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Are we producing PHAs? On the target selection for a proposed mitigation demo-mission within the NEO-Shield project

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Abstract

The Chelyabinsk event on February 15th, 2013 has shown once again that even small near earth objects (NEOs) can become a real safety concern. Even-though we believe to have the capabilities to avert larger potentially disastrous asteroid impacts, only the realization of mitigation demonstration missions can confirm this claim. The target selection process for such deflection demonstrations is a demanding task, as physical, dynamical and engineering aspects have to be considered in great detail. One of the top priorities of such a demonstration mission is, of course, that a harmless asteroid should not be turned into a potentially hazardous object (PHO). Given the potentially large uncertainties in the asteroid's physical parameters as well as the additional uncertainties introduced during the deflection attempt, an in depth analysis of the impact probabilities over the next century becomes necessary, in order to exclude an augmentation of potential risks. Assuming worst case scenarios regarding the orbital, physical and mitigation induced uncertainties, we provide a keyhole and impact risk analysis of a list of potential targets for the mitigation demo-mission proposed in the framework of the NEO-Shield project.

1. Introduction

The combined occurrence of a deep close encounter with the asteroid 2012 DA14 and the airburst of the Chelyabinsk bolide on February 15th, 2013 has left no one doubting that PHOs are more than a hypothetical threat to the Earth. In contrast to other natural disasters, however, impacts of large asteroids can be averted - in theory. Initiated by the European commission in 2012, the NEOShield project is aimed at establishing a comprehensive picture of the NEO deflection process (Harris et al., 2012). While many aspects of NEO mitigation can be investigated using analytical and numerical tools as well as laboratory experiments (Holsapple & Housen, 2012; Bombardelli & Baù, 2012; Jutzi et al., 2008, 2009, e.g.), only a full-fledged demonstration mission will allow for an accurate evaluation of current deflection techniques. Hence, the design of a demonstration mission is one of the NEOShield project's main goals.

2. Target Selection

Selecting viable targets for such mitigation tests is no trivial task, as the potential target object should be characterized sufficiently well in order to avoid surprises during a mitigation attempt. An unknown small companion, for instance, can cause unexpected complications ranging from minor deviations of the deflection goal to complete mission failure. The most essential topic in target selection, however, is the issue of creating potentially hazardous objects (PHOs) from previously harmless NEOs. It is commonly thought to be sufficient to choose non Earth-crossing Atira- or Apollo-class NEOs to ensure post mitigation safety. If the deflection scenario should be as realistic as possible on the other hand, mitigation tests on Earth-crossing NEOs seem to be the better choice. In any case, due the uncertainties in the asteroid's surface properties, internal structure, and orbital parameters, the performance of deflection missions can vary significantly. Even if a precursor rendez-vous mission is used in order to get a better picture of a NEO's orbit as well as its physical properties, the targeting process of a kinetic impactor vehicle, for instance, introduces uncertainties in the delivered momentum (Saks et al., 2012). Thus, a detailed post-mitigation keyhole and impact risk analysis of the preselected mission targets becomes desirable. Thereby, not only the initial orbital uncertainties, but also the additional mitigation induced variability in the transferred momentum have to be accounted for. We make use of a list of potential mitigation test mission targets compiled by

NEOShield collaborators (Fitzsimmons, 2013) and investigate whether attempted changes in a NEO's orbit would result in increased impact probabilities.

3. Results

We provide NEO mitigation test targets considering low delta-v requirements, orbital uncertainties, simple mitigation success assessment, and - most importantly - we present a selection of those targets that will remain harmless after a mitigation demonstration attempt.

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