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LUNADRONE: A SMALL FLYING VEHICLE FOR LUNAR PIT EXPLORATION

Abstract

The LuNaDrone mission concept aims at exploring lunar pits, vertical shafts that may provide access to underground caves, by means of a small spacecraft capable of performing autonomous flights. The LuNaDrone project, which is led by Politecnico di Torino with the involvement of selected Italian SME's under the aegis of CEIPIEMONTE, was previously introduced at IAC-22 (A3,IP,61,x71889). Since then, major advancements have been made regarding LuNaDrone's mission architecture and on-board systems.

Although the spacecraft's design is intended to make it compatible with the exploration of several hard-to-access lunar sites, such as craters and PSRs, the use-case being studied specifically concerns the exploration of skylights. This choice stems from the high level of interest in lunar lava tubes. Indeed, these geological structures would be a strategic asset for human activities on the Moon, and their exploration could answer significant science questions. This interest is renewed by recent research, like the one by Horvath et al., (2022), that confirmed the thermally stable nature of these lunar sites and its important implications for long-term lunar exploration; or the one by Wagner, R.V., Robinson, M.S. (2022) that suggests the implementation of low-cost precursor missions involving simple flying vehicles for initial reconnaissance of these sites. Statements such as these support the choice that emerged from the early design activities that began in 2020: to develop LuNaDrone as a low-cost small flying spacecraft, capable of exploring the hidden regions of lunar pits to assess the existence of a lava tube extending beneath. In addition, such a mission would provide detailed morphologic information and preliminary data to assist in designing a more focused follow-on mission.

LuNaDrone is a compact spacecraft which would land on the Moon aboard a lander, such as those being developed for NASA's CLPS program. The drone is equipped with a monopropellant propulsion system and a range-visual-inertial navigation system that will enable it to perform a controlled flight that will take it from the landing site to the hidden regions of the pit to be explored.

In addition to an updated definition of the mission architecture, the results of the latest developments of the most critical on-board systems, especially the navigation system, are presented. For the latter, an improved prototype of the sensor package has been developed and used to gather datasets to test the visual navigation algorithm and quantitatively evaluate the performance with respect to the requirements of the mission flight profile.