ASTEROID DEFLECTION CAMPAIGN DESIGN FOR SCENARIOS WITH DECADE-LONG WARNING TIMES

IAA-PDC-17-05-09

Paul W. Chodas[a,1], **Anastassios Petropoulos**[(a)], **Frank E. Laipert**[(a)], **Ryan S. Park**[(a)]
[(a)] *Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Dr., CA 91109 USA*

Keywords: *planetary defense, asteroid deflection, mission design, astrodynamics*

ABSTRACT

The asteroid impact scenarios explored at the latest two Planetary Defense Conferences have had medium-length warning times of 7 and 10 years, where "warning time" is roughly the time between a threatening object's discovery and its potential impact. A warning time between 5 and 15 years is generally short enough to prompt quick decisions on mitigation, and yet long enough that numerous spacecraft mission options are available for the deflection campaign. This paper examines mission design options for the 2017 PDC hypothetical threat scenario. As with the 2015 PDC scenario, uncertainty in the mass of the asteroid is a key consideration in the deflection campaign design. One or more dedicated missions to refine knowledge of both the physical and orbital properties of the asteroid prior to deflection should therefore be strongly considered as part of the deflection campaign strategy. Ideally, these characterization missions should reach the target as early as possible, in order to inform the deflection campaign design. Chemical and Solar Electric Propulsion (SEP) mission design options are presented for both characterization and deflection missions. SEP kinetic impactor missions have optimum launch opportunities arising roughly yearly, launching roughly opposite the impact node. We consider different types and numbers of ion thrusters, including NEXT and Hermes (from the Asteroid Redirect Mission), different solar-electric power levels, and different launch vehicles from the medium and heavy lift classes. We show that late launches (2023 and onwards) can still provide viable deflections if a heavy-lift launch vehicle and high-powered SEP system are used. These dates may be late enough that mission development could potentially begin after the flyby of the characterization mission. In a lower-risk posture, impactor-mission development would occur in parallel with the characterization mission, and could employ smaller launch vehicles and SEP systems. Impactor missions can be diverted from impact even in the final days preceding an originally planned impact, allowing for the possibility that the navigation cameras of the impactor can themselves provide some final updates to the asteroid's orbit to inform the final decision of whether or not to impact the asteroid. Navigation considerations for the final approach trajectory (terminal guidance) are also considered, so that, for example, suitable approach phase angles suitable for optical navigation are ensured by the mission design. The feasibility of a rapid-fire sequence of impactors is

[1] Corresponding author
Email address: paul.w.chodas@jpl.nasa.gov

assessed from a navigational standpoint, given that the dust cloud generated by one impactor would hamper the closed-loop navigation of the follow-on impactors.