National Aeronautics and Space Administration

FY24 Strategic Initiatives Research and Technology Development (SRTD)

Enceladus and Mars Sample Handling System for SCHAN Life Detection Instrument

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Strategic Focus Area: In-Situ Extant Life Detection Technology **| Strategic Initiative Leader:** Victor S Abrahamsson

Objectives:

- Develop a sample handling and distribution system (SHaD) and integrate it with the Supercritical CO2 and Subcritical H2O Analysis instrument (SCHAN) for Enceladus (TRL5) and Mars (TRL4) lander mission applications.
- Enceladus system (E-SHaD) - complete TVAC tests for the fully integrated Enceladus system with SCHAN in 100 mTorr pressure and -40 ˚C temperature; integrated system TRL5.
- Mars system (M-SHaD) - demonstrate receiving 1 cc (ml) sample and process the sample by holding 22 MPa pressure at 200 ˚C, and then transfer the sample to the SCHAN instrument; integrated system TRL4.

Background:

- The NASA Decadal Survey covering missions for the next decade identified an Enceladus mission which collects plume material as a high priority both as a flagship mission and for a New Frontiers program mission. Plumes in the southern region of Enceladus continuously emit material from the subsurface ocean. A primary objective of an Enceladus mission would be to analyze plume material to detect evidence of life in the subsurface ocean if it exists there.
- The SCHAN instrument is a prime candidate to perform this life detection analysis.
- The instrument requires a dedicated front-end sample handling system specific to the mission applications. Developing a specific sample handling system is especially important as it has a big impact on the overall system performance. This task developed the needed sample handling front end for the SCHAN instrument for Enceladus and Mars lander applications (Figure 1).

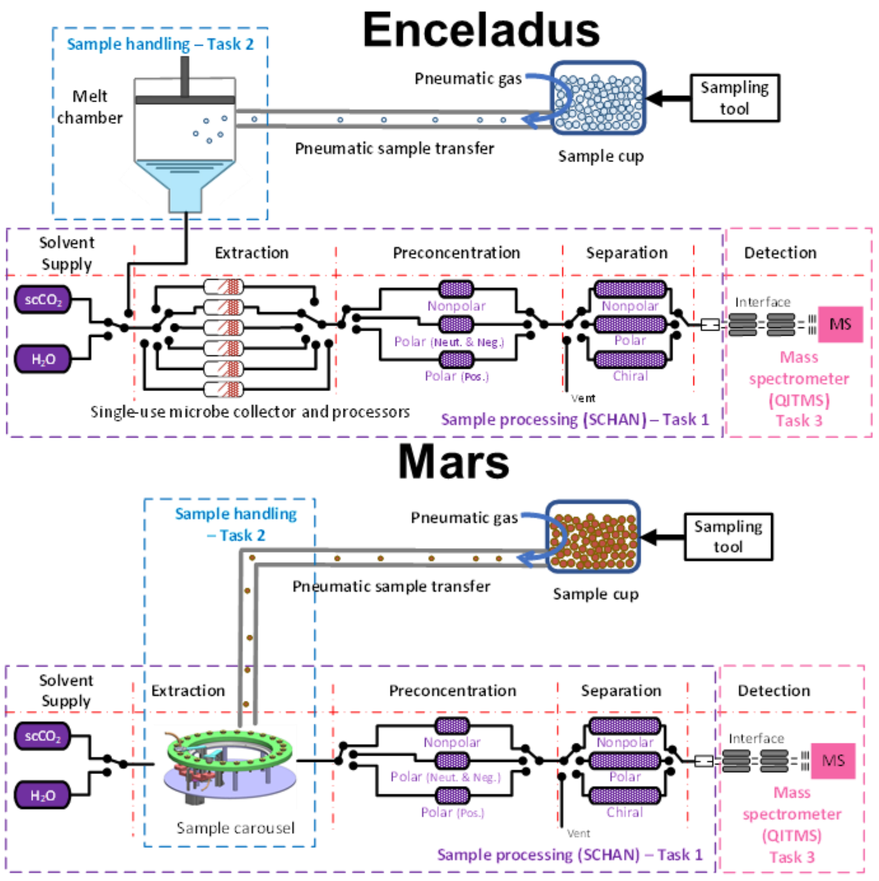

Figure 1 Block Diagram of the Life Detection System shown in an Enceladus configuration (top) and a Mars configuration (bottom)

Approach and Results:

- 7 milestones for the FY24 task: 1) complete the design and analysis of Mars TRL4 sample handling configuration to accommodate 1 cc (ml) sample volume and process at 200 °C and 22 MPa pressure; 2) IEEE Aerospace Conference paper presenting the work status; 3) complete TRL5 TVAC tests for the fully integrated Enceladus configuration with the SCHAN instrument in 100 mTorr pressure and -40 °C temperature; 5) complete the fabrication and assembly of the Mars TRL4 unit; 6) demonstrate TRL4 Mars unit testing to receive 1 cc (ml) sample and hold 22 MPa pressure and 200 °C temperature; 7) demonstrate the TRL4 M-SHaD integrated with SCHAN and QITMS instruments functionality of solid sample processing and transfer for detection of fatty acids at <10 ppb.
- The TRL5 E-SHaD was developed in the previous FY and was integrated with the SCHAN instrument and a mass spectrometer for demonstrating the functionality and TVAC testing. The functionality was demonstrated by placing the E-SHaD in a freezer at -40 ˚C and atmospheric pressure. The E-SHaD was then integrated with the SCHAN instrument and an off-the-shelf mass spectrometer to complete TVAC tests in 100 mTorr pressure and -40 ˚C temperature to represent the conditions under the lander deck, to bring the integrated system to TRL5 (Figure 2). Testing is in progress. Documentation for the TRA is being prepared.
- The TRL4 M-SHaD design was configured with multiple single-use chambers capable of processing 1 cc (ml) sample at 200 ˚C temperature and 22 MPa pressure. The chambers have a cylindrical shape with access and single use face seals at both ends, were placed on a carousel for locating between a pneumatic sample transfer station and a sample processing station. The design and analysis of the critical components were completed, the parts were fabricated and assembled, and the unit was tested before integration with the SCHAN instrument drive electronics (Figure 3) for integrated testing and functionality demonstration.

