

**PDC2025**  
**Stellenbosch, Cape Town, South Africa**

**x Deflection / Disruption Modeling & Testing**  
**x Space Mission & Campaign Design**

**A Gravity Tractor Mission Concept to a Binary Asteroid**

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**Keywords:** *Gravity Tractor, Slow-pull Mitigation Technique, Binary Asteroids, Mission Concepts*

There are a number of possible mitigation strategies that have been identified in the event a hazardous asteroid is discovered. NASA's DART mission recently demonstrated the kinetic impactor technique [1]. The gravity tractor (GT) is attractive as the next technology for demonstration since other techniques may be prohibited by cost and legality [2]. A GT demonstration mission would align with NASA's goal to "[d]evelop preliminary mission designs for future NEO deflection mission campaigns" [3]. Here, we present the design of a mission that would demonstrate a GT by changing the orbit of the secondary in an asteroid binary system.

The GT concept for deflecting asteroids involves bringing a spacecraft near an asteroid and controlling the spacecraft so that the asteroid's orbit is altered by the spacecraft's gravity [4]. This slow-pull mitigation strategy can achieve greater precision in an asteroid's post-deflection orbit than impulsive mitigation techniques. GT also has the benefits of being agnostic to the material properties of the asteroid and not requiring contact between the spacecraft and asteroid. A GT may be used as the "primary" mitigation technique for hazardous asteroids that are found sufficiently far in advance of their Earth impact dates, or as a "secondary" mitigation technique applied after a "primary" impulsive technique to ensure the avoidance of gravitational keyholes. Inspired by the success of the DART mission, we are studying whether GTs will be more easily tested in a binary asteroid system in the same way that kinetic impactors are: a small velocity change on the order of what would be necessary in a real emergency is more easily detected and measured on an asteroid satellite's orbit than it is on a single asteroid's heliocentric orbit [5].

We report on the preliminary design of a GT demonstration mission to a binary asteroid system. We identify three main goals that a GT mission to a binary asteroid should

achieve: (1) guide and navigate the spacecraft to the vicinity of the secondary and precisely control its relative position (within a few body radii), (2) measure the change in the secondary's orbit due to the GT, and (3) demonstrate long-duration tractoring operations in close proximity to the asteroid. We present mission requirements needed to achieve these mission goals. These requirements are used to define a concept of operations for a binary asteroid system "characterization phase" and "tractor phase," which would lead to a measurable deflection of the secondary within a 12-month timeframe for asteroid proximity operations. We present the mission design, baseline payload, and spacecraft design that would meet these investigation requirements. In sum, this report outlines a demonstration mission of a GT at reasonable cost that will accomplish NASA's goal of demonstrating a slow-pull asteroid deflection technique.

## References

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**Comments:** *Oral presentation slot preferred.*