Technical University of Munich - Institute of Astronautics

Project **LUVMI** - The Lunar Volatiles Mobile Instrumentation

The Objective: Uncover the moon's darkest secret

The moon, an arid desert?
Since the Apollo missions, the moon appeared as a hostile, barren landscape. With its surface covered in dry regolith and with the absence of a tempering atmossphere, it is subject to temperature fluctuations of up to +/- 140 K. It was believed, that water, even if it had once existed, would have evaporated into the vacuum of space.

A secret hidden in darkness
The low inclination of the lunar orbit of only 1°32' allows depressed areas in high latitudes to remain in eternal darkness. These permanently shadowed areas are never reached by heating sunlight and therefore remain extremely cold. Infrared observations have shown that in some craters, especially near the lunar south pole, the temperature never exceeds 40 K. This is so cold that water ice could exist, despite the vacuum of space. Such locations were dubbed "cold traps" for their ability to capture volatile elements and gases like H, HO, H2, H2O, CH4, CO2, SO2 and others, that were released by meteroite impact or the solar wind.

A glimpse from space
As these cold traps are never illuminated by the sun, they remain too dark to be observed directly.

Nonetheless, recent years have brought new light into the shadow: Remote sensing satellite missions like Chandrayaan-1 or Clementine have provided strong indications that significant amounts of volatiles, among them water, are frozen in cold traps at the lunar poles. In 2009, the NASA LCROSS mission crashed a spent upper rocket stage into the Cabeus crater near the lunar south pole. In the resulting ejection plume, a water content of 5.6 +/- 2.9 % was observed.

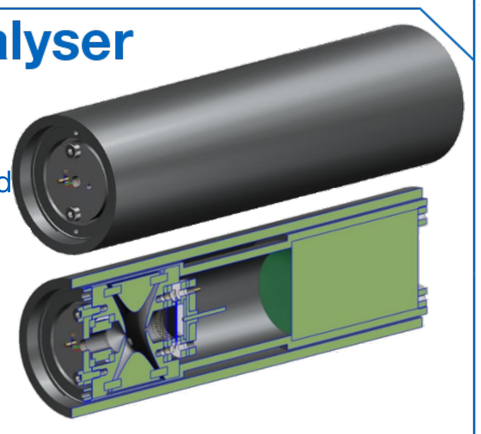
Fuel for thought
If these indications were to be revealed as true, huge amounts of water ice could exist on the moon. The Cabeus crater alone, with its 95km diameter, could provide thousands of tons of easily accessible water, hydrocarbons and more. These resources could be used to produce rocket fuel, oxygen, potable water, grow plants and much more - making a permanent human presence on the lunar surface possible.

The challenge
In-situ measurements are necessary as a definitive proof for the existence of lunar water. But so far, no mission has investigated permanently shadowed craters from the ground.

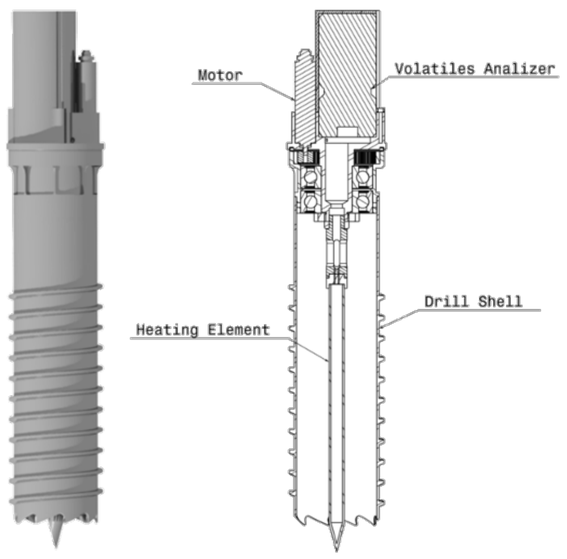
Project LUVMI intents to change that.

Volatiles Analyser

The Volatiles Analyser is a ultra-light miniature ion-trap mass spectrometer, developed by the Open University. Although it weighs less than 500g, it is able to identify all relevant species.



