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The *Beacon* Mission

Aaron Boley⁽¹⁾ and Matthew J Payne⁽²⁾

⁽¹⁾ *The Outer Space Institute and the Department of Physics and Astronomy, 6224 Agricultural Rd, Vancouver, B.C.-V6T 1Z1, Canada; acboley@phas.ubc.ca*

⁽²⁾ *Harvard-Smithsonian Center for Astrophysics, 60 Garden St., MS 51, Cambridge, MA 02138, USA; mpayne@cfa.harvard.edu, matthewjohnpayne@gmail.com*

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ABSTRACT

Beacon is a concept for a proposed mission to place transponders on multiple NEOs and to track those NEOs over decade timescales. The corresponding positional and distance information, along with photometric monitoring, will (1) improve the orbital determination for the target NEOs, (2) provide a highly sensitive test for perturbative forces on the NEO population, and (3) establish unique labs for future deflection studies. Furthermore, *Beacon* is a pathfinder for creating a network of tagged asteroids that will improve our knowledge of the evolving orbits of NEOs and establish a relay network for future deep space operations by state and non-state actors.

There are numerous asteroids that would satisfy the overall objectives of the mission. Here, we argue that tagging 99942 Apophis may provide the greatest *scientific* yield as part of a pathfinder tagging mission. Apophis is known for its small Earth MOID (47,000 km) and anticipated close approach in 2029 [1], but also for the relevance of the Yarkovsky effect to its impact risk [2]. The asteroid has a diameter of about 370 m [3] and a surface composition that is consistent with an LL chondrite [4].

The 2029 encounter with Earth will potentially place Apophis within Earth's GEO belt. We propose to tag Apophis before this approach to ensure that a high-precision orbital prediction can be obtained for the encounter, supporting additional missions that will study Apophis during and after the Earth flyby. Having Apophis tagged will further provide an immediate, high-accuracy orbit as it transitions from an Aten-class orbit to the anticipated Apollo-class orbit.

Apophis's chaotic orbit and repeated close approaches with the Earth make it non-ideal for conducting deflection/redirection *planetary defence studies*. The DART mission and, indirectly, the *Deep Impact* mission represent 1st-generation minor body redirect studies, which is an important but limited step in assessing planetary defence capabilities. *Beacon* would build on this effort by creating a natural laboratory and proving ground for 2nd-generation asteroid redirection studies using one or more moderate size NEOs with low impact risks (non-PHAs). The main requirements for selecting candidate asteroids for this phase of *Beacon* are (1) frequent low delta-V intercept opportunities and (2) a diameter of a few hundred meters. We discuss a number of potential targets which satisfy these criteria, while satisfying a suite of launch-date and launch-platform opportunities.

- [1] Georgini et al. 2008, *Icarus*, vol 193, issue 1
- [2] Farnocchia et al. 2013, *Icarus*, vol 224, issue 1
- [3] Müller et al. 2014, *A&A*, vol 566, id.A22
- [4] Reddy et al. 2018, *AJ*, vol 155, Issue 3, id.140
