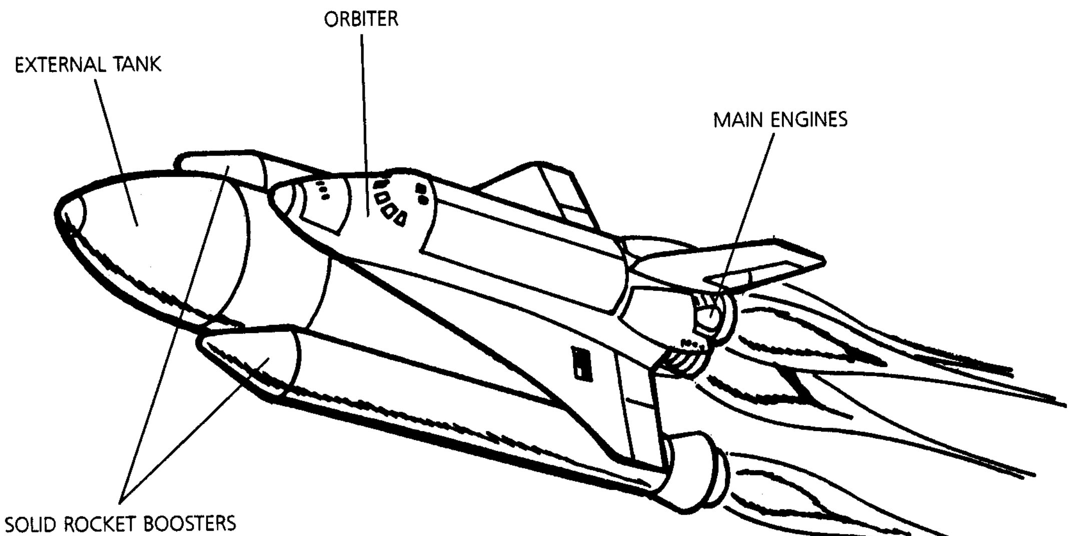
The Space Shuttle is a spacecraft that can be used for many flights into space. It carries people and experiments to Earth orbit. Scientists and engineers ride in the Shuttle and operate experiments in space. Someday, the Shuttle may carry you to Earth orbit.

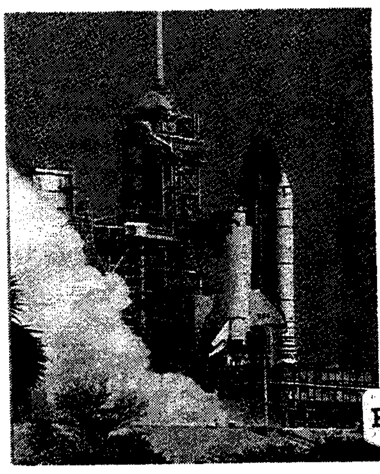
The Space Shuttle has four major parts: The orbiter, the Solid Rocket Boosters (two), the External Tank, and the set of three Space Shuttle main engines in the rear of the orbiter. Only the orbiter and the main engines go into Earth orbit. The other parts are for liftoff and powered flight.

NASA's Marshall Space Flight Center in Huntsville, Alabama, provides the boosters, the External Tank, and the main engines for the Space Shuttle.



Space Shuttle
(Rockwell International)

Manned space transportation system operated by NASA from Kennedy Space Center, Fla., lifts 46,000 pounds to 160-nautical-mile, 28.5°-inclined orbit. The delta-winged orbiter has flown more than seventy missions since its first use April 12, 1981.



