Mars Lander User Guide

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# Compilation Instructions

There are no unusual compilation instructions, however if you wish to change the type of integrator used change the value of integrator to either VERLET or EULER in the file ‘lander.h’. Similarly, to increase the average wind speed change the average\_speed constant in the wind()function in the file ‘Dynamics.cpp’.

# Autopilot Modes

In all modes, the console will post updates on any changes or transfers such as fuel levels and why it has taken certain precautions.

## Orbital Re-Entry

This is the first half of a maneuver that will transfer the current circular orbit to a different radius orbit. Upon activating the autopilot, the simulation will freeze while it waits for you to input a radius as a multiple of Mars’ radius into the console window that appears with the simulator. Upon arriving at the desired radius, the autopilot mode will transfer to Orbital Transfer or Descent depending on the landers position (see below). This mode is active in scenarios 0 and 6.

## Orbital Transfer

The fuel will refill and stay fixed at full (as it is unlikely there will be enough fuel to complete transfer) and the autopilot will correct the elliptical orbit from Orbit Re-Entry to a circular one if the radius is not within the exosphere. The autopilot will then reset back to Re-Entry, allowing you to perform further maneuver.

## Orbital Descent

The lander is within the exosphere so will attempt to land with the remaining fuel on the surface using a proportional gain controller to linearly reduce the velocity to a safe regime. The autopilot may freeze for a moment as it tunes to the ideal value of to be most fuel efficient or softest landing (which version can be toggled using the ‘m’ key, the default is fuel efficiency). This mode is active in scenarios 1, 2, 4, 7 and 8 but will be switched to from Orbital Re-Entry if a radius within the exosphere is input.

## Orbital Injection

Using a PID controller the lander will go into an orbit of radius input by the user as described in Orbital Re-entry. There is no fuel decay, and the autopilot will switch to Orbital Re-entry once it has reached a stable orbit.

# Additional Mechanics

## Wind

Using the wind key to toggle on or off (default is off) there will be wind of a given average speed over a normal distribution (providing minor gusts now and then). The autopilot may eject the parachute if it is being dragged by it, and the user will be notified if this happens on the console.

## Any Angle Attitude Stabilization

The direction of the lander can be modified using the ‘x’ and ‘z’ keys to manually rotate it.

## Planetary Rotation

The mechanics of the planet’s rotation is taken into account, so if the lander has 0 velocity it will still have a ground speed relative to Mars. Scenarios 7 and 8 were added to mimic 1 and 5, but give the lander 0 ground velocity at the start of the simulation.