Guidance Navigation and Control Challenges for the ESA Asteroid Impact Mission

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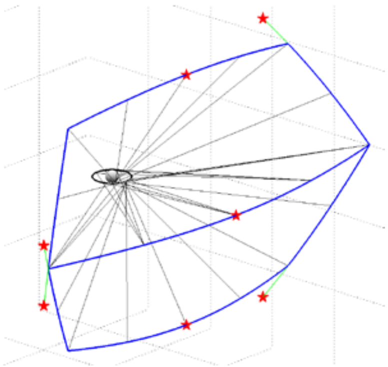
The Asteroid Impact Mission (AIM) is a small mission of opportunity currently undergoing preliminary design. AIM's goals are to demonstrate new technologies, to carry out fundamental asteroid research and to assess the capabilities of a kinetic impactor for planetary defence (the latter performed in collaboration with NASA-led DART as part of the AIDA mission). Launched in October 2020, AIM will reach the binary asteroid system Didymos in 2022. AIM will perform high-resolution visual, thermal and radar mapping of the Didymos system, focusing in particular on the smaller asteroid (informally called Didymoon) to build detailed maps of its surface and interior structure. The AIM main spacecraft is planned to carry three smaller spacecraft – the MASCOT-2 asteroid lander, provided by DLR, and two CubeSats (COPINS).



The distances during close proximity operations needed for the operation of remote-sensing payloads (less than 10 km) and for deploying MASCOT-2 (less than few hundred meters) impose significant challenges on the Guidance Navigation and Control (GNC) subsystem in terms of performance and reliability, especially considering that some level of autonomy is needed for such operations. Due to cost constraints, the GNC subsystem for AIM is designed relying as much as possible on the flight experience obtained from other ESA missions (especially ROSETTA) and on the technology developments carried out in support to other ESA mission studies to NEOs (mainly Marco-Polo and Marco-Polo-R).

Deployment of MASCOT-2 drives the GNC performances. MASCOT-2 has no means of propulsion and needs to fully rely on the AIM spacecraft for being injected into a ballistic trajectory that achieves successful landing on Didymoon. One of the foreseen release strategies consists in injecting AIM on a safe hyperbolic arc that approaches Didymoon in the proximity of the Lagrangian point L2 (Fig. 1). MASCOT-2 will exploit the unstable manifold passing through L2 to minimise the velocity at touch-down.

Uncertainties in the ephemeris of the asteroids require that relative navigation techniques are used. The baseline is to use vision-based navigation to track unknown features (Fig. 2) on the surface of the asteroids (a technique which has reached TRL6 from previous developments for Marco-Polo-R and dedicated tests with the AIM cameras) with optional use for navigation of laser and radar altimetry information as well as of infra-red images provided by payloads on board AIM.

This paper will address the challenges encountered in the trajectory and navigation design for AIM and describe the current design solutions adopted for the mission.

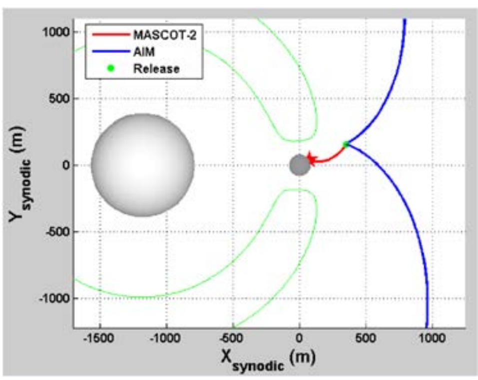


Fig. 1. MASCOT-2 deployment in synodic frame.

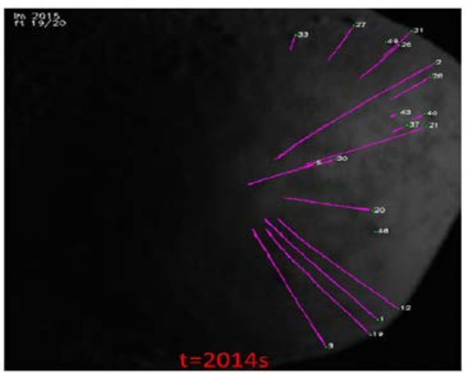


Fig. 2. Feature-tracking for relative navigation.