SPACE SYSTEMS SYMPOSIUM (D1)
Innovative and Visionary Space Systems Concepts (1)

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INTERPLANETARY BALLISTIC MISSILE (IPBM) SYSTEM ARCHITECTURE DESIGN FOR NEAR-EARTH OBJECT THREAT MITIGATION

Abstract

Asteroids and comets have collided with the Earth in the past and are predicted to do so in the future. This paper presents a preliminary conceptual design of an integrated space systems architecture (ISSA) for NEO deflection missions, which may utilize various options such as gravity tractors, kinetic impactors, or nuclear mitigators [1-4]. An existing flight-proven Delta IV Heavy vehicle is assumed as a baseline launch vehicle which can launch a 6,000 kg payload into an interplanetary trajectory with $C_3 = 25$ $(km/s)^2$. The proposed baseline ISSA, which is modular, reconfigurable, and adaptable, consists of a Delta IV Heavy launch vehicle (with the Star 48 upper stage), a 1500-kg cruise vehicle (a Dawn-like spacecraft equipped with flight-proven ion engines), and a 4500-kg kill vehicle. The kill vehicle consists of a 1500-kg nuclear or kinetic-impact payload, 1500-kg propellant for terminal guidance/intercept, and 1500-kg spacecraft bus. Near a target asteroid the cruise vehicle will release the kill vehicle, and it will observe the deflection event during its flyby of the target asteroid (similar to Deep Impact mission). For a certain class of NEOs that may not require high-energy deflection techniques, the combined cruise/kill vehicle can be configured as a single 4000-kg gravity tractor (GT) to be placed in a standoff hovering position or as two 2000-kg GTs to be placed in a halo orbit around a target NEO. A slow-pull GT mission will require rendezvous and proximity operation near a target NEO. Two or three Delta IV Heavy launch vehicles will be required for a class of NEO deflection missions assumed in this paper although an actual number of launch vehicles will depend on the mission warning time, the size of a target NEO, the operational mission scenario, the overall mission reliability requirement, and many other factors. This paper focuses on a system-level assessment of the practical viability, performance, and operational flexibility of such a baseline ISSA to prepare for its actual development in the near future. Technological advances required for advanced spacecraft design, precision terminal guidance/intercept, standoff nuclear explosions, and control of multiple GTs in halo orbits are also discussed.

[1] Wie, B., "Dynamics and Control of Gravity Tractor Spacecraft for Asteroid Deflection," Journal of Guidance, Control, and Dynamics, Vol. 31, No. 5, 2008.

[2] Adams, R. B. et al., "Survey of Technologies Relevant to Defense from Near-Earth Objects," NASA-TP-2004-213089, NASA-MSFC, July 2004.

[3] Barrera, M. J., "Conceptual Design of an Asteroid Interception for a Nuclear Deflection Mission," AIAA Paper 2004-1481, 2004 Planetary Defense Conference: Protecting Earth from Asteroids, Orange County, February 2004.

[4] Adams, R. B. et al., "Near Earth Object (NEO) Mitigation Options Using Exploration Technologies," presented at 2007 Planetary Defense Conference, Washington, DC, March 2007.