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A FRAMEWORK FOR NEAR-EARTH ASTEROID MINING CAMPAIGN DESIGN AND ANALYSIS

Abstract

This paper presents a generic framework for near-Earth asteroid mining campaign design and analysis. The framework is designed to support mining campaign design through a numerical approach. It integrates various modules that cover target selection, trajectory generation, mission opportunity search, economic analyses and campaign scheduling and optimization. Each module is independent and can be exchanged for various mission scenarios and fidelity levels. The framework generally requires three types of data inputs, including ephemeris data, asteroid taxonomy and physical data, and cost modelling related data. Launch vehicle performance, spacecraft configurations and mining equipment parameters are directly obtained from literature. The use of the framework is first illustrated in the Bennu mining campaign design. For Bennu water mining with impulsive propulsion, three mining seasons are observed, during which the NPV reach $2,000 M, while the valley value of NPV outside the mining season is $500 M. The framework is also used in the case of mining 2014 UV210, assuming the asteroid contains both water(as propellant) and precious metals (as product). This provides unique opportunities for retrieving PGMs more cheaply in future. By using the framework for mission prefeasibility study, it is found that using ISPP to transport PGMs may increase economic returns by 83%. The framework is also utilized in sensitivity analysis. Several key factors deciding the profitability of NEA mining campaign are identified, including the number of manufactured spacecraft, spacecraft dry mass and maintenance cost. Using the proposed framework, mining campaigns are numerically designed. Based on the observation of periodic change of economic return, NEA mining seasons are discovered and categorized into three major types based on their feasibility for mining. Targets with different types of mining seasons have different levels of constraints on mission windows, and different mining strategies can be made accordingly.