Forward Planning for the Science of Mars Sample Return – Open Questions and Next Steps

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Image: Mars Express HRSC,ESA/DLR/FU Berlin

MSR Science Planning Group (MSPG)

MSPG established by NASA and ESA to help develop a stable foundation for international scientific cooperation for the purposes of returning and analyzing samples from Mars.

Terms of Reference derived jointly between ESA and NASA MSR teams based on science planning needs. Guiding questions:

- What are the science-related attributes of a Sample Receiving Facility(-ies) (SRF) that can be used as the basis for cost and schedule estimation?
- What are the mechanisms whereby MSR partner-affiliated scientists will be given equitable access to the returned samples?

MSPG Workshops

The main science-related cost drivers for a **Sample Receiving Facility (SRF)** are thought to be:

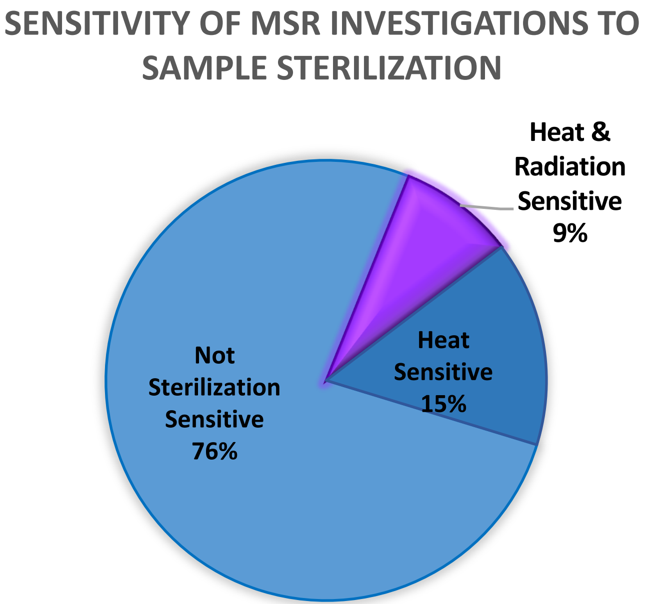
1. The challenge of conducting science activities inside high-containment space (Bio-Safety Level [BSL]-4)
2. Contamination control

Two workshops were held to address top-level questions:

WORKSHOP #1	***WORKSHOP #2***
To what extent does MSR science need to be done in containment?	How do the science objectives affect SRF contamination control requirements?
Universities Space Research Association (USRA) HQ, Columbia, MD, USA (14-16 Jan 2019)	University of Leicester, UK, (1-3 May 2019)

Workshop #1: Science in Containment

What role does contained space need to play in ensuring that <u>all</u> MSR scientific objectives are met?



<u>MAJOR FINDING:</u> A large majority of the MSR-related science investigations, as identified by iMOST (2019), could be acceptably performed on sterilized samples, thus potentially enabling the analysis of MSR samples in uncontained laboratories without a dependency on the results from planetary protection testing.

Workshop #1: Science in Containment

What role does contained space need to play in ensuring that <u>all</u> MSR scientific objectives are met?

Initial Activities / Catalogue Building

1. Basic Characterisation
(non-destructive analysis)
2. Preliminary Examination
(minimum permissible destructive analysis)

Planetary Protection tests

Sterilization -sensitive Science

Time -sensitive Science

\+

Sterilization -tolerant Science

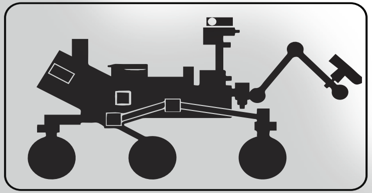
<u>Sterilize then analyze</u>

<u>Wait for PP tests, analyze unsterilized material</u>

<u>MAJOR FINDING</u>: The scientific community, for reasons of scientific quality, cost, timeliness, and other reasons, strongly prefers that as many sample-related investigations as possible be performed in PI-led laboratories outside of containment.

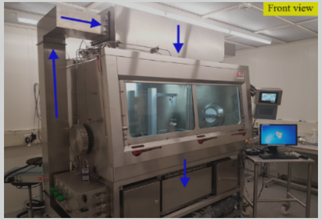
Workshop #2: Contamination Control (CC)

Earth-sourced contamination



Mars-sourced signal

Instruments: GC-MS etc.



