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Author: Dr. Thomas Colvin
IDA Science and Technology Policy Institute, United States

Dr. Keith Crane
IDA Science and Technology Policy Institute, United States
Dr. Bhavya Lal
Science and Technology Policy Institute, United States

ASSESSING THE ECONOMICS OF ASTEROID-DERIVED WATER FOR PROPELLANT

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. This paper assesses the economic viability of using asteroid-based resources to support government and commercial space missions between 2030 and 2050.

The economic viability of asteroid resources for space missions will be driven by three major factors: the cost of the asteroid mining and in-space processing infrastructure; the total demand for the in-space resources over which the infrastructure cost will be spread; and the competing cost of launching those same resources from Earth. We estimate the cost of asteroid mining infrastructure by dividing it into seven phases (prospect, transport, contact, excavate, process, store and transfer, and utilization) and developing independent cost estimates associated with the technology required in each phase. We estimate demand for asteroid resources by investigating the exploration plans of NASA and other world space agencies, as well as potential sources of demand from the private space sector. Finally, we estimate the costs of delivering equivalent amounts of the demanded resources from earth instead of from an asteroid.

We assess that water for on-orbit propellant is the only asteroid-derived resource that may become economical in our period of interest. We estimated that demand for propellant in space over this 20-year period was about 6,000–10,000 metric tons of propellant, with an estimated worth about $15 billion. Our estimates are significantly lower than most in the literature, which tend to assume the emergence of a large, currently undefined, commercial demand. We estimate that the cost of delivering propellant from an asteroid to low-Earth orbit (LEO), $2–3,000/kg, could be comparable to the estimated costs of delivering propellant to LEO using a Falcon Heavy. For delivery to the LOP-G orbit around the Moon, asteroid-derived propellant could be less expensive than launch from Earth. Estimates of the cost of manufacturing propellant from asteroids range from $900 to $5,000 per kilogram to lunar orbit.