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 deorbit, 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 deorbit. 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. We assume that asteroid resource extraction ventures will be successful in the identification, capture, and retrieval of asteroid 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 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 cavities and depressions (ACDs). The ACDs in the surface are a result of the extraction efforts. Depending on the asteroid’s composition, the ACDs could be re-cast as a natural shield against space debris and offer shielding against radiation due to the material composition of the asteroid. The thickness of the material surrounding the ACDs would determine the passive shielding potential of the ACDs.

Theory

Asteroid assets post resource mining operation can be utilized for further scientific research and storage after their useful life for resource extraction has been exhausted. The Artificial Cavities or Depressions (ACD) created by mining operations can then be used for storage or as a protective vessel for future missions. The ACDs can be repurposed into prefabricated capsules that would act as a natural shield against space debris and offer shielding against radiation due to the material composition of the asteroid. The thickness of the material surrounding the ACDs would determine the passive shielding potential of the ACDs.

Calculations

Bilingham et al. found that a column density value of 500 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 asset is needed. Carry calculated the average bulk density of Bus-Demo 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.

\[ T_e = \frac{C}{\rho_a} \]  

\[ \sigma_{T,e} = (\mu \rho_a) (T_e) \]  

\[ T_e = \frac{T_{e,m}}{\rho_a} \]  

To achieve a 300% safety factor, the Te,m was multiplied by 3.

\[ T_s = (T_e,m) \frac{3}{3} \]  

Results

Fig. 1. A front view of an asteroid shell with a single, large sealed ACD space debris, as well as providing a further revenue stream for the asset’s owner be would make use of the existing characteristics of the asset and would help to combat timeters to tens of cubic meters. The ACDs will be surrounded by massive amounts of 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 deorbit, 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 deorbit. 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.

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