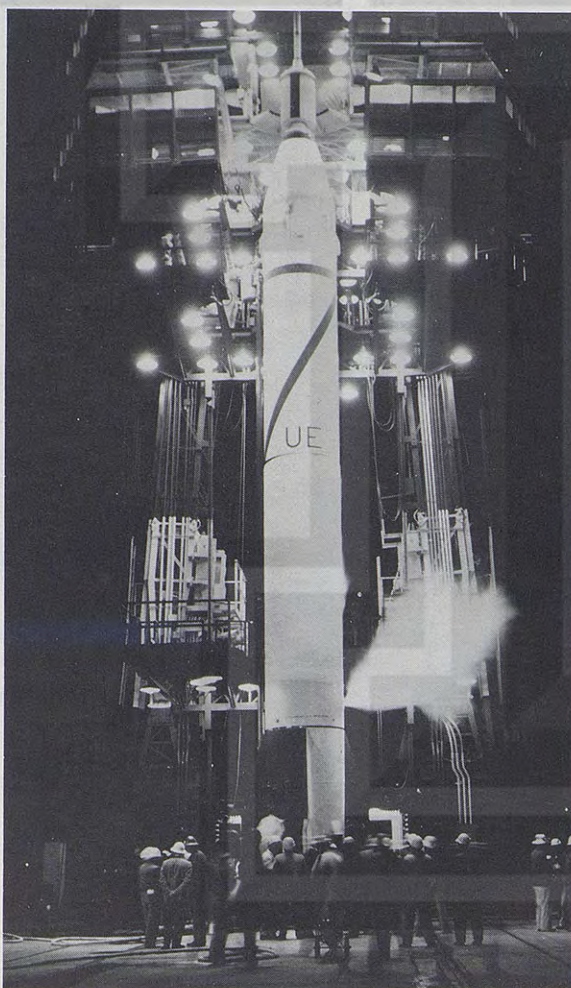
The Cape was ideal for testing missiles. Virtually uninhabited, it enabled personnel to inspect, fuel and launch missiles without danger to nearby communities. The area's climate also permitted year-round operations, and rockets could be launched over water instead of populated areas. The first launch 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.



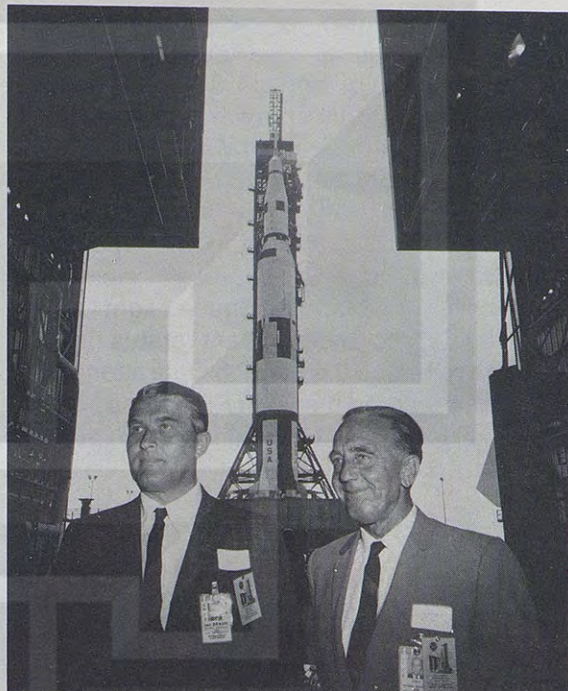
The first launch from Cape Canaveral — July 24, 1950. The modified German V-2 rocket attained an altitude of 10 miles. Note the primitive facilities. A tarpaper shack served as a blockhouse. The pad service structure was made from painters scaffolding.

Origins

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 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.

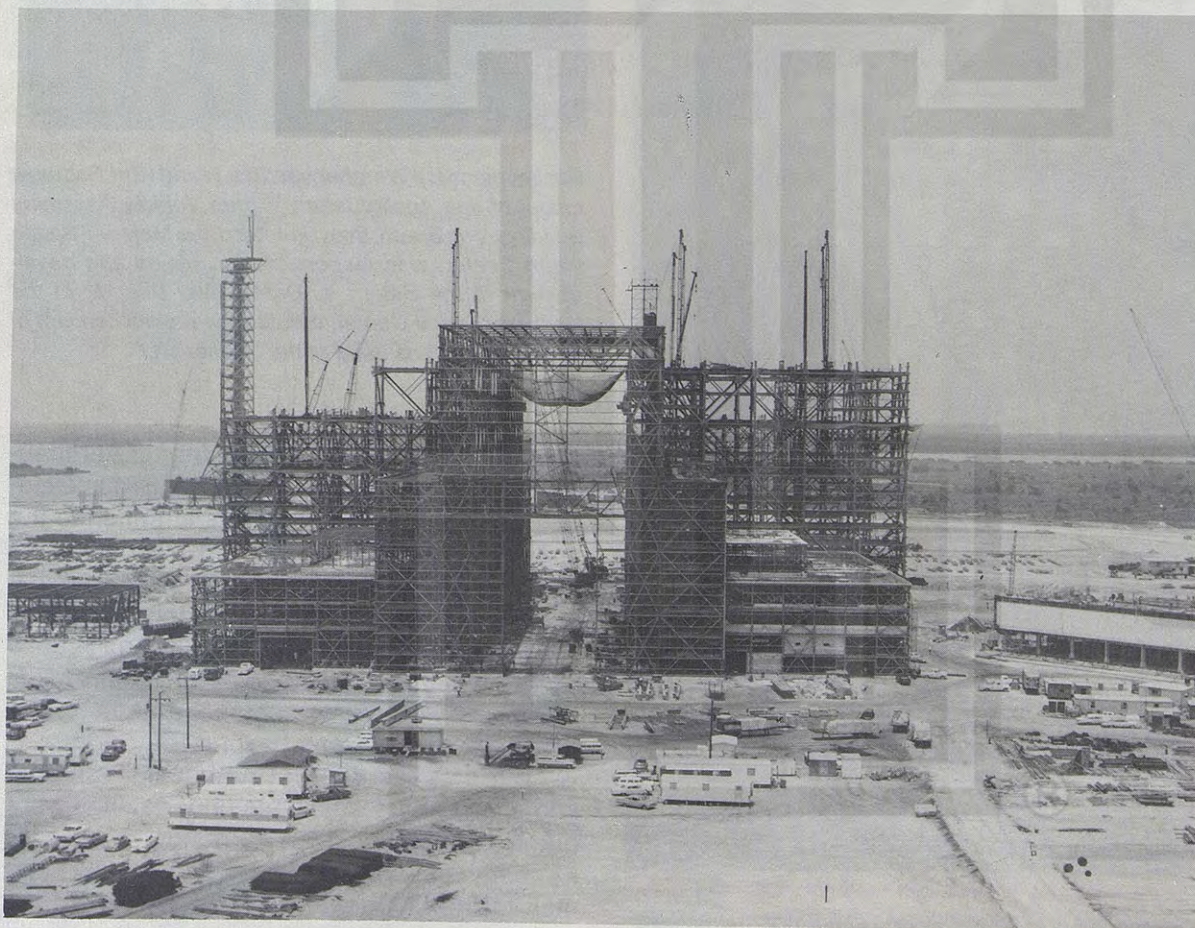
But even as the first Americans ventured into space, more ambitious undertakings were planned. In May 1961, President John F. Kennedy announced that the U.S. would send men to the Moon and back by the end of the decade. The program, called Apollo, would require the largest rocket ever built — the 363-foot-tall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

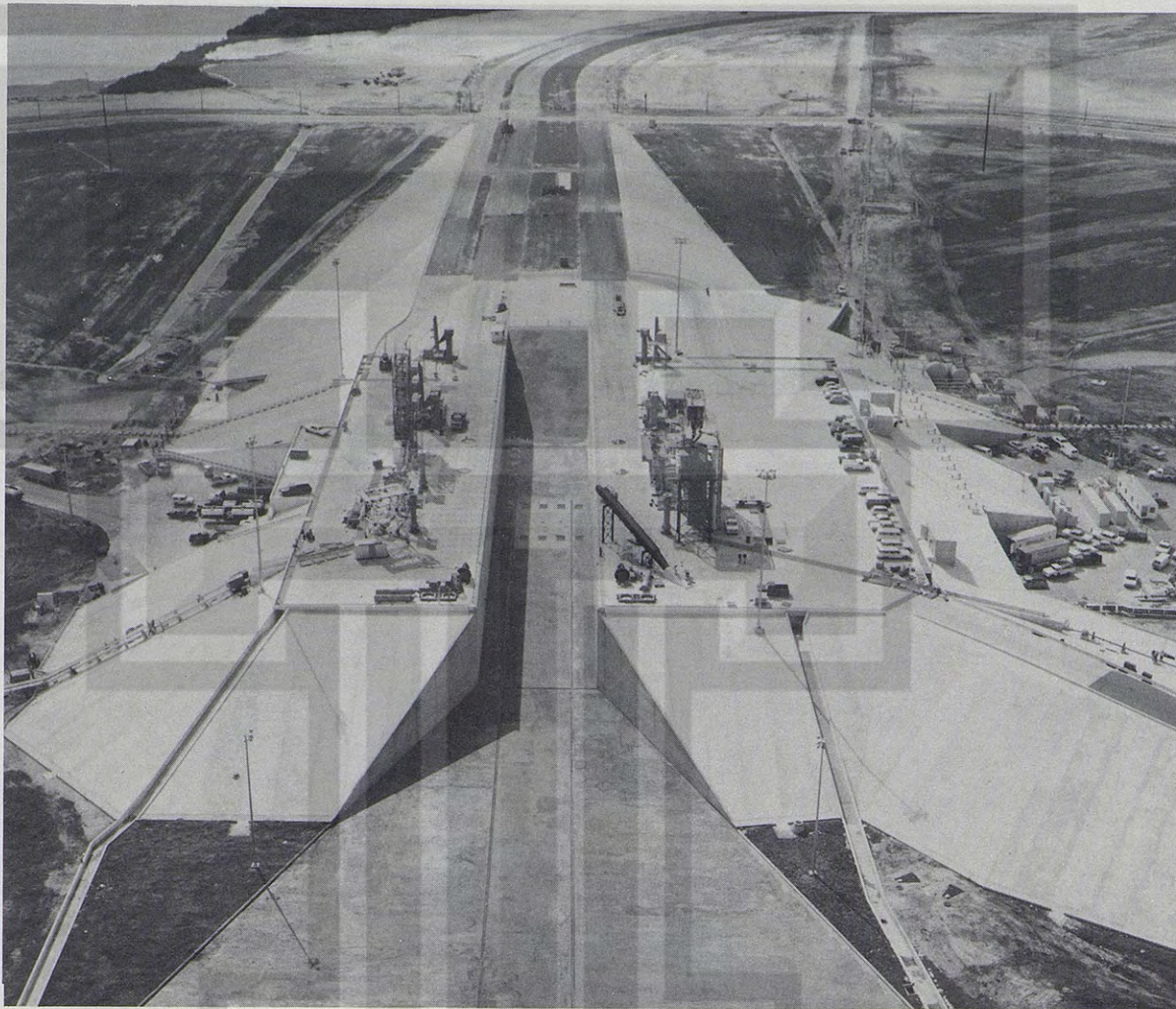
And so it is today. Kennedy Space Center . . . America's Spaceport . . . has become the "gateway to the universe," home port for voyages of exploration undreamed of centuries ago — manned by men and women who, like their forebears, still dream of discovering and settling new worlds.



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. At left rear is one of three Mobile Launcher Platforms built to carry Apollo/Saturn V moon rockets.

Origins



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 and direction of

the U. S. Air Force. NASA no longer launches any unmanned space vehicles except the comparatively small and inexpensive Scout.

Cargoes destined for space — whether a planetary explorer to survey Jupiter and Saturn, a communications satellite for a private firm, 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 Vandenberg AFB at the Western Test Range in California, and supported Air Force launch activities there.

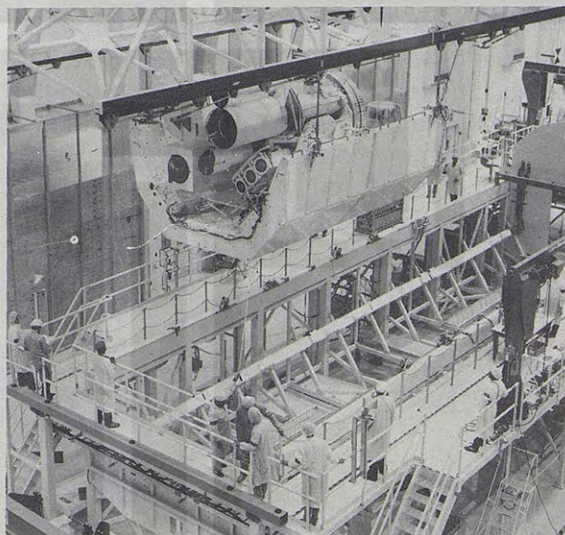




A Delta rocket lifts off from Complex 17, Cape Canaveral. The workhorse of the nation's space program while under NASA, Delta orbited more scientific, weather and communications satellites than all other vehicles of its class combined.

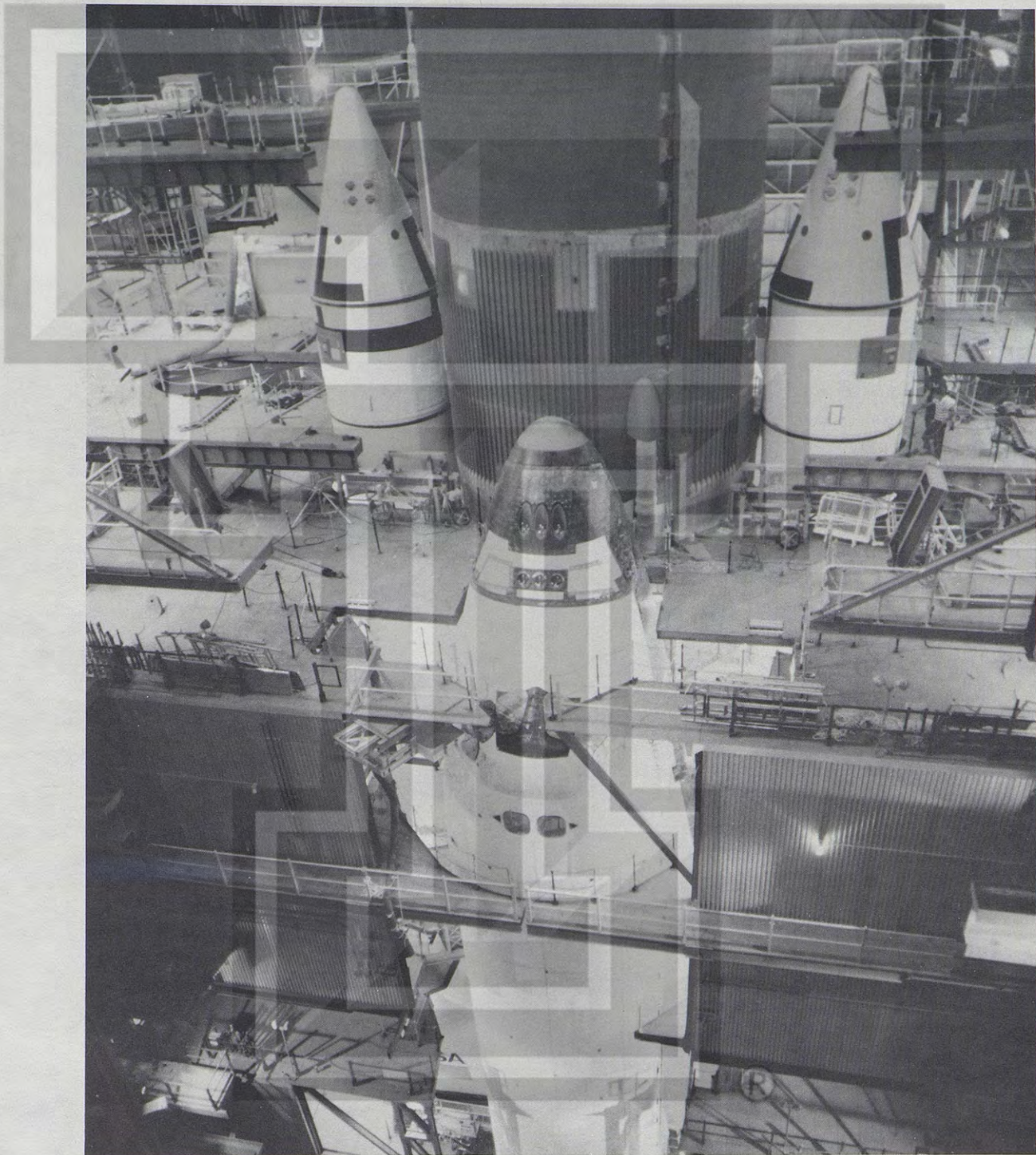
The history of the Kennedy Space Center is a chronicle of the Space Age, written in the blinding glare and thunder of rockets and space vehicles. Its distinguished record of achievement in the development and conduct of space vehicle checkout and launch operations is unmatched.

