Studies of Short Time Response Options for Potentially Hazardous Objects: Current and Forthcoming Results

PDC 2017 - May 15-19, 2017 - Tokyo, Japan

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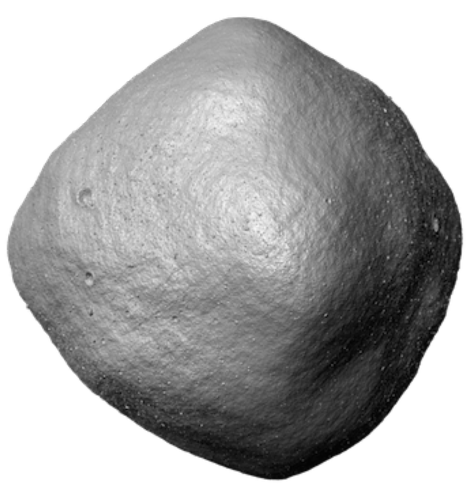
Case Study 1

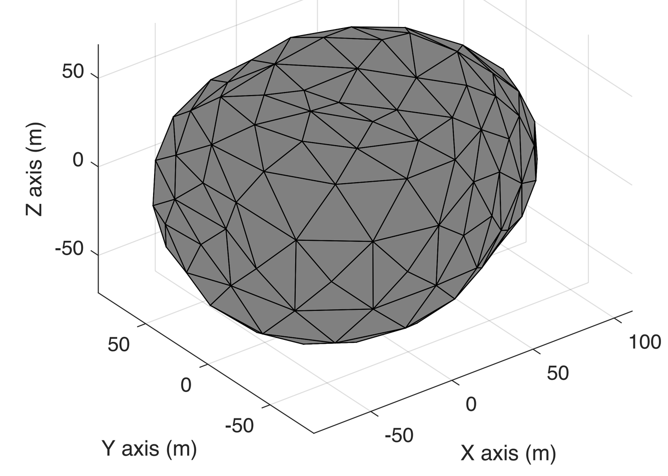


101955 Bennu (1999 RQ$_{36}$)

- ~500 m in size

- To be visited by the OSIRIS-REx spacecraft

Case Study 2

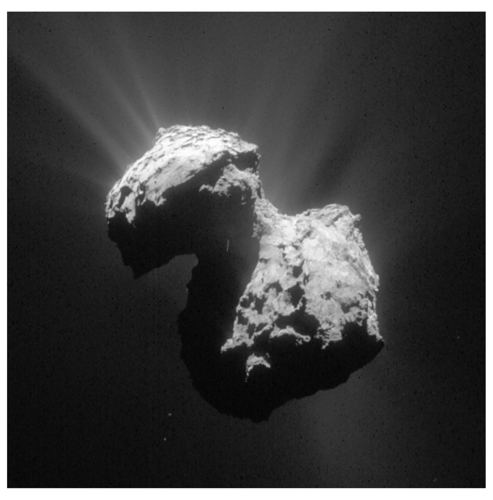


Secondary of Binary PHA 65803 Didymos (1996 GT)