Receiving isolator cabinet

Modified after M-2020 SDT (2014)

What are our strategies to achieve MSR science objectives, given SRF-related contamination?

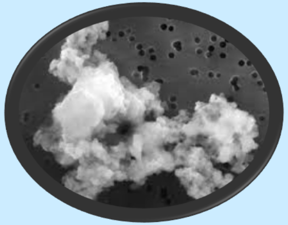
Workshop #2: Contamination Control (CC)

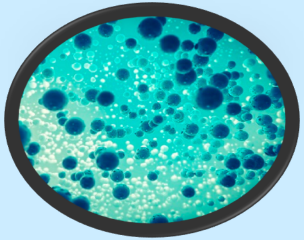
Potential SRF Sample-Intimate Hardware Cleanliness Requirements

Viable Organisms (<1)

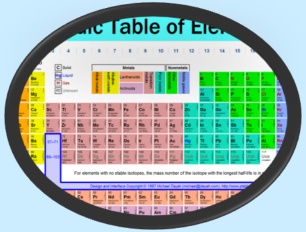
Outgassing (~1 ng/cm2/hr)

Particulate (PCL 50-300)

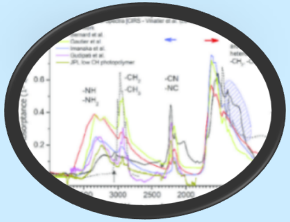




Total Organic Carbon
Tier 1 Compounds: 1 ppb
Tier 2: 10 ppb, TOC: 10ppb

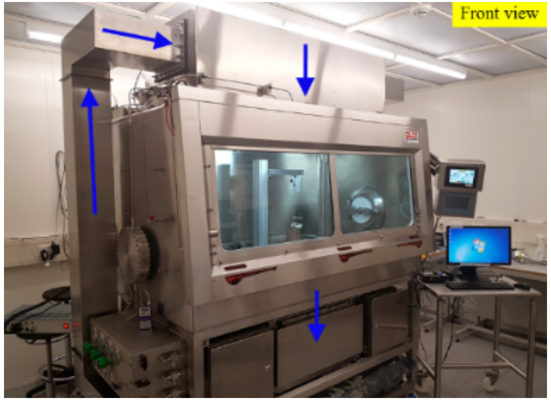


Inorganics pg-mg of 34 elements



Non-volatile residue (<100 ng/cm2)

Notional sample-receiving isolation cabinet inside SRF (example only)



