# COMET HOPPER: A MISSION CONCEPT FOR EXPLORING THE HETEROGENEITY OF COMETS.

B. C. Clark[1] (benton.c.clark@lmco.com), J. M. Sunshine[2] (jess@astro.umd.edu), M. F. A'Hearn[2], A. L. Cochran [3], T. L. Farnham[2], W. M. Harris[4], T. J. McCoy[5], and J. Veverka[6]

[1] Lockheed Martin, Space Exploration Systems, Denver, CO, 80201; [2] Dept. of Astronomy, Univ. of Maryland, College Park, MD, 20742; [3] McDonald Observatory, Univ. of Texas, Austin, TX, 78712; [4] Dept. of Applied Science, Univ. of California, Davis, CA 95616; [5] Dept. of Mineral Sciences, Smithsonian Institution, Washington, DC, 20560, USA; [6] Dept. of Astronomy, Cornell Univ., Ithaca, NY, 14853.

**Mission Concept**: The Comet Hopper (CHopper) mission explores the compositional and morphologic heterogeneity of a comet. Recent cometary flybys (Deep Impact at 9P/Tempel 1, Stardust at 81P/Wild 2, and Deep Space 1 at 19/P Borrelly) have revealed great diversity among comets as well as significant variation within individual bodies. Understanding the inherent diversity of a comet nucleus and the origins thereof are now a clear objective of future cometary exploration. CHopper is an instrumented lander that will build upon the results of these recent missions. With a 2012-2013 launch Chopper will examine in detail the inner coma and surface of comet P/McNaught 2 (P/2004 R1). CHopper observes the comet while formation flying over one full orbital period obtaining measurements during the descent to, and on the surface of, the nucleus.

CHopper takes advantage of the low cometary gravity field to take off and land ("hop") multiple times (**Fig. 1**) during each descent to the surface. As shown in **Fig. 2**, six "sorties" to the surface are envisaged to investigate changes with heliocentric distance. Each sortie will begin with a landing readiness assessment. If all systems are nominal, the spacecraft will descend to the surface and subsequently hop twice. Each landed operations campaign will last a few days, collecting science from all instruments. The sortie concludes when the spacecraft lifts off the surface and resumes far operations.

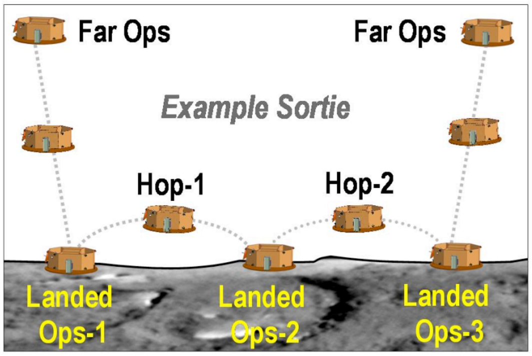


***Fig. 1***: *CHopper's ability to land at multiple sites enables exploration of comet heterogeneity.*

CHopper will explore the inner coma during descents and ascents and during far operations over the comet's full orbit. CHopper will thus provide a unique dataset for exploring the relationship between the nucleus and the coma, and for investigating changes in the coma at various distances from the surface and over its orbit including distances beyond where water sublimation dominates.

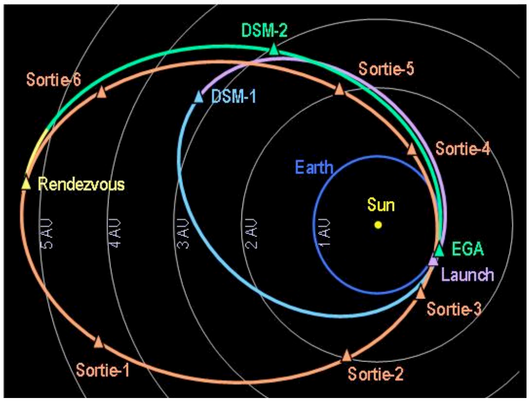


***Fig. 2*** *CHopper descends to the surface at six sorites spaced at various heliocentric distances over one orbital period.*

**Preliminary Payload**: Our instruments are chosen to optimize the use of both landed operations and formation flying, to maximize our ability to probe how the comet works. In addition to high resolution imaging and multi-spectral mappers, the *in situ* scientific payload instruments under consideration include a dust flux monitor, organic analyzer, elemental analyzer, microscopic imager, and gas mass spectrometer. For most of these instrument categories, more than one candidate instrument exists that is already flight-proven for deep space missions.

**Nuclear Power Source**: Visiting a comet multiple times at a wide range of heliocentric distances is simply not achievable with traditional solar energy sources; large solar panels are not amenable to prolonged exposure to a comet's inner coma or landing on unknown terrain. Consequently, the success of CHopper in determining the heterogeneity of a comet requires the use of nuclear power sources like the ASRG.

**Acknowledgements:** This effort is supported by a grant from NASA's Discovery and Scout Mission Capabilities Expansion (DSMCE) program and funds from Lockheed Martin Space Systems. We thank S. Spath and J. Hupp for their key contributions in concept definition.