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ASSESSING THE MATURITY OF ASTEROID RESOURCE UTILIZATION TECHNOLOGIES

Abstract

The United States (U.S.) and other countries have a growing international interest in harnessing space-based resources. Congress passed the U.S. Commercial Space Competitiveness Act in 2015, which gave U.S. space firms the right to own and sell natural resources they mine from bodies in space, including asteroids. The U.S. Department of Commerce Secretary, Wilbur Ross, announced that the Department is working to create a mission authorization process that will enable endeavors such as asteroid mining to flourish. Other countries have followed with similar heightened levels of interest in and funding for asteroid mining-related activity. We assess the maturity of technologies necessary for asteroid resource mining and utilization, with a specific focus on mining water for propellant.

Rather than analyze a specific mining architecture, we develop a seven-stage framework for asteroid resource utilization and analyze the technology necessary for each phase. The seven phases are: 1) to prospect for asteroids that are economical to mine; 2) to transport equipment or extracted resources to and from the asteroid; 3) to establish physical contact with the asteroid, e.g. landing or grappling; 4) to excavate material from the asteroid, including conveyance of the material to a processing plant; 5) to process and purify the desired resource from the excavated material; 6) to store and subsequently transfer the resource to an end user; and 7) to use the asteroid resource at its final destination. Technologies are assessed via literature review and interviews with technology experts from government, academia, and industry.

Technologies in each stage of the asteroid mining framework are at various stages of readiness. Prospecting is the most mature, with funding-to-fly being the principal constraint as all significant technical challenges have been effectively overcome. There is a consensus view that asteroid mining technologies for the contact, excavate, and process phases are still nascent with some prominent experts in the field stating "at this time [2018], all ISRU technologies are TRL 4 or less". Alternatively, a few interviewees claimed some relevant technologies to be at TRL 6, which is generally seen at the required maturity for NASA to consider incorporating them into mission plans. Further, there is an asteroid mining architecture in the literature that has cleverly designed around the technical challenges of the contact, excavate, and process phases. From a technology development and testing perspective, we assess that the first use of an asteroid-derived resource is more than a decade away.