ASTEROID INVESTIGATION MISSION: THE EUROPEAN CONTRIBUTION TO THE AIDA EU-US COOPERATION

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ABSTRACT

The ¨AIDA¨ cooperation was initiated in 2011 between ESA, DLR and Observatoire Côte d´Azur (OCA) on one side and NASA and John Hopkins University Applied Physics Laboratory (JHU/APL) on the other, to assess concepts of mutual interest, with an initial focus on Planetary Defense. The US part, Double Asteroid Redirection Test (DART) would impact a high-velocity projectile into the smaller asteroid of the target binary system 65803 Didymos on October 2022 with the purpose of modifying the relative orbit.

The mission goal for ESA's Asteroid Impact Mission (AIM) study is to characterise the components of a binary asteroid, especially from the dynamical point of view. The mission concept focuses on the monitoring aspects i.e., the capability to determine, in-situ, the key physical properties of a binary asteroid playing a role in the system's dynamic behaviour. For this purpose, even if not a must, choosing a target whose dynamics have already been well characterised from the ground (e.g., by means of radar and photometry observations). Current baseline targets are asteroids 65803 Didymos (planned reference cooperative mission with US) or 1996FG3.
An AIM fly-by mission was also considered, however, due to a more limited return on the mission goals, and significant technical challenges and mission risks, this scenario has been abandoned in favour of an AIM rendezvous spacecraft.

The main objectives of the AIM rendezvous spacecraft are:

- Determine binary asteroid orbital and rotation state
- Analyse size, mass and shape of both binary asteroid components
- Analyse geology and surface properties
- Observe the impact crater and derive collision and impact properties (requires the DART mission).

Within the study all major design trade-offs have been carried out. Given the demanding mass envelope imposed by the use of the VEGA LV, the selection of the spacecraft propulsion technology (chemical or electrical) was of particular importance. The analysis considered mostly the reference interplanetary trajectory (direct transfer or including swing-bys) and the resulting mass at arrival. Due to the low values of the arrival mass at the asteroid, chemical propulsion was discarded. The resulting baseline trajectory involves an Earth swing-by and assumes a performance of a SNECMA PPS-1350 Hall-effect thruster, as the one demonstrated by ESA's SMART-1 lunar mission.
The AIM rendezvous mission is designed to be compatible with the VEGA launch vehicle, which would require an additional "kick motor" (e.g., STAR-48) to perform the Earth escape

burn. On arrival, the spacecraft would perform continuous observations from a serious of "station points" fixed point relative to the asteroid inertial frame and at a safe distance, out of the sphere of influence of both Didymos components. It would also deploy cubesat-sized probes that would perform seismic experiments, in this way complementing remote sensing data and providing an insight into the level of internal cohesion. In order to be able to image the two bodies for precise measurements of the orbital state, distances of 13.5 to 17 km were considered for the 1st characterisation point.
If the AIM spacecraft arrives at the target before the DART spacecraft, the impact of the DART spacecraft will be observed from a 2nd characterisation point of 100 km to avoid any damage by debris generated in the impact. AIM would then prospect the post-impact environment, and the associated change in the binary asteroid relative orbit (which could be compared with telescope and radar observations from ground) and resulting debris (which cannot).

A strawman payload for the characterisation of the asteroid consists of a Narrow Angle Camera, a Micro laser Altimeter, a Thermal IR Imager and a NIR spectrometer. A Call for Experiment Ideas has been carried out in 2013, which has resulted in the identification of instrumentation concepts that will be explored in the frame of industrial activities in 2014.

As part of ongoing analysis work technology demonstration options to be considered also include: lightweight high speed / high resolution camera, 3D camera, TriDAR for mapping and proximity operations, on-board autonomy (i.e. autonomous diagnostic and decision making), tone-base cruise health monitoring, housekeeping data compression, high performance DHS and GNC for proximity operations (incl. non-space spin-in e.g. parallel "voting" computer architectures, GNC software auto-coding), precise s/c tracking and vision-based orbit determination, lightweight seismometer, deployable monitoring nanosats, spacecraft impact vulnerability protection and recovery operations.

The subject of this paper is in particular the additional mission analysis work to be carried out in early 2014 in order to assess options for missions involving Electric Propulsion and the VEGA LV on combination with an alternative upper stage, e.g. Lisa Pathfinder Propulsion Module. The analysis will also consider alternative and backup scenarios leading to an increased mission flexibility.