Scaling of Size, Mass, Power consumption and Thermal Consideration for Small Lunar Rovers

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Motivation & Problems

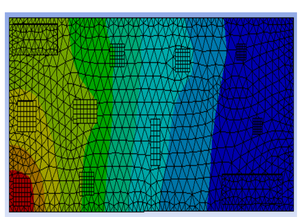
The first Moon robot weighed a ton. The Sojourner robot to Mars weighed only 11kg. As robots miniaturize there is always ambition to do more with less. This research investigates the correlation between size, mass, power consumption, and thermal consideration of small lunar rovers. The goals of this research is to:

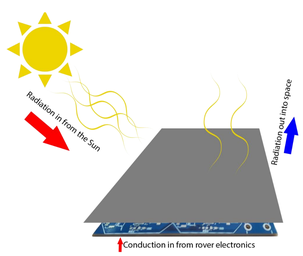
1. Find the minimum size of lunar rovers

2. Investigated the effect of size and thermal coating on the operation time

Approach

We began by studying the characteristics of a lunar rover in development the Andy rover. The size, mass, and power consumption this rover was then proportionally scaled. The rovers radiator and electronics were discretized, then were simulated using finite element analysis in ANSYS. The rover’s scale was modified and the simulation repeated.





Red: 22 centigrade
Blue: 19 centigrade

Radiator plate
Heat Transfer

A radiator receives heat from the sun, the solar panel, and its avionics. It also emits heat to the black space keep the electronics in a comfortable temperature range.

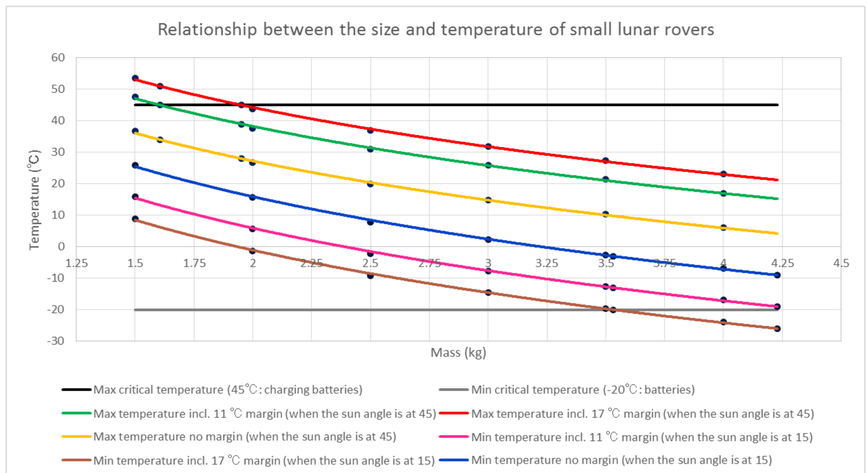
Investigated the minimum size of lunar rovers

A lunar rovers temperature is inversely proportional to its surface area. Smaller rovers have a much harder time cooling down.

The minimum size of small lunar rover

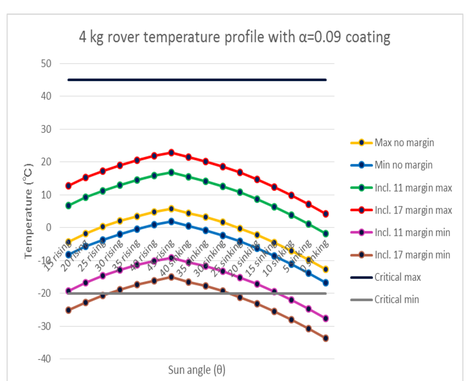
- **1.95 kg**: a **17** ℃ margin was applied
- **1.6 kg**: an **11** ℃ margin was applied (with reliable data)

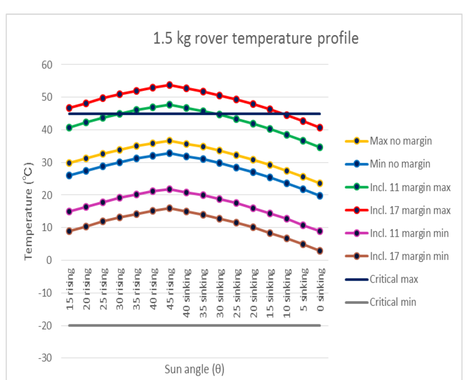
*45 and -20 ℃ are the critical operation temperatures.



The size effect on the operation time

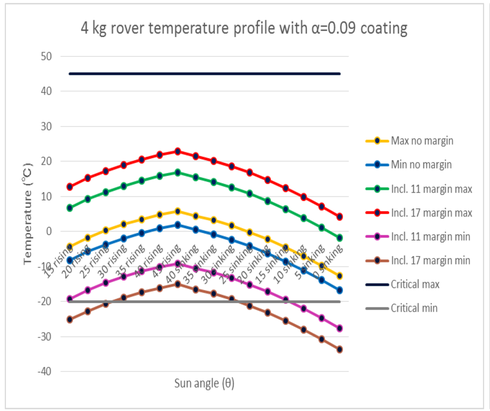
Temperature profiles of smaller rovers were found to be higher than that of the larger ones.

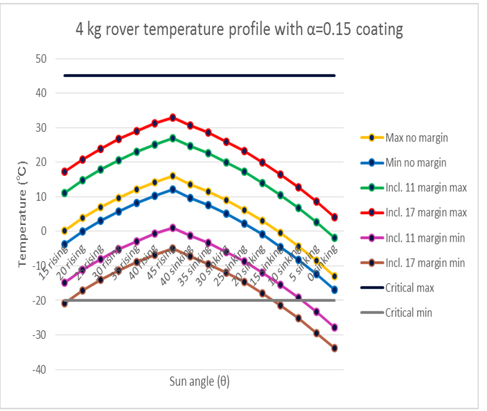




The coating effect on the operation time

Changing coating on the radiator can extend the operation time for around two days in the case of a 4 kg rover. However, the maximum temperature also increased, so the coating should be chosen carefully while considering the balance of the maximum and minimum temperature.





Conclusion

Based on the current temperature constraints of the components available the minimum mass of lunar rovers is determined as 1.95 kg. Also, we confirmed that the size of the radiator as well as its coating can change the operation time to some extent.

Future Work

Future work will need to incorporate radiation from the lunar surface. The mechanical designs of small lunar rovers will need to be altered to expand radiator area and to keep the electrical components close to any radiative surfaces. Therefore, after thermal experiments for calibrating this simulation, thermal and mechanical solutions should be integrated and the prototype should be manufactured in the near future.

Acknowledgements

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