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# SCORPION: A LOW-COST MULTI-PHASE AND MULTI-OBJECTIVE ASTEROID MISSION

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## Abstract

Planetary Defense is one of the medium-term goals of most space agencies together with NEA characterization, Human Spaceflight, Small Bodies Sample Collection, and Asteroid Mining, to name a few. However, the technology readiness level (TRL) of some of the required technologies to perform such missions is not yet at the necessary level. In particular, these missions require agile and precise navigation and guidance techniques that only autonomous on-board GNC systems can achieve.

This paper presents the results of a GMV internal study proposing a low-cost multi-phase and multi-objective small body mission, SCORPION, suitable to raise the TRL of such technologies (not limited to GNC, i.e. precise altimeter, optical ground communications, secondary payloads, or inter-satellite link communications with secondary payloads) with an emphasis on the test and flight validation of autonomous GNC systems based on optical measurements while enabling scientific as well as commercial and planetary defense purposes.

Besides its natural science and planetary defense return values, and as a technology demonstration mission, SCORPION is designed to be low cost. This is achieved by adapting existing platforms, re-using systems previously flown on past missions when possible, reduced ground operations both in terms of life time and ground controls requirements, and technical complexity.

In order to test as many technologies or mission scenarios (i.e. impact, science, proximity operations) as possible, the mission is comprised of several phases, that present different validation conditions and technical challenges: (1) low-cost Earth escape, (2) interplanetary cruise, (3) autonomous NEO(s) fly-by ('s), (4) autonomous NEA #1 impact rehearsal, and (5) autonomous NEA #2 impact. The inclusion of fly-by and impact scenarios along the nominal path, a part from its evident scientific value allowing multiple NEAs characterization, is important as it allows the test, under very different dynamical conditions, of different autonomous GNC , image-processing (IP) techniques and satellite operations procedures that are required in the diverse mission scenarios previously described as potential objectives. Low and high-thrust scenarios are analyzed for the different phases.

GMV has been playing a major role in the development of GNC systems in the European context. In order to propose a low-cost approach the available development and lessons learned are traced together with their applicability to the SCORPION mission. These experience comprise the design and

development of autonomous navigation and guidance techniques (CLEON, CHILON, CHILON2, NEOGNC, IANT), the study and development of autonomous GNC and FDIR systems for different missions (Marco-POLO-R, Phobos-SR, AIM, JUICE, NEOSHIELD2), the study and development of different IP algorithms (feature tracking, centroiding, landmark matching) and their validation within the GMV's robotic testbed ***platform-art***©.

**This paper is considered to be in the Mission & Campaign Design area.**