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US (ITAR) Classification: Not Controlled  
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*Rated by Steve Eckersley on 22/06/21*

# Lunar Volatile and Mineralogy Mapping Orbiter (VMMO): Viable Science from Lunar CubeSats

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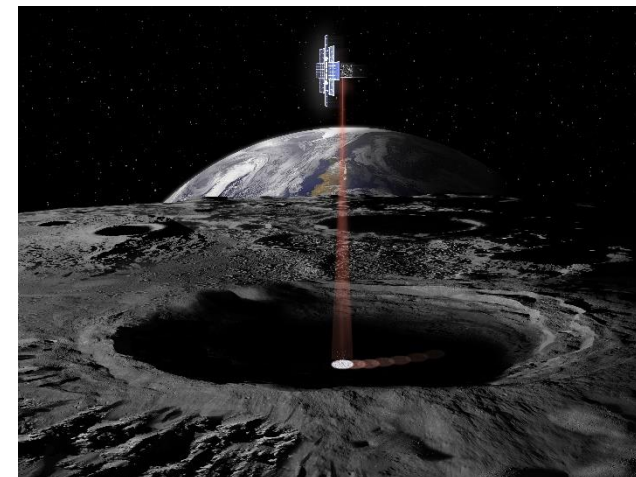
**AUGUST 7-12, 2021**



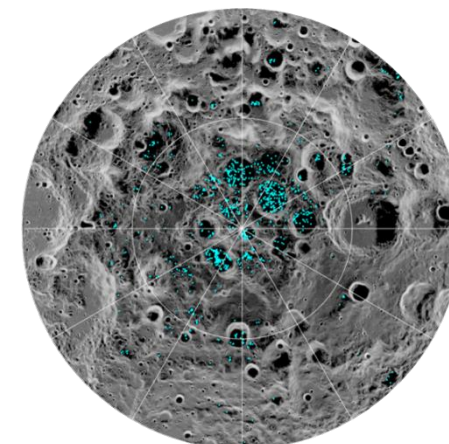
# Background



- NASA's Artemis programme aims to have humans return to the Moon by 2024.
- Crucial to understand location and extent of water ice deposits on Lunar surface for future lunar habitats.
- Technology capability improvements and miniaturisation are enablers for advanced CubeSat missions.
- Future NASA Lunar CubeSat missions will map water ice deposits to a resolution on the order of kilometres.



Lunar Flashlight [NASA]



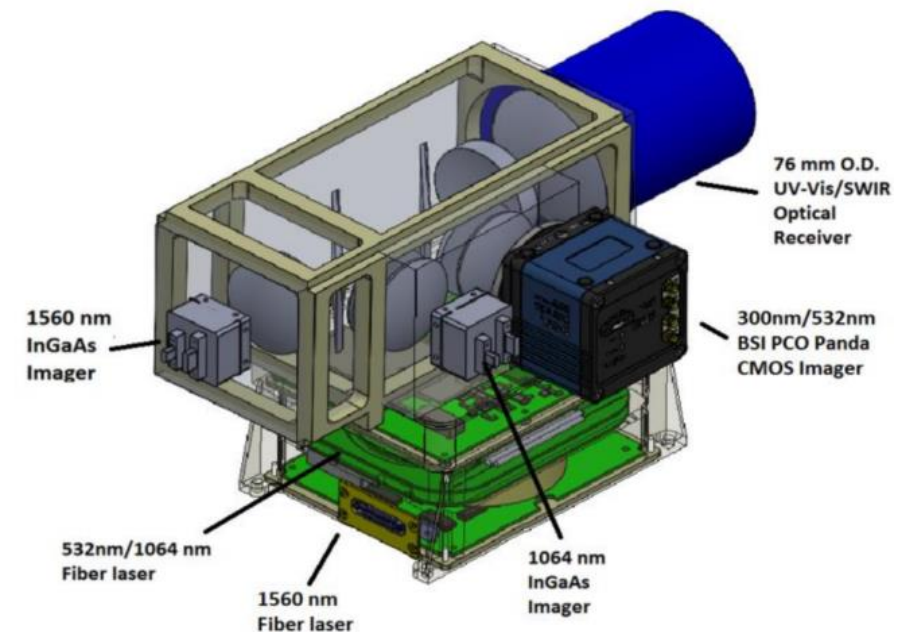
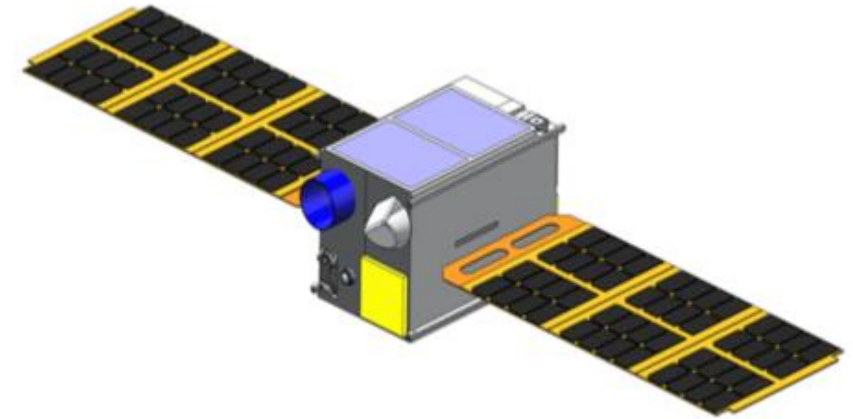
Distribution of surface ice at Lunar south pole [NASA]

