Lunar and Asteroid Mining (11)
Space Resources Fundamentals & Asteroid Mining (1)

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NEAR-EARTH ASTEROID RESOURCE ACCESSIBILITY AND FUTURE CAPTURE MISSION OPPORTUNITIES

Abstract

Asteroids and comets have for long been the target of speculative thinking on resources for future space exploitation. The utilization of their resources has often been suggested as necessary for future ambitious space endeavours. This paper revises this notion by estimating the amount of accessible resources as a function of specific energy to transport these resources back to the Earth's orbital neighbourhood. The accessible resources can be estimated by analysing the volume of Keplerian orbital element space from which Earth can be reached under a certain specific energy threshold and then mapping this onto an existing statistical near Earth object model. The specific energy required to transport resources back to Earth can then be defined by a multi-impulsive transfer requiring; first, an impulse to both phase the asteroid with the Earth and reduce the Minimum Orbital Intersection Distance (MOID) below a minimum critical distance that allows a final insertion impulse at the periapsis of the hyperbolic encounter with Earth. A resource map can then be devised estimating the amount of material available as a function of energy investment to access different types of resources. The map then shows that considerable resources can be accessed at relatively low energy levels. More importantly, asteroid resources can be accessed with an entire spectrum of energy levels, unlike other more massive bodies such as the Earth or Moon, which require a minimum energy threshold implicit in their gravity well. The paper also reviews all surveyed known asteroids in search of possible candidates for relatively near-term scenarios for asteroid exploitation. Thus, the paper envisages moving a whole asteroid or a large segment of raw material to a bound Earth orbit for a later utilization, which would allow a more flexible mining operation at the Earth's neighbourhood. Under this premises, a preliminary set of capture missions can already be envisaged for the best set of capture opportunities. A set of capture opportunities can then be estimated by optimizing Lambert transfers to stable invariant manifolds associated to planar Lyapunov orbits. This process is computationally slow and requires a first pruning for candidate asteroids which can be done by means of Jacobi constant, approximated as Tisserand's parameter, or number of local minima of the MOID. As an outcome of the paper, a series of realistic examples of asteroid utilization missions, ranging from small demonstration missions to missions delivering material resources to support future human space ventures, are presented.