**Asteroid Impact Mission (AIM): the european component of the AIDA space project.** P. Michel[1], M. Küppers[2], I. Carnelli[3], A. Galvez[3], K. Mellab[4], A. F. Cheng[5], and the AIM team, [1]Lagrange Laboratory, Université Côte d'Azur, Observatoire de la Côte d'Azur, CNRS (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]European Space Agency (ESA) Headquarters, (8-10 rue Mario Nikis 75738 Paris Cedex 15), [4]European Space Agency (ESA) ESTEC, (Keplerlaan 1, 2201 AZ Noordwijk ZH, The Netherlands), [5]JHU/APL, USA.

**Introduction:** The Asteroid Impact Mission (AIM) is a rendezvous mission and the European component of the Asteroid Impact & Deflection Assessment (AIDA) mission under study at ESA and NASA [1]. AIM is a small mission of opportunity demonstrating key technologies for future exploration missions while focusing on asteroid monitoring aspects i.e., the capability to determine in-situ the key properties of the small natural satellite of the near-Earth asteroid binary system Didymos used as the AIDA target [2]

AIM is under a Phase A/B1 study at ESA from March 2015 to the summer 2016. If funded for launch in 2020 with an arrival to Didymos in 2022, it will be the first mission to characterize a binary asteroid, including its internal structure. It will also give access to the detailed conditions of the impact by the Double Asteroid Redirection Test (DART, Fig. 1) under phase A study by NASA [3], as well as its outcome, allowing for the first time to get a complete picture of a collisional event at asteroid scale, a better interpretation of the deflection measurement and a possibility to compare with numerical modeling predictions.

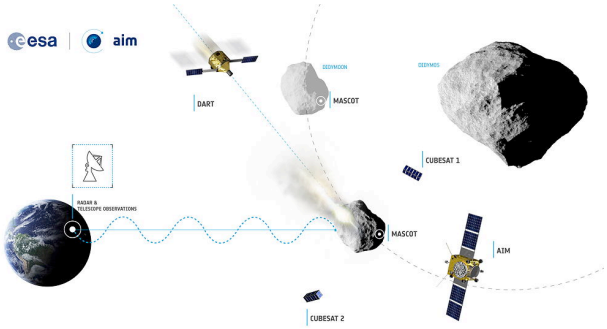


**Figure 1: AIDA: AIM and DART**

**Baseline payloads:** AIM is planned to carry the following remote sensing and in-situ instruments: a Visual Imaging System, a lander (based on the heritage of the DLR MASCOT onboard the Japanese mission Hayabusa 2), a thermal infrared imager, a high frequency (decimeter-wave) radar, and a low frequency (60 MHz) radar, to measure Didymos surface and subsurface physical properties and to study internal structures. AIM also includes an optical communication demonstration that can be used as a laser altimeter and CubeSat payloads.

**Objectives:** AIM has several objectives. First, it will characterize for the first time the secondary of a binary asteroid, allowing us to better understand the formation and properties of these systems that represent 15% of the NEA population. Second, AIM will demonstrate the technologies required by a simple monitoring spacecraft as well as establishing the suitability of binary asteroids as candidates for future explorations and asteroid deflection tests. Finally AIM will demonstrate, on the minimum expression of a deep-space mission, new technologies for optical communication, inter-satellite links, and on-board resource management.

Five studies of Cubesats are going on throughout the Phase A/B1, with various objectives, such as touching down to assess the surface material, gravity field, subsurface structure, perform near infra-red spectrometry, close range imaging, or characterizing and imaging the ejecta plume from the DART impact.

The characterization of Didymos' satellite by AIM will provide precious knowledge on the physical/compositional properties of a binary near-Earth asteroid. Physical and compositional properties of small bodies provide crucial information on the dynamical and collisional history of our Solar System. In addition, the formation mechanism of small binaries is still a matter of debate, although several scenarios have been proposed to explain their existence. In particular, rotational disruption of an NEA, assumed to be an aggregate, as a result of spin-up above the fission threshold due to the YORP effect (a thermal effect which can slowly increase or decrease the rotation rate of irregular objects) has been shown to be a mechanism that can produce binary asteroids with properties that are consistent with those observed. These properties include the oblate spheroidal shape of the primary, the size ratio of the primary to the secondary and the circular equatorial secondary orbit [4]. Other fission scenarios have been proposed which imply different physical properties of the binary and its progenitor [5]. Binary formation scenarios therefore place constraints on, and implications for the internal structure of these objects.

