THE HERA MISSION: EUROPEAN COMPONENT OF THE ASTEROID IMPACT AND DEFLECTION ASSESSMENT (AIDA) MISSION TO A BINARY ASTEROID. P. Michel[1], M. Kueppers[2], A. Cheng[3], I. Carnelli[4], and the Hera team, [1]Université Côte d'Azur, Observatoire de la Côte d'Azur, CNRS, Laboratoire Lagange (CS 34229, 06304 Nice Cedex 4, France; michelp@oca.eu), [2]European Space Agency (ESA), European Space Astronomy Centre (ESAC) (P.O. Box, 78, E-28691 Villanueva de la Cañada, Madrid, Spain), [3]JHU/APL, USA, [4]European Space Agency (ESA) Headquarters, (8-10 rue Mario Nikis 75738 Paris Cedex 15).

Introduction: Hera is a small mission of opportunity built on the previous Asteroid Impact Mission (AIM) concept studied by ESA, whose objectives are to investigate a binary asteroid, to observe the outcome of a kinetic impactor test, and thus to provide extremely valuable information for asteroid impact threat mitigation, mining, and science purposes [1]. It is part of the Asteroid Impact & Deflection Assessment (AIDA) mission, in which the second component is NASA's Double Asteroid Redirection Test (DART) mission. DART's primary objective is to impact the small moon of a binary asteroid system, thus performing the first asteroid deflection test, and to observe the outcome from ground-based observatories [2]. The target is the binary near-Earth asteroid (NEA) (65803) Didymos (1996 GT). Within the NEA population, Didymos provides currently the best astrodynamics properties to conduct an efficient deflection mission. In particular, its secondary component, called hereafter Didymoon, is the target of the DART mission. With its 163 ± 18 m diameter, it allows for the first time to gather detailed data not only from a binary asteroid but also from the smallest asteroid ever visited. Such a size is considered to be the most relevant for mitigation, mining, and science purposes [3].

Baseline payload: The baseline payload of Hera includes an Asteroid Framing Camera, a miniaturized LIght Detection And Ranging (LIDAR) instrument and a 6U CubeSat carrying two additional instruments (a hyperspectral imager called ASPECT for Asteroid SPECTral Imaging and a second instrument addressing one among the following: radio science, seismology, gravimetry, or volatile detection). The spacecraft design allows for 40 kg of additional payload mass. Current options under investigation include the Small Carry-on Impactor proposed by JAXA (a replica of the one on-board the Hayabusa2 sample-return mission) and a high-frequency radar for the measurement of subsurface properties. Other options, such as a small lander, are not completely ruled out. A Radio Science Experiment (RSE) will also be performed, which does not involve any additional on-board hardware but only complex on-ground data processing.

Hera main objectives: Hera will demonstrate European capabilities to: 1- determine the momentum transfer by the hyper-velocity impact of DART by measuring the mass of Didymoon as well as the resulting effects on Didymoon's surface (e.g., the crater's size); 2- carry, deploy and operate a CubeSat in interplanetary space, dedicated for the first time to the spectral characterization of a small body, with a second scientific investigation among radio science, seismology, gravimetry, and volatile detection; 3- perform close-proximity operations in the environment of a binary system and the smallest asteroid ever visited.

Most operations will be done at 10 km from Didymoon's surface but occasionally much closer approaches are foreseen. For instance, 2–3 flybys may be performed to obtain a nearly complete map of the object at higher resolution.

Although Hera's primary objectives focus on planetary defense and technology demonstration, the mission will also have a great science return, as a by-product. In particular, Hera will obtain: 1- the first detailed images of a binary asteroid in orbit, offering informed constraints to models describing binary formation and dynamics, and verifying/constraining predictions arising from the radar shape model; 2- the first images and in-situ compositional analyses of the smallest asteroid ever visited, enabling the determination of the geophysical and compositional properties of such a small body compared to larger ones; 3- an improved understanding of physical/compositional properties and geophysical processes in low gravity, with implications for our understanding of small-body surface properties and their evolution; 4- the first documentation of an asteroid-scale impact outcome (from DART and optionally the SCI), orders of magnitude beyond the scale accessible in the laboratory.

Hera schedule: DART is planned to launch in 2021 and impact Didymoon in 2022 [2]. The development of Hera (if approved) foresees instead a launch in October 2023, therefore arriving at the asteroid a few years after DART. There are then two cases considered: (I) DART's launch is postponed in order to perform the impact while Hera is already at the binary asteroid; (II) Hera arrives a few years after the DART impact. In the latter case, all original objectives can still be met, except for the direct observation of the impact and the ejecta evolution. We note that the outcome of the impact, except for the ejecta dynamics, can still be measured a few years after the impact itself, as no change in the outcome is expected to happen on this short timescale

Conclusions: The Hera mission provides a robust and cost-effective means to perform a planetary defense validation test with a solid balance between risk and innovation. In the frame of the AIDA collaboration, Hera concretely contributes to a truly international planetary defense initiative [3]. In its current formulation, Hera will be the first mission to carry, deploy, and communicate with an interplanetary 6U CubeSat in the vicinity of a small body, which will perform complementary in-situ spectral observations. The satellite and its CubeSat will also observe for the first time the outcome of a kinetic impact deflection test and drastically improve our understanding of the impact process at asteroid scale, which will serve for the extrapolation to other scenarios, with many important implications for solar system science.

References: [1] Michel, P. et al. (2016) *Advances in Space Research, 57*, 2529-2547. [2] Cheng A. F. et al. (2016) *Planet. Space Sci., 121*, 27–3 . [3] Michel, P. et al. (2018) *Advances in Space Research*, in press.