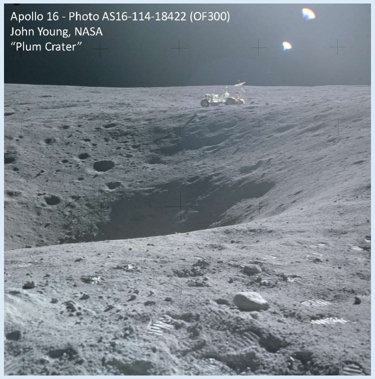
LUNAR25 Lunar Geotechnical Probe

Johns Hopkins Applied Physics Laboratory · Johns Hopkins University

Matthew Konkol, Alexander Pivovarov, Aidan Green, Xander O'Malley

Background

In support of future missions to the Moon and beyond, it is imperative to collect large amounts of scientific data regarding the properties of lunar topsoil, called "regolith". The best way to do so is to create a sensor system which can be mass-manufactured and mounted to commercial autonomous rovers. Penetrometer tests have not been performed since the Apollo missions in the 1970s, and no tests have been done on the highlands – uncharted territory with harsher environment.



More thorough regolith testing supports construction of permanent and semi-permanent habitats in future manned missions.

Objectives

JHU APL wanted a probe that could measure the most important lunar regolith characteristics in situ – bearing strength, shear strength, relative permittivity, and temperature.

Measurement	Definition	Maximum
Bearing Strength	Regolith resistance to compressive loads	200 kPa
Shear Strength	Regolith resistance to shear (lateral) loads	10 kPa
Relative Permittivity	Regolith resistance to electromagnetic fields	10
Temperature	Concentration of heat	-10° – 30°C

Goal: reliably capture all measurements to a depth of 5-10cm in abrasive LHS-2E regolith simulant. Measurements must be taken to reasonable precision (5–10%) for the duration of 50 tests.

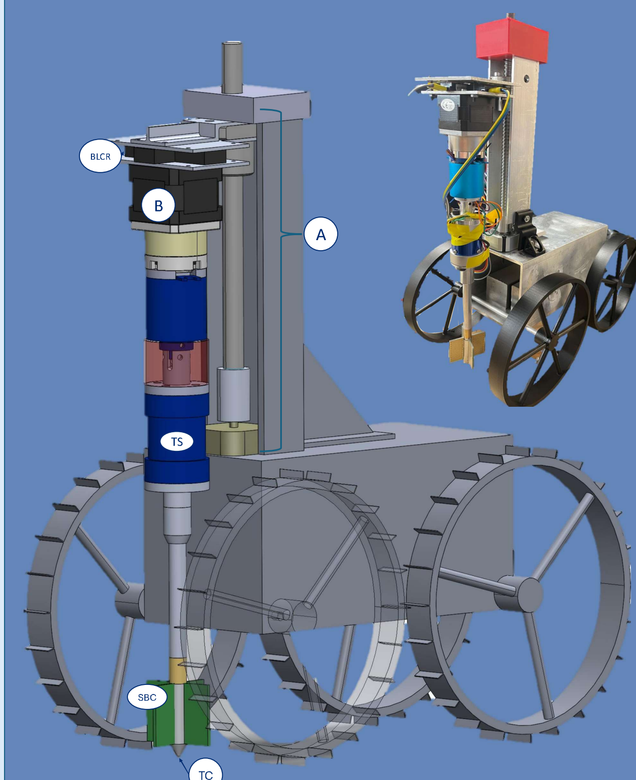
System must fit within 10x10x30cm bounding box, weigh less than 2kg, and may draw no more than 150W at any time.

System Overview

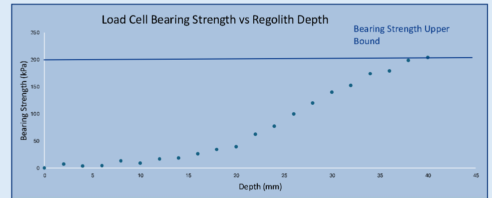
We developed four subsystems in accordance with the four sensing requirements of the probe system:

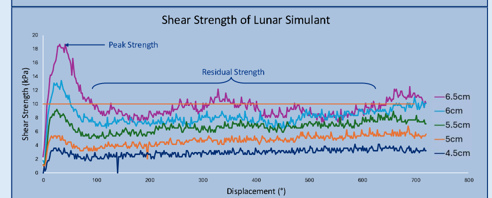
System Acronym	System Full Name	Sensing Function
BLCR	Button Load Cell Rosette	Applied axial load → regolith bearing strength
TS	Torque Sensor	Applied torque load → regolith shear strength
SBC	Strip-Board Capacitor	Environment capacitance → regolith permittivity
TC	Thermocouple	Temperature of probe tip

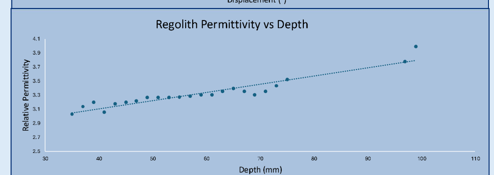
We also developed two movement systems to fulfill the requirements: System A and System B in the figure below. System A controls vertical movement using a stepper motor and lead screw, and System B enables probe rotation through a stepper motor and integrated planetary gear train.

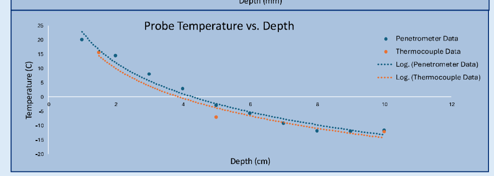


Performance

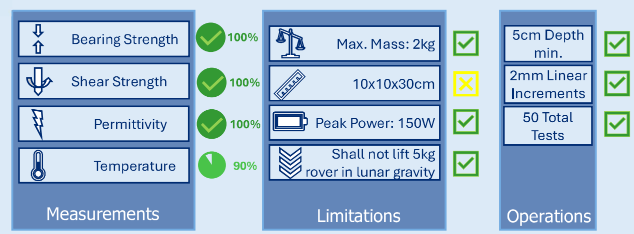








Conclusions



The penetrometer can successfully and accurately record all required data types – temperature measurement accuracy may vary depending on system operation speed. We breached the bounding box vertically, but future models can reduce component size depending on rover dimensions and probe mounting options. The penetrometer exceeded 50 tests in regolith simulant without sensor deterioration.

Acknowledgements: Dr. Tyler Powell, Dr. Angela Stickle, Rich Bauernschub, Dr. Stephen Belkoff, Mark Cooper, Patrick Deans