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TOPIC: Impact Effects & Consequences

COMPUTATIONAL ANALYSIS OF GROUND EFFECTS FROM BOLIDE DISRUPTION VIA THE PI METHOD

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ABSTRACT

The PI ("Pulverize It") method proposed by Lubin et. al. is a method for planetary defense from asteroids and comets which can operate in a terminal interdiction mode with extremely short warning times. The PI method mitigates an incoming threat by completely disrupting the bolide via hypervelocity penetrators, producing a fragment cloud with lateral and longitudinal spread which enters the Earth's atmosphere and results in a series of airburst events at varying altitudes >30 km. This highly de-correlates and distributes the energy of the original parent bolide since the burst times of the individual fragments are separated by times that are longer than the blast wave pulse duration for each airburst. Although de-correlated, each airburst produces ground effects which are important to analyze to design mission profiles with acceptably low damage. The primary ground effects of concern include optical flashes, acoustical blast waves, wind effects, and dust production. Using a Monte Carlo simulation technique which models the airburst events from a specified number of fragments, we explore a variety of cases with varying intercept times and disruption energies and find that threats mitigated by the PI method produce vastly less damage on the ground when compared to the same unfragmented case. Our model follows each fragment resulting from the disruption of the parent bolide and computes the resulting acoustic blast wave and optical signature produced by it for any observer on the Earth. The model inputs the parent bolide diameter, speed, density distribution, angle of attack, yield strength, and the fragmentation distribution, and allows for statistical variations in the fragmentation process, which in turn results in variation in the time evolution of the resulting acoustic and optical signatures at the surface of the Earth. We show that for an 800m diameter threat with >10 years of warning time, the PI method offers an effective planetary defense solution that makes use of pre-existing technologies and launch vehicles. We show that the ground effects from an 800m bolide fragmented into <10m pieces are reduced to short- and long-term non-lethal effects by intercepting the threat as little as 100 days prior to impact, and that further reduction of the ground effects can be achieved with far earlier intercept times. In this scenario, most of the fragments miss the earth entirely and those that do impact the Earth are <10m in diameter and are highly de-correlated, leading to blast wave over-pressures well under 2 kPa and optical energy distribution of no greater than 10 kJ per square meter. Our simulations show that PI can mount a realistic terminal defense mission profile for an 800m asteroid with an intercept time as low as 75 days.

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Comments: N/A