GEP-ExoMars: a Geophysics and Environment Observatory on Mars

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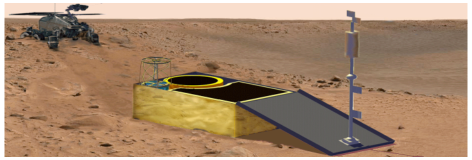

Fig.1: Artist's view of a stand-alone, RTG-powered GEP-version after soft deployment by a rover.

ExoMars and: Why is the Earth habitable, while Mars is not?

The ExoMars mission is the first ESA led robotic mission in the Aurora Programme and combines technology development with investigations of major scientific interest. ExoMars will launch 2013 (landing 2 years later) with a backup scenario launch 2016 (landing in the same year, using a direct trajectory). Exomars will consist of a ´descent module (DM) and a rover. The DM contains a stationary, long-living Geophysics Environmental Package (GEP).

ExoMars science is addressing the question of life on Mars. The so called Pasteur payload on board the ExoMars rover will search for extant and extinct life; this is obviously an extremely challenging endeavour, a negative result will not really prove anything.
A complimentary approach may address the question of habitability: Assume that if a planet is habitable, life will flourish!

The GEP has been proposed with a core payload consisting of a seismometer, a meteorological package/atmospheric probe, a heat flow and physical properties package, a radio science experiment and a magnetometer. Additional payload elements are considered (and are presently in the payload confirmation review of ESA).
GEP may also be considered as payload for further missions (e.g. ESA-Aurora after ExoMars or NASA Scout) allowing eventually to build up a network of stations for global investigation of Mars (or the Moon). For future missions, an RTG power concept is proposed that would allow operation for > 6a and independece from the dust environment.

Instruments

Instrument	Heritage	Mass / kg	Average power / W	Description
SEIS	Netlander (Phase B)	1,800	0,28	Seismic suite: 2 VBB oblique seismometers plus one Short period horizontal MEMS (Micro-Electro Mechanical System) sensor (SEIS-SP) completing the trihedron. Target sensitivity < 1E-9 ms-2Hz-1/2.
ATM	Beagle-2 (flown)	0,824 incl. boom	0,095	Meteo suite: wind, temperature, pressure, humidity, optical depth (UV/VIS monitoring). Modes: low/nominal/campaign/dust devil rates
HP3	Beagle-2 (flown)	1,488	0,003	Heat flow and physical properties package. Deployed by a mole up to 5 m deep in Martian regolith: TEM, a thermal measurement suite (thermal conductivity, heat capacity, thermal gradient [heat flux]); DACTIL, a set of accelerometers (orientation, depth)
MSMO	Champ, Astrid-2 satellites (flown)	0,233	0,03	Tri-axial vector magnetic field sensor includingt and attitude sensors. Range +/- 1E4 nT, resol. 0.02 nT, offset accuracy <0.1 nT and <30 ppm, noise 12 pT (0.01 to 10 Hz)
ARES	Netlander (Phase B)	0,142	0,105	Atmospheric electricity probe to measure electric conductivity, quasi DC electric field (up to 300 V/m), ELF/VLF radio-electric emissions (10 Hz to 4 kHz)
LaRa	TRL5	0,675	0,2	Geodesy (high precision nutation, polar motion, LOD, ionospheric properties) with X-band transponder by measuring doppler shifts. One frequency. Direct Lander-Earth link. Can be used as TM/TC backup
MiniHUM	TRL 4	0,06	0,02	Humidity microsensor, coulometric (Keidel) cell ; Mixing ratio 1e-7 .. 1E-3 with 5% accuracy absolute together with capacitive humidity sensor and dew point sensor.
IRAS	ISS	0,452	0,1	Ionising Radiation Sensor; several segmented planar silicon PIN-detectors around segmented organic scintillator (BC430) in telescope configuration. Neutron and gamma count and dose rates, LET spectra.
TOTALS		**5,7**	**1,2 incl. converter losses**	