# VMMO Mission Overview

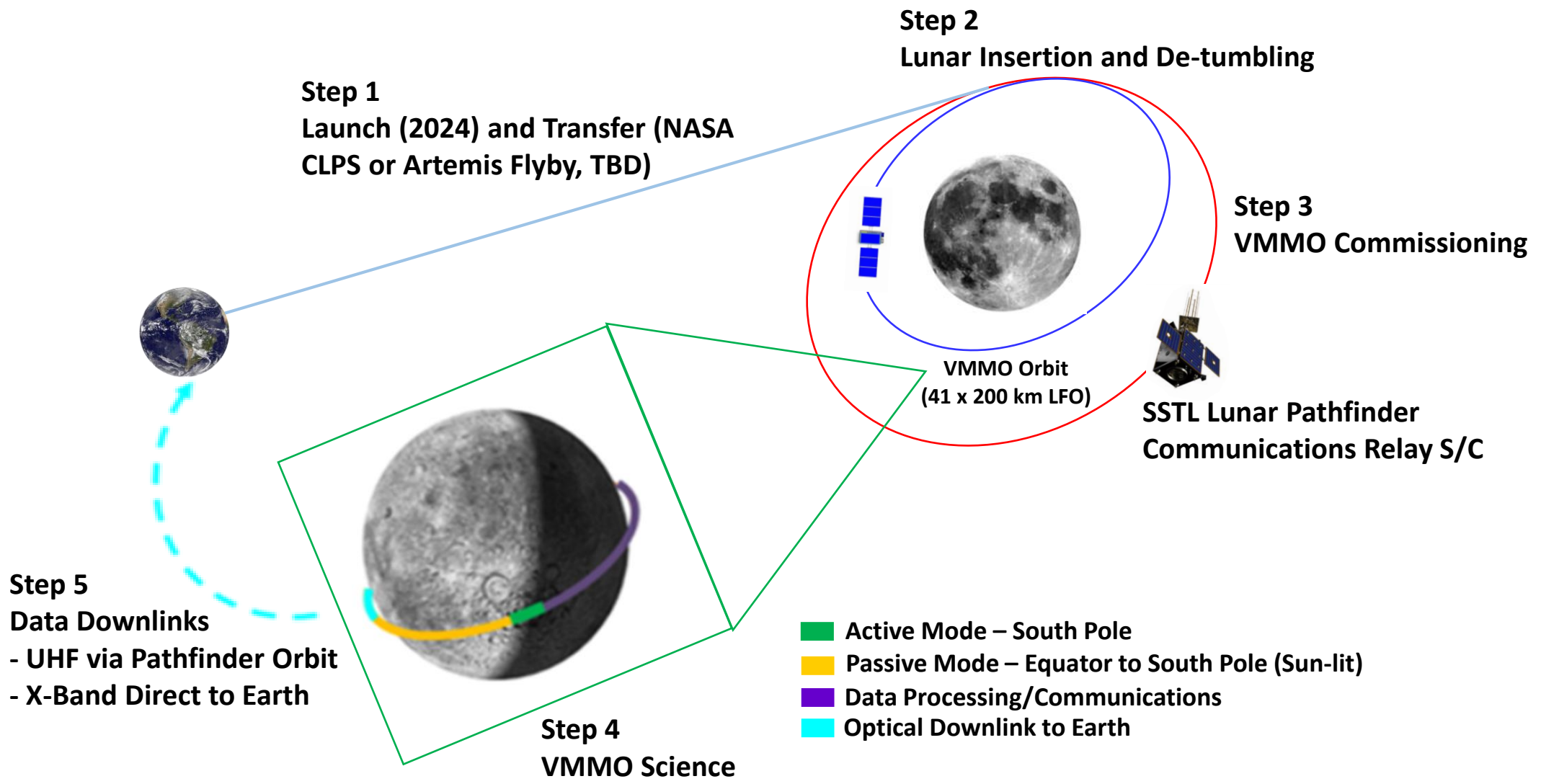


## Mission Objectives:

- 1) Detect water ice and other volatiles in the permanently shadowed regions of the Lunar south pole (10m spot size, 100m map spatial resolution)
- 2) Detect in-situ resources such as Ilmenite in sun-lit portions of Moon
- 3) Determine whether night-time frost deposition occurs
- 4) Study Lunar diurnal water cycle
- 5) Perform optical communications downlink demonstration to Earth
- 6) Test CubeSat components in the cis-lunar environment

