Asteroid Impact Mission (AIM): the European component of the AIDA space project

P. Michel[1], M. Küppers[2], I. Carnelli[2], K. Mellab[2], H. Sierks[3], A.F. Cheng[4], and the AIM team[5]
[1]Univ. Côte d'Azur, Obs. Côte d'Azur, CNRS, Lagrange Lab., [2]European Space Agency, [3]MPI for Solar System research, Germany, [4]APL/JHU, [5]various.

AIM-D²: a revised version

AIDA is a joint cooperation between ESA & NASA. It consists of two separate spacecraft: the European orbiter AIM [1] and the US kinetic impactor DART [2]. AIM & DART are both planned to launch in late 2020. AIM will arrive at the target a few months before DART to perform the target's characterization. The DART impact is planned in October, 2022 when the target will be within 0.072 AU of the Earth and observable with ground-based telescopes.

Reduced from the original AIM mission design [1], a minimum payload suited to address AIM objectives, resulting in the **AIM-D² (AIM-Deflection Demonstration)** mission, was assessed in January-March 2017. This addressed all primary objectives of AIM (demonstration of an asteroid deflection, close-proximity operations and interplanetary Cubesat) and secondary objectives indirectly (e.g., internal structure through bulk density determination and system dynamics) [3].

AIM-D² is robust programmatically and cost wise due to its simplicity, and has several technology objectives.

It will demonstrate European capabilities to:

- Perform close proximity operations in the environment of a binary asteroid system and the smallest asteroid ever visited (163 meters in diameter).
- Carry, deploy and operate a Cubesat in interplanetary space, contributing for the first time to spectral characterization of a small body.
- Determine the mass of the target body and dynamical changes after the DART impact; measure crater size, ejecta, and momentum transfer [2].

AIM target: the binary asteroid 65803 Didymos

Table 1 gives basic data on AIM target, Didymos, based on observations to date. The secondary, which is the main target of the mission, is assumed to orbit in the equatorial plane of the primary. Figure 1 shows the current shape model from radar and lightcurve observations. From [1].

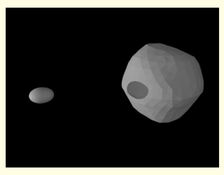


Figure 1: Preliminary shape model of the primary from combined radar and lightcurve data, diameter ~780 m. The secondary is estimated to be more elongated.

Primary Diameter	0.780 ± 10% km
Secondary Diameter	0.163 ± 0.018 km
Total System Mass	(5.278 ± 0.04) × 1011 kg
Component Bulk Density	2,100 km m−3 ± 30%
Primary Rotation Period	2.2600 ± 0.0001 h
Component Separation	1.18 +0.04/−0.02 km
Secondary Orbital Period	11.920 +0.004/−0.006 h

Table 1: Didymos System Basic Properties

AIM-D² payload

AIM-D2 carries two payloads (Fig. 2): AIM Framing Camera AFC (flight spares of the NASA Dawn mission camera provided by the MPS, Germany [4]; Fig. 3), and the Cubesat ASPECT supported by Finland and Czech Republic.

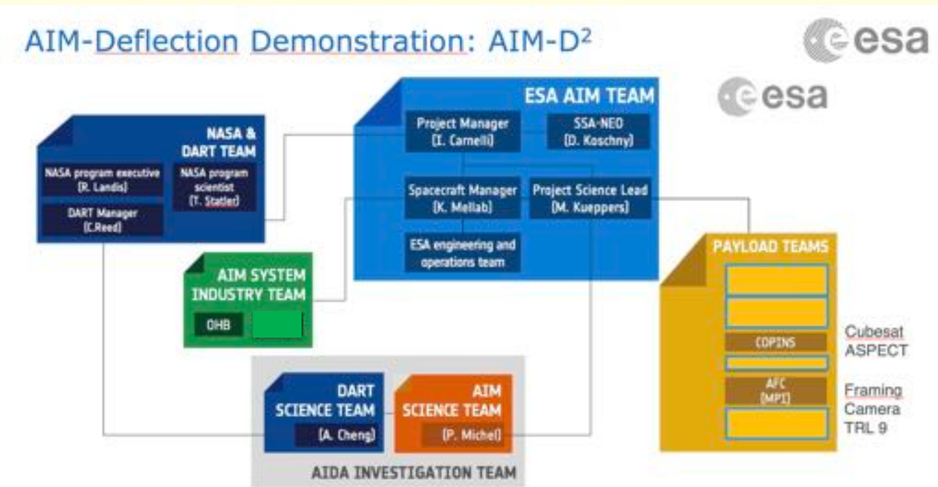


Figure 2: AIM-D² baseline payloads and consortium.

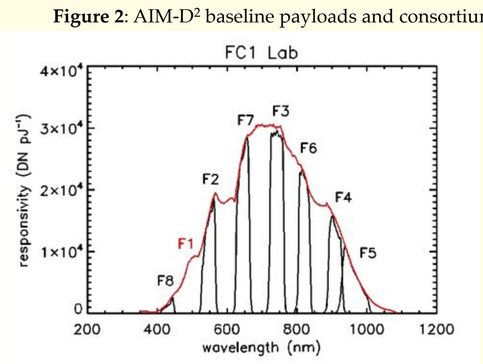


Figure 3: AFC color band passes [4].

AIM-D²: Deflection Demonstration

AIM-D² science return and firsts

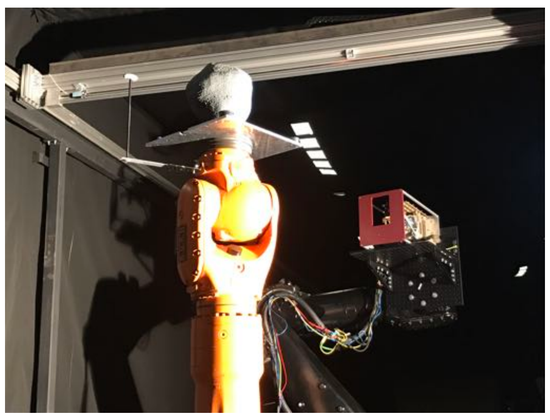
AIM-D² stand-alone

- First images of a binary asteroid in orbit
- First images and in-situ compositional analysis of the smallest asteroid ever visited
- Understanding of binary formation (15% of small asteroids are binaries).
- Understanding of physical/compositional properties and geophysical processes in low gravity, with implications on our understanding of small body surface properties and their evolution.

AIM-D² with DART

- First documented impact experiment at asteroid scale, orders of magnitude beyond the scale accessible in laboratory
- Validation of numerical simulations of hyper-velocity impacts that are used in planetary science (planet and satellite formation, impact cratering and surface ages, asteroid belt evolution …)
- Provide constraints for collisional evolution models of small body populations and planetary formation.

Laboratory simulation of observation of Didymos by the AFC performed at GMV (Spain).



References

[1] Michel P. et al. (2016), Adv. Space Research 57. [2] Cheng, A. F. et al. (2016) Plan. Space Sci. 121 . [3] Michel, P. et al. (2017), ASR, in prep.
[4] Sierks et al. (2011), Space Sci. Rev., DOI 10.1007/s11214-011-9745-4.