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Thermal Modelling and Analysis of Planetary Landers for Lunar Exploration

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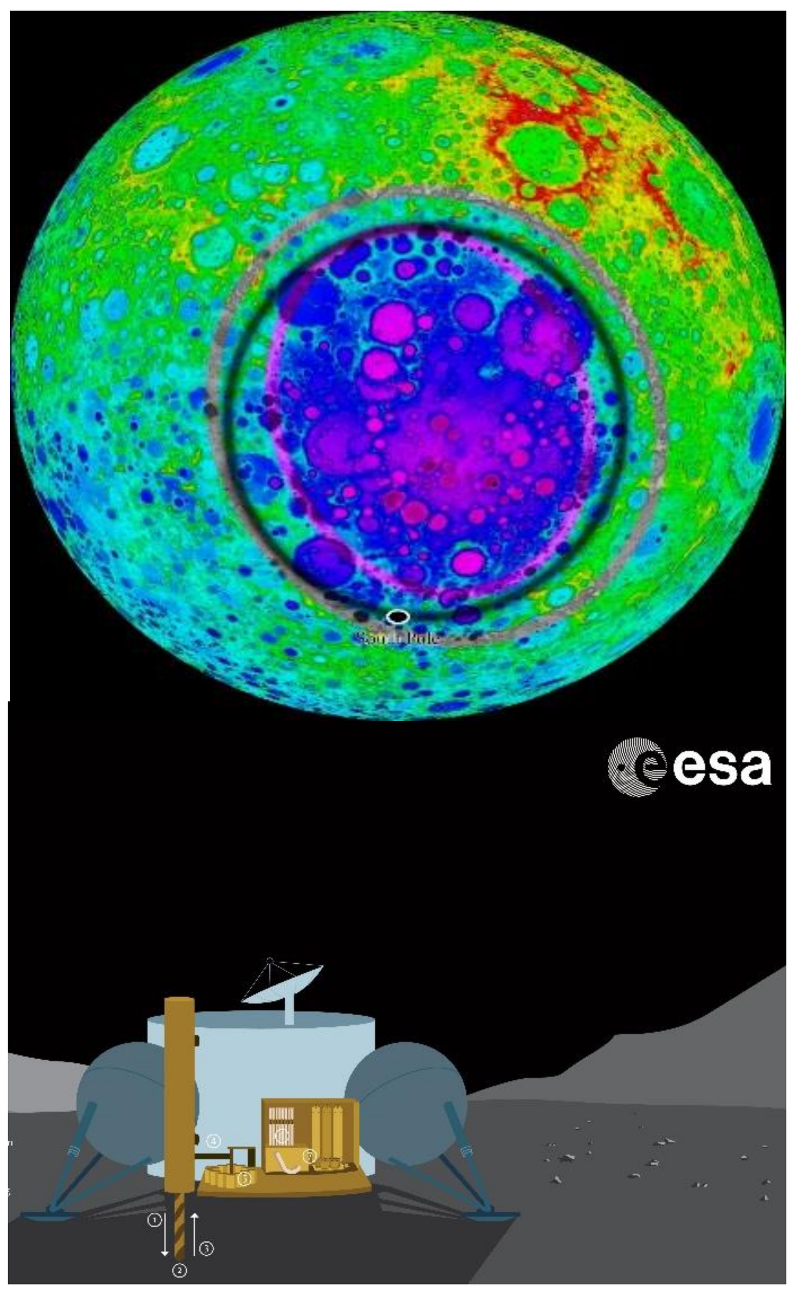
Background

- The case study presented is Luna-27 (ESA-Roscosmos).
- European technology on-board:

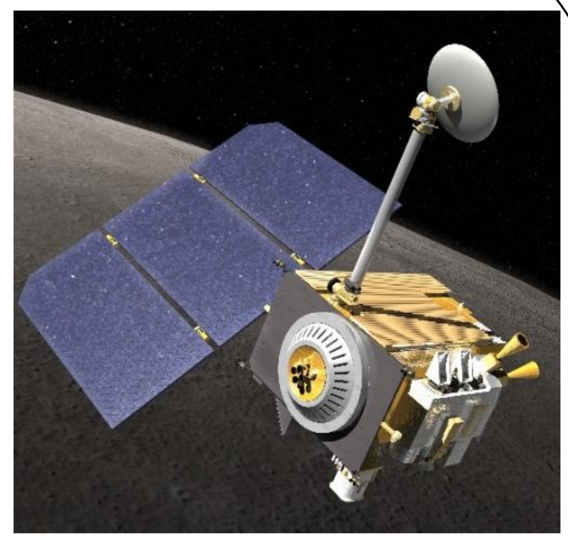
1. PILOT (Precise Intelligent Landing using On board Technology).
2. PROSPECT (Platform for Resource Observation and in-Situ Prospecting in support of Exploration, Commercial Exploitation and Transportation).

