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ASTEROID MINING: MULTIPLE SPACECRAFT LOGISTICS FOR MARS SUPPLY

Abstract

The expansion of humankind to extraterrestrial bodies will require supplying colonies with materials. Necessary resources can be either used in a closed loop, produced from in-situ available resources or resupplied from Earth on a regular basis. In cislunar space, all three options may be combined for optimal efficiency. However, when considering more distant bodies such as Mars, supplying a settlement with resources from Earth becomes increasingly challenging, considering higher requirements in delta-v and reduced launch opportunities for transfers between Earth and Mars. Near-Earth asteroids have been considered as an alternative point of extraction for some resources, such as water and metals. This is of particular interest in the case a settlement's size has reached a threshold above which Earth-based supply together with in-situ resource production cannot support the needs anymore. This paper describes a method and digital tool designed to optimize an interplanetary economy including Earth, Mars and asteroid groups, which can supply a Martian colony with the additional resources required for enabling sustainability and growth. We begin by identifying which resources will be lacking and when, considering a prospective Mars colony starting in 2050, as an example mission. These are then compared to a database of possible target asteroids. Delta-v maps showing local minima on a timescale are then created for each considered asteroid using defined input parameters including payload, maximum delta-v and number of vehicles. From this, optimized schedules for multiple spacecrafts to mine asteroids and thus support a prospective colony with required resources at different stages of colony growth is produced. We demonstrate that asteroid mining could provide the colony with a greater number of supply opportunities considering more frequent launch windows, smaller delta-v for material transportation and various consumable types that cannot be resourced in-situ. Recommendations include specifications for vehicle architecture based on the variations tested in payload and number of vehicles and further observation and cataloguing of Near-Earth asteroids.