Update on ESA Planetary Protection Activities

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Current R&D

Micro-meteoroid environment

→ Jovian micro-meteoroid and dust environment (to be finished end of 2013)
→ Update of interplanetary micro-meteoroid model including information on streamers (to be finished in mid 2013)
→ Consolidation of interplanetary micro-meteoroid environment (planned for mid 2014, lasting about 2 years)

Break-up/burn-up analysis tool

→ Based on same tool used for Earth entry debris analysis
→ Includes the European Mars Climate Database and the US Mars GRAM
→ Includes two tools – one simple one that can be used in Phase A/B and a complex one for verification of requirements
→ Planned to be finished by 2nd quarter of 2013

In-flight containment system for Mars Sample Return

→ Currently in the testing phase for seals and in-flight verification system
→ Team has included PPWG recommendation #52 (based on ESF report)
→ Continuation of this activity is planned

Current R&D

Biohazard assessment on samples returned from Mars

→ Activity is focused on statistically relevant sub-sampling of samples returned from Mars to evaluate with high confidence whether the samples are safe for release from containment
→ Hypothesis to falsify is that the samples do contain evidence of life (positive hypothesis)
→ Due to the criticality, two independent teams work on this in parallel
→ Both teams have been started
→ Completion of activity is expected by the end of 2013

Double wall isolator system for samples returned from Mars

→ Such an isolator system has been identified as key element for a Mars sample return containment facility in numerous NASA and ESA studies
→ Activity is focused on containing the samples returned from Mars and at the same time keeping the quality of the samples intact
→ Completion of feasibility study is expected by the begin of 2014
→ Follow-on activity already planned for 2014

Current R&D

Bioburden assessment and analysis tool

- → Work performed by NASA-GSFC with ESA funded input for statistical analysis of the data
- → Tool is based on experience gained by Mars Pathfinder, Mars Exploration Rovers, and the Mars Science Laboratory missions
- → Test version available end of November 2012
- → Final version for project use planned for Q1 2013

Bioburden wipe assay validation

- → Work performed by NASA-KSC and Univ. of Regensburg (ESA funded)
- → Specification will dramatically reduce the number of culture plates used for wipe assay and time through combined use with Millipore detection system
- → Activity is planned to be completed by Q1 2013

New R&D planned to start in 2013

Inactivation levels for life forms

→ Cover heat and ionising radiation
→ Take into account targets identified in ESF report and matrix effects
→ Support Phobos categorisation and Mars sample return technology developments

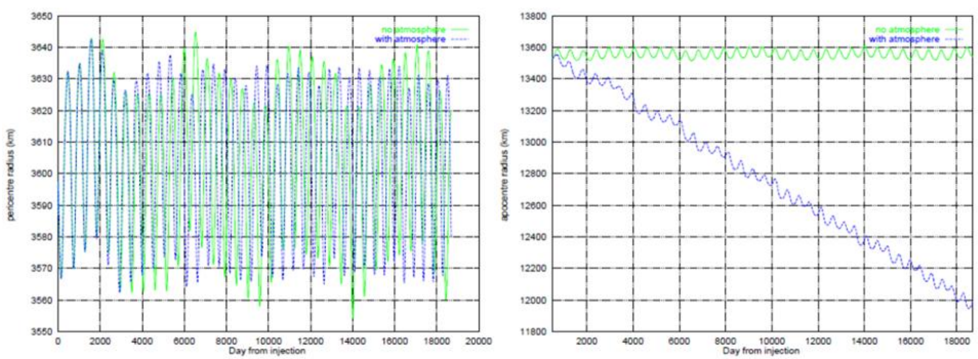
Effect of hypervelocity impacts

→ Simulating impact of material transferred from Mars to Phobos
→ Take into account result of Melosh et al study
→ Evaluate temperature and pressure effects on projectile
→ Feasibility test already completed

Mission Extensions

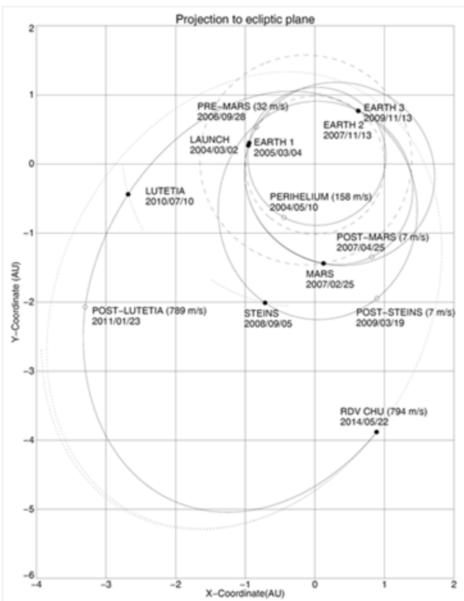
Mars Express

→ Launched: 2 June 2003
→ Planetary protection approach: orbital lifetime
→ Current status: elliptical orbit with a pericenter of 300 km and an apocenter of 10.000 km; orbit stable for □50 years → mission remains compliant with orbital lifetime requirement
→ End of mission: S/C remains in stable orbit; impact on Phobos expected after several 100's of years



