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THERMAL DESIGN OF LUNAR PENETRATOR

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This study investigates the thermal design of a lunar penetrator. A network of penetrators could provide useful seismological data about the Moon to scientists. However, the science is limited by the thermal sub-system, as the temperatures experienced by the penetrator can be as low as 35 K at the lunar south pole. With the seismology tests aiming to run for up to a year, this study aims to research for how long the penetrator could survive without the use of a Radioisotope Heater Unit (RHU).

Moon penetrator

- Length: 0.56 m; Diameter: 0.12 m
- Total Mass: 13 kg; Payload mass: 7 kg
- Power source: primary 500W.hr battery
- Deceleration on impact: 15,000 g
- Operating temperature: -40°C to +50°C
- No Radioisotope Heater Unit (RHU)

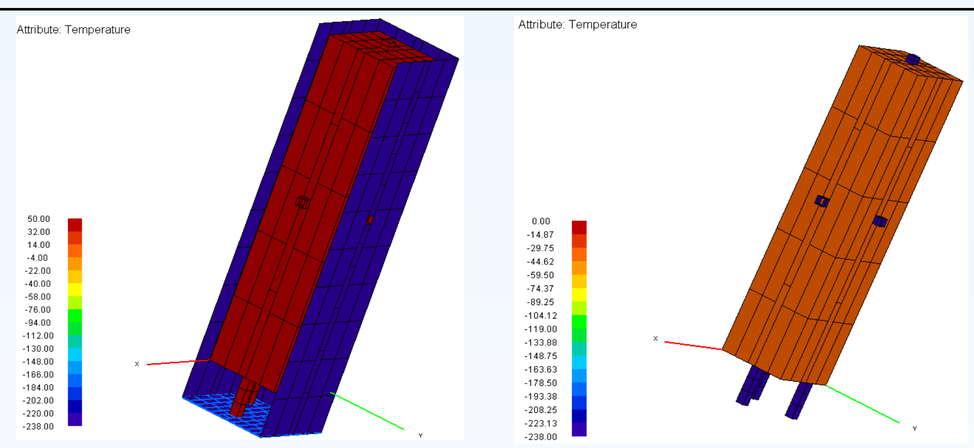
Lunar environment

- Lunar South Pole, polar cold trap (e.g. Shackleton Crater)
- Depth: > 0.8 m
- Regolith temperature: 35 K
- No sunlight
- Conductivity of regolith: 0.015 W/m.K

Thermal subsystem design

Vacuum flask design: the payload casing is held away from outer shell to minimise conduction.

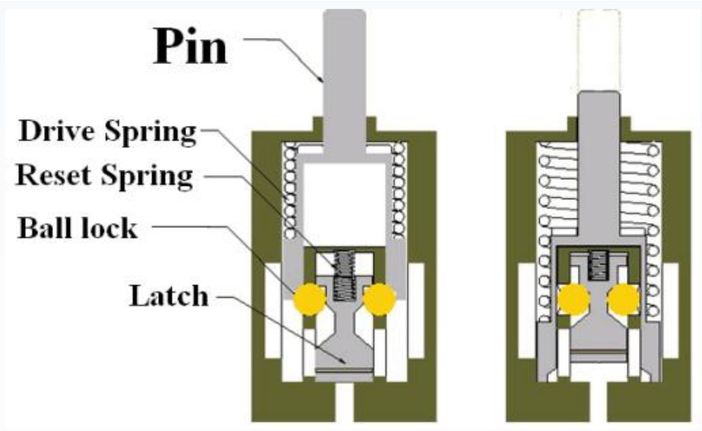
- Struts: S-grade glass fibre
- Radiation insulation: gold or beryllium coating
- 5mm of Aerogel insulation inside payload casing



