THE INSIGHT SEIS EXPERIMENT. D.Mimoun[1], P.Lognonné[2], W.B.Banerdt[3], K.Hurst[3], S. Deraucourt[2], J.Gagnepain-Beyneix[2], T.Pike[4], S. Calcutt[5], M. Bierwirth[6], R. Roll[6], P. Zweifel[7], D. Mance[7] , O.Robert[2], T. Nébut[2], S. Tillier[2],T. Gabsi[2], Ph. Laudet[8], L. Kerjean[8], R. Perez[8], D.Giardini[7], U.Christenssen[6], R.Garcia[9], and the SEIS Team.
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Introduction: In comparison to our knowledge of the interior of the Earth, and, to a lesser extend, to our knowledge of the interior of the Moon since the Apollo missions, very little is known about the interior of Mars. In spite of the various missions flown to our red neighbour, all what we know about the interior (and therefore the history of Mars) has been deduced by indirect means, such as gravity field measurements, mean density computations and the absence of a magnetic field at planetary scale (e.g [1]). In order to fill this gap, the first attempt to send a seismometer was done during the Viking missions. Unfortunately, accommodation difficulties led to put them on the top of the landers, were it appeared that they recorded the lander motion due to the wind [2]. Despite widely recognized scientific interest [3], several attempts to send seismometers to Mars remained unsuccessful [4].

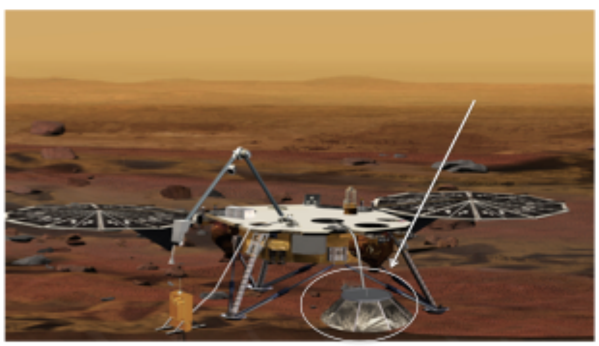

Figure 1: SEIS deployed on the ground next to the the INSIGHT Lander

The InSight mission (Interior exploration using Seismology, Geodesy, and Heat Transfer) formerly nown as GEMS, has taken up this challenge and has been pre-selected in the frame of the 2012 Discovery mission selection

SEIS heritage and Technology Readiness Level (TRL) Status: The SEIS planetary seismometer dedicated to missions to the terrestrial planets has been developed since more than ten years by IPGP (Institut de Physique du Globe de Paris) with the support of CNES (French Space Agency). SEIS was primarily developed for the NetLander mission [5]. It succesfully passed its PDR (with a TRL >5) in the frame of the European ExoMars mission. Most of the instrument subsystems are therefore at a high TRL. The SEIS instrument as a whole has been conceived as a wide international cooperation, subsystems being provided by several European institutions, including the Max Planck Institute for Solar System Research (MPS), Katlenburg-Lindau, Germany, ETH from Zürich, IPGP from Paris, Imperal College from London, Oxford University, and also now the Jet Propulsion Laboratory of Pasadena, California.

Figure 2: SEIS breadboard (courtesy MPS)

SEIS Scientific Objectives: The SEIS will be the major contributor to the InSight mission science objectives. Its main objectives are:

- Determination of magnitude, rate and geographical distribution of the Martian internal seismic activity
- Determination of the Martian core size, composition, physical state (solid or liquid)
- Determination of the Martian crust thickness, structure and composition
- Determination of the Martian mantle composition and structure
- Measurement of the rate of meteorite impacts rate

Functional description: The SEIS instrument is a composite of several physical measurements. It integrates a Very Broad Band (VBB) 3 axis seismometer, complemented by another trihedron of MEMS Short Period (SP) seismometers. Each VBB is a leaf-spring, inverted pendulum type seismometer with a highly sensitive displacement transducers and an electromagnetic feedback. The sensors are sealed into a vacuum sphere and mounted on a levelling mechanism. The Short Period sensors are based on silicon microdevices. They also use highly sensitive displacement transducers with electromagnetic feedback. SEIS includes also all environmental sensors for pressure, wind and temperature, to help with the decorrelation of the environment. A dedicated electronics manages the overall experiment and ultra-low noise, 24-bit A/D converters perform the acquisition.

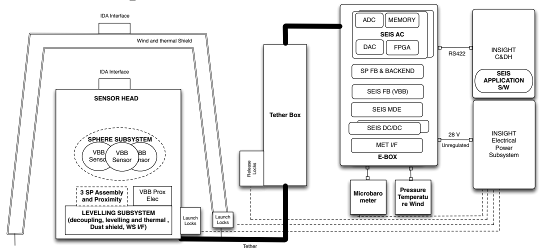

Figure 3: SEIS Functional description; sensor head with wind and thermal shield are deployed on the ground

The SEIS software, developped by CNES and JPL, will be included in the lander Command and Data Handling unit. All critical subsystems have built-in redundancy, while VBB and SP overlapping bands provide, to a certain extend, redundancy for key measurements such as body waves or part of surface waves.

Environment related noise: A very thorough care has been taken to protect SEIS from any external environment related noise: the SEIS instrument will be deployed on the ground by an Instrument Deployment Arm (IDA) and protected from the wind and temperature by a wind and thermal shield (WTS), also deployed by the IDA. The WTS is mechanically decoupled from the sensor head to avoid any wind-related influence and provides an insulation with a 18 hour thermal time constant with respect to the external temperature fluctuation. In addition, microbarometer measurements will help to mitigate any pressure related background noise (eg [6].)

SEIS Performance: The instrument provides sufficient margins with respect to L1 high-level mission requirements, to cope with the uncertainties of the Mars seismic activity, as depicted in the figure 4. The low frequency (below 0.02 Hz) performance is related to the Phobos tides and Mars normal modes measurements, while the [0.1-1 Hz] window performance provides the core of the science return (Surface and Body Waves). High frequency content, complemented by the short period seismometer measurements, will monitor body waves and meteoritic impacts.

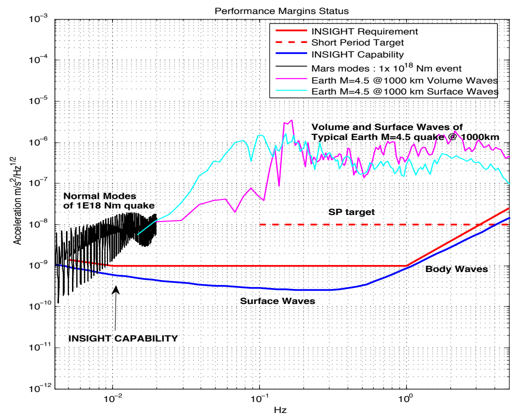

Figure 4: SEIS performance versus typical signals expected on Mars: normal modes (on the left) and typical M=4.5 Earthquake at 1000 km

Operational profile: To lower as much as possible the operational cost, instrument operation has been designed to be very simple. The operational scheme is very close to a “deploy and forget” scheme (The first month being dedicated to instrument deployment and calication). After this first month, at each pass of a relay satellite, continuous data, as well as event data will be transmitted. The data profile is versatile, with a threshold science compatible to a 8 Mbits/sol upload capability to Earth.

Ressources: The current best estimate of the SEIS experiment with all redundancies is about 8 kg for the sensor head and about 3 kg for the electronic box. The power consumption on the primary power line (28 V) is about 4.5W**.** The nominal upload data rate to Earth is about 48 Mbits/sol.

References:

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