ATROMOS Mars Polar Lander Thermal Model

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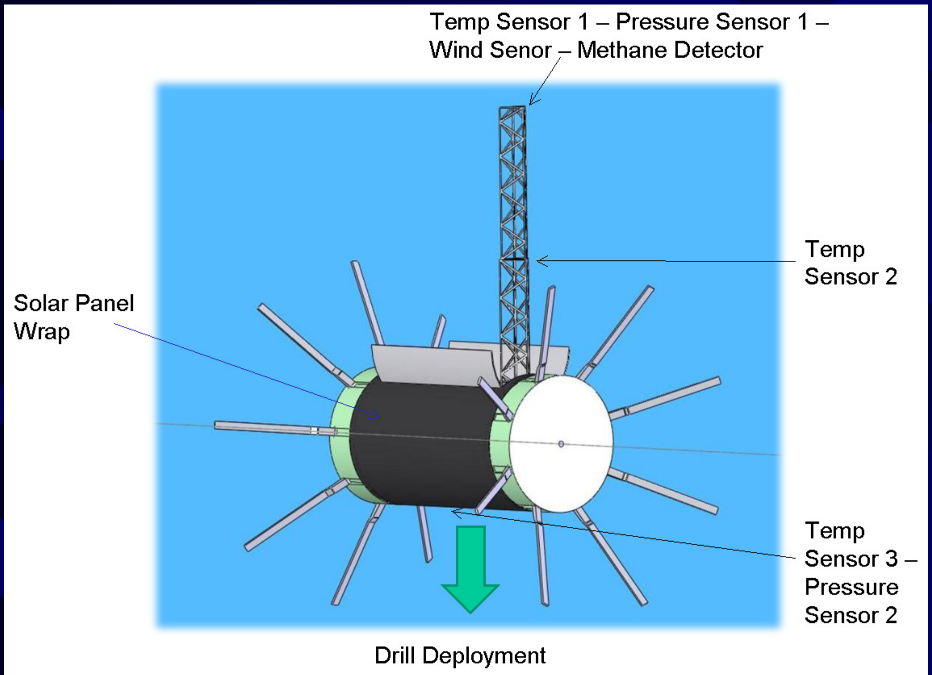
Overview

- Introduction to ATROMOS
- Radioactive Heating Units
- Thermal Design Setup
- Results
- Future Work

Introduction

- A mission to Mars has a lot of potential to have something go wrong
- A failure isn't necessarily a waste; something is always learned
- Instead of sending one large and expensive spacecraft to Mars, send several smaller and less expensive spacecraft to Mars; this would increase chances of success
- Scatter those scout spacecraft all over the surface, instead of one place

Introduction

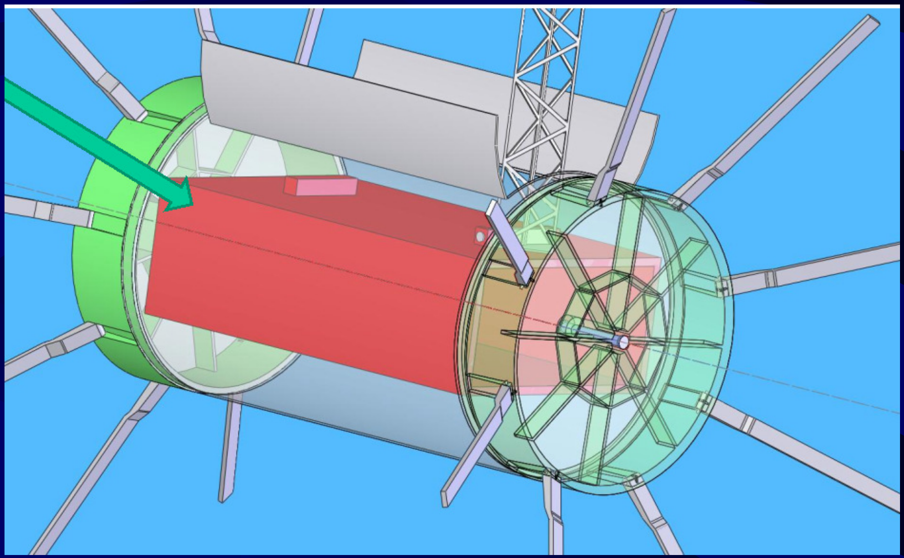


CAD drawing of ATROMOS deployed

- The ATROMOS lander is meant to be a scout spacecraft
- Destination is the Martian polar ice caps
- The mission is to investigate the possibility of past life and the polar climate.

