MARS SAMPLE RETURN: CONSIDERATIONS FOR THE CURATION OF ASTROMATERIALS FROM A RESTRICTED PLANET.

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Introduction: The joint NASA/ESA Mars Sample Return (MSR) campaign is underway. The MSR collection would represent the most geologically diverse astromaterial collection ever returned and should provide information on topics ranging from Martian geological and biological history to Martian environmental hazards and *in situ* resource utilization to support potential human exploration [1]. Although Jezero Crater and the surrounding area are not Mars special regions, the scientific opinion is that Mars as a whole is of significant interest to the process of chemical evolution and/or the origin of life. Therefore, due to possibility, however remote, that the samples could contain extraterrestrial life, MSR is classified as a *Category V: Restricted Earth Return* mission by the NASA Planetary Protection Office. As a result of this classification, a MSR Sample Receiving Facility (SRF) must not only provide a pristine environment to ensure samples are protected from terrestrial contamination for scientific investigations, but it must also provide high-containment to isolate the samples from Earth's biosphere until the samples are deemed safe for release in a pristine state and/or sterilized.

Background: The SRF is first and foremost a curation facility, however it will be utilized for an array of tasks and scientific objectives, including:

- Receive samples within the flight hardware
- Deintegrate the sample tubes from the hardware and put in a stable state
- Characterize the sample within the tubes
- Open the sample tubes and extract samples
- Perform initial sample characterization/cataloging
- Conduct a sample safety assessment
- Execute preliminary examination of samples
- Enable select competed/early science
- Prepare, sterilize, and distribute samples for science outside of the SRF
- Sample isolation/storage

The SRF is not intended to be the long-term curation facility for Martian samples. The nominal utilization period for the SRF is anticipated to be 2-5 years. However, to account for possible delays in schedule or the identification of extant life, this anticipated period of time must be flexible to accommodate schedule extensions and contingency plans. Due to the high-containment requirements, a traditional receiving/curation facility cannot be utilized for MSR.

Planning Strategy: As a result of the complexity of designing, constructing, and operating a contamination-controlled high-containment facility, NASA initiated an assessment of current technologies. Personnel toured both contamination-controlled and high-containment facilities around the world, exploring the implementation of new technology and standard practices. The report, entitled: "Tours of High-Containment and Pristine Facilities in Support of Mars Sample Return (MSR) Sample Receiving Facility (SRF) Definition Studies" compiles the knowledge of experts in their fields and offers recommendations for the best path forward [2]. NASA and ESA have used this data, as well as outputs from numerous MSR science working groups, to perform the Mars SRF Assessment Study (MSAS) and the European Extraterrestrial Sample Infrastructure (EETSI) System Study.

While EETSI investigated the preliminary design, costs, and schedules for new, traditionally built fixed SRF and Sample Curation Facilities (SCF), MSAS was a scoping study, designed to assess the feasibly of utilizing traditional versus more novel infrastructure, specifically:

1. Lease and renovation of existing space
2. Construction of a new, traditional fixed facility
3. Construction of a modular facility (new or within an existing building)
4. Construction or renovation of a hybrid facility to address requirements with multiple modalities that may include a combination of modalities 1-3.

The assessment also considered the following aspects of the SRF for each modality:

- Ability to meet requirements
  - Regulatory
  - Planetary protection
  - Contamination control
  - Science and curation
- Ability to meet changing needs for equipment, timelines, and facility use
- Timelines for design, construction, commissioning, installation of equipment, testing, training, and operational readiness drills
- Cost for construction and operation, including those associated with hazard resilience

- Ease of access for international users
- Decommissioning, repurposing, sale, or lease following use of the facility
- Uncontained preparatory laboratory spaces
- Uncontained ancillary spaces
- Waste management

The outputs for MSAS and EETSI have been critical to understand the potential trades and identify priorities for the SRF. However, while options were able to be refined, a second phase (MSAS2) will develop high-concept designs at multiple locations in order to optimize the technical capabilities, cost, and schedule of the SRF. As part of the next steps in planning, the NASA/ESA Mars Sample Receiving Project (SRP) Joint Curation Office (JCO) is: 1) developing a curation plan following guidelines from the NASA NPR 7100.5 [3], 2) supporting the international MSR Working groups (e.g., MSR Campaign Science Group (MSGC); Measurement Definition Team (MDT); Sample Safety Assessment Protocol (SSAP) Tiger Team), and 3) acting as the technical leads for the SRF requirements development (e.g., MSAS2; Location Request for Information (RFI)). Upon completion of MSAS2, the SRF design concepts would be utilized to inform site-specific design but the location of the SRF will not be finalized until NASA's completion of the National Environmental Policy Act (NEPA) process.

Closing: Every sample return mission offers scientists and engineers unique challenges and opportunities, MSR is certainly not an exception. While differences in robotics and spacecraft are often apparent, differences in the approach for the curation of a given collection are usually more nuanced. NASA's Astromaterial Acquisition and Curation Office, and other international space agency partners, have developed strong foundations of best-practices and lessons learned. Although MSR represents the first Restricted Earth return in five decades, the knowledge gained from the development and operations of the Lunar Receiving Laboratory are informing the potential curation strategies for MSR. Whether the SRF is reutilized by NASA for another Restricted Earth return or turned over to a partner for other types of high-containment work, the knowledge gained during technology development, SRF design, construction, and operations will lay the foundation for sample return missions for the next five decades.

Supporting Documents:

Mattingly R.L. et al. (2020) JPL/NASA Report http://hdl.handle.net/2014/50446