Space Shuttle Launch Guide

*This guide is tailored around select space shuttle add-ons for Orbiter Simulator. See **www.eharm.net** for the recommended space shuttle add-on configuration.*

Countdown at T-3 hours

Flight crew begins entry into the orbiter
Astronauts perform air-to-ground voice checks with Launch and Mission Control
Close Shuttle crew hatch
Begin Eastern Range final network open loop command checks
Perform hatch seal and cabin leak checks
Complete white room close-out
Close-out crew moves to fallback area
Primary ascent guidance data is transferred to the backup flight system

Enter planned 10-minute hold at T-20 minutes

NASA Test Director conducts final launch team briefings
Complete inertial measurement unit preflight alignments

Resume countdown at T-20 minutes

Transition the orbiter's onboard computers to launch configuration
Start fuel cell thermal conditioning
Close orbiter cabin vent valves
Transition backup flight system to launch configuration

Enter estimated 45-minute hold at T-9 minutes

Launch Director, Mission Management Team and NASA Test Director conduct final polls for go/no go to launch

At T-9 minutes and counting, the Ground Launch Sequencer (GLS) computer located in the Firing Room begins controlling the countdown automatically. The GLS monitors more than 1000 critical functions through liftoff. At T-31 seconds, the orbiter's onboard computers take over.

the Ground Launch Sequencer may be simulated with the LC39-EAFB 2006.1 by pressing "G" but it is for PAD animations only. The GPCMFD that comes with Shuttle Fleet does have a simple launch sequencer function added along with the OPS 1 displays. Unfortunately you don't get a nine-minute countdown but you do get 10 seconds.

To activate this launch sequencer function you most enter item 777 into the GPC MFD OPS 1 ten seconds before launch time. With the Shuttle Fleet add-on this will trigger a fully automated launch of the shuttle. The sequence will continue until Main Engine Shut Off. At this point the orbiter is only suborbital. An OMS 2 burn will need to be performed manually to circularize orbit.

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Use this guide along with the Space Shuttle Mission Checklists to reference all necessary Orbit/Add-on key commands. This Guide is for you to follow the main launch events in an easy to read format.

Resume countdown at T-9 minutes

T-9:00 Start automatic ground launch sequencer (C3)
T-7:30 Retract orbiter crew access arm
T-6:15 Start mission recorders
T-5:00 Start Auxiliary Power Units (R2)
T-5:00 Arm SRB and ET range safety safe and arm devices
T-4:55 Start liquid oxygen drain back
T-3:55 Start orbiter aero surface profile test
T-3:30 Start main engine gimbal profile test
T-2:55 Pressurize liquid oxygen tank
T-2:55 Begin retraction of the gaseous oxygen vent arm
T-2:35 Fuel cells to internal reactants
T-1:57 Pressurize liquid hydrogen tank
T-1:00 Deactivate SRB joint heaters
T-0:50 Orbiter transfers from ground to internal power
T-0:31 Ground Launch Sequencer go for auto sequence start
T-0:21 SRB gimbal profile
T-0:10 Flares are ignited under three main engines
T-6.6 Ignition of three Space Shuttle main engines
T-0:0 SRB ignition and liftoff

First Stage

First-stage ascent extends from SRB ignition through SRB separation, or SRB staging.

T+00:00:20 Roll

By about 20 seconds after lift-off, the vehicle is at 180 degrees roll and 78 degrees pitch.

T+00:01:00 Throttle up

To keep the dynamic pressure on the vehicle below a specified level, on the order of 580 pounds per square foot (max q), the main engines are throttled down at approximately 26 seconds and throttled back up at approximately 60 seconds.

T+00:02:07 SRB Sep

SRB separation occurs at about two minutes after launch. At separation, the first stage is complete, and the software automatically shifts to major mode 103 (second stage).

SRB separation is normally performed automatically by the onboard GPCs; however, the flight crew can command separation through use of the SRB separation switches on panel C3.

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Second Stage

Second-stage ascent begins at SRB separation and extends through main engine cutoff and external tank separation. The GN&C; software is in major mode 103 (second stage).

Second-stage navigation is the same as that of first stage. Second-stage flight control continues through MECO.

Second-stage guidance uses a cyclic, closed-loop scheme to calculate the necessary commands to take the vehicle to a specified set of target MECO conditions.