Introduction

- ATROMOS has to be small, lightweight, and power efficient
- This extends to the thermal protection system
- Instead of an active thermal system, which can be heavy and draw a lot of power, a lightweight passive system needs to be used



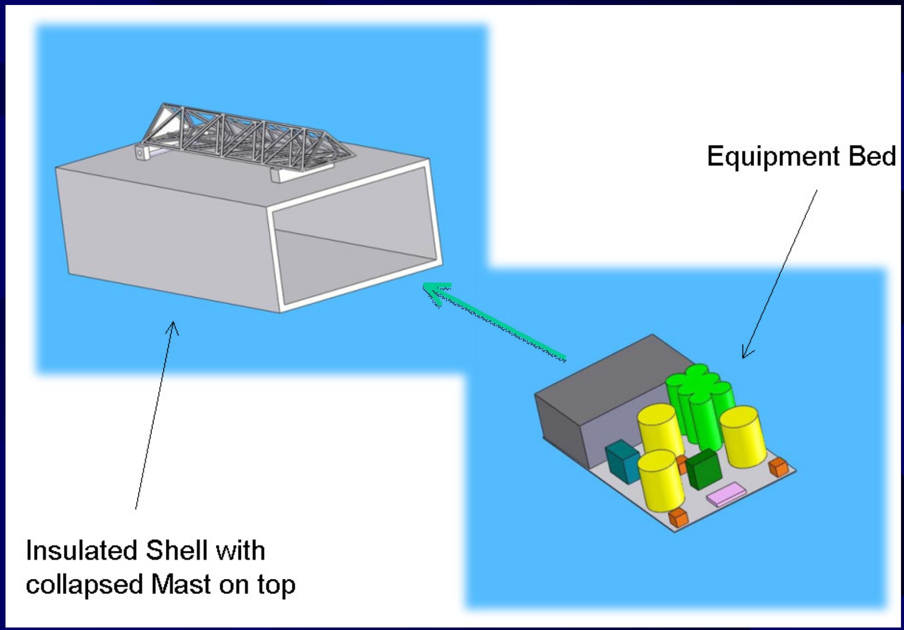
CAD drawing showing warmbox within ATROMOS

Purpose of Thermal Modeling

- To find out if Atromos will survive extreme temperatures at Martian poles
- Make the most efficient use of the RHU heat source

Radioactive Heating Units

- The key to ATROMOS's thermal protection is a radioactive heating unit (RHU)
- RHUs work through the radioactive decay of plutonium, outputting 1 W of heat for each RHU
- RHUs require no electrical power; in fact, some versions actually generate electrical power



