PDC2015
Frascati, Roma, Italy

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IAA-PDC-15-04-23

BILLIARDS: A Demonstration Mission for Hundred-Meter Class Near Earth Asteroid Disruption

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Keywords: *Planetary Defense, Asteroid Redirection, Asteroid, Disruption*

ABSTRACT

A theoretical mission is studied in which an asteroid is captured and redirected for use as a natural kinetic impactor for the purpose of planetary defense. The Baseline Instrumented Lithology Lander, Inspector, and Asteroid Redirection Demonstration System (BILLIARDS) is a proposed demonstration mission to characterize and redirect a small asteroid (less than 10m in diameter) referred to as the Alpha asteroid to collide with a larger asteroid (hundreds of meters in diameter), referred to as the Beta asteroid. This collision will disrupt the Beta asteroid or alter its trajectory, thereby demonstrating a capability to prevent such an asteroid from colliding with Earth. The concept of redirecting a smaller asteroid into a larger asteroid is attractive for this type of mission because it utilizes natural kinetic energy available beyond Earth's gravity well for the majority of the energy delivered to the Beta asteroid. By contrast, a purely artificial kinetic impactor spacecraft must have all of its mass and energy lifted out of Earth's gravity well. This allows for an impact energy of several terajoules without the use of nuclear devices.
The mission begins with the launch of a spacecraft to rendezvous with the alpha asteroid. After rendezvous, the spacecraft characterizes the Alpha asteroid and captures it. The spacecraft then adjusts the heliocentric orbit of the Alpha asteroid to place it onto a collision course with the Beta asteroid. The spacecraft will separate into two modules several hours before collision. The Instrumentation Module (IM) will

maneuver onto a flight path from which it can safely observe the collision, while the Terminal Guidance Module (TGM), will remain attached to the Alpha asteroid to perform the necessary maneuvers to ensure collision with the Beta asteroid. The Alpha asteroid will collide with the Beta asteroid shortly thereafter. Current analysis predicts that, due to the energies involved, the Beta asteroid will be disrupted (rather than merely deflected) for a wide range of likely scenario parameters. After the collision, the evolution of the Beta asteroid or its remnants will be analyzed, using flyby observations from the IM and/or ground- and space-based observing assets, in order to compare the actual and predicted outcomes and use the comparisons for model calibrations and improvements.

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