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## Structures

**Overview:** The main structural components are some of the **heaviest** components on the PLSS, which offer significant opportunities for mass optimization:

**Backplate:** Aluminum backplate where all the components of the PLSS are attached.

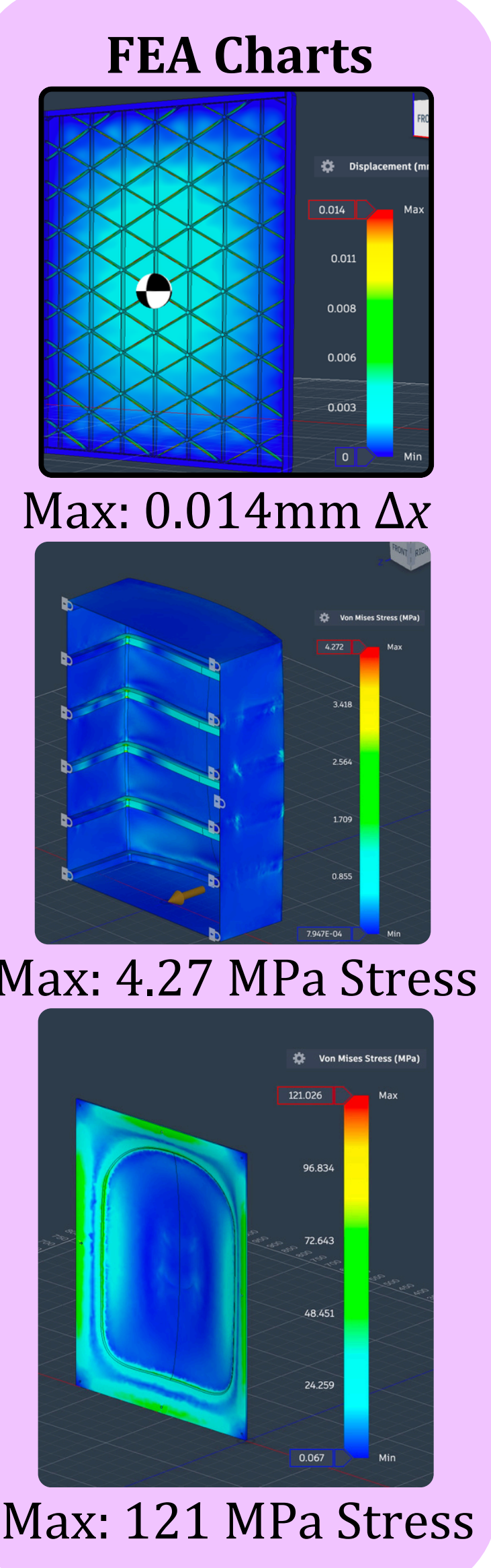
- **Isogrid pattern** removes extra material.  
**Mass reduction: 13.4 kg**

**Cover:** Aluminum encompassing structure for the PLSS components.

- The outer Ortho-fabric textile layer is embedded with grounded aluminum fibers to **repel** Mars regolith.  
**Mass reduction: 3.5 kg**

