**SAMPLE HANDLING AND PROCESSING ON MARS FOR FUTURE IN SITU MISSIONS.** L. W. Beegle[1] J. C. Soto[2], J. Lasnik[2] and S. Roark[2], [1]Jet Propulsion Laboratory, 4800 Oak Grove Dr., Pasadena Ca, 91109-8099, Luther.Beegle@jpl.nasa.gov, [2]Ball Aerospace & Technology Corp. jsoto@ball.com, jlasnik@ball.com, seroark@ball.com

**Introduction:** *In situ* technologies are currently being developed that have sensitivities approaching terrestrial laboratories and a compelling case can be made for lower cost/risk *in situ* investigations. State-of-the-art detection techniques with very high sensitivity can play a major role in determining the pathway for Mars exploration over the coming decades. Technologies have been developed that enable astronauts to perform scientific research as well as make key in situ robotic measurements that are required for astronaut safety such as identifying soluble toxic species and life detection.

In order for samples to be analyzed for fragile biomarkers, they need to undergo sometimes intensive sample processing [1]. When each instrument is designed with its own processing unit, many of the same functions are duplicated and more mass is required than if duplicate functions are consolidated. A centralized processing station that provides several instruments with the type of sample that they require would result in analytical instruments being developed that have lower mass as a group than they would have individually (i.e. the whole suite would weigh less than the sum of the individual independent instruments). Laboratory investigations of organic material present in rock and soil samples collected from terrestrial environments inevitably include some form of solvent extraction for wet chemistry analysis. For most biologically relevant molecules, solvent extraction gently removes organic molecules trapped inside rocks. After this step, filtering particulates and removing soluble ions that can mask biological samples, is necessary to gain both detection and quantification of organic molecules. Solvent extraction has the following advantages over other techniques:

- Solvent extraction leaves organics intact (i.e. no fragmentation) which is crucial when attempting to determine the difference between biotic and abiotic organic material by avoiding degradation of heat-sensitive functional groups.
- Quantitative results tend to be more reproducible and less dependent on the matrix material of the bulk field sample when compared with pyrolysis.
- Lower limits-of-detection of organics are possible through the concentrating of samples in solution by removing excess solvent before analysis.
- Direct interface into conventional instruments is easily achievable, which is in contrast to alternative techniques such as supercritical fluid extractions with $CO_2$.

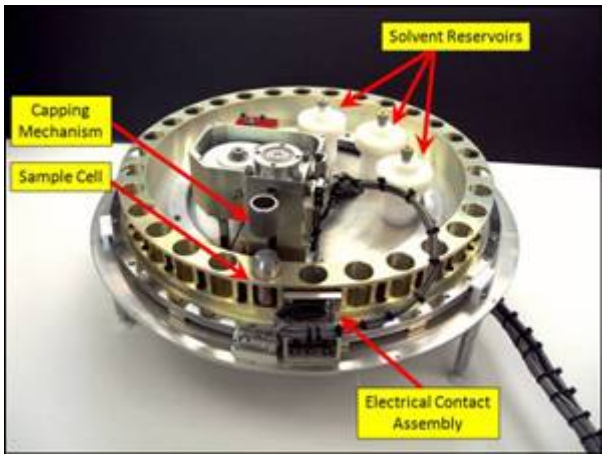
**WASP SYSTEM DESCRIPTION:** We have developed a **W**et-chemistry **A**utomated **S**ample **P**rocessing (WASP) system to TRL-5 that consists of a sample inlet sub-system, carousel, sample cells, heaters, solvent reservoirs, post processing system and distribution sub-system to multiple different analytical instruments. The WASP receives fines, extracts organics through solvent extraction, processes the extract by removing non-organic soluble species and delivers sample to multiple instruments for analysis (including for non-organic soluble species). The system is complete it will have the following performing metrics for terrestrial field testing:

- **Number of samples: 30.** On future flight missions the number of samples to be analyzed would be developed given total mission constraints but is expected to be able to be between 20-100 samples.
- **Quantity of sample to be analyzed: 100 mg.**
- **Number of different solvent combinations: 3.**
- **Maximum temperature and pressure: 200°C and 2000 PSI.** The WASP is fully programmable, so any parameters from room temperature to the maximum can be programmable.
- **Minimal cross sample contamination.** Samples would flow into the system from the same distribution point delivered there by an arm, and solvent + organic have to flow out of the WASP and into the analytical instrumentation. The allowable percentage of cross sample talk has to be well below the percentage from the main sample acquisition apparatus.
- **Minimal cross instrument contamination.** The fluid used in this apparatus should not contaminate the rover environment. The cells need to stay sealed after use, with minimal fluid escape, over mission life times.
- **Sample transfer to multiple instruments.** In order for a facility instrument to be mass effective, fluid must be able to be transferred into multiple instruments.
- **Planetary Protection, ATLO and Cruise.** For a flight mission, the WASP would have to undergo sterilization to meet planetary protection requirements.

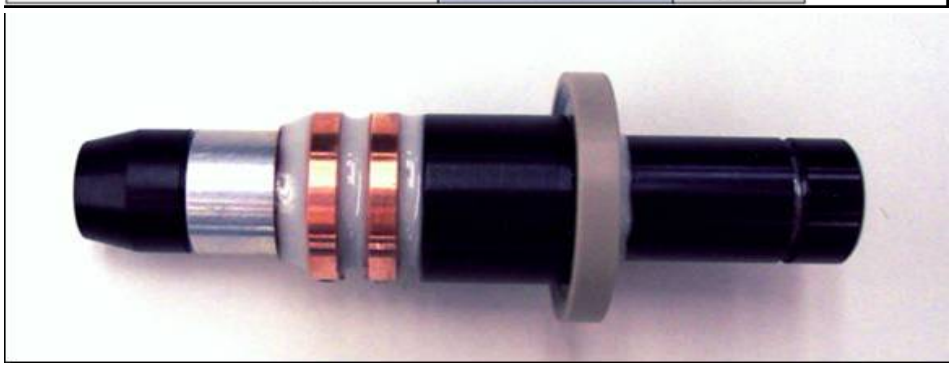
For a flight system, many of these parameters can be changed, where needed for scientific investigations.

**Capping description:** The key technology developed was the cell capping system. The cells were initially designed for a one time use application and later modified to be multi use to facilitate development and field testing. The cap and sample cell pair can be seen in the figure below. Sealing is handled by and O-ring, and the cap retention are held in place by a C-clip. The Cap and Test Cell are designed to be compatible with rigid and malleable polymer O-ring seals, allowing for off the shelf components. The latest design allows for a removable seal gland to disassemble the cap from the test cell. The cells have been tested to 2000 psi and heated to 220°C. The heating of the test cell was initially designed to use a custom Mica heater but later development replaced it with a COTS 1" 30-watt Kapton heater. Heat management is accomplished through the LabVIEW software sub-routines using an external infrared sensor. Testing was performed with 100% methanol as a solvent. No leakage of solvent occurred in any of the 20 tests that we preformed.

The end-to-end field deployable WASP system including sample carousel flight proven actuators and computer control (but excluding sample cells and solvents) has a mass of 13.7kg and is considered worse case as no effort was made to reduce sample mass. Each of the current 30 sample cells has an estimated mass of 0.039 kg. It can operate for multiple back end instruments including ones to measure dust toxicity, organic content, and other soluble inorganic detection investigations.







**Challenge areas:** this work directly relates to challenge areas 5 and 18.

**References:** [1] Beegle, L. W., et al., (2007). A concept for NASA's mars 2016 astrobiology field laboratory. Astrobiology 7 (4): 545-577. [2] Beegle, L.W. et al. (2011) Automated Sample Handling and Processing on Mars for Future Astrobiology Missions. Aerospace Conference, 2011 IEEE, paper #1602.