Aerocapture Simulation in Basilisk, an Open-Source Astrodynamics Software

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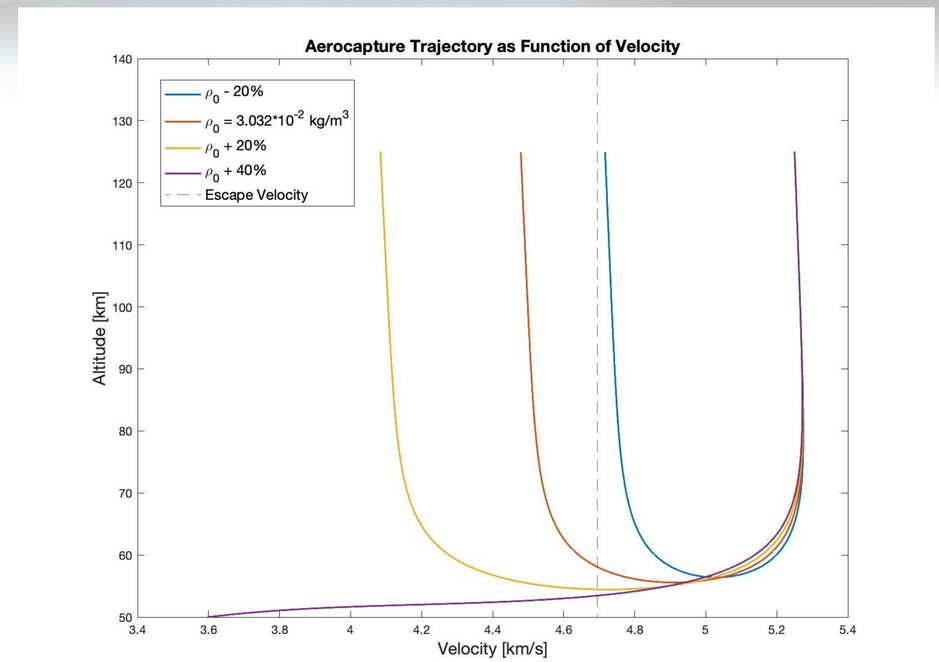
Aerocapture

A method of orbit insertion where a payload is launched into the atmosphere of a planet with chosen parameters using a single pass to effectively decelerate the spacecraft into a desired orbit. This method can enhance planetary science missions since the atmosphere pass allows for a reduction in propellant mass. This enables shorter cruise durations, thus higher arrival velocities, a necessary feature for missions for ice giants.

Basilisk

Open-source high-fidelity 6-DOF astrodynamics software framework capable of faster than real-time spacecraft simulations and hardware-in-the-loop testing. Basilisk achieves simulations in minimal time through capabilities written as C/C++ modules and configured in Python scripts.