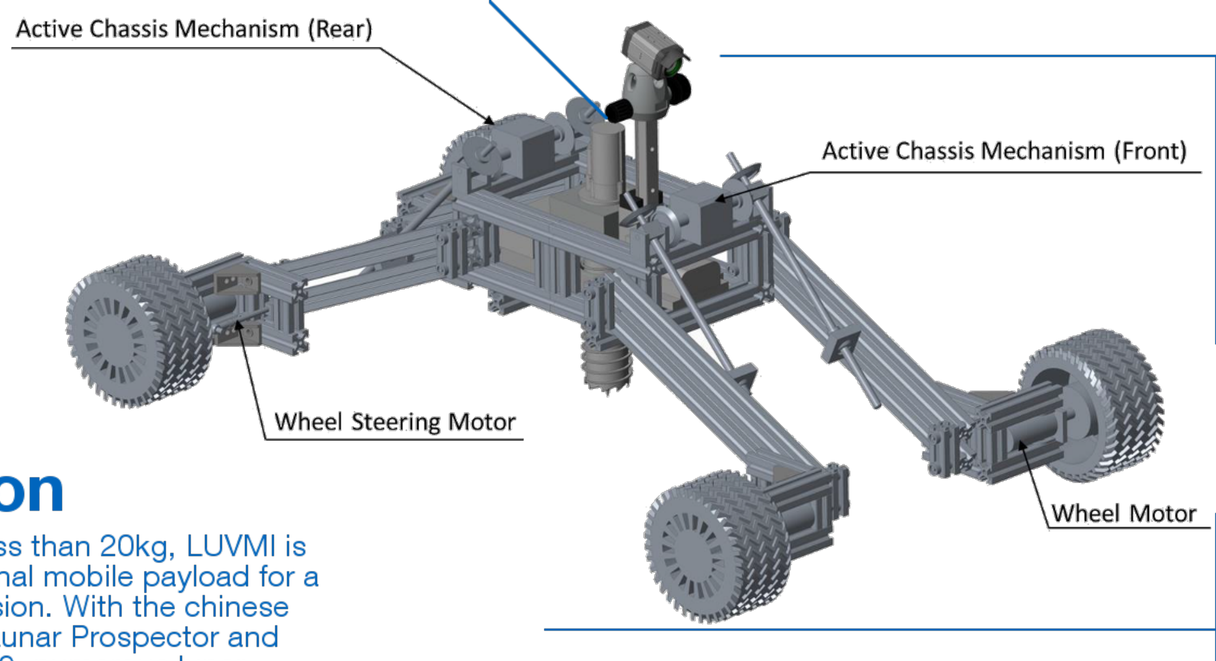
Lunar Volatiles Scout



Developed in a coorperation of TUM and OHB System, the Lunar Volatiles Scout is a novel design that unites soil extraction, sample handling mechanism and analysis oven in one compact and efficient unit. Instead of extracting a sample for subsequent analysis in an external oven, the Volatile Sampler brings the oven into the soil.

With the rotating drill shell, the LVS can be inserted into the lunar regolith, which is then heated by the heating element. The released gas is then led to the mass spectrometer.

This approach significantly reduces the instrument mass and increases soil sample volumes. The VS has a mass of less than 1kg.



Surface Imaging

LUVMI features a novel surface imaging technology, that employs a Mico-Lens Array to capture multiple dimensions of information about a scene with a single image exposure. This allows images to be refocused afterwards or generate an image at "total focus", with extraordinary depth of field.
This technology, developed by Dynamic Imaging Analytics, bears great potential for space applications, as it allows to generate 3D-images from a single camera, provides excellent signal to noise ratios and operates without an active focusing mechanism.

The Mission

With a total mass of less than 20kg, LUVMI is intended as an additional mobile payload for a lunar pole landing mission. With the chinese Chang'e 4 and 6, US Lunar Prospector and Russia's LUNA 27 to 29, numerous lunar lander missions are planned to launch within the next 8 years. The European Space Agency is likely to participate in most of these missions.

With a range greater than 50km, the ability to traverse steep slopes and to acess shadowed areas, LUVMI could significantly improve the scientific return of any of the above missions, with only little additional weight.

Multi-purpose structure

The LUVMI architecture is built on the multi-purpose structure, developed by Space Applications Services. The structure supports 4 wheels and motors, an active chassis mechanism, that enables control of the ground clearance for optimal payload operations, and an adaptable payload platform.
The structure is realised by an innovative sheet metal design, which allows quick and affordable design iterations.

Interested?

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