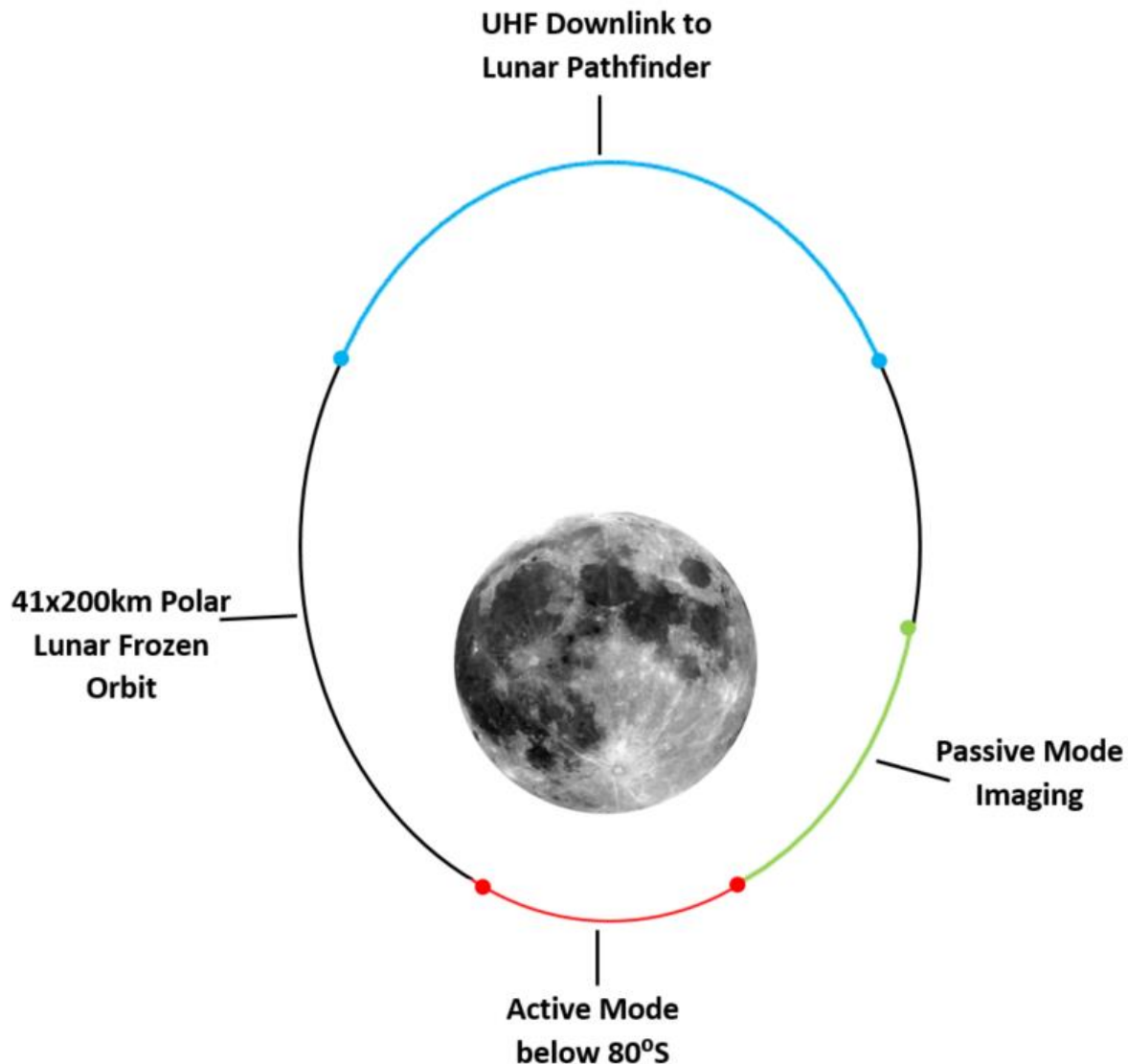


# Mission CONOPS





# Payload Operations



- **Active Mode**

- LVMM 532nm, 1064nm and 1560nm fibre lasers on
- LVMM UV/Visible and SWIR imagers on
