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Extension of the DART Mission to Kinetic Deflection

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ABSTRACT

Mitigation of a hazardous NEO can be accomplished by deflecting it so that it misses the Earth. Strategies to deflect an asteroid include impacting it with a spacecraft (a kinetic impactor), pulling it with the gravity of the mass of a spacecraft (a gravity tractor), using the blast of a nearby nuclear explosion, and modifying the surface or causing ablation by various means including lasers or particle beams. None of these approaches has been tested on a NEO. The Double Asteroid Rendezvous Test (DART) mission is a proposed demonstration of kinetic deflection, the most mature technique for mitigating the impact hazard of a Near Earth Object (NEO).

The main objectives of the DART mission, which includes the spacecraft kinetic impact and an Earth-based observing campaign, are to:

- Perform a full scale demonstration of the spacecraft kinetic impact technique for deflection of an asteroid, by targeting an object large enough to qualify as a Potentially Hazardous Asteroid (that is, larger than 100 m);
- Measure the resulting asteroid deflection, by targeting the secondary member of a binary NEO and measuring the period change of the binary orbit;

- Understand the hypervelocity collision effects on an asteroid, including the long-term dynamics of impact ejecta; validate models for momentum transfer in asteroid impacts, inferring physical properties of the asteroid surface and sub-surface.

The DART target is the secondary member of the binary asteroid 65803 Didymos, with the impact scheduled to occur in September 2022. The DART impact on the secondary member of the Didymos binary at ~7 km/s will alter the binary orbit period by at least 4 minutes, assuming a simple transfer of momentum to the target. The period change may be significantly greater, as the momentum transferred to the target asteroid may exceed the incident momentum of the kinetic impactor, possibly by a large factor.

This paper presents the results of a study of the extension of the DART design to an actual deflection mission. The required modifications to the DART design were determined for two cases, Bennu and the hypothetical threat from the 2015 IAA Planetary Defense Conference. This modified design was then assessed against a different asteroid, 2015 TB145. The DART-derived design was effective in deflection, and execution of the DART mission allows for a more rapid response in case an actual threat was detected.