T+00:02:30 Two Engine TAL
T+00:04:00 Negative Return
T+00:04:30 Press to ATO
T+00:05:30 Single Engine OPS 3
T+00:06:20 Press to MECO and Single Engine Zaragoza 104
T+00:07:00 Single Engine Press 104

Guidance also governs the main engine throttle command so that acceleration does not exceed 3 g's.

T+00:07:40

The main engines are throttled down at approximately seven minutes 40 seconds into the mission to maintain 3 g's for physiological and structural constraints.

Approximately 10 seconds before MECO, the MECO sequence begins; about three seconds later the main engines are commanded to begin throttling at 10-percent thrust per second to 65-percent thrust.

This is held for approximately 6.7 seconds, and the engines are shut down.

T+00:08:20 TMECO

At MECO, the vehicle attitude commands (roll, pitch and yaw) are frozen, and body rate damping is maintained during the coast period by the reaction control system, which is accomplished by the transition digital autopilot.

The MPS prevalves are closed and a flag is set for the external tank separation sequence after the MPS prevalves for all main engines have been commanded closed.

The onboard general-purpose computers perform ET separation automatically.

If needed a manual separation could be accomplished by positioning the ET separation switch on panel C3 to man and depressing the ET separation push button.

In the automatic orbiter/ET separation sequence, the transition DAP commands separation 18 seconds after main engine cutoff.

After ET separation, the two umbilical doors (one each for the 17-inch liquid oxygen and liquid hydrogen umbilical disconnects) are closed automatically for the entry phase.

If the automatic function fails to close the umbilical doors, the flight crew can manually close them by using the ET umbilical door switches on panel R2.

After initiation of the orbiter/ET separation sequence, there is approximately 11 seconds of mated coast before the orbiter and external tank separate.

The ET tumble system produces a tumble rate of 10 to 50 degrees per second after separation.

In Kennedy Space Center launches, the external tank is on a suborbital trajectory that normally results in an impact location in the Indian Ocean.

Just before orbiter/ET separation, the reaction control system is inhibited. It is re-enabled immediately after ET separation to an inertial attitude hold.

The transition DAP then commands the RCS to thrust the four forward and six aft negative RCS jets for a minus Z translation to achieve a 4-foot-per-second separation vertically, ensuring orbiter clearance from the arc of the rotating tank.

When the orbiter has gained the necessary separation the software makes an automatic transition to major mode 104 (OMS-1 insertion) when the negative Z translation is complete.

T+00:08:42 MECO OMS 1 Not Required

Flight crew monitors the onboard systems to ensure that the major GN&C; events occur correctly and on time. These events include:

- Closed-loop guidance convergence
- 3-g throttling
- MECO
- ET separation
- Negative Z translation following ET separation.

To monitor these events, the flight crew uses the dedicated displays-the main engine status lights on panel F7 and the PASS ascent trajectory and the BFS ascent trajectory 2 display.

Orbit Insertion

The first thrusting period is referred to as OMS-1 and boosts the orbiter to the desired apogee; the second burn is called OMS-2 and typically circularizes the orbit. Except in the case of a direct insertion, when only one OMS thrusting period is required to circularize the orbit.

The OMS-1 and OMS-2 burns could be changed to compensate for a system failure by selecting a delayed OMS-1, AOA or ATO abort option.

Execution of OMS-2 burn occurs near apogee approximately 40 minutes into flight.

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The main events that occur during the orbit insertion phase include.

- Execution of the OMS-1 thrusting period, typically about two minutes after MECO;
- MPS propellant dump, which begins during OMS-1;
- Positioning of the main engine nozzles for entry;
- Shutdown of the three auxiliary power units;
- MPS power-down
- MPS vacuum inerting to ensure that all traces of MPS propellants are vented to space

In the following hours the crew will open the payload bay doors and deploy the radiators.

Later that day or the following day the KU-band antenna is deployed.

Rendezvous maneuvers are perform for the next couple of days for docking with ISS.

The GN&C; software for the majority of on-orbit operations is called OPS 2 (on orbit), which is further divided into major mode 201 (orbit coast, in which the majority of attitude and pointing operations occur) and major mode 202 (maneuver execute, in which OMS translations are targeted and executed).

The events for this checklist come directly from the following NASA website:
http://spaceflight.nasa.gov/shuttle/reference/shutref/events/