THEO & MUFN: Defending Earth Against the 2023 PDC Hypothetical Asteroid Impact

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ABSTRACT

Planetary defense is an emerging field among the aerospace community. As the rate of near-Earth object (NEO) discoveries increases, so too does the probability that we will discover an NEO on a collision course with Earth. This paper documents a planetary defense mission campaign design to defend against the hypothetical Earth impactor 2023 PDC. At its 90th percentile mass estimate, the asteroid could have a diameter of approximately 1120 m. The asteroid makes no close approaches until Earth impact and has the potential to affect over a billion people, depending on its actual size. This paper describes a mission campaign consisting of both reconnaissance and mitigation missions that will be deployed to neutralize the threat posed by the asteroid. The reconnaissance orbiter named THEO (Terrestrial Hazard Exploration Orbiter) will survey the asteroid to clarify its morphological, gravitational, and dynamical properties. This information will be used to inform the design of the subsequent mitigation mission. THEO will be designed to have a mission lifetime of 12 years which will enable it to observe the mitigation mission and confirm its success. Two 21-day launch periods have been identified that minimize post-launch Δv requirements and include current launch vehicle capabilities. For the purposes of this paper, the mitigation mission has been designed assuming a geocentric impact for the 90th percentile mass estimate of the asteroid because a precise impact location and an accurate mass estimate will not be available until THEO reconnoiters 2023 PDC. The mitigation mission, named MUFN (Mitigation Using a Fission Nuclear device), will send three spacecraft to rendezvous with 2023 PDC and alter the asteroid's trajectory prior to Earth impact through a series of standoff nuclear detonations. The MUFN spacecraft are identical in design, each employing a hypergolic bipropellant thruster. Each MUFN spacecraft launches on a SpaceX Falcon Heavy Expendable launch vehicle between 2028 and 2030 and carries four 340 kt nuclear explosive device

(NED) equipped satellites, named BelaSats (Bull's Eye, Laser Asteroid Satellites (Sats)). The BelaSats are designed to sequentially deploy, maneuver to an optimal standoff distance antiparallel to the asteroid velocity vector, and detonate the NED to impart a change-in-velocity to the asteroid. After arrival at 2023 PDC, each MUFN spacecraft will station-keep above the asteroid. The NED-equipped BelaSats will deploy from the MUFN spacecraft and maneuver 180 degrees out of phase from MUFN to the 'front' of the asteroid. Once there, each BelaSat will detonate and impart 2.3 mm/s of velocity change to the asteroid. After the ablation debris has cleared, MUFN will complete a single orbit around the asteroid to survey the blast site. After MUFN has completed its survey, it will release another BelaSat. This process will repeat until all BelaSats have been released by all MUFN spacecraft. All denotations will occur between 2029 and 2031. After all BelaSats have detonated their NED payloads near the 2023 PDC asteroid to deflect its orbit, the asteroid will fly safely by Earth at a minimum altitude of 2000 km instead of colliding on October 22, 2036.

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