EXPLORATION MISSIONS TO THE KUIPER BELT AND OORT CLOUD. S. A. Stern[1], W. B. McKinnon[2], J. M. Moore[3], M.W. Buie[1], A. Zangari[1] , J.R. Spencer[1], A.H. Parker[1], and R. L. McNutt, Jr.[4], [1]Southwest Research Institute, 1050 Walnut Street, Suite 300, Boulder, CO 80302, [2]Department of Earth and Planetary Sciences, Washington University, St. Louis, MO 63130, USA, [3]NASA [3]National Aeronautics and Space Administration Ames Research Center, Space Science Division, Moffett Field, CA 94035, [4]Johns Hopkins University Applied Physics Laboratory, 11101 Johns Hopkins Road, M/S 200-E254, Laurel, MD 20723.

Introduction and Background: The Kuiper Belt (KB) and Oort Cloud (OC) are a scientific wonderland containing a treasure trove of information about the origin of our solar system, the accretion of the planets, the workings of small planets, the nature of planetesimals, and more. The Kuiper Belt is known to contain numerous dwarf planets, only one of which has been explored to any degree [1]—Pluto. The Oort Cloud is likely to contain many more dwarf planets and quite plausibly many larger ones. Further exploration of these worlds, as well as small Kuiper Belt Objects (KBOs) that are relics of the dwarf planet formation era is crucial to understanding both the origin of our solar system and the workings of small planets.

The KBO population, viewed broadly, stretches from the Jupiter-family comets, through the Centaurs, across the 'classical' Kuiper Belt objects outside Neptune's orbit, to scattering and detached deep space objects well beyond [2, and refs. therein]. As of December 2016, nearly 2500 such bodies are known, but the actual population is much larger, perhaps 200,000 bodies of 100-km diameter or more and with a combined mass of at least 0.03–0.10 Earth masses. The Kuiper belt is dynamically complex, and composed of numerous resonant and non-resonant subpopulations [e.g., 3]; understanding its details has opened a window to understanding the origin and evolution of the early Solar System that never existed before.

Next Step Missions: With the 2015 flyby of Pluto and the planned 2019 flyby of KBO 2014 MU_{69}, the New Horizons mission has only undertaken the very earliest reconnaissance phase of the exploration of the Kuiper Belt.

The overall science strategy for incrementing knowledge of solar system objects was articulated by the Committee on Planetary and Lunar Exploration (COMPLEX) in the 1970's; it begins with flyby reconnaissance and progresses exploration with orbiters and then landers [4].

The Kuiper Belt and Oort Cloud will next require a series of flyby missions to explore the diversity of phenomenology and origins of the objects found in these vast, primordial reservoirs. Additionally, Pluto system orbiters or landers are also needed to understand its unexpectedly complex surface geology, atmospheric dynamics and volatile transport, its satellite system, and the possibility and characteristics of its suspected interior ocean.

Technology Needs: Both flyby and orbiter missions to the Kuiper Belt and Oort Cloud benefit from fast transport, as well as power at heliocentric distances too large for conventional solar arrays. Additionally, orbiters require breaking propulsion from high speed transits. Yet to date, robotic flyby exploration of the solar system has never combined high flyout speeds with braking near the target to enabld orbiters and landers. The employment of high launch energies coupled with efficient radioisotope propulsion [5] is a natural solution to this problem [6]. Orbiters additionally require high bandwidth communications in order to be effective. Laser communications may be a solution but will also impose significant pointing stability requirements on the spacecraft during downlinks.

Finally, we note that flyby missions to these locales involving surface impactors and landers also desire technology requirements with such survivable penetrator systems and payloads for impactor landers, and very light mass/surface area loading for landers on fragile surfaces.

Presentation: We will review the nature of the Kuiper Belt and Oort Cloud, the scientific promise of further exploration in these locales, various strawman exploration mission concepts and science objectives for these destinations, the technology developments that such missions would benefit from.

References: [1] Stern et al., Science, 350, 2015. [2] McKinnon W.B. (2015) in *Treatise on Geophysics, 2nd Ed.*, chap. 10.19, Elsevier. [3] Gladman B. et al. (2008) *The Solar System Beyond Neptune*, Univ. Ariz. Press, 43–57. [4] Wasserburg, G. J., et al. (1978), *Strategy for Exploration of the Inner Planets: 1977-1987*, 53 pp, Washington, D. C. [5] Noble, R. J. (1993), 29th JPC, 7pp., *AIAA 93-1897*. [6] Oleson, S. R., et al. (2003), 13pp., *IEPC-2003-0137*.