PDC2013
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REQUIREMENTS FOR MITIGATION PRECURSOR RECONNAISSANCE, A STUDY FROM THE NEOSHIELD PROJECT

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Keywords: *NEOShield, mitigation, reconnaissance, requirements*

ABSTRACT

The NEOShield project (Harris et al. 2012, Acta Astronautica, in press), which commenced in January 2012, is being funded by the European Union for a period of 3.5 years. The primary aim of the project is to study in detail the three most promising techniques to mitigate the NEO impact risk: the kinetic impactor, blast deflection, and the gravity tractor, and to devise feasible demonstration missions. NEOShield also aims to address the issue of an international strategy to deal with the impact threat and how to organize, prepare, and implement mitigation plans.

Our contributions to NEOShield include the study of NEO physical and dynamical properties. We are currently investigating the issue of how best to obtain the information required to design an effective mitigation mission once a hazardous asteroid has been discovered.

Pre-mitigation reconnaissance plays a central role in any asteroid deflection scenario, as it is vital in providing the necessary orbital and physical data of a potential impactor to instigate a successful deflection mission. The assessment of

the true impact probability for the hazardous asteroid is the first important aspect in this regard, since it can render an expensive mitigation mission obsolete. Hence all of the available techniques (like optical astrometry and radar ranging), as well as the effect of non-gravitational forces and keyholes, have to be considered in the orbit refinement process.

If the impact threat is confirmed, the prevention of a collision with the Earth would require either the destruction of the object (ensuring that the fragments would not be hazardous themselves) or, more realistically, deflecting it slightly from its catastrophic trajectory (ensuring that the deflection operation does not simply move the object to another hazardous orbit). In either case, the final aim of the mitigation mission is to modify the trajectory of the impacting NEO.

The mass is one of the primary parameters governing the design of an effective mitigation mission; it also provides an upper bound on the amount of damage that would be caused by the object should it impact on Earth. In order to mount an effective mission to destroy or deflect a hazardous object, knowledge of several other physical properties is also required, such as composition, and internal structure and strength. Information on the object's elemental composition and internal strength is particularly important for the planning of a mitigation attempt involving a standoff explosion. The magnitude and positioning of an impulse, in the case of a kinetic impactor, or the application of a continuous or periodic thrust, may also depend on the mass distribution throughout the irregularly-shaped body, the body's surface characteristics, and its spin vector. A large degree of porosity (e.g., due to internal fractures or a rubble pile structure), or a binary nature, would add significant complexity to the planning of a mitigation mission. Possibilities for mitigation precursor rendezvous or fly-by missions, including the dynamical accessibility of the NEO with a spacecraft, are further considerations for the selection of the best mitigation strategy.

It should be noted that the information requirements from a mitigation point of view are different to those of purely scientific investigations. Hence we address purely mitigation-relevant aspects:

I. Assessment of the true impact probability through the orbit refinement, including the necessity for a reconnaissance mission.
II. Identification of what physical properties are relevant to a particular type of mitigation method.
III. Examination of the relevance and accuracy of a variety of observational techniques and data types, and ways in which this crucial information can be provided.
IV. Consideration of a programme of reconnaissance observations, in particular the balance between Earth-based remotely-sensed observations and in-situ investigations from a spacecraft, including the onboard instrumentation.

Our goal is to develop a precursor reconnaissance strategy based on a prioritised list of observational requirements (in terms of wavelength, resolution, precision, etc.).