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.

Mission



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, from 1958 through 1989, the Spaceport team also launched more than 300 unmanned space vehicles, primarily Del-tas, Atlas-Centaur, Atlas-Agenas, and Titan-Centaur. These lifted off from NASA-operated facilities on Cape Canaveral Air Force Station and Vandenberg AFB.

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 workforce of (in

round numbers) about 2,600 KSC Civil Service employees, plus about 50 NASA personnel from other Centers, and close to 14,000 contractor personnel who work for private companies under contract to NASA. The largest contractor organization handles Shuttle processing and launch operations. The second largest provides maintenance and support for the Center itself, while the third helps customers prepare 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



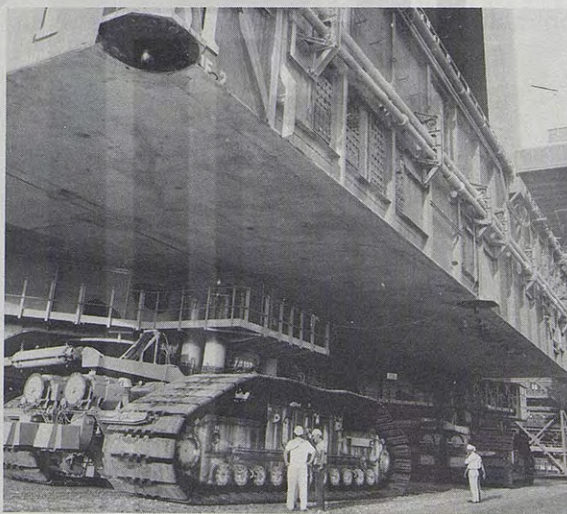
in the world; the Orbiter Processing Facility, filled with complicated equipment used to prepare Shuttle orbiters for flight; Pads 39A and 39B, from which Shuttles lift off; NASA-operated Space Shuttle support and spacecraft checkout facilities on Cape Canaveral; and a host of other processing and support 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



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.

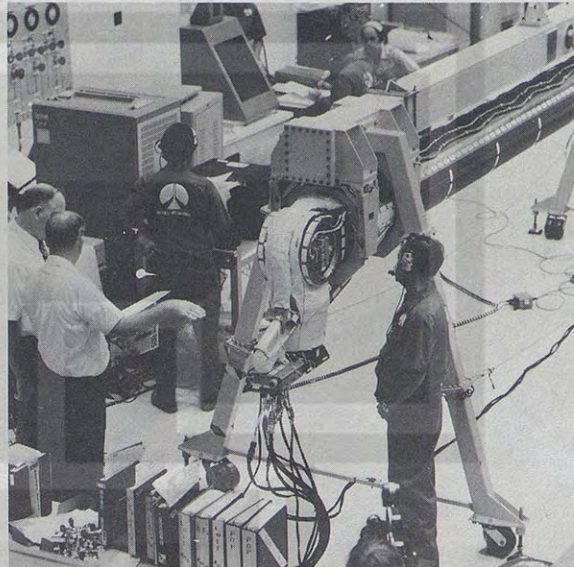
People and Facilities

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.

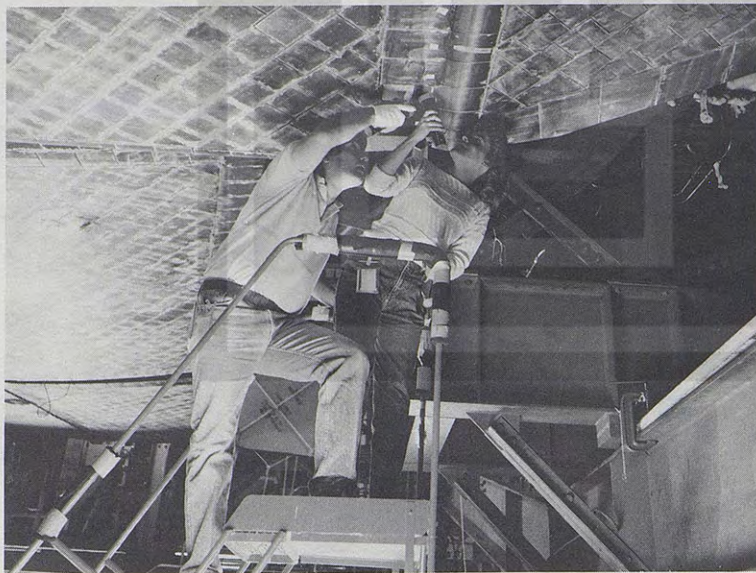
Many Spaceport professionals deal with more routine matters, such as designing and overseeing the construction of office or supply buildings, setting up and operating computer systems, or performing materials and structures tests.

The engineering departments do their work along with other groups that might be found at any industrial facility. Several logistics organizations order supplies and keep them available in warehouses. Another operates a facility-wide bus system and supplies vehicles for local use. Writing and graphics departments produce a variety of publications. A local printshop prints them. 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.

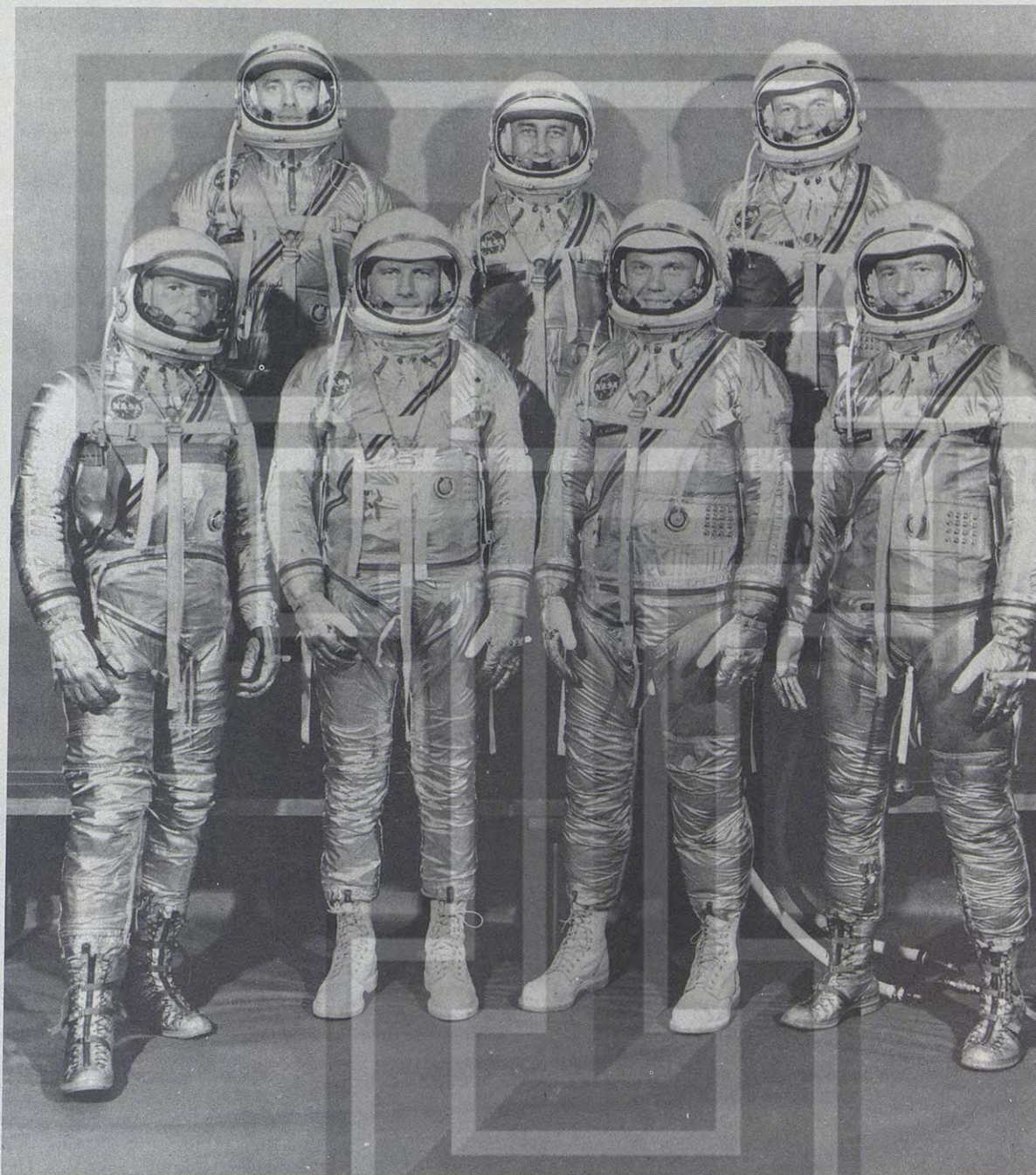
Manned Flight - The First Era

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 manned 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 re-examined. 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 some 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 manned spaceflight, 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;

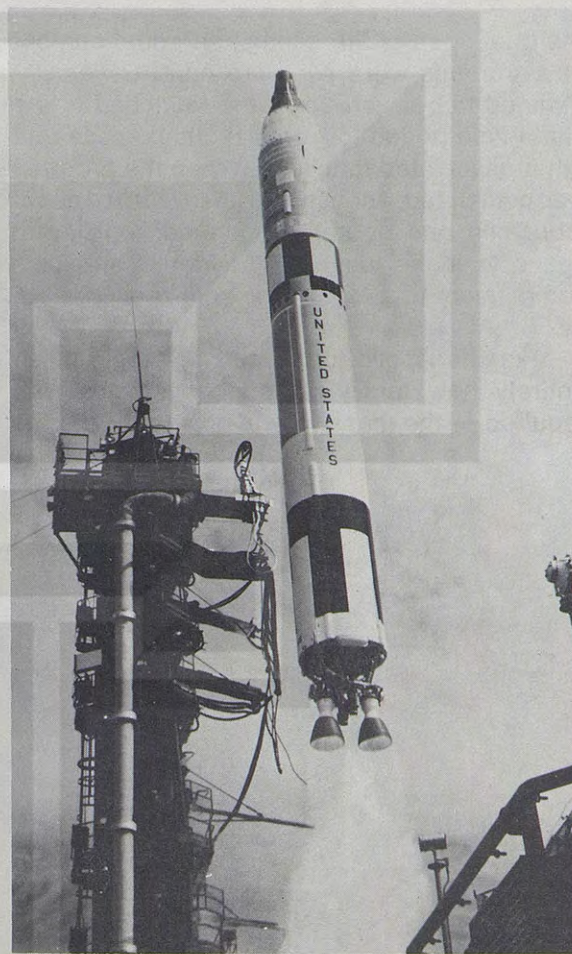
John H. Glenn, Jr.; and Scott Carpenter; (back), Alan B. Shepard, Jr.; Virgil I. "Gus" Grissom; and L. Gordon Cooper.

Manned Flight - The First Era

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 manned 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.

For the Apollo lunar landing program, an entirely new family of launch vehicles was required — the massive and powerful Saturns.



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.

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.

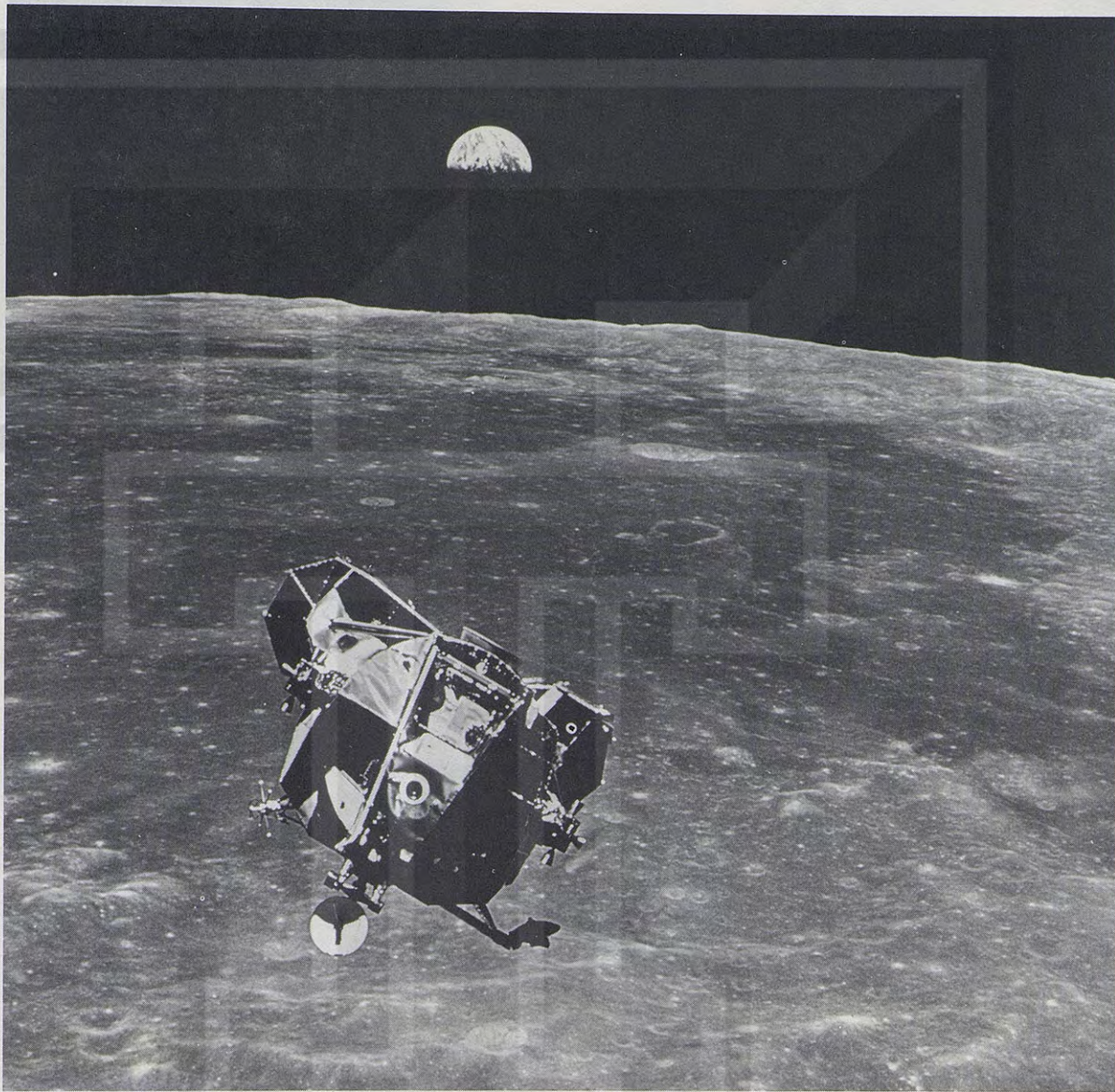
On November 9, 1967, the first Saturn V - 363 feet tall, and still the largest vehicle ever flown - was launched on a test flight from Complex 39 at the Spaceport. This powerful three-stage vehicle produced more than seven-and-one-half million pounds of thrust, equal to about 180 million horsepower -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