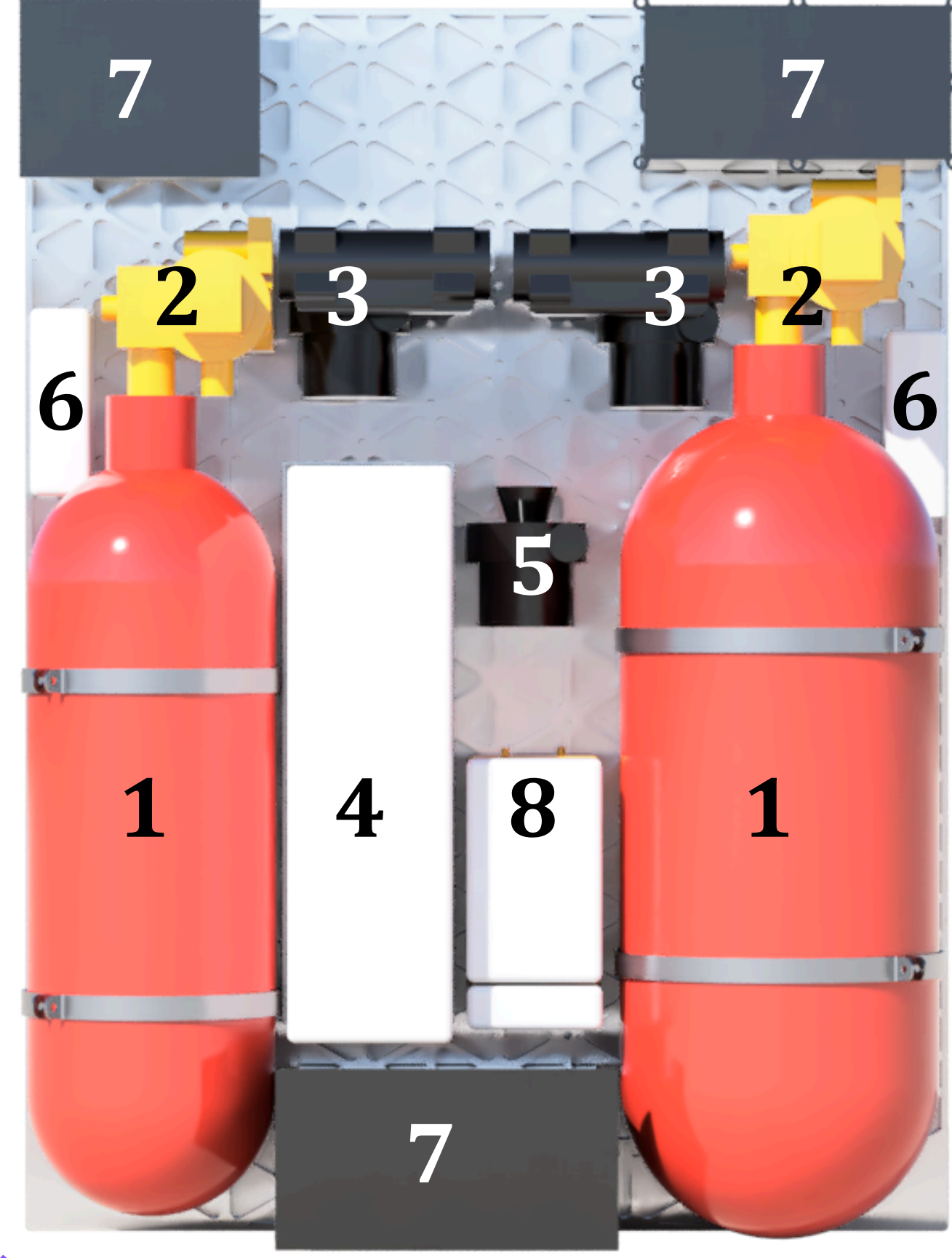
**Hatch:** Required to maintain constant suit pressure.

- **Separates** Hard Upper Torso (HUT) of the suit and the PLSS backpack for a **simplified suit design.**



## Project Overview

The goal of this project is to investigate Portable Life Support System (PLSS) designs for Mars extravehicular activity (EVA), with the overarching goal of reducing total system mass to less than 60 kg while maintaining system functionality.



- Components:
1. Oxygen Tank
  2. Regulator
  3. Pump Stacked with Fan
  4. Lithium Hydroxide Canister
  5. Fan
  6. Multi-Parameter Astronaut Life Support Sensor
  7. Avionics Boxes
  8. Batteries Stacked with Spacesuit Water Membrane Evaporator