- ~150 m in size

- To be impacted by the DART spacecraft

Case Study 3



Comet 67P/Churyumov-Gerasimenko

- Scaled down to ~200 m in size

- Visited by the Rosetta spacecraft

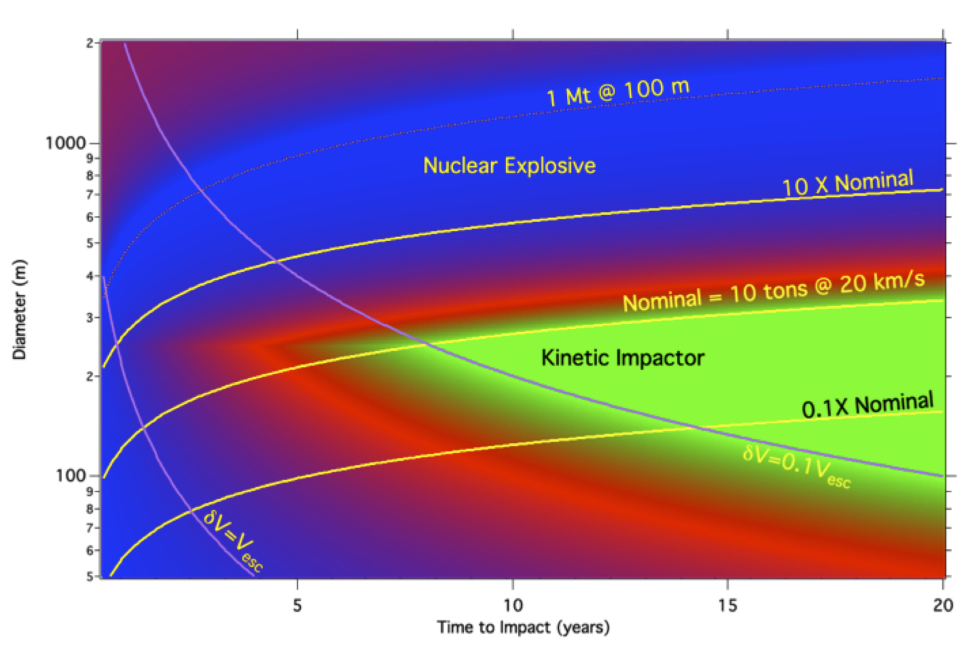
NASA's Goddard Space Flight Center (GSFC) and the National Nuclear Security Administration - Department of Energy National Laboratories --- Lawrence Livermore National Laboratory, Los Alamos National Laboratory, and Sandia National Laboratory --- are collaborating on Planetary Defense Research.

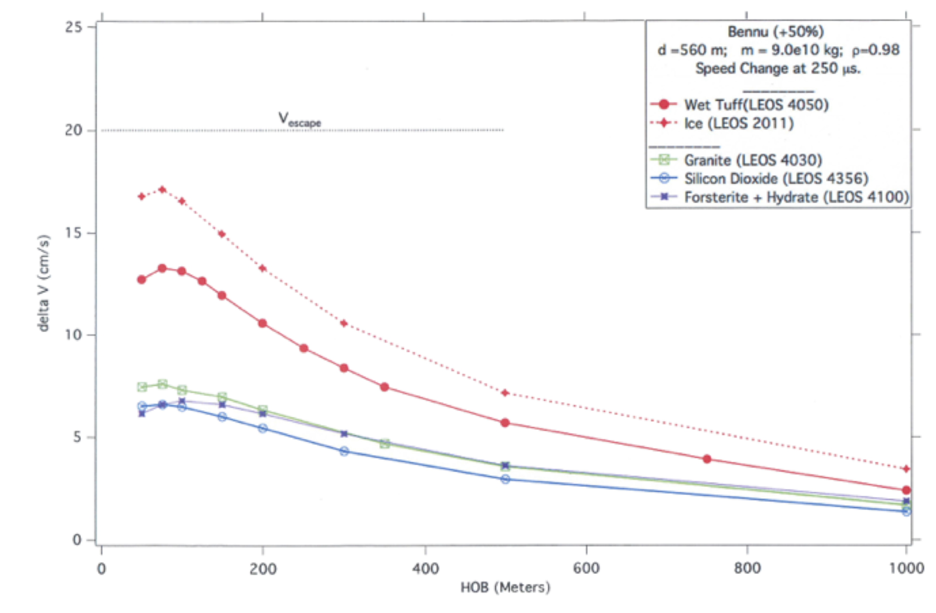
The research program is organized around three case studies:

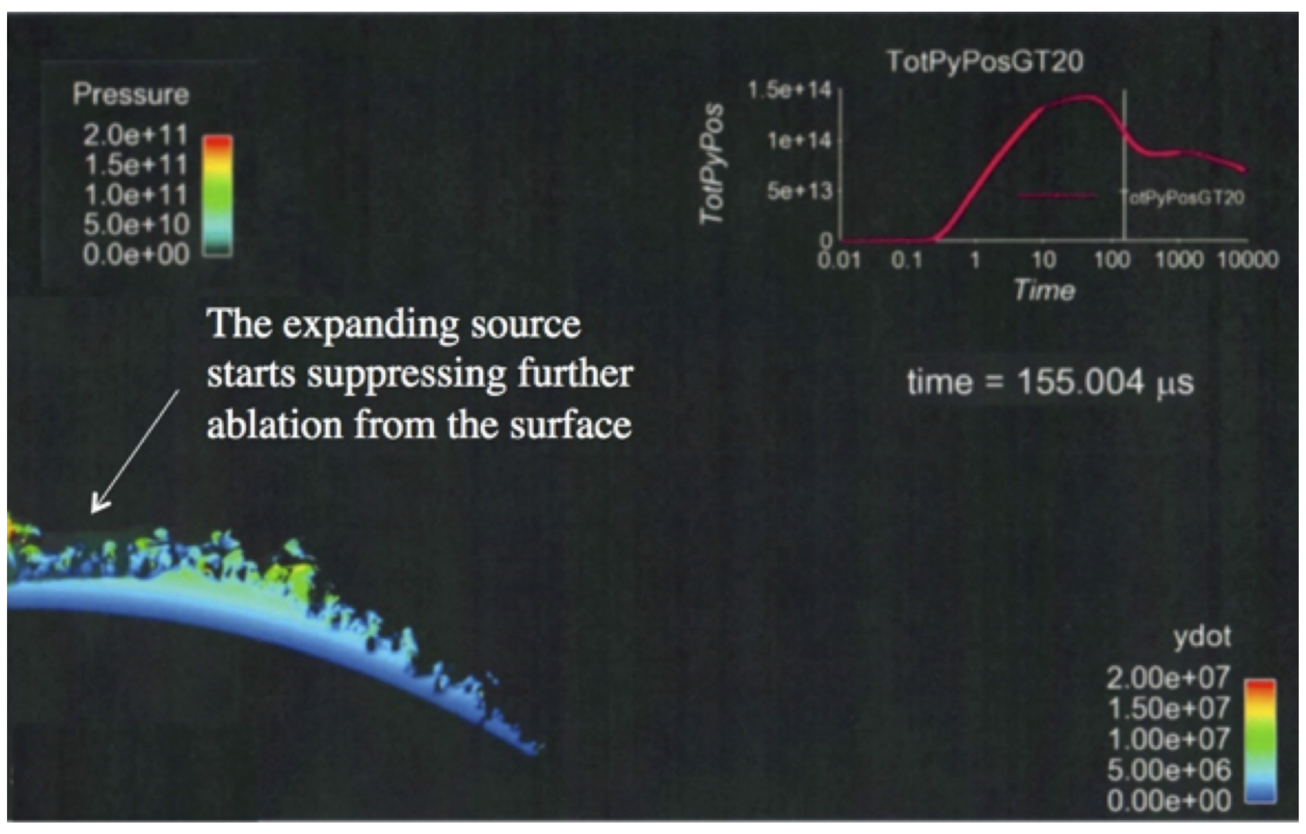
1. Deflection of the Potentially Hazardous Asteroid (PHA) 101955 Bennu (1999 RQ36) [OSIRIS-REx mission target]
2. Deflection of the secondary member of the PHA 65803 Didymos (1996 GT) [DART mission target]
3. Deflection of a scaled-down version of the comet 67P/Churyumov-Gerasimenko [Rosetta mission target]

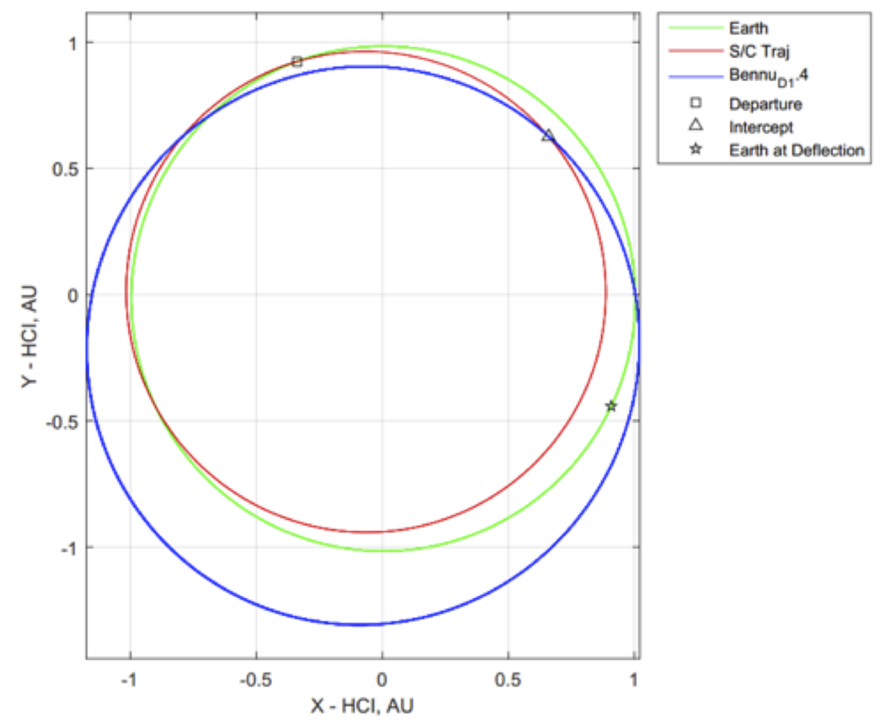
NASA/GSFC is providing astrodynamics and spacecraft/mission design expertise, while NNSA/DOE/LLNL/LANL/SNL are providing expertise in modeling the effects of kinetic impactor spacecraft and nuclear explosive devices on the target objects.