- Target south polar region: Shackleton, Faustini and Cabeus craters

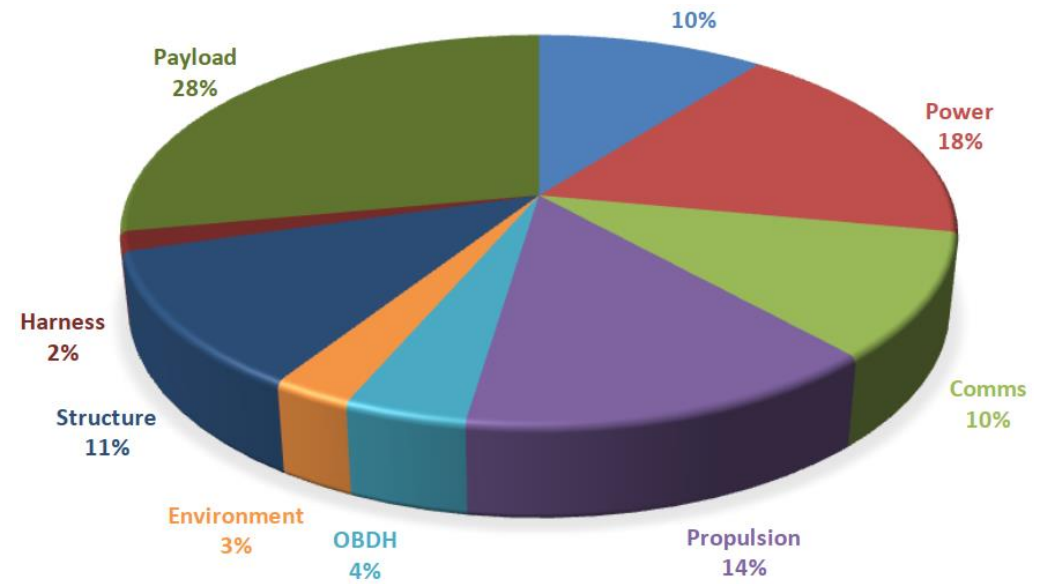
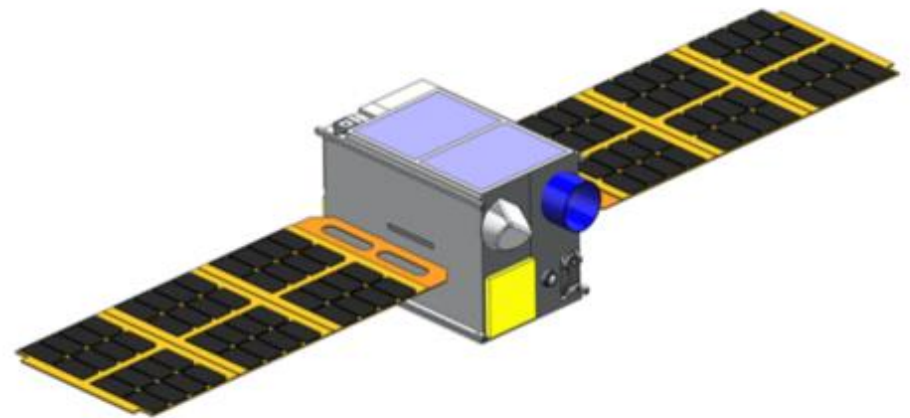
- **Passive Mode**