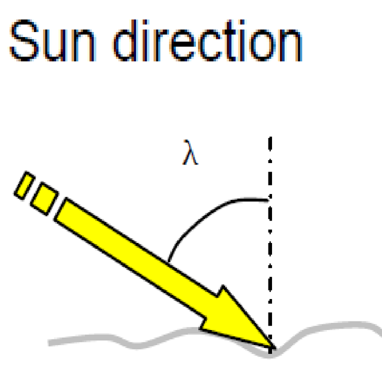
- The mission aims to identify any potential supplies for a future lunar base, such as minerals and lunar water or ice.
- Samples from below the surface will be extracted with the drill and examined in-situ.

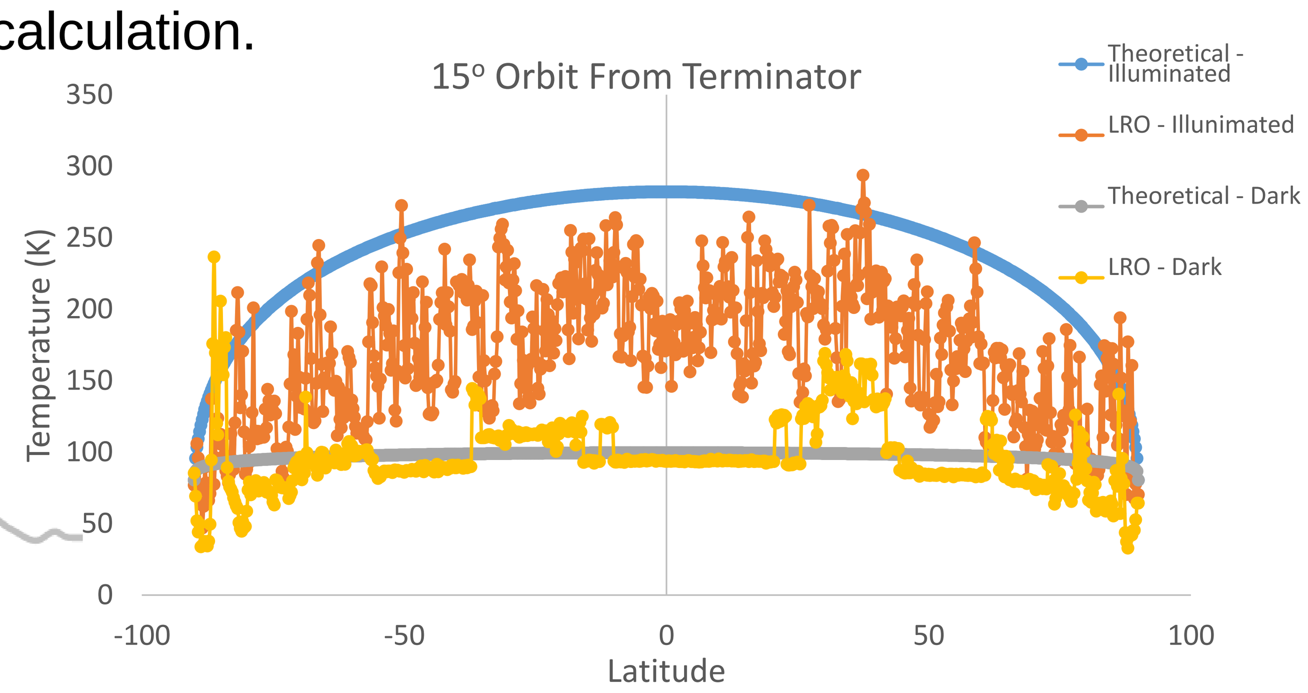


Lunar Environment Analysis

- NASA's Lunar Reconnaissance Orbiter (pictured) is utilised for acquiring temperature data.
- The equation below can theoretically predict the average temperature along lunar orbits.
- The graph below indicates the correlation between data and theoretical calculation.





