

# SpaceX

# FALCON HEAVY

v.230920  
for Orbiter 2016 (v.160828)

## INSTALLATION

Extract all files to the root of your Orbiter program directory, preserving the directory structure. This should NOT overwrite anything in the standard Orbiter package.

## RECOMMENDED ADD-ON

"LC39A SpaceX"

<https://www.orbithangar.com/searchid.php?ID=7090>

Orbiter2015 Hi-Res Texture Pack for West Coast USA "EarthHi\_11\_05.zip"

[https://mirror.orbiter-radio.co.uk/orbiter/assets/packages/Earth/EarthHi\\_11\\_05.zip](https://mirror.orbiter-radio.co.uk/orbiter/assets/packages/Earth/EarthHi_11_05.zip)

## WHAT'S IN THIS ADD-ON?

The SpaceX "Falcon Heavy" launcher with optional Star48BV kick motor, adaptors, etc.

Launch pads for LC39A, SLC40 and SLC4E (VAFB).

LZ Landing pads, FRV and ASDS vessels for fairing recovery and booster landings.

Launch scenarios for various test-masses and orbits, STP2 and Tesla Roadster launches.

Elev-mod tiles for flat landing zones at KSC and VAFB.

Features: Control Panel for launch parameter input, optional Ascent-to-Orbit autopilot and 1<sup>st</sup> stage boosters Flyback-EDL autopilot.

Payload "attachment" by editing .scn file, or in-sim by payload name input.

Expendable, Dragon Adaptor, No Fairing, Custom Adaptor mesh, Charred look options in .cfg file.

## QUICKSTART

Scenarios are in the "FalconHeavy for Orbiter2016" folder on your Orbiter launch pad.

Select a scenario and press [V] at T-10s to start the ascent autopilot.

All launch parameters are set and 1st Stage Core and Boosters Auto-Flyback-EDL to the ASDS recovery vessel or LZ landing pads is already enabled (if appropriate).

## SCENARIOS

Test scenarios are in separate folders arranged by orbit type:

LEO 200km circular orbit at 29° inclination.

GTO 200km circular orbit at 29° inclination, 2500m/s dV remaining.

ISS 350km circular orbit at 51.6° inclination.

POLAR 700km circular orbit at 96° inclination.

Each orbit type has scenarios for various different booster recovery modes at the maximum payload mass.

## FALCON HEAVY COCKPIT CONTROLS

Available commands and launcher status info are displayed on the HUD.

**K** = Open / Close Launch Control Panel

**V** = Start Launch Autopilot at T-10s

**N** = Manual Jettison Boosters or Core

**J** = Manual Jettison Fairing or Payload

**E** = Set View +Z / -Z

**B** = 2<sup>nd</sup> Stage Fuel Dump

## FALCON HEAVY LAUNCH CONTROL PANEL

Press K to Open/Close Launch Control Panel

Type required value in appropriate box and click “Enter” to input.

The screenshot shows the 'FalconHeavy Launch Control' interface with the following sections:

- Payload Management:** Includes fields for 'New Payload' (with 'Enter Name' and 'Attach' buttons), 'Current Payload' (with '33K\_Sat' and 'N/A'), and 'Total 33000kg'.
- Target Orbit Parameters:** Includes 'Inclination' (-29.0000 deg.), 'Perigee' (200.0 km), and 'Apogee' (200.0 km), each with an 'Enter' button.
- Core Stg. Apogee at MECO:** Field with '175.0 km' and 'Enter' button.
- Upper Stg. Orbit Insertion Alt.:** Field with '200.0 km' and 'Enter' button.
- CORE Flyback-EDL:** Includes 'Flyback Autopilot Status' (ENABLED, On/Off), 'Flyback Mode' (FLYBACK-EDL, Change), 'Flyback Target CORE' (ASDS, Enter), 'Flyback Fuel Reserve' (65000 kg, Enter), and 'Estimated Fuel Required' (65000 kg, Apply).
- BOOSTERS Flyback-EDL:** Includes 'Flyback Autopilot Status' (ENABLED, On/Off), 'Flyback Mode' (FLYBACK-EDL, Change), 'Flyback Target PORT' (LZ2, Enter), 'Flyback Target STBD' (LZ1, Enter), 'Flyback Fuel Reserve (per Booster)' (48749 kg, Enter), and 'Estimated Fuel Required' (48749 kg, Apply).
- Launch Control:** Includes 'T-10 Launch Autopilot' (START/STOP button, OFF), 'Launch Time UTC' (hh mm ss: 00 00 00, Set, OFF, On/Off), and 'Hardback Gantry' (ENGAGE/RETRACT).
- Manual Jettison:** Includes 'Fairings' and 'Booster' buttons, each with a 'Jettison' button.
- Estimated FRV Position:** Lng. 0.000 Lat. 0.000
- Estimated ASDS Position:** Lng. -74.985 Lat. 27.899 Core; Lng. -77.441 Lat. 28.219 Boosters
- Acceleration Limiter:** Field with '39.24 m/s<sup>2</sup>' and 'Enter' button.
- Refresh** button at the bottom right.