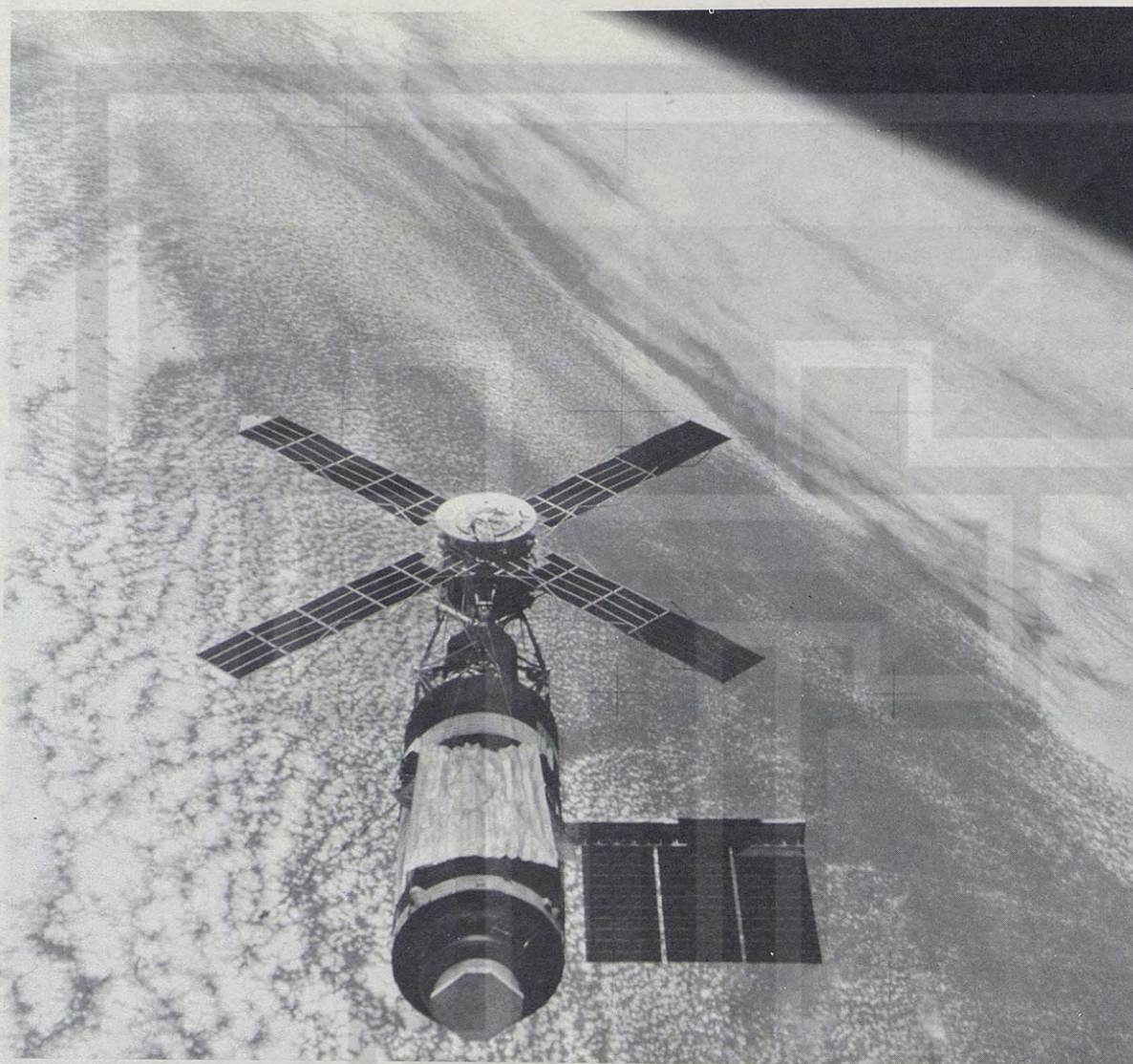
Manned Flight - The First Era



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 the records of mankind as the greatest and most far-reaching feat of scientific exploration in all human history.

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 the precursor to an American 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

Manned Flight - The First Era

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.

Skylab was launched unmanned. The Kennedy team later sent up three separate crews of astronauts to occupy it. They were transported by Apollo/Saturn 1B 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, a total time in microgravity that still has not been equalled by any other American astronauts.

One last mission remained to be flown before America entered a long hiatus of manned 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 remains the only such international meeting in space to date.

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

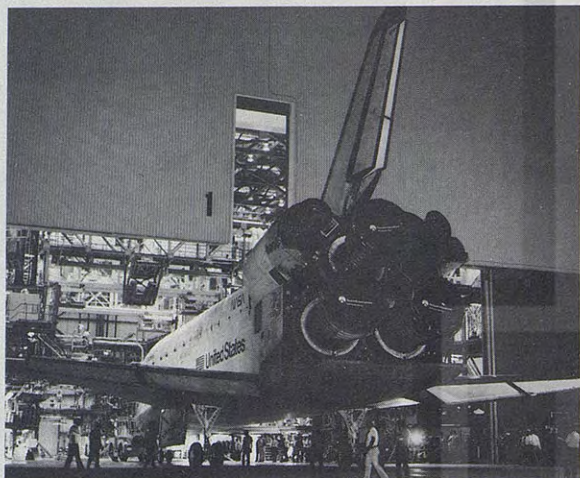
NASA had blazed new trails across the heavens with expendable vehicles and spacecraft, but the cost had been high. To continue the exploration and utilization of space on a permanent basis, a more economical way to reach orbit was urgently needed. This had become apparent well before the end of the Apollo 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 minimum 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. 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.

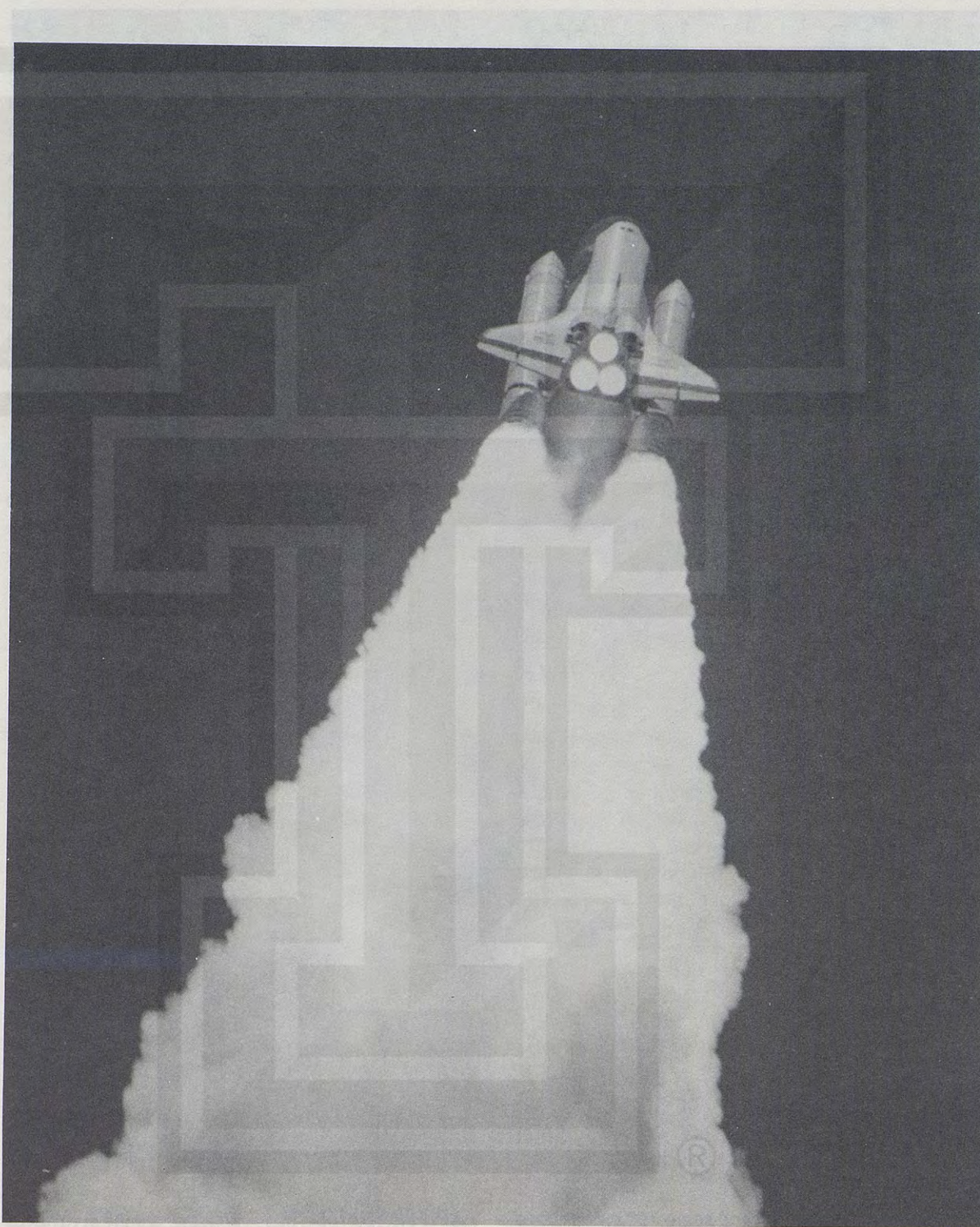


The orbiter Columbia is slowly backed out of the Orbiter Processing Facility, after a stay of 42 days in preparation for its fourth journey into space. At the end of its successful flight, the Space Shuttle was ready to take up the task of serving as America's primary launch vehicle.



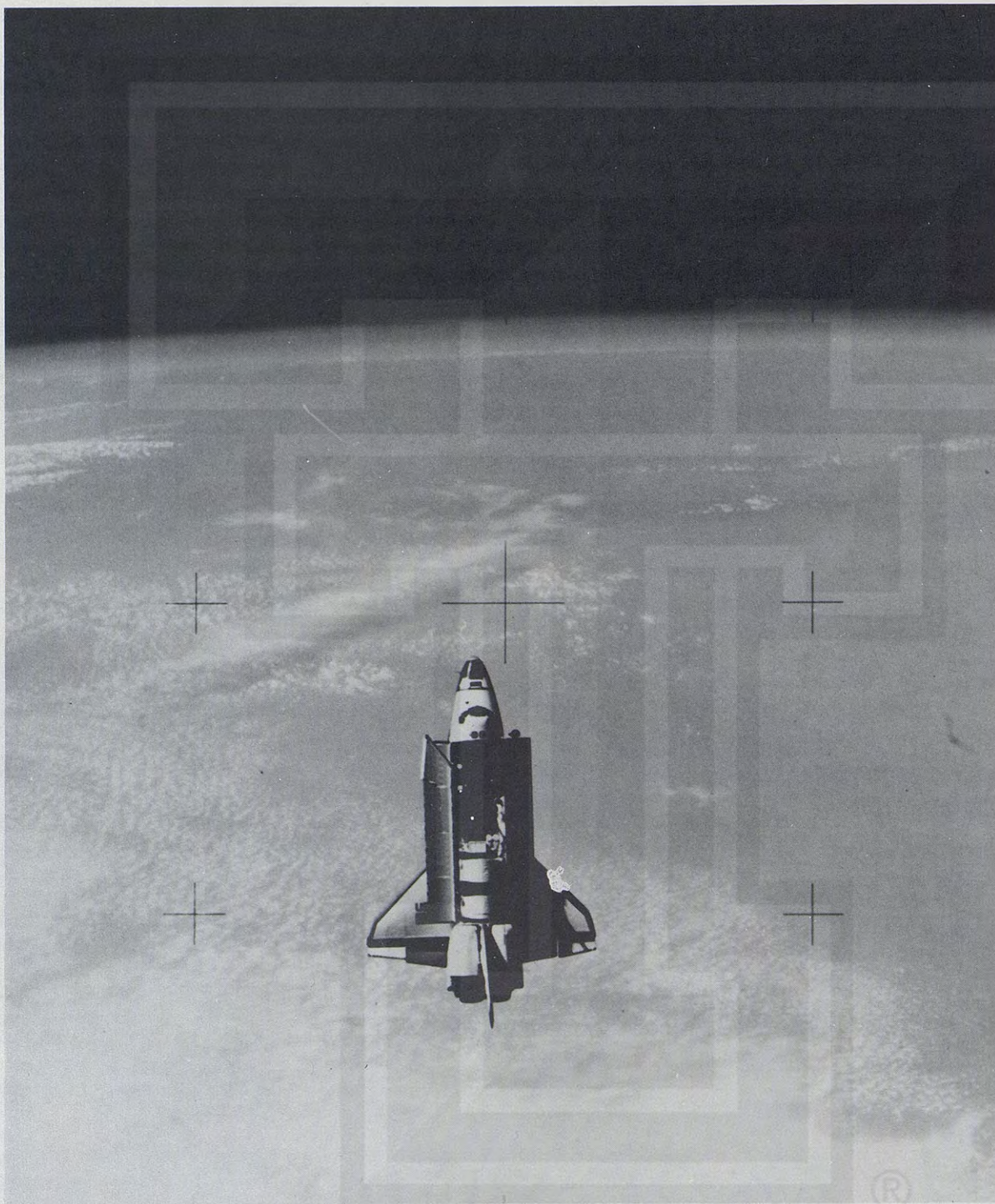
An assembled and ready Space Shuttle heads for Pad A as the shadows of twilight creep over the Space Center.

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 space-

craft. 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 West German spacecraft SPAS-01. It had been deployed from the orbiter's cargo bay earlier. At the

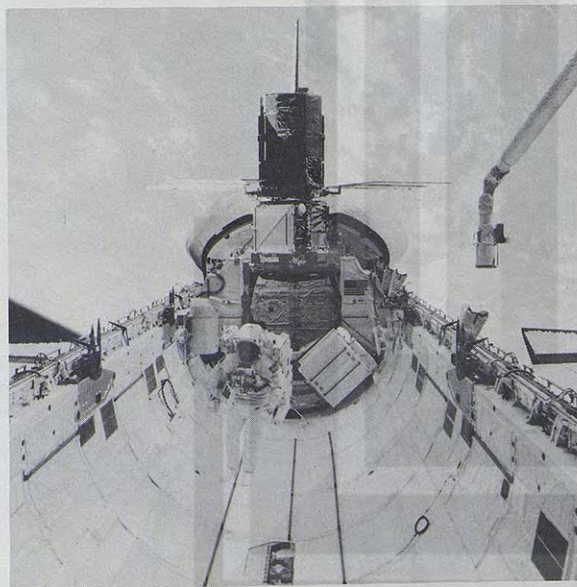
rear of the open bay, half in shadow, are the sunshields that protected two communications satellites before deployment.

A New Approach - The Space Shuttle

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 firing rooms 1 and 2 in the Launch Control Center.

Once the first Space Shuttle mission was over, and the orbiter Columbia was 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.

By 1986, NASA was approaching a goal of 12 to 13 Shuttle launches a year, using a fleet of four orbiters — Columbia, Challenger, Discovery and Atlantis. Then, on January 28, tragedy struck. The orbiter Challenger and its crew were lost during launch.



The recovered Solar Maximum Mission satellite sits on a special stand in the cargo bay, after repairs in orbit by astronauts James van Hoften and George "Pinky" Nelson. Van Hoften, in the foreground, performs a series of experimental maneuvers using the manned maneuvering unit.

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. The Space Shuttle was becoming a true national and international asset, carrying into orbit student experiments, small business payloads, and foreign payload specialists. The next major logical step, the Space Station, had been authorized by President Reagan in January 1984.

There was a 32-month hiatus in manned spaceflight before the next Space Shuttle lifted off, on September 29, 1988. The problem in the design of the solid rocket boosters that had caused the loss of Challenger had been found and corrected. Many other critical flight systems had been re-examined and recertified. The unique checkout and launch facilities at the Spaceport, and the detailed procedures and software that determined their operation, had all been reviewed and improved where necessary. Every effort had been made to ensure the safety of the crew and vehicle, and the mission was fully successful.

The original promise of the Space Shuttle remained undiminished. The Kennedy NASA/industry team was doing its part to fulfill the dream of steady progress in living and working on the new frontier of space.