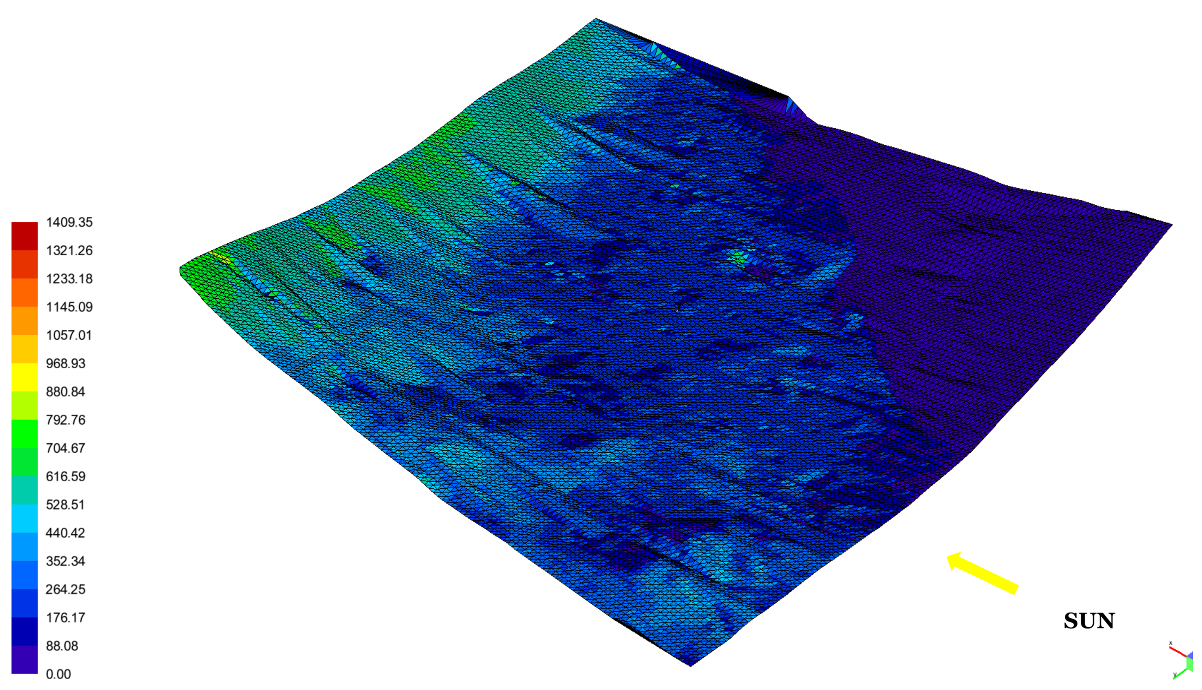


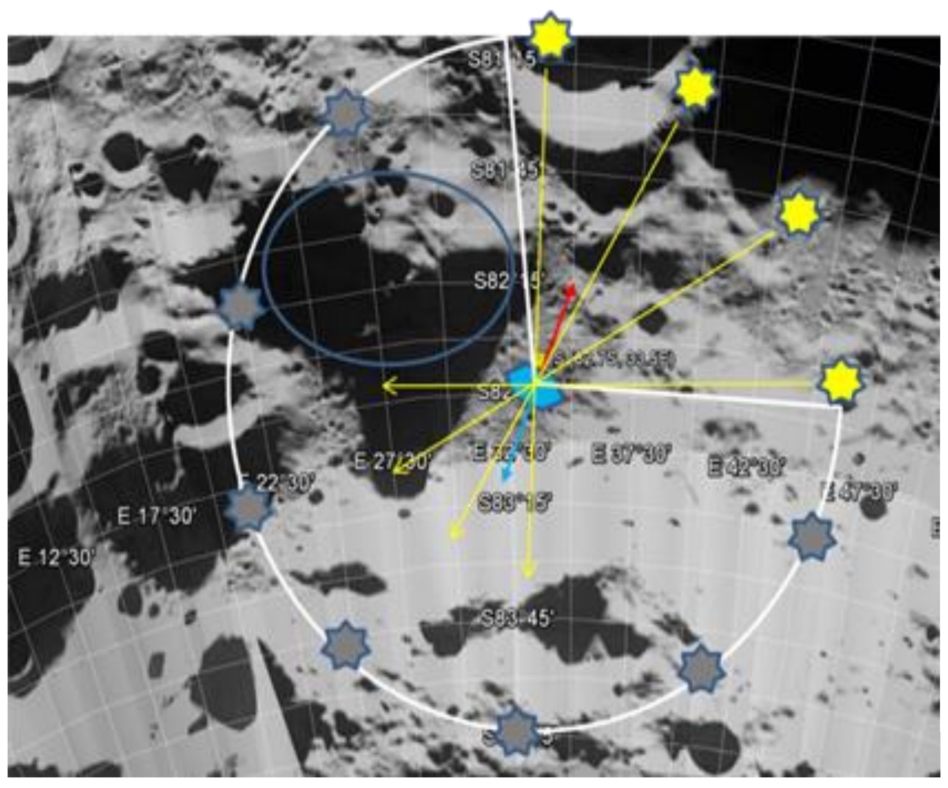
Illuminated: $T_{moon} = ((1\text{-}a).\ Cs.\ \cos(\lambda)/(\varepsilon.\sigma) + (2.3+3.1*\cos(lat)^{1/4})/(\varepsilon.\sigma))^{(1/4)}$