## PAYLOAD MANAGEMENT

There can be up to 100 payload attachment points specified in the .cfg file.

Default position is located at the centre of the payload-attach-ring on the 2<sup>nd</sup> Stage.

Payloads can be added by editing the scenario and using the “Attached” parameter (see example scenarios included).

Alternatively, any vessel already existing in the scenario can be attached by entering the payload *name* and clicking the “Attach” button.

The first available attachment point on the payload will be used for attachment.

## **TARGET ORBIT PARAMETERS**

### *Inclination*

Enter the required orbit inclination (Equatorial frame), Use negative value for Southerly launch azimuth, positive for Northerly launch azimuth. Minimum value is current latitude.

### *Perigee*

Enter target orbit Perigee (km)

### *Apogee*

Enter target orbit Apogee (km)

## **CORE STG. APOGEE AT MECO**

Core booster stage apogee target at MECO(2<sup>nd</sup> stage separation) – *calculated automatically*, but can be changed manually if you want to try different flight profiles.

## **UPPER STG. ORBIT INSERTION ALT.**

Upper stage altitude at final orbit insertion – *default setting is orbit insertion at perigee*. Can be set to any value between, or equal to, apogee and perigee. Insertion at perigee is most fuel efficient.

## **CORE FLYBACK-EDL**

### *Flyback Autopilot Status*

Enable or disable the autopilot for core stage Flyback-EDL

### *Flyback Mode*

Select either 3-burn *Flyback-EDL* mode, or 2-burn *EDL-Only* mode.  
(If stage is to return to launch site LZ pad, full *Flyback-EDL* mode should be used)

### *Flyback Target CORE*

Enter the name of vessel(landed) or surface-base, as target for core stage flyback and landing. Enter NULL for no target.

### *Flyback Fuel Reserve*

Enter the amount of fuel reserved by core booster for Flyback-EDL (kg).

### *Estimated Fuel Required*

Flyback-EDL fuel requirement calculated from core apogee, port/starboard booster fuel reserve, flight azimuth, target position, etc. Not always reliable!  
Click "Apply" to enter this value as Flyback Fuel Reserve.

## **BOOSTERS FLYBACK-EDL**

### *Flyback Autopilot Status*

Enable or disable the autopilot for Port and Starboard booster stages Flyback-EDL

### *Flyback Mode*

Select either 3-burn *Flyback-EDL* mode, or 2-burn *EDL-Only* mode.  
(If stages are to return to launch site LZ pads, full *Flyback-EDL* mode should be used)

### *Flyback Target PORT*

Enter the name of vessel(landed) or surface-base, as target for Port booster stage flyback and landing. Enter NULL for no target.

### *Flyback Target STBD*

Enter the name of vessel(landed) or surface-base, as target for Starboard booster stage flyback and landing. Enter NULL for no target.

### *Flyback Fuel Reserve*

Enter the amount of fuel reserved by Port and Starboard boosters for Flyback-EDL (kg) per booster.

### *Estimated Fuel Required*

Flyback-EDL fuel requirement (per booster) calculated from core apogee, flight azimuth, target position, etc. Not always reliable!

Click "Apply" to enter this value as Flyback Fuel Reserve.

## **ACCELERATION LIMITER**

Main engine automatically throttled to limit maximum acceleration. Default 4g.

## **ESTIMATED ASDS POSITION**

Suggested locations for ASDS recovery vessels. Calculated from fuel reserve, flight azimuth, core apogee, etc. Not always reliable!

Usually a good idea to separate the Port and Starboard ASDS vessels by a few hundred meters (otherwise boosters land on top of each other!)

