

PhD (& Internship) Position

Understanding Extraterrestrial Soil Mechanics Through Low-Gravity Laboratory Testing

Key words: Geotechnical Engineering, Planetary Science, Granular Physics, Space, Experiments

Department: Electronics, Optronics, and Signal Processing Department (DEOS)

The student will be part of the [Space Systems for Planetary Applications \(SSPA\)](#) team at ISAE-SUPAERO.

JOB DESCRIPTION:

With the increasing number of space missions that involve interactions with regolith-covered planetary bodies, understanding the behaviour of extra-terrestrial surface materials has become crucial for both robotic and human exploration. Such knowledge is also essential to accurately interpret observed surface phenomena. Studying granular materials (such as soils or regolith) in extra-terrestrial environments presents significant challenges. Gravitational acceleration differs by several orders of magnitude between Earth and smaller planetary bodies like asteroids. These variations alter the normal stress (or weight) exerted by objects on planetary surfaces, which in turn affects the behaviour of surface materials. In addition to the reduced gravity, the vacuum environment of space must also be accounted for on airless bodies; the absence of an atmosphere eliminates effects such as air drag, pore pressure, and humidity, which on Earth contribute to grain cohesion and energy dissipation. Additionally, the frictional characteristics of regolith are expected to differ greatly between planetary bodies; comminution and thermal fracturing tend to create sharp, angular grains, while aeolian processes and saltation produce more rounded particles. Variations in grain surface friction, shape, and size distribution all play a role in determining how easily grains can move, ultimately influencing the overall mechanical behaviour of the material.

The goal of this thesis is to further our understanding of the response of planetary surfaces to geotechnical testing – in particular dynamic penetration testing. The thesis will involve terrestrial and low-gravity experiments using a new facility at ISAE-SUPAERO (Fig. 2; Wilhelm et al., 2025). The results are directly relevant to the upcoming ESA Hera (Michel et al., 2025) and JAXA MMX (Kawakatsu et al., 2023) space missions.

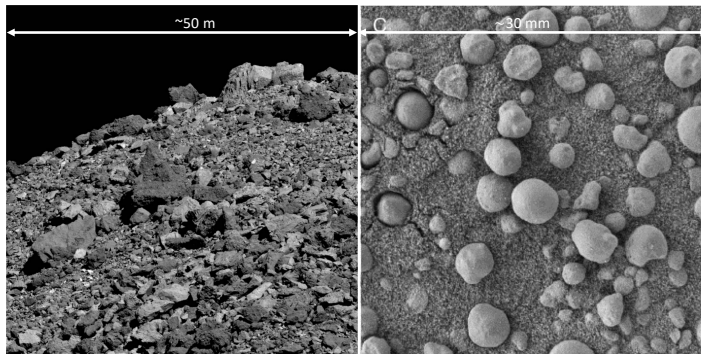


Figure 1. Left - Particles on surface of asteroid Bennu, Image Credits: OSIRIS-Rex/NASA/Goddard Space Flight Center/University of Arizona. Right - Particles on the surface of Mars, Sullivan et al., (2011).

MISSIONS:

The specific tasks will be to perform dynamic penetration experiments using the new 'GRAVITE' experimental facility, then to analyse the experimental data to understand the influence of the impact angle in addition to the roles of material parameters, gravity and vacuum. Discrete Element Method simulations (e.g., Sunday et al., 2020, 2021) may also be performed to complement the analyses. The student will be part of the Space Systems for Planetary Applications (SSPA) team at ISAE-SUPAERO. The team is primarily focussed on the development of space missions and the associated technologies for the geophysical exploration of the Solar System.

