

Computational Framework for Assessing the Financial Feasibility of Asteroid Mining

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Project Abstract

The goal of this project is to determine the feasibility of mining near-Earth asteroids. The primary research objective is to quantify and compare the viability of in-situ mining versus orbital transfer and retrieval. Using data from [NASA JPL's Small Bodies Database](#), this project will first identify candidate asteroids based on practical orbital parameters. Then, it will model the energetic requirements, represented by delta-v (ΔV), for both mining scenarios for each candidate. This project, providing a data-driven ranked list of asteroids, is meant to serve as a basis for determining the economic practicality threshold for future resource extraction programs.

Methodology

Data Processing and Candidate Selection

The first step is to filter the JPL Small Bodies Database to create a curated list of high-potential candidates. The data, which contains essential Keplerian elements, will be imported into a [pandas DataFrame](#). The filtering criteria are suggested to be:

- Inclination (i) $< 5^\circ$ to exclude candidates requiring costly plane-change maneuvers.
- Earth Minimum Orbit Intersection Distance (MOID) < 0.05 AU to ensure proximity to Earth.
- Absolute Magnitude (H) < 22 to exclude bodies smaller than ~140m in diameter, ensuring a potentially higher return.

Comparative Analysis of Mission Architecture

For each asteroid candidate, two primary mission scenarios will be modeled using orbital mechanics libraries such as [poliastro](#) in Python. The key output metric for comparison will be the total change in velocity (ΔV), which serves as a proxy for propellant expenditure. In addition to ΔV , cost to and return on investment will be considered.

In-Situ Mining (ISM)

In-Situ Mining (ISM) involves sending a mining craft to the asteroid, processing materials on-site, and returning the refined resources to Earth. This analysis will focus on calculating the total ΔV for a round-trip trajectory from Earth to the asteroid to Earth.

Asteroid Retrieval via Hohmann Transfer

Asteroid Retrieval involves calculating the total ΔV required to transfer the entire asteroid from its current orbit into a stable and accessible near-Earth location such as a Distant Retrograde Orbit (DRO) for easier research and mining. The complex maneuver required to alter the body's trajectory will be modeled, as well as the ΔV required to send mining craft and equipment and bring back material. This is heavily dependent upon the asteroid's mass, which is estimated from its absolute magnitude and assumed albedo.

Initial Assumptions

Because each mission is fundamentally different and not a plethora of research is available on either, there are multiple pathways each could take. For example, ISM could be complicated by sending a crewed mission or fabricating equipment in space on-site. Likewise, retrieval must prove economic viability, considering time to return and spacecraft design and crew to meet the body. Both, however, could also be impacted by propulsion technology and its cost at the time of launch.

Ranking and Visualization

The final phase, synthesizing the data into a clear, comparative ranking, is of utmost importance. A Feasibility Score will be calculated for each asteroid, weighing the costs against potential rewards. The cost factor will be primarily based on the total

ΔV required in each mission scenario, and the value factor on the asteroids estimated size and likely composition (if spectral data is available, otherwise can be inferred).

Notes

- Pork chop plots for launch date optimization?
- How to keep the planet safe if maneuvers do not go as planned?
- How will this impact the future of space exploration?
 - Incentivize the capitalistic machine, benefitting space travel?

Data

The filtered data has been downloaded and saved in a CSV file with these columns, which includes required Keplerian elements:

- epoch: in Julian date format (e.g. 2461000.5)
- a: semimajor axis (au)
- e: eccentricity (0-1)
- i: inclination (deg)
- om: longitude of the ascending node (deg)
- w: argument of perihelion (deg)
- ma: mean anomaly (deg)
- full_name
- H: absolute magnitude (at 1 au from each the sun and the observer)
- diameter: km
- albedo: geometric albedo (number)

