National Aeronautics and Space Administration

FY23 Strategic Initiatives Research and Technology Development (SRTD)

# Additively Manufactured Rover Chassis with Integrated Thermal Control for Extreme Cold Environments

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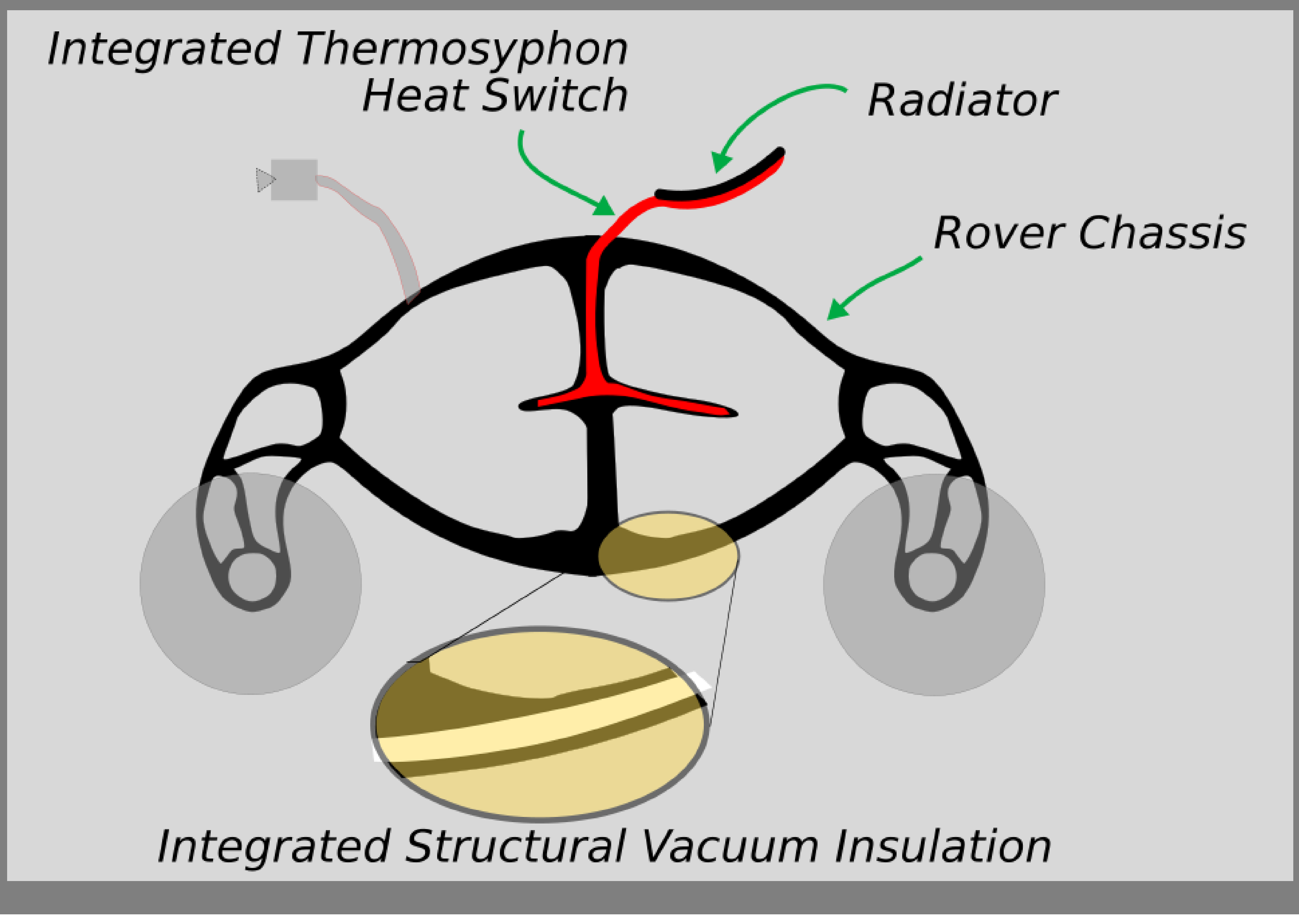
**Strategic Focus Area:** Lunar Science/ Moon and Mars Extreme Cold, Steep Terrain Rover **| Strategic Initiative Leader:** John D Baker

