ABSTRACT

THE RESTRICTED FULL THREE BODY PROBLEM: APPLICATIONS TO BINARY ASTEROID EXPLORATION

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There is much current interest in understanding the formation and evolution of the small bodies of our solar system. In addition, current astronomical observations suggest that 16% of the Near Earth Asteroid population is made of binary asteroids. A robotic mission sent to one of these systems provides double scientific opportunities to investigate their composition and their dynamical characteristics, thus motivating this research.

The Full Two Body Problem (F2BP) models a binary system taking into account the entire mass distribution of at one or both bodies. It is important to understand the motion of the binary system itself before studying the motion of particles or spacecraft in this environment, which is referred as the Restricted Full Three Body Problem (RF3BP). The F2BP model used herein is an ellipsoid-sphere system, which reduces the complexity of the problem while keeping interesting dynamical features. The current research looks at the conditions for the system to be in relative equilibrium. It is found that the equilibrium states are the minimum energy points of nearby periodic families. Simulations indicate possible paths from unstable to stable configurations, giving insights on how these binary systems may evolve in time.

In modeling the dynamics of a spacecraft in this relatively small scale environment compared to the sun and planets, these systems can be thought of as being "mini"

Three Body Problems, where the motion is strongly perturbed by the system's dynamics and by solar effects. These dynamics are analyzed using libration points, energy constraints, periodic orbits, and other methods of astrodynamics for a binary in relative equilibrium, and also accounting for perturbed motion of the primaries. Since the ellipsoidal body introduces surface constraints, the thesis also explores motion on the surface of these bodies, using transit trajectories between the two bodies and impact dynamics and control of landers.

Finally, an innovative mission proposal is developed that takes advantage of the unique dynamical environment at binary asteroids to carry out a scientific exploration mission. A case study is presented for the binary system 1999 KW4 and compared to other observed binary systems.