**Deflection / Disruption Modeling & Testing**

# A VIRTUAL COCOON OF POSSIBLE TRAJECTORIES OF A PROJECTILE ASTEROID AS A TOOL FOR PLANETARY DEFENCE

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## ABSTRACT

A planetary defense concept based on deviation of a potentially hazardous asteroid from its initial trajectory by a kinetic collision is discussed. The success of the DART mission proved that this approach is practically implementable using a spacecraft as a projectile. But the effectiveness of the approach in this case is limited by the mass of the spacecraft which usually is significantly less than a mass of the targeted asteroid and, therefore, is unable to provide a significant change in parameters of its trajectory. A possible way to solve this problem may consist of using a driven projectile asteroid instead of the projectile spacecraft during the collision with the targeted potentially hazardous asteroid. This projectile asteroid may be preliminary selected in such a way that its mass is much bigger than a mass of the projectile spacecraft, but still low enough to fulfill some small rocket propelled maneuvers amplified by gravity assist maneuvers near the Earth. Possibilities of implementation of such an approach have been confirmed by the authors in the earlier publications.

In order to build a planetary defence system one needs to take into account the necessity of sending the projectile asteroid to a discovered hazardous celestial object in the reasonable time. To satisfy this demand the following scenario is proposed. Initially, the most acceptable projectile asteroid has to be selected. It may be either a small enough asteroid or a boulder taken from the surface of some an appropriate asteroid. Then, the selected projectile asteroid is transferred with gravity assist maneuver to a heliocentric orbit resonant (in the 1:1 ratio) with the orbit of the Earth. The heliocentric orbit of the projectile asteroid should be chosen from a set of resonant orbits differ only by inclination, because it this case the projectile asteroid reaches a vicinity of the Earth two times per year. After this the planetary defence system is ready to use. At each Earth flyby the projectile asteroid may be transferred to the trajectory colliding the targeted hazardous object by gravity assist maneuver if such an object is discovered. A set of possible colliding trajectories corresponding to a bunch of all possible gravity assist maneuvers forms a surface in space, which can be described as a virtual hemisphere (the whole sphere is covered in two flybys) or a virtual cocoon. It should be mentioned here that this cocoon changes in time due to deformation caused by the Sun influence. If during the reasonable period of time the Earth is kept inside of this virtual cocoon, then any object approaching the Earth will intersect the cocoon and, therefore, may be intercepted.

Practically this means that when a potentially hazardous celestial object is discovered and its trajectory is defined, our goal is to find a moment of intersection of the trajectory of the discovered object with the virtual cocoon. The intersection point

defines a particular colliding trajectory and the corresponding gravity assist maneuver necessary for transfer the projectile asteroid to this trajectory, which provides a practical way to perform the cinetic collision and to avoid the impact of the potentially hazardous object with the Earth.

Results of modeling the operations of the proposed concept are presented.