EuroCares
Potential Contributions to Planetary Protection Objective 5

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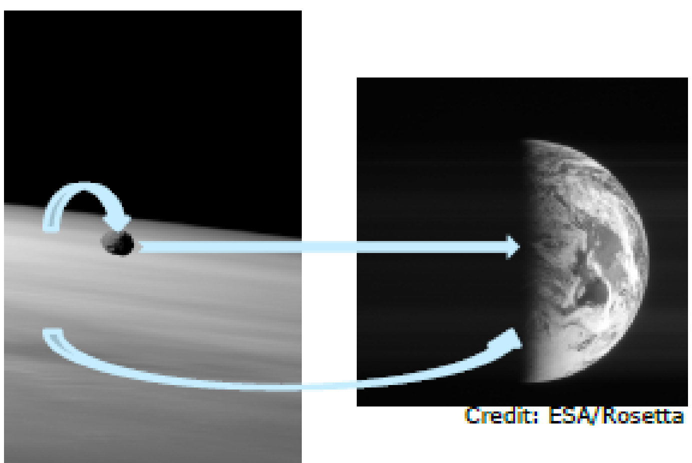
Phobos Sample Return

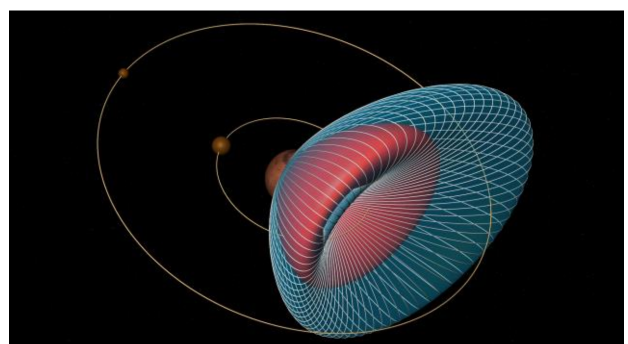
In support of mission studies, an assessment of planetary protection categorization for Phobos sample return missions has been initiated

- → Transfer of material from Mars to Phobos (Melosh *et al*., 2011)
- → Different models predict an abundance of martian material on Phobos in the ppm range with uncertainties that span several orders of magnitude (Chappaz *et al.,* 2012; Ramsley and Head III, 2013) and major transfers as young as 3 million years (Werner *et al*., 2014)
- → Level of biological inactivation of material transferred from Mars to Phobos due to hypervelocity impact on Phobos and exposure to the ionizing radiation and temperature environment on the surface and near sub-surface of Phobos is uncertain

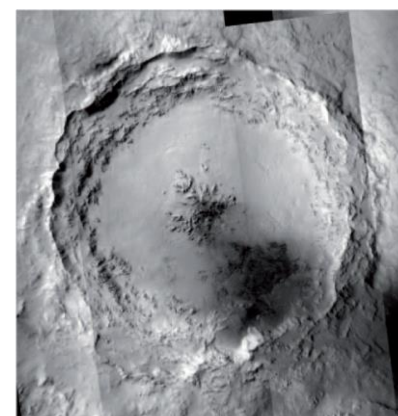


Credit: ESA/Rosetta

Credit: ESA/Mars Express



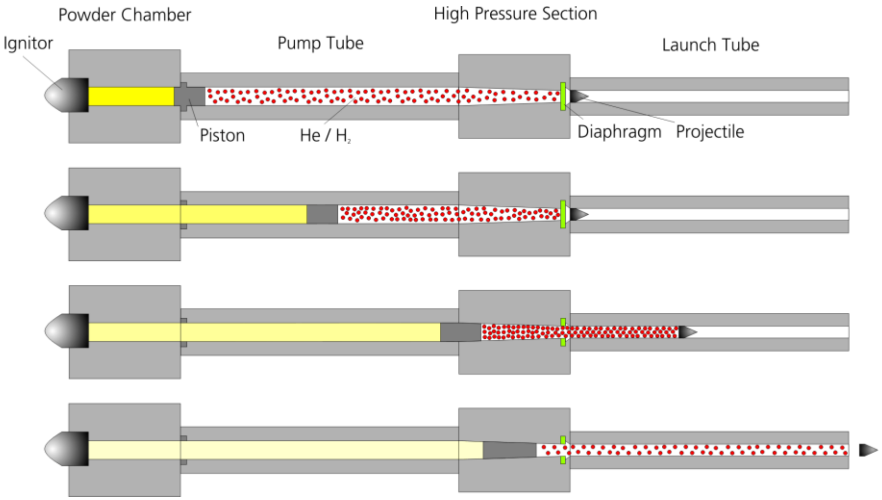
Credit: J. Melosh, Purdue Univ.