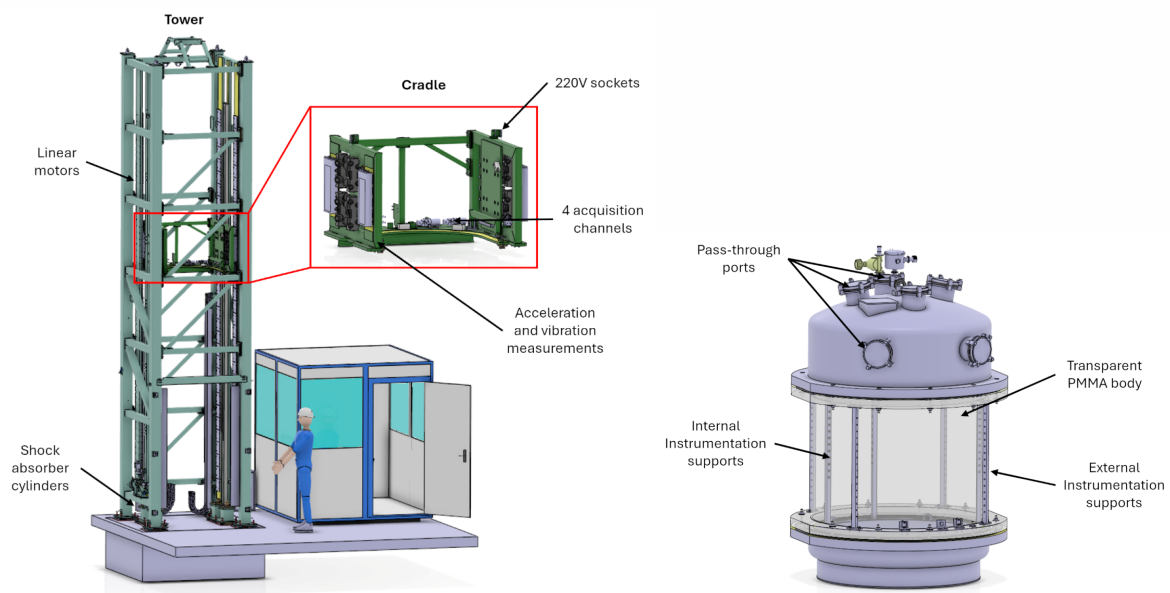


Figure 2: (Left) The 7 m high variable gravity laboratory at ISAE-SUPAERO. (Right) The vacuum tight container with an internal diameter of ~80 cm. From Wilhelm et al., (2025).

REQUIRED PROFILE:

Candidates should hold a Master's degree (or be in the final year of a Master's program), preferably in engineering, planetary science, or physics; however, applicants from other relevant disciplines will also be considered. Profiles that will be particularly valued include those with experience in geotechnical soil testing and those familiar with soil or granular mechanics. Prior experience with experimental work and/or with coding languages such as C/C++, python, or cuda will be considered an asset. The ideal candidate will have a solid understanding of physics, enabling them to analyse complex problems and interpret data effectively. They should demonstrate rigor, autonomy, and a strong aptitude for hands-on experimental work, while also enjoying collaboration within a small, dynamic research team. Proficiency in both French and English would be advantageous.

COMPENSATION: 2670€ / month (gross salary). The PhD thesis will be funded through the European Research Council (ERC) GRAVITE project (Grant Agreement N° 1087060).

DURATION: 36 MOIS

LOCATION: TOULOUSE

RESPONSIBLE OF THE SUBJECT:

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APPLICATION PROCESS: Candidates should contact the PhD supervisor (N. Murdoch) with a letter of motivation and CV. Please include the contact details of two referees. There is also a possibility for the student to complete a 3-to-6-month Masters-level internship on this project before starting the PhD. Applications will be accepted until the position is filled.

REFERENCES: Kawakatsu et al., (2023) Acta Astronautica, 202, 715-728; Michel et al., (2025) SSR 221:70; Murdoch et al., (2017) MNRAS 468, 2, 1259–1272; Murdoch et al., (2021) MNRAS 503, 3460–3471; Sullivan. et al., (2011) Journal of Geophysical Research: Planets, 116(E2); Sunday et al., (2020) MNRAS 498, 1062–1079; Sunday et al., (2021), Astronomy & Astrophysics 656, A97; Sunday et al., (2022), Astronomy & Astrophysics 658, A118; Wilhelm et al., (2025), EPSC-DPS.

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