Significance of results/benefits to NASA/JPL:

- The SCHAN instrument could be used for life detection in a Mars, Enceladus, or other ocean world mission. The SCHAN instrument will provide unique capability of detecting ppb-level chemical biosignatures from as few as ~10-4 cell/g of live or dormant organisms.
- The SCHAN instrument, with the dedicated sample handling system, now at TRL 5 (Enceladus) and TRL 4 (Mars), could be used in a NF5 mission to Enceladus, in an Orbilander-type flagship mission or Mars Life Explorer (Search for Life) mission.

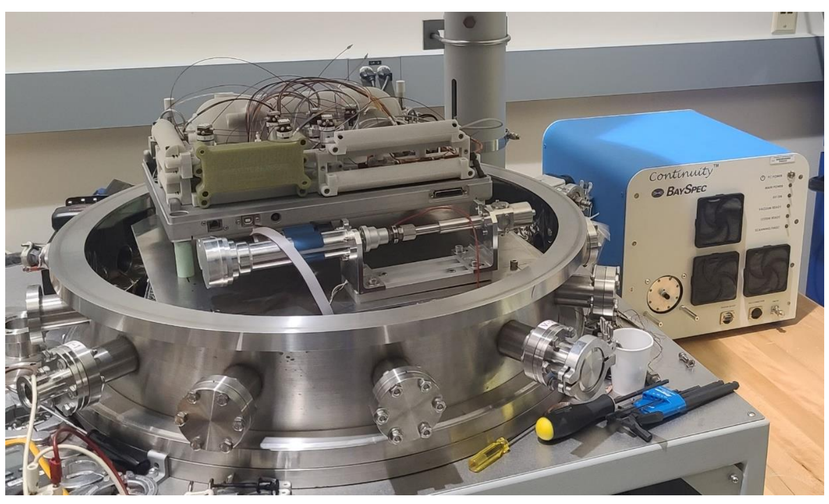

Figure 2 TRL5 E-SHaD integrated with the SCHAN instrument and an external off-the-shelf mass spectrometer for TVAC testing

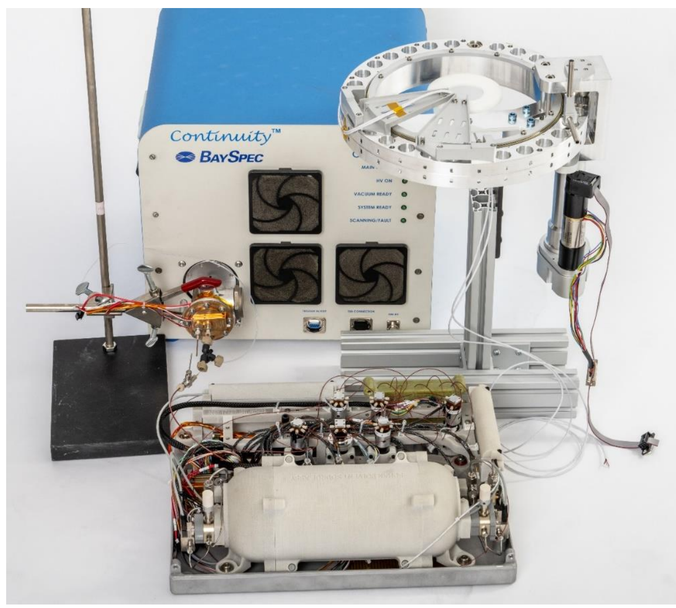

Figure 3 TRL4 Mars sample handling system integrated with the SCHAN instrument and off-the-shelf mass spectrometer**.**

Publications:

1. M. Badescu, T. Okamoto, V. Abrahamsson, P. Backes, F. Zhong and B. L. Henderson, "Enceladus Sample Handling System for SCHAN Life Detection Instrument," 2024 IEEE Aerospace Conference, Big Sky, MT, USA, 2024, pp. 1-9, doi: 10.1109/AERO58975.2024.10521127.
2. Henderson, B. L., V. Abrahamsson, M. Badescu, S. Madzunkov, F. Zhong, T. Okamoto, P. Backes, H. Kraus, A.F. Davila, J. Prothmann, W. Schubert, F. Chen, A. Williams, M. Tuite, Y. Lin. “Pushing the Limits of In-Situ Organic Detection”. *2024 Lunar and Planetary Sciences Conference*, LPI Contributions 3040, The Woodlands, TX, 2024.
3. Abrahamsson, V., B. L. Henderson, M. Badescu, S. Madzunkov, F. Zhong, T. Okamoto, P. Backes, H. Kraus, W. Schubert, F. Chen, Y. Lin, A.F. Davila, A.J. Williams, M. Tuite, “Towards Integrated Organic Biosignature Analysis on Mars and Ocean Worlds: From Sample Handling to Detection with the SCHAN Instrument”. *2024 Astrobiology Science Conference*, AGU, Providence, RI, 2024.

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