AIDA: Measuring Asteroid Binary System parameters and DART-Imparted Deflection using the AIM Spacecraft

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The Asteroid Impact and Deflection Assessment (AIDA) mission is to demonstrate an asteroid deflection through a high velocity spacecraft impact on the moon of the binary asteroid system, Didymos. The NASA DART spacecraft would be launched on an impacting trajectory, while the ESA AIM spacecraft would be orbiting and observing the system before and after the impact. Radio science measurements with AIM provides information on the complex dynamics of the binary system. Combined with the DART experiment, the ability to measure the imparted ΔV has significant implications for how well the AIDA mission serves as a deflection demonstration. In addition, the impact-induced deflection, cratering, and mass transfer can be interpreted as indicators of surface properties.

We provided preliminary analyses of the measurability of the DART impact as function of generic AIM spacecraft proximity operations and knowledge of the Didymos system from radio science techniques. The study used a realistic model of the Didymos system[1], made of a simple sphere-ellipsoid binary asteroid system. We developed an array of proximity operations trajectories, including asteroid component flybys, terminator orbits and standoff observation orbits during impact, and simulated optical navigation and radiometric measurements. In each of those cases, the spacecraft and binary components trajectories were integrated in the full n-body problem. From these input data, and including consider parameter effects and a realistic cadence of small force events (such as desats) in orbit determination processes, we estimated the uncertainties on the spacecraft trajectory, the system state (position, velocity, orientation and angular rates of both components), and the binary component GMs and gravity fields. The uncertainty information derived from these estimates was used to explore the observability of impact-induced ΔV. The ΔV and binary component GMs, poles and states measurability were quantified and parameterized as a function of orbit geometry and altitude of close approaches. We showed that to measure the impact ΔV to within 0.1 mm/s by AIM, the knowledge of the Didymos system needed to be significantly improved, which could be obtained with proximity operations such as terminator orbits within 5 km of the system barycenter. Standoff polar observation orbits were designed at 100 km and 50 km from the system, accounting for radio science results from closer terminator orbits (2 km over 12 days). Preliminary simulations and results showed that ΔV measurements could be obtained to within 0.1 mm/s (over 30 days) and to within 0.05 mm/s (over a week), respectively.

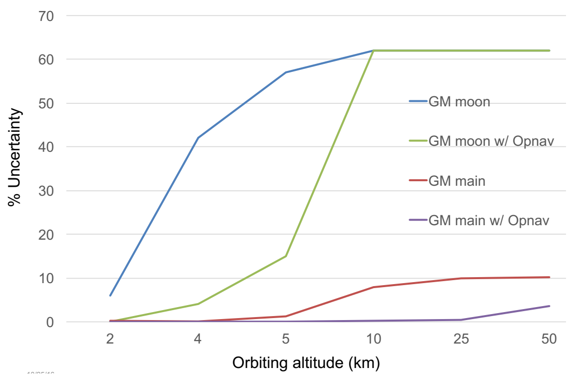

Fig. 1. Asteroid GM uncertainties vs orbiting altitudes, with/without optical navigation.

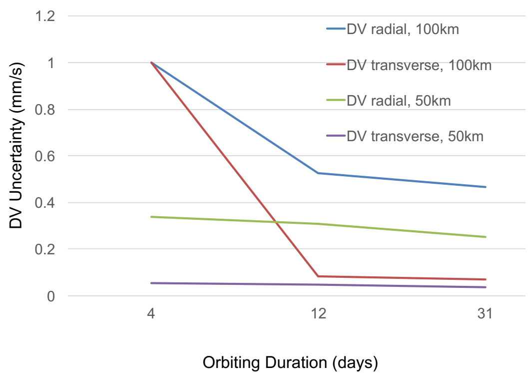

Fig. 1.DV uncertainties vs Time for 100km and 50km orbiting platforms.

References

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