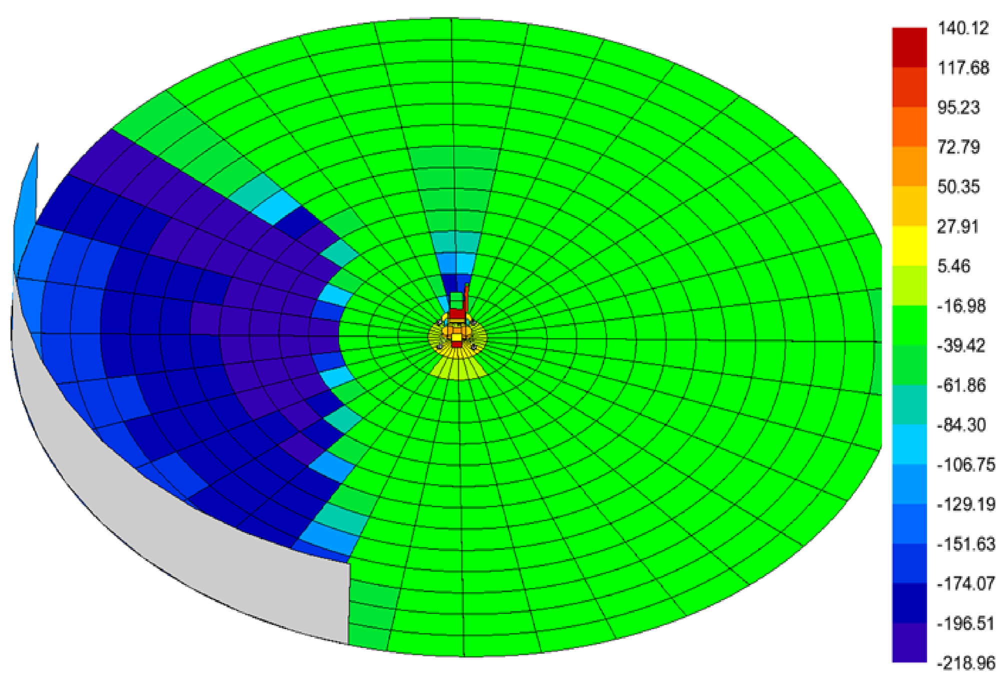
Non illuminated: $T_{moon} = ((2.3+3.1*\cos(lat)^{1/4})/(\varepsilon.\sigma))^{(1/4)}$

Landing Site Modelling

- The landing site is modelled in terms of topography and shadowing.
- Extreme case shadowing is modelled to provide margin if landing site is altered.



