INA – YOUNG OR OLD? M. S. Robinson[1], B. W. Denevi[2], and E. J. Speyerer[1], [1]School of Earth and Space Exploration, Arizona State University (robinson@ser.asu.edu), [2]Johns Hopkins University Applied Physics Laboratory.

Introduction: Irregular Mare Patches (IMPs) are an enigmatic lunar landform thought to have formed as a result of basaltic volcanic processes. A few IMPs were initially identified in Apollo-era photography [**1**], with Ina being the largest (3 km across). Later observations from the Lunar Reconnaissance Orbiter Camera revealed more than fifty such features distributed within nearside mare environments [**2**]. Origin hypotheses typically invoke late-stage caldera forming events that include collapse and magma eruptions [**1,2** and references therein]. However, many unaddressed issues remain and the origin of IMPs remains uncertain. Some workers posit that the IMPs are relatively young (<100 My; crater size-frequency distribution (CSFD) model age) making them the youngest volcanic features on the Moon [**2**]. More recent work proposes an exotic formation mechanism, the eruption of magmatic foams, resulting in a landform with low physical strength, and as a result the young model age based on CSFD is unreliable [**3,4**]. Instead this work proposes that Ina and the IMPs were formed more than 3 By ago.

Landing Area: To test these competing hypotheses, we propose landing within Ina (18.647°N, 5.300°E; Fig. 1).

Science Goals and Objectives: The overarching science goal is to test the age of Ina to understand the duration of lunar volcanism and implications for the thermal evolution of the Moon (SCEM Report Obj. 5b and 5d). Science objectives are 1) determine the physical properties of the two main units (smooth materials (sm) and uneven materials (um) [**2**]), 2) delimit and characterize primary volcanic landforms at 10 cm scale, 3) document the morphology and topology of impact craters down to diameters of 1 m, and 4) monitor the environment for signs of geologically recent activity (heat flow and gas release). Objectives 1-3 characterizes landforms predicted from the competing origin hypotheses. Objective 4 tests if Ina has increased heat flow relative to the global average (tests recent volcanism hypothesis) and the idea of recent gas release hypothesis [**5**].

Required Capabilities: Objectives 1-3 require high resolution stereo imaging with pixel scales (px) of <=1 cm (derived topography 5 cm scale) of representative areas (20k m^2) covering both units (sm, um) nested within 3 cm (60k m^2) stereo coverage. Objective 1 also requires higher resolution monoscopic images of the regolith to test for physical strength properties demonstrated by spacecraft interactions with the surface (during landing (2 cm px) and on the surface (0.5 cm px)). The imaging experiment likely requires a flying platform such as the Intuitive Machines (IM) hopper [**6**] slated for a test flight on the IM-1 CLPS mission (December 2022). Objective 4 requires a deployable heat flow probe sensitive to better than 10-6 W cm^{-2} and a measure of particle density (pressure) above the average lunar background. Overnight capability is not required for the primary Objectives (1-3) but would enhance return from Objective 4.

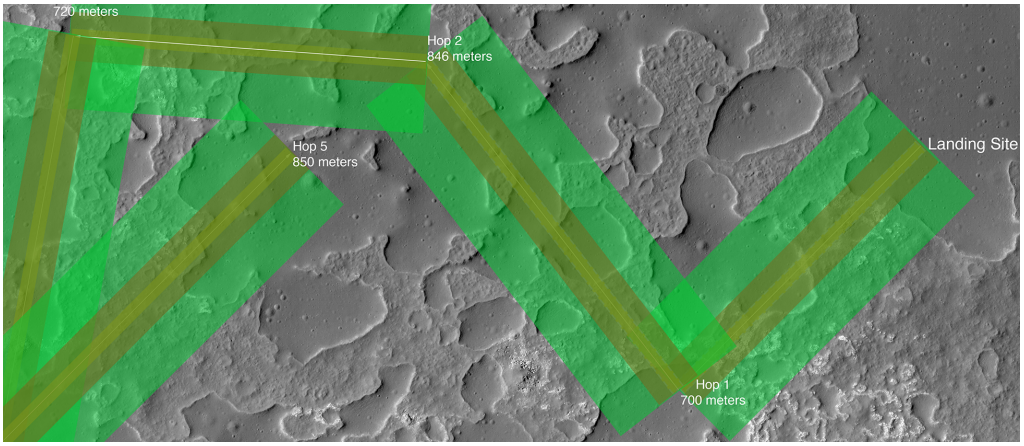

Fig. 1. Strawman ConOps for Ina CLPS mission. Color strips indicate imaging footprints from three cameras acquired during nominal 100 m altitude flights (hops): Narrow Angle Camera (bright yellow, 0.8 cm px, 30 m wide), Medium Angle Camera (dull yellow 2.8 cm px, 120 m wide), Wide Angle Camera (green 9 cm px, 360 m wide). In addition, higher resolution images are acquired at each landing site during ascent and descent. ConOps based on known capabilities of IM S.P. Hopper [**6**].

References:

[**1**] Strain and El Baz (1980) *PLSC* 11, 2437-2446. [**2**] Braden et al. (2014) *Nat. Geosci*., 787-791/ [**3**] Qiao et al. (2017) *Geology* 45(5), 455-458. [**4**] Wilson and Head (2017) *J. of Volc. and Geothermal Res*., 113-127. [5] Schulz et al. (2006) *Nature* 444, 184-186. [**6**] Atwell et al. (2020) *LSSW*, Abstract #6011.