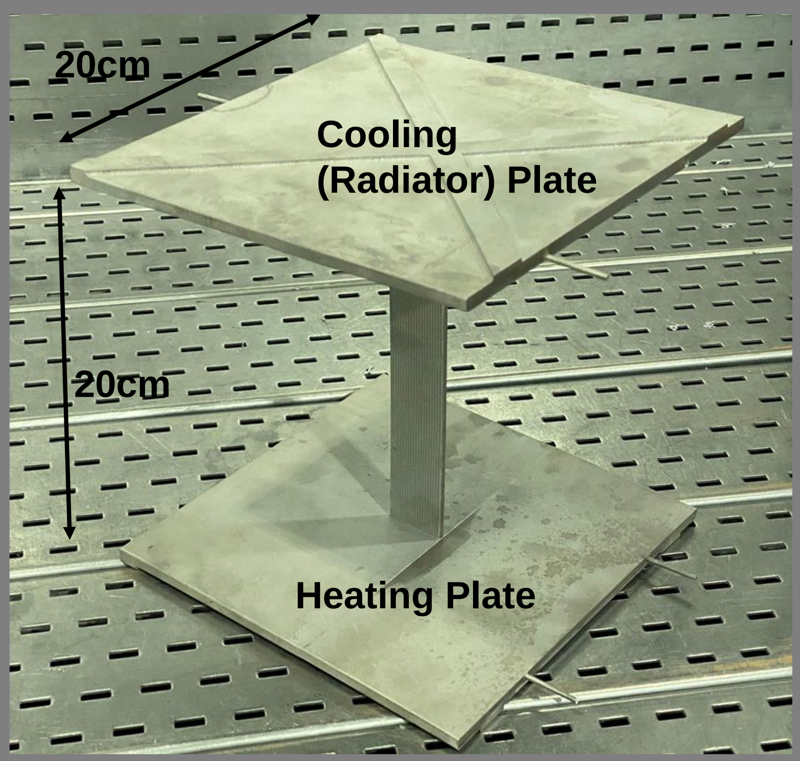
## Objectives:

The goal of this three-year strategic RTD task is to develop an topologically optimized additively manufactured (AM) rover chassis that incorporates a heat switch and insulation elements to enable new mission concepts to the Moon and Mars. The rover chassis is a mutlifunctional thermal-structural component. This year was the second year of the task and the high-level goals were to mature the basic thermal technology elements (AM heat switch and AM thermal insulation), as well as develop a notional rover chassis design. The final goal will be to qualify at TRL 5 an AM rover chassis that has been thermally/structurally optimized and incorporates a heat switch and insulating elements.

