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INVESTIGATIONS OF SHORT WARNING TIME RESPONSE OPTIONS FOR HAZARDOUS NEAR-EARTH OBJECTS

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ABSTRACT

While we believe that the majority of NEAs 1 km in size or larger have been discovered and found to not threaten Earth within the next century, population models predict there are still tens of thousands of undiscovered NEAs 100 m to 1000 m in size. Furthermore, those models predict that there are hundreds of thousands, or even millions, of NEAs smaller than 100 m yet large enough to cause damage should they strike the Earth, and we have discovered only a small fraction of a percent of those objects.

Thus, there exists a very large undiscovered population of NEAs ranging from Chelyabinsk-like objects (just large enough to pose a threat to the ground) to objects several hundred meters in size (large enough to deliver hundreds, or even thousands, of Mt of energy). Small NEAs are faint in the sky and thus difficult to detect until they are very close to Earth, especially with only ground-based survey telecopes. This makes a short warning scenario likely, owing to the prevalence of small but dangerous NEAs in the population and the difficulty in detecting them due to their small sizes. While NEA search efforts continue, we must prepare to respond quickly to hazardous NEAs that are discovered within only several years, or even several months, of when they will collide with our planet, absent our intervention. Systems capable of reliably and effectively responding to such scenarios will naturally also be quite capable of dealing with less demanding scenarios in which more warning time is available.

Towards this end, NASA's Goddard Space Flight Center (GSFC) and the Los Alamos, Lawrence Livermore, and Sandia National Laboratories have recently begun a joint research project entitled "Studies of Short Time Response Options for Potentially Hazardous Objects (PHOs)." GSFC's work on this project is funded by NASA's Near-Earth Object Program.

In this paper we describe the current research plan and present preliminary results obtained thus far. Our effort involves combining the core capabilities of GSFC and the National Labs to provide a detailed assessment of capabilities for two key proposed planetary defense techniques: Kinetic Energy Impactors (KEIs) and Nuclear Explosive Devices (NEDs). A range of engagement strategies will be analyzed, including both NEA deflection and disruption. These studies will advance the state of the art in our understanding of how energetic systems are likely to affect asteroidal (or cometary) bodies, as well as how spacecraft systems and flight trajectories should be designed in order to robustly deliver energetic payloads (kinetic or explosive, or both) to target objects, particularly under short warning time conditions, and accounting for real-life constraints, including payload integration and the complete spacecraft lifecycle. Techniques for spacecraft trajectory optimization and end-to-end mission design, scientific knowledge of asteroid and comet characteristics and chemistry, and state of the art energetic systems modeling on cutting edge computing systems will all be combined to produce designs---and design strategies---that will inform effective and reliable responses to short warning time NEA impact scenarios.

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