

# A Shuttle Flight

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## LAUNCH!

The Space Shuttle is launched from the Kennedy Space Center at Cape Canaveral, Florida. A Shuttle flight takes months of careful preparation. Each launch is preceded by a countdown, usually starting about two days in advance, to make sure that everything occurs at the right time and in the right sequence.

About two hours before launch, the astronauts go up the launch pad elevator, enter a hatch on the side of the orbiter, and are strapped into their seats lying on their backs. The crew then spends the next two hours on the launch pad making final preparations for the launch.

Seven seconds before lift-off, the external tank begins supplying fuel to the three main engines. These engines are running at full power before lift-off. The three main engines alone do not have enough thrust to lift the Space Shuttle off the launch pad. In these few seconds before lift-off, the engines are checked thoroughly by the Shuttle computers. This is important because once the solid rockets are ignited they cannot be turned off.

### Night Launch of Endeavor



At precisely “zero” in the countdown, the solid rockets are ignited. The combined thrust of the solid rockets and main engines is so powerful that the Space Shuttle is lifted straight into the air.

During the first part of the launch, the Shuttle continues to accelerate in order to travel above the Earth’s atmosphere. Approximately one minute into the flight, the Shuttle is rising upwards at the speed of sound (Mach 1). The solid rockets and the Shuttle’s main engines continue to burn.

About two minutes after lift-off, the solid rockets have used all their fuel. The empty solid rockets are released and pushed away from the Shuttle. They parachute back to Earth, while the orbiter and external tank continue upward. The spent solid rockets land in the ocean near Florida, and are picked up and recycled for use on a future Shuttle mission.

When the Shuttle is about 60 miles above the Earth, well above the atmosphere, it begins to change its trajectory to fly more horizontally to the Earth. This allows it to pick up speed. Once the Shuttle reaches the height it’s aiming for, and attains the critical speed it needs to stay in orbit, the three main engines are shut off. This happens about eight and a half minutes after launch. The nearly empty external tank is then released; it re-enters the atmosphere, and disintegrates during re-entry. The orbiter is the only piece that makes it into orbit.

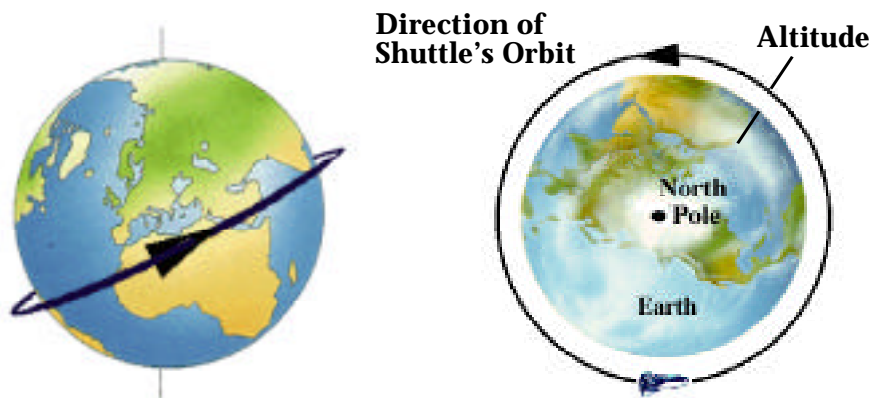
The orbiter is initially in a rather low, non-circular (elliptical) orbit. It needs to raise its orbit slightly or else it will soon re-enter the atmosphere and return to Earth. The Shuttle can no longer use its main engines since the external tank (which contained the fuel they burn) is gone. When it needs to change its orbit, it relies on a smaller set of engines. About forty-five minutes after the main engines are shut off, the orbiter fires the “OMS” (Orbiter Maneuvering System) engines to put it into a stable orbit around the Earth.



