

# FALCON9 for Orbiter2016

Falcon9 "Block 5"  
Add-On 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

"LC39A SpaceX" modified LC39A launchpad.

<https://www.orbiter-forum.com/resources/lc39a-spacex.3092/>

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 "Falcon9 Block 5" launcher, with recoverable 1<sup>st</sup> Stage and Fairings.  
Historical OG2, NROL76 satellite launch scenarios and test scenarios.

Features optional Ascent-to-Orbit autopilot and 1st Stage Flyback-EDL autopilot, etc.  
Optional Star48BV kick motor.

Recoverable Fairings with RCS, parafoil, autopilot guidance.

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

Config file options: Expendable, No Fairing, Crew Dragon Adaptor, Cargo Dragon Adaptor, Custom Adaptor Mesh, Used Booster Skin, Fairing Recovery.

Also includes LC39A strongback, SLC40 and SLC4E launchpads, LZ landing pads.

ASDS booster recovery vessel, FRV fairing recovery vessel.

Elev\_mod tiles for flat LZ areas at KSC and VAFB.

## QUICKSTART

Scenarios are in the "Falcon9 for Orbiter2016" folder on your Orbiter launch pad.

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

All launch parameters are set and 1st Stage Auto-Flyback-EDL to the ASDS, LZ1 or LZ2 is already enabled. Fairing recovery vessel FRV is on station.

## SCENARIOS

*OG2 launch* - launch eleven OG-2 sats from SLC40 at 01:29 UTC, 22 Dec 2015

Target orbit 615 x 750km, 47° inc. Press [V] for ascent autopilot at T-10.

*NROL76 launch* – launch 10,000kg satellite from LC39A at 11:15 UTC, 01 May 2017

Target orbit 375km x 425km, 50° inc. Press [V] for ascent autopilot at T-10.

### *Test Scenarios*

Various test-mass satellites to LEO, SSO\*. 1<sup>st</sup> stage flyback to ASDS, LZ1, etc.

\*If you have the "EarthHi\_11\_05.zip" installed, use scenarios in the "HiRes VAFB Scenarios" sub-folder.

## SCENARIOS using LC39A SpaceX add-on

If you want to use the “LC39A SpaceX” add-on (LC39A launch pad modified for SpaceX) please note that your scenario environment entries (between BEGIN\_ENVIRONMENT and END\_ENVIRONMENT) must include the line:  
CONTEXT SpaceX

## FALCON9 MAIN CONTROLS

Press **K** for **Launch Control Panel** display On/Off

The screenshot shows the 'Falcon9 Launch Control' window with the following sections:

- Payload Management:** New Payload (Enter Name, Attach), Current Payload (TESS, N/A), Total 365 kg.
- Target Orbit Parameters:** Inclination (29.50 deg., Enter), Perigee (200.0 km., Enter), Apogee (200.0 km., Enter).
- 1st Stg. Apogee at MECO:** 125.00 km., Enter.
- 1st Stage Flyback-EDL:** Flyback Autopilot Status (ENABLED, On/Off), Flyback Target Name (ASDS, Enter), Flyback Mode (FLYBACK-EDL, Change), Flyback Fuel Reserve (36086 kg, Enter), Estimated Fuel Required (36086 kg, Apply).
- Estimated ASDS Position:** Lng. -75.971 Lat. 28.994.
- Estimated FRV Position:** Lng. -73.932 Lat. 29.135.
- Launch Control:** T-10 Launch Autopilot (ON/OFF button highlighted, OFF), Launch Time UTC (hh mm ss: 00 00 00, Set, OFF, On/Off), Hardback Gantry (ENGAGE / RETRACT, Apply).
- Manual Jettison:** Jettison Fairings (Jettison), Jettison 1st Stg. (Jettison).

A 'Refresh' button is located at the bottom left.

## FALCON9 COCKPIT SHORTCUTS

[K] = Open/Close Launch Control Panel  
[V] = Start Launch Autopilot at T-10s  
[J] = Manual jettison fairing or payload  
[N] = Manual jettison 1<sup>st</sup> Stage  
[E] = Set camera view +Z / -Z  
[B] = 2<sup>nd</sup> Stage Fuel Dump  
[M] = Forward Lamp

### Payload Management

*New Payload* – Enter payload name, will be attached to next available attach point.  
There can be up to 20 payloads maximum.  
See .cfg File Options section for attach point configuration.

*Current Payload* – Displays next payload for deployment.  
Jettison button only available after Fairing separation.  
Payloads are deployed in reverse order of attachment.

*Total* – Sum of payloads masses.

### Target Orbit Parameters

*Inclination* - Enter target inclination (degrees, equatorial frame)  
Use positive inclination for Northerly launch azimuth, negative inclination for Southerly azimuth. Inclination must be greater than current latitude.

