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

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NASA has been directed by Congress to undertake a comprehensive search to detect asteroids larger than 140m in diameter, with the expectation that early detection of an object can lead to well thought out and effective measures to deflect or otherwise mitigate the hazards from an object found to be on a collision course with the Earth. While many potential mitigation scenarios are possible given sufficient lead time between detection and a possible collision, there are some situations for which very little time will be available for effective action. One example of such a low-probability scenario would be a collision in the main asteroid belt resulting in a drastic change in the orbit of a small body or in the production of a large fragment falling directly into the inner solar system on a highly eccentric orbit. Another example is the appearance of a newly discovered comet on a trajectory that will impact or at least closely approach the Earth, much as comet Siding Spring (C\2013 A1) flew by Mars. Both of these cases suggest that it might be wise to begin preparations for mitigation efforts before we would be certain that impact will occur, because delay will significantly reduce our chances for successful mitigation.

NASA's Goddard Space Flight Center (GSFC) and DOE's National Nuclear Security Administration (NNSA) have partnered on a collaborative effort to research approaches for deflecting or disrupting potentially hazardous objects that are found to be on a collision course with the Earth. GSFC serves as a focal point for information concerning observational characterization and physical properties of potential impactors, as well as for the design and implementation of space flight missions to small bodies in the solar system. The NNSA serves as a focal point for understanding and calculating the effects of high-energy input to targets of various sizes, and for the design and implementation of devices to deliver precise, highly energetic yields under well-controlled circumstances. Within these two organizations there is sufficient expertise to work through detailed studies of various potential terrestrial impact scenarios with comets and asteroids, including the methods that might be applied to deflect or disrupt the incoming body, as a function of the total time available between recognition of the threat and the predicted date of impact.

The first priority of these studies will be the development of methods to characterize the physical properties of the threat with sufficient precision to enable determination of the energy that must be delivered to deflect or disrupt the target, or to characterize the limits of our current observational techniques and the resulting uncertainties in the derived properties of the target that must be taken into account prior to the mitigation attempt. With sufficient warning time, extended ground-based studies of the incoming object will provide information supporting the launch of a space reconnaissance mission. These missions could be used to gain significant insight into the mass, density, spin rate and even the internal structure and composition of the body. However, such data must be gathered sufficiently far in advance to affect the design of the deflection or disruption mission. The time and resources that would be spent on a reconnaissance mission must be balanced against how the information gained could be used to increase the effectiveness of the mitigation.

A second priority will be the development of a reaction timeline that lays out the steps required to launch an operational mitigation mission with adequate margin to deal with the threat while still sufficiently far from the Earth. Such study might recommend that certain steps be undertaken well in advance and that the resulting be built in advance and then stored for later use when a threat is identified. Alternatively, the study might conclude that it would be quicker and more efficient to simply use commercially available assets from ongoing production lines and repurpose them rather than either recondition or thoroughly check out components that have been stored for extended times. An overall goal of this study will be to determine “minimum” sets of reaction times for various threat scenarios under the present levels of national readiness, to increase our level of confidence by identifying the necessary steps to take in order to decrease these times such that any credible threat could be mitigated, thereby increasing our probability of survival.

Finally, the third priority of these studies will be to evaluate the potential effects of mitigation attempts that occur at minimal distance from the Earth. While the planet might be saved, the resulting cloud of debris would sweep through cis-Lunar space and could possibly disable or destroy a large number of our orbital assets. This could result in the loss of much of our space communications network, Earth observing systems (including weather satellites) and GPS networks, not to mention the many military assets of various nations who depend on such systems for their national security. Space-based assets that survive the initial wave of destruction would remain vulnerable to secondary collisions with large clouds of orbital debris from the initial collisions; it could be nearly impossible to replace systems that were destroyed until such times as the debris clouds disperse or are somehow eliminated.

As a part of a 5-year effort, codified in a recently signed Inter-Agency Agreement, NASA/GSFC will conduct a limited number of flight mission studies to investigate reconnaissance and mitigation options for several types of imminent threats using a collaborative Mission Design Center venue, involving scientists and engineers from Los Alamos, Sandia and Lawrence Livermore National Laboratories. The results of these studies, design reference asteroid parameter compilations, and the complex simulations performed using the DOE National Laboratories’ unique petascale computing facilities will be published in the peer-reviewed scientific literature, including, but not limited to, the journals of the American Geophysical Union and IEEE.

Simply put, this unique government team will create an end-to-end series of scenario-driven mitigation studies, and will provide the “playbook on how to deal with potentially hazardous objects” to decision makers in the relevant agencies who will be tasked with dealing with actual discovered asteroid or comet impact threats to human populations.