Countdown starts: 43 hours and counting

At 43 hours to launch the countdown clock is activated. This occurs when the Shuttle Test Director verifies that the launch team is in place and ready to proceed. Over the course of the next 16 hours a number of activities take place including activation and testing of the navigational systems; and preliminary inspections of the flight deck. At 27 hours to launch the countdown is put on hold. This hold normally lasts four hours. During this time all non essential personnel are cleared from the launch site.

The countdown clock at the Kennedy Space Center prior to launch of the STS-114 Return to Flight Shuttle mission on 26 July 2005. (Image: NASA)

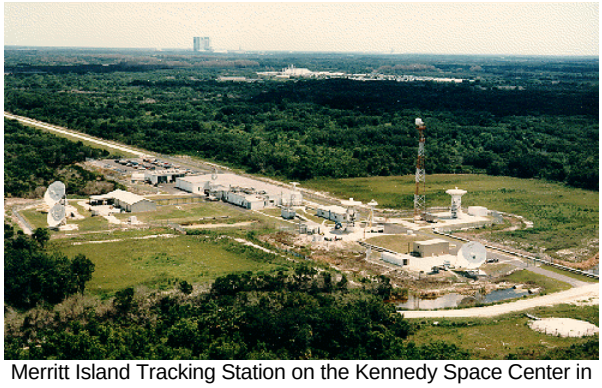
When the countdown resumes preparations begin to load liquid oxygen and liquid hydrogen into the storage tanks for the orbiter's fuel cells, which provide power for the orbiter during the mission. Upon completion, the launch pad area is reopened. A second hold in the countdown occurs at 19 hours until launch. This again lasts about four hours.

When the next countdown period begins, the orbiter's three main engines are prepared for propellant tanking and flight, the launch pad sound suppression system is filled with water and various close-out activities take place. With 11 hours to launch the longest hold period begins lasting 12-13 hours. Checks take place on guidance, navigation and communication systems, and the Rotating Service Structure is rolled back to its park position.

The clock begins again at 11 hours to launch. The orbiter's fuel cells are activated and all non-essential personnel are cleared from the blast danger area. The payload bay and other orbiter cavities are filled with gaseous nitrogen in preparation for filling the external tank with its super-cold propellants. Another hold period occurs at 6 hours to launch, lasting about two hours. If the launch team verify that the launch criteria are met, during this period, the launch pad is cleared of all personnel and the countdown begins again.

The Rotating Service Structure after rollback to the park position prior to launch of the STS-97 Shuttle Mission. (Image: NASA)

The propellant transfer lines are chilled and loading of the External Tank with almost 2 million litres of propellant (liquid oxygen and liquid hydrogen) begins. Hereafter the Final Inspection Team proceeds to the launch pad to conduct a detailed analysis of the vehicle. During the following hold period at 3 hours to launch tracking antennas at the nearby Merritt Island Tracking Station are aligned for lift-off.



Merritt Island Tracking Station on the Kennedy Space Center in Florida. (Image: NASA)

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From 3 Hours and Counting to T minus 10

Just after the clock begins with 3 hours to launch the crew departs for the launch pad. After arriving they are assisted into the orbiter via the so-called White Room at the end of the orbiter access arm. The astronauts now carry out voice checks with the Launch and Mission Control Centres at the Kennedy and Johnson Space Centers. The hatch is closed and hatch seal and cabin leak checks take place.

Michel Tognini, Head of ESA's European Astronaut Centre in Cologne, Germany, in the White Room before entering the Shuttle for the STS-93 mission in July 1999. (Image: NASA)

The penultimate hold in the countdown is initiated at 20 minutes to launch at which time the Shuttle Test Director conducts final launch team briefings. Once the countdown begins about ten minutes later the orbiter's onboard computers and backup flight system are changed to launch configuration. The last hold in the countdown is at 9 minutes to launch. If a go for launch is agreed the final countdown starts.

With 7 minutes 30 seconds until launch the Orbiter Access Arm is retracted and the orbiter's flight recorders are activated. The orbiter's elevons, speed brakes and rudder are checked and manoeuvred to their launch position. The main engine nozzles are also checked for readiness.