*Perigee* - Enter target perigee (km.alt.)

*Apogee* - Enter target apogee (km.alt.)

If Perigee greater than Apogee, values are automatically swapped.

### 1<sup>st</sup> Stg. Apogee at MECO

Default value is automatically calculated from Apogee/Perigee.  
Enter 1<sup>st</sup> Stage Apogee (km.alt.) at MECO (maximum 450km).

### 1<sup>st</sup> Stage Flyback-EDL

*Flyback Autopilot Status* - Enable or disable the 1<sup>st</sup> Stage flyback autopilot.

*Flyback Target Name* - Enter name of vessel(landed) or base for flyback target.  
(Enter NULL for no target).

*Flyback Mode* - Change between the full “FLYBACK-EDL” sequence, and “EDL ONLY” which performs the targeted reentry and landing burns only (no Flyback burn).  
EDL ONLY target must be located a few (20~30) km short of ballistic impact point of 1<sup>st</sup> Stage after separation. Obviously, you cannot return to launch site using EDL ONLY!

*Flyback Fuel Reserve* - Enter fuel reserved for 1<sup>st</sup> stage flyback (kg) (Maximum 80000kg)

*Estimated Fuel Required* - If the Falcon9 is on the launch pad, it will show a very approximate estimate of the fuel required for the Flyback-EDL burns, based on current flyback target position, flyback mode and 1<sup>st</sup> stage apogee at MECO parameter.

*Estimated ASDS Position* - Shows approximate position for ASDS vessel for 1<sup>st</sup> stage recovery, based on launch azimuth, flyback mode and 1<sup>st</sup> stage apogee at MECO.

NOTE: ASDS position influences the estimated fuel reserve – if you change ASDS position remember to “Refresh” the control panel for updated fuel reserve estimate.

*Estimated FRV Position* - Shows approximate position for FRV (Fairing Recovery Vessel).

### Launch Control

*T-10 Launch Autopilot* - Activate the Launch Autopilot at T-10 seconds. Can be stopped and re-started but this is NOT recommended, and can result in serious flight anomalies!

### *Launch Time UTC*

*Set* – Enter lift-off time (UTC)

*On/Off* – Enable/disable launch timer (countdown is displayed and Launch Autopilot activated at T-10. Manual launch control [V] is disabled while Launch Timer is enabled)

### *Hardback Gantry*

If Falcon9 is attached to the launch pad, you can raise or lower the Hardback.

### Manual Jettison

*Jettison Fairings* - Manual fairing jettison.

*Jettison 1<sup>st</sup> Stg.* - Manual 1<sup>st</sup> stage jettison.

Refresh - Refresh the current parameters.

### Launch Control Panel Notes

FLYBACK-EDL usually requires 30000kg – 50000kg fuel reserve.

EDL ONLY fuel reserve is restricted to 23000kg.

The Estimated Fuel Required display is very “rule of thumb” and may not be reliable.

Setting a fuel reserve will reduce the maximum 1<sup>st</sup> Stage Apogee by ~50km per 10000kg (from a maximum of 450km using no fuel reserve). Setting 1<sup>st</sup> Stage Apogee higher than current maximum will reduce fuel reserve by ~10000kg per 50km. Fuel reserve will compensate automatically for changes to apogee, and vice versa.

## **FALCON9 1st STAGE COCKPIT CONTROLS (post stage separation)**

[K] = Enter Flyback Target

Enter name of vessel(landed) or surface base.

[M] = Set Flyback Mode

Change between the full FLYBACK-EDL sequence, and EDL ONLY mode.

[B] = Enable/Disable Flyback Autopilot

Current sequence status is shown on the HUD.

[P] = Engine Selection

Cycle through either 9, 3 or 1 engines (not available when Autopilot active)

[G] = Deploy Landing Gear

[E] = Set Camera +Z / -Z Set the camera view forwards or backwards.

## **FAIRINGS**

If there is a recovery vessel named “FRV”, the fairings will try to guide themselves toward it. Parafoil deployment is automatic at 5-6km alt. Glide range ~20km, from 6km altitude.

[P] = Enable/Disable Autopilot

Passive, non-recoverable fairings option is available via .cfg file.

