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ENHANCED GRAVITY TRACTOR TECHNIQUE FOR PLANETARY DEFENSE

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ABSTRACT

Given sufficient warning time, Earth impacting near-Earth objects (NEOs) can be deflected with a variety of different “slow push/pull” techniques. The gravity tractor is one technique which uses the gravitational attraction of a rendezvous spacecraft with the NEO to provide a velocity change and gradually alter the trajectory of an impactor. This approach requires the use of a high-efficiency propulsion system, such as Solar Electric Propulsion (SEP), to allow the spacecraft to maintain separation without pluming the NEO, which reduces the effectiveness of the technique. One of the short comings of the traditional gravity tractor approach is that the applied force is small and depends on the mass of the spacecraft. This results in operational times of many years or decades to appreciably alter the impactor’s trajectory. An innovative technique, known as Enhanced Gravity Tractor (EGT), uses mass collected in-situ to augment the mass of the spacecraft, thereby greatly increasing the gravitational force between the objects. The collected material can be a single boulder, multiple boulders, regolith or a combination of different material types using a variety of collection techniques. The mass of the collected material

would likely range from tens to hundreds of metric tons based on the size of the impactor and warning time available. Depending on the SEP system's capability (i.e., power, thrust, and propellant) and the mass collected, the EGT approach can reduce the deflection times by a factor of 10 to 50 or more and propellant requirements by a factor of two to three, thus reducing the deflection times of several decades to years or less. Additionally, the ability of multiple spacecraft to orbit the target in formation to provide the necessary velocity change can further reduce the time needed by the EGT technique to divert hazardous NEAs. NASA's Asteroid Redirect Robotic Mission (ARRM) option to collect a boulder from the surface of a large (~100+ m) near-Earth asteroid would provide the first ever demonstration of the EGT technique on a hazardous-size asteroid and validate one method of collecting in-situ mass. This paper provides an overview of the key aspects and benefits of the EGT technique, describes the ARRM EGT demonstration and mass collection method, and discusses other mass collection approaches and planetary defense techniques that can be implemented utilizing a spacecraft with a high-efficiency propulsion system and mass augmentation.

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