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BIRDY - Deep-space SmallSat for reconnaissance of a PHA

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Abstract

Near-Earth Objects (NEOs) are of particular interest in planetary science for our understanding of the origin of the Solar System, they ar bodies of interest for in space resource utilisation (ISRU), and they are—with some comets—the principal character in planetary defence. Various efforts have been undertaken at international level since the late 90s to detect and catalogue NEOs, to identify potentially hazardous asteroids (PHAs), assess their risk, and last, propose measures of mitigation in case of a future impact. If such impacting object is of size larger than approx. 50 m, the warning time is likely large enough to be able to mitigate the risk by a space mission that deviates the asteroid's trajectory. When the impact risk of a PHA is large, reconnaissance missions to the threatening NEO are generally required, before any action for mitigation in space. These are needed to first have a better assessment of the orbit and impact probability, and next to have an in-depth vision of the hazardous object, and so derive the best scenario and approach for mitigation (as for instance kinetic impactor, or gravitational tractor). One of the main parameter to characterise such object - and the effect of a possible impact on Earth, as well as the mitigation process and technologies to adopt, is the total mass and internal structure of the small body. Indeed, given the mass of the target, the impact and entry into the Earth atmosphere can considerably vary. Besides, most mitigation space missions—including the gravity tractor—also need to have a good knowledge of the total mass of the threatening NEO (be it a single body, binary, or multiple system). Moreover, kinetic impactor also needs more inputs on the surface, shape, and global structure of the hazardous NEO.

In that case, any reconnaissance mission arriving at the target before the mitigation spacecraft, should be able to confidently derive the target's mass, its porosity, as well as its surface and its internal structure. Radio and radar techniques are very powerful for such purpose by deriving the gravity field and homogeneity of the body. Given the potential small or moderate size of the NEO asteroid to deviate (several hundreds of meters), one requires very close approaches to ensure good SNR measurements. This can be done with a dedicated SmallSat or CubeSat in proximity operations, that can take more risks than the main reconnaissance mission. Radio-science is then performed with the CubeSat from the DSN network (or other deep-space communication system) and using the mothercraft as a relay. To ensure enough target fly-bys, overall manoeuvrability, and adequate mission lifetime, autonomy in propulsion system is needed. Continuous slow push appears to be an interesting technique to develop for that purpose. Additionally, autonomous navigation and TCM by reducing the need of ground-based operations, also appears to be of general interest for reducing mission costs. A stand-alone deep-space CubeSat can surely fit the objectives, but it requires more development, and to overcome more technological challenges. Hence a daughtercraft CubeSat in proximity operations, ensuring inter-satellite links, appears to be a more viable option.

We will present our BIRDY CubeSat concept to a small Solar System body, preferably piggy-back of a mothercraft, to perform proximity operations. BIRDY includes increased autonomy, and radio-frequency instrumentation to derive the internal structure of the target. Being rather simple in design and payload, and following nanosat standards, it is of moderate cost; but more importantly it can be replicated and developed rapidly for launch in alert.

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