A Mars Sample Return Sample Handling System

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We present a sample handling system, a subsystem of the proposed Dragon landed Mars Sample Return (MSR) mission [1], that can return to Earth orbit a significant mass of frozen Mars samples potentially consisting of: rock cores, subsurface drilled rock and ice cuttings, pebble sized rocks, and soil scoops. The sample collection, storage, retrieval and packaging assumptions and concepts in this study are applicable for the NASA's MPPG MSR mission architecture options [2].

Our study assumes a predecessor rover mission collects samples for return to Earth to address questions on: past life, climate change, water history, age dating, understanding Mars interior evolution [3], and, human safety and in-situ resource utilization. Hence the rover will have "integrated priorities for rock sampling" [3] that cover collection of subaqueous or hydrothermal sediments, low-temperature fluid-altered rocks, unaltered igneous rocks, regolith and atmosphere samples. Samples could include: drilled rock cores, alluvial and fluvial deposits, subsurface ice and soils, clays, sulfates, salts including perchlorates, aeolian deposits, and concretions. Thus samples will have a broad range of bulk densities, and require for Earth based analysis where practical: in-situ characterization, management of degradation such as perchlorate deliquescence and volatile release, and contamination management.

We propose to adopt a sample container with a set of cups each with a sample from a specific location. We considered two sample cups sizes: (1) a small cup sized for samples matching those submitted to in-situ characterization instruments, and, (2) a larger cup for 100 mm rock cores [4] and pebble sized rocks, thus providing diverse samples and optimizing the MSR sample mass payload fraction for a given payload volume. We minimize sample degradation by keeping them frozen in the MSR payload sample canister using Peltier chip cooling. The cups are sealed by interference fitted heat activated memory alloy caps [5] if the heating does not affect the sample, or by crimping caps similar to bottle capping. We prefer cap sealing surfaces be external to the cup rim to prevent sample dust inside the cups interfering with sealing, or, contamination of the sample by Teflon seal elements (if adopted).

Finally the sample collection rover, or a Fetch rover, selects cups with best choice samples and loads them into a sample tray, before delivering it to the Earth Return Vehicle (ERV) in the MSR Dragon capsule as described in [1] (Fig 1). This ensures best use of the MSR payload mass allowance. A 3 meter long jointed robot arm is extended from the Dragon capsule's crew hatch, retrieves the sample tray and inserts it into the sample canister payload located on the ERV stage. The robot arm has capacity to obtain grab samples in the event of a rover failure. The sample canister has a robot arm capture casting to enable capture by crewed or robot spacecraft when it returns to Earth orbit.

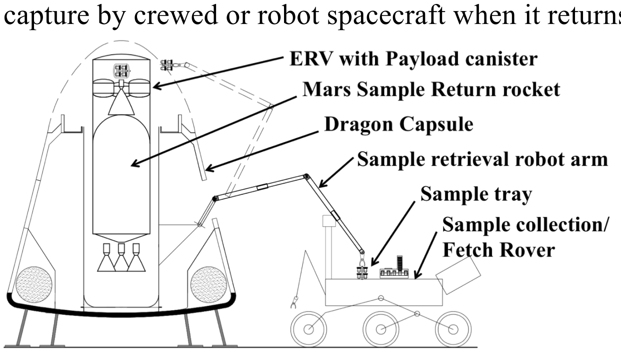

Fig 1: Loading samples into a Dragon landed MSR

[1] Lemke et al. 2013, IPP workshop 10, San Jose CA June 17-21, 2013
[2] MPPG Summary of final report, 2012 NASA at http://www.nasa.gov/offices/marsplanning/home/,
[3] Planning for Mars Returned Sample Science: Final report of the MSR End- to-End International Science Analysis Group (E2E-iSAG), 101 pp., posted December, 2011, by the Mars Exploration Program Analysis Group (MEPAG) at http://mepag.jpl.nasa.gov/reports/.
[4] Zacny et al. 2013, LPSC 1331,
[5] Younse et al. 2013, LPSC 1198.