SHEPHERD, A GAS-FILLED ENCLOSURE FOR ASTEROID HANDLING AND RESOURCE UTILIZATION. B. Damer[1], P. Jenniskens[2], C Calva[1], [1]FlowSpace, PO Box 830, Boulder Creek CA 95006 (bdamer@digitalspace.com), [2]SETI Institute, 189 N Bernardo Av ste 200, Mountain View, CA 94043 (petrus.m.jenniskens@nasa.gov).

Introduction: SHEPHERD is a concept for gentle capture (with no hard surface contact) with an near-Earth asteroid (NEA), within a gas-filled fabric enclosure. Friction with the gas will enable de-spinning and de-tumbling of the NEA. Solar powered pumps and ductwork emitting and returning a gas (such as xenon) via a system of nozzles allows waves of gas to be projected to a presenting surface of the NEA. These waves impart a driving force delta-v to change the orbit of the asteroid (fig 1). Coupled with thrust from an external solar electric propulsion system the entire assembly is coupled into a synchronized movement and the asteroid can be repositioned. Delivery and release of some target NEAs in pristine condition to lunar orbit for crewed sampling is possible in a reasonable period of time (2-4 years). The enclosure must be kept safely centered on the position of the NEA during the driving phase. The differential pressures exerted on the NEA and surface regolith will be much less than the expected cohesion forces of weakly consolidated rubble piles, and therefore the NEA can be safely handled.

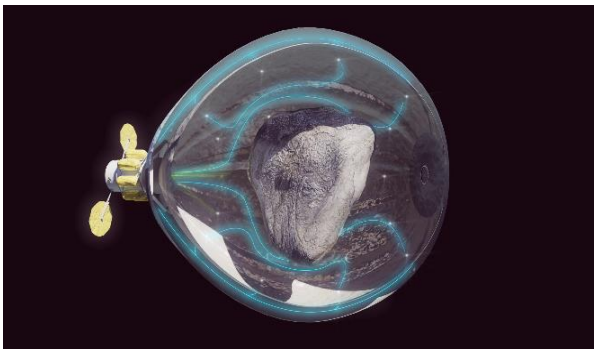

Fig 1: SHEPHERD illustrating NEA managed by gas flow within a sealed fabric enclosure

Technical Challenges: The encapsulation of an asteroid requires the extension of a helium balloon fabric bag with an open end which after extension around, but not touching the NEA, must be sealed (fig 2). Perfect seal closure of fabric through tightening self-sealing material around a closure plug has been proposed but is at a low TRL. Other technical challenges include the automated station keeping of the object within the enclosure and ameliorating the effects of dust and small objects lifted off the NEA through interaction with the gas.

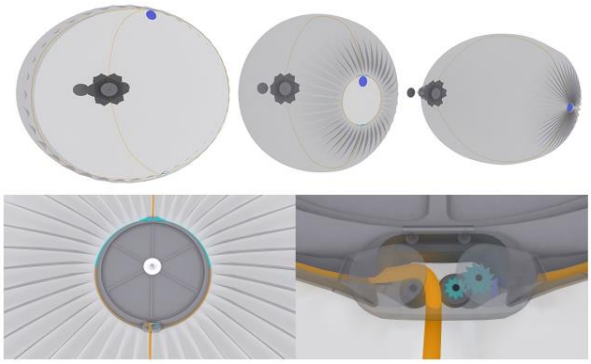

Fig 2: SHEPHERD encapsulation and seal closure

Applications: Originally proposed for the NASA ARRM program [1] the SHEPHERD concept is now in commercial development for a number of missions: as a platform for satellite servicing, and for a future system for resource extraction from NEAs. By heating the gas in the enclosure, volatiles contained in the NEA can be sublimated into the gases and returned via ductwork to condense and fill tanks. Water and other volatiles can be separated into fuels and consummables to supply deep space missions such as those planned to take human crews to Mars (fig 3). SHEPHERD can also be used to 3D print large parts in space using carbonyl gas extraction from encapsulated metallic NEAs and to form liquid biospheres from rock-ice asteroids to feed mission crew, space stations or habitats.

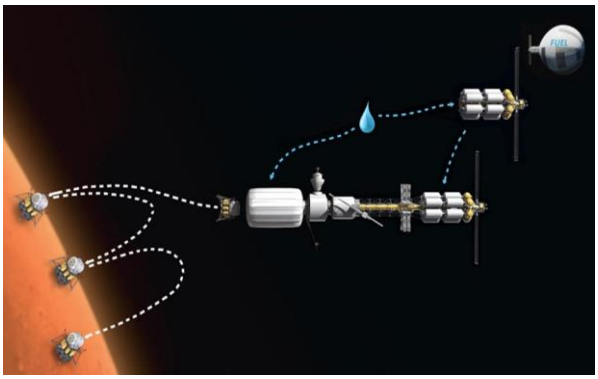

Fig 3: SHEPHERD delivery of fuel and consummables to a crewed Mars mission

References: [1] Muirhead B. (2013). ARRM. *NASA Reports.* [2] Jenniskens P. et al. (2015) *New Space*, 3, 1: 36-43.