SEIS-NL : a VBB - 3 Axis - Seismometer to study Mars internal structure

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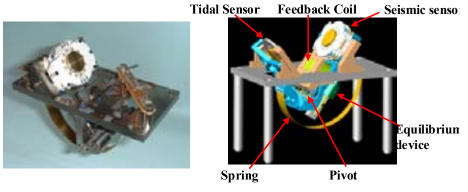
The Space Department of IPGP has started to develop seismometers for the Mars 96 Russian mission.

Since 1994, we have started to design a new seismometer for future Martian exploration programs. A VBB 3 axis mock-up was realized and tested in 1997. This instrument proposed an interesting concept with a very low mass, a low volume, a low power consumption and it reached performances close to reference terrestrial seismometer like STS-2.

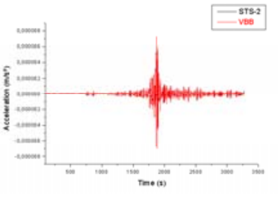
In the framework of the Netlander mission which will install 4 landers on Mars in 2007, we started to up-grade the VBB seismometer to fit its performances to the objectives of the first seismic network planned to be installed on Mars.

Mock-up

1996 : VBB 1.0 — 2001 : VBB 2.0



Results (1/2)



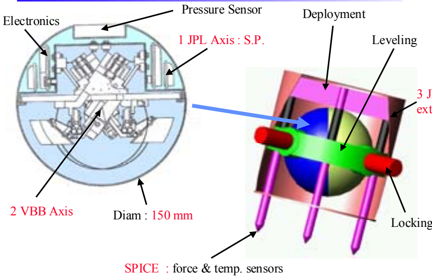
Turkmenistan, 06/12/00, 5:00 PM T.U., M = 7.2

- VBB 1.0 (1996) :
  - f_0 = 1.6 Hz, Q = 1000,
  - M.Q.T = 15,
  - S = 2 10³ V.s²/m,
- VBB 2.0 (2001) :
  - f_0 = 0.5 Hz, Q = 300,
  - M.Q.T = 15,
  - S = 1.2 10⁵ V.s²/m,

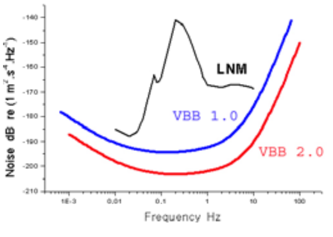
Objective 1 : Low Noise / High Sensitivity

- **Mechanics :**
  - High mechanical amplification : (> 3.10^{-2} s²)
    Tilted Inverted Pendulum technology (high amplification / low mass),
  - Very Low Brownian Noise : (< 10^{-10} m/s².Hz$^{-1/2}$)
    High Quality Factor (damping reduction on assemblying, spring…),
- **Electronics :**
  - High Sensitivity displacement transducers : (10⁶ V/m)
    Dedicated differential capacitance sensors (tidal & seismic outputs),
  - Mixed analog / digital feedback : (> 140 dB)
    Provides stability / adjustment required.

Integration



Results (2/2)

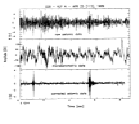


VBB 1.0 :
Efficient terrestrial seismometer.

VBB 2.0 :
Now compatible with Mars objectives.

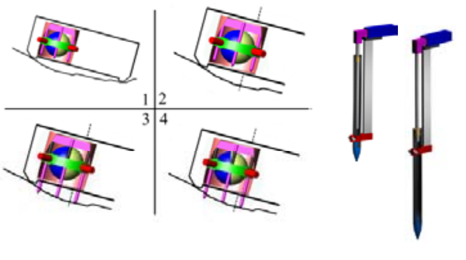
Objective 2 : Low Sensitivity to Environment

- **Temperature :**
  - Low thermal drift : (< 1 µm/K)
    Specific materials and treatments for spring.
    Thermo-mechanical finite element model (NASTRAN).
  - Passive protection :
    Lander used as a thermal shield + Efficient Thermal Insulation.
  - Active correction :
    Decorrelation with T measurement (µK).
- **Pressure :**
  - Passive protection :
    Lander used as a windshield + evacuated rigid structure.
  - Active correction :
    Decorrelation with P measurement (µbar).



Installation Scenario

Mechanically Uncouple SEIS / Lander - Couple SEIS (JPL) / Ground

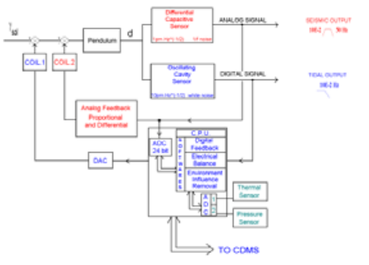


POWER Breakdown

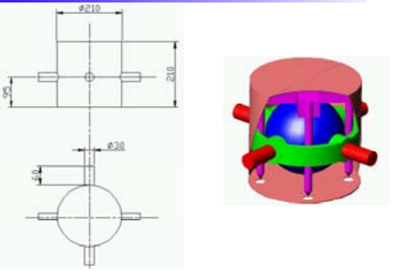
		Mean or continuous Power (mW)				
Inside sphere						
	IPGP-VBB (2 axis)	CCD :capacitive detector		10		
		CCO :capacitive oscillator		40		
	Feedback electronics			40		
	JPL-SP micro seismometer (1 axis)			40		
	A/D 24 bits			50		
	Inclinometers, temperature pressure sensor			20		
	Sub total inside sphere				**200**	
JPL-SP micro seismometer (3 axis)						
	sub-total				**120**	
Inside the SEC						
	Microprocessor			180		
	Sub total inside CDMS				**180**	
TOTAL witout installation		**(continuous power)**				**500**
Heater		**300 mW during 8 hours**			**100**	
TOTAL witout installation, mean power						**600**
Installation devices						
Estimation to 1 Wh/day during 2 days (night and day) with						
with an absolute maximum of					**400**	
TOTAL during installation						**900**

Block diagram

SEIS-NL Electronics will be provided by ETH



Volume requirement



MASS Breakdown

SPHERE (sensors)				730
VBB axis (x2)			290	
Mobile part	2	85		
Fixed part	2	35		
Locking device	2	25		
JPL axis			40	
Sensor		30		
Fixation		10		
Pressure, temperature			30	
Pressure		20		
Temperature		2		
Fixation		8		
Proximity electronics			95	
Electronics		60		
Fixation		25		
Wires		10		
Structure			275	
Inner structure (supporting sensors, electronics..)		130		
Titanium sphere + isolation		105		
External interface		40		
LEVELLING DEVICE				310
Structure		170		
Mechanisms		80		
Interface		60		
LOCKING DEVICE				240
Structure	4	10		
Mechanisms	4	40		
Interface	4	10		
INSTALLING DEVICE				300
Structure		90		
Mechanisms		140		
Interface		60		
Electronics, sensors…		10		
EXTERNAL JPL AXIS				150
Sensor	3	45		
Fixation		15		
EXTERNAL ELECTRONICS (inside lander/CDMS)				200
CABLES				70
TOTAL (without margins)				2000