INTERNATIONAL MARS ARCHITECTURE FOR THE RETURN OF SAMPLES (iMARS) PHASE II SCIENCE SUB-TEAM REPORT – SAMPLE SCIENCE MANAGEMENT PLAN. C. L. Smith[1], T. W. Haltigin[2], and the iMARS Phase II Science/Earth Operations Subteam[3-14]. [1]Dept of Earth Sciences, The Natural History Museum, Cromwell Road, London, SW7 5BD, UK. C.L.Smith@nhm.ac.uk. [2]Canadian Space Agency, 6767 Route de l'Aéroport, Saint-Hubert, Québec, J3Y 8Y9, Canada. timothy.haltigin@asc-csa.gc.ca., iMARS Phase II Science/Earth Operations sub-team (H. Amundsen[3], C. Conley[4], R. de Groot[5], A.-M. Harri[6], E. Hauber[7], G. Kminek[5], O. Korablev[8], D. Koschny[5], B. Marty[9], L. May[4], S. McLennan[10], M. Meyer[4], R. Orosei[11], S. Siljeström[12], N. Thomas[13], J. Vago[5], A. C. Vandaele[14], and L. Zelenyi[8])

Introduction: In 2006, the international Mars Architecture for the Return of Samples (iMARS) Working Group was chartered by the International Mars Exploration Working Group (IMEWG) to develop the scientific and engineering requirements for an internationally-supported and -executed Mars Sample Return (MSR) mission potentially occurring in the 2018-2023 timeframe. This iMARS "Phase I" effort produced consensus on an architecture for a baseline MSR mission, as well as several conclusions and suggestions for the next steps of campaign definition [1].

In 2013, IMEWG reaffirmed that returning Martian samples to Earth remains a high priority of the Mars exploration community and that a number of important developments have occurred since the initial Phase I work. IMEWG thus agreed to reconstitute iMARS and to proceed with the second phase of planning activities for an MSR concept. The iMARS Phase II kick-off meeting took place in March 2014 and the group's activity is scheduled to end in Spring 2015.

Phase II Goals and Principles: The group's overarching objectives were to: 1) incorporate developments since the publication of the Phase I work, and; 2) expand on the science management aspects that were recommended in the report [1-4], with developments in mission plans and technology since the initial report being of particular interest.

An MSR mission will, by definition, be multidisciplinary in nature and will require international participation for the successful implementation of all mission elements, from launch through to return of samples to Earth and their long-term use by scientists worldwide. All efforts were made to ensure that the team comprised international expertise on cosmochemical, geochemical, bioscientific, and management aspects. Here, we report on the ongoing work of the Science/Earth Operations sub-team.

In doing so, we seek feedback from our colleagues in the Mars exploration community. Because the aim is to propose a science management structure that will facilitate participation by a varied research community, it is imperative to incoporate the community's thinking on the many types of investigations that will be performed on the samples, the concept and design(s) of the planetary protection and preliminary examination activities, the sample containment facility(ies), and the downstream management of the samples for decades to come.

Sample Science Management Framework: As a starting point, the Phase II group was tasked to "...presuppose successful identification and collection of a set of samples …[and]… develop the framework of a sample management plan". In response, four key areas were identified at the kick-off meeting that focused discussions over the following months: Organisation, Science Management, Science Operations and Data, and Curation Plan.

Organisation: This topic oulines the the general structure of the institute and the facilities that are required, including the need for physical and/or virtual facilities. A key Phase I recommendation was for the formation of an "International Mars Science Institute" (IMSI), which would "…be a virtual institute, a confederation of Mars Science agencies, or countries that are substantially involved in MSR…" [1]. The purpose of the IMSI would be to encourage and facilitate collaboration and allow for "direct access to the missions, laboratories and samples themselves" [1].

We suggest that the IMSI itself can have a significant virtual component, 'staffed' by expert teams tasked to work on topics relevant to the mission concept and the sample suites collected (regolith, atmospheric, volcanic, sedimentary, life detection, etc.). These teams would be responsible for developing the analytical protocols, and serve as a first level of peer-review at various stages of the MSR mission.