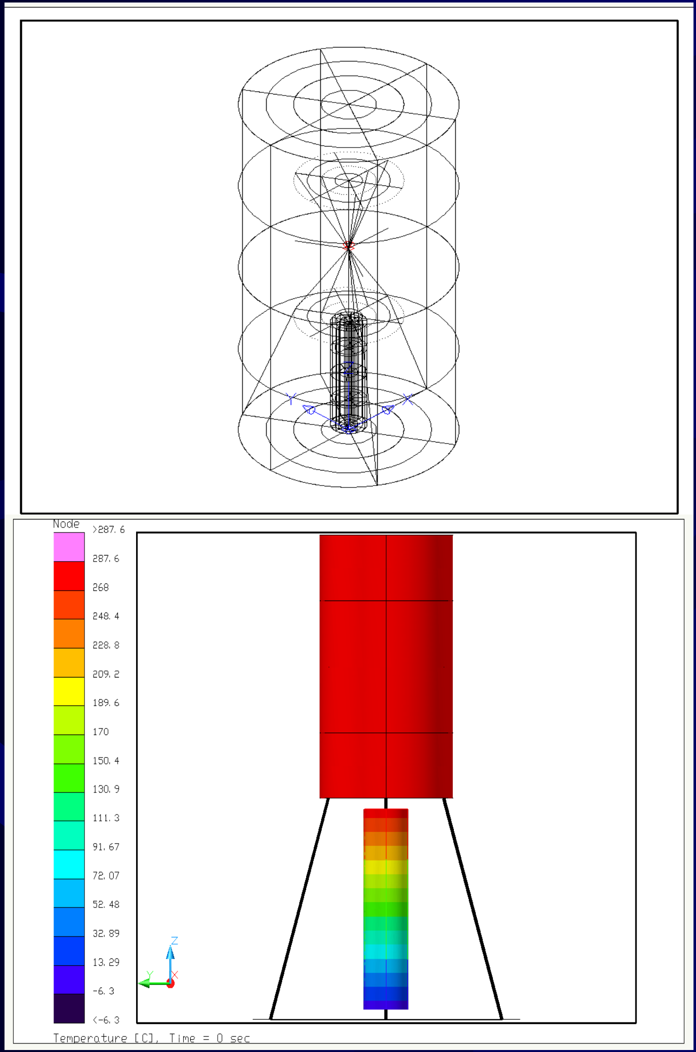
Drawing showing the equipment within warmbox

RHU Model

a) CAD drawing of RHU and b) steady-state temperature plot of RHU

a)

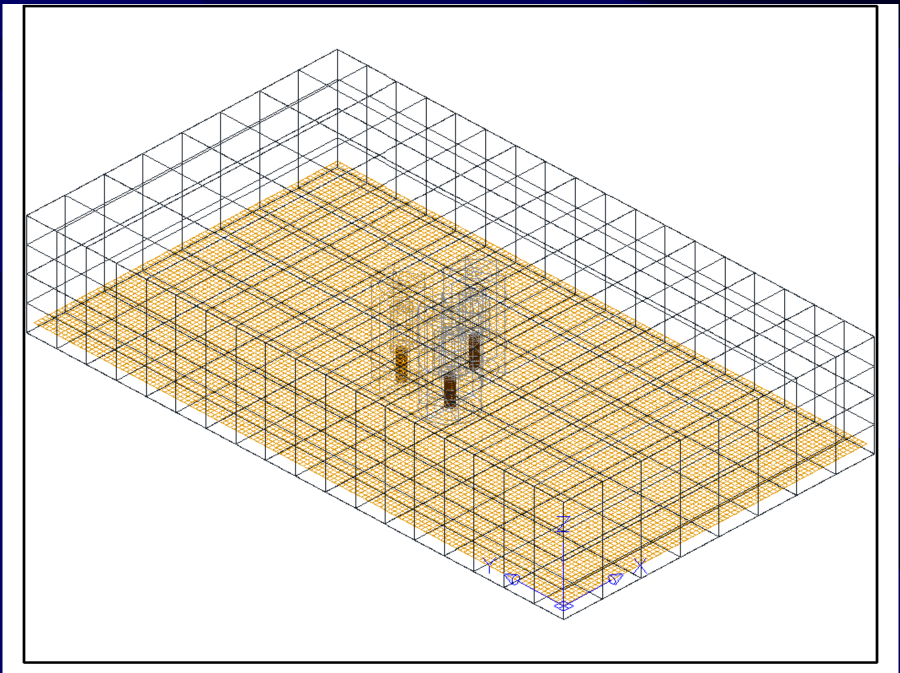
b)



- 1 W point source conducting to inner aluminum canister
- Canister rests on a ceramic rod modeled as ordinary brick
- Canister and ceramic housed inside outer aluminum cylinder
- Stainless steel wires leak heat from canister to outer cylinder
- Temperature difference across ceramic: 282 °C (if outside is –40 °C)