NASA Facts

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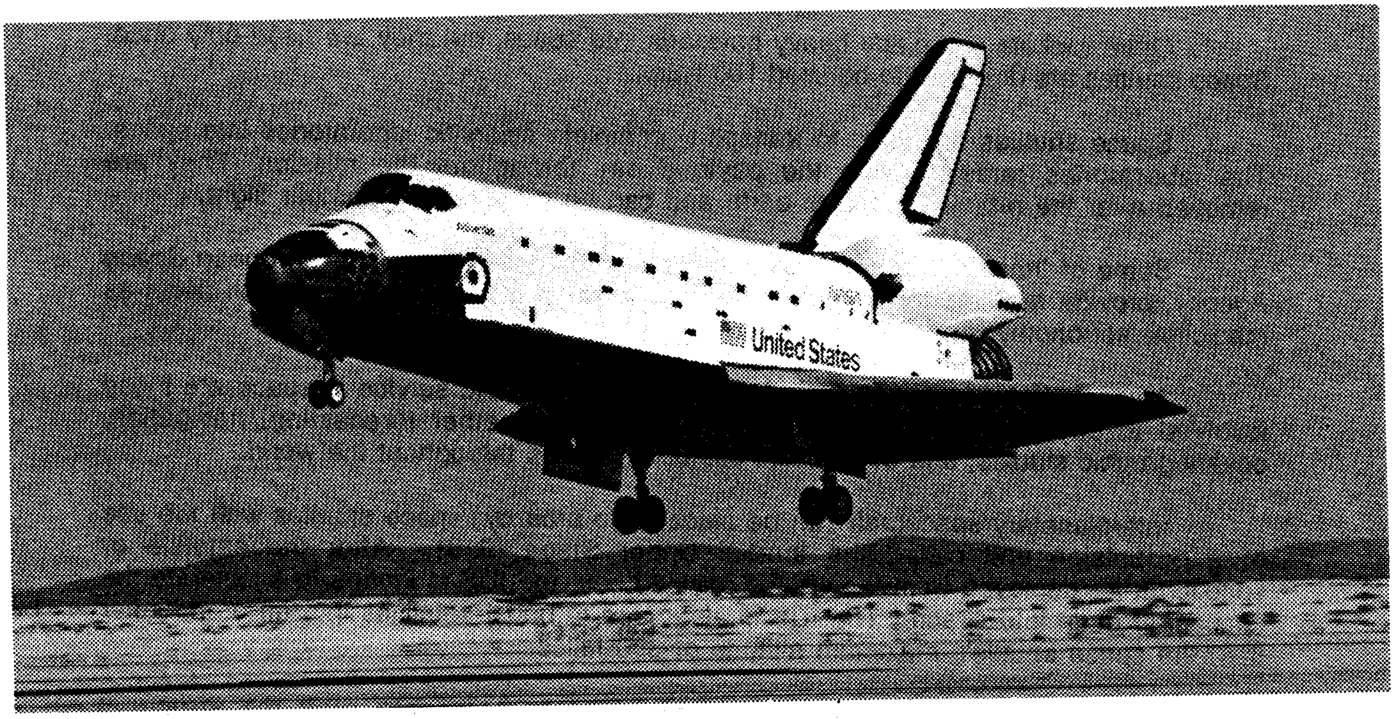


The Space Shuttles

Space Shuttles are the main element of America's Space Transportation System and are used for space research and space applications. The shuttles are the first vehicles capable of being launched into space and returning to earth on a routine basis.

Space shuttles are used as orbiting laboratories in which scientists and mission specialists conduct a wide variety of scientific experiments, and study and photograph stars, galaxies, the planets, and other bodies in and beyond the universe.

Crews aboard space shuttles place satellites in orbit. They also rendezvous with satellites to carry out repairs and return them to orbit. Satellites are also returned to earth in space shuttles for refurbishment and reuse.

A True Aerospace Vehicle

The space shuttles are true aerospace vehicles. They leave earth and its atmosphere under rocket power provided by three liquid-fueled main engines and two solid-fuel boosters attached to an external liquid fuel tank.

After their missions in orbit end, the shuttles streak back through the atmosphere and are maneuvered to land like an airplane. The shuttles, however, are without power and they land on runways like a glider.

Other rockets can place heavy payloads into space, but they are used only once. Space shuttles are designed to be used 100 times.

Space shuttles are used to transport complete scientific laboratories into space. The laboratories remain inside the payload bay throughout the mission. They are removed after the orbiter returns to earth and can be prepared for another flight.

Some of these laboratories, like the Spacelab developed by the European Space Agency, provide facilities for several specialists to conduct experiments in such fields as medicine, astronomy, and materials manufacturing.

