The Hera Milani CubeSat Mission

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ABSTRACT

The Hera mission is the European component of the Asteroid Impact and Deflection Assessment (AIDA) international cooperation between ESA and NASA. Upon its arrival and rendezvous with binary asteroid Didymos in early 2027, Hera plans to deploy two CubeSats in the close proximity of the binary system. Interplanetary CubeSats provide low-cost opportunities to extend the scientific and technological return of exploration missions. Hera's CubeSats, named Milani and Juventas, will be the first nanosatellites to orbit in the close proximity of a small celestial body and to perform scientific and technological operations around a binary asteroid.

Milani is a 6U CubeSat with full 6-DOF maneuvering capabilities, to control both its translational and attitude motion. After release, Milani will communicate with Hera via an Inter-Satellite-Link (ISL) and with ground stations via Hera during its whole lifetime. After separation, the mission of Milani will be independent from that of Hera, and it is designed to achieve its own mission goals and objectives.

The main scientific goal of Milani is to provide a detailed mapping of the surface of Didymos (primary of the binary system) and Dimorphos (secondary), using the ASPECT hyperspectral imager. ASPECT will be also used to characterize the surface of the asteroids in terms of space weathering, shock effects, evidence of surface material transfer, and surface roughness. Selected features will be imaged to the finest detail, e.g., the area on Dimorphos surface where NASA's DART (Double Asteroid Redirection Test) spacecraft is expected to impact in 2022. In addition, the scientific goals of Milani include the characterization of Didymos environment, using the VISTA thermogravimeter to detect presence of fine dust. Finally, Milani will provide a crucial support to Hera's scientific goals: Milani's tracked motion near Didymos will provide observables to the Hera radio-science experiment, to support the characterization of Didymos gravity field.

Due to the novelty of its concept, Milani will provide a unique opportunity for in-orbit technological demonstrations on interplanetary CubeSats. The Hera-Milani-Juventas Inter-Satellite Link (ISL) will be the first ever network between spacecraft and CubeSats in an

asteroid environment. This will be achieved by adhering to a mission profile where the range from the asteroids is progressively reduced passing from the Far-Range Operation Phase (FRP) to the Close-Range Operation Phase (CRP). After accomplishing its main objectives, Milani is planned to enter an Experimental Phase (EXP), where autonomous GNC operations will be performed, including a landing attempt on Dimorphos.

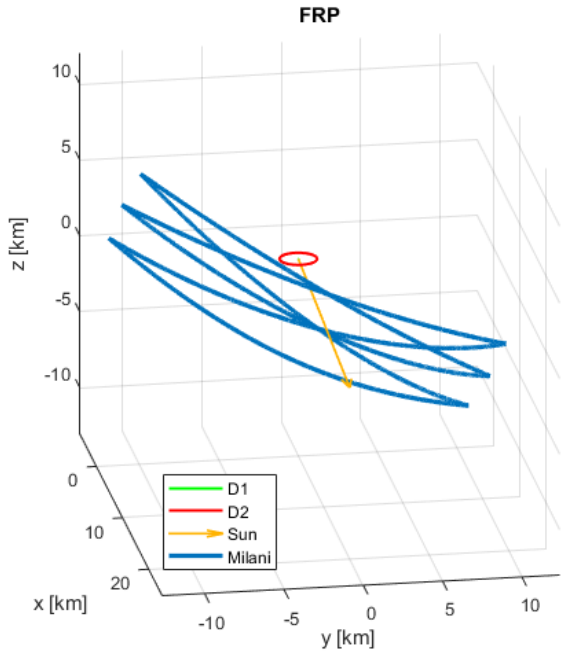

Figure 1: *Far Range Phase (FRP) of the Milani mission.*

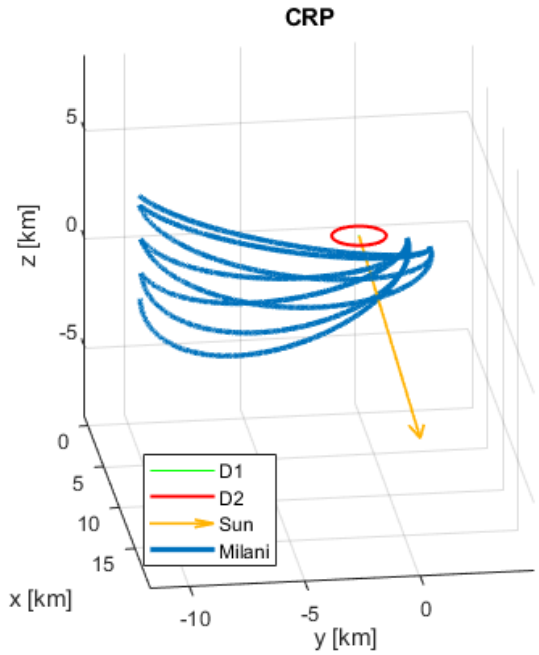

Figure 2: *Close Range Phase (CRP) of the Milani mission.*

Figure 3*: Didymos system seen with the Milani NavCam (2048 x 1536 pxl, 21 x16 deg) from a distance of 8.6 km.*

The Milani mission has been approved in mid 2020 and is currently in its phase B design. Milani is developed within Italy, Czech Republic, and Finland-based consortium. Project partners are Tyvak International (prime, platform), Politecnico di Torino (requirements, thermal, radiation, debris analysis), Politecnico di Milano (mission analysis and GNC), Altec (ground segment interfaces), CIRA (vehicle environmental campaign), HULD (software), VTT and University of Helsinki (ASPECT), Reaktor Space Lab (ASPECT DPU), Institute of Geology CAS and Brno University of Technology (ASPECT algorithms), and INAF-IAPS (VISTA payload development).