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- [ ] **Key International and Political Developments**
- [ ] **Advancements and Progress in NEO Discovery**
- [ ] **NEO Characterization Results**
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THE HIGH-FIDELITY ASTEROID DEFLECTION EVALUATION SOFTWARE (HADES): ASSESSING THE IMPACT OF ENVIRONMENTAL AND SYSTEM UNCERTAINTIES ON THE ASTEROID'S THREAT MITIGATION OF 2017 PDC THROUGH SLOW PUSH METHODS

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ABSTRACT

The environment near asteroids, comets and small moons is highly complex because of the general lack of target body's precise data, where simplifications regarding the shape and the composition of the small bodies can drive to a completely incorrect picture of the dynamics of its surroundings. This deeply affects the space missions design, because the performance of the whole GNC system can be strongly affected by the a-priori knowledge of the operative environment, both in terms of sensors/actuators assembly and due to the simplifications implemented for the on-board computers. Several aspects, such as rotational motion, composition and mass, might further complicate operations when the spacecraft is carrying out a deflective mission. To tackle this problem the current paper is then dedicated to analyse the effects of the modelling assumptions on the GNC and deflective action.

The paper will take into consideration the deflection of the 2017 PCE asteroid under uncertainties. It will show that performance of the deflective action and of the spacecraft navigation strongly depend on available characterisation of operating environment, in terms of size, shape, rotation and composition which, as a consequence, can lead to quite diverse results in the achieved deflection and control budget.

The proposed analysis will be performed by means of the High-fidelity Asteroid Deflection Evaluation Software (HADES), which deals with the high-fidelity modelling of spacecraft operations at irregular shape asteroids. The software can handle any operational orbit, with particular care paid to inertial hovering. Different control techniques based on both continuous and discrete methods have been considered and implemented. The spacecraft orbit determination is performed through a performance model or by on-board measurements, a navigation camera and a LIDAR, which are processed by an Unscented H-infinity Filter (UHF).

For instance, in Figure 1 we consider a 100 m asteroid with a spacecraft hovering at 300 m while pointing a laser [1] onto the surface with the shape given by the asteroid (433) Eros. We performed an uncertainty analysis considering different power levels at the laser and restricting the uncertain parameters to the size, characteristics of the asteroid and to the performance parameters that define the laser model. Due to the lack of precise information about the asteroid size drawn from the imprecise optical observation for small objects, we assume a maximum uncertainty of 20 m with respect to the nominal size of the asteroid. For what concern the density, we consider that the asteroid will be a S-type one with 2000 kg/m^3. Figure 1 (left) shows curves of level for deflection parameter (in Earth radii) as a function of deflection time and the available power maintaining uncertain parameters fixed at their mean values. Small powers can deflect the asteroid but will require longer operations. Figure 1 (right) reports the expected deflection probability taking into account a Monte Carlo simulation where the uncertain parameters were varied and operations lasted 7 years. It demonstrates that 3 Earth radii deflection can be achieved with 95% confidence only when we employ a 20 kW laser system.

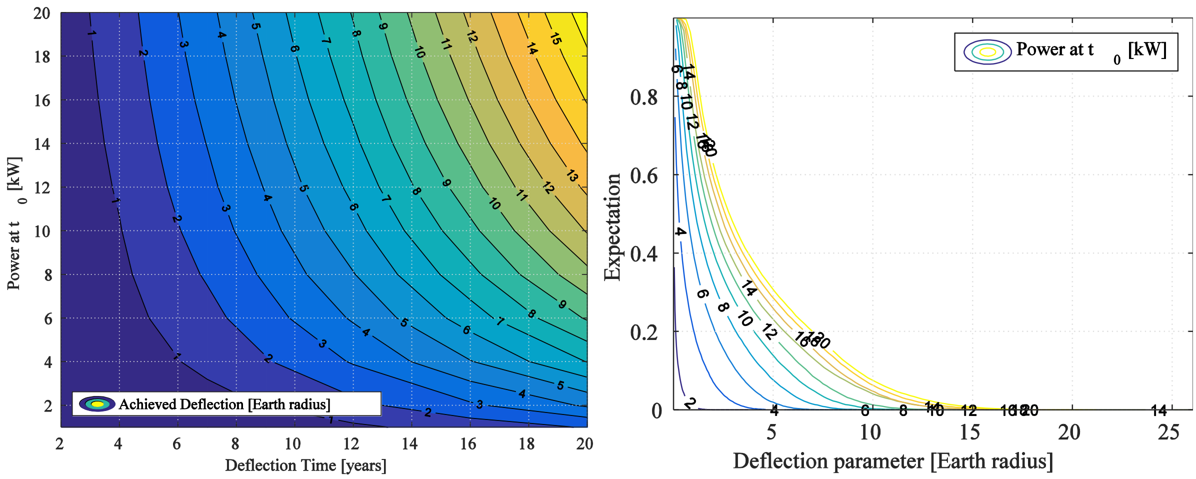

Figure 1. Power available at the laser vs. time of operation with nominal asteroid (left) and expected deflection probability considering uncertain parameters.

References

[1] N. Thiry, "Recent advances in laser ablation modelling for asteroid deflection methods" in SPIE Optical Engineering + Applications 2014 International Society for Optics and Photonics

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