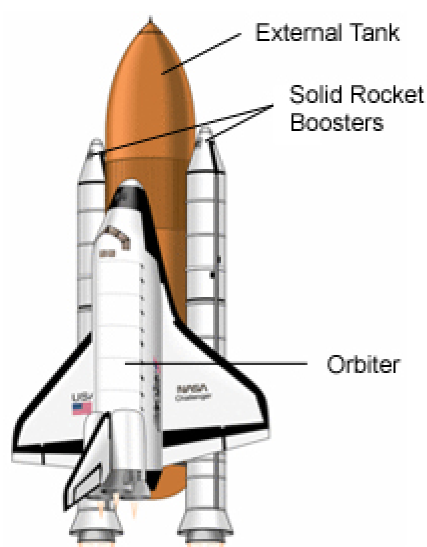
READING: Aeronautics of the Space Shuttle

Keywords

Mojave Desert: An area in the U.S. that includes parts of southeastern California, Nevada, Arizona, and Utah. It covers more than 25,000 square miles.
Lifting Body: An airplane or spacecraft that has a unique body design, which causes an upward force known as lift to help it glide.
Thrust: A force that pushes an object.
Configuration: Where something is placed, or how it is arranged on a regular basis.
Delta Wing: Shaped like a V.
Hypersonic: Traveling at or greater than five times the speed of sound.
Drag: This is a force that acts opposite the direction of movement, causing something to slow down. Drag is a type of frictional force.
Vacuum: Refers to a location that contains very few gas molecules. These gas molecules are vastly far apart.
Fuselage: The middle part of an airplane or spacecraft where the passengers or cargo is located.
Rendezvous: Pronounced ron-day-voo, this is a meeting or gathering between two or more things.
Mach 1: The speed of sound, which in air is around 732 miles per hour.
Descent: The process of going downward.
Elevon: A combination of an elevator and an aileron.
Ailerons: Found on most airplanes at the trailing edge of each wing, ailerons control an airplane's roll motion.
Fin: The orbiter's vertical stabilizer has the rudder, which controls its ***yaw*** (nose left, nose right).
OMS: The (orbital maneuvering system) engines that the Shuttle uses to maneuver into orbit.
RCS: The reaction control system engines allow the commander to perform the motions of roll, pitch, and yaw while the orbiter is maneuvering out of orbit and re-entering the Earth's atmosphere. The RCS engines also are used while the orbiter is maneuvering in the upper atmosphere.
Subsonic: Slower than the speed of sound.

The Space Shuttle is a Lifting Body

On August 12, 1977, a specially designed Boeing 747 jetliner was giving another aircraft a piggyback ride. Approximately 24,000 feet above the Mojave Desert, a high-tech glider was released from its flying perch. It glided effortlessly without engine power to a smooth landing on the desert floor. A new era in space transportation had begun.



That high-tech glider was the Space Shuttle. The Space Shuttle is designed to simply ferry or "shuttle" people, satellites, and other cargo between Earth and space. It is a reusable spacecraft unlike any other that had come before it. It is a more efficient and economical vehicle as compared to its predecessors: capsules and rockets. The Space Shuttle, with a shape like a bulky glider, is actually a lifting body. A lifting body is a specially constructed spacecraft that cannot launch under its own power, but needs additional rocket engines for thrust. The Shuttle is a unique lifting body in that it is a high-tech glider.

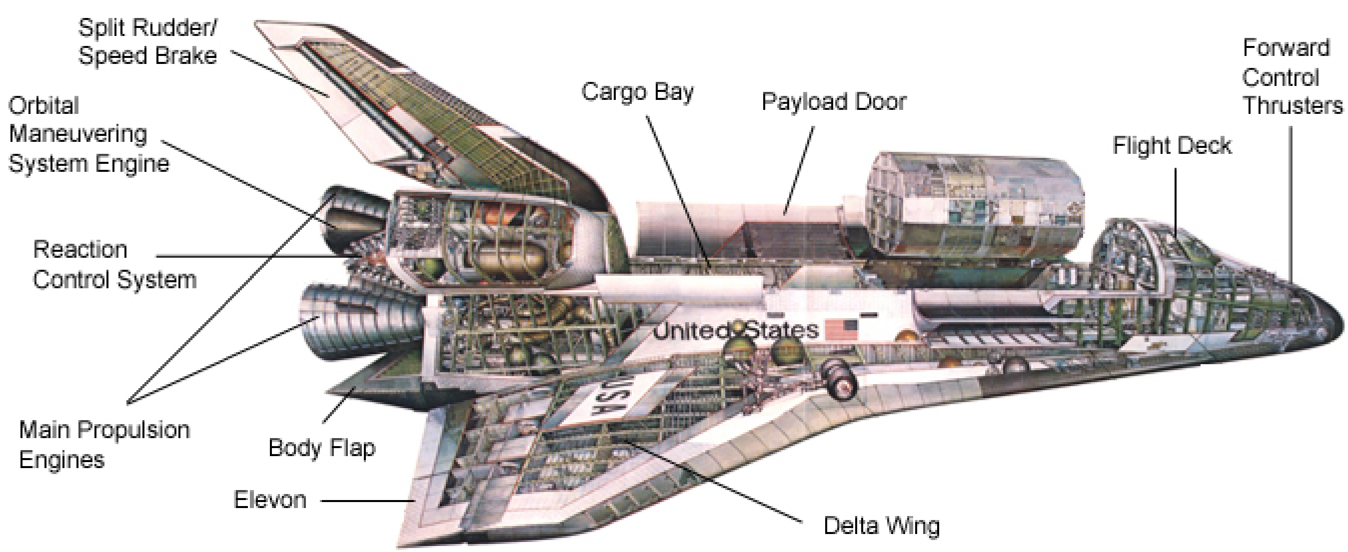
Basic Structure

The Space Shuttle is made up of four parts: an orbiter (the Shuttle itself), two solid rocket boosters (both reusable), and one external fuel tank (which is not reusable). The image above shows a spacecraft that is launched in an upright position and attached to two solid rocket boosters and an external fuel tank. At launch, the orbiter's three main engines are fired (fueled by the external fuel tank) as well as the solid rocket boosters. Together, they provide the Shuttle with the millions of pounds of thrust to overcome the Earth's gravitational pull.

