USING SMALL ASTEROIDS TO DEFLECT LARGER DANGEROUS ASTEROIDS

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ABSTRACT

The Russian Ministry of Education and Science has awarded us a “megagrant” to study planetary protection from potentially hazardous asteroids. Primarily, this involves developing ideas for surveys to find objects that pass close to the Earth, and develop strategies for deflecting any object found to be on a collision course with the Earth.

Various ways are proposed in published works describing how to change an asteroid’s orbit in order to prevent its collision with the Earth: Changing the reflection characteristics (albedo) of asteroid's surface to alter the small Yarkovsky acceleration; the use of a “gravitational tractor”, when the asteroid's trajectory is changed due to the spacecraft’s gravitational effects; targeting a spacecraft to an asteroid to collide with it (kinetic impact). In all these cases, the change in the asteroid’s orbital parameters is quite small, generally comparable to the size of the asteroid’s orbit determination errors. In this paper plans are discussed to develop a method of asteroid deflection, which is radically different from those mentioned above.

The main idea of the proposed approach consists of targeting a very small asteroid to impact a larger dangerous one. The minimum size of this small asteroid is determined by the ability to detect it and to determine its orbit. The small object may have a diameter of about 10 -15 meters. Asteroids are selected from the near-Earth class with the fly-by distance from Earth of the order of hundreds of thousands of kilometers. According to current estimates, the number of near Earth asteroids with such sizes is high enough. So there is a possibility to find the required small asteroid.

Further, the possibility is evaluated of changing the small asteroid’s orbit so that by application of a very limited delta-V impulse to the asteroid, the latter is transferred to a gravity assist maneuver (Earth swingby) that puts it on a collision course with a dangerous asteroid. It is obvious that in order to apply the required ΔV pulse it is necessary to install on the small asteroid an appropriate propulsion system with required propellant mass. A control system similar to that used on a spacecraft is also necessary.

The NEAR project experience, when the spacecraft landed on the asteroid Eros, holds out a hope for such a mission to possibly prevent a dangerous Earth-asteroid collision, on conditions that a suitable small asteroid is detected and the parameters of its orbit are determined with sufficient accuracy.

Project Deep Impact, when a spacecraft was used as a projectile that was separated from the main fly-by spacecraft and then hit the nucleus of Comet 9P/Tempel, further confirms the feasibility of such a task.

In addition an extensive study has already been accomplished that determined the feasibility of capturing a small asteroid into lunar orbit [1]. This study will build on that one, since the goal is the same, to move a small asteroid to a target. In the case of [1], the target is a lunar orbit, while our target is a potentially hazardous object (PHO), or, more likely, an Earth swingby that would change the small asteroid's orbit to intercept a PHO. However, for the proposed concept, the problem is more complicated, since for the nominal asteroid collision trajectory, the possible level of corrective impulse is significantly lower than for the Deep Impact mission, limited to no more than about 10 m/sec. In this case, the proposed method's effectiveness may be, as shown by preliminary calculations, to be almost two orders of magnitude more efficient than the direct spacecraft guidance to a dangerous asteroid, if the efficiency is measured in terms of changes in the asteroid-goal (Earth B-plane) vector.

In this paper it is planned to obtain sufficiently reliable estimates of the necessary correction impulse and to find ways to reduce it to a level that allows us to offer a technically feasible concept. Of course, any real test of this (or of any other deflection) strategy should first be performed on a benign asteroid whose orbital parameters give the asteroid no significant chance of a natural impact with the Earth during at least the next million years, even in the case of small changes in its orbit.

1. Brophy, J., et al., "Asteroid Retrieval Feasibility Study", Keck Institute for Space Studies, http://www.scribd.com/doc/90441535/28/Getting-to-Lunar-Orbit, April 2, 2012