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Mars Sample Return (MSR) Sample Receiving Project (SRP) Measurement Definition Team (MDT-1): Overview and Status

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Introduction: The planned 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 is collecting a stunningly diverse set of samples for potential return. and the planning for the missions to retrieve and deliver the samples is underway.

The currently envisaged high containment facility to which the samples would initially be delivered is referred to as the Sample Receiving Facility (SRF). 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 appointed the international Measurement Definition Team Phase 1 (MDT-1). While the overall process of the MDT is similar to traditional Science Definition Teams (SDTs), the scope of this MDT is distinct because they must focus 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 (Figure 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.
- Measurement Traceability Matrices: Develop traceability matrices flowing from objectives to investigations to measurements and required capabilities within the SRF.
- Reference Instruments: Provide descriptions of proposed suites of instruments capable of collecting the needed measurements, as well as interface requirements and any special accommodation considerations.
- Concept of Operations (ConOps): Describe a feasible model concept of operations for activities to be conducted within the SRF that will maximize overall science return.

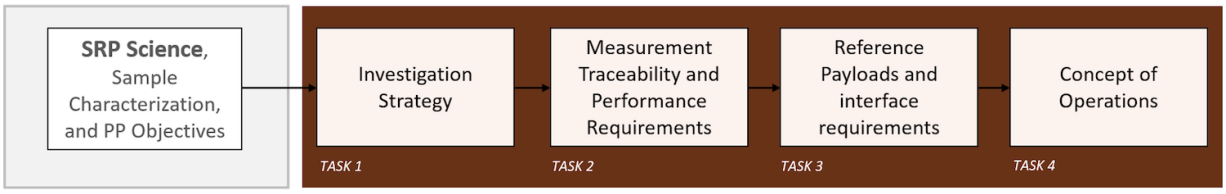

Figure 1. Generalized flow chart of MDT-1 Tasks.

MDT Composition: The MDT-1 committee consists of twenty competitively selected members of the international science community, co-chaired by Heather Graham and Chris Herd, an executive team consisting of Project Science representatives, and six ex-officio members representing NASA and ESA curation, the Centre for Disease Control (CDC), and liaisons with the Sample Safety Assessment Protocol Tiger Team (SSAP-TT).

MDT Process and Status: The essential deliverables of MDT are achieved via the sequential flow of Tasks 1-4 (Fig. 1), the starting point for which is a baseline set of science objectives. At a high-level, there are four proposed science objectives of Mars Sample Return, each of which are elaborated to form a total set of 17 proposed sub-objectives. These were formulated by the MSR Campaign Science Group (MCSG) [5], by adapting and building on proposed objectives laid out by numerous prior studies (e.g. [6]).

Since September 2023, MDT has first elaborated each of the 17 sub-objectives into specific research questions (Task 1), which were used to define specific measurements that can address them (Task 2).

A key step in MDT's workflow has been to establish and apply logic to determine whether a measurement would need to be done inside the SRF. The model conceived produces a minimum set of measurements to be done in the SRF such that the scientific integrity of samples is preserved, and thus science objectives may be addressed.

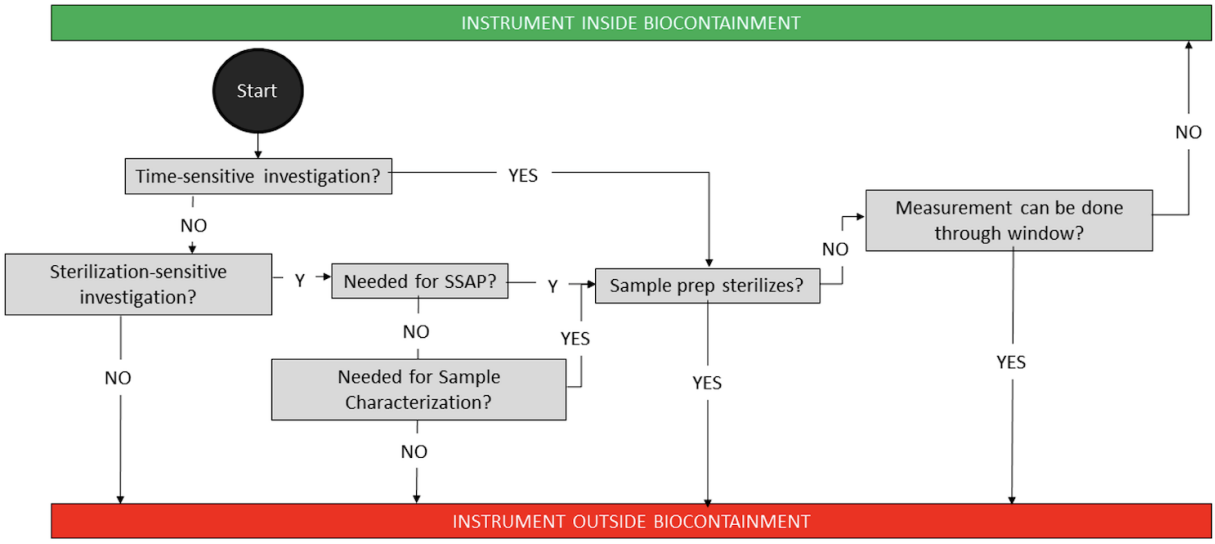

Figure 2. Logic for determining whether a measurement must be done within the SRF (i.e. within biocontainment).

Measurements determined necessary to be in the SRF were then grouped and linked to the corresponding set of reference instruments and complemented with additional information, including measurement performance requirements, sample preparation needs, instrument accommodation considerations and sample mass requirements. With the resulting dataset, fully backward traceable to measurements, investigations and science objectives, Task 4 (ConOps) was addressed.

Two aspects required specific treatment in MDTs work plan: 1. Work by the SSAP-TT resulted in measurement requirements that are incorporated into MDT's traceability matrix. Members of SSAP-TT and MDT-1 worked closely together to ensure that accurate and complete information was incorporated into measurement traceability. 2. Measurements necessary for initial sample characterization (e.g. box in Fig. 2) were established via a dedicated analysis of what sample properties must be known to properly allocate sub-samples for all the scientific 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.

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