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# THE EVOLUTION OF SHAPE: DESIGNING THE NEXT GENERATION OF KINETIC IMPACTORS


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## ABSTRACT


Deflection by kinetic impactor is one of the most mature planetary defense mitigation techniques, and is the only demonstrated planetary defense technology to date. Within this context, it is important to identify how to optimize a kinetic impactor design for planetary defense. Though mass and impact velocity influence the effectiveness of a kinetic impactor directly, control over these parameters is limited

by launch and orbit considerations. Due to those mission design constraints, kinetic impactor design optimization focuses instead on more controllable characteristics, such as shape, density, and mass placement of the impactor. We present in this work a detailed numerical study of kinetic impactor design using the ogive shape as the primary control. The ogive is a commonly employed ballistic shape which can be varied continuously between a blunt hemisphere to a narrow, pointed rod. By varying the aspect ratio and the angle of the leading edge of this simplified shape, variation between two commonly employed approximate shapes (spheres and rods) can be studied in detail. We present the scaling of the momentum transfer efficiency, beta, with ogive shape in both strong competent and weak granular targets for a variety of impact speeds (2 to 15 km/s) to establish performance variation with shape across a wide range of impact conditions. This study is undertaken using 2D, axisymmetric hydrocode simulations using the CTH code. We also present a first look of our results for 3D simulations of obliquely impacting ogives. Our results will inform both future numerical efforts and future experimental investigation of kinetic impactor effectiveness. Initial 2D axisymmetric results into strong competent basalt targets indicate that there is a projectile geometry effect on the crater lip and resulting $\beta$. We see that ogives with sharp leading edges couple their energy deeper into the target surface resulting in convex crater walls that extend out and over the excavated crater and tend to deflect ejecta from contributing to the momentum enhancement factor. The degree of this geometry effect will be studied more in 3D and as a function of target strength.

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