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# THE POTENTIAL BENEFITS OF AN ION BEAM DEFLECTION (IBD) DEMONSTRATION MISSION

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## ABSTRACT

Ion beam deflection (IBD) is a planetary defense technique based on high-power solar electric propulsion (SEP) technology. It uses momentum transferred from an ion beam impinging on the threat object to change its orbit. IBD is essentially independent of all physical characteristics of the asteroid except for its shape and mass. The 2021 Rapid Mission Architecture Study for the Planetary Defense Decadal Survey states that "…*KI [Kinetic Impactor] and IBD have similar overall performance envelopes, but the risk of asteroid disruption is a significant limitation for successful KI deflections over a large region of the parameter space*." A key advantage of IBD is that it provides similar performance to KI while eliminating asteroid disruption as a concern. A second key advantage is that this technique requires the IBD vehicle to rendezvous with the asteroid providing the opportunity for up-close characterization and precise determination of its orbit prior to the initiation of deflection operations.

The disadvantage is that IBD requires months to years of operation at the asteroid, depending its size, in order to produce the required deflection. Shorter deflection times are obtained with higher power IBD systems. IBD is much more effective than the other slow-push techniques including the much-studied gravity tractor. It may represent a sweet spot in planetary defense techniques providing a capability comparable to kinetic impactors, but without its disruption limitations, and providing much more effective deflection capabilities than gravity tractors. Just as the DART mission is providing valuable information about the capabilities and limitations of kinetic impactors, a demonstration of IBD would provide similarly valuable information for this alternate technique.

This paper provides an assessment of options to perform an in-space demonstration of IBD. Three demonstration options of increasing cost, complexity, and efficacy are examined:

(1) **Option 1:** Augment a small-body rendezvous mission that already has a solar electric propulsion system for its primary mission and use it to perform an IBD demonstration. This would demonstrate the ability of the spacecraft to target the small-body with the ion beam and to maintain the beam on the target over an extended period of time—days to weeks. No measurable deflection of the small body is expected. Compensation for the thrust generated by the ion beam would be provided by an existing reaction control subsystem (RCS).

(2) **Option 2:** This is similar to Option 1 but augments the ion propulsion subsystem to provide the thrust compensation instead of relying on the RCS. This represents a more realistic configuration for an actual IBD planetary defense configuration. No augmentation of the solar array is included. Both the deflecting and compensating ion thruster subsystems are operated from the original solar array. No measurable deflection of the small body is expected.

**(3)** **Option 3:** This option is similar to Option 2 but augments the solar array size and the total electric propulsion propellant. The objective of this option is to be able to operate for a sufficiently long period of time to produce a measurable deflection.