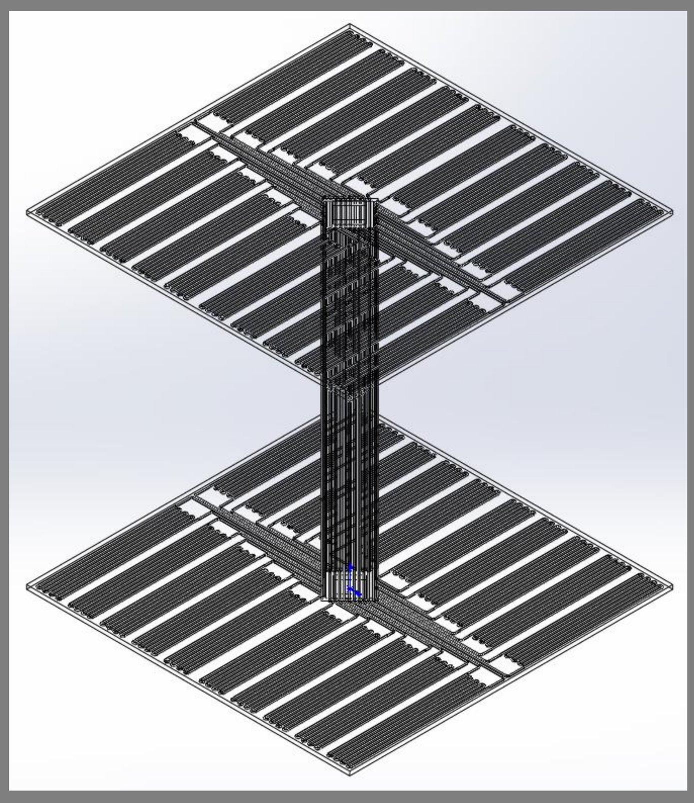
## CONCEPT




## Two-Phase Heat Switch

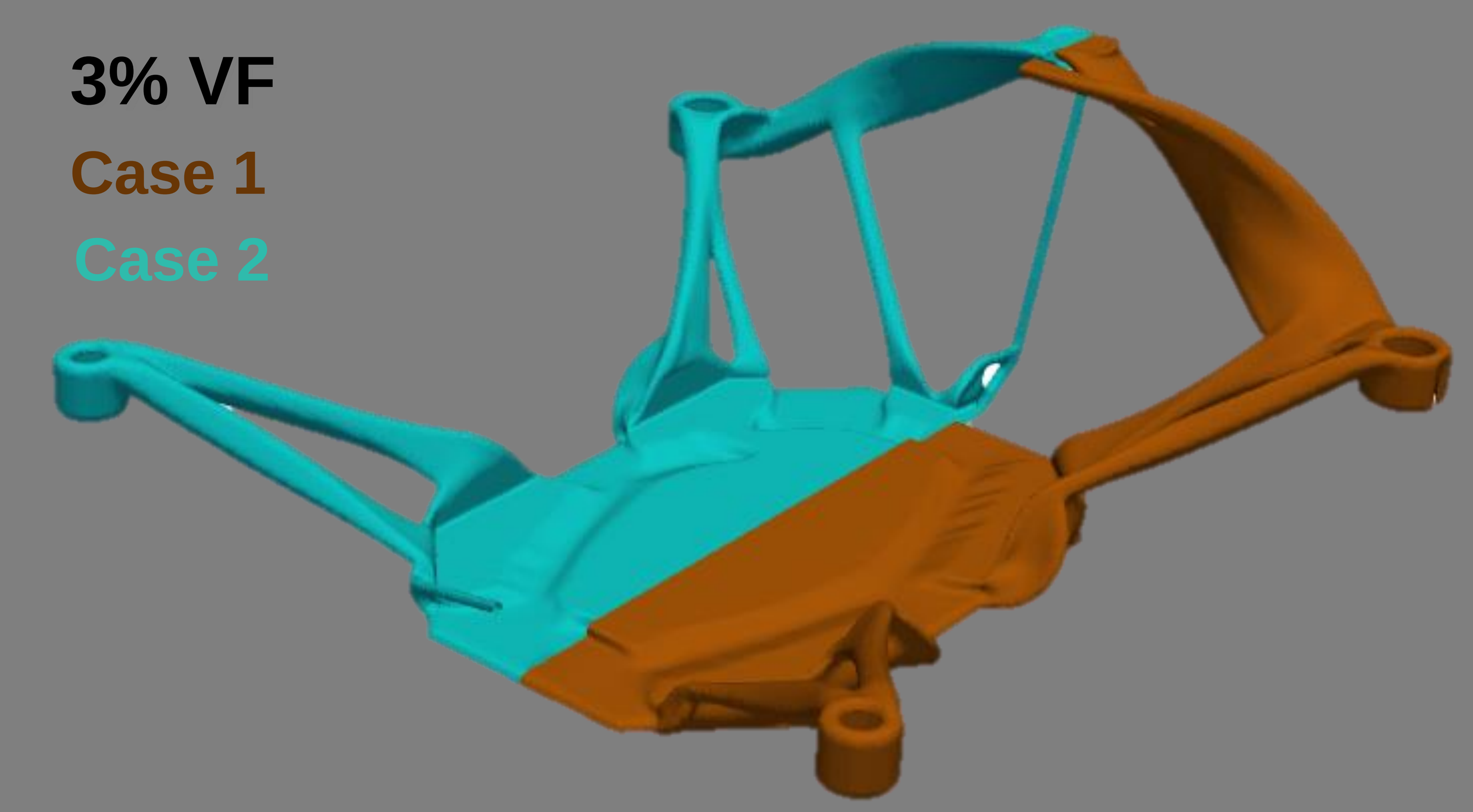


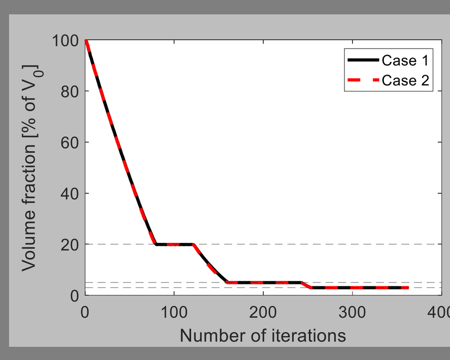

3D Printed Heat Switch

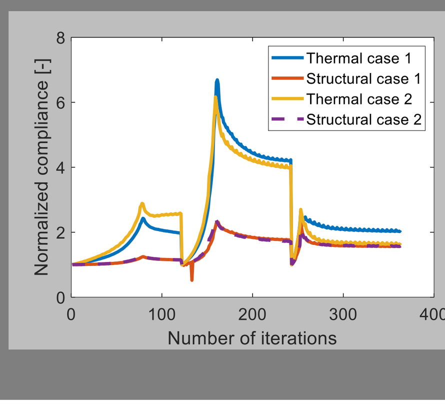


Internal Channels

## Mechanical and Thermal Topology Optimization



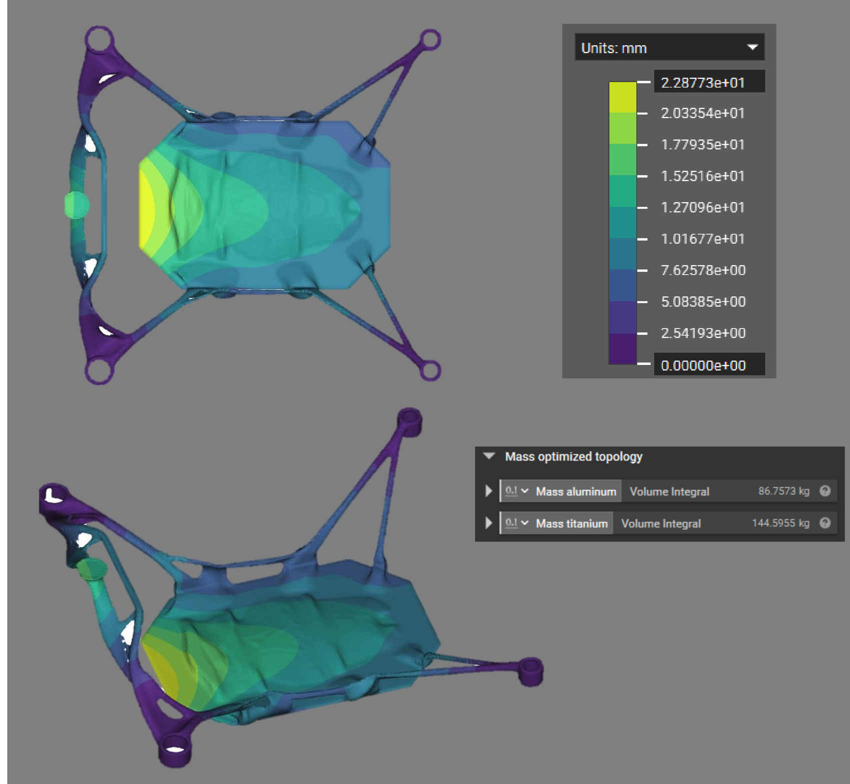




| | Case 1 | Case 2 | |
|---|---|---|---|