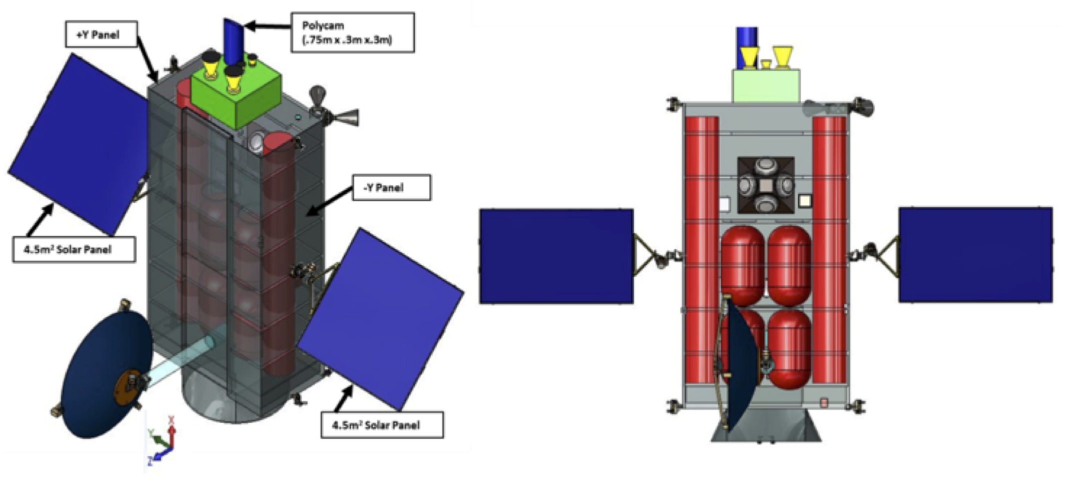
Our research is oriented toward defining solution spaces for the problem of responding to incoming asteroid/comet scenarios with relatively short time available to respond (e.g., <10 years)











Hypervelocity **A**steroid **M**itigation **M**ission for **E**mergency **R**esponse (HAMMER) Spacecraft Concept Design
* Multi-role vehicle: Kinetic impactor or nuclear device delivery

Current preliminary findings:

* Existing nuclear devices appear to be effective for Planetary Defense purposes.

* Good agreement is seen between different modeling codes at the different laboratories.

* A single ~8 metric ton HAMMER-like kinetic impactor is not sufficient to deflect a Bennu-class (>500 m) asteroid.

* A single ~8 metric ton HAMMER-like kinetic impactor may be capable of deflecting asteroids ~100--300 m in size or smaller, depending on factors including asteroid density and orbit.

* However, asteroids smaller than ~100--200 m in size may not be able to physically tolerate the imparted velocity change required to deflect them. Attempting to deflect them may be likely to accidentally weakly disrupt them, in which case deliberate robust disruption may be preferred.

* Short time response is particularly relevant to cometary nuclei (most energetic, lowest lead time Earth impact threats). In any case, short time response will require prior testing and validation of Planetary Defense spacecraft systems, as well, as taking steps to dramatically reduce the time needed to prepare the spacecraft for launch.

Acknowledgments: This research was supported by NASA ROSES grant NNH14ZDA001N-SSO, and is a US government interagency collaborative effort with contributions from additional personnel beyond the authors: Joseph A. Nuth, Luke D. Oman, Keith S. Noll, William M. Farrell (NASA/GSFC); Kirsten M. Howley, Megan Bruck Syal, J. Michael Owen, Joseph V. Wasem, Eric B. Herbold, Robert A. Managan, Souheil M. Ezzedine, Damien C. Swift (LLNL); Galen R. Gisler, James Ferguson (LANL); Mark B. Boslough (Sandia National Laboratory); and Phil Yang (George Mason University).