Among the types of satellites the shuttle can orbit and service in space are those involved in environmental and resources protection, weather forecasting, navigation, oceanographic studies, and other fields useful to citizens throughout the world.

Interplanetary spacecraft can be placed into orbit by space shuttles with the use of a propulsion unit called the Inertial Upper Stage (IUS). After the satellite or spacecraft is deployed from the shuttle payload bay, the IUS is ignited to accelerate the spacecraft deep into space. The IUS is also used to boost satellites into an orbit higher than the space shuttle's maximum altitude of 600 miles.

In the future, space shuttles will be used to carry into orbit the structural components that will be assembled and become the space station, a permanent facility in which crews of astronauts will work for extended periods of time in space. The space station will have its own solar power units and astronauts will carry out a wide range of scientific activities. Space shuttles will not only be used to help construct the space station, but will be used to ferry crew members and supplies between it and earth.

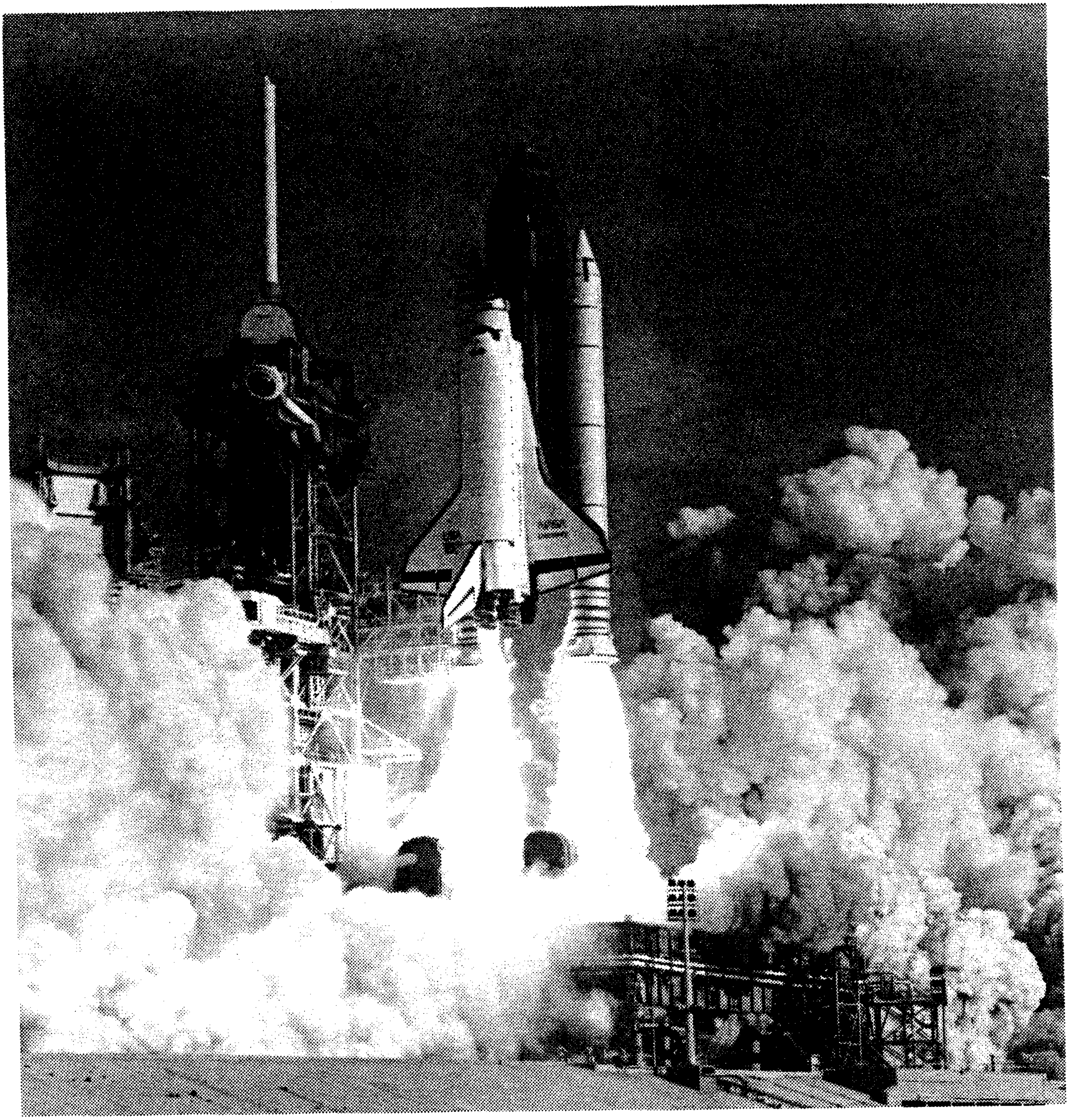
Development History

In 1969, shortly after the first moon landing of the Apollo program, the President's Space Task Group recommended that the United States initiate a program to develop a new space transportation system. In 1970 NASA initiated engineering, design, and cost studies dealing with the concept of a reusable manned spacecraft that utilized strap-on solid propellant rockets and an expendable liquid fuel/oxidizer tank.

On Jan. 5, 1972, President Richard M. Nixon gave NASA authority to proceed with development of this type of reusable space system. NASA selected the Space Transportation Systems Division of Rockwell International, Downey, Calif., to build the orbiters. Rockwell's Rocketdyne Division builds the three main engines used on each orbiter. Morton Thiokol, Brigham City, Utah, makes the solid rocket booster motors, and Martin Marietta Corp., New Orleans, La., makes the external fuel tank.

A Typical Shuttle Mission

Space shuttles are launched from the NASA John F. Kennedy Space Center in Florida.