Unmanned Space Missions

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

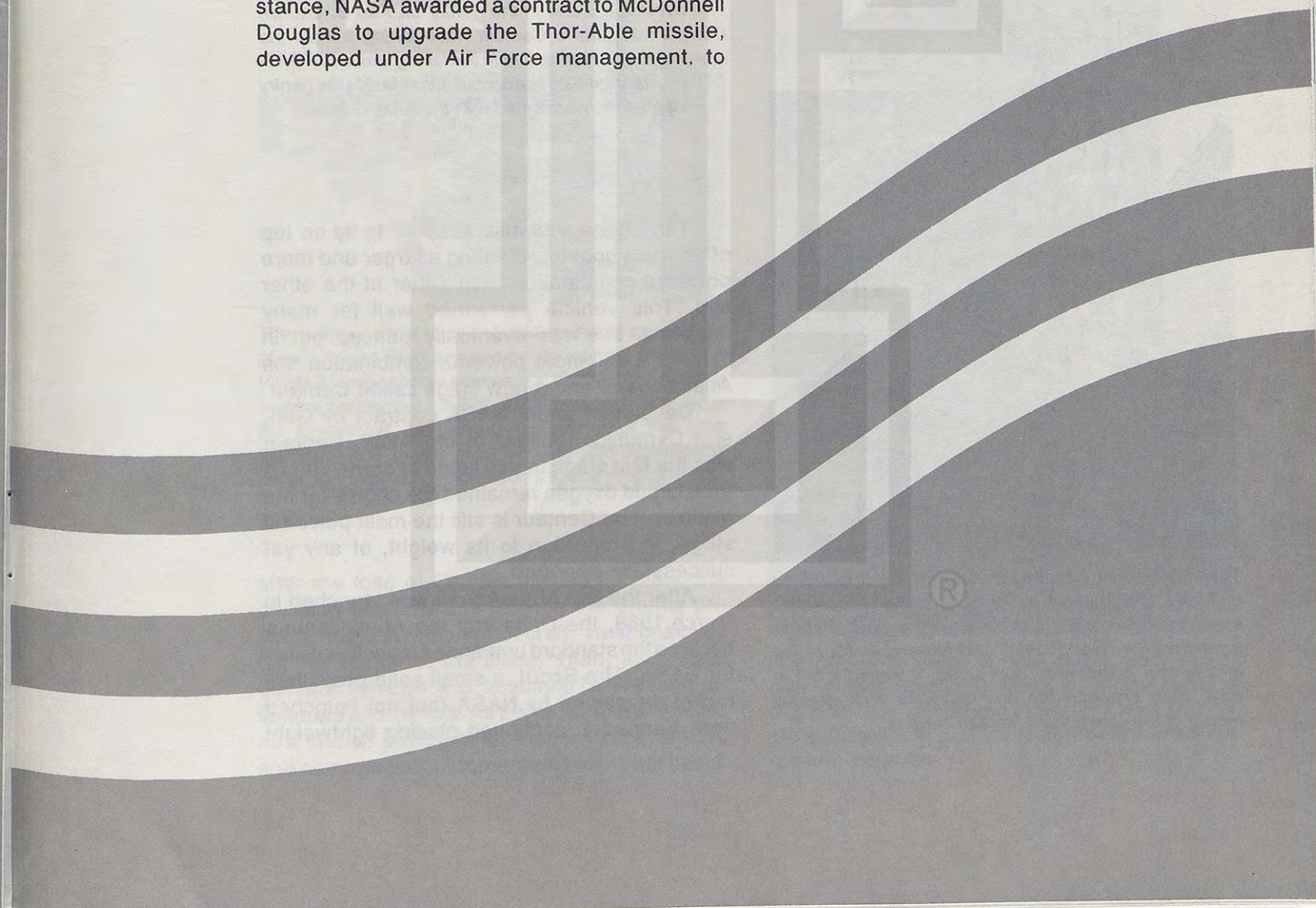
During this span, more than 300 launches were conducted for programs ranging from solar system exploration to improved weather forecasting, global communications and Earth resources studies. These projects, which have more than repaid the nation's investment in time, money and technical talent, depended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

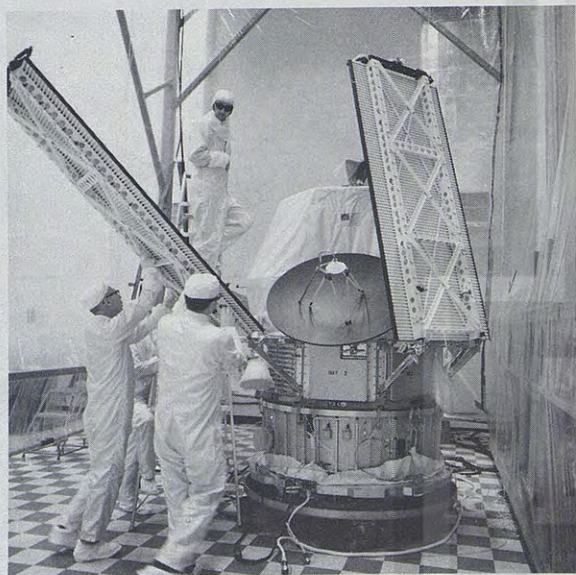
become the Thor-Able-Delta launch vehicle — later known simply as the Delta.

A group of employees from the Naval Research Laboratory had been at the Cape for some time, launching the early Vanguard vehicles which 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.

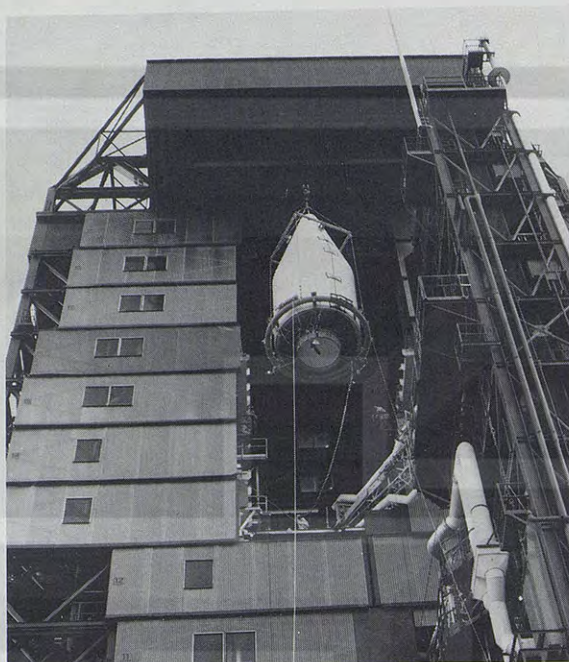


The upgraded Thor-Able vehicle soon acquired the reputation of being "Dependable Delta." By the end of 1989 over 180 had been launched by NASA, from facilities on Cape Canaveral and Vandenberg AFB. This was more than all other vehicles of an equivalent size combined. The Delta was continuously upgraded over the years, until, during its last years under NASA, it could place a spacecraft weighing up to 2,800 pounds into a geosynchronous transfer orbit — a weight ten 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.



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.



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.

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.

After the last Atlas-Agena was launched in March, 1968, the Delta and the Atlas-Centaur became the standard unmanned launch vehicles for NASA. The Scout, a small solid propellant rocket developed by NASA (but not launched from Kennedy), continued placing lightweight

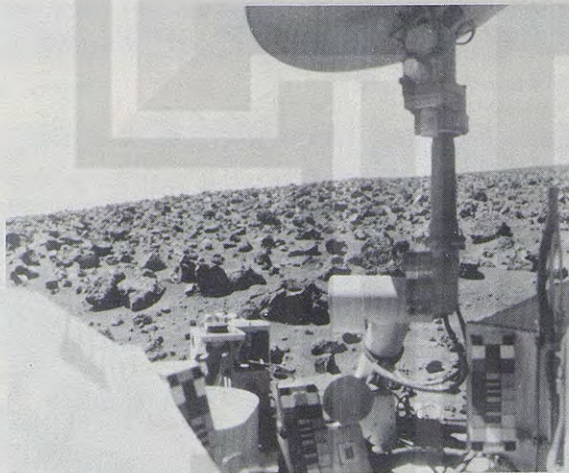
Unmanned Space Missions

spacecraft in orbit. 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 gas giant planets. Titan-Centaur was discontinued after these six operational missions.

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

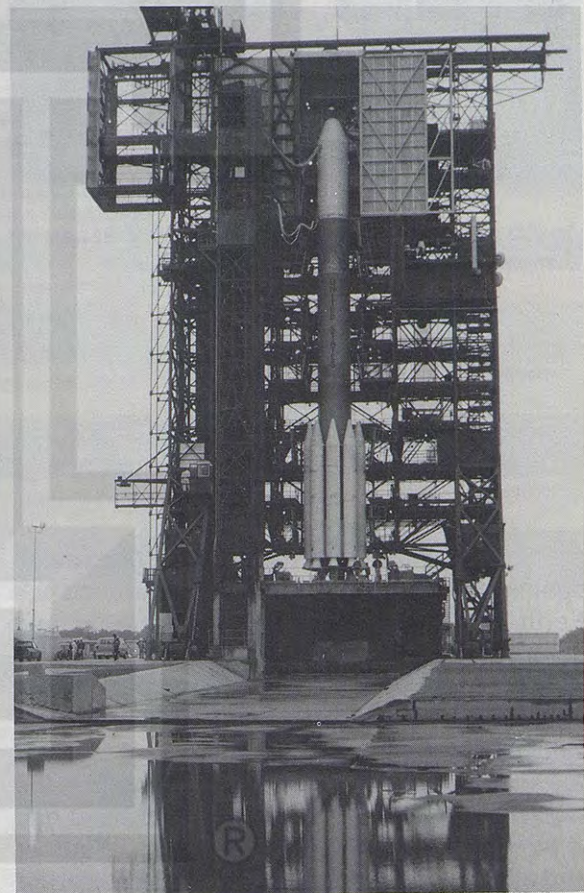
As the new system matured, many payloads were shifted from unmanned launch vehicles to the more economical Shuttle. But

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.

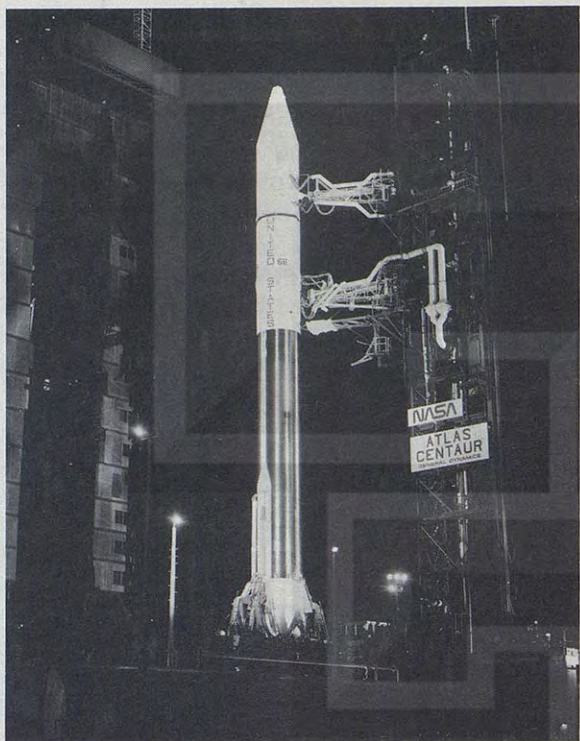


The salmon sky and red, boulder-strewn expanse of Mars' Utopian Plain as seen by the camera of NASA's Viking 2 lander shortly after setting down on the planet's surface September 3, 1976. Portions of the lander are in the foreground. Unmanned exploration of the solar system is one of the most exciting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

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 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.



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

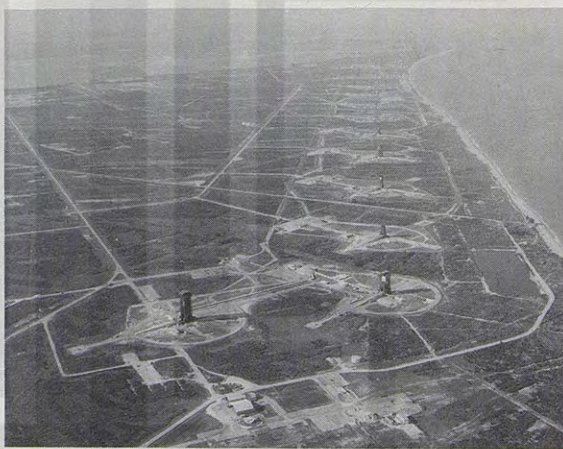


An Atlas/Centaur stands poised on Pad B at Launch Complex 36, waiting to lift a satellite into orbit.

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 weathermen track dangerous storms, and add a new dimension to accurate weather forecasting.



The two gantries of Launch Complex 36 (foreground), where Atlas/Centaurs are launched, still stand on the easternmost point of Cape Canaveral. But the line of gantries extending north from the right-hand pad in this 1964 photograph have almost all been torn down. 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.

Spacecraft	Launch Date	Mission Description/Results
TIROS 1	4/1/60	Relayed thousands of cloud pictures, demonstrating the feasibility 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 geosynchronous 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 assessment 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.
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 September 11, 1985.
HEAO 2	11/13/78	Examined selected x-ray astronomical sources in detail with the largest X-ray 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.
Hubble Space Telescope	4/24/90	Largest optical telescope in orbit; now returning stellar and planetary images of unequalled quality and usefulness.

A Place to Visit

Whether it's a bustle of Spaceport activity, the solitude of a nature trail or the unspoiled beauty of a pristine seashore, the Kennedy Space Center offers the visitor a wide variety of things to do and see.

A must stop on anyone's space itinerary is the Kennedy visitors center, Spaceport USA — a modern, sprawling complex of exhibit halls, theaters and supporting amenities that lures about three million visitors a year, ranking it among the top tourist attractions in Florida.

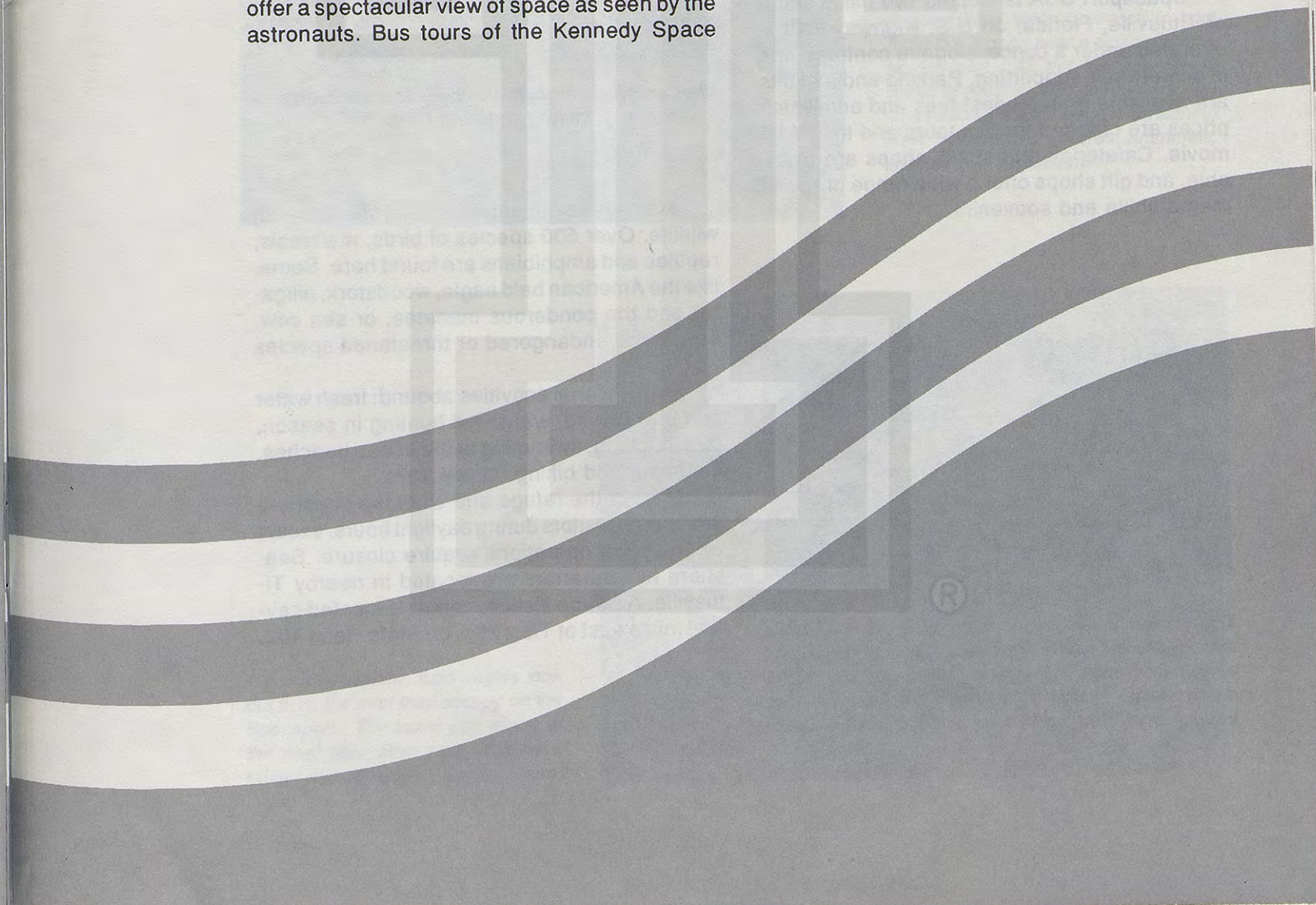
Open every day of the year except Christmas, Spaceport USA provides visitors a rare opportunity to experience the sights, sounds, color and drama of America's role in space.