Rosetta

→ Launched: 2004
→ Gravity assists: 4 (1 Mars, 3 Earth)
→ Final target: Comet 67/P 2014
→ Final disposition: Co-orbiting the comet around the sun; ecliptic inclination is 1.8° for Mars and 7.1° for the comet; mission analysis shows closest Mars approach of comet/spacecraft is 94 million kilometers in the time period of 50 years after launch



Herschel End-of-Mission

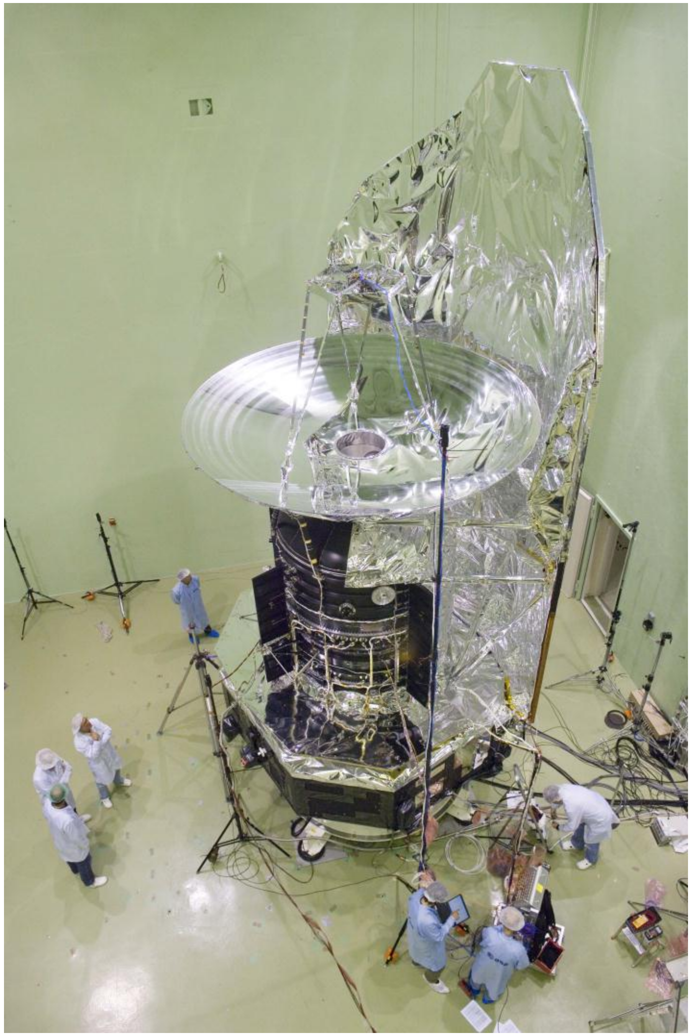
Infrared observatory launched in 2009 to L2

End of mission 1st quarter 2013

Science team proposed impact on lunar poles and coordinated observations of released volatiles

Impact with steep incident angle, velocity 2.5 km/sec and a mass of 2.8 tons

Science directorate requested to evaluate implications for planetary protection



Herschel End-of-Mission

Planetary protection category II description:
Target bodies (i.e. Moon) for which there is significant scientific interest relative to the process of chemical evolution and the origins of life but for which scientific opinion provides only a remote chance that contamination by a spacecraft can compromise future investigations

- ✓ Science case (i.e. benefit of impact) has been presented

Associated requirement:
An organic materials inventory of bulk constituents, incl. products of the propulsion system, in quantities above a limit agreed with the PPO shall be provided by the project

Conclusions:

1. Final disposition on lunar poles is compliant with ESA, NASA, and COSPAR planetary protection policies and requirements
2. Additional requirement to provide organic material inventory:
   - ✓ Herschel Declared Materials List (DML)
   - ✓ Description of fuel (hydrazine chemical analysis)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Mars Sample Return backward contamination – Strategic advice and requirements
Report from the ESF-ESSC Study Group on MSR Planetary Protection Requirements.