- Spectral channels at 300nm, 532nm, 690nm, 1064nm and 1560nm
- Fibre lasers powered off
- Map lunar in-situ resources such as Ilmenite during the lunar day (from equator to the South Pole)

# VMMO Spacecraft Overview (1)



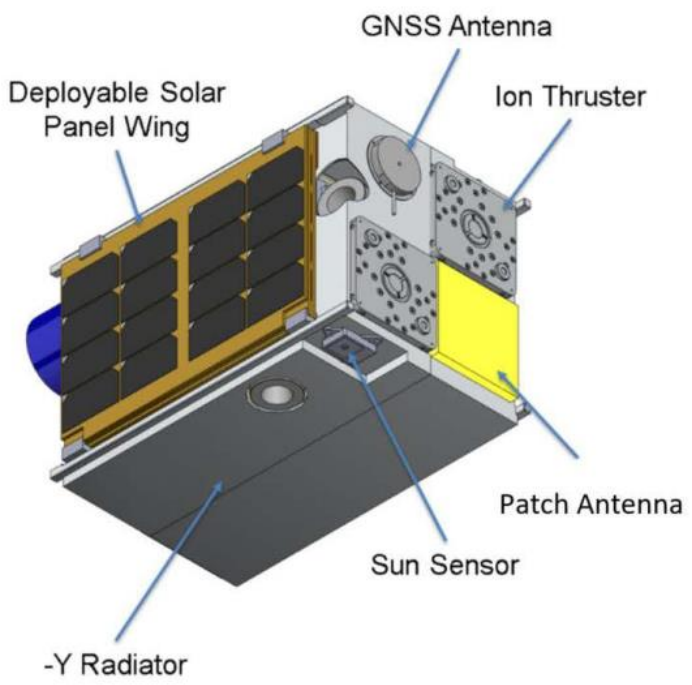
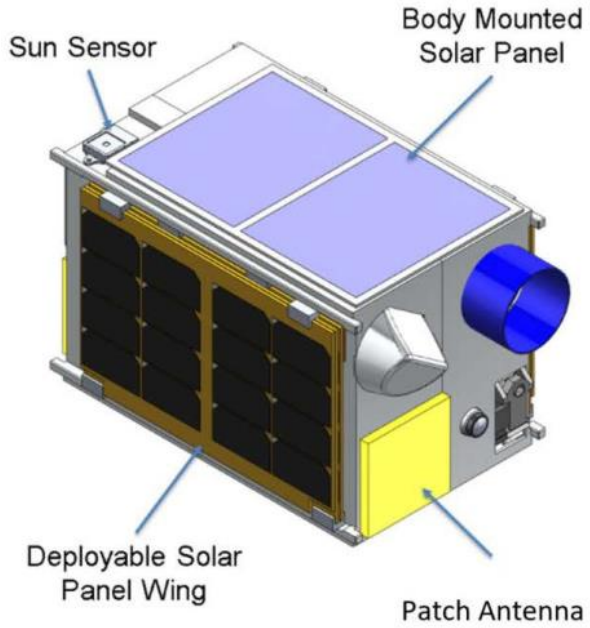
- 12U CubeSat
- Mass 22.4kg (inc. unit margin)
- 2x tracking solar arrays
- 1x body mounted solar array
- 2x 77Wh Li-Ion batteries
- EOL orbital average power (~51-83W)