Indoor and outdoor exhibits and displays feature the spacecraft, the rockets and the programs that have extended our reach beyond the Earth. Dramatic large-screen IMAX movies offer a spectacular view of space as seen by the astronauts. Bus tours of the Kennedy Space

Center and Cape Canaveral facilities trace the evolution of the nation's space program from its infancy to the Space Shuttle era.

Educational services are available as well. The Educators Resources Laboratory provides extensive facilities to aid teachers in the preparation of aerospace-related teaching materials. Slides, videotapes and text materials can be copied for use in the classroom.

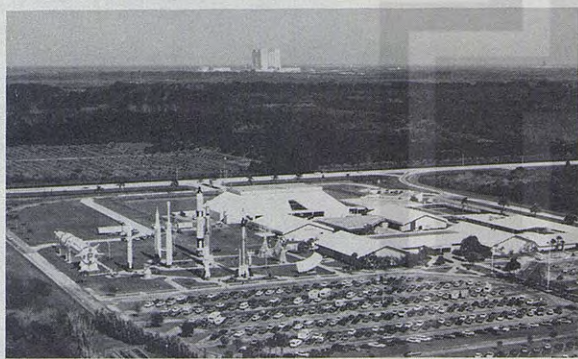
At the Exploration Station, educational programs and hands-on activities illustrate and explain the principals of rocketry and space science to students of all ages. Students often work with actual hardware used for space missions.





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

Spaceport USA is located two miles south of Titusville, Florida, off U.S. Highway 1. It is operated under a concessionaire contract, and is entirely self-supporting. Parking and exhibits are available free. Modest fees and admission prices are charged for bus tours and the IMAX movie. Cafeterias and snack shops are available, and gift shops offer a wide range of space memorabilia and souvenirs.



The KSC visitors center, Spaceport USA, is accessible to the public and open for business every day of the year except Christmas. The fourth most popular tourist destination in Florida, Spaceport USA pays for itself through small charges for tours and the IMAX theater.

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.



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

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 refuge visitors center is located several miles east of Titusville, on State Road 402.

A Place to Visit



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, ammmals, reptiles and amphibians.



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.

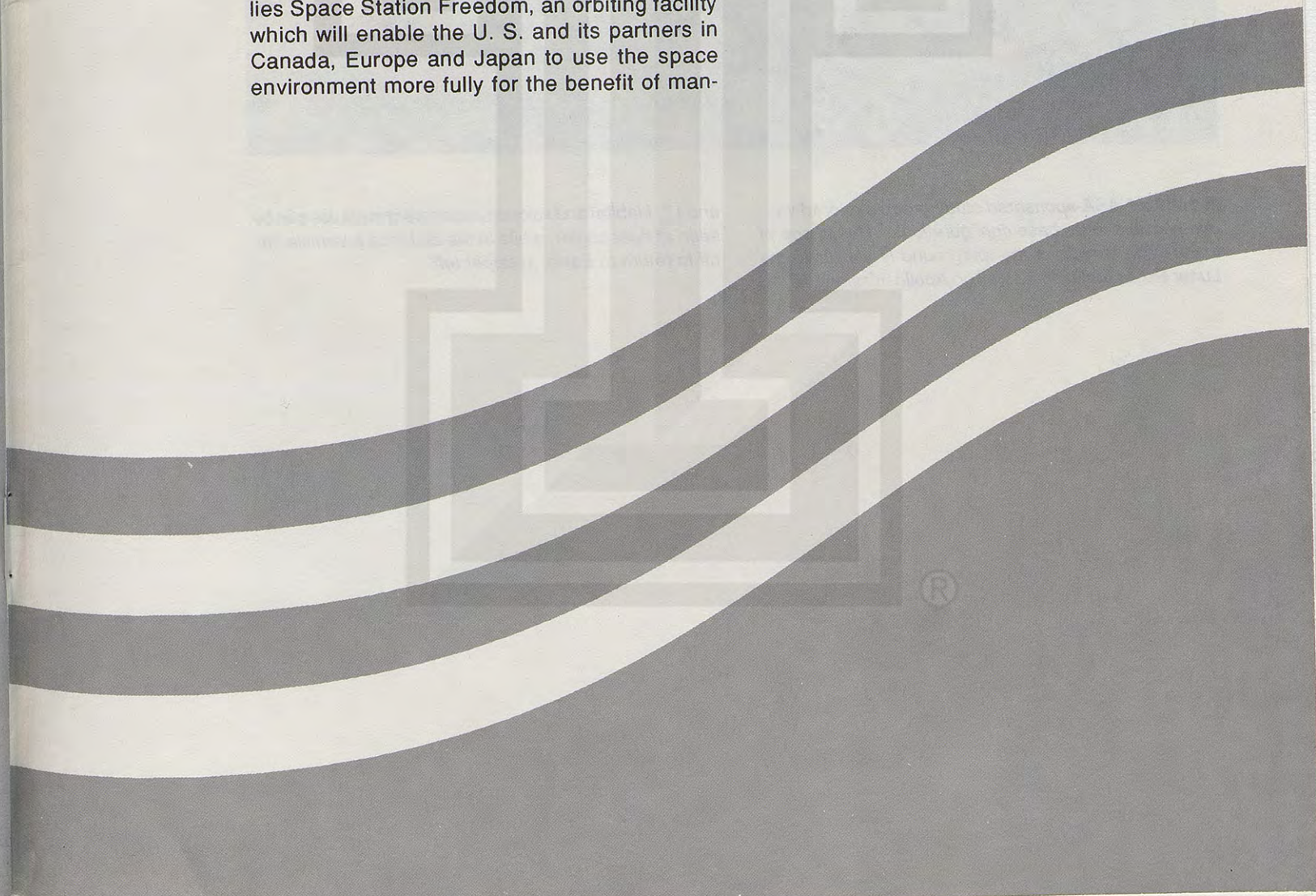
Future Outlook

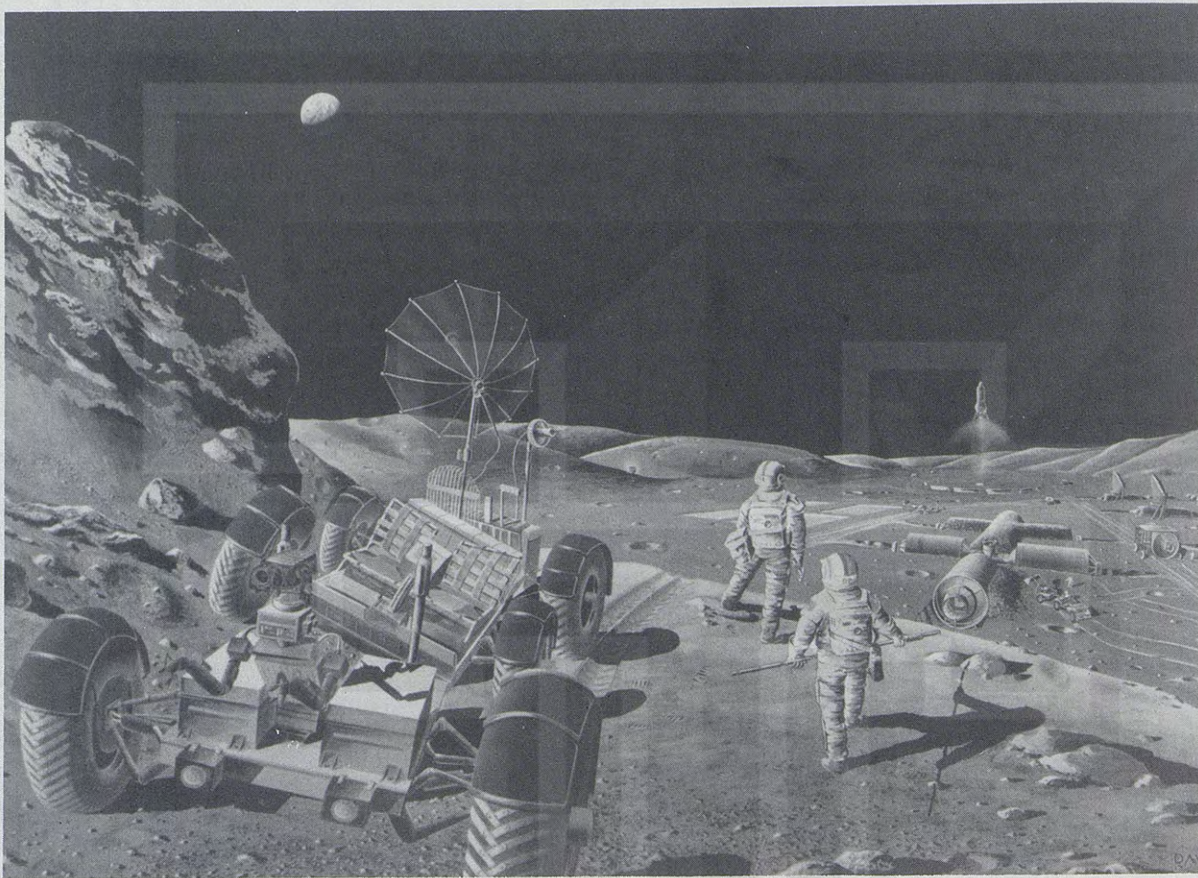
The most pressing task facing NASA when Space Shuttle flights resumed in September 1988 was to reduce the backlog of payloads. Some very important scientific satellites, including Galileo to Jupiter, Magellan to Venus, and the Hubble Space Telescope into Earth orbit, were successfully launched. Several military payloads were placed in orbit, as was a new Tracking and Data Relay Satellite for NASA. The Long Duration Exposure Facility was recovered and returned to Earth, and millions of tomato seeds that had been in space almost six years were distributed to schools across the country. Other major scientific satellites are now in the "pipeline" for launching in the 1990's, some on unmanned space vehicles for which NASA will contract with the manufacturers for launch services.

Beyond these more immediate challenges lies Space Station Freedom, an orbiting facility which will enable the U. S. and its partners in Canada, Europe and Japan to use the space environment more fully for the benefit of man-

kind. This project is now well along in design and planning. In 1989 President George Bush directed NASA to start a program called Space Exploration Initiative (SEI), of which building the Space Station is the first major step. SEI will take humans back to the Moon, this time to stay, and then on to Mars.

NASA is also entering on a "Mission to Planet Earth," which will involve designing and building new satellites to more closely monitor and analyze the environment. New unmanned heavy-lift vehicles may be needed to support these planned programs. Smaller manned vehicles, including one capable of taking off from a runway and flying directly into orbit, are





In 1986 a NASA-sponsored study group explored various possible lunar base configurations. This is one of them. The vehicle in the foreground is similar to the Lunar Rover that worked well on Apollo missions 15, 16

and 17. Habitat and science experiment modules can be seen at right center, while in the distance a vehicle lifts off to return to Earth, at upper left.

Future Outlook

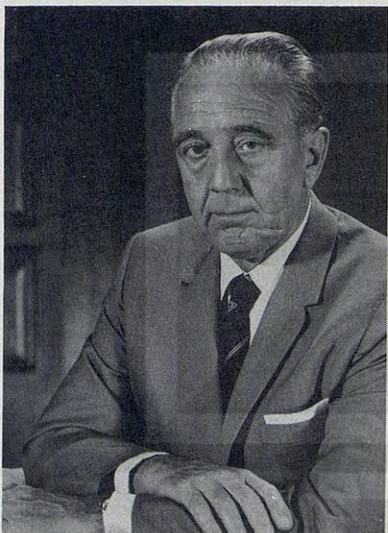
in the preliminary design stages. NASA also intends to develop a crew rescue vehicle for the Space Station, which the crew could use to return to Earth quickly in an emergency.

The outlook for space activities in the 21st century is exciting and challenging. We can envision such important achievements as industries operating in orbit, Moon bases, and manned expeditions to Mars. Now that the space frontier has been crossed, there is no turning back. Human curiosity and the desire for knowledge demand more. As science and technology

inexorably move forward to new horizons, the men and women of NASA and its contractors will be challenged as never before to keep pace.

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 put the United States into 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. For America's Spaceport is truly the threshold to space.

Directors of the Kennedy Space Center



Dr. Kurt H. Debus
1961 - 1974



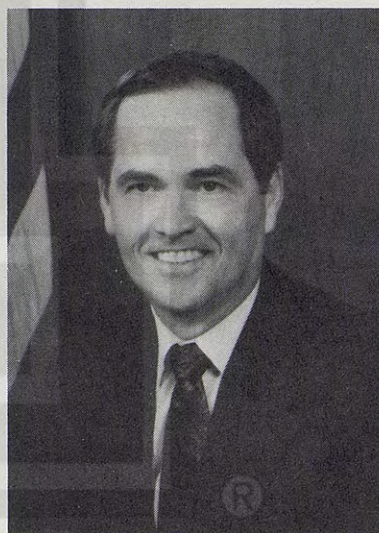
Richard G. Smith
1979 - 1986



Lee R. Scherer
1974 - 1979



Lt. Gen. Forrest S. McCartney
1986 - 1991



Robert L. Crippen
1992 -



National Aeronautics and
Space Administration

John F. Kennedy Space Center



Dr. Dietlein

KSC Survival Guide

Florida Area Code is 407
for KSC Area

Travel Lodge Titusville 1(407)267-9111

Titusville Holiday Inn 1(407)269-2121

SPANISH MAIN 1(407)784-5046

Oceans Landing 1(407)783-9430

Morrit Island Holiday Inn 1(407)452-7711

Econo Lodge 1(407)784-2550

Cocoa, Motel 6 1(407)783-3103

Cocoa, Holiday Inn 1(407)783-2271

✓✓ Cocoa, Hilton 1(407)799-0003

Excellent Seafood buffet
\$14.95

Cocoa, Crossway Inn 1(407)783-2221

Cocoa, Wakulla Motel 407-783-2230

✓ Dixie Crossroads 268-5000
(Titusville)
- Shrimp of all kinds

✓✓ Radison Hotel 783-0000
(nice outdoor bar)

✓ Alma's Italian 783-1981
Restaurant
(delicious Italian!)