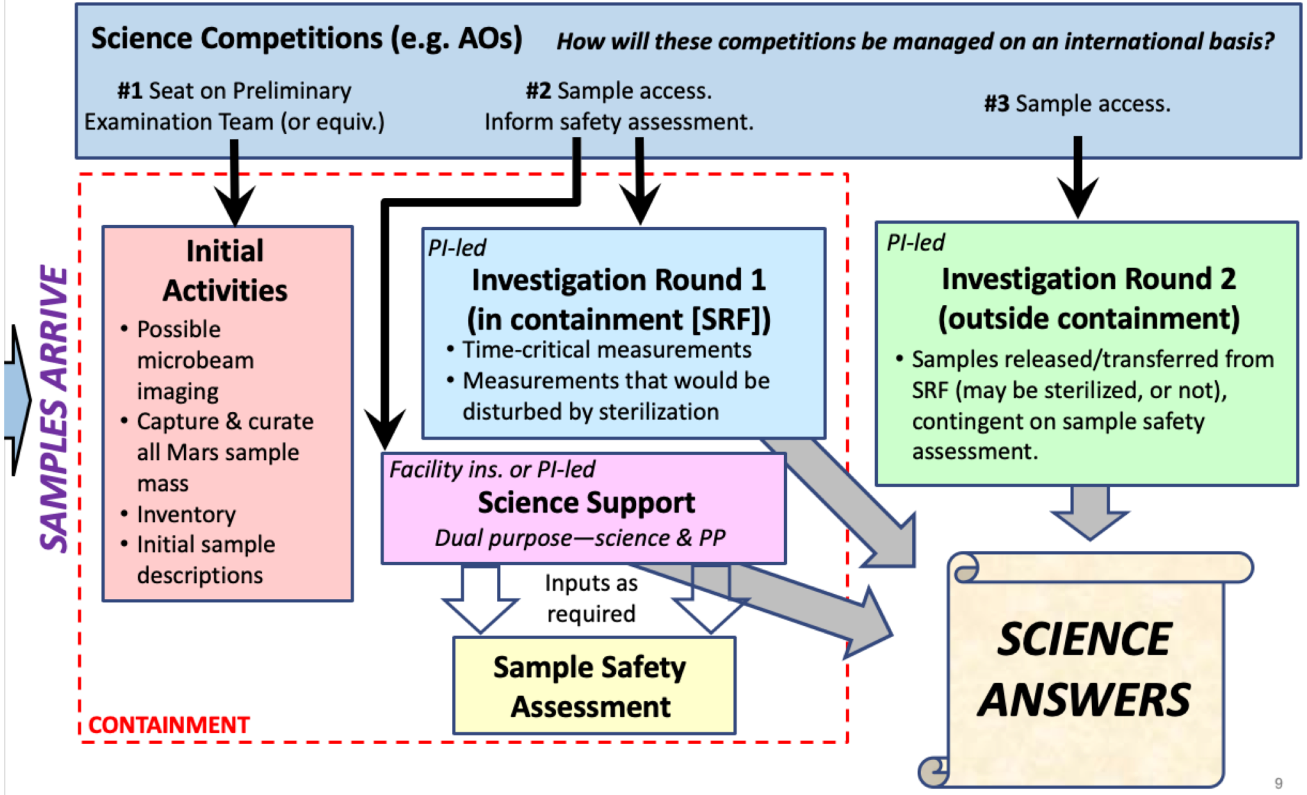
For the SRF, requirements have not yet been established. Some should be stricter than for Mars 2020.

Concept for Opportunities for Science

Multiple access points for scientists.

To these activities (after sample return), and to the precursor working groups:

- **Membership** can be open to partners, or worldwide.
- **Selection** can be appointed, competed, or open.



Science Management: Guiding Principles

Science Maximization
- Access to samples must be based on the scientific benefits of the proposed investigations

Transparency
- Access to samples must be fair, open, and competed wherever possible

Maximize Opportunity
- International scientists must have multiple opportunities throughout the process to earn access to the samples

One Return Canister : One Collection
- Samples must be treated as a single collection, regardless of whether or not there is more than one curation facility

Preservation
- Samples must be carefully curated, and allocated for destructive analysis only in accordance with prioritization of important science objectives agreed by the community.