Model Layout

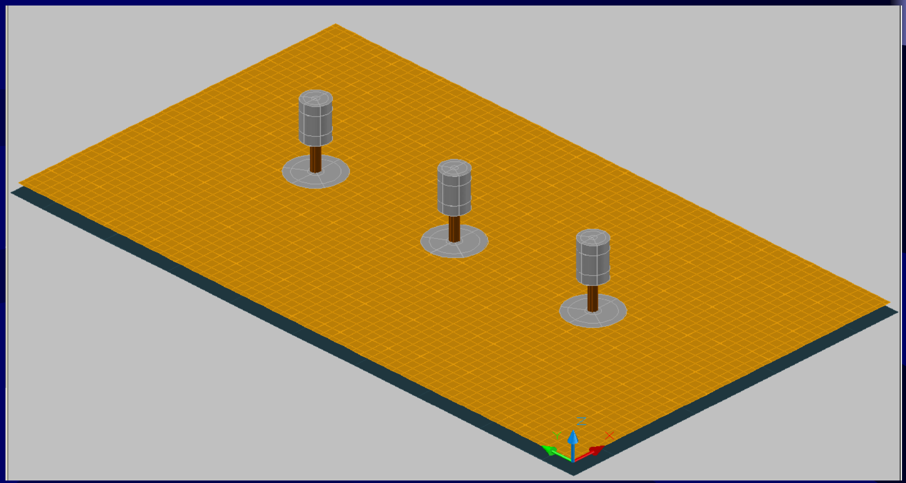
- Modeled three RHUs and warmbox only
- Conduction/convection; no radiation
- Copper plate inside fiber glass warm box
- Four fiber glass "cushions" to minimize contact between plate and box
- Outside temp: -140 °C
- Initial inside temp: -40 °C
- Ideal steady state inside temp: -20 °C to 30 °C



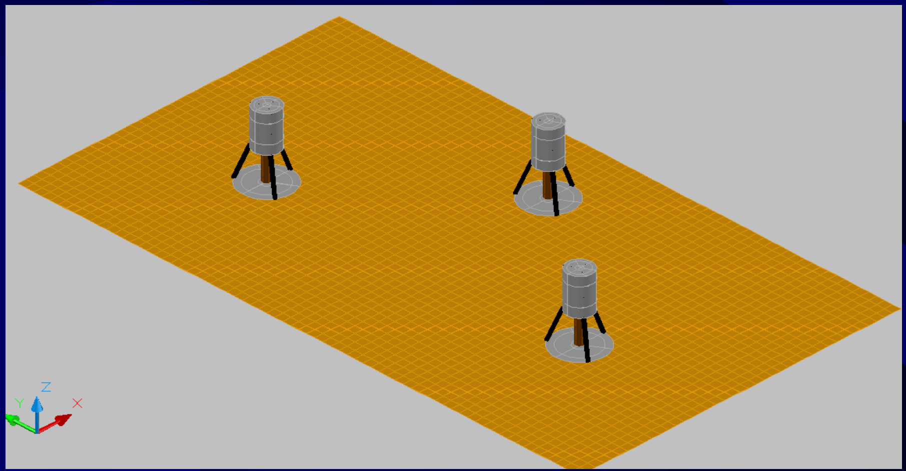
Basic layout for the thermal model

RHU Placements

- 9 cases were run
- Average temperatures for different placements only have a 1.3 °C range
- Types of placements:
  - Linear (equidistant)
  - Equal areas
  - Equilateral triangle

