Deep Space Gateway Asteroid "Recycler" Mission, L. Graham[1], M. Fries[1], J. Hamilton[1], R. Landis[1], K. John[2], W. O'hara[3], [1]ARES NASA Johnson Space Center, Houston, TX 77058 (marc.d.fries@nasa.gov), [2]Jacobs Technology ESCG, Houston, TX 77058, [3]Wyle Laboratories, 2400 NASA Parkway, Houston, TX 77058..

Introduction: A cislunar platform at the Earth Moon Lagrangian point 2 (EML2) near rectilinear halo orbit (NRHO) around the Moon provides an opportunity for an economically viable, reusable planetary science-based sample return program. By utilizing the Weak Stability Boundaries (WSB), as well as the latest advancements in smallsat technologies, a reusable, reconfigurable "recycler" sample return platform can be developed and implemented. Planetary science sample returns have the benefit of providing contextual information for the specific source, as well as identifying in-situ esources available for future Solar System mining.

Concept of Operations: While not in an optimum location, a platform at NRHO can be utilized as either a receiving point for inbound or an outbound originating point for planetary science sample return missions.
A location at EML1 or EML2 itself would represent an origination/return point that would require less delta-V to accomplish these missions. Missions similar to OSIRIS-REX, Hayabusa 2, the ESA Asteroid Impactor Mission (AIM) or even a Mars moon sample return, could follow the low energy transfer trajectories available at the WSB and thus be able to affect a ballistic capture or departure. Use of this approach could require approximately 5-7 km/s delta-V propulsion from the spacecraft. Similarly, outbound trajectories would also be a low energy transfer exercise and would provide opportunities for multiple sampling targets for Near Earth Objects (NEOs), main belt asteroids, Mars moons and the Moon itself. [1]

Secondary Experiments: In addition, both because of the extensive mission time in-transit and the wide volumes of space traversed by these spacecraft, an externally-mounted "stardust" collector could also be incorporated into each and every mission. This has the advantage of adding a passive experiment to obtain additional interstellar material samples with no additional mission costs beyond the initial design, development and fabrication. In the same vein of passive experiments, a Materials International Space Station Experiment (MISSE)-type experiment could also be employed to test long term exposures of various materials and computing elements to the environment of deep space over the mission transit time of an interplanetary mission.

Spacecraft Concept Conceptually, the spacecraft would be a 300-600 kg-class vehicle, powered by solar arrays and propelled by redundant low power iodine-fed electric propulsion units. The spacecraft would be designed to be highly radiation resistant so as to not require the removal and replacement of avionics or other sensitive components after every mission. For those components that might need replacement after a 5+ year mission, such as imagers and solar arrays, they would be designed to be able to be rapidly removed and replaced by simple robotics or humans. For those components that need to be replaced to address a specific mission (such as a sample canister for a Mars moon sample versus a C-type carbonaceaous main belt asteroid sample), they can be designed to be incorporated into a mission specific "cartridge" also allowing rapid robotic removal and replacement. In terms of spacecraft design, the primary structural frame of the recycler could allow a pre-planned component improvement program so each refit, as it is needed, incorporates better, more modern technology. This applies to spacecraft systems as well as improved, miniaturized science instruments. Additional benefits from such a vehicle and mission include improved protection of samples from thermal effects of re-entry and implementation of stringent Planetary Protection requirements (through crewed interaction with samples prior to Earth return).

Science Benefit As one example of the benefits, the main asteroid belt consists of 26 "classes" of asteroids, as defined by the Small Main-Belt Asteroid Spectroscopic Survey (SMASS). This is material left over from the early assembly of the Solar System but it was spared incorporation into planetary bodies and so retains much of the chemical, mineralogical, morphological, and isotopic signatures of the young Solar System. The asteroids range from silicate-rich "S" type bodies in the inner Solar System to carbonaceous "C"-type bodies which predominate at the reaches of the Belt closes to Jupiter. While inferred matches can be surmised between asteroid spectral classes and meteorite types, only sample return can establish definitive ground truth that a given asteroid spectral class is appropriately assigned to a meteorite type.

Example Mission An illustration of one example "recycler" mission is a rendezvous and sample return mission to a potential Near Earth Asteroid (NEA). The most recent near-Earth pass for 2012 TC4 occurred on October 12, 2017 at 1:42 AM EDT at an altitude of 42000 kilometers over Antarctica. With a known closest approach orbit and a relative velocity of 7.65 km/s it represents a rendezvous challenge, but a still credible possibility, to match this velocity for the rendezvous and sample gathering and return to cislunar space. Other asteroids, such as the asteroid 2000

SG344 (at 20-89 m in size) and with a relative velocity of 3.56 km/s represent a more interesting mission possibility. Finally, objects with slower relative velocities, or objects closer to the inner solar system or objects in the main asteroid belt may offer more credible opportunities for sampling if a platform is already standing by, waiting in orbit and able to begin an intercept mission on short notice. Of interest in this category might be the main belt "active" asteroid 7968 Elst-Pizarro that also exhibits comet-like dust activity (such as the development of a coma or tail). With the advent of multiple "on-call" sampling and sample return mission capability, asteroids such as the main belt asteroid 253 Mathilde also become credible targets. With a 52.8 km diameter and a C-type asteroid with a bulk density of 1.3 g/cm^3 and a porosity > 50%, and with craters larger than its radius, it represents an interesting investigation into the formation of the early solar system.

Summary: The recycler is a mission concept that capitalizes upon a crewed presence in cislunar space to comprehensively sample multiple locations in the Solar System, using robotic sample return spacecraft, and thus significantly expanding the understanding of the young Solar System.