LICIACube: the Light Italian Cubesat for Imaging of Asteroids in support to DART

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Introduction: "LICIACube – the Light Italian Cubesat for Imaging of Asteroids" is a 6U CubeSat managed by the Italian Space Agency (ASI) [1] that is part of DART (Double Asteroid Redirection Test), the first NASA space mission demonstrating the applicability of the kinetic impactor method for planetary defense [2]. With a mass of about 550 kg and an impact velocity of about 6.6 km/s, DART is expected to change the binary orbital period of the 160-m Dimorphos by about 10 minutes, an effect that can be easily measured by ground-based telescopes.

In the framework of the AIDA (Asteroid Impact & Deflection Assessment) collaboration, the data obtained by DART and LICIACube will be combined with those obtained by the ESA Hera mission, that will be launched in 2024 and will rendez-vous with Didymos in 2027 for a deeper characterization of the binary system and of the effects of the DART impact.

Spacecraft and Payloads: The LICIACube spacecraft design is based on a 6U CubeSat platform, developed by the aerospace company Argotec ([3], [4], [5]) for the Italian Space Agency (ASI).

LICIACube is equipped with two optical cameras, narrow and wide FoV (see Fig. 1). The primary instrument, named LEIA (Liciacube Explorer Imaging for Asteroid), is a catadioptric camera composed of two reflective elements and three refractive elements with a FoV of ± 2.06° on the sensor diagonal. The optic is designed to work in focus between 25 km and infinity and the detector is a monochromatic CMOS sensor with 2048x2048 pixel. The latter is equipped with a Panchromatic filter centered at 650nm±250nm.

The primary camera will acquire pictures from a high distance providing high level of details of the frame field.

The secondary instrument, named LUKE (Liciacube Unit Key Explorer), is the Gecko imager from SCS space, a camera with an RGB Bayer pattern filter, designed to work in focus between 400 m to infinity. The sensor unit is designed to contain the image sensor interfacing with a NanoCU, while the optics consists of a ruggedized, mission configurable aperture, lens and required spectral filters. Moreover, the hardware is capable of directly integrating the image data to the integrated mass storage.

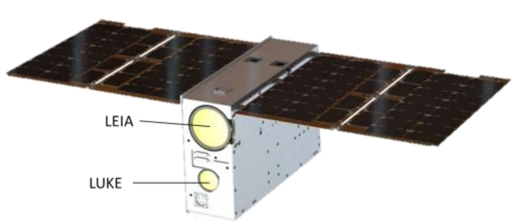

Figure 1 – LICIACube and its payloads.

Mission scenario and acquisition procedure: DART was launched on 24th November 2021, and will impact Dimorphos, the secondary member of the (65803) Didymos binary asteroid, in autumn 2022 (see Fig. 2).

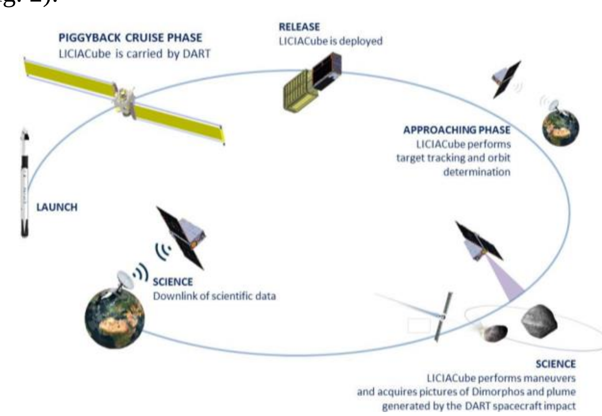

Figure 2 – The LICIACube nominal mission.

During the interplanetary cruise, LICIACube is hosted as a piggyback. Ten days before the impact it will be released in the proximity of the target on it autonomous path towards the Didymos system, reaching a minimum distance of about 55 km.

Starting from about 45 s before T0, the nominal DART impact time, five different acquisition phases have been foreseen (see Fig. 3). DART impact observation (red); Ejecta observation (yellow); High resolution observation of the surface properties and the crater (blue); Non-impact hemisphere observation (green); Plume evolution in forward scattering (purple). Each planned observation will be formed by a sequence of different images acquired at the maximum frame rate possible and possibly with different integration times.

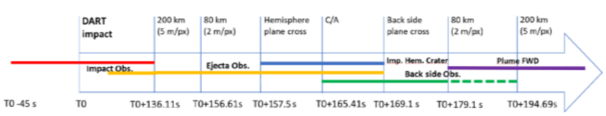

Figure 3. Scientific observation phases timeline: T0 is the nominal DART impact time.

Scientific Objectives and Data Exploitation: The LICIACube scientific objectives are: i) to document the DART impact's effects on the secondary member of Didymos, ii) to characterize the shape of the target, and iii) to perform dedicated scientific investigations on it (see Fig. 4). During the LICIACube fly-by we will perform a radio science experiment, exploiting the information carried by radio link between the S/C and the Earth focused on the precise orbit determination, and providing an assessment of the accuracies achievable in the estimation of the scientific parameters of interest, like the masses and the extended gravity field of Didymos.

Images acquired by LEIA and LUKE will allow us to constrain the shape and volume of Dimorphos as well as its physical properties.

High-resolution images, obtained by LEIA at the closest approach, will allow us to study the surface morphology of Dimorphos and the presence of boulders/large blocks on its surface. By comparing pre- and post-impact surface areas we will have the unique opportunity to witness how the boulders size-frequency distribution and density changed as a result of the DART impact.

The LUKE data will give us also the opportunity to investigate the composition of Dimorphos throughout spectrophotometric analyses. So we will be able to map the surface composition of the object and to derive the surface heterogeneity at the observed scale.

The images of the plume, compared with numerical models of dust dynamics, will allow us to have measurements of the motion of the slow ejecta and to estimate the structure of the plume.

The architecture of the LICIACube Ground Segment is based on the Argotec Mission Control Centre, antennas of the NASA Deep Space Network and data archiving and processing, managed at the ASI Space Science Data Center where images are planned to be integrated in the MATISSE tool [6, 7] for visualization and analysis.

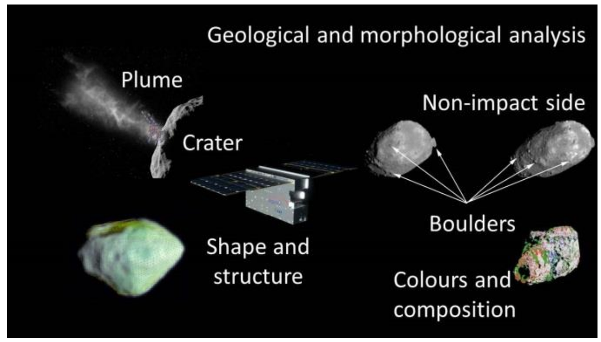

Figure 4 – Scientific Objectives of LICIACube

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