## IN ORBIT!

The Shuttle's orbit around the Earth: **The Space Shuttle stays in orbit because of the speed it reaches during launch, and the Earth's gravity. There are no engines running while the Shuttle is in orbit—they're not needed. The Shuttle follows the same path around the Earth like a car on a racetrack. Meanwhile, the Earth rotates beneath it. The Shuttle orbits the Earth at a speed of about 17,500 mi/hr (about 5 mi/sec!); at that speed, it takes about 90 minutes to circle the Earth once. This means that the Shuttle sees about 45 minutes of daylight and 45 minutes of darkness each time it goes around the Earth.**

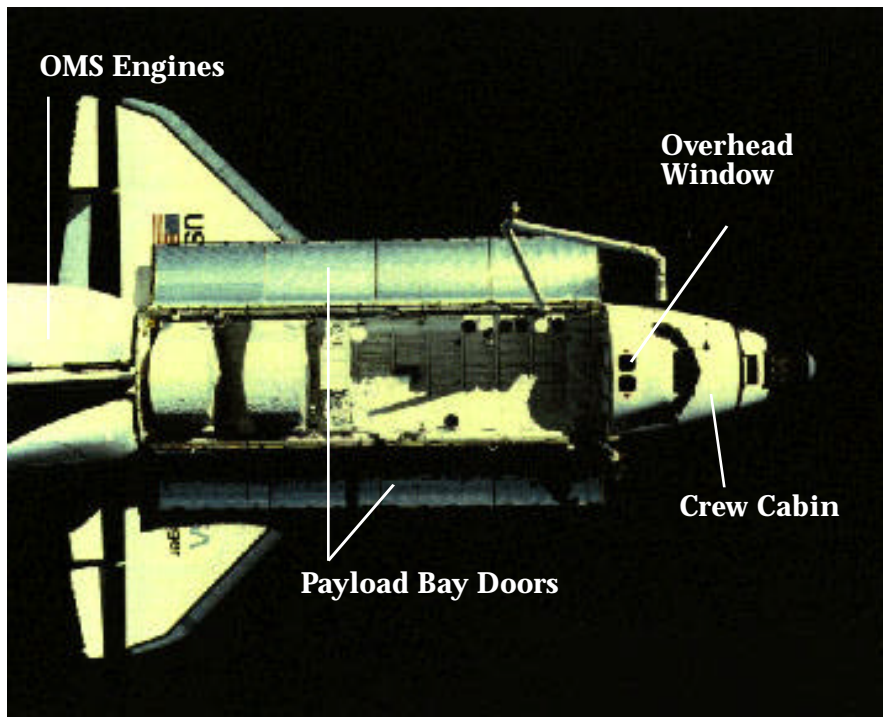
Side and Top Views of the Shuttle's Orbit



**While in orbit, the Space Shuttle is a spacecraft, not an airplane. Because the Shuttle does not need any engines to stay in orbit, it does not matter which way it is facing. It can be traveling nose forward, tail forward, right-side up, or upside down. The EarthKAM camera will point directly down at Earth when the Shuttle is upside down. This Shuttle orientation is called “-ZLV”, which means the minus z axis of the Space Shuttle (which goes through the top of the Shuttle) is pointed in the “local vertical” (LV) direction. The EarthKAM camera will only be taking pictures of the Earth when the Shuttle is in this orientation...upside down.**



The Shuttle in orbit: The part of the Shuttle that would be the passenger section of an airplane is called the payload bay. It is 60 feet long and about 15 feet across. It carries cargo (satellites, experiments, etc.) into space or back to Earth. The payload bay is not pressurized and is open to space. Astronauts have to wear spacesuits to go out into the payload bay.



The payload bay doors play an important role in the Shuttle mission. When these doors are open, the Shuttle's internal heat can be radiated into space. This is the primary means of cooling the Shuttle. Because of this, the doors must be opened within the first couple of hours of the flight or the Shuttle has to return to Earth.

