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STATISTICAL MULTICRITERIA EVALUATION OF ASTEROID DEFLECTION METHODS

Abstract

We assess in this paper 3 different deflection approaches for a wide range of virtual collision scenarios: the kinetic impactor is considered for the family of impulsive deflection methods whereas the family of slow-push methods is represented by the laser ablation and the ion beam shepherd techniques. A sample of 100 deflection scenarios was created from realistic distribution of PHA eccentricities, semi-major axis and inclination and, for each case, a virtual impactor scenario was formed by modifying the argument of perigee so that the virtual PHA crosses the ecliptic plane at a distance of 1AU. A fixed asteroid diameter of 156m and 212m are considered. A realistic model of each deflection method was integrated within a systematic approach to size the spacecraft and predict the achievable deflection for a given mission. The available mass to perform the deflection depends on the transfer strategy. For the case of the kinetic impactor, a direct injection using a multiple-revolution Lambert arc is considered. For the case of slow-push methods, a low-thrust transfer is retained in order to take advantage of the large electrical power available which would otherwise remain unused during the transfer phase. In all cases, the launch capability of Delta 4 Heavy – RS-68A upgrade version (10-tons at C3=0) is assumed. Finally, global optimization techniques are used to compare the methods with respect to 2 criteria: the minimum duration between the departure date and the time of virtual impact required to deflect the PHA by more than 2 Earth radii or the miss-distance achieved within a total duration of 10 years. Our results provide an interesting insight into the range of applicability of individual deflection methods and suggest the need to develop multiple methods in parallel for a global mitigation of possible threats.