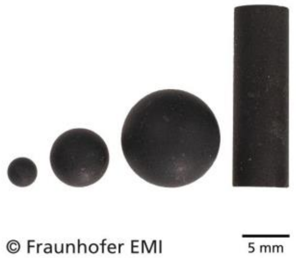


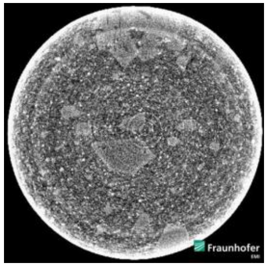
Credit: Werner *et al.,* 2014, NASA MRO CTX

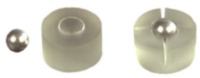
Phobos Sample Return

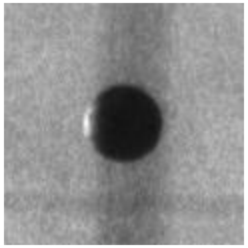
- Preliminary tests carried out by the Fraunhofer Institute, Ernst Mach Institute, Freiburg, Germany, demonstrate the feasibility to manufacture basaltic projectiles, accelerate them to 5 km/sec, and recover them from a low-density target
- A subsequent workshop at the Fraunhofer Institute established the baseline for the type of tests that would be required to support an assessment of the sterilisation potential of martian material transferred to Phobos











Phobos Sample Return

- Consortium under the lead of the Open University is conducting the tests and modelling
- NASA funded a team at the Marshall Spaceflight Centre and the Purdue Univ. to support this activity
- Tests cover impact tests, ionizing radiation tests (gamma, proton and helium), and rapid heat inactivation tests
- Test campaigns is expected to finish after the summer 2016
- Results will feed in to an assessment of the planetary protection category for a Phobos sample return mission

Credit: Open University

The Open University | Public Health England | ThalesAlenia Space | Kallisto Consultancy | IWF

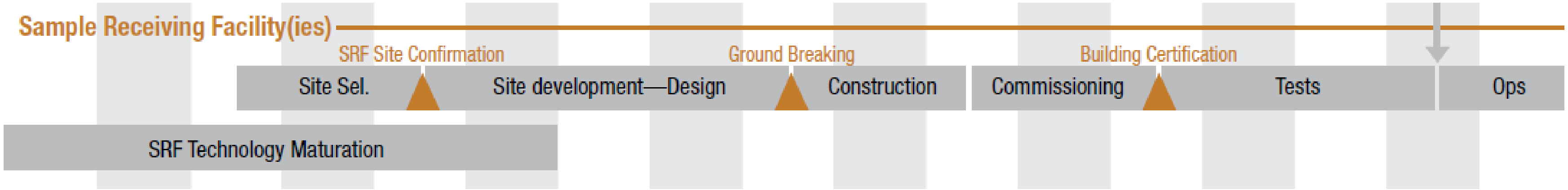
Mars Sample Return

Recent bi-lateral discussions between ESA and NASA about Mars sample return cooperation scenario

- → NASA Mars 2020 lander/rover selects and acquires samples
- → NASA Mars orbiter 2022 could include an ESA contribution to capture and prepare the samples for the flight to Earth (i.e. capture of samples in orbit and application of flight containment system)
- → Subsequent ESA Courier mission could bring an Earth Return Vehicle (ERV) to Mars to get the contained samples from the NASA Mars orbiter and returns to Earth

