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SENSITIVITY OF GROUND DAMAGE PREDICTIONS TO METEOROID BREAKUP MODELING ASSUMPTIONS

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ABSTRACT

Ground damage resulting from meteoroid airburst blast waves has been widely studied and a number of analytical models have been presented. These models typically provide good qualitative descriptions of the breakup physics, but are necessarily limited by simplifying assumptions. As a consequence, their predictions of energy deposition during the atmospheric entry can vary significantly depending on the specific modeling assumptions. In this paper, we perform meteoroid breakup assessments using modern hydrocode tools. Computed energy deposition curves are produced for a range of modeling assumptions, including problem dimensionality, material constitutive models, entry conditions, as well as meteor size, density, strength, and shape. In addition, simplified inhomogeneous meteoroid composition is investigated. The computed energy deposition curves are compared to analytical models to highlight differences from the range of modeling assumptions and meteoroid properties.

Computed results show that the notion of a breakup altitude is overly simplistic, as meteoroid breakup appears to be a more continuous process. Depending on the analysis, meteoroid failure either begins at the stagnation point or on the shoulder region. Structural failure does follow the “pancaking” theory in certain cases, but the rate of radius increase is computationally much lower than predicted by the analytical models. This translates into a more gradual energy deposition rate. In addition, the current computations do not exhibit a continual cracking behavior and therefore do not show smaller fragments filling gaps between larger fragments—instead smaller fragments are left in the wake. However, the large fragments do remain behind a

single bow shock until significant separation is achieved. A range of simulations was performed to illustrate how these breakup processes vary with modeling assumptions.

The kinetic energies of the meteoroid fragments are integrated over time to produce the energy deposition curves. These curves are used as initial conditions for blast propagation using a Cartesian Euler flow solver. Resulting flow solutions produce associated ground damage footprints from the airburst. The ground damage is shown to vary with modeling parameters, and is compared to the analytical predictions for reference.

The existing computations have been performed for a range of representative meteoroids, but the process will be repeated for the 2013 PDC15 asteroid once the details are posted to the conference website. It is expected that the existing results in the paper will be updated with 2013 PDC15 results, considering the sensitivity of ground damage to the uncertainty of the asteroid characterization.

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