GEP goals

To study the long term habitability of Mars by understanding and constraining Mars planetary evolution

- Internal structure, volcanic and thermal evolution, present geologic/tectonic activity

- To study the present environment and search for resources
  - Atmospheric circulation, UV radiation, storms dynamics, ionospheric properties
  - Deep subsurface structure and detection of water
- To prepare the European exploration of Mars and Solar system
  - Monitor the Martian environment
  - Start a permanent presence of Europe on the surface of Mars

Scientific objectives

- Measure the seismic activity of Mars
- Determine interior structure and the CO_2 cycle
- Measure the heat flow to constrain the power budget of the planet
- Measure fundamental atmospheric properties to study the meteorology
- Measure the magnetic field
- Search for water underground and measure the humidity
- Monitor the ionising radiation (gamma, n) on the Mars surface

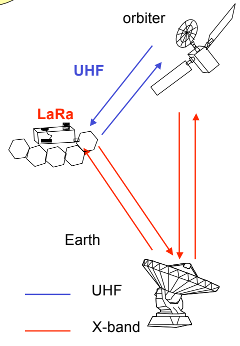

Fig.2: LaRa, prinicple of operation

System

Constraints

20 kg total, 5 kg payload, no RTG but solar generator (landing between 15°S and 45°N, below 0 m MOLA). Operation for at least 1 Martian year: confidence that this is feasible (MER experiences with dust loss factor on solar generator). An RHU (8.5 W, same as for the rover) can be used to keep the central electronics and the battery warm.

Structural design

ExoMars-GEP will be integrated into the Lander (the Descent Module which delivers the rover).

Power concept

Since the mean power consumption of GEP is very low (at the order of 3-4 W), a solar generator (< 2m^2,TJ GaAs cells) will support permanent operations at the given constraints (latitude, all seasons including global dust storms, > 2 a operational life). A 100 Wh Li-Ion secondary battery is used to buffer peak power demands (mainly for telecommunications)

Energy/Data budgets:

A very low average power consumption is crucial for the operation of GEP. The payload has an average consumption of ca. 1.3 W, while the CDMS and data acquisition consumes ca. 1.0 W; 0.2 W are foreseen for the telecom system (with a much higher peak power demand, of course).
Data rates of ca. 10 Mbit/sol are foreseen, with a large mass memory (8 Gbit) permitting long autonomous intervals and preprocessing of data.

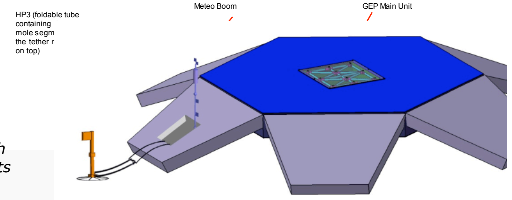

Fig. 3: DM (Soyuz, vented airbags) with GEP elements

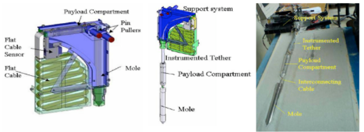

Fig.4: HP3:configuration and breadboard

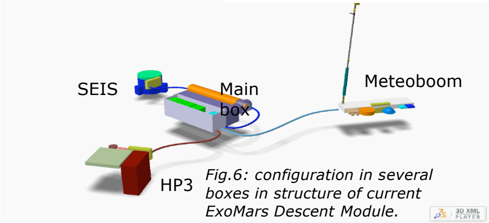

Fig.6: configuration in several boxes in structure of current ExoMars Descent Module. ATM/ARES on Meteoboom.
Credits: CNES (CIC)

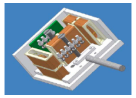

Fig. 5: MSMO sensor

Conclusions

The GEP station will essentially contribute to the Exomars mission, covering additional aspects for answering the question about possible habitability of Mars.

Currently still being in phase B, a final design of the mission (launcher, launch date, airbag choice, payload, accommodation of GEP in the DM is expected for June 2007.

GEP will be a precursor for the setup of a planned network of permanent stations on Mars.