The orbiter processing area is several miles from the launch pads. After the orbiters are readied for flight they are mated with the external fuel tank and the solid rocket boosters and the assembled components receive final detailed systems checks before they are moved to the launch pad.

The orbiter's main engines and the booster rockets ignite simultaneously to lift the shuttle and its crew away from earth and into space. About two minutes after launch, the solid rocket boosters complete their firing sequence and separate from the external tank and, by parachute, fall back into the ocean where they are recovered and used again. The orbiter continues its flight into space with the main engines furnishing ascent power for another eight minutes before they are shut down, just before achieving orbit. The external tank, now empty, separates and falls back into the atmosphere and breaks up over a remote area of the ocean. It is not reusable.

In orbit, space shuttles circle the earth at a speed of about 17,500 mph. Each orbit is about 90 minutes and the crew sees a sunrise or a sunset every 45 minutes.

Orbital altitudes for shuttle missions range from as low as 155 miles to as high as 600 miles, based on mission requirements. The flight paths are within a region over earth extending from 57 degrees north to 57 degrees south of the equator.

Missions usually last up to 10 days, but the crew has food, fuel, and other supplies to remain in orbit several days longer than planned in case they cannot come back on time due to bad weather at the landing sites.

The crew size varies and can be as many as eight people, although up to 10 can be carried under special conditions. The crew includes the commander, the pilot, and enough mission specialists and payload specialists to carry out the specific mission. Mission specialists are responsible for equipment and resources supporting the payloads during the flight, while the payload specialists are in charge of the specific payload equipment. The mission commander, pilot, and mission specialists are NASA astronauts and assigned by NASA. Payload specialists may or may not be astronauts, and are nominated for the mission by the payload sponsor.

