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HIGH-FIDELITY BLAST PROPAGATION FOR PDC25 IMPACT SCENARIOS

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Risk analysis for the PDC25 impact scenario shows a preliminary impact corridor featuring entry angles ranging from nearly vertical in Cape Town to grazing angles below 20° near St. Petersburg. These varying entry angles are a key factor in determining whether asteroids of different sizes burst above, below, or near their "optimal" (maximal damage) burst height at different locations. These variations in entry conditions lead to unexpected trends in blast damage estimates across different asteroid sizes and potential impact sites [Wheeler et al., 2025].

The primary drivers of these trends are burst height and energy. While smaller meteors typically burn up high in the stratosphere, larger asteroids tend to penetrate more deeply before experiencing a terminal airburst. This behavior contrasts with the yield scaling used in classical Height-of-Burst (HoB) based ground overpressure predictions which shows that the optimal burst height for larger blasts increases with blast energy [Glasstone & Dolan, 1977]. These effects become more pronounced for larger blasts as buoyancy plays an increasing role [Aftosmis et al., 2019]. Since larger asteroids penetrate more deeply, they may burst well below the optimal altitudes that maximize the blast radii for a given level of overpressure. Conversely, more modestly-sized asteroids may peak nearer their optimal height, resulting in increased ground damage and affecting a larger population in risk studies. For a given material composition and entry speed, size and entry angle are the two leading factors determining burst height. [Wheeler et al., 2017].

The wide range of entry angles in the PDC25 impact scenario brings these issues to the forefront. The impact risk analysis performed for this exercise uses fast-running, physics-based methods to predict blast damage areas based on HoB methods [Wheeler et al., 2025]. This analysis is strongly influenced by the fact that more moderately sized asteroids can burst closer to their optimal height, producing greater blast damage than larger asteroids, which may burst well below their optimal HoB or even impact the ground.

This work presents a series of high-fidelity 3D numerical blast simulations to investigate specific impact cases from the PDC25 impact scenario and compares results with those from the risk model to validate its findings. We examine entries at three locations and three energy levels to explore their influence on blast dynamics and ground overpressure maps. Specifically, we consider asteroids near the median mass, the 95th percentile mass and near the maximum likely mass, which correspond to 50, 200 and 600 megatons of energy at entry. We simulate near-vertical (87°) entry corridors at Cape Town, South Africa, shallow entries (34°) near Athens, Greece and grazing angles (18°) near St. Petersburg, Russia. These scenarios provide an interesting array of conditions where the entering asteroids burst above, near, or below their optimal HOB altitude. The simulations both confirm the risk analysis with more detailed physics modeling and provide deeper insights into the entry and blast dynamics of these impact scenarios, helping to build a more intuitive understanding of the observed trends.

References:

- L. Wheeler, M. Aftosmis, W. Spurlock, A. Coates and J. Dotson. “Airburst Blast Damage Factors for the PDC25 Impact Scenario: Why the largest asteroid is not the worst case" 9th IAA Planetary Defense Conference, May 2025,
- S. Glasstone and Philip J. Dolan. *The Effects of Nuclear Weapons*, Third Edition, 1977. *http://www.fourmilab.ch/etexts/www/effects/*
- M. Aftosmis, D. Mathias, and A. Tarano, Acta Astronautica, 156:278–283, 2019. *https://doi.org/10.1016/j.actaastro.2017.12.021*
- L. Wheeler, P. Register, D. Mathias, Icarus, 295:149-169, Oct., 2017. *https://doi.org/10.1016/j.icarus.2017.02.011*

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Comments:

The authors prefer an oral presentation format for this work.