The Mars Sample Return Lab(s) — Lessons from the Past and Implications for the Future

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Introduction: It has been widely understood for many years that an essential component of a Mars Sample Return mission is a Sample Receiving Facility (SRF). The purpose of such a facility would be to take delivery of the flight hardware that lands on Earth, open the spacecraft and extract the sample container and samples, and conduct an agreed upon test protocol, while ensuring strict containment and contamination control of the samples while in the SRF.

Any samples that are found to be non-hazardous (or are rendered non-hazardous by sterilization) would then be transferred to long-term curation. Although the general concept of an SRF is relatively straightforward, there has been considerable discussion about implementation planning.

Design Studies: The Mars Exploration Program carried out an analysis of the attributes of an SRF to establish its scope, including minimum size and functionality, budgetary requirements (capital cost, operating costs, cost profile), and development schedule. The approach was to arrange for three independent design studies, each led by an architectural design firm, and compare the results. While there were many design elements in common identified by each study team, there were significant differences in the way human operators were to interact with the systems. In aggregate, the design studies provided insight into the attributes of a future SRF and the complex factors to consider for future programmatic planning [1].

Based on the analysis and interpretation of the industry study concepts, the following considerations are suggested for planning an SRF to meet the needs of a future MSR mission:

(1) Design. There is more than one possible design for a stand-alone SRF that would meet the requirements of MSR. Because the full set of requirements is not defined at this time, it is not possible to optimize the design. However, it is possible to understand the likely possibilities enough to generate first-order budgeting and planning parameters.

(2) Size. A minimal stand-alone SRF is estimated to have an overall size of about 35,000–60,000 square feet, including 25,000–40,000 square feet of containment related space that makes up the facility core (of which 5,000–10,000 square feet are the high-containment laboratory rooms; the remainder would consist of facility support systems including air handling, chemical showers, waste cookers, etc.), up to 5,000 square feet of high-containment lab support space (test and repair shops), and 10,000–15,000 square feet of office, administrative, and logistical support space (including storage and security).

(3) Schedule. The schedule needed to construct and commission an SRF is estimated to be 7–9 years. Most of this variance relates to whether NASA uses an internal or an external site selection process. Because of the schedule-constrained nature of an MSR (*i.e.*, once the samples have left Mars, spacecraft trajectories have a defined schedule that cannot be easily slipped), it is prudent to add additional schedule reserves, and a good planning number is 10 years.

(4) Capital cost. The cost of an SRF would depend upon the specific design approach, as well as on the final test protocol executed in the facility. However, for future planning a reasonable budget estimate is the escalated equivalent of $120 million real-year dollars.

(5) Operating cost. During the years the martian samples would be evaluated in the facility, the annual building operating budget would be estimated at $7 million, which includes a building operations staff of 20–30 persons. This estimate does not include the large number of personnel that would be required to carry out the work of a test protocol for detecting possible life and biohazards.

(6) Advance technology development. Most of the technology needed to design and construct an SRF already exists in the biosafety, pharmaceutical, and sample curation communities. However, along with decontamination techniques, double-walled glovebox containment, dexterous ultra-clean robotics, pristine sample preservation, and scientific equipment required for proper sample analysis, some aspects of the project will need to be planned at two specific points in the building life cycle: (a) those that affect the facility design and will need to be known before facility construction, (b) those that affect the instrumentation, the experiments, or both, that will need to be known before the facility is equipped.

(7) Partnering opportunities. Although not fully analyzed in the industry study concepts, it is likely that partnering opportunities might result in cost savings, operational efficiency, or other benefits. Such opportunities could be evaluated against the reference planning parameters described above to determine whether this would be a better way to meet the needs of an MSR than with a stand-alone SRF.

References: [1] Beaty, D.W. *et. al*. (2009) *Astrobiology, 9*, 745-758.