## Launch Autopilot Sequence

T-10s .....	Countdown
T -2s .....	Throttle-up to 100%
100m alt. ....	Start roll to launch azimuth
57m/s vel. ....	Start pitch down, follow gravity turn
30km alt. ....	Start guidance steering, 4g limiter (3g for Dragon)
Flyback fuel res. limit reached.....	1 <sup>st</sup> Stage MECO and separation, 2 <sup>nd</sup> stage ignition
1 <sup>st</sup> Stage separation +20s .....	Fairing separation
Final Orbit reached .....	2 <sup>nd</sup> stage MECO

## 1<sup>st</sup> Stage FLYBACK-EDL Autopilot Sequence

1st Stage separation.....	Go to flyback burn attitude, perform burn (3 engines)
Burn complete.....	Go to reentry attitude
Reentry 100km - 20km alt. ....	Enable/perform reentry burn (3 engines)
Velocity < 2 Mach. ....	Enable aerodynamic steering
3km - 2km alt. ....	Start landing burn, deploy landing gear (1 engine)

## 1<sup>st</sup> Stage EDL ONLY Autopilot Sequence

1st Stage separation.....	Go to reentry attitude
Reentry 100km - 20km alt. ....	Enable/perform reentry burn (3 engines)
Velocity < 2 Mach. ....	Enable aerodynamic steering
3km - 2km alt. ....	Start landing burn, deploy landing gear (1 engine)

## PAYLOAD MANAGEMENT

You can attach any *existing* vessel during simulation runtime.

Press [K] for the Launch Control Panel, enter vessel name and click on [Attach] button.

This will select the first available attachment point on the payload and attach it to Falcon9 at the next available attach point.

You can also edit the scenario manually by adding the ATTACHED line to the payload vessel entry. (See included scenarios for examples).

There can be up to 20 payloads.

Falcon9 payload attach points can be set in the .cfg file (see .cfg File Options section)

Payloads are jettisoned in reverse order of attachment.

Jettison speed is 1m/s along attachment direction vector.

Payload jettison is disabled while fairings are in place.

## .cfg FILE OPTIONS

Config files for the Falcon9 are located in Config/Vessels/Falcon9R\_V12/ folder.

Add the following lines for the required variant:

Dragon = 1	Add adaptor for <i>Cargo</i> Dragon, no fairing
Dragon = 2	Add adaptor for <i>Crew</i> Dragon, no fairing
NoFairing = 1	No fairing
NoFairRecovery = 1	Passive Fairings, no parafoil recovery.
Adaptor = Falcon9R_V12/star48bv_adaptor	Add custom mesh to 2 <sup>nd</sup> stage payload ring.
Expendable = 1	Passive 1 <sup>st</sup> stage post separation.
Charred = 1 or 2	Charred or Very Charred booster skin.

Set the Falcon9 payload attachment points position, direction, rotation.

20 maximum (PayloadAttach0 → PayloadAttach19) e.g.

PayloadAttach0 = 0 0 26.646 0 0 1 0 1 0 (default position)

PayloadAttach1 = 0 0 28.646 0 0 1 0 1 0

etc.

See examples:

f9\_v12.cfg

f9\_v12\_charred.cfg

f9\_v12\_drg.cfg

f9\_v12\_expendable.cfg

f9\_v12\_nofairrecovery.cfg

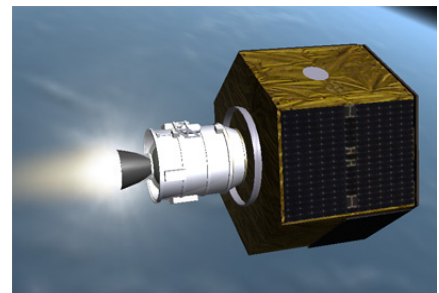
f9\_v12\_star48.cfg

f9\_v12\_og2.cfg

## STAR48BV KICK-MOTOR

An optional Star48BV solid rocket motor is included. It can be attached to the Falcon9R like any other payload.

A further payload can be attached to the Star48BV 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 Falcon9 is included (see Fairing / Payload Adaptor Options)

[P] = Enter Payload Name

Attach any existing vessel to the Star48BV, at the payload interface ring.

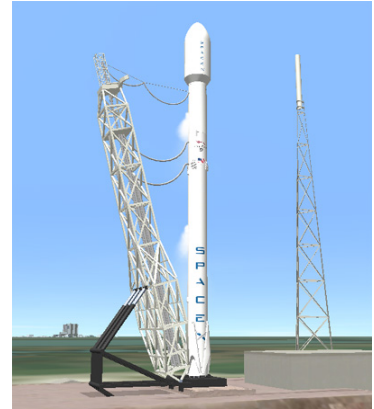
[J] = Jettison Payload

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

## 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)

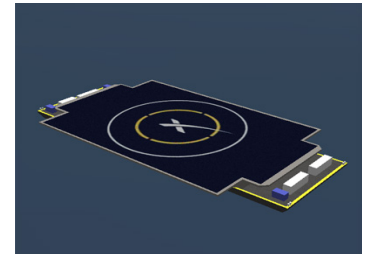
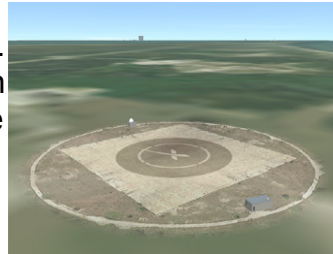


### LAUNCH PAD "HOLD DOWN"

If Falcon9R is attached to launch pad (see ATTACHED parameter in scenario file), attachment is released when Falcon9 main engine reaches %95 thrust (after 2 seconds if using Launch Autopilot)

### "LZ" LANDING PADS and "ASDS" BARGE

Auto proximity night lights – illuminated when any vessel approaches within 5km. ASDS should be placed along the launch groundtrack, some distance ahead of the 1st Stage Core at separation (or close to 1<sup>st</sup> Stage 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, estimated pos. shown on Launch Control Panel.

