IN-SITU INSTRUMENTATION FOR ASTEROID GEOPHYSICAL EXPLORATION

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Introduction: Understanding the physical properties and internal structure of asteroids is key for science, planetary defence and future in-situ resource utilisation. Ground rotation and translation sensors are complementary instruments that can be used in-situ (on the surface) to infer the mechanical properties and internal structure of planetary bodies at different scales [1]. In the framework of two European Commission Horizon 2020 projects (PIONEERS and NEO-MAPP), we are developing **two in-situ geophysical instruments**, designed specifically to fit inside a small lander and function in the challenging environment of the asteroid surface.

6 Degrees of Freedom instrument: The 6 Degrees of Freedom instrument makes precise measurements of the landing dynamics (acceleration profile, rotation), the in-situ rotational dynamics, and the ground acceleration and rotation during active seismic experiments. The instrument combines MEMS accelerometers, small fibre optic gyroscopes (and electronics and mechanical interface) in order to be sensitive to motion in three translational and around three rotational axes. The consortium, led by ISAE-SUPAERO, have a strong expertise in state of art instrument development (SEIS/INSIGHT, BlueSeis). The instrument is expected to reach TRL 6 (proto-flight model) in late 2023.

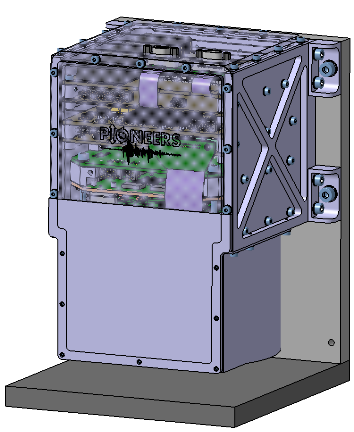
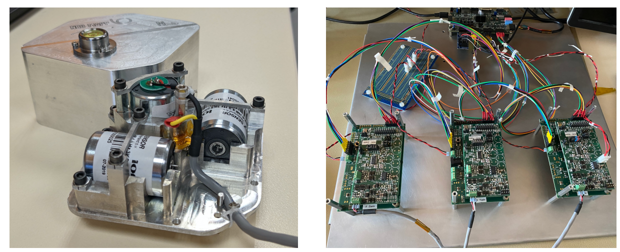


Figure 1: The 6 Degrees of Freedom PIONEERS Instrument. The dimensions are 97 x 97 x 150 mm and the instrument mass is ~1.5 kg.

Compact seismometer: The compact seismometer measures the ground motion along 3 axes generated by natural [2] or artificial [3] seismic activity. The instrument consists of 3 small geophone sensors, the analog and digital electronics and the mechanical interface. The sensors are commercial sensors specifically designed for borehole extreme environment, and the dedicated acquisition electronics are being developed at ISAE-SUPAERO. The instrument is currently at TRL 4/5 (engineering model).



(a) (b)

Figure 2: Photos of the compact seismometer. (a) Integrated seismic sensors, (b) Breadboard of the 3 axis seismometer electronics. The instrument has a volume of ~2L and a mass of ~1 kg.

Conclusions: The two in-situ geophysical payloads being developed at ISAE-SUPAERO are complementary (Table 1) and can be flown together or separately. The concept of operations can be adapted depending on the mission profile.

Table 1: Comparison of the science objectives of the 6 Degree of Freedom instrument and the compact seismometer

Science objective	Measurements	6 Degree of Freedom Instrument	Compact Seismometer
Surface mechanical properties	Landing dynamics	✓	
Density distribution and internal structure	Precise measurements of rotational dynamics	✓	
Subsurface and internal structure	Active seismic experiment	✓	✓
	Natural seismic experiment		✓
Impact physics	Active seismic experiment	✓	✓
Seismic background noise estimates	Monitoring of natural seismic sources		✓
Diurnal and orbital activity	Monitoring of natural seismic sources		✓

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