The Orbiter as a High-Tech Glider

The orbiter is shaped much like an airplane. It has many of the same parts as an airplane except for its engine ***configurations***. The orbiter has wings that create lift. It also uses a double-***delta wing*** configuration to achieve the most efficient flight during ***hypersonic*** speed as well as provide a good lift-to-drag ratio during landing. For control, each wing has an "elevon." An ***elevon*** is a combination of an elevator and an aileron. On an airplane, the elevator controls the motion of pitch (nose up, nose down). In addition, on most airplanes, the elevator is located on the horizontal stabilizer as part of the tail section. ***Ailerons***, which control an airplane's roll motion, are mostly found on the trailing edge of each wing. Because of the orbiter's delta wing configuration, the elevators and ailerons are combined as elevons and placed at the trailing edge of each wing.

The orbiter's vertical stabilizer, or ***fin***, has the rudder, which controls its ***yaw*** (nose left, nose right). The split-rudder on the orbiter works as a rudder and also a speed brake (found on most airplanes as a spoiler located on the wing). It does this by splitting in half vertically and opening like a book. This deflects the airflow, increases drag, and decreases the orbiter's speed as it rolls along the runway upon landing.



The airplane-like control surfaces on the orbiter are useless in the vacuum of space. However, once the orbiter re-enters the Earth's atmosphere, these control surfaces interact with the air molecules and their airflow to control the orbiter's flight path.

The engines are the major difference between this high-tech glider and airplanes. The orbiter has the ***OMS*** (orbital maneuvering system) engines as well as the ***RCS*** (reaction control system) engines. The Shuttle maneuvers into orbit using its orbital maneuvering system (OMS). The OMS has two rocket engines located on the outside of the orbiter, one on each side of the rear fuselage. These rockets give the orbiter the thrust it needs to get into orbit, change its orbit, and rendezvous with a space station or another space vehicle. The OMS also is used to exit orbit for re-entry into the Earth's atmosphere.

The second set of small engines includes one set of engines near the orbiter's nose and two other sets in the rear on the pods. These RCS engines allow the commander to perform the motions of roll, pitch, and yaw while the orbiter is maneuvering out of orbit and re-entering the Earth's atmosphere. The RCS engines also are used while the orbiter is maneuvering in the upper atmosphere.

Re-entry and Landing

The commander begins the de-orbit burn by firing the orbiter's engines to slow its speed and take it out of orbit. The RCS engines turn the orbiter around so that it is moving backwards at a slower speed. To maneuver the orbiter while it is in this position, the commander uses the RCS engines to control roll, pitch, and yaw motions. The OMS engines (space engines) are then fired, taking the orbiter out of orbit and thrusting it into the Earth's upper atmosphere. The RCS engines are used one last time to turn the orbiter around so that it is moving nose forward and pitched up slightly. In the upper reaches of the atmosphere the vehicle's motions of yaw, pitch, and roll are controlled by the RCS engines. As the atmosphere thickens, the airplane’s control surfaces become usable. The orbiter re-enters the atmosphere at a high angle of attack (about 30 degrees). This high angle of attack is used to direct most of the aerodynamic heating to the underside of the vehicle, where the heat resistant tiles give the greatest amount of protection.

At an altitude of approximately 30 miles, the orbiter makes a series of maneuvers and S-turns to slow its speed. At 9.5 miles in altitude and at a speed of Mach 1 (the speed of sound), the orbiter can be steered using its rudder. The on-board computers fly the orbiter until it goes subsonic (slower than the speed of sound). This happens about 4 minutes before landing. At this time, the commander takes manual control of the orbiter and flies a wide arc approach. At 7.5 miles from the runway, the orbiter is flying about 424 miles per hour at an altitude of 13,365 feet. About 2 miles from the runway, the orbiter is flying at nearly 360 miles per hour on a glide slope of 22 degrees.

Once lined up with the runway on approach, the orbiter continues its steep glide slope of 18 - 20 degrees. The commander levels the descent angle at a final glide slope of 1.5 degrees by performing a "flare maneuver." The nose of the orbiter increases its pitch (nose up), which slows its speed. The orbiter touches down at a speed between 215-226 miles per hour. It is slowed and eventually brought to a stop by the speed brake, wheel brakes, and a drag chute.

Space Shuttle Quick Facts

- The orbiter is the size of a DC-9 jet.
- Each orbiter was built to make 100 missions.
- Orbiters are named after pioneering sea vessels.
- The external tank contains liquid oxygen and liquid hydrogen to fuel the Space Shuttle’s three main engines. This is the only part of the Space Shuttle never used again.
- The two solid rocket boosters are built to be used on at least 20 different missions.
- The Space Shuttle is important for scientific research in a weightless environment, releasing and fixing satellites, and carrying parts and crew to and from the International Space Station.
- The first Space Shuttle launch occurred on April 12, 1981.
- The orbiter, two solid rocket boosters, and external tank are lifted off the launch pad by 7,800,000 pounds of thrust.

It is this unique aerospace vehicle, a lifting body that launches like a rocket, orbits like a spacecraft, and lands like a glider, that continues to link Earth and space.