ESA responded to this new campaign outline

- → Placed a CCN to the existing flight containment system contract to evaluate an accelerated development for the capture mechanism (TRL-6) and the flight containment system (TRL-4) with a focus on test and verification of current design
- → Initiated a concurrent design activity for the MSR Courier mission
- → Prepared proposal (ExPeRT) for next ESA council meeting at ministerial level in December 2016 (mission implementation decision proposed for 2019)



Credit: iMars Phase 1, 2008

Planetary Protection Protocol

Life detection conference formulated basic principles (Allwood *et al*, Astrobiology, Vol.13, 2013)

- Employing a hypothesis-driven approach in the development of life-detection investigation strategies and measurements for science (null hypothesis = there is no life in the sample) and planetary protection (positive hypothesis = there is life in the sample) provides a sound framework
- Disproving either the positive or null hypothesis can only be accomplished by collecting a sufficient amount of statistically significant data
- Evidence for life lies not in a single, “smoking gun” observation, but rather in a suite of observations spanning samples and different contexts

Life detection workshop established a protocol baseline (Kminek *et al*, Life Sciences in Space Res., Vol. 2, 2014)

- The test protocol should be data driven, i.e., responsive to the results of the individual or combined measurements
- Sample preparation and organic extraction need to be tailored and tested with analogue materials
- Terrestrial and/or synthetic analogue materials need to be developed and used as controls before and during the execution of the test protocol
- Proposed set of sequence and type of tests on samples

Planetary Protection Protocol

Proposed sequence for sample analysis

Sequence for sample analysis	Sample condition	General type of analysis
I	Sample acquisition on Mars	Remote and *in-situ* analysis on Mars to characterise the sample type and the geological context
II	Any solid sample material on the outside of the sample containers	Solid sample analysis; full sequence (non-destructive & non-invasive, non-destructive & minimal invasive, and destructive)
III	Head space gas	Gas sample analysis; full sequence
IV	Solid samples in containers	Solid sample analysis; non-destructive & non-invasive
V	Solid samples removed from containers	Solid sample analysis; non-destructive & minimal invasive
VI	Fluid inclusions from solid samples removed from containers	Liquid sample analysis; full sequence
VII	Solid sample removed from containers	Solid sample analysis; non-destructive & minimal invasive, destructive

Examples for types of sample analysis with a focus on life-detection

Invasiveness	Solid sample analysis	Gas sample analysis	Liquid sample analysis
Non-destructive & non-invasive	• 3D X-ray micro-tomography • Surface imaging and spectroscopy	Not applicable	Not applicable
Non-destructive & minimal invasive (no specific sample preparation)	• Microscopy • Fluorescence • IR, visible, UV, deep UV spectroscopy • SEM	• IR, visible, UV, deep UV spectroscopy	• Microscopy • Fluorescence • IR, visible, UV, deep UV spectroscopy
Destructive (specific sample preparation)	• SEM, TEM, nano-X-ray-tomography • XRD, XANES • GC-MS, GC-IRMS, FTICR-MS, LC-MS, TOF-SIMS, Nano-SIMS • Target independent biopolymer sequencing	• GC-MS, GC-IRMS, FTICR-MS, LC-MS	• GC-MS, GC-IRMS, FTICR-MS, LC-MS, TOF-SIMS, Nano-SIMS, • Target independent biopolymer sequencing, flow cytometry

Euro-Cares Contributions?

Identification of host rocks and materials to prepare Mars, Phobos, and asteroid analogue and synthetic samples

- Take into account the work of MEPAG E2E-iSAG and the Return Sample Science Board (chair: Hap McSween, European contribution by Mark Sephton)
- Consider the expected sample size and physical state, i.e. Hayabusa 2, M2020 sample acquisition systems

Prepare standard analogue samples and synthetic samples, e.g., EC-1, EC-2, etc. for the specific target bodies

- Take into account the synthetic samples prepared for the ESA activity on Phobos

Identify laboratories to run tests on the various analogue and synthetic samples

Credit: NASA

Credit: Open University