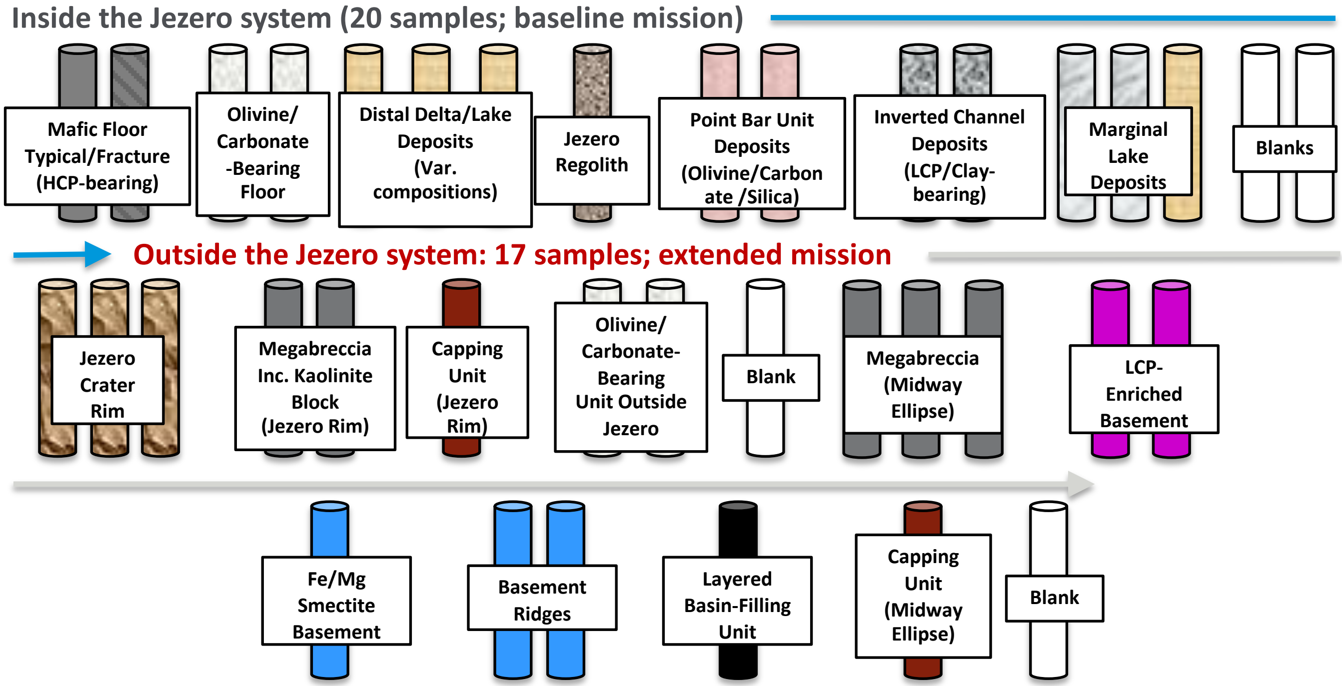
Science Management: Analogues

	NASA-ESA PARTNERSHIP	US-ONLY
YES	***MSR***	***Genesis*** ***Stardust*** ***Osiris-REx***
NO		***Apollo 11***

We can learn from these precedents, but for MSR, we need new, hybrid approaches.

FINDING – The overall strategies for managing MSR returned sample science are similar, but not identical to, those used for the Apollo 11 sample return and various PI-led sample returns (e.g. Stardust, Genesis, O-Rex, etc.). For MSR, we need a hybrid approach.

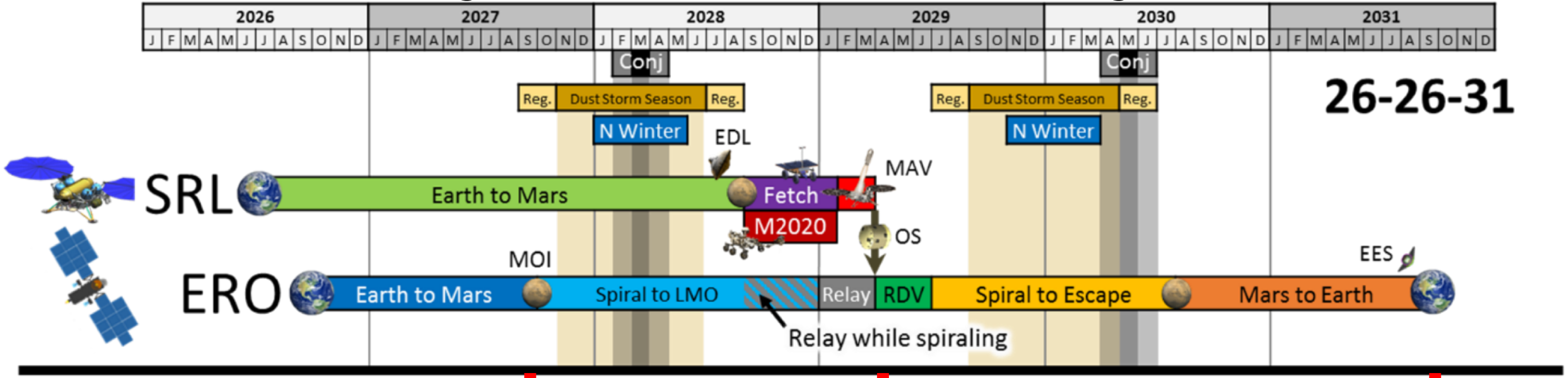
Importance of Managing as One Collection



FINDING – The returned sample collection will have been selected and optimized for its geologic and geochemical diversity. The similarities and differences between samples (as part of the design of the sample suites) will be as important or more than the absolute composition of individual samples. As such, to optimize the value of the returned samples, they need to be managed as one collection.

Science Integrated with Flight Schedules

Current working reference timeline for the MSR flight elements.