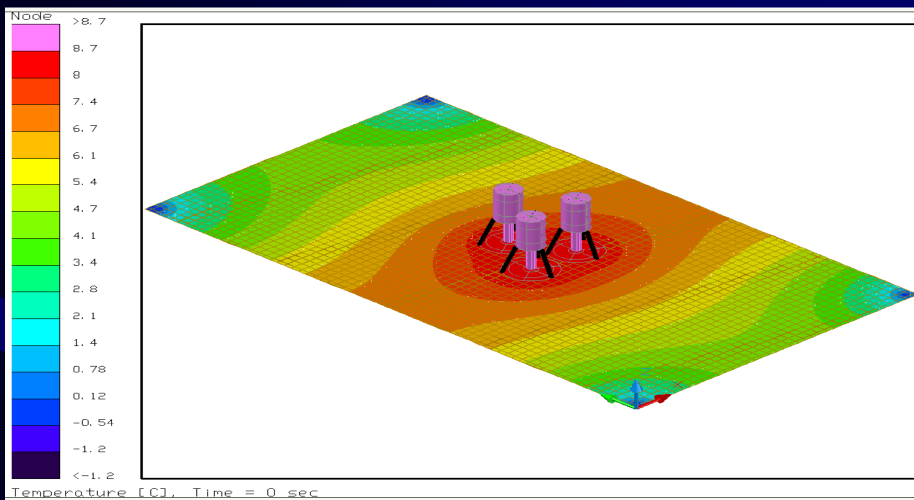


a) Equidistant placement

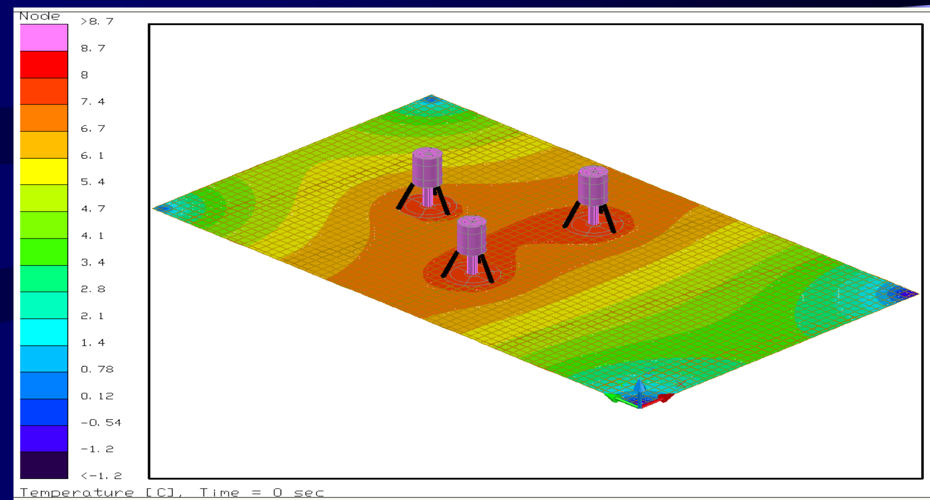


b) RHUs covering equal areas

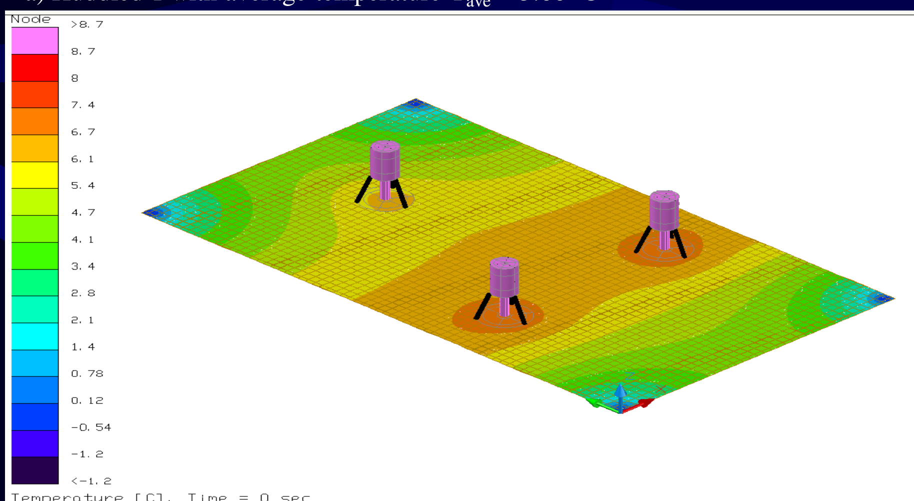
RHU Placements



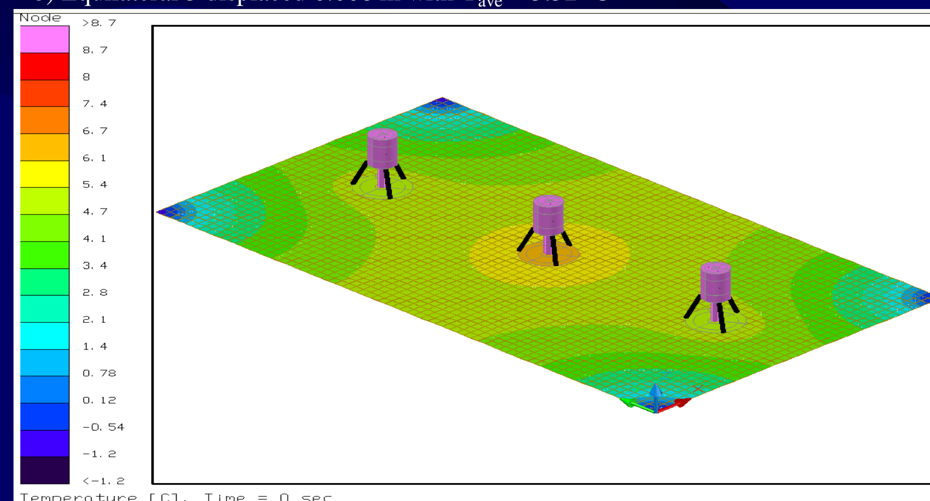
a) Huddled 1 with average temperature T_{ave} = 5.66 °C



b) Equilateral 3 displaced 0.008 m with T_{ave} = 5.52 °C

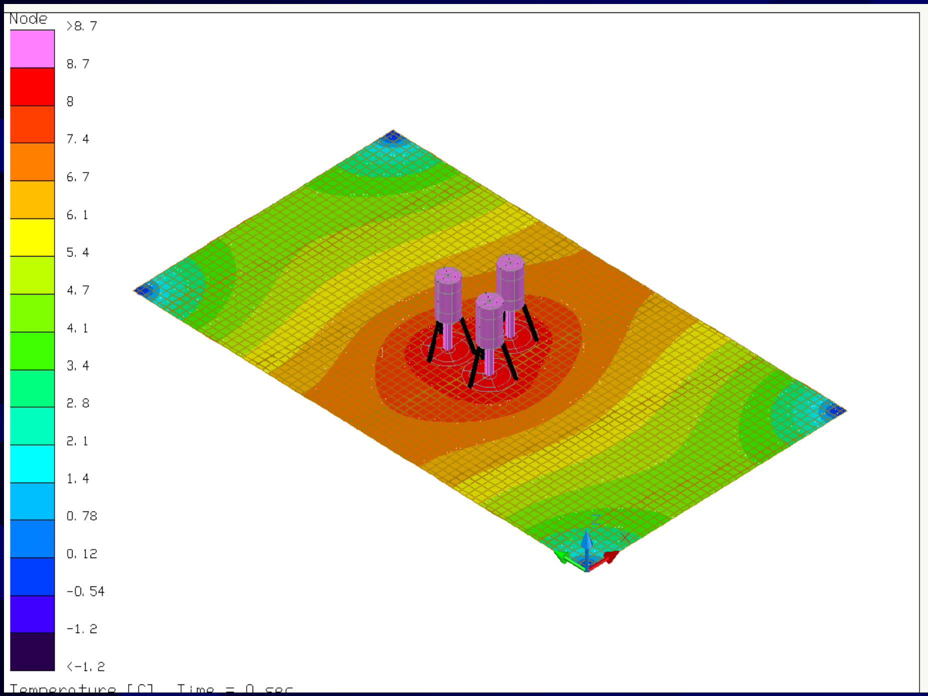


c) Centroid 2 with T_{ave} = 5.27 °C



d) Equal areas with T_{ave} = 4.42 °C

Warmest Configuration



Huddled 2 with T_{ave} = 5.67 °C

- RHUs huddled close together; base of triangle is lengthwise across plate
- Average temperature across copper plate: 5.7 °C

Improvements

- Experiment with different materials
- Include the electronics heat output
- Include radiation calculations
- Model different types of insulation
- Instead of a large copper plate, have a circuit board design to route heat more efficiently to the instruments

Questions?