Creation of a trajectory framework that is sustainable for a continuous exploration of Mars and its moons

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Abstract

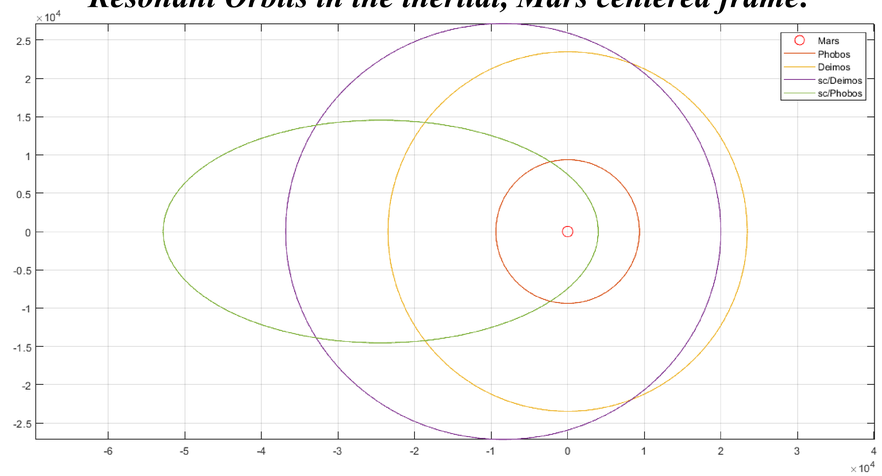
As humanity looks to the Cislunar region in recent space flight operations, the question remains: where will technology advance next? Mars is of particular interest with both the public and private sector aiming to get humans on the planet in the coming decades. Investigating stable trajectories in the Mars-Phobos-Deimos system for telecommunications and observation is the next step in developing future mission plans. Innovations in orbital mechanics must be considered, neither the Two Body Problem (2BP) nor the Circular Restricted Three Body Problem (CR3BP) are sufficient to effectively model satellite motion. Instead, in similar fashion to the patched-conics solution of transfers between the influence of celestial bodies, a patched CR3BP-2BP-CR3BP method of propagating the orbits is proposed. To begin, assumptions about Deimos and Phobos will be made—co-planar orbits and spherical symmetry to name a few. Once the problem has been successfully modeled, each assumption will be undone methodically to increase modeling accuracy. Impulsive maneuvers will be considered, as well as low, continuous thrust maneuvers. The aim of this project is to develop a robust, sustainable trajectory framework that can be used in future missions.

Methodology

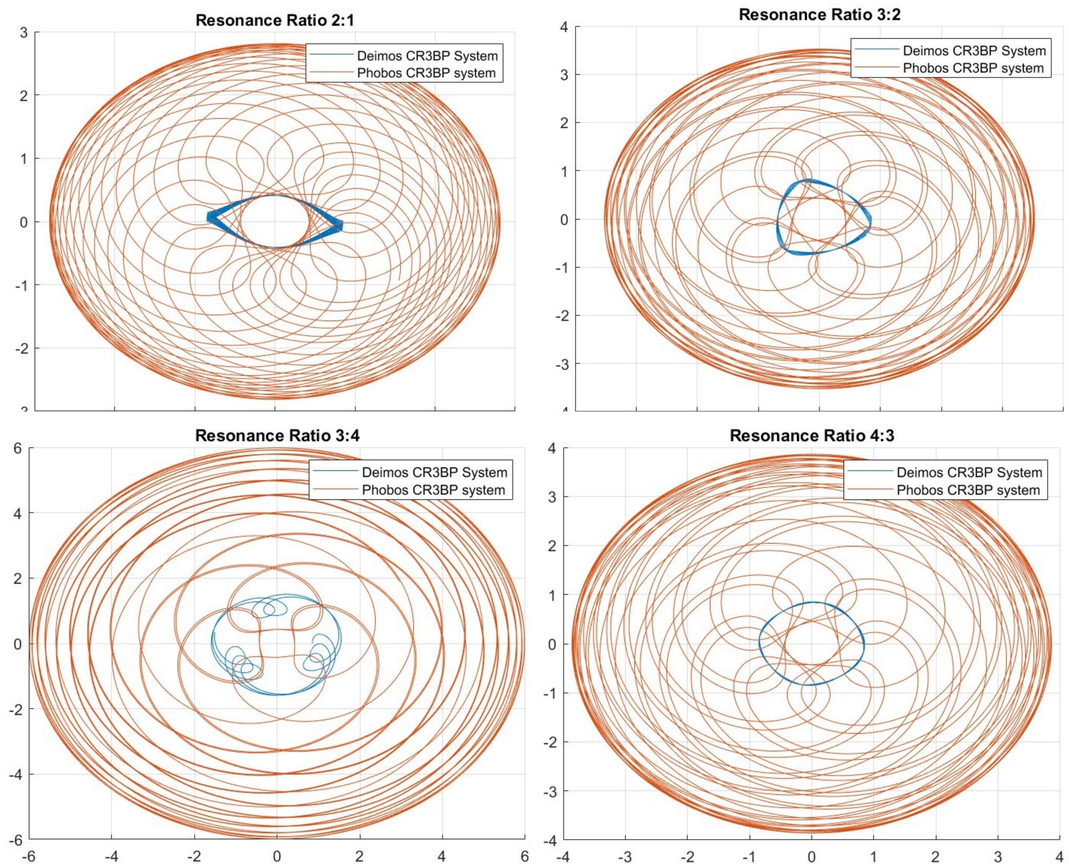
To create the initial range of initial conditions that can be explored as the simulations become increasingly complex, we begin with the propagation of the resonant orbits within a two-body propagation. This is completed in the inertial frame and is then translated into the rotational frame. This excludes the mass of the moons during the orbit; however, this is corrected when the simulation will move into the CR3BP simulation as the dynamics from the moons' gravitational effects will be included.

Results

Resonant Orbits in the inertial, Mars centered frame:

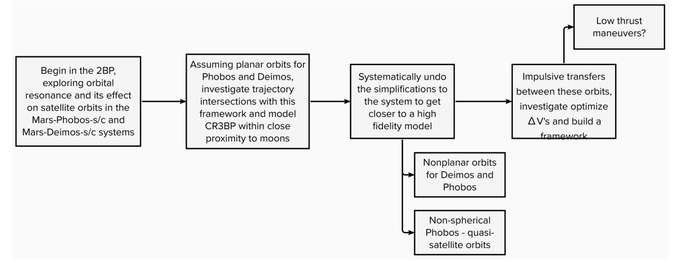


Resonant Orbits in the rotating frame, with various resonance ratios:



Future Goals

Given current progress, the next steps are to build upon the resonant orbit framework and begin to introduce complications that make the model more accurate and closer to a high-fidelity model. Non-planar orbits for the moons, irregular gravitational fields particularly in proximity to Phobos, and introducing the CR3BP in proximity to the moons.



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