PLANNING MEASUREMENTS ON SAMPLES FROM MARS: STATUS REPORT FROM THE MARS SAMPLE RETURN (MSR) SAMPLE RECEIVING PROJECT (SRP) MEASUREMENT DEFINITION TEAM (MDT-1).

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Introduction: The planned joint NASA-ESA Mars Sample Return (MSR) Campaign is a multi-mission effort intended to bring scientifically selected samples of Mars rock cores, regolith, and atmosphere to Earth for the purpose of scientific investigation and discovery. The Mars 2020 Perseverance Rover continues to augment a stunningly diverse set of samples for potential return and the planning for the flight missions to retrieve and deliver the samples is underway.

Once the samples arrive on Earth they would pass into the custody of the Sample Receiving Project (SRP). The SRP would be responsible for realizing the scientific potential of the samples. In addition to achieving a defined set of scientific objectives, the SRP would be responsible for ensuring that the samples are held under high containment conditions according to planetary protection requirements. This will be necessary until such time as the samples can be deemed not to pose a threat to Earth’s biosphere via a Sample Safety Assessment Protocol (SSAP) or sterilization. Another key functionality of SRP will be curating and maintaining the scientific integrity of the samples for the duration of the Project, at which time they would be transferred to long term curation.

The currently envisaged high containment facility to which the samples would initially be delivered is referred to as the Sample Receiving Facility (SRF). Due to the long lead time needed to design and construct the SRF, it is necessary to start planning for the facilities and instrumentation needed inside the SRF as early as possible. It is strongly preferred to do as many measurements on the samples as possible in existing laboratories outside of containment for reasons including scientific quality and cost, but certain measurements will be needed to be made within the SRF. Sample investigations within the SRF would need to be carried out in support of the following three elements:

- **Initial Sample Characterization:** required to plan properly for the optimized use of the samples for curation, safety, and scientific purposes (for a recent summary, see [1]);
- **Safety Assessment:** implement a protocol derived from the Sample Safety Assessment Framework [2];
- **Science Investigations:** support time-sensitive [3] and sterilization-sensitive [4] investigations that cannot be done using sterilized samples outside of high containment.

To minimize the footprint, cost, and complexity of the SRF in handling the samples from Mars, it is crucial to define properly the minimum set of investigations, measurements, instrumentation, and operations concept required to cover the initial characterization, safety assessment, and science investigation needs. NASA and ESA have tasked the international Measurement Definition Team Phase 1 (MDT-1). While the overall process of the MDT is largely similar to traditional Science Definition Teams (SDTs), the scope of this MDT is distinct because it focused on the specifics of the measurement implementation plan, as well measurements needed for sample characterization and planetary protection.

**MDT-1 Statement of Task:**

The MDT was asked to perform four tasks (Fig. 1):

- **Task 1: Overarching Investigation Strategy**
  Determine options and priorities for activities inside and outside the SRF, providing a narrative rationale for the scientific basis underpinning the proposed investigations.

- **Task 2: Measurement Traceability Matrices**
  Develop traceability matrices flowing from objectives to investigations to measurements and required capabilities within the SRF.

- **Task 3: Reference Instrument Set**
  Provide description of proposed suite of instruments capable of collecting the needed measurements as well as interface requirements and any special accommodation considerations.

- **Task 4: Concept of Operations (ConOps)**
  Describe a feasible model concept of operations of activities to be conducted within the SRF that will maximize overall science return.
**Committee Details & Process:** The MDT-1 committee consists of twenty competed members of the international science community, co-chaired by Heather Graham and Chris Herd, an executive team consisting of Project Science representatives, as well as six ex-officio members representing NASA and ESA curation, the CDC, and liaisons with the Sample Safety Assessment Protocol Tiger Team (SSAP-TT).

The committee began by outlining investigation strategies that would allow the proposed scientific objectives of SRP to be achieved, prioritizing investigations with the highest potential to yield ground breaking science discoveries.

There are 17 proposed scientific objectives of SRP that flow down from four high level objectives:

1. Reconstruct the formation and alteration history of the returned samples to transform our understanding of the geological processes and environments of Mars (5 sub-objectives)

2. Determine the astrobiological significance of the martian geological record represented by the samples (3 sub-objectives)

3. Provide new insights into planetary-scale formation and evolution in the inner Solar System (6 sub-objectives)

4. Identify and characterize potential risks and opportunities for future human missions (3 sub-objectives)

The committee was organized into sub-groups that focused on developing the investigation strategies for each sub-objective and then proceeded to propose corresponding observations, measurements, and measurement techniques that would be optimized to carry out these investigation strategies in the form of a measurement traceability matrix. For measurements that would need to take place inside the SRF, the MDT-1 has also proposed performance requirements and reference instruments.

In order to generate a similar measurement traceability matrix for the sample safety assessment protocol, members of the MDT-1 have worked with the SSAP-TT, which has been tasked with developing the next steps in the sample safety assessment protocol.

The matrix of measurements needed for initial sample characterization has been derived from an analysis of what sample properties would need to be known in order to properly allocate sub-samples for all of the previously determined investigations.

Specific criteria were used to determine whether a measurement should be done within the SRF in order to determine which set of measurement techniques needed to be explored down to the level of instrument performance requirements and reference instruments (Fig. 2).

**Next Steps:** Once MDT Phase 1 has completed its work, the traceability matrix and reference instrument list for the SRF would become inputs into future SRF design studies as well into the future Announcement of Opportunity (AO) for competed instruments to be installed in the SRF. A future committee may be needed to refine the concept of operations for the measurements to be performed within the SRF, which would also feed into further studies. A next iteration of the Measurement Definition Team would be formed closer to the expected date of sample arrival on Earth and could be tasked to refine planning for measurements to take place outside of the SRF, in PI-led laboratories, to inform the AO for those investigations.

**Disclaimer:** The decision to implement Mars Sample Return will not be finalized until NASA’s completion of the National Environmental Policy Act (NEPA) process. This document is being made available for informational purposes only.

**References:**