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.



## MULTIPLE LAUNCHERS

If you want to use more than one Falcon9 in your scenario, you will need to do a little engineering!

Make a copy of the *f9\_v12.dll* module (for each extra launcher) and re-name it (e.g. *f9\_v12\_duplicate.dll*).

Similarly, make a copy of *f9\_v12.cfg*, re-name it (e.g. *f9\_v12\_duplicate.cfg*)  
Open it with a text editor (e.g. Notepad) and change the "Module" line to point to your renamed .dll, thus:

```
Module = Falcon9R_V12\f9_v12_duplicate
```

Ensure the *scenario* vessel entry points to your new *f9\_v12\_duplicate.cfg*, e.g.  
*Falcon9\_002:Falcon9R\_V12\f9\_v12\_duplicate*

## FALCON 9 ADD-ON SPECS

1st Stage Empty Mass	22200 kg
1st Stage Fuel Mass	402500 kg
1st Stage Max Thrust SL	846200 N x 9
1st Stage RCS (gimballed main engines)	38000 N (4 pairs, pitch/yaw/roll)
1st Stage ISP SL	2767 Ns/kg
1st Stage ISP Vac	3051 Ns/kg
1st Stage RCS(N) Fuel Mass	300 kg
1st Stage RCS(N) Max. Thrust	1200 N (6 pairs)
1st Stage RCS(N) ISP SL	800 Ns/kg
2nd Stage Empty Mass	4300 kg
2nd Stage Fuel Mass	104275 kg
2nd Stage Max Thrust Vac	979800 N
2nd Stage RCS (gimballed main engine)	13000 N (pitch/yaw)
2nd Stage ISP Vac	3433 Ns/kg
2nd Stage RCS(N) Fuel Mass	100 kg
2nd Stage RCS(N) Max. Thrust	500 N (4 pairs)
2nd Stage RCS(N) ISP Vac	800 Ns/kg
Payload Interface Ring	1.57m diameter
Fairing Mass (each)	875 kg
Fairing RCS(N) Fuel Mass (each)	40 kg
Star48BV Empty Mass	144.7 kg
Star48BV Fuel Mass	2011.8 kg
Star48BV Max Thrust Vac	68720 N
Star48BV ISP Vac	2865.5 Ns/kg
Star48BV RCS Fuel Mass	20 kg
Payload Interface Ring	1.05m diameter

## PERFORMANCE - 1<sup>st</sup> Stage Recovery Mode / Orbit Type / Max.Payload

	Expendable	ASDS (EDL only)	ASDS (Flyback EDL)	LZ(Flyback-EDL)
LEO	22500kg	18500kg	16000kg	15000kg
GTO	8300kg	6300kg	5500kg	?
SSO Direct	?	?	7000kg	6000kg
SSO 2-burn	?	?	12500kg	?
ISS	?	15000kg	?	?

LEO	200 x 200km	28.61° inc.	KSC
GTO	200 x 300km + 2500m/s dV	28.61° inc.	KSC
SSO direct	700 x 700km	96.00° inc.	VAFB
SSO 2-burn	200 x 700km + 150m/s dV	96.00° inc.	VAFB
ISS	313 x 333km	51.65° inc	KSC



## NOTES

When main engine is off, attitude control is by cold nitrogen thrusters. RCS Nitrogen is very limited.

I've tried to make the performance of the Falcon9 as realistic as possible, given the estimates, data, information and mis-information I have managed to gather on the www.

The ascent, flyback, landing and parafoil guidance algorithms are entirely my own nonsense, just to see if and how it can be done.

Estimations of ASDS and FRV location are not always reliable, especially with high PeA, high Inc., Flyback to LZ combination.

Compatible with OrbiterSound4.0 (but OrbiterSound4.0 may not work in Orbiter2016)  
T-10 countdown, stage separation call-out, fairing separation call-out.

Thanks as ever to Dr.S, Don, Barry, Fred18, IronRain, Kyle and everyone else.

Special thanks to Marg and francisdrake for exhaust and contrail textures, and Donamy for grid-fins :-)

BrianJ  
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