ESATAN model: t = 0 and t = 38 hrs

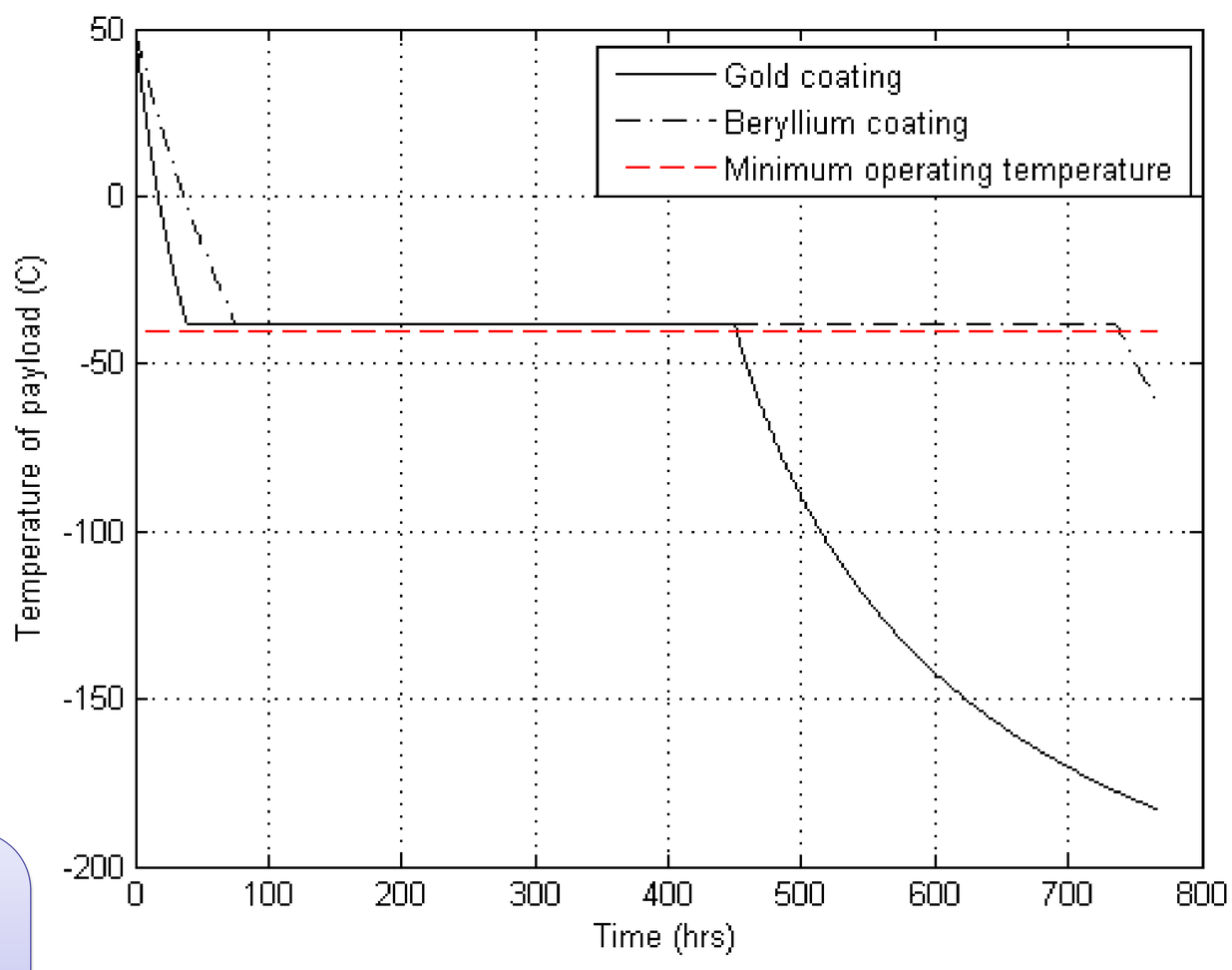
Technology selection

- Retractable rear strut, based on Shape Memory Alloy (SMA) technology, which severs a conduction path when the temperature falls below a pre-set level.
- Microheaters powered by battery, which compensate for the heat flow out of the payload.



TiNi Aerospace: P5-STD retractable strut

Design Level		Penetrator lifespan
Aluminium casing		< 1 second
Vacuum flask, S-glass fibre struts	Gold coating	8.34 hours
	Beryllium	9.50 hours
Aerogel insulation	Gold coating	1.6 days
	Beryllium	2.9 days
Retractable strut	Gold coating	1.67 days
	Beryllium	3.25 days
Microheaters	Gold coating	18.80 days
	Beryllium	30.75 days



Conclusion

The lifespan is sufficient to conduct heat flow and composition studies, but not the 1-year seismology experiments required for MoonLITE mission. RHU may need to be considered.

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