ASDS Position and Flyback Fuel Reserve are *interdependent* – if you change one you may need to change the other to match.

## **LAUNCH CONTROL**

### *T-10 Launch Autopilot*

Click "Start/Stop" button to activate/disable ascent-to-orbit autopilot.

### *Launch Time UTC*

Set lift-off time (hh mm ss), click "On/Off" to enable or disable.

Ascent-to-Orbit autopilot is engaged automatically at T-10s.

Countdown is displayed on screen.

### *Hardback Gantry*

Click "Engage/Retract" to raise or lower gantry (while FalconHeavy on pad)

## **MANUAL JETTISON**

*Fairings* - Click "Jettison" to release fairings.

*Booster* - Click "Jettison" to release Port/Stbd. Boosters, click again to release Core.

## **REFRESH**

Click to check current parameter values.

## 1<sup>st</sup> STAGE BOOSTER COCKPIT CONTROLS (post stage separation)

<b>M</b> = Set Flyback Mode	Toggle between full Flyback-EDL and EDL-Only modes
<b>B</b> = Enable Auto Flyback-EDL	Enable / disable autopilot
<b>P</b> = Engine Selection	Cycle through either 9, 3 or 1 engines
<b>J</b> = Deploy/Stow Grid Fins	
<b>G</b> = Deploy Landing Gear	
<b>E</b> = Set View +Z / -Z	

## ASCENT-TO-ORBIT AUTOPILOT SEQUENCE

T-10s	Countdown
T-2s	Throttle-up to 100%
100m alt.	Start roll to launch azimuth
200m alt.	Start pitch down, follow gravity turn, Core throttle down to 40%
50km alt.	Start guidance steering
Bstr.Reserve Fuel limit	Booster separation, core throttle up to 100% (4G limit)
Core Reserve Fuel limit	Core separation, 2nd stage ignition
Core sep. +20s	Fairing separation
Final Orbit reached	MECO

## CORE/BOOSTER “FLYBACK-EDL” SEQUENCE

Core/Booster sep.	Go to flyback burn attitude, perform burn
MECO	Go to reentry attitude
130km alt.(Boosters 100km)	Enable/perform reentry burn
15km alt., < Mach2	Start aerodynamic steering
1-2km alt.	Start landing burn, gear deploy

## CORE/BOOSTER “EDL-ONLY” SEQUENCE

Core/Booster sep.	Go to reentry attitude
160km alt.(Boosters 100km)	Enable/perform reentry burn
15km alt., < Mach2	Start aerodynamic steering
1-2km alt.	Start landing burn, gear deploy

## RECOVERABLE FAIRINGS

The FalconHeavy has a “recoverable fairings” option. Fairings are equipped with RCS, a parafoil and guidance. The parafoil is automatically deployed at 6-7km and the guidance will steer a course (accounting for wind) for any vessel named “FRV”.

Use “recoverable fairings” by setting the *RecoverableFairing* = 1 flag in the .cfg file (see below).

## CONFIG FILE OPTIONS (.cfg)

Config files for the FalconHeavy are located in Config/Vessels/FalconHeavy/ folder. By editing the .cfg file for the FalconHeavy, you have various options:

<i>TimeAccLimit = TRUE</i>	Time acceleration limited to 1 at staging
<i>Expendable = 1</i>	Core expendable, boosters reusable
<i>Expendable = 2</i>	Core expendable, boosters expendable
<i>Dragon = 1</i>	Cargo Dragon adaptor, no fairing
<i>Dragon = 2</i>	Dragon2 adaptor, no fairing
<i>NoFairing = 1</i>	No Fairing
<i>LargeFairing = 1</i>	Extended 22m fairing
<i>RecoverableFairing = 1</i>	Use recoverable fairings
<i>UpperInsulation = 1</i>	Upper stage grey insulation
<i>CntrUsed = 1</i>	Charred skin – Centre Booster
<i>PortUsed = 1</i>	Charred skin – Port Booster
<i>StbdUsed = 1</i>	Charred skin – Starboard Booster
<i>PayloadAttach0 = pos dir rot</i>	Payload attachpoint Pos Dir Rot vectors

*Adaptor = FalconHeavy/star48bv\_adaptor\** Adaptor file path/mesh name

\*Adds adaptor mesh at centre of 2nd stage payload interface ring.