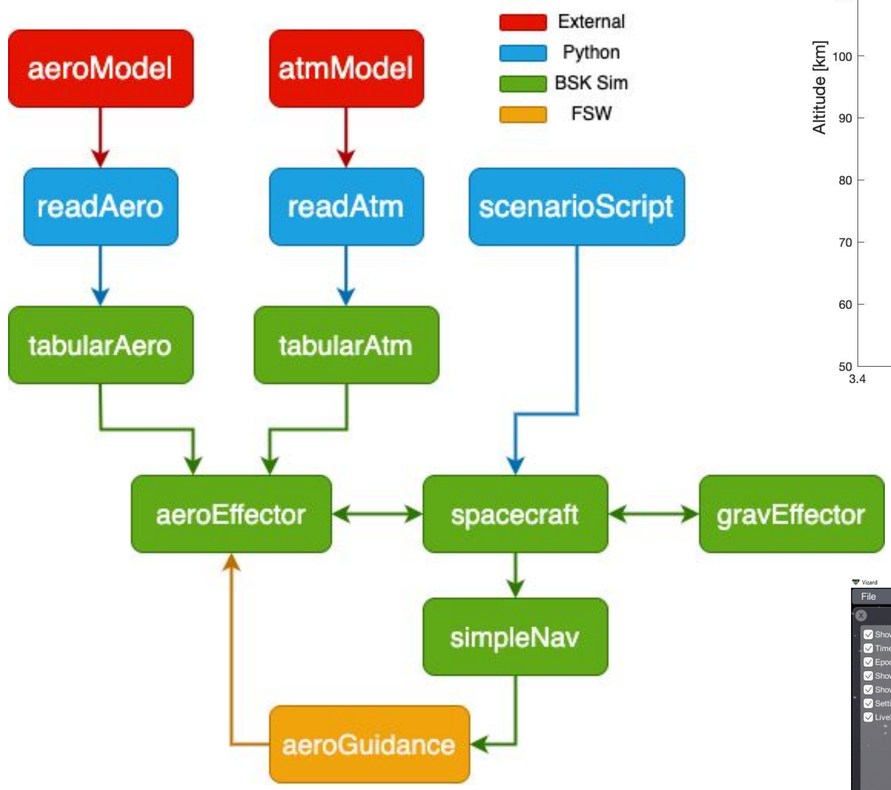


TabularAtmosphere

Computes local density and temperature based on from user-supplied table, sample tables such as the Global Reference Atmospheric Model (GRAM) tables for all the planets developed by NASA, and the US Standard Atmosphere table of 1976.

A helper function, ReadAtmTable, handles the file reading and data formatting to make data from any planet chosen by the user accessible to the C++ module. An interpolation calculator reads in the input data and parses through the altitudes to locate the user requested value or interpolate where necessary. The respective density and temperatures are then output.

TabularAtmosphere performs similar to the existing ExponentialAtmosphere module in Basilisk. Both return atmospheric density based on altitude. ExponentialAtmosphere differs by using the exponential model form and is less accurate at higher altitudes as the atmosphere dissipates. TabularAtmosphere covers this deficiency so is especially useful for aerocapture scenario when the spacecraft is first entering the atmosphere.

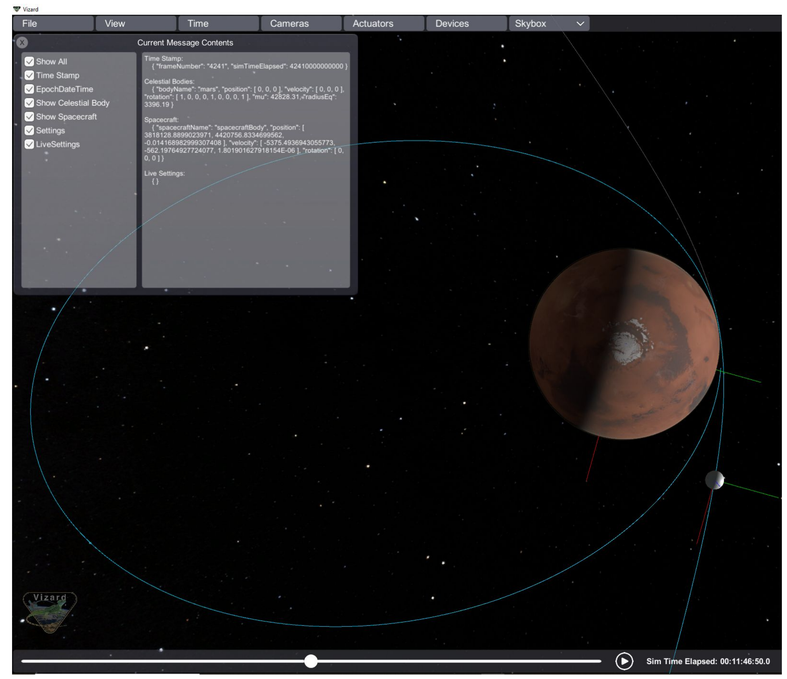


Aerocapture Scenario

Basilisk uses scripts to simulate various astrodynamics scenarios so an integrated example script was created specifically for aerocapture. The modules TabularAtmosphere and AeroEffector are implemented to properly demonstrate the maneuver and report relevant parameters such as energy over time and peak heat flux. Earth and Mars are available in the script to perform aerocapture using the GRAM tables to show resulting plots for altitude as a function of time and velocity, density and energy versus time, and more.

AeroEffector

Module that determines drag and lift forces and moments using an aerodynamic database within Basilisk. Lift and drag coefficients act as a function of Mach number in the database where the module interpolates this data to obtain the required coefficient for force calculations. AeroEffector performs similar to DragEffector by returning drag coefficients but extends upon that module with coefficients for lift and moments.



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