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PANIC – A Mission Concept Study for a Miniaturized Autonomous Lander for In Situ Characterization of a Near-Earth Asteroid

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Introduction

In spite of data gathered from ground-based observations, several fly-bys and the dedicated NEAR and Hayabusa asteroid rendezvous missions, several key questions regarding the bulk composition, surface geology, internal structure and formation mechanisms of Near-Earth Objects (NEOs) still remain unanswered. In situ measurements of an asteroid's surface would help to address outstanding issues concerning their physical, geological and mineralogical nature. However, no successful in situ characterization was ever accomplished on an asteroid's surface yet. Lessons learned from small satellite missions in recent years in addition to experiences gathered from miniaturized hardware and components derived from commercial-off-the-shelf (COTS) parts open up new opportunities for low-cost missions beyond low-Earth orbit (LEO), enabling a reasonable science return within small mission budgets.

Probe Design

We present a mission concept study on a cost-efficient, autonomous, micro-scale surface lander, also referred to as *PANIC* – the *Pico Autonomous Near-Earth Asteroid In Situ Characterizer*. The lander has the shape of a regular tetrahedron with an edge length of 35 cm and a mass of less than 10 kg, housing three science instruments in its proposed configuration. It was designed to achieve maximum simplicity, to limit risks and reduce cost, while still enabling fully autonomous operations to answer key scientific questions. Due to its concept, PANIC can land on a compositionally diverse set of objects with only minimal redesign. We anticipate an uncontrolled hard landing that is dependent entirely on a suitable deployment from an orbiting spacecraft and an in-depth analysis of the possible trajectories for the lander to encounter the target body. The lander has also no required landing orientation due to its ability to autonomously reorient itself in an upright position by using its three petals. Additionally, it will have the ability to hop in the microgravity environment to allow for several measurements at different surface locations.

Scientific Objectives

The acquired data using the proposed configuration will help strengthen the compositional link between meteorites and asteroids. Other key scientific goals are the investigation of the microscale particle size distribution and effects of space weathering. In addition, the lander may be used as a technology demonstrator to test new miniaturized hardware for future applications and related missions, to study the mobility on an asteroid's surface and to develop suitable approaches on autonomy.

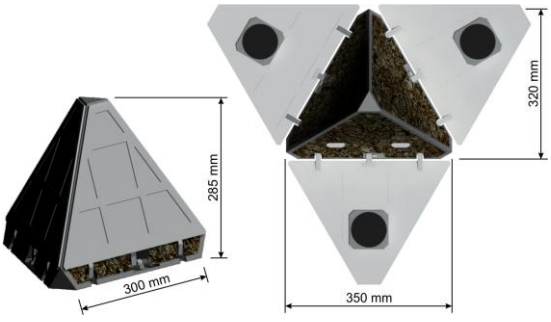

Figure 1: PANIC's design as a proof-of-concept CAD-model. The lander's external dimensions can be inscribed into a cuboid sized 350 x 320 x 285 mm³.