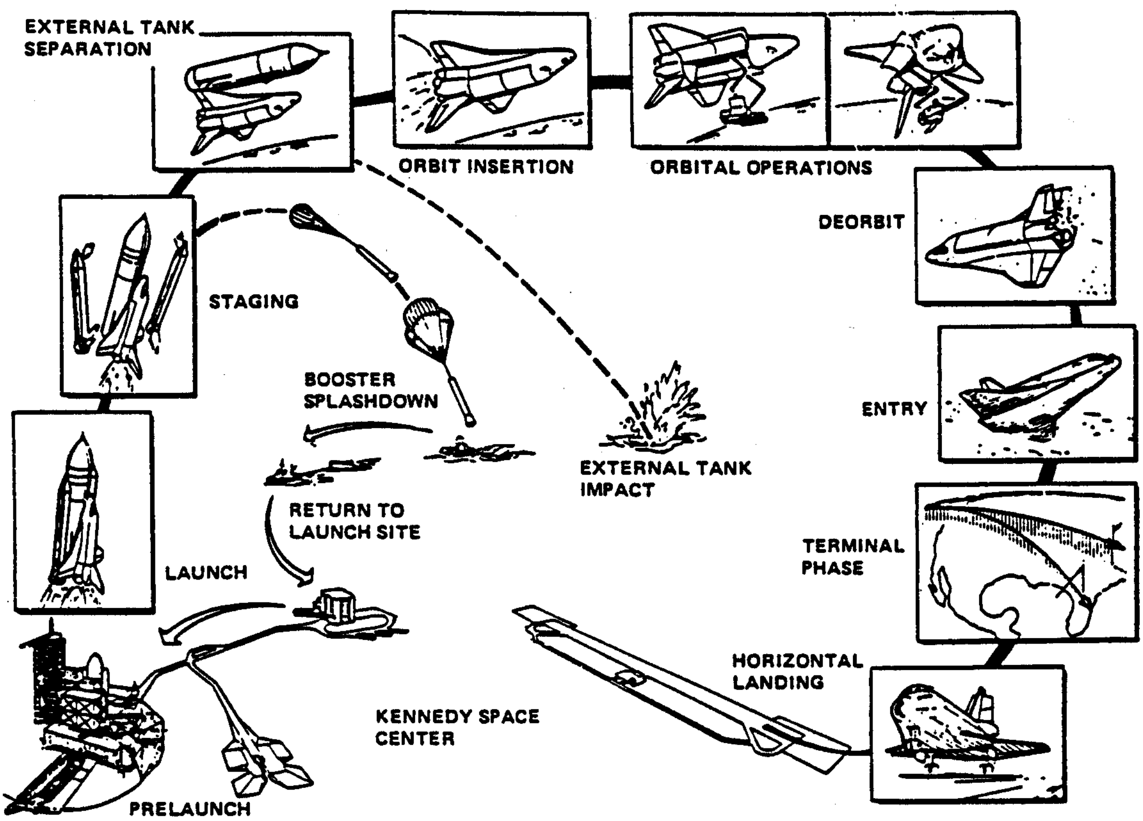
When the mission ends and the orbiter begins to glide back through the atmosphere, special insulation covering the outside portions of the vehicle acts as a heat shield to keep it from getting too hot from air friction and damaged by the heat. Most of the insulation used to protect the orbiter in places where it gets extremely hot is shaped like small tiles. The tiles, about six inches square and made of silica, shed heat so well that one side is cool enough to hold in bare hands while the other side is red hot and withstands temperatures of 2300 degrees (F). Some tiles get damaged during launch or landing and are replaced.

After the space shuttles began flights in April 1981 Edwards Air Force Base, Calif., the location of NASA's Dryden Flight Research Center, was the primary landing site. The shuttles used the main 15,000-foot runway, or on Rogers Dry Lake, which has seven designated runways on the natural clay surface. The Kennedy Space Center is now the primary landing site, with Edwards remaining as an alternate.

When certain developmental tests on orbiter systems are being carried out, Edwards is an excellent landing site because of the safety margin presented by the lakebed and the number of runways from which mission controllers and shuttle crews can choose.

The landing speed of the orbiters ranges from 205 to 235 mph, based on the weight of the vehicle.

Among improvements to the orbiters since flights began have been installation of a drag parachute at the aft end of the fuselage. They are deployed when the orbiters land to help lower rollout speed to reduce tire and brake wear. Endeavour, the newest orbiter, was the first to have the drag chute system installed. They have been retrofitted on the three other vehicles.



Post-Landing Operations

As soon as the landing occurs, a team of space shuttle recovery operations specialists carefully inspect the orbiter to be sure no gases or fuels are present that may be toxic. This clears the way for the shuttle crew to power down the vehicle while other ground operations personnel begin connecting up ground support equipment and prepare to tow the spacecraft from the landing site to the space shuttle deservicing area at either the Kennedy Space Center in Florida or at Dryden.