ESF Recommendations

1. Considering the many uncertainties and unknowns about putative Mars biological entities and the potential consequences of releasing such entities into the Earth's biosphere, as well as about public perception of risk in the frame of an MSR mission, the ESF-ESSC Study Group recommends that the Best Available Technology Precautionary Principle is applied when considering the potential release of unsterilized Mars particles.

2. In accordance with past advice, the ESF-ESSC Study Group recommends that a Mars sample should be applied to Risk Group 4 (as defined by the World Health Organization) a priori.

3. The ESF-ESSC Study Group recommends that the Best Available Technique (BAT) optimization concept is used as a benchmark and adapted to the specificities of an MSR mission in order to guarantee that the probability of an unintended release and also the magnitude of this release is minimized. BAT only implies that available techniques (at a reasonable cost) are used, yet it seems important to set a limit to define and recommend adequate requirements for the release probability and magnitude. Should these requirements not be achievable with available technology, new technologies would have to be developed to meet them.

ESF Recommendations

4. The ESF-ESSC Study Group concurs with the conclusions from NRC reports (1997, 2009) that large-scale effects arising from the intentional return of Mars materials to Earth are primarily those associated with replicating biological entities. However, bearing in mind new knowledge produced in recent years, the Study Group considers that, if there were Earth-like life forms on Mars, virus-type and GTA-type entities' ability to interact with Earth organisms cannot be ruled out. Based on this, the ESF-ESSC Study Group recommends that not only self-replicating free-living biological entities are considered as potentially having consequences on the Earth's biosphere but also virus-type and GTA-type entities.

5. The Study Group considers transparent communication about accountability, benefits, risks and uncertainties relating to an MSR mission to be crucial throughout the whole process. It is recommended that tools to effectively interact with individual groups of stakeholders are developed.

6. Based on standards established and adopted at the national and international levels, the ESF-ESSC Study Group recommends that the probability of release of a potentially hazardous Mars particle shall be less than one in a million.

ESF Recommendations

7. The probability that a single unsterilized particle of 0,01 µm diameter or greater is released into the Earth's environment shall be less than 10^{-6}.

If the size requirement cannot be met without decreasing the overall level of assurance for the non-release of such a particle, the release of a single unsterilized particle of up to 0.05 µm can be considered as a potentially tolerable systems-level adjustment, assuming that it has been demonstrated that this size is the lowest achievable at a reasonable cost. In such a case, the actual maximum particle size potentially released (as planned from design) would have to be independently reviewed by interdisciplinary groups of international experts to determine:

→ whether this size value is the best reasonably achievable at a reasonable cost,

And, if yes:

→ taking into consideration the latest scientific developments in the fields of astrobiology, microbiology, virology and any other relevant discipline, whether the release of such a particle can be considered as tolerable.

The release of a single unsterilized particle larger than 0,05 µm is not acceptable under any circumstance.

ESF Recommendations

8. Considering that (i) scientific knowledge as well as risk perception can evolve at a rapid pace over the time, and (ii) from design to curation, an MSR mission will last more than a decade, the ESF-ESSC Study Group recommends that values on level of assurance and maximum size of released particle are re-evaluated on a regular basis.

9. Building capacity to respond to a release of Mars material is of utmost importance and should draw upon available experience in the fields of public health and emergency response. In addition to current prevention strategies, it is recommended that potential release scenarios (including undetected release) are clearly defined and investigated, and that response strategies are developed from these. It is critical that such strategies are designed to be implemented as soon as possible and at the local level and that they encompass:
   - → observation of pre-defined indicators
   - → rapid detection of anomalies
   - → effective warning procedures
   - → analysis, resistance and mitigation procedures

Scenarios and response strategies should be reassessed and updated on a regular basis.

ESF Recommendations

10. Considering the global nature of the issue, consequences resulting from an unintended release could be borne by a larger set of countries than those involved in the program. It is recommended that mechanisms dedicated to ethical and social issues of the risks and benefits raised by an MSR are set up at the international level and are open to representatives of all countries.

11. Information on the geochemical and physical context of the Mars sample to be returned and having access to this information will be key elements to define and refine scenarios and assumptions about potential Mars biological entity(ies) returned to Earth. Such information should be gathered and made available to the relevant stakeholders as soon as possible in the process.

What happens now?

→ The ESA-PPWG endorsed the recommendations of the ESF with minor adjustments; ESA is already using the size limit in industrial contracts

→ NASA PPS is invited to comment on the final ESF report & ESA PPWG recommendation.

→ Present agreed requirements as joint PPWG/PPS submission to the COSPAR General Assembly, Planetary Protection Panel 1, August 2014.

→ Implement detailed formulation of requirements in NASA and ESA Agency level documentation.