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Small Bodies Missions and Technologies (4)

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ASTEROID IMPACT MISSION: EFFECTIVE STRATEGIES TO LAND ON SMALL BINARIES

Abstract

ESA Asteroid Impact Mission (AIM) is planned to be the first mission to rendezvous with a binary asteroid. AIM, together with DART (Double Asteroid Redirection Test) makes the Asteroid Impact Deflection Assessment (AIDA), a joint cooperation between ESA and NASA, devoted to assess, on scaled scenario, the effectiveness in deflecting threatening Near Earth Asteroid (NEA) from its heliocentric path, for Earth protection. While DART, from NASA, impacts the NEA binary 65803 Didymos system small secondary – Didymoon –, AIM focuses on its detailed characterization before and after the impact. A cluster of scientific instruments are on board, some of them being the new version of already flown solutions on either Rosetta or Hayabusa missions; CONSERT is one of those, a radar for tomography which needs a lander-orbiter architecture to host both transmitters and receivers. Rosetta highlighted the challenge in running close proximity activities as well as landing partially active probes on surface of extremely irregular bodies such as comet 67P, whose shape and mass distribution were completely unknown and unexpected during the mission design phase. Similarly to Rosetta mission, AIM deploys a small passive probe: MASCOT-2 which has to get to Didymoon throughout a completely ballistic descent. MASCOT-2 doesn't feature any anchoring mechanism and this makes the release even more challenging since Didymos system's gravity field is expected to be weak, being the Didymoon surface escape velocity evaluated to be 4-6 cm/s. Moreover, while in the binaries close proximity, the gravity field is highly unstable and chaotic because of the two-attractor scenario. The paper presents the effective AIM trajectory design Politecnico di Milano identified from the launch, to the close proximity manoeuvres, up to the MASCOT-2 release included, during the phase A/B1 study, led by OHB System AG. In particular, the highest up-to-date fidelity Dydimos model is used to finalize the MASCOT-2 landing trajectory and dynamics; the binary orbital mechanics is modelled as a Restricted Three-Body Problem and shape-based models are exploited to represent the two asteroids refined gravitational contributions on the vehicle flying in the two natural bodies' proximity. The dynamics increased complexity is here exploited to detect landing strategies, otherwise not detectable with a simplified single attractor modelling. The winning strategy to softly land and reduce the bouncing is identified: even assuming the worst coefficient restitution from the soil at contact, MASCOT-2 will most likely bounce, eventually reaching a stable position on Didymoon with no escape risk.