

Origins and Chronology of the Asteroid Retrieval Mission (ARM) Concept

Exploiting the natural resources of asteroids is an idea that predates the Space Age. In his *Exploitation of Asteroids* (1903), it was one of Tsiolkovskii's fourteen points in the conquest of space. NASA has been conducting studies related to asteroids and asteroid mining beginning with the 1970s. However, propulsion and transportation remained a main feasibility issue.

2007-2009: John Brophy (JPL), who led the development of the ion-propulsion system for NASA's Dawn mission, forms a team with members from JPL, JSC, GRC, and UCSC to assess the use of near-term solar electric propulsion (SEP) for the capture and return of a small near-Earth asteroid (NEA) back to Earth. It is recognized that high-power SEP can potentially overcome the propulsion/transportation limitations.

2008-2010: Silvano Casini (former head of ASI) suggests to Marco Tantardini (The Planetary Society) to work on the idea of moving an asteroid for purposes of mining. Tantardini discusses this idea with Louis Friedman (The Planetary Society), Martin Lo (JPL), and others.

2010: John Brophy and his team respond to a NASA internal call for proposals "supporting early formulation of revolutionary concepts to benefit NASA missions and meet other national and global challenges," proposing to rendezvous with a small NEA, capture it, and return it to the International Space Station using high-power SEP. The proposal is awarded (PI: John Brophy) and members from JPL, JSC, GRC, and UCSC investigate the feasibility of the ARM concept. The study concludes that it would be challenging but appears feasible (October 2010 report).

October 2010: Friedman, Lo, Tantardini, and Colin Williams (JPL) consider the concept as a topic for a Keck Institute for Space Studies (KISS) study topic, leading Martin Lo to suggest the idea of a robotic ARM to Earth-Moon L2, as a precursor to a human spaceflight mission.

January 2011: Brophy, Friedman, and Fred Culick (Caltech) lead a KISS study on the feasibility of capturing and returning a small NEA. The study includes participants from 6 NASA centers, 8 universities, Planetary Society, the B612 foundation, commercial companies, and others. The study concludes that an ARM is feasible, based on a high-performance SEP system, and could be launched before the end of this decade, with a cislunar destination (April 2012 report).

Fall of 2012: A follow-on KISS technology-development study, led by Paul Dimotakis (Caltech), Brophy, and Friedman, extends the effort to technology in support of an observational campaign to identify target asteroids, and to other components. A preliminary report is presented to a NAS/NRC Technical Panel (28 March 2013).

November 2012: NASA initiates a JPL study (PI: John Brophy), with GRC and JSC support, to investigate an ARM in further detail to ensure that its feasibility can withstand detailed scrutiny. The study affirms its feasibility with a possible launch as early as 2017 (31 March 2013).

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