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Enhanced Gravity Tractor Derived from the Asteroid Redirect Mission for Deflecting Hypothetical Asteroid 2017 PD

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ABSTRACT

The National Aeronautics and Space Administration (NASA) is developing the Asteroid Redirect Mission (ARM) to robotically visit a hazardous-size near-Earth asteroid (NEA) with a rendezvous spacecraft, collect a multi-ton boulder and regolith samples from its surface, demonstrate an innovative planetary defense technique known as the Enhanced Gravity Tractor (EGT), return the asteroidal material to a stable orbit around the Moon, and have astronauts explore the returned material in the mid-2020s. Launch of the robotic vehicle to rendezvous with the ARM reference target, NEA (341843) 2008 EV_5, is planned for late 2021 [1,2]. The gravity tractor technique uses the gravitational attraction of a station-keeping spacecraft with the asteroid to provide a velocity change and gradually alter the trajectory of the asteroid. EGT utilizes a spacecraft with a high-efficiency propulsion system, such as Solar Electric Propulsion (SEP), along with mass collected in-situ to augment the mass of the spacecraft, thereby increasing the gravitational force between the objects [3]. 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 EGT approach can greatly reduce the deflection time required for the traditional gravity tractor technique in which only the spacecraft mass is used to generate the gravitational attraction force. The robotic segment of ARM, which uses a 50 kW-

class SEP system, will provide the first ever demonstration of the EGT technique on a hazardous-size asteroid and validate one method of collecting in-situ mass. A deflection effort derived from the ARM robotic spacecraft to deflect the hypothetical asteroid 2017 PD will be presented assuming that the ARM mission has already been developed and successfully demonstrated the spacecraft operations and the EGT technique. The key characteristics of asteroid 2017 PD, such as its orbit, diameter (100-250 m), density, and spin state, are not well known prior to arrival at the asteroid. A potential impact in July 2027 provides approximately ten years to rendezvous with the asteroid, confirm its characteristics and that it is on an Earth-impacting trajectory, perform the deflection operations, and verify that the deflection was successful. The range of asteroid 2017 PD characteristics that would be applicable to the EGT technique and the capabilities required of the ARM-derived robotic spacecraft which would be needed to deflect the impactor utilizing this technique will be included. In cases where the EGT was not able to provide sufficient capability to deflect 2017 PD, the role of the spacecraft and technique in a hybrid deflection effort will be discussed.

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