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**MISSION OPPORTUNITIES FOR THE FLIGHT VALIDATION OF THE KINETIC
IMPACTOR CONCEPT FOR ASTEROID DEFLECTION**

**Sonia Hernandez⁽¹⁾, Brent W. Barbee⁽²⁾, Shyam Bhaskaran⁽³⁾, and
Kenneth Getzandanner⁽⁴⁾**

⁽¹⁾*Graduate Student, Dept. of Aerospace Engineering and Engineering Mechanics,
The University of Texas at Austin, 210 E. 24th St., Austin, TX, 78712, USA, 512-471-
7593, sonia.hernandez@utexas.edu*

⁽²⁾*NASA/GSFC, Code 595, 8800 Greenbelt Road, Greenbelt, MD, 20771, USA, 301-
286-1837, brent.w.barbee@nasa.gov*

⁽³⁾*Jet Propulsion Laboratory/California Institute of Technology, 4800 Oak Grove Dr.,
Pasadena, CA 91109, 818-354-3152, shyamkumar.bhaskaran@jpl.nasa.gov*

⁽⁴⁾*NASA/GSFC, Code 595, 8800 Greenbelt Road, Greenbelt, MD, 20771, USA, 301-
286-1327, kenneth.getzandanner@nasa.gov*

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ABSTRACT

The kinetic impactor technique for deflecting near-Earth objects (NEOs), whereby a spacecraft is directed to collide with the NEO to alter its orbit via momentum transfer, is one of several proposed methods for defending Earth against hazardous NEOs. This technique must be validated by one or more flight test missions to be considered reliable during an actual incoming NEO scenario, but such missions have not yet been carried out. In previous work¹ a survey was performed on a subset of the known near-Earth asteroid (NEA) population whose orbits are completely exterior or interior to Earth's orbit (for safety reasons) to identify all target NEAs that offer notionally feasible opportunities for kinetic impactor flight validation missions. The previous survey was constructed with a filter which is based on optimized mission mass. Also, a detailed model was developed for predicting the deflection of the NEA's orbit as a proxy for the experimental observability of the change in the NEA's velocity.

In this paper we build upon the results from the previous study by augmenting the target NEA filter to incorporate additional criteria such as the approach phase angle of the spacecraft with respect to the NEA. This is because an operationally realistic NEA intercept mission will require a sufficiently low approach phase angle to facilitate acquisition of the NEA by the spacecraft's onboard sensors during terminal guidance. Additionally, new filter steps are devised that utilize all criteria to optimally balance key parameters such as approach phase angle, NEA diameter, relative velocity at intercept, and current NEA orbit knowledge to produce refined lists of the most promising candidate target NEAs for a future flight validation mission.

We further extend these new results by addressing the experimental observability of the kinetic impact effects more directly than in the previous study. In lieu of predicted NEA orbit deflection as a proxy for the observability of the kinetic impact experiment, we now simulate the orbit determination process to predict the accuracy with which we can estimate the change in velocity imparted to the NEA by the kinetic impactor to demonstrate the viability of the deflection experiment, using an analysis methodology similar to that shown in Ref 2. The orbit determination simulation includes simulated measurements made by an observer spacecraft in the vicinity of the NEA, simulated ground tracking of the NEA and kinetic impactor spacecraft, and simulated onboard terminal guidance performed by the kinetic impactor spacecraft via optical navigation relative to the NEA. We also repeat the analysis without the simulated observer spacecraft measurements to assess the feasibility of kinetic impactor flight tests with a single spacecraft. If feasible, that type of mission could be more cost-effective than one that requires a separate observer spacecraft.

Finally, we combine all of the aforementioned analysis with high-fidelity optimization of the mission trajectories to produce complete detailed mission designs for one or several notionally feasible and affordable future kinetic impactor flight validation test missions deployed to currently known target NEAs. We also present lists of the most promising target NEAs for kinetic impactor flight validation test missions.

References

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