The OMS engines, at the rear of the Shuttle, are used to change the Shuttle's orbit while the Shuttle is in space.

In the nose of the orbiter is the two-level "crew cabin," a pressurized area where the astronauts live and work during the Shuttle missions. The upper level is called the flight deck and resembles the cockpit of an airplane. The flight deck has most of the controls for the Space Shuttle and for the satellites and experiments the Shuttle is carrying. There are windows at the front, top, and back



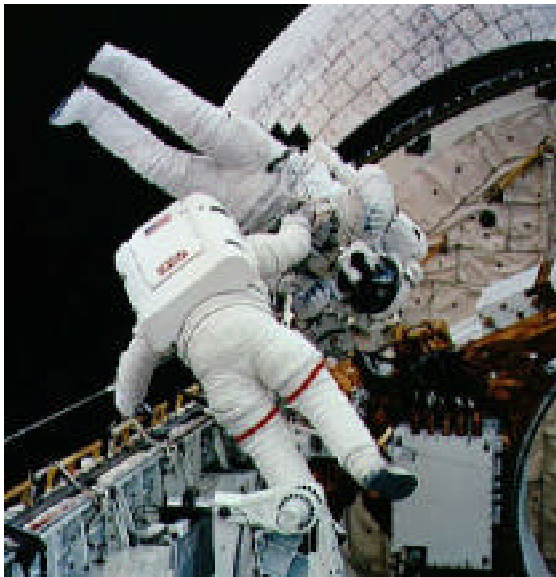
of the flight deck. The top windows, called the overhead windows, are where the EarthKAM camera is mounted when it is flown on the Shuttle.

The lower level is the Shuttle's mid-deck where food, water, clothes, and sleeping bags are stored. The bathroom is also on this level. The EarthKAM camera is stored in a locker on the mid-deck during launch.

The astronauts inside: There are usually five astronauts on-board the Space Shuttle. There are two pilots, the commander and the pilot, and three mission specialists, who are scientists or engineers. They train together for about a year before the mission, so they know each other and their duties very well. While the Space Shuttle is in orbit, the astronauts (and all other things in the Shuttle) are weightless. It usually takes a day or two for the astronauts to get adjusted to this.

The duties that astronauts perform depend on the purpose of their particular Shuttle mission. Their duties may include releasing new satellites into orbit, retrieving defective satellites for later repair, carrying out different experiments, or guiding the Shuttle to rendezvous with other spacecrafts.

Occasionally, the astronauts have work to do outside the crew cabin. To go outside on a spacewalk, astronauts must wear specially made spacesuits to protect them from the vacuum of space, the lack of air, and extreme temperatures in space.



EarthKAM

## Re-Entry and Landing!

Once the mission has been completed, the crew is ready to return to Earth. To leave orbit, the Shuttle fires its small OMS engines for about three minutes. This decelerates the Shuttle which lowers its orbit into the atmosphere. Once within the Earth's atmosphere, the Shuttle is slowed down rapidly by aerodynamic drag caused by the collisions between the orbiter and the air molecules. This friction also heats the outside of the Shuttle to over 2,500 degrees. To protect the Shuttle from this intense heat, the Shuttle is covered with approximately 32,000 heat-resistant tiles.

The Shuttle's OMS engines cannot be used in the atmosphere, so the Shuttle re-enters without the use of any engines. It is a glider! Computers control most of the re-entry and continuously estimate the distance to the landing site. The orbiter responds to the computer's estimates by adjusting the size of the turns it makes as it approaches the landing site. The Shuttle slows down to below Mach 1 (the speed of sound) just minutes before landing. The Shuttle commander then takes control and flies the Shuttle to landing. As the Shuttle approaches the runway, the commander lowers the landing gear. The orbiter lands with a speed of a little over 200 mph either on the long Shuttle runway at the Kennedy Space Center (KSC) in Florida or at Edwards Air Force Base in California.

Columbia Landing at KSC