Hoses from two large mobile units are attached to the orbiter during the towback from the landing site. One is a large air conditioning unit to direct cool air into the orbiter's aft fuselage, payload bay, wings, vertical stabilizer, and orbital maneuvering-reaction control system pods to dissipate heat generated by atmospheric reentry. The other unit is a Freon coolant system to protect the flight crew area and avionics systems from excessive heat during post-landing systems checks.

When the orbiters land at Dryden, they are towed to the Mate-Demate Device (MDD). It is a large gantry-like structure where the orbiters receive post-flight servicing and are prepared for the ferry flights back to the Kennedy Space Center with the NASA 747 Shuttle Carrier Aircraft (SCA). Before the ferry flights begin, all orbiter systems are checked thoroughly and certain fuel lines and tanks are purged.

Post-flight servicing and ferry flight preparations at the MDD normally take about five days. When the orbiter is ready for the ferry flight, it is lifted by the MDD and placed on special mounts atop the SCA fuselage. Ferry flights back to the Kennedy Space Center usually take one to two days, based on weather along the route.

Component Descriptions

The space shuttle system is composed of several large components: the orbiter, the main engines, the external tank , and solid rocket boosters. The gross launch weight is about 4.5 million pounds (varies based on payload weight and consumable supplies).

Orbiter: Each orbiter is 121 feet long, has a wingspan of 78 feet, and a height of 57 feet. It is about the size of a DC-9 commercial airliner, and can carry a payload of 65,000 pounds into space. The payload bay is 60 feet long and 15 feet in diameter. The landing weight will vary from mission to mission and ranges from 200,000 pounds to 230,000 pounds. Most of its basic construction, like an aircraft, is of aluminum. The forward fuselage houses the cockpit and crew cabin and crew work areas. The mid-fuselage area consists of the payload bay, and the wing and main landing gear attach points. The aft fuselage houses the main engines, the orbital maneuvering system, the reaction control system pods, the wing aft spar, and the attach point for the vertical tail. Each orbiter is designed with a lifetime of about 100 space missions.

Main Engines: Each main engine, operating on a mixture of liquid oxygen and liquid hydrogen, produces a sea level thrust of 375,000 pounds and a vacuum thrust of 470,000 pounds. They can be throttled over a thrust range of 65 to 109 percent, allowing a high power setting during liftoff and initial ascent, but a power reduction to limit acceleration of the orbiter to 3Gs during final ascent. The engines are gimbaled (movable) to provide pitch, yaw, and roll control during ascent phases of flight. Normal engine operating time on each flight is about 8.5 minutes. Each engine has a designed lifetime of about 7.5 operating hours.

External Tank: Each external tank is 154 feet long and 28.6 feet in diameter. They are constructed primarily of aluminum alloys. Empty weight of an external tank is 78,100 pounds. When filled and flight ready, each has a gross weight of 1,667,677 pounds and contains nearly 1.6 million pounds (143,060 gallons) of liquid oxygen and more than 226,000 pounds (526,126 gallons) of liquid hydrogen. The external tank is the only major part of the space shuttle system not reused after each flight.

Solid Rocket Boosters: The space shuttle solid rocket boosters are the largest solid propellant motors ever built and the first to be used on a manned spacecraft. Each motor is made of 11 individual weld-free steel segments joined together with high-strength steel pins. Each assembled motor is 116 feet long, 12 feet in diameter, and contains more than l million pounds of solid propellant. The propellant burns at a temperature of 5,800 degrees (F) and generates a lift-off thrust of 2.65 million pounds. The exhaust nozzles are gimbaled to provide yaw, pitch, and roll control to help steer the orbiter on its ascent path. The solid propellant is made of atomized aluminum powder (fuel), ammonium perchlorate (oxidizer), iron oxide powder (catalyst), plus a binder and curing agent. The boosters burn for two minutes in parallel with the main engines during initial ascent and give the added thrust needed to achieve orbital altitude. After two minutes of flight, at an altitude of about 24 miles, the booster casings separate from the external tank. They descend by parachute into the Atlantic Ocean where they are recovered by ship, returned to land, and refurbished for reuse.