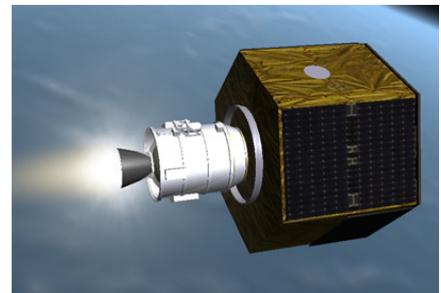
Origin (0,0,0) should be at bottom of adaptor mesh.

See examples in *f9h.cfg* file, in Config/Vessels/FalconHeavy/.

## STAR48BV KICK-MOTOR

An optional Star48BV solid rocket motor is included. It can be attached to the FalconHeavy like any other payload.

A further payload can be attached to the Star48BV in the same way - an existing vessel can be attached during simulation by pressing **P** and entering vessel name, or edit the ATTACHED parameter in the scenario file before starting the sim.



Payload mass is added to Star48BV.

A 62" to 48" adaptor for attaching the Star48BV to the FalconHeavy is included (see Fairing / Payload Adator Options in CFG files)

Once ignited, the Star48BV will burn at full throttle until depletion.

## STAR48BV COCKPIT CONTROLS

**P** = Enter Payload Name Attach existing vessel to the Star48BV, at payload interface ring.

**J** = Jettison Payload

## LAUNCH PADS and LANDING PADS

Launch pads feature retractable gantry, LOX vent and liftoff smoke effects, auto night lights.

[G] = Raise / Lower Gantry                    [M] = Water Deluge On/Off  
[K] = Night Lights On/Off                    [V] = LOX vent On/Off  
[B] = Crew Access Arm Extend/Retract (LC39A)  
[N] = Crew Access Arm Visible/Invisible (LC39A)  
[P] = Attach Launcher to Pad (enter name, any existing vessel)



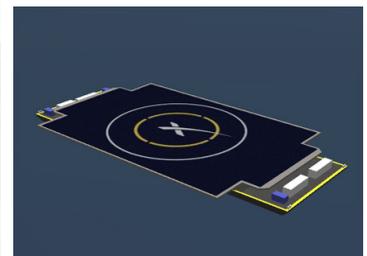
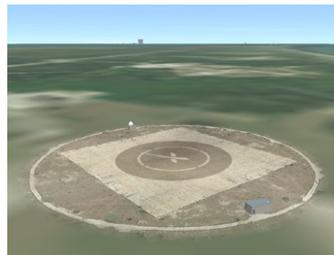
### LAUNCH PAD "HOLD DOWN"

If FalconHeavy is attached to launch pad (see ATTACHED parameter in scenario file), attachment is released when main engine reaches %95 thrust (after 2 seconds if using Launch Autopilot)

### LZ LANDING PADS and ASDS

Auto proximity night lights – illuminated when any vessel approaches within 5km.

ASDS should be placed along the launch groundtrack, some distance ahead of the booster at separation (or close to booster ballistic impact point if EDL ONLY flyback mode is selected)



[N] = Landing Pad Mesh Visible/Invisible (LZ pad only)

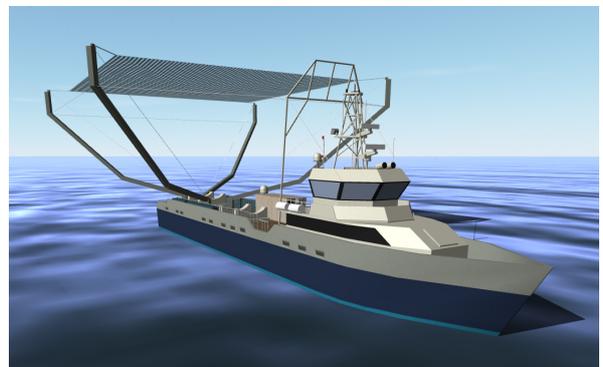
### “FRV” FAIRING RECOVERY VESSEL

Place further along flightpath than ASDS.  
Will collect and stow fairings if they fall within the net.

Max speed ~30kts, data on HUD, night lights.

*Must* be named “FRV” for fairing guidance.