**Total Mass Savings**  
**106 kg → 72.5 kg**

## Crew Systems

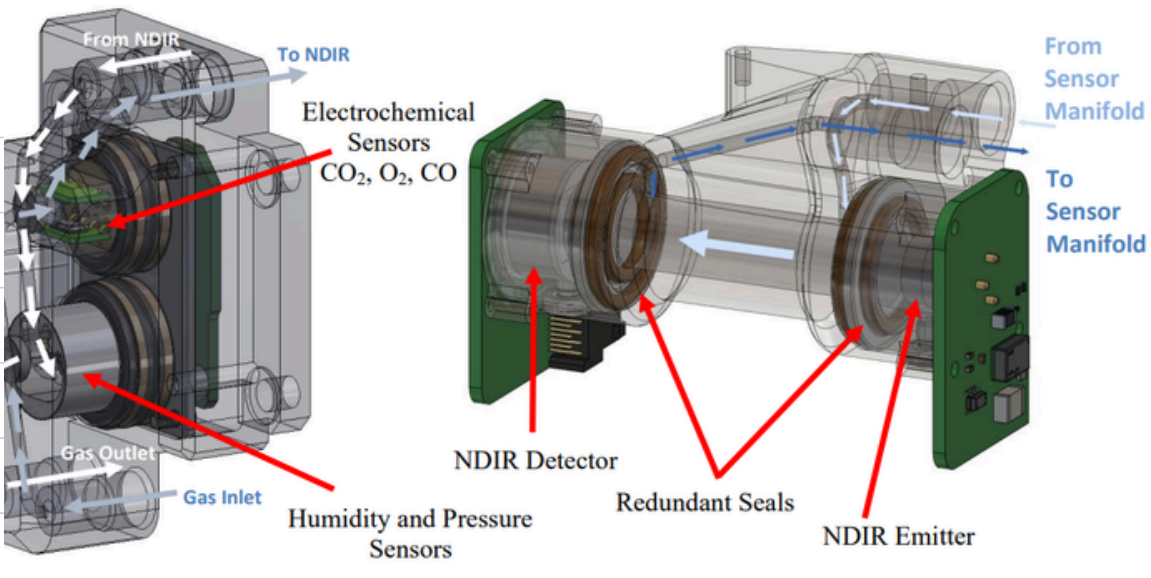
**CO<sub>2</sub> Scrubber & Trace Contaminant Control (TCC):**

- Choose Lithium Hydroxide (LiOH) (+2.95 kg) over Rapid Cycle Amine (RCA) scrubber (+8-17 kg).
- Eliminates vacuum pump & sweep gas loop.
- Pre-deploy integrated LiOH and TCC canister to Mars.

**Integrated sensor array:** Non-Dispersible Infrared (NDIR) CO<sub>2</sub>, electrochemical O<sub>2</sub>/CO<sub>2</sub>, humidity]

- Actuation:
  - Thermal pump: 1.52 L/min
  - Ventilation fan: 6.0 ACFM
- Additional: Resistance temperature detectors, regulators