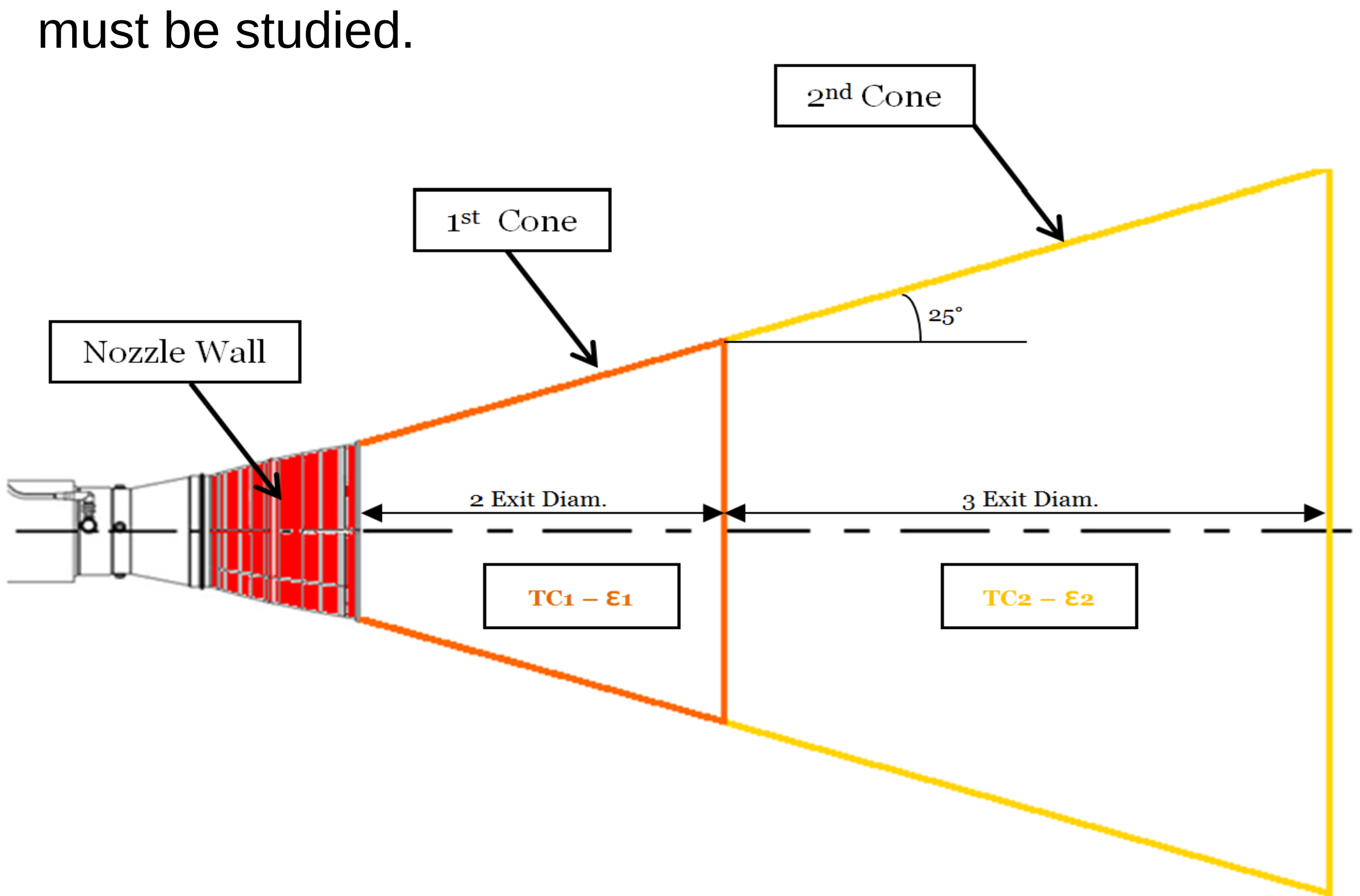


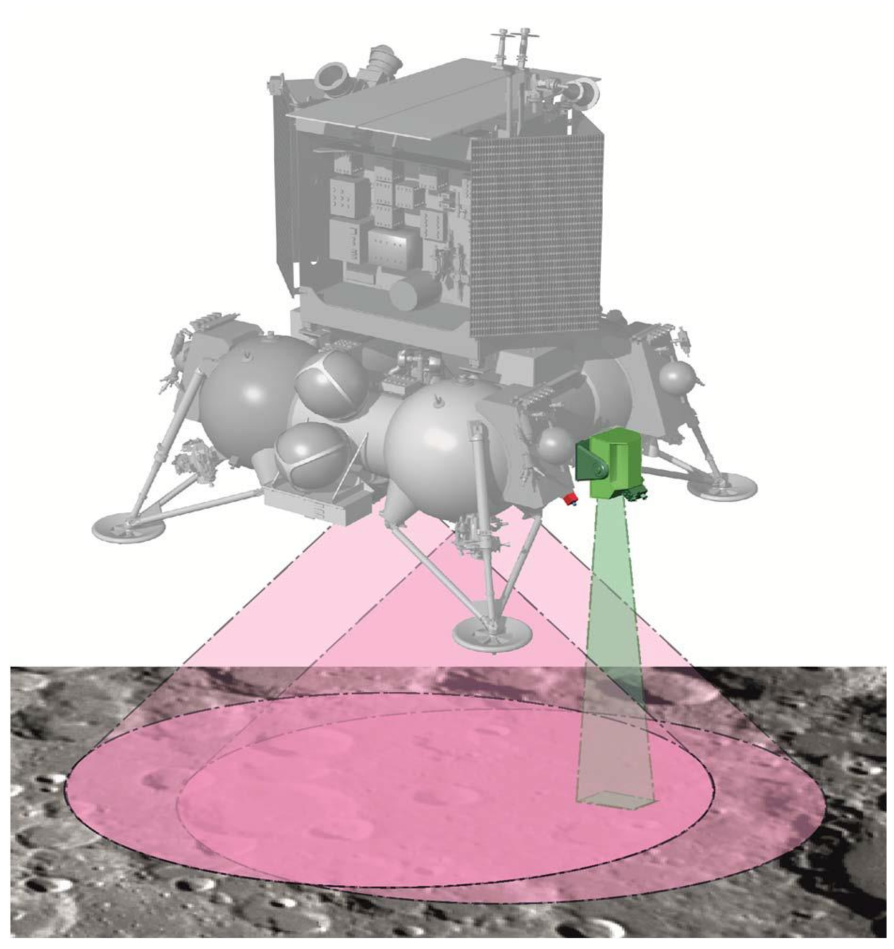


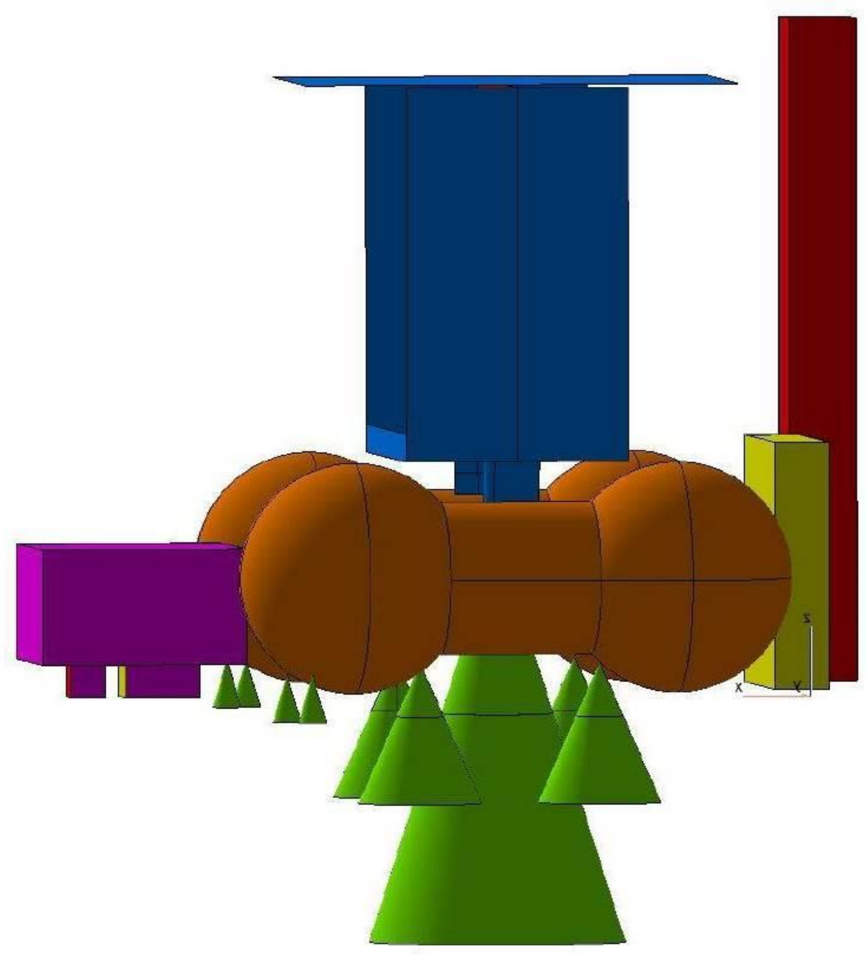
- Elevated surfaces were modelled to replicate the daylight cycle that is experienced on the proposed landing site.
- Topography data from LRO was also thermally modelled (left) to validate extreme case modelling (above, right).

Thruster and Plume Study

- The thruster nozzles, as well as the plume they create during landing, are in close proximity to the LIDAR imaging cameras.
- The thermal impact they may have on the cameras must be studied.







- A mathematical model for the radiative heat transfer impingent on the camera as a result of the plume was devised by modelling truncated cones.
- The most significant heat loads impingent on the cameras are from the thruster nozzles themselves. The heat load of the plumes can be considered negligible.