PDC2013
Flagstaff, AZ, USA

Please send your abstract to iaapdc@iaamail.org
until January 18, 2013 deadline

(please choose one box to be checked)

☐ **Planetary Defense – Recent Progress & Plans**
☐ **NEO Discovery**
☐ **NEO Characterization**
☒ **Mitigation Techniques & Missions**
☐ **Impact Effects that Inform Warning, Mitigation & Costs**
☐ **Consequence Management & Education**

PERFORMANCE AND DERIVED REQUIREMENTS OF A GRAVITY TRACTOR SERVING AS A PRECURSOR TO A KINETIC IMPACTOR WITHIN THE NEOSHIELD STUDY FRAMEWORK

Julie Bellerose(1), Cyrus Foster(2), and David Morrison (3)
(1)*Carnegie Mellon SV / NASA ARC, MS 23-11, Moffett Field CA 94035, 650-604-2025, julie.bellerose@west.cmu.edu*
(2)*SGT / NASA ARC, Moffett Field CA, 94035, 650-604-4774, cyrus.foster@nasa.gov*
(3)*The SETI Institute, Carl Sagan Center, 189 Bernardo Ave, Mountain View, CA 94043, 650-336-3171, dmorrison@seti.org*

Keywords: *gravity tractor, small spacecraft, NEOShield, near-Earth asteroids*

ABSTRACT

Independent studies and competitions over the last decade have provided a wealth of methods for deflecting near-Earth Objects (NEO)s on Earth close approaches or from direct impacting trajectories. Among current proposals, the preferred options reported include nuclear detonations, gravity tractors and kinetic impactors (see NASA HQ 2006 and NRC 2010 reports). The advantage of a gravity tractor is that it does not depend on the physical properties of the potentially hazardous asteroid (PHA). A gravity tractor operates by exerting a gravitational force on a NEO over a time scale of years in contrast to impulsive alternatives such as nuclear detonations and kinetic impactors.

This paper provides an in-depth analysis of the deflection achieved by a gravity tractor acting on a "most likely PHA" recently studied through the NEOShield study. We investigate spacecraft in the 1000 kg to 2000 kg range, for NEO between 50 m to 200 m in diameter. Other case studies such as 2011 AG5 and Apophis are also investigated, accounting for size uncertainties and Apophis size update from its recent Earth flyby. For these small NEOs, we evaluate the concept limitations and discuss trades to be made in the mission implementation.

As a gravity tractor/kinetic impactor concept is also being investigated within the NEOShield study, we look at the measurements' and operations' requirements imposed on the gravity tractor serving as a precursor to an impactor spacecraft. We outline the necessary NEO data and resolutions required to assist a follow-on impactor, and review a number of remote sensing and surface instruments now available for NEO applications. Then, for a typical payload, we describe the corresponding approach and follow-on proximity operations accounting for the low gravity environment. As close approach to the NEO requires knowledge of the mass and gravity field, we investigate various methods of measurement for the NEO sizes mentioned above. We show simulations of spacecraft orbits and hovering, and of the particular near-surface and surface dynamics. Since mission operations at small bodies vary depending on the nature of the target and the measurements and resolutions required, we discuss the performance, trades and challenges involved in performing those close proximity operations in such low gravity environments.

Finally, we present a case study of a small spacecraft for the NEO sizes mentioned above. We discuss spacecraft platform and mission architecture that can provide the required keyhole deflection, and show an example of a capable instrument suite to obtain NEO physical measurements for a follow-on impactor. The design also tackles the additional challenge of autonomously approaching and intercepting a possibly tumbling asteroid with unknown weathered surface features, orientations and illuminations. We discuss guidance, navigation, and control techniques that can be used at various stages of the NEO approach.