With just under 3 minutes to launch the liquid oxygen tank is brought to flight pressure and the so-called beanie cap is removed, which prevents ice build up on the oxygen vents. At 2 minutes to launch the crew lock their visors. The external tank's liquid hydrogen is brought to flight pressure by closing the boil off vent. With 50 seconds to launch the orbiter switches from ground to internal power.

STS-106 on launch pad. White Room is attached to the orbiter at the end of the Orbiter Access Arm. The beanie cap is shown at the top of the External Tank prior to removal. (Image: NASA)

With 31 seconds to launch the Shuttle's onboard computers start their terminal launch sequence. The sound suppression system is turned on and water begins to pour onto the deck of the Mobile Launch Platform and pad areas to protect the Shuttle from acoustic damage at lift-off. At T minus 11 seconds the Solid Rocket Booster range safety destruct system is activated.

Sound Suppression System test on launch pad 39A at the Kennedy Space Center. (Image: NASA)

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Lift Off to Orbit

The "go for main engine start" command is issued at T-10 seconds. Flares are ignited under the main engines to burn away any residual gaseous hydrogen. The flight computers order the opening of valves which allow the liquid hydrogen and oxygen to flow into the engine's turbopumps. At T-6.6 seconds the Space Shuttle main engines start, throttling to 90 percent thrust in 3 seconds. At this point the Solid Rocket Booster ignition sequence starts and we have lift off.

Launch of the STS-114 Mission on 26 July 2005. (Image: NASA)

Once the Solid Rocket Boosters ignite the Shuttle is now committed to launch. The Shuttle lifts off the pad and clears the tower at about 7 seconds after launch. After the tower is cleared Mission control is handed over to the Johnson Space Center.

One minute after launch the dynamic pressures on the Shuttle are greatest at an altitude of 10.2 km. At this point the main engines are "throttled down," to about 75 percent, to keep the dynamic pressures on the vehicle's surface within allowable levels. After passing through this phase, the main engines are throttled up to full power.

At 2 minutes after launch the fuel of the Solid Rocket Boosters is expended. These are thereafter jettisoned from the orbiter. The Shuttle is at an altitude of about 48 km and travelling at a speed of 4650 km an hour. The spent Solid Rocket Booster casings continue to gain altitude up to 75 km before they begin falling back to Earth.

Five minutes after launch, when the spent casings have descended to an altitude of about 5 km, their parachute deployment sequence starts, slowing them for a safe splashdown in the Atlantic Ocean. The boosters are retrieved, and returned to a processing facility for refurbishment.

Recovery vessel towing Solid Rocket Booster casing. (Image: NASA)

For the orbiter, at eight minutes after launch, main engine cut-off occurs. The Shuttle is now travelling at a speed of almost 27000 km/h. After main engine cut-off, a brief firing of the orbiter's two Orbital Manoeuvring System thrusters changes the trajectory and orbit is achieved at an altitude of 225 km. This takes place just after the external tank has been jettisoned and while the orbiter is flying "upside down" in relation to Earth.

External Tank from the STS-114 Return to Flight mission following jettison. (Image: NASA)

The separated external tank continues on a ballistic trajectory and enters the Earth's atmosphere to break up over a remote area of the Indian Ocean. Meanwhile, an additional firing of the Orbital Manoeuvring System thrusters places the orbiter into its planned orbit.

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Deorbit and Landing Procedures

Mission Control give the order to perform the deorbit burn about 1 hour prior to landing. Before performing the deorbit burn the orbiter is turned so that the tail is facing the direction of travel. The Orbital Manoeuvring System engines are fired for 3 to 4 minutes to slow the orbiter down enough to reduce the orbiter's altitude. The orbiter is then turned back to travelling nose first using control thrusters and now freefalls for about 30 minutes using control thrusters to control roll, pitch and yaw. The orbiter enters the upper layers of the Earth's atmosphere at an altitude of about 120 km and travelling at a velocity of 7.6 km per second. On re-entry super-heated plasma envelops the orbiter causing a communications blackout until an altitude of about 45 km.

Aerial view of the Shuttle Landing Facility at the Kennedy Space Center. (Image: NASA)

As the air pressure increases, the forward control thrusters are turned off. Hereafter the aft control thrusters are turned off as the ailerons on the orbiter's wings begin to operate to help control the orbiter more like an aircraft. The orbiter's wing elevators then become operational and the pitch thrusters are stopped. When the orbiter's velocity falls below Mach 10 a speed brake on the vertical tail opens. This is about 12 minutes to touchdown. At Mach 3.5, the rudder is activated and the final yaw jets are stopped.