Note: If not named “FRV”, fairing guidance will not operate and you must use the vessel to chase the fairings as they descend, which can be interesting :-)



## FALCON HEAVY ADD-ON SPECS

*1st Stage - Core, Port, Starboard Boosters (each)*

Empty Mass	22500 kg (Core 25600kg)
Fuel Mass	409500 kg
Max. Thrust SL	845148 N (x 9)
Max. Thrust Vac.	914111 N (x 9)
ISP SL	2767 Ns/kg
ISP Vac	3050 Ns/kg
RCS(N) Fuel Mass	400 kg
RCS(N) Max. Thrust	1000 N (6 pairs)
RCS(N) ISP	800 Ns/kg

### *2nd Stage*

Empty Mass	4000 kg
Fuel Mass	107500 kg
Max Thrust Vac	934000 N
ISP Vac	3385 Ns/kg
RCS(N) Fuel Mass	100 kg
RCS(N) Max. Thrust	500 N (4 pairs)
RCS(N) ISP Vac	800 Ns/kg

### *Fairings*

Mass	875 kg (each) Standard 14m fairing
Mass	1250 kg (each) Extended 22m fairing

### *Star48BV*

Empty Mass	144.7 kg
Fuel Mass	2011.8 kg
Max Thrust Vac	68720 N
ISP Vac	2865.5 Ns/kg
RCS Fuel Mass	20 kg

## FALCON HEAVY PERFORMANCE (not complete for all recovery mode combinations!)

<i>Orbit Type</i>	<i>Core Recovery Mode</i>	<i>Booster Recovery Mode</i>	<i>Max.Payload (kg)</i>
GTO	Flyback-EDL to ASDS	Flyback-EDL to LZ	13000
GTO	Flyback-EDL to ASDS	Flyback-EDL to ASDS	14000
GTO	Expendable	Flyback-EDL to LZ	21000
GTO	Expendable	Expendable	27000
ISS	Flyback-EDL to LZ	Flyback-EDL to LZ	24000
ISS	Flyback-EDL to ASDS	Flyback-EDL to LZ	32000
ISS	EDL-Only to ASDS	EDL-Only to ASDS	39000
LEO	Flyback-EDL to LZ	Flyback-EDL to LZ	25000
LEO	Flyback-EDL to ASDS	Flyback-EDL to LZ	33000
LEO	EDL-Only to ASDS	Flyback-EDL to LZ	38000
LEO	EDL-Only to ASDS	EDL-Only to ASDS	41000
LEO	Expendable	Expendable	64000

## FalconHeavy performance cont.

<i>Orbit Type</i>	<i>Core Recovery Mode</i>	<i>Booster Recovery Mode</i>	<i>Max.Payload (kg)</i>
POLAR	Flyback-EDL to LZ	Flyback-EDL to LZ	17000
POLAR	Flyback-EDL to ASDS	Flyback-EDL to LZ	22000
POLAR*	EDL-Only to ASDS	EDL-Only to ASDS	(2-burn) 35000

GTO = 200km orbit + 2500m/s dV remaining, 29° inclination

Launch Site: KSC

ISS = 350km orbit, 56° inclination

Launch Site: KSC

LEO = 200km orbit, 29° inclination

Launch Site: KSC

POLAR = 700km orbit, 96° inclination

Launch Site: VAFB

POLAR\* = 200km x 700km orbit + 200m/s dV, 96° inclination

Launch Site: VAFB

## NOTES

### *Double Launch*

Each launcher in the scenario needs it's own copy of "f9h.cfg" and "f9h.dll"

See the "Double Launch" scenario as an example.

### *VAFB HiRes Tiles*

If you have installed the EarthHi\_11\_05.zip pack, you should use the scenarios in the "HiRes VAFB Scenarios" sub-folder, for correct placement of SLC4E launch pad and LZ landing pads.

### *Earth Elev\_mod tiles*

Includes earth Elev\_mod tiles:

/13/000157/000168.elv

/15/000699/001131.elv

For flat LZ areas at KSC and VAFB\*(only if VAFB HiRes Tiles installed).

### *Fuel Reserve Estimate and ASDS Position Estimate*

These are calculated by empirically derived curve-fitted functions and may not always be reliable!

Compatible with OrbiterSound4.0 (but OrbiterSound4.0 may not work in Orbiter2016)

## CREDITS

Tesla Roadster textures and D3D9 magic by Felix24

Original Tesla Roadster Sketchup model by Craig D.

<https://3dwarehouse.sketchup.com/model/d5b9471bcaaf15d4824c4ee0076cfe45/Tesla-Motors>

## THANKS TO.....

MartinS, IronRain, Felix24, Barry, Donamy, Kyle and everyone at the forum

Have fun :-)

BrianJ

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