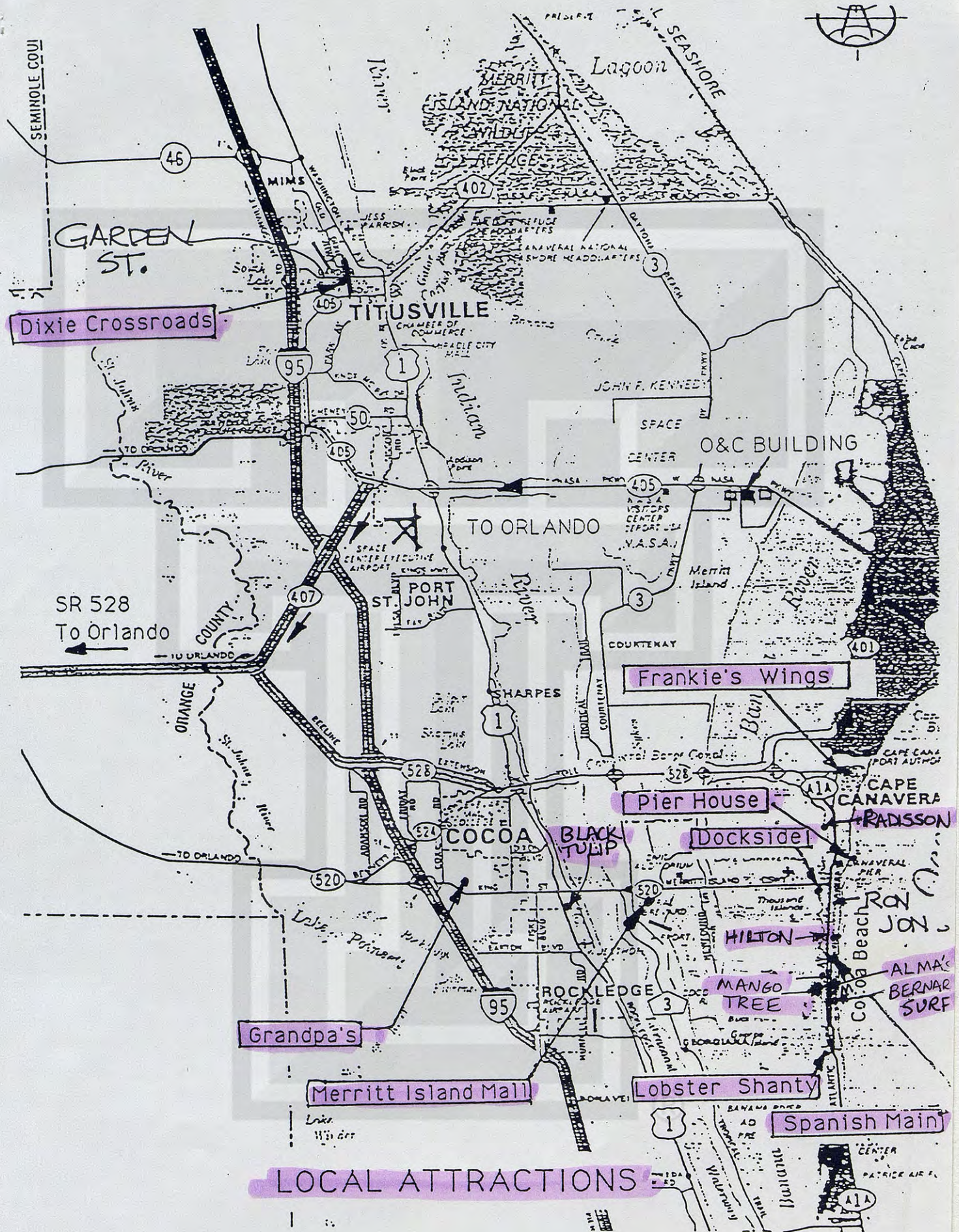
✓✓ Bernard's Surf 783-2401
(great steak & seafood -
slightly fancy)

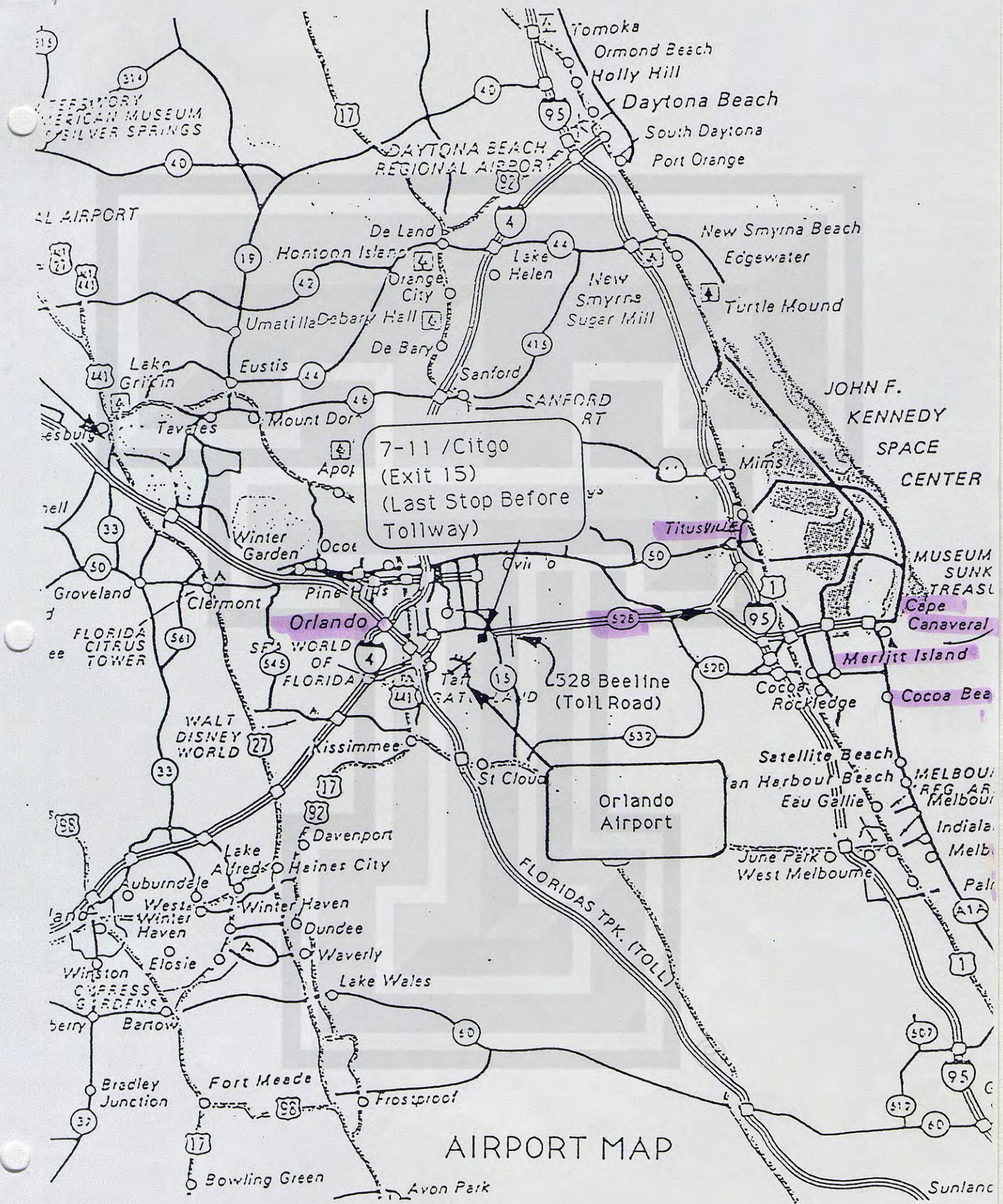
~~Mango Tree 799-0513
(exclusive gourmet)
~ \$250 for 4 people
(need reservations)~~

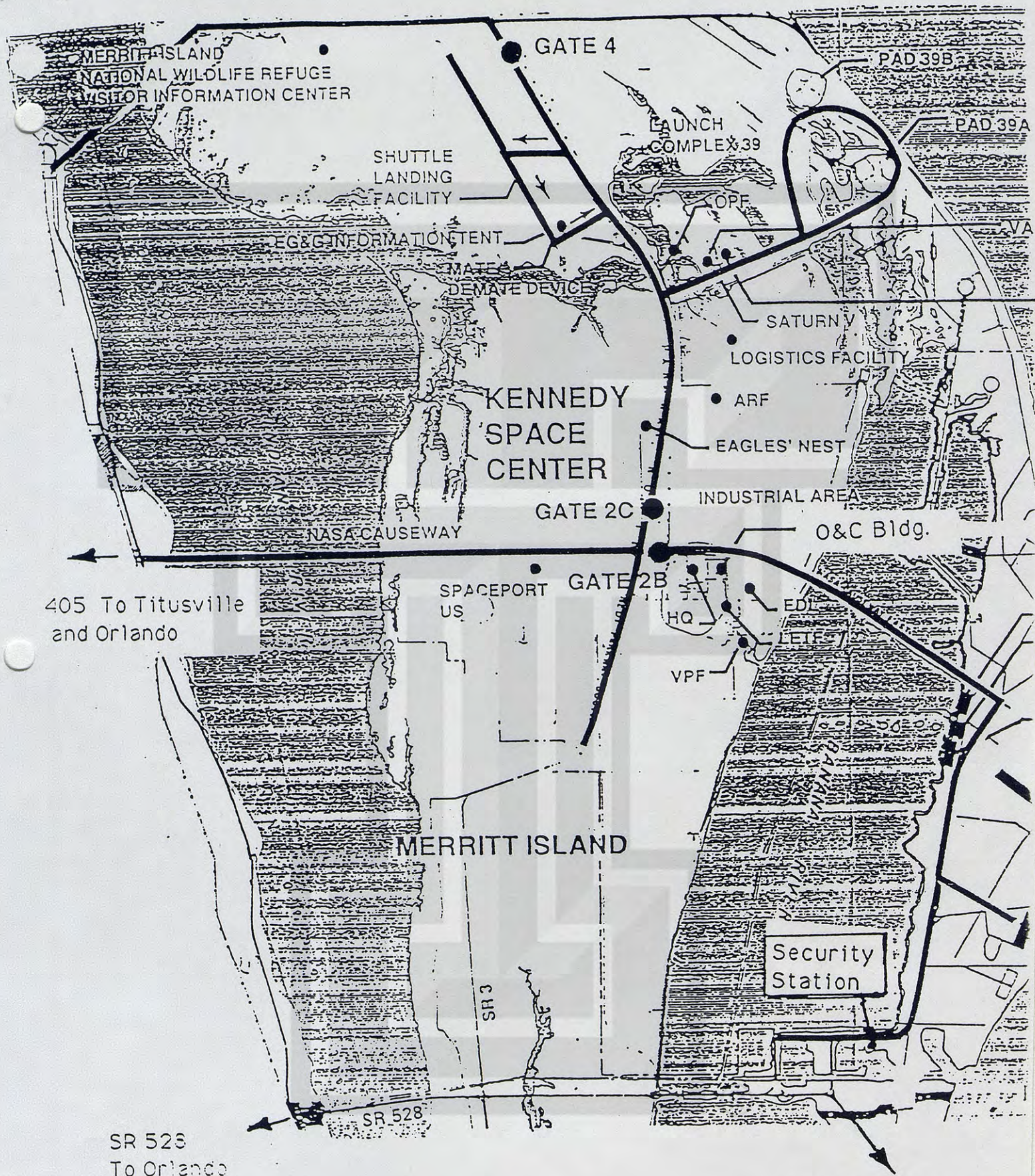
Pier House
Restaurant -
great seafood,
excellent vista
& ambience