The samples will initially be housed within a sample containment facility (SCF), a building or buildings requiring in-house capabilities for life detection/biohazard testing, preliminary sample examination, physical and chemical sample preparation and sample sterilisation. Whilst most science team members can be distributed internationally, it will be imperative to retain a strong, tangible link with the physical needs of the SCF. It is thus strongly recommended that a close interaction between IMSI administration and SCF senior management be maintained via collocation at the main facility.

Science Management: This topic defines the scientific leadership, institute membership and putative funding sources. Because of the need for close interacttion of IMSI and SCF management, there may be tensions arsing in attempting to balance the desire for scientific investigation against planetary protection and sample safety requirements. It is thus suggested that a 'Director' oversees the operations of both the IMSI and SCF, and serves as the link to the stakeholders of the international aganices funding the MSR mission. Funding is, of course, a complex issue. Though details will require extensive follow-on negotiation, we believe that proportional access to samples will be based on the relative contributions to mission architecture.

Science Operations and Data: This topic defines the plan for the scientific investigation of the samples and access to samples. Discussion inputs for these items have been derived from previous space exploration sample return missions, and terrestrial scientific efforts such as the International Ocean Discovery Program (www.iodp.org) that have a surprising number of similarities that could help inform an MSR concept.

It is recommended that sampling strategies and protocols be published well ahead of the samples being returned to Earth. These protocols will be dependent on sample type and information gathered during the mission itself, and should also be peer-reviewed and updated on a regular basis.

Preliminary examination will be carried out under containment and allocations to external scientists will be goverened by a rigorous allocations procedure overseen by a combination of SCF and IMSI staff as well as external experts. All data will be made publically available with the preferred dissemination route via peer-reviewed publications.

Scenarios for allocation of samples will be dependent on sample type and also whether the sample must remain 'contained' (i.e. has not yet passed the planetary protection tests required to prove it it non-hazardous) or can be released in an uncontained manner. It is also recognized that the scenario of samples being "stuck in containment" is of concern to many stakeholders [1], and thus efforts must be made to ensure the safe release of samples to community members in a timely manner.

Curation Plan: This topic focuses on the sample handling, storage and distribution from receipt of samples to decades hence. Although some guidance for sample curation can be derived from exisiting NASA (e.g. Apollo, Stardust samples) and JAXA (Hayabusa samples) models, the anticipated distribution and tracking of "contained" and "uncontained" samples within and outside the facility for martian samples adds siginifcant complexity.

Morevover, sample sterilization remains a critical issue. Whilst some work has been done on this topic [5] it is recommended that further research be conducted, especially with respect to the effect of γ-ray sterilisation on organics.

Finally, it is widely acknowledged that a portion of samples should be kept 'pristine' for future studies. Though the group concurs with the recommended 40% as previously suggested by [6], there remains much debate as to *which* 40% of sample should be chosen. Such a decision will likely be based on information garnered during sample acquisition and preliminary examination.

Key Recommendations: Throughout the group's discussions on the above topics, three themes were seen to cross-cut the topics and recur regularly: 1) Peer review is critical in all areas and at all stages. Given the expeted timeframe of a MSR mission it is acknowledged that this is an evolving process and will incorporate the best knowledge at a given time. 2) Planetary Protection and Preliminary Examination studies should be considered together, as they are complementary and intrinsically related. 3) Verification and validation methods (e.g. sterilisation methods, sample containment and sample handling technologies, preliminary examination methods) should be investigated and refined starting immediately, as these and topics must be finalized well before the first sample is returned to Earth.

We continue to look forward to discussions with our colleagues in the international scientific and engineering communites and welcome any feedback.

References: [1] iMARS Working Group (2008) Preliminary Planning for an International Mars Sample Return Mission. Report of the International Mars Architecture for the Return of Samples (iMARS) Working Group. [2] Smith C. L. et al. (2014) *8th International Conference on Mars*, *Abstract #1249.* [3] Smith C. L. et al. (2014) *Meteoritics & Planet. Sci., 49 Suppl., Abstract #5401.* [4] Haltigin T. W. et al., (2014) *AGU Fall meeting, Abstract P21D-3951.* [5] Allen C. et al. (1999) *JGR, 104, 27043-27066.* [6] McLennan S. et al. (2012) *Astrobio, 12, 176-230.*

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