Science needs to provide sample priorities for SFR traverse planning, landing site optimization.

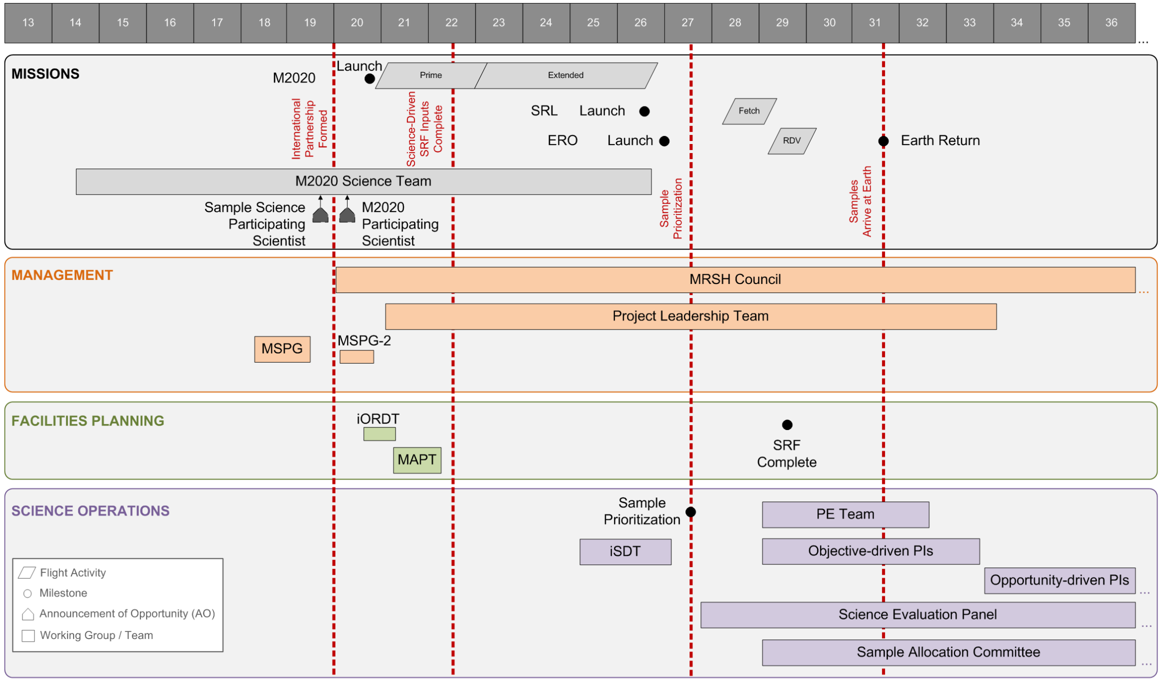
We know which, and how many, samples will be returned.

We know exact details of sample mass, state.

FINDING – The Science Planning timeline must be coordinated with the MSR flight project timeline

Concept for Timeline of MSR Science

- MSPG defined a conceptual timeline for the major science bodies to conduct MSR Science.
- Details include formation mechanism, composition, authority, tenure and objectives.
- Based on needs for specific input and decision-making at key points in development of MRSH infrastructure, and science planning.

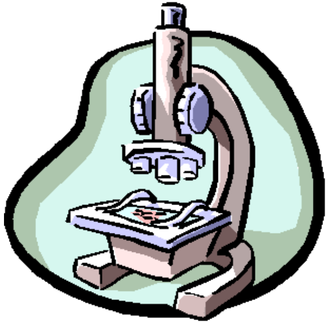


Scientist Opportunities in MSR

Returned sample science will create many opportunities for the science community, on an international basis.

Committee work

Workshops



Sample-based research, curation

Program management

FINDING – A number of opportunities for scientists to get involved in Returned Sample Science exist.