777-8414
Phoenix - Indian Harbor
past Air Force Base

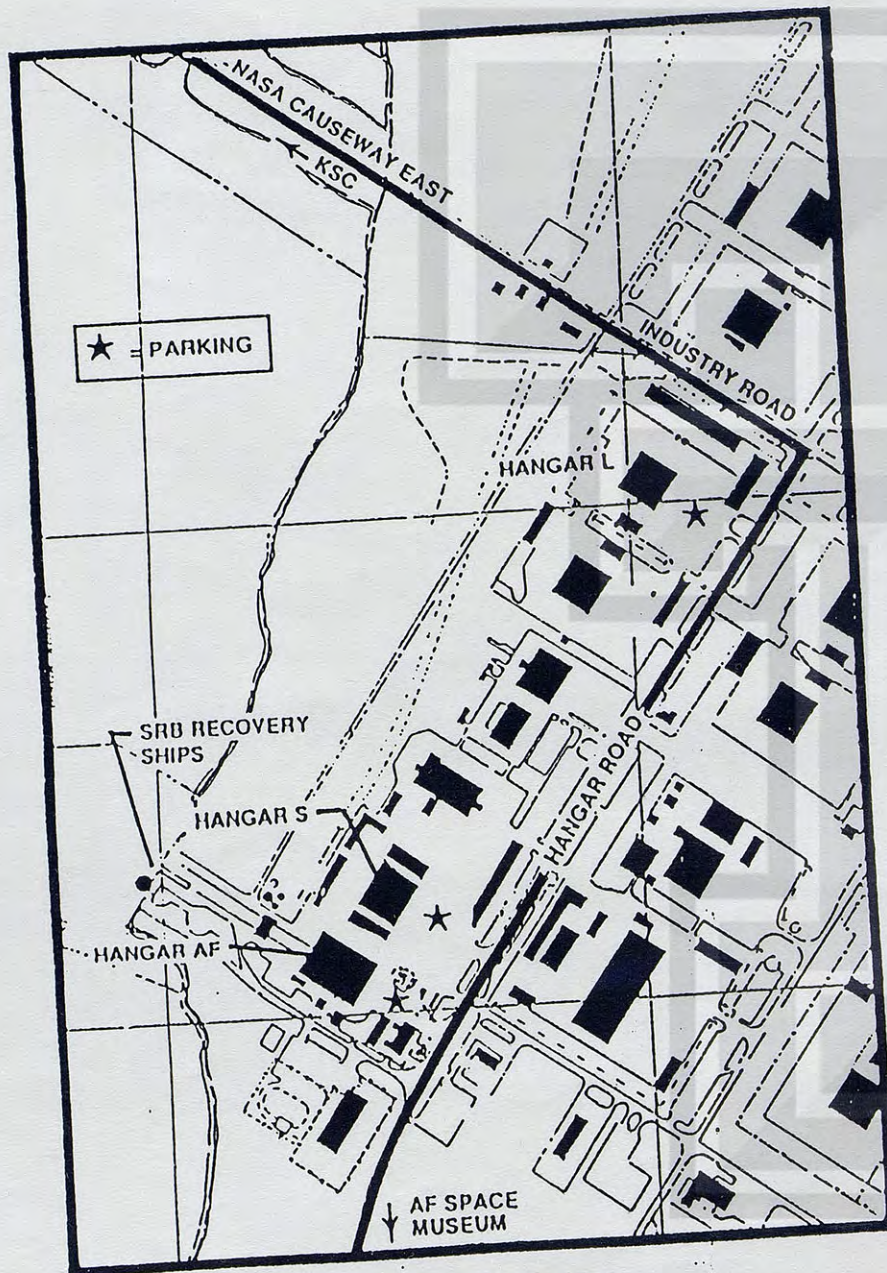
Black Tulip -
Cocoa -
exclusive gourmet



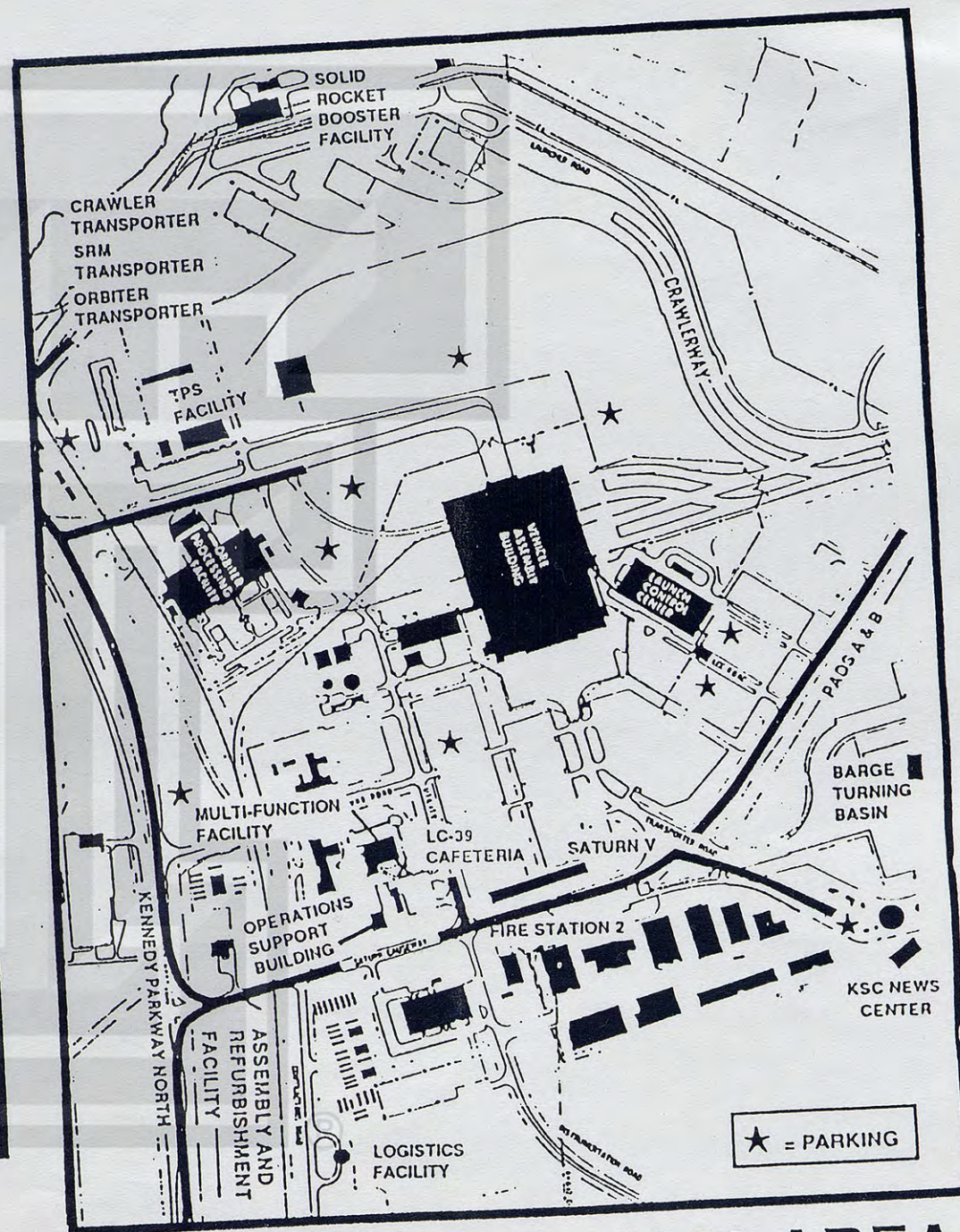




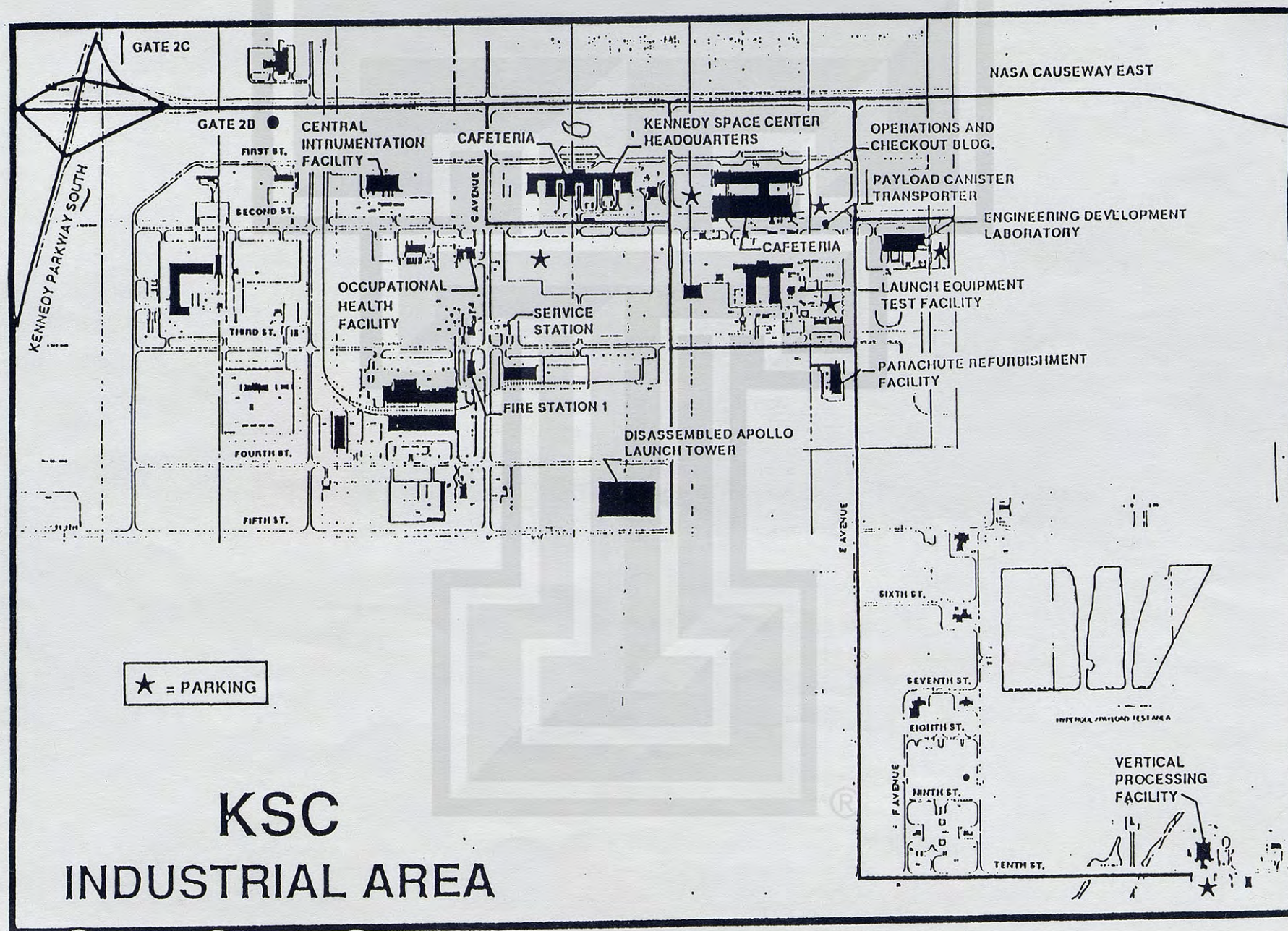
KSC MAP

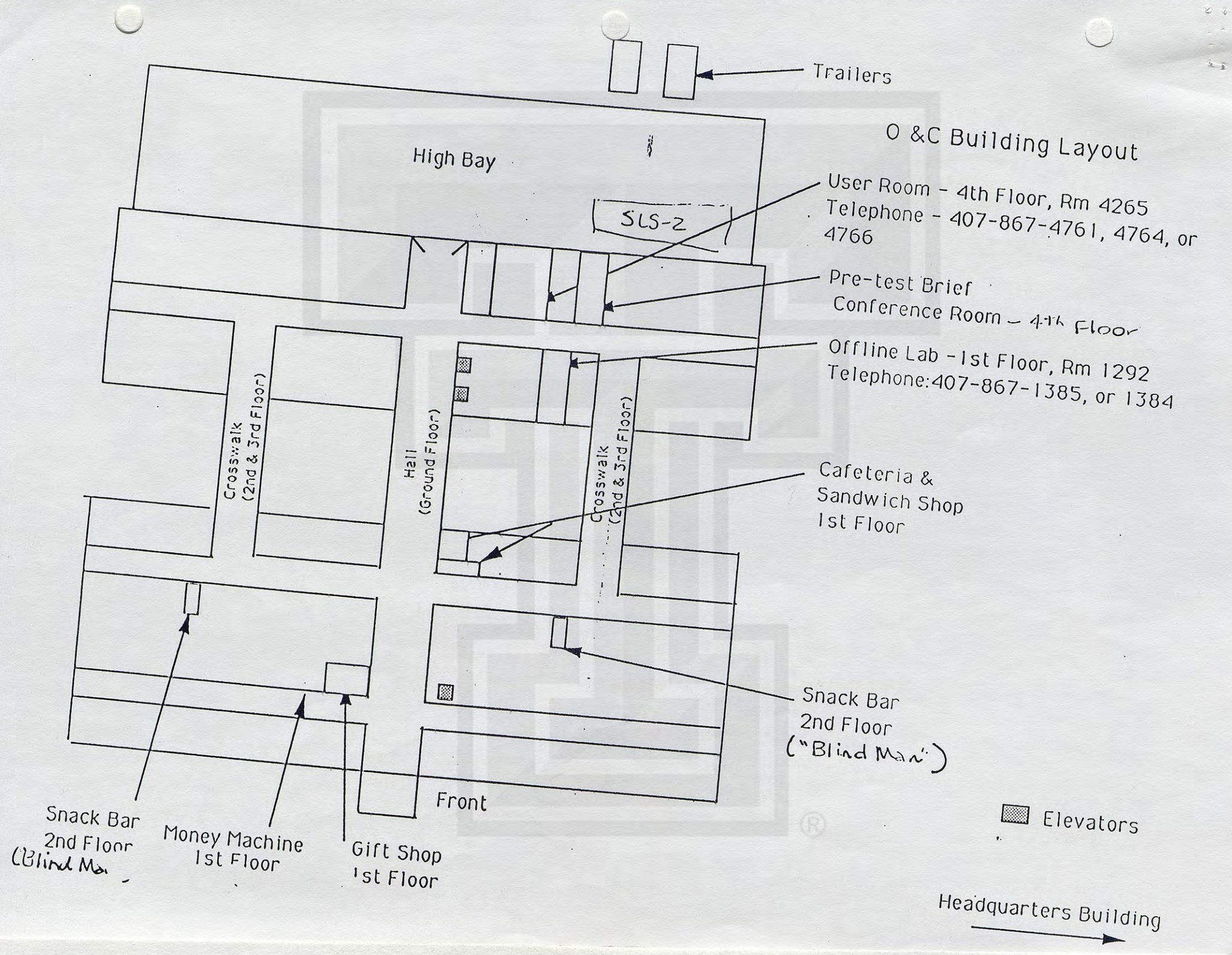


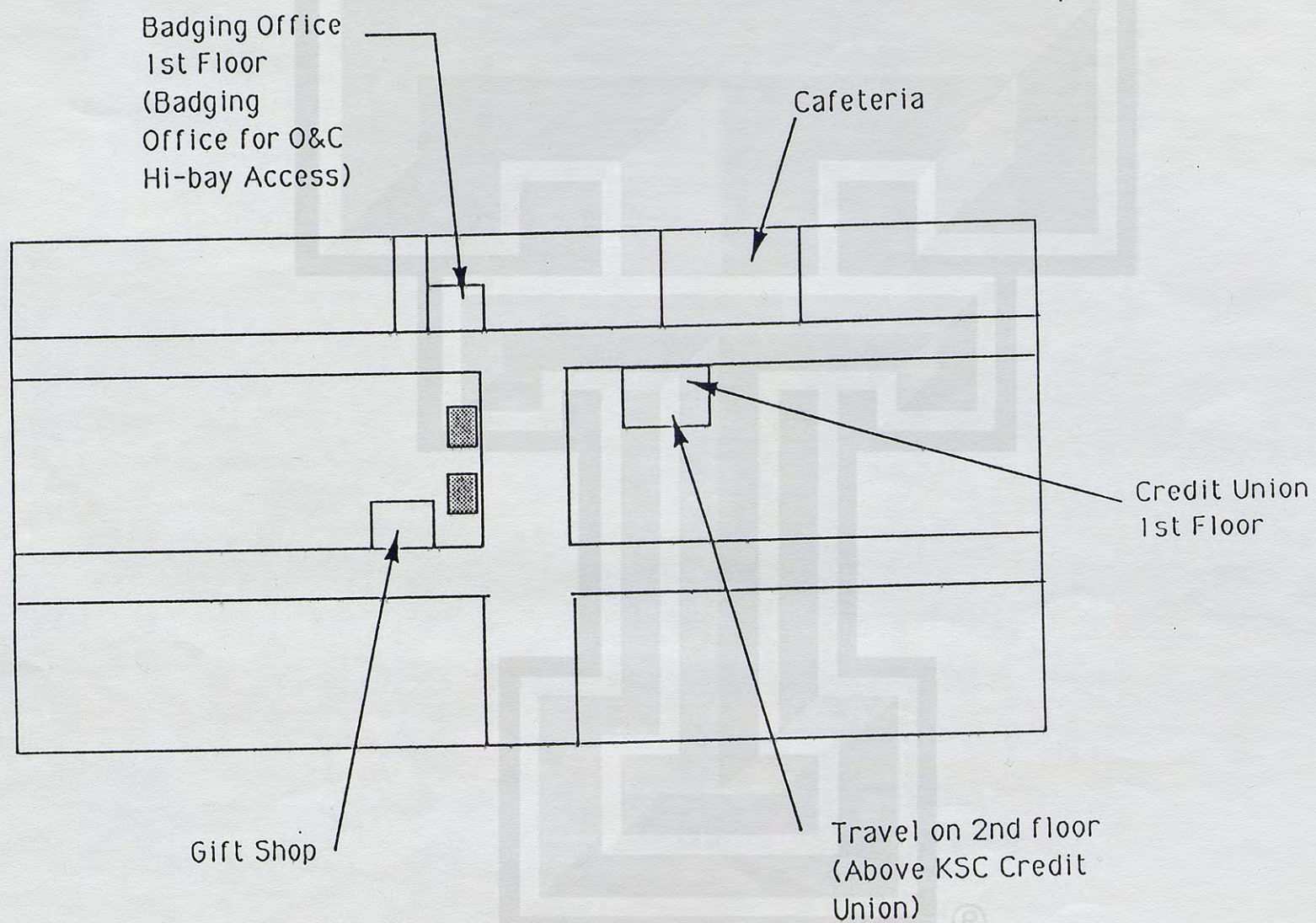
CCAFS
INDUSTRIAL AREA



LAUNCH COMPLEX 39 AREA







HEADQUARTERS BUILDING

**STS-65 Guest Activity Schedule
NASA Guest Center, Room 2001
Spaceport USA, Kennedy Space Center**

Launch

<u>Wed., July, 6 1994 (L-2)</u>	Guest Registration, Room 2001	12:00 noon-4:00 p.m.
<u>Thurs., July 7, 1994 (L-1)</u>	Guest Registration, Room 2001	8:00 a.m.-4:00 p.m.
	Briefing on STS-65 in IMAX II Theater	10:00 a.m.-10:45 a.m.
	Tour of Space Center	11:00 a.m.-1:00 p.m.
	Briefing on STS-65 in IMAX II Theater	1:00 p.m.-1:45 p.m.
	Tour of Space Center	2:00 p.m.-4:00 p.m.
<u>Friday., July, 8 1994</u> (Launch morning)	Guest Registration, Room 2001	8:00 a.m.-12:00 noon
	NASA TV, Spaceport Theater (Crew prelaunch events including breakfast, suiting & entering orbiter)	9:00 a.m.-12:00 noon
	Food & Beverage at Lunch Pad	9:00 a.m.
	Buses board near Room 2001	10:45 a.m.-11:45 a.m.
	Launch Window	12:43 p.m.-3:13 p.m.

Tours originate from the Rocket Garden and include a drive by the launch pad. Sign up in advance.

Briefings will include an update of the Space Shuttle processing at KSC, mission objectives of STS-65, and information on the STS-65 crew.

