Finding suitable quantities of key resources for life-support and refueling is vital to future sustained lunar manned bases and commercial activities. There are large uncertainties in the lunar near-surface distribution of water ice volatiles and relevant in-situ resources, such as ilmenite (FeTiO$_3$). Moreover, planned future lunar orbiter missions have relatively limited spatial resolution, in the km range, for the volatile mappings relative to typical lander and rover range capabilities, especially for operations within the lunar Permanently Shadowed Regions (PSRs) that could shelter accumulated water ice deposits.

VMMO, for Volatile and Mineralogy Mapping Orbiter, is a low-cost 20 kg 12U Cubesat that comprises the Lunar Volatile and Mineralogy Mapper (LVMM) multi-wavelength chemical lidar science payload, the Compact LunAr Ionizing Radiation Environment (CLAIRE) monitoring payload, a COTS electronics test bed, and the supporting 12U Cubesat bus with propulsion, direct to Earth S-band and 1560 nm optical communications, on board data processing and a suite of altitude and pointing sensors for semiautonomous vision-assisted navigation from lunar orbit.

VMMO will most likely be deployed from a commercial lunar transportation provider, such as Astrobotics, into a suitable near-polar injection orbit. The on-board propulsion will be used to achieve a stable lunar frozen orbit for the subsequent science operations with a perilune over the south pole under 100 km to assist the LVMM volatile and mineralogy mappings.

The compact LVMM is a multi-wavelength Chemical Lidar (<6.1 kg) which will use single-mode (SM) fiber lasers emitting simultaneously at 532 nm, 1064 nm and 1560 nm. This will permit stand-off mapping of the lunar water ice distribution using active laser illumination, with a focus on selected permanently-shadowed craters in the lunar south pole; Shackleton, Faustini and Cabeus. This combination of selected laser spectral channels can provide very sensitive discrimination of water/ice in various types of Mare and Highland regolith, based on breadboard validation. The use of the SM fiber lasers enables a small laser beam divergence to provide high spatial resolution in...
the 10 m range at the lunar surface. There is some relevant flight heritage as part of the Fiber Sensor Demonstrator (FSD) payload on ESA's Proba-2 spacecraft that is still operational after more than 10 years in low earth orbit.

LVMM can also be used in a passive multispectral mode at 300 nm, 532 nm, 1064 nm and 1560 nm to map the lunar ilmenite in-situ resource distribution during the lunar day using the characteristic surface-reflected solar illumination. By combining the passive lunar day measurements with the active lunar night measurements, some new insights into the lunar diurnal water cycle should be possible.

This paper discusses the VMMO science requirements and the supporting 12U Cubesat platform and LVMM multiwavelength chemical lidar payload and some of the associated design trade-offs.