Small asteroids undergo substantial physical evolutions, and yet the geophysics and mechanics of these

processes are still a mystery. AIM will allow us to address fundamental questions, such as: what are the subsurface and internal structures of asteroid's satellites and how does an asteroid's surface relate to its subsurface? What are the geophysical processes that drive binary asteroid formation? What are the strength and thermal properties of a small asteroid's surface? What is the cohesion within an aggregate in microgravity? What are the physical properties of the regolith covering asteroid surfaces and how does it react dynamically to external processes, such as the landing of a surface package and/or an impact?

**AIM within AIDA:** AIDA will include both AIM and DART. The primary goals of DART are (i) to demonstrate a hypervelocity spacecraft impact on a small near-Earth asteroid (NEA) and (ii) to measure and understand the deflection caused by the impact. The DART mission includes ground-based optical and radar-observing campaigns of Didymos both before and after the kinetic impact experiment, as well as modeling and simulation programs. DART has the further objective to learn how to mitigate an asteroid threat by kinetic impact. AIM will make detailed measurements of the DART impact and its outcome, providing a fully documented impact experiment at asteroid scale to develop and validate models for momentum transfer in asteroid impacts.

**AIM mission scenario and close proximity operations:** two industrial consortia led by the industries OHB System and QinetiQ Space, respectively, are studying the AIM mission and spacecraft until summer 2016. The launch will take place in 2020 for an arrival at the asteroid in May 2022, allowing a first characterization of the target before the DART impact, planed in late September/early October 2022. Figure 2 shows the sequence of AIM close proximity operations before and after the DART impact.

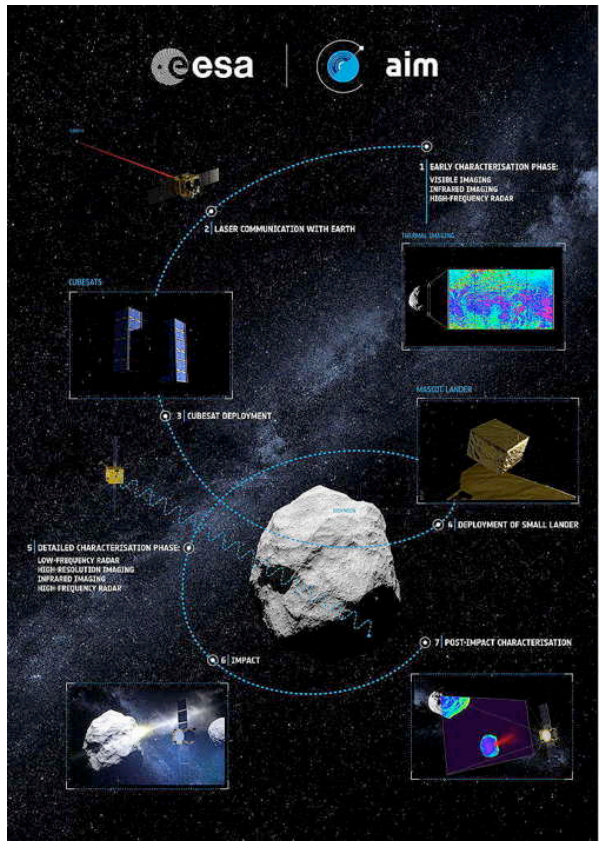


**Figure 2: AIM close proximity operations.**

**Conclusions:** AIM will return fundamental new information on a binary system, on the internal and surface structure and on the mechanical response of a small asteroid in the 100-meter-size range. Within AIDA with DART, it will be the first fully documented impact experiment at real asteroid scale, allowing numerical codes to be tested and used for similar and other scientific applications at those scales. In particular, it will ofer the possibility to improve greatly our knowledge on the impact cratering process at asteroid scale, and consequently on the collisional evolution of asteroids with implications for planetary defense, human spaceflight, and Solar System science.

**References:**

[1] Cheng A. F. et al. (2015) *Acta Astronautica, 115*, 262-269. [2] Michel, P. et al. (2016) *Advances in Space Research,* submitted. [3] Cheng, A. F. et al. (2016) *Planetary and Space Science*, in press. [4] Walsh K et al. (2008) *Nature, 454*,188-191. [5] Jacobson S. A and Scheeres D. J. (2011) *Icarus, 214*, 161-178.