Approach for Science Management Definition

1. Define:
   - Tasks
   - Need by dates
   - Dependencies
   - Required expertise
2. Inventories of **what**, **when** and **who**
3. Collate to **timeline of distinct working groups** and bodies that collectively form the science management structure. Specifically:
   - Rationale
   - Composition (selection and membership)
   - Inputs/Outputs
   - Timing

WHAT NEEDS TO BE DONE		WHEN			WHO
Category	**Functionality**	**Precedent(s)**	**Complete Before**	**Appx. Start**	**Proposed Responsibility**
Science Operations					
Sample Objectives & Management	Select final samples for return	M2020 collects samples	SRL arrives at Mars	2027	Sample Prioritization Workshops with final decision or acceptance of recommendations made by MRSH Council
Sample Objectives & Management	Define objectives and priorities for initial round of PI-led sample investigations. Determine the criteria for MSR campaign scientific success.	M2020 collects samples	MAV launch + 6 months	2026	iSDT
Sample Objectives & Management	Generate the inputs to an international AO to compete for initial allocations of the MSR samples	M2020 collects samples, MAV is loaded and launched	MAV launch + 6 months	2026	iSDT
Sample Analysis	Prepare a catalog of the samples received in the SRF, with descriptions sufficient to form the basis for the initial sample allocation competition.	Samples received in SRF	Initial allocation decisions	2031	PE Team
Sample Objectives & Management	Review sample investigation proposals and rate the scientific merit	proposals received in response to AO	as quickly as possible	2027	Science Evaluation Panel
Sample Objectives & Management	Merge ratings for scientific merit with additional constraint from available funding, available sample mass, long-term curation planning, geopolitical considerations, and diversity factors to prepare an allocation recommendation	Proposal review, PET results, knowledge of funding availability	PIs receive initial round of samples	2031-2032	Sample Allocation Committee
Sample Objectives & Management	Approve release of samples to investigators, along with necessary funding to investigate them	Sample Allocation Committee recommendation	PI-led Investigations begin	2031	MRSH Council (MC)
Sample Analysis	Perform the initial science investigations on the returned samples. Make discoveries, and achieve the stated campaign scientific objectives	Initial sample allocations	end of proprietary period	2031-2032	PIs (and their respective science teams), consortia
	Perform second round and beyond				

MSPG-2

Announcement of Opportunity for MSPG-2 membership closes 4 May:
https://www.esa.int/Science_Exploration/Human_and_Robotic_Exploration/Research/Research_Announcements#MSPG-2

MSPG-2 will address MSR science and curation planning, potentially including:

- Inputs to the "Science Management Plan", working from recommendations made by MSPG.
- Technical issues related how the implementation of MSR impacts the potential scientific usefulness of the samples. E.g. Sample sterilization (and sensitivity of science measurements), use of penetrative imaging (synchrotron imaging or CT scanning) on sample tubes prior to opening, sample handling/transport issues.
- Developing a list of high-level requirements for the SRF, needed to represent the needs and interests of science, curation, and planetary protection.
- Identification of key decision points and their timings related to handling and opportunities for analysis of returned samples, incorporating inputs from science, curation, and planetary protection.

Conclusions

- **Science planning opportunities exist in the near-term:** E.g. Participation in the NASA Mars 2020 'Perseverance' Rover mission, and in working groups such as MSPG-2.
- **Samples will be received at facility in US then made available for transfer. Activities:** 1. Initial cataloging, analysis and tests. 2. Science in containment. 3. Science outside containment.
- **Sample science management is planned to be internationalized** amongst MSR partner countries/agencies.
- **Additional analysis and curation facilities** in Europe/US may or may not exist. Sample science management planning should be facility agnostic.
- **Large number of working groups** will exist in the next decade. You will be needed to participate.
- **National research programmes must support preparation for MSR** where needed: e.g. sensitivity of science potential to sterilization techniques, develop hypotheses to test, advance analytical techniques for small sample masses.

Reference Documents

- **NASA-ESA Statement of Intent for MSR [2018]:** https://mepag.jpl.nasa.gov/announcements/2018-04-26%20NASA-ESA%20SOI%20(Signed).pdf
- **MSPG Reports & Presentations:** https://mepag.jpl.nasa.gov/reports.cfm?expand=mspg
- **iMOST Report** – International MSR Objectives and Samples Team (iMOST), *'The potential science and engineering value of samples delivered to Earth by Mars sample return'. Meteorit Planet Sci, 54: S3-S152.* https://doi.org/10.1111/maps.13242
- **Presentations from 2nd International MSR Conference (Apr 25-27, 2018, Berlin):** https://atpi.eventsair.com/QuickEventWebsitePortal/2nd-international-conference-on-mars-sample-return/home