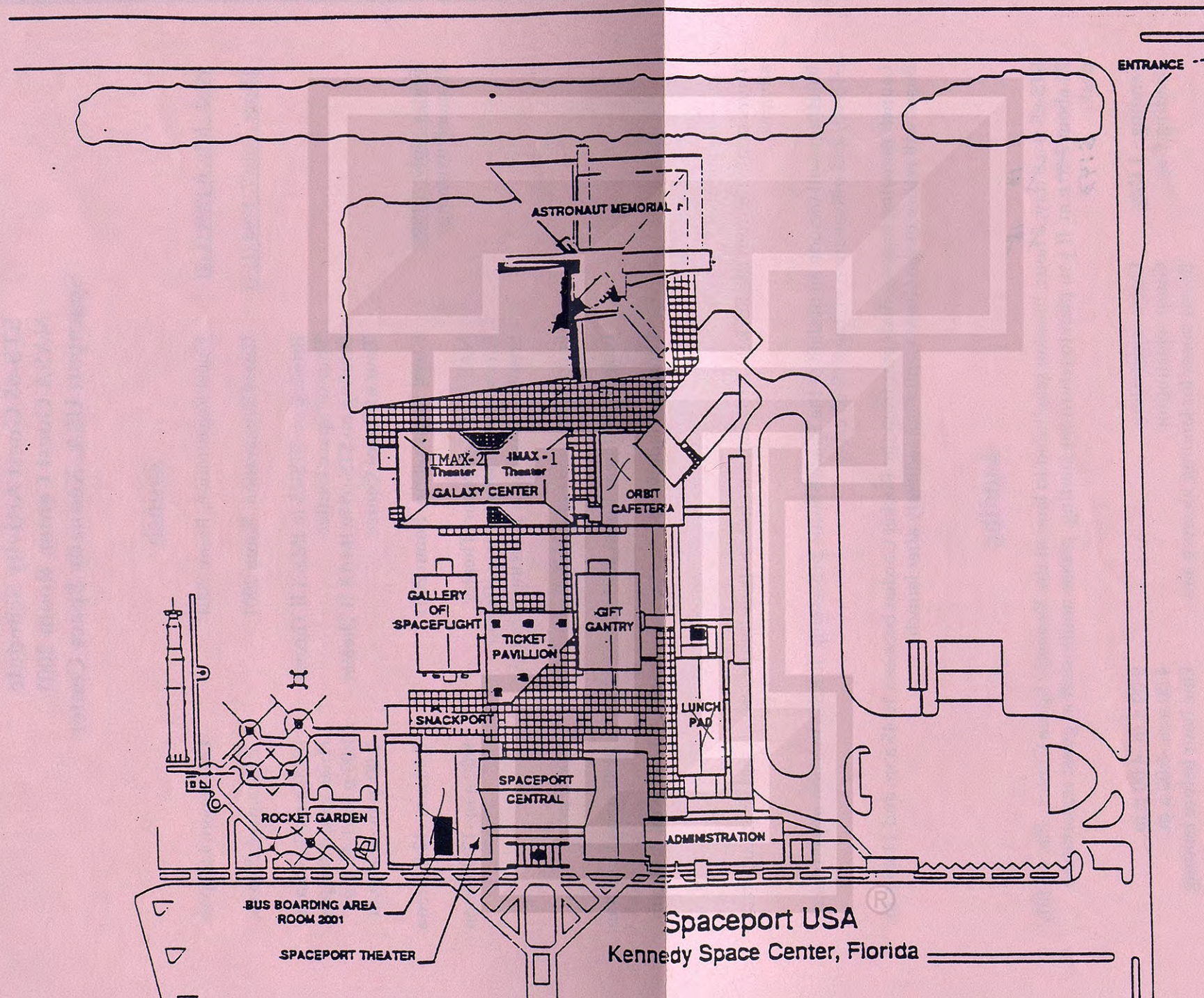
Launch morning buses will depart from the Rocket Garden between 10:45 a.m. and 11:45 a.m. Buses will return to the Guest Center immediately after launch.

Landing

STS-65 is a ¹³9 day, ¹⁸5 hour, mission scheduled to land at the Kennedy Space Center, Fla. on July 22 about 7:00 a.m. If you plan to return for landing, please notify staff at guest registration desk. 6:43

Landing - 1 Day	Guest registration	9:00 a.m.-4:00 p.m.
Landing Day	Guest registration	4:00 a.m.-6:00 a.m.
	Board buses for landing viewing site	One hour before landing

Guest Center Telephone: (407) 867-2144
Recorded launch/landing update: (407) 867-2314





National Aeronautics and
Space Administration

Crew of Space Shuttle
Mission STS-65





The Crew of Space Shuttle Mission STS-65

Commander

Robert D. Cabana (Col., USMC)

Robert Cabana was born and raised in Minneapolis, Minnesota. He received a bachelor of science degree in mathematics from the U. S. Naval Academy in Annapolis, Maryland. After graduation, he was commissioned in the United States Marine Corps and earned his wings as a Naval flight officer and a Naval aviator flying the A-6 Intruder with the 1st and 2nd Marine Aircraft Wings. Following his graduation from U. S. Naval Test Pilot School in Patuxent River, Maryland, he flew numerous ordnance and flight system test projects in the A-4 and A-6 airplanes and participated in development of the flight control system for the X-29 flight technology demonstrator. He has logged over 4,900 hours flying time. Cabana was selected to be an astronaut in 1985 and was pilot on STS-41 and STS-53.

Pilot

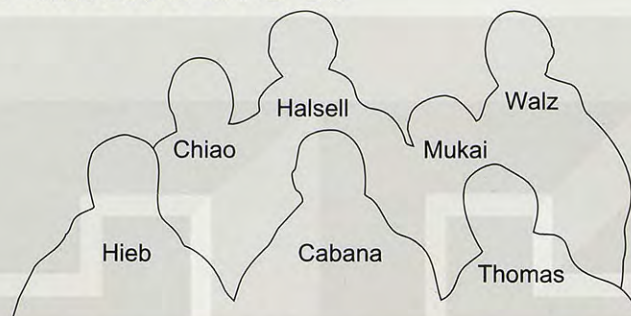
James D. Halsell, Jr. (LTC, USAF)

Jim Halsell was born in Monroe, Louisiana. He earned a bachelor of science degree in engineering from the United States Air Force Academy, a master of science degree in management from Troy University, and a master of science degree in space operations from the Air Force Institute of Technology. Following his graduation from the Air Force Academy, Halsell trained as a pilot and served as an F-4D aircraft commander. He later became a squadron flight lead, instructor pilot, strike package commander and Chief of the Squadron Standardization/Evaluation Branch at Moody Air Force Base. Halsell then served as an Air Force test pilot in the F-4, F-16, and SR-71 aircraft. NASA selected Halsell to become an astronaut in 1990. This will be his first space flight.

Payload Commander

Richard J. Hieb

Richard Hieb was born in Jamestown, North Dakota. He received a bachelor of arts degree in mathematics and physics from Northwest Nazarene College and a master of science degree in aerospace engineering from the University of Colorado. Following graduation, he joined NASA and worked in many different areas of flight operations, including crew development



and spacecraft rendezvous procedures. Hieb became an astronaut in 1985, and flew as a mission specialist aboard STS-39 and STS-49. On STS-65, he will serve as payload commander.

Mission Specialist

Leroy Chiao (Ph.D.)

Leroy Chiao was born in Milwaukee, Wisconsin, but considers Danville, California, to be his home town. Chiao received a bachelor of science degree in chemical engineering from the University of California, Berkeley, and a master of science degree and a doctorate in chemical engineering from the University of California, Santa Barbara. After receiving his doctorate degree, Chiao began working for Hexcel Corporation on process engineering research on advanced aerospace materials. Dr. Chiao joined Lawrence Livermore National Laboratory to work on processing research for fabrication of aerospace composites. In 1990, Dr. Chiao was selected by NASA to become an astronaut. This will be his first space flight.

Mission Specialist

Donald A. Thomas (Ph.D.)

Donald Thomas was born in Cleveland, Ohio. He received a bachelor of science degree in physics from Case Western Reserve University and master of science and doctorate degrees in materials science from Cornell University. Upon graduation, Dr. Thomas joined AT&T Bell Laboratories as a senior member of the technical staff. He also worked as an adjunct professor in the Department of Physics at Trenton State College. Dr. Thomas later joined Lockheed Engineering and Sciences Company to review

materials used in Space Shuttle payloads. He then became a materials engineer at NASA's Johnson Space Center and worked on advanced composite materials for use on Space Station and was a principal investigator for a microgravity crystal growing experiment that flew on STS-32. NASA selected Dr. Thomas to be an astronaut in 1990. This will be his first space flight.

Mission Specialist

Carl E. Walz (Major, USAF)

Carl Walz was born in Cleveland, Ohio. He received a bachelor of science degree in physics from Kent State University and a master of science degree in solid state physics from John Carroll University. While stationed at McClellan Air Force Base in California, he worked as a radiochemical project officer, responsible for analysis of radioactive samples from the Atomic Energy Detection System. As a flight test engineer at the F-16 Combined Test Force, Edwards Air Force Base, he worked on F-16C avionics and armament development programs, flying F-4 and F-16 aircraft. He also served as a flight test program manager at Detachment 3, Air Force Flight Test Center. Walz was selected by NASA to become an astronaut in 1990 and flew as a mission specialist on STS-51.

Payload Specialist

Chiaki Naito-Mukai (M.D., Ph.D.)

Chiaki Naito-Mukai was born in Tatabayashi, Gunma Prefecture, Japan. She received a doctor of medicine degree and a doctorate in physiology from Keio University School of

Medicine. Dr. Mukai has worked as a resident in general surgery at Keio University Hospital. She has also been a part of the medical staffs in general surgery of Shimizu General Hospital and emergency surgery at Saiseikai Kangawa Hospital. She later became a resident in cardiovascular surgery at Keio University Hospital and has served on the medical staff in cardiovascular surgery at the Saiseikai Utsunomiya Hospital. Dr. Mukai later returned to Keio University Hospital as the chief resident in cardiovascular surgery and later was promoted to assistant professor of the Department of Cardiovascular Surgery, Keio University. In 1985, Dr. Mukai was selected by the National Space Development Agency of Japan (NASDA) as one of three Japanese payload specialists candidates for the STS-47 flight. As a NASDA astronaut, she became a visiting scientist at the Division of Cardiovascular Physiology, Space Biomedical Research Institute at the Johnson Space Center. She is also a research instructor of the Department of Surgery at Baylor College of Medicine, Houston, TX. STS-65 will be her first space flight.



STS-65 Crew Insignia

STS-65 is a Spacelab flight aboard the Space Shuttle Columbia and is the second International Microgravity Laboratory mission (IML-2), reflected in the emblem by two gold stars shooting toward the heavens behind the IML lettering. The Space Shuttle Columbia is depicted orbiting the logo and reaching off into space, with the Spacelab in the payload bay on an international quest for a better understanding of the effects of space flight on materials and life sciences.

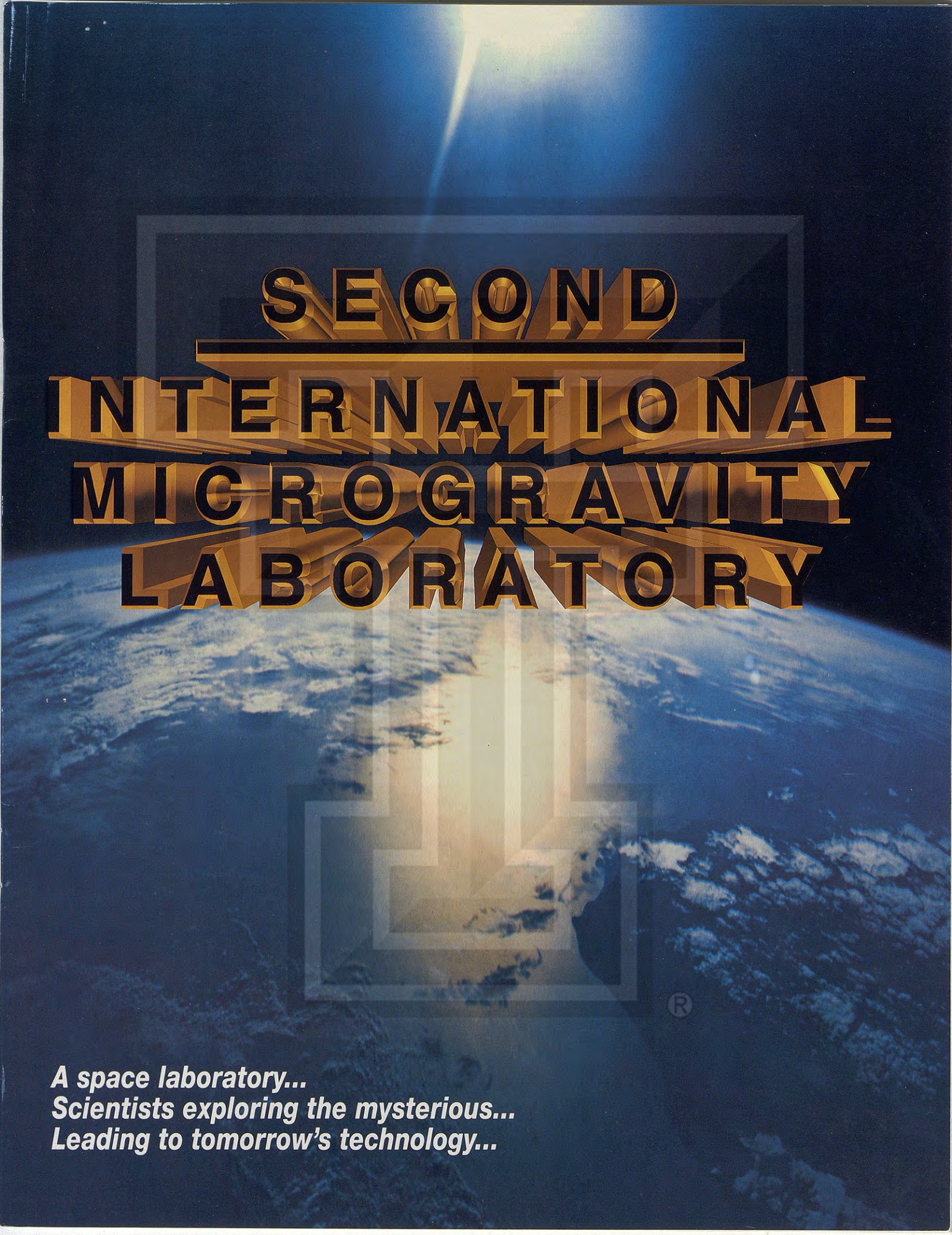


launch.2

September 29, 1988

KENNEDY SPACE CENTER, Fla. — The Space Shuttle Discovery and its five man crew was launched from pad 39-B at 11:37 a.m. September 29, 1988. As STS-26 embarks on its four day mission, the event marks America's return to manned space flight. On the first day of orbit, the crew deployed their primary payload, the Tracking and Data Relay Satellite (TDRS-C). The Inertial Upper Stage (IUS) then boosted the satellite into a geosynchronous altitude from low Earth orbit. The crew members of STS-26 are: Commander Rick Hauck; Pilot Richard Covey; and Mission Specialists Dave Hilmers, Mike Lounge, and George "Pinky" Nelson.





SECOND INTERNATIONAL MICROGRAVITY LABORATORY

*A space laboratory...
Scientists exploring the mysterious...
Leading to tomorrow's technology...*

Errata

On the Insert:

Update the IML-2 Program Manager
as *Mr. Gary W. McCollum, NASA Headquarters*

On page 33:

Change Spinal Changes in Microgravity measurement
from "4.8 to 7.4 mm" to "60 to 80 mm (2-3 inches)"

On page 36:

Change Dr. A. Viviani's affiliation under Bubble Drop, and
Particle Unit from "MARS Center, Naples, Italy"
to "*Seconda Universita di Napoli, Aversa, Italy*"

On page 37:

Add to Advanced Protein Crystallization Facility
"Crystallization of Octarellin"
*Principal Investigator: Dr. J. A. Martial, University of Liege
Sart-Tilman, Belgium*

On page 40:

Update the Program Manager as *Mr. G. W. McCollum*
Update the Life Sciences Program Scientist as *Dr. V. S. Schneider*
Update the Operations Controller as *Ms. P. M. Nordness*