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INTEGRATED MODEL FOR A COST TRADEOFF STUDY BETWEEN A NETWORK OF LANDERS AND PLANETARY HOPPERS

Abstract

Rovers, such as the Mars Exploration Rovers have been successfully deployed in the past to explore celestial bodies. Though they can be effective, situations exist where rovers are not ideal for exploration. They are ill-suited to explore fissures, valleys, craters, and crags because of unfavorable terrain. Furthermore, Near Earth Objects (NEOs) possess low gravity that prevents rovers from generating enough traction for locomotion. Landers, like Phoenix, can be used to explore scientific sites that are unreachable over the surface, but cannot move to other points of interest after landing. Hoppers can be used to move over a surface, hopping or hovering over otherwise impassible terrain, and dropping payloads or performing scientific experiments at each site. Though other alternatives exist, this paper focuses on developing a methodology to analyze the tradeoff between exploration architectures comprised of landers and hoppers. While many metrics can be used to compare design alternatives, cost efficiency was the measure of effectiveness chosen for this model. The amount of mass required in orbit around a celestial body was taken as a proxy to the overall mission cost. As such, an integrated model was developed and implemented to determine the in-orbit mass required to complete a specified scientific exploration mission using both architectures. The algorithm utilizes a conceptual model of both landers and hoppers to calculate overall mass requirements for a specified number of landing sites, site-to-site separation, and gravity field. Several other parameters must also be defined to complete the mission definition. A lunar exploration mission was investigated using the integrated model. It was found that the more cost-efficient architecture depended on the scientific objectives. For example, a mission consisting of deploying 10-kg payloads at six lunar sites each separated by 5 km could be performed by a network of landers with 588 kg of in-orbit mass, compared to 629 kg for a single hopper. However, if the payload was only required to visit each site instead of being deployed, the mass of the hopper architecture decreases to 327 kg. Sensitivity studies reinforced that neither landers nor hoppers dominated the trade space. The specific contribution of this research is a methodology for quickly exploring the cost efficiency trade space between a network of landers and a hopper at a conceptual level. A mission designer could use this model to determine which exploration architecture is most promising to take to the next level of analysis.