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Characterization and deflection missions of the fictitious asteroid 2019 PDC

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Keywords: kinetic impactor, rendezvous, flyby reconnaissance, deflection

The orbit of the fictitious asteroid 2019 PDC, generated for the 2019 Planetary Defense Conference, was conceived to challenge current mission design capabilities. The high eccentricity and long period of the orbit limit the observational data available between discovery in 2019 and impact in 2027 to only two intermediate apparitions. Preliminary characterization missions will be required to determine the mass, size, and physical properties of the asteroid prior to determining the most adequate deflection strategy. The high inclination of the orbit relative to the ecliptic plane makes rapid rendezvous missions particularly challenging, and confines efficient flyby options close to the nodes.

In this paper, we first present several low-thrust and ballistic mission profiles aimed at characterizing the asteroid assuming that spacecraft will be ready for launch as early as June 2021 (a little more than two years after discovery). Rapid reconnaissance flyby missions can potentially reach the asteroid in a few months and will collect valuable data for a preliminary physical characterization. Parametric analyses varying the flyby conditions upon arrival provide the navigation and scientific teams with flexible options to maximize the value of the data returned by the mission. In particular, the relative velocity and Sun-phase angle at arrival are important design constraints for an effective exploration during a flyby. Rendezvous missions require longer transfer times (typically over two years) but result in a more exhaustive characterization of the asteroid thanks to a prolonged stay at the target. In addition, a spacecraft operating in close proximity to the asteroid can monitor the collision of a kinetic impactor and estimate the change in the orbit of the asteroid after deflection. The second part of the paper investigates how to deflect the nominal trajectory of the asteroid using a kinetic impactor. Due to the inherent uncertainties of the physical properties of the asteroid, we conduct parametric analyses of the deflection performance based on several assumptions about, for example, its density, size, and composition. Accurate models of the momentum transfer efficiency will not be available until the data from the characterization missions has been processed. We explore several trajectory options for moving the asteroid's impact location on the B-plane at Earth in different directions, increasing the flexibility of the deflection strategy. Deflection missions are analyzed together with characterization missions to define optimal planetary defense campaigns against the hypothetical asteroid 2019 PDC.

Comments: *Oral Presentation*

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