The orbiter now begins manoeuvres, which will enable it to start final landing procedures at the desired altitude and velocity. The orbiter performs a series of four steep banks, rolling over as much as 80 degrees to one side or the other, to slow down. The series of banks gives the Shuttle's track toward landing an appearance similar to an elongated letter "S."

With 5 minutes until landing the orbiter is now in subsonic flight, at 14900 m and about 35 km from its touchdown point. The commander takes over control of the orbiter for final approach and landing manoeuvres.

At an altitude of 5000 m the orbiter is now about 16 km from touchdown. As it aligns with the runway, the orbiter begins a steep descent with the nose angled as much as 19 degrees down from horizontal. This is six times steeper than the 3-degree glide slope of a typical commercial jet airliner as it approaches landing.

STS-112 landing on 18 October 2002. (Image: NASA)

During the final approach, the vehicle drops toward the runway 20 times faster than a commercial airliner as its rate of descent and airspeed increase. At less than 600 metres above the ground, the commander raises the nose and slows the rate of descent to bring it into its final landing glide slope of 1.5 degrees in preparation for touchdown. With 15 seconds until touchdown the landing gear is deployed.

At touchdown the orbiter is travelling at a speed ranging from 340 to 360 km/h. The drag chute is deployed, and the orbiter coasts to a stop. Once the orbiter has rolled to a stop, the post-landing procedures begin.

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Post-Landing Operations

Once the orbiter has rolled to a stop on the runway, post-landing activities get underway involving the Orbiter Recovery Convoy. Mission responsibility has shifted from the Johnson Space Center back to the Kennedy Space Center. The Orbiter Recovery Convoy consists of a number of specially-designed vehicles and a team of specialists who safe and service the orbiter and assist in crew egress. Included in the convoy are 11 special vehicles and units, augmented by various conventional command and emergency vehicles. The main job of the recovery convoy is to service the orbiter, prepare it for towing, assist the crew in leaving the orbiter and finally to tow it to servicing facilities.

After landing, the first staging position of the convoy is 60 m up wind from the orbiter. The safety assessment team moves to about 30 m of the port side of the orbiter. A crew dressed in protective clothing moves to the rear of the orbiter to test for possible explosive hazards and toxic gases. If present in high levels and if calm weather conditions the Vapour Dispersal Unit moves in to blows away the potentially dangerous gases using a mobile wind machine.

Start of post landing procedures. Safety assessment crew vehicle is to the right of the orbiter. (Image: NASA)

As soon as it is possible lines are attached to the orbiter to determine the on board hydrogen concentration. If the concentration is less than 4 percent, convoy operations continue. However, if it should be greater than 4 percent, an emergency power down of the orbiter is ordered. The flight crew is evacuated immediately and the convoy personnel clear the area and wait for the hydrogen to disperse. If the hydrogen level is below 4 percent, the flow of coolant and purge air through the umbilical lines begins. Purge air provides cool and humidified air conditioning to the payload bay and other cavities thereby removing any residual explosive or toxic fumes.

When it is determined that the area around and in the orbiter is safe, additional post-landing operations can begin. The first priority is to assist the flight crew off the orbiter. The Crew Hatch Access Vehicle moves to the hatch side of the orbiter and the access white room is secured. The hatch is opened and a physician boards the orbiter to make a brief medical examination of the crew. The crew then leaves the orbiter and departs.

Crew Transport Vehicle pulls up to Space Shuttle Discovery to offload the crew following landing of the STS-114 mission. 9 August, 2005. (Image: NASA)

The flight crew is replaced on board the orbiter by an exchange crew who make preparations for ground towing operations, installing switch guards and removing data packages from onboard experiments, if required. Meanwhile, after allowing for a 30-minute orbiter tire cool down, the orbiter is prepared for towing. The Tow Vehicle is then positioned in front of the orbiter and the tow bar connection is made. Finally, about two hours after landing the orbiter is towed off the runway.

Space Shuttle Discovery being towed following landing of the STS-114 mission. (Image: NASA)

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