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ARNE - EXPLORING THE MARE TRANQUILLITATIS PIT

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Lunar mare “pits” are key science and exploration targets. The first three pits were discovered within Selene observations [1,2] and were proposed to represent collapses into lava tubes. Subsequent LROC images revealed 5 new mare pits and showed that the Mare Tranquillitatis pit (MTP; 8.335°N, 33.222°E) opens into a sublunarean void at least 20-meters in horizontal extent [3,4]. A key remaining task is determining pit subsurface extents, and thus fully understanding their exploration and scientific value. We propose a simple and cost effective reconnaissance of the MTP using a small lander (<130 kg) named Arne, that carries three flying microbots (or pit-bots) [5,6,7]. Key measurement objectives include decimeter scale characterization of the pit walls, 5-cm scale imaging of the eastern floor, determination of the extent and topology (50-cm scale) of the sublunarean void(s), and measurement of the magnetic and thermal environment.

Arne will make a noontime descent and optically lock onto the MTP rim and floor shadow. Some 100 meters above the surrounding mare Arne will descend vertically at a rate of ~1 m/s in a fixed orientation. At the top of the pit Arne will optically determine the position of boulders on the floor known from LROC images [3], and then maneuver to a relatively smooth spot in view of the Earth. After landing and initial surface systems check Arne will transmit full resolution descent and surface images. Within two hours the first pit-bot will launch and fly into the eastern void. Depending on results from the first pit-bot the second and third will launch and perform follow-up observations. The primary mission is expected to last 48-hours; before the Sun sets on the lander there should be enough time to execute ten flights with each pit-bot.

The pit-bots are 30-cm diameter spherical flying robots [5,6,7] equipped with stereo cameras, temperature sensors, sensors for obstacle avoidance and a laser rangefinder. Lithium hydride [5,6] and water/hydrogen peroxide power three micro-thrusters and achieve a specific impulse of 350-400 s. Each pit-bot can fly for 2 min at 2 m/s for more than 100 cycles; recharge time is 20 min. Arne will carry a magnetometer, thermometer, 2 high resolution cameras, and 6 wide angle cameras and obstacle avoidance infrared sensors enabling detailed characterization of extant sublunarean voids.

[1] Haruyama et al. (2010), 41st LPSC, #1285. [2] Haruyama et al. (2010), GRL, 36, dx.doi.org/10.1029/2009GL0406355. [3] Robinson et al (2012), PSS, 69, dx.doi.org/10.1016/j.pss.2012.05.008 [4] Wagner and Robinson (2014), Icarus, dx.doi.org/10.1016/j.icarus.2014.04.002. [5] Thangavelautham et al. (2012), IEEE ICRA [6] Strawser et al. (2014), J. Hydrogen Energy. [7] Dubowsky et al. (2007), Proc. CLAWAR.