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Planetary Protection Policy applied to Planetary Seismometers development

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Origin of Planetary Protection policy:

Article 9 of the UN "*Outer Space treaty*" specifies "*States Parties of the Treaty shall pursue studies of outer space, including the Moon and other celestial bodies, and conduct exploration of them so as to avoid their harmful contamination… and where necessary, shall adopt appropriate measures for this purpose*". This Treaty has been signed and ratified by all space faring Nations on January 27th, 1967.

The present COSPAR policy is the following: "*… the conduct of scientific investigations of possible extraterrestrial life forms, precursors and remnants must not be jeopardized*". This policy has been proposed by Space Agencies and Scientific Organizations involved in planetary exploration. COSPAR give recommendations classified in five categories depending on the explored body (Venus, Mars,…) and on the type of mission (orbiter, lander, fly-by, Earth return…).

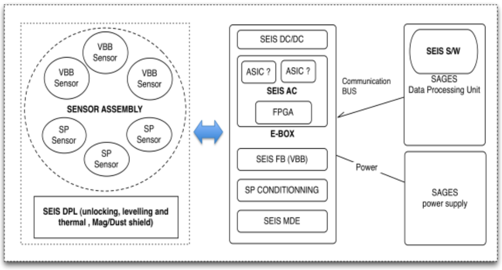
Planetary Protection constraints for Mars and the Moon:

The planetary protection classification based on the mission objectives must be in agreement with the COSPAR Planetary Protection Policy. Planetary Protection category IVb is for landed systems with life-detection experiments. Mission intending to access a Mars Special Region would be in category IVc. A Special Region is defined as a region within terrestrial organisms are likeky to propagate or a region which is interpreted to have a high potential for the existence of extant Martian life form.

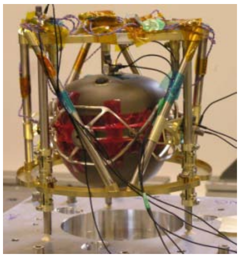
Previously the Moon was considered Category I, "Not of direct interest for understanding the process of chemical evolution..."requiring no documentation of activities beyond launch. To protect possible polar volatile deposits, the COSPAR Planetary Protection Panel has recommended that the Moon should become Category II "Of significant interest relative to the process of chemical evolution ... but only a remote chance that contamination by spacecraft could jeopardize future exploration".

SEIS Planetory Seismometer instrument:

Scientific objectives: The SEIS Seismometer will study the seismic activity of the planet (Mars or the Moon) and frequency of meteorites impacts. These seismic events will be characterized by their approximate distance and azimuth, as well by their magnitude. The seismometer will also allow to characterize shallow and deep interior of the planet, and especially the water environment as a function of depth in the deep subsurface, the crust thickness of the landing site, the core size and possibly, if the seismic activity is between the middle and upper bound of present estimates, the mantle structure.



Selene-SEIS functional architecture (option 1)



Mars configuration: deployment & leveling system

Instrument design: In the previous Mars configuration, the seismometer was powered and serviced by the lander. It was based on a hybrid 4-axis instrument, composed of 2 Very Broad Band (VBB) sensors, 2 Short Period (SP) sensors and had a mass of about 3100 g (with margins), including the sensors deployment system, the sensors acquisition and control electronics.

In the Moon configuration (Selene 2 mission, option 1) the seismometer is based on a 6-axis instrument, composed of 3 VBB sensors and 3 SP sensors.

General approach to planetary protection compliance:

For a martian mission, the general approach to fulfill planetary protection requirements for the whole instrument SEIS Planetory Seismometer is to consider that each subsystem (SEIS-Sphere, SEIS-AC, SEIS-DPL, SEIS-SP, SEIS-E-Box) would be sterilized and cleaned at its own level and would be delivered in sterile bags (Tyvek) to the AIV facilities.

Bioburden reduction approach: the preferred methods for sterilization is Dry Heat Microbial Reduction (DHMR @110°C during 50h) according to Planetary Protection specifications or using H_2O_2 gas plasma (Sterrad100s® process) with a medical qualified procedure (SAL 10-6) as it was done for the Mars96 mission. The process has to be submitted to the Mission Planetary Protection Officer for approval.

This is a medical qualified procedure (high sterilization margin) which should be qualified on EQM for compatibility with H/W. The biological level would be certified through parametric verification and microbiological indicators on FM. Packaging would be done with double Tyvek® bag and through-feed connectors.

Compatibility tests of H/W samples : tests with Sterrad 100S® process have been realized (Dec 2008) at ASP Johnson and Johnson Company (Illkirch, France facilities). We tested,

- for SEIS-Sphere subsystem, PCB with specific components (large capacitors)
- for SEIS-SP subsystem, harness (copper on Kapton), connectors and heater (copper on Kapton),
- for SEIS-DPL subsystem, Dyneema ropes (polyethylene) for deployment system

This would permit to identify critical materials.

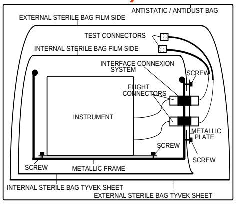
SEIS H/W samples tested at ASP Johnson & Johnson facilities

Identification and description of controlled facilities : Work of integration has to be done in laminar flow hood within a clean room (ISO7 or better)

As explained in SEIS Planetary Protection plan, each subsystem would be cleaned, sterilized and packaged at its own level in facilities belonging to each Institute responsible of sub-system. That means that we would use facilities on each integration site.

Mars96 mission heritage (OPTIMISM seismometer):

for Planetary Protection aspects the seismometer team can benefit of Mars96 heritage in terms of procedures. Specific procedure has been validated using the Sterrad 100S® process (ASP Johnson and Johnson medical process). The procedure was used with reduced plasma phase. Sterilized equipments were packaged into two successive similar bags (qualified for the sterilization method).



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[2] Lognonné P. & B. Mosser, Planetary Seismology, 14, 239-302 *Survey in Geophysic*, 1993. P. Lognonné et al. The NetLander Very Broad band seismometer, Planet. Space Sc., 48,1289-1302, 2000

[3] COSPAR Planetary Protection Policy (20. October 2002).

[4] NASA NPR 8020.12C Planetary Protection provisions for robotic extra-terrestrial missions.

[5] CNES MA1-PO-0-0321-2845-CN MARS Project - Planetary protection program - Hydrogen peroxide plasma gas sterilization procedure.

[6] P. Schibler, I. Krause, S. Calcutt, P. Zweifel, EXM-SEIS-RS-IPGP-0056_Planetary_Protection_Implementation_Plan.

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