# VMMO Spacecraft Overview (2)

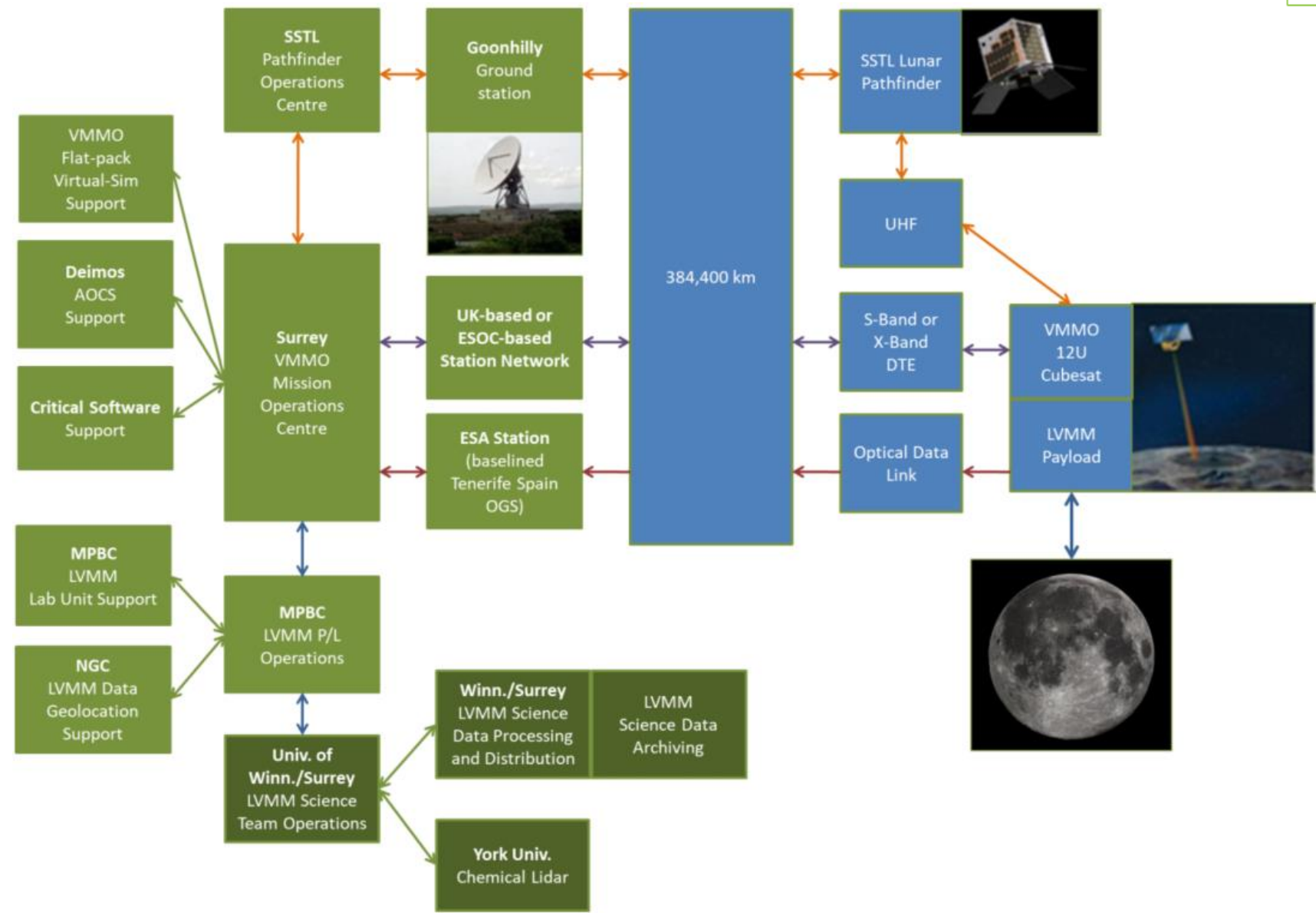


- 3-axis stabilised
- Navigation:
  - X-band ranging
  - GNSS demo
- Electric propulsion:
  - 2x IFM nano thrusters
  - Indium propellant
- OBC:
  - GR-XCKU development board
  - ESA's LEON 3 processor system on a chip
- Thermal: Passive & Active





# Ground Segment and Communications





# Conclusion



- Some of the key challenges involved in designing a CubeSat for lunar orbit include:
  - Accessing the lunar orbit;
  - Deep space communications;
  - Power generation and power requirements (e.g. for propulsion and communications);
- VMMO is an ambitious mission that will generate valuable data on the location and extent of water ice and other lunar volatiles across the Lunar South Pole.

# Acknowledgements



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Thank you

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