Major Subsystems

Orbital Maneuvering System (OMS): Two rocket units at the orbiter's aft end, at the base of the vertical tail, are used to place the vehicle onto its final orbital path and they are used for extended maneuvering while in space. The OMS is also used to slow the vehicle's speed in orbit at the end of the mission. When the orbiter slows down, gravity begins pulling it back into the atmosphere and it glides back to earth for a runway landing. The OMS uses nitrogen tetroxide and monomethyl hydrazine for fuel. Each engine produces 6,000 pounds of thrust.

Reaction Control System (RCS): This system consists of 44 nozzles on both sides of the nose and each side of the aft fuselage pod near each OMS engine. The RCS is used throughout the mission to move or roll the orbiter as the crew carries out tasks which require the vehicle to be pointed certain ways for experiments or photography. The RCS uses the same types of fuel as the OMS. Thirty-eight of the thrusters produce 870 pounds of thrust each. The six others each produce 25 pounds of thrust.

Electrical Power: Three fuel cells supply electrical power on the orbiter during all phases of a mission. The units are located in the mid-body area of the payload bay. Electrical power is produced by the chemical reaction of hydrogen and oxygen, which are supplied continuously as needed to meet output requirements. A by-product of this reaction is drinking water used by crew. Each fuel cell is connected to one of three independent electrical distribution systems. During peak and average power loads, all three systems are used. During minimum loads, only two are used and the third is on standby, but can be brought back on line instantly if needed. The system provides up to 24 kilowatts of power, ranging from 27.5 to 32.5 volts of direct current.

Hydraulic Power: Three auxiliary power units (APU) furnish power to operate hydraulic systems on the orbiters such as the main engine gimbaling controls, the nose and main landing gear and brake systems, and the rudder, speed brake, and elevon flight control surfaces. The APUs are fueled by hydrazine which is changed into a hot gas by a granular catalyst. The momentum of the expanding gas spins turbine blades and this energy is transferred to gearboxes on the hydraulic pump units. All three APUs operate during launch, but only two are needed for reentry and landing.

Environment Control and Life Support System: The orbiter's environmental control and life-support system purifies the cabin air, adds fresh oxygen, keeps the pressure at sea level, heats and cools the air, and provides drinking and wash water. The system also includes lavatory facilities. The cabin is pressurized to sea level (14.7 psi) with 21 percent oxygen and 79 percent nitrogen, comparable to earth's atmosphere. The air is circulated through lithium hydroxide/charcoal cannisters which remove carbon dioxide. The cannisters are changed on a regular basis. Heat from the cabin and flight-deck electronics is collected by a circulating coolant water system and transferred to radiator panels on the payload bay doors where it is dissipated. The fuel cells produce about seven pounds of water each hour. It is stored in tanks, and the excess water is dumped overboard when the tanks are full. The lavatory unit collects and processes body waste, and also collects wash water from the personal hygiene station. The lavatory unit, located in the mid deck area, operates much like those on commercial airlines but is designed for a weightless space environment.

Thermal Protection: The thermal protection system is designed to limit the temperature of the orbiter's aluminum and graphite epoxy structures to about 350 degrees (F) during reentry. There are four types of materials used to protect the orbiter. Reinforced carbon-carbon is a composite of a layer of graphite cloth contained in a carbon matrix. It is used on the nose cap and wing leading edges where temperatures exceed 2,300 degrees (f). High-temperature reusable surface insulation consists of about 20,000 tiles located mainly on the lower surfaces of the vehicle. They are about six inches square and made of a low-density silica fiber insulator bonded to the surface in areas where temperatures reach up to 1,300 degrees (F). Low-temperature reusable surface insulation also consists of tiles. There are about 7000 of this variety on the upper wing and fuselage sides where temperatures range from 700 to 1,200 degrees (F). Flexible reusable surface insulation (coated Nomex felt) is sheet-type material applied directly to the payload bay doors, sides of the fuselage and upper wing areas where heat does not exceed 700 degrees (F).