**Mass reduction: ~5-14 kg**

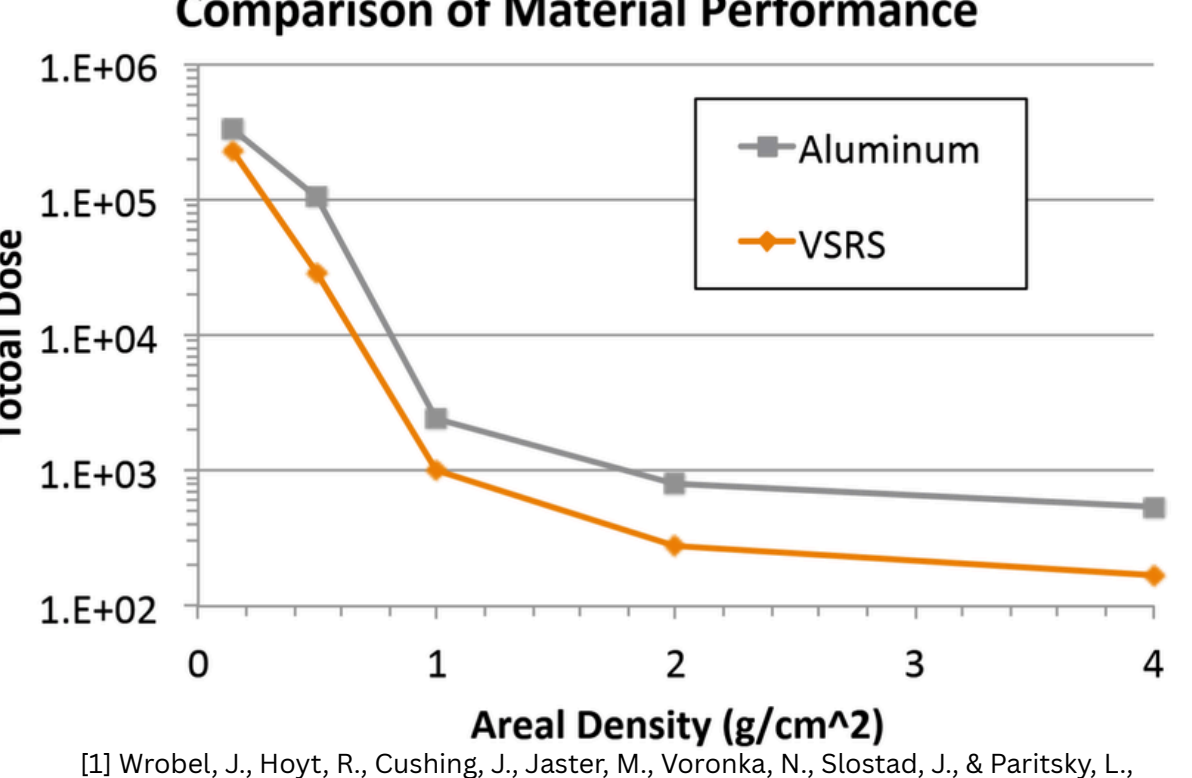
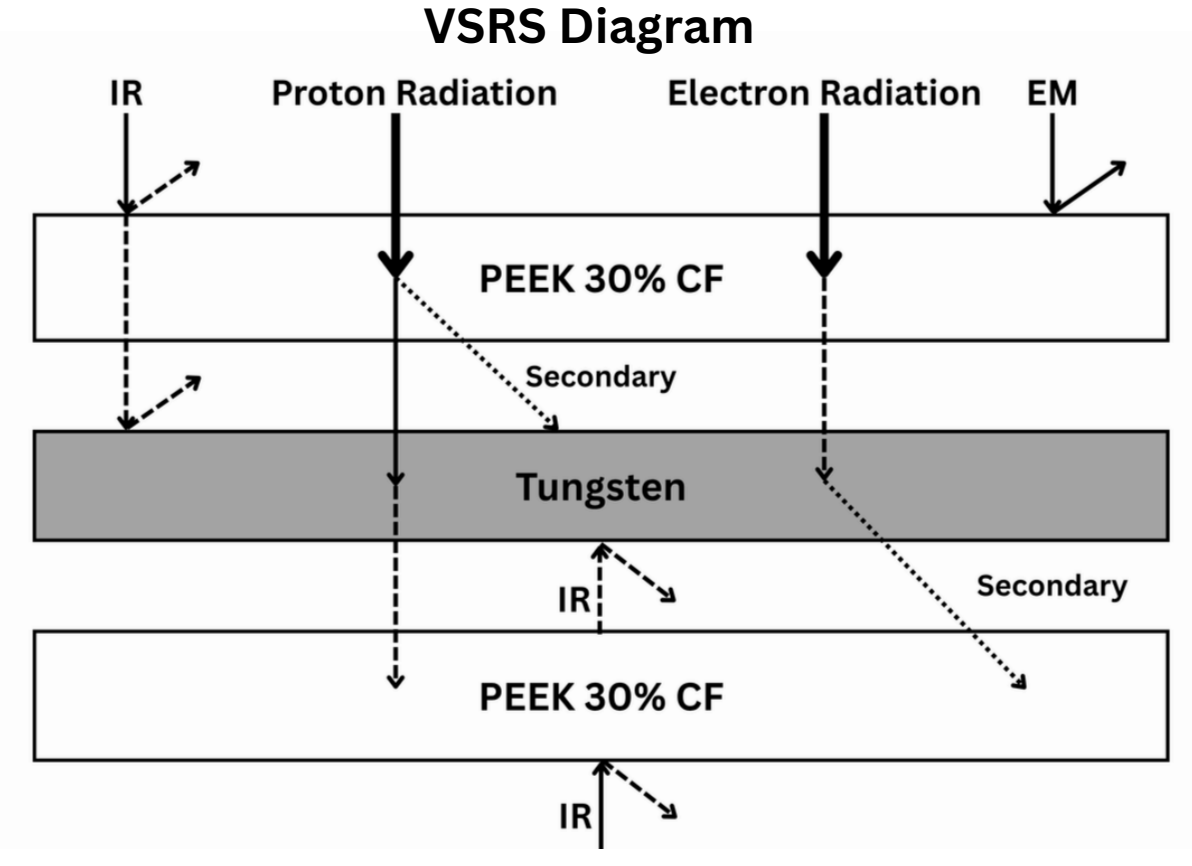
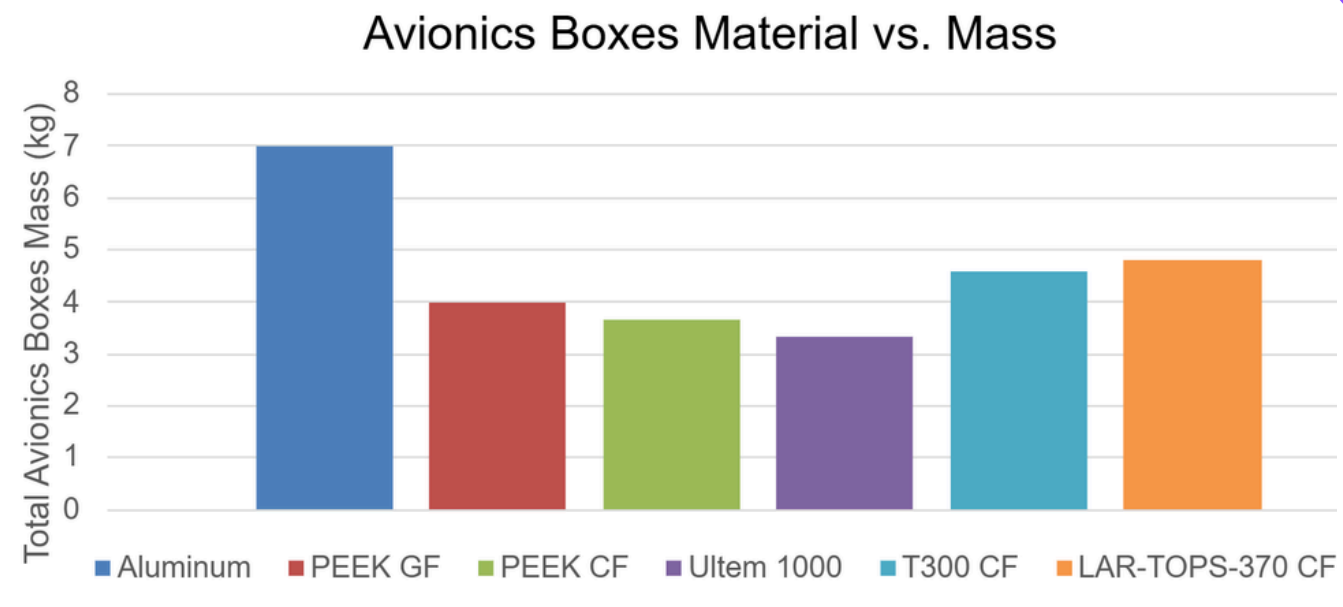


[2] Makel, J., Wangberg, F., Martin, R., and Ogilvie, R., "Continued Development of Multi-Gas Microsensor Array for the Exploration Portable Life Support System," 54th International Conference on Environmental Systems (ICES) (No. ICES-2025-222), July 2025.

## Avionics

**Overview:** Switch aluminum avionics boxes to PEEK thermoplastic & consolidate electronics.

**Mass reduction: 4.01 kg.**



[1] Wrobel, J., Hoyt, R., Cushing, J., Jaster, M., Voronka, N., Slostad, J., & Paritsky, L., "Versatile Structural Radiation Shielding and Thermal Insulation through Additive Manufacturing," Smart Satellite Conference, 2013.