| k1 | 1 | 1 | |
| k2 | -0.01 | -0.03 | |
| Level 0 - VF | 20 % | 20% | FEM element size = 16 mm |
| Level 1 - VF | 5 % | 5% | FEM element size = 10 mm |
| Level 2 - VF | 3 % | 3% | FEM element size = 8 mm |

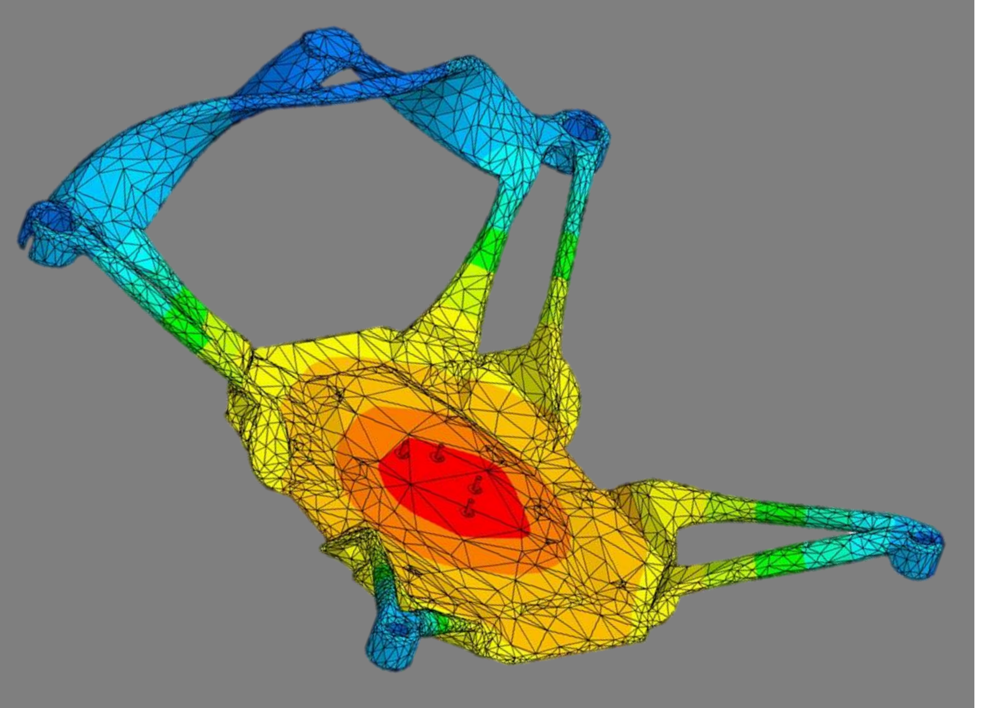
$$\min \quad k_1 \frac{C_S}{C_{S0}} + k_2 \frac{C_T}{C_{T0}}$$

$$s.t. \quad V \leq VF$$

$C_S$ is the structural compliance ≡ strain energy
$C_T$ is the thermal compliance ≡ thermal energy
0 denotes the initial value
$k_1$, $k_2$ are the associated weights in the objective
$V$ is the volume of the part relative to the initial domain
$VF$ is the prescribed fraction of the initial domain volume




FEA displacement - Titanium



Simulation in Thermal Desktop

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