

Space Studies of the Earth-Moon System, Planets, and Small Bodies of the Solar System (B)
Mars Sample Return (B4.4)
Consider for oral presentation.

TOURS OF HIGH-CONTAINMENT AND PRISTINE FACILITIES IN SUPPORT OF MARS SAMPLE RETURN (MSR) SAMPLE RECEIVING FACILITY (SRF) DEFINITION STUDIES

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During 2019 and 2020, the NASA Tiger Team RAMA (acronym of the authors) toured several high-containment biosafety laboratories and pristine space-mission facilities worldwide to better understand their practices, capabilities, and lessons-learned to aid in planning a Sample Receiving Facility (SRF) in support of Mars Sample Return (MSR). The team also included tours of a manufacturer of mobile and modular high-containment facilities as well as manufacturers of isolators and gloveboxes. In addition, the team visited the European Space Agency (ESA) ultraclean and sterile ISO 3 / airborne molecular contamination -9 (AMC-9) isolator line to clean and assemble the most critical hardware for ESA's ExoMars Mars Lander System, and researchers developing a novel double-walled isolator (DWI) and robotic handling techniques in support of an MSR SRF. The RAMA team visits covered several construction modalities for an MSR SRF: (1) a new traditional fixed facility; (2) use of an existing fixed Biosafety Level 4 (BSL-4) facility; (3) a novel modular BSL-4 approach; and (4) a hybrid combination of fixed, modular, and existing facilities.

A new fixed facility approach can be tailored to MSR's needs and is the approach used by all U.S. BSL-4 laboratories constructed to date. However, this approach could be the most expensive modality, take the longest to implement (8-12 years), and have significant programmatic risk of delay. The utilization of an existing BSL-4 facility may be possible depending on the final contamination control and science requirements for the MSR SRF. Due to the internal dimensions of the labs visited and facility structural requirements, it is unlikely that any modification can be made to the facility to meet cleanliness requirements. Furthermore, due to possible construction delays, possible capacity issues, and potential cross contamination vectors from in-house select agents, there may also be significant programmatic risks for sharing an

existing facility. Another approach is building a contemporary modular facility. This is a novel approach that has recently been used for a BSL-3/3Ag facilities. The modular elements would be installed in a traditional building or shell structure. A modular facility has many advantages over a traditional fixed facility with lower costs, shorter design/construction/ commissioning schedule, and flexibility for easier retrofits and future expansion. Lastly, a hybrid approach of combining the use of either: (1) a modular facility inside a new fixed facility or (2) a modular and/or fixed BSL-4 annex in conjunction with an existing BSL-4 space should be considered. The advantage of a hybrid approach is that the facility could leverage the strengths of other approaches.

Beyond facility construction approaches, the RAMA team investigated technologies and techniques for isolating and handling Martian samples in pristine environments. For example, ESA has been studying and developing a DWI breadboard along with other sample-handling technologies. The research and development investment for clean, remote manipulation and robotics at the start of the facility design phase would be beneficial to the SRF. Additionally, understanding the lessons learned from Thales Alenia Space during the construction and operation of the most advanced state-of-the-art precision cleaning, sterilization, and assembly glovebox isolators ever developed for spacecraft hardware are also critical for the SRF.

The RAMA team lays out a summary of the 18 facilities toured, and includes 43 observations, 18 findings, and 22 areas of possible follow-up that the RAMA team and others could pursue to enable further findings. The observations and findings illustrate that constructing an MSR SRF would combine the complexity of both high-containment and pristine facilities, and merging these technologies would be challenging, but achievable.