A Novel Lifecycle Extension Plan for the Efficient Usage of On-Orbit Post-Consumer Assets

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A Novel Lifecycle Extension Plan for the Efficient Usage of On-Orbit Post-Consumer Assets

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Abstract

Asteroid mining is a potential form of commercial space industry, and significant amounts of research have gone into the feasibility of that activity. Less research has been done on what happens to the asteroid post-mining; the two primary end-of-life scenarios for the remains of a mined asteroid are not ideal. The remains could be destroyed, which entails complex technical and legal challenges, or they could remain in orbit, which could lead to collisions and a general increase in space debris. This proposal outlines a solution for the post-consumer asteroid issue which avoids creating more space debris and the risky business of deorbiting. This solution is to use the post-consumer asteroid shell as a shelter for delicate equipment or as a “garbage can in space,” which would hold the remains of defunct satellites until the time they could be more safely deorbited. The shell of the asteroid would provide protection from space debris impacts and some radiation. This proposal also discusses some of the major technical and legal challenges that this solution would face, and how stakeholders could potentially address them. More research is required to gain a better understanding of the challenges and opportunities that this proposal faces, which can be conducted during the long-term development of commercial asteroid mining technologies.

Introduction

The majority of space exploration has been motivated by political competition or scientific interest, rather than by economic interests. A potential boom for the space industry has been identified in resource extraction from asteroids. Space agencies and companies have developed technologically feasible plans to retrieve asteroids, some of which place the captured asteroid in lunar orbit. Other studies have proved a Earth orbit would be technologically feasible find some shit to cite. We assume that asteroid resource extraction ventures will be successful in the identification, capture, and retrieval of astroid assets to Earth orbit.

Once these assets are returned to the Earth and completely mined, they can be deorbited, abandoned on orbit, or used for a further mission. The primary objective of this study is to identify a useful secondary mission to prolong the profitable lifetime of the asset in Earth orbit. A further objective of this study is to reduce the risk to human life and property that could arise from deorbiting asteroid assets.

A mined asset combines two useful characteristics - an on-orbit source of mass and an object with artificial caverns and depressions (ACD). The ACDS in the surface are a result of the extraction efforts. Depending on the asteroid’s composition, the ACDS will vary in size and depth, potentially ranging in volume from a few cubic centimeters to tens of cubic meters. The ACDS will be surrounded by massive amounts of material, which could be used as passive shielding. We propose that the ACDS in the asteroid be used to store space debris and delicate payloads ("objects"). This solution would make use of the existing characteristics of the asset and would help to combat space debris, as well as providing a further revenue stream for the asset’s owner beyond the finite resources the asset holds.

Calculations

Billingham et al. found that a column density value of 0.5 g/cm² of passive shielding material is required to simulate radiation levels of 0.5 rem/year, and the radiation exposure from a solar flare is attenuated to below 20 rem [17]. In order to calculate the thickness of the walls needed to simulate radiation levels on Earth, the density of the asteroid shell is needed. Corey calculated the average bulk density of Bus-Dromo taxonomic classes of asteroids in 2012 [15].

To calculate the Te, the constant for column density was divided by the pa of common types of asteroids.

\[ T_e = C/pa \]

To research the potential implementation of inflatable habitats within assets

Results

To research atmospheric effects on the asteroid asset

Conclusions and Recommendations

Conclusions

1. Comprehensive study of asteroid assets considered for the implementation of this proposal is required.
2. The placement of space debris into the asteroid asset will be technically challenging, though they might become less so as related technologies develop.
3. Asteroid material could provide adequate passive shielding material against radiation if utilized on orbit.

Recommendations

The authors recommend multiple areas of further study, which are concentrated into two main areas: Pre-Mission and Mission-Specific.

- To conduct comprehensive study of asteroid assets returned to Earth orbit
- To experiment to determine the effectiveness of the mission design with a coherent non-coherent asteroids.
- To research atmospheric effects on the asteroid asset
- To research different designs for ACD covers
- To research the potential implementation of inflatable habitats within assets
- To determine the space debris impact of such a mission
- To compare the space debris creation vs. mitigation potential of the mission

Finally, the authors of this paper recommend a full-scale feasibility study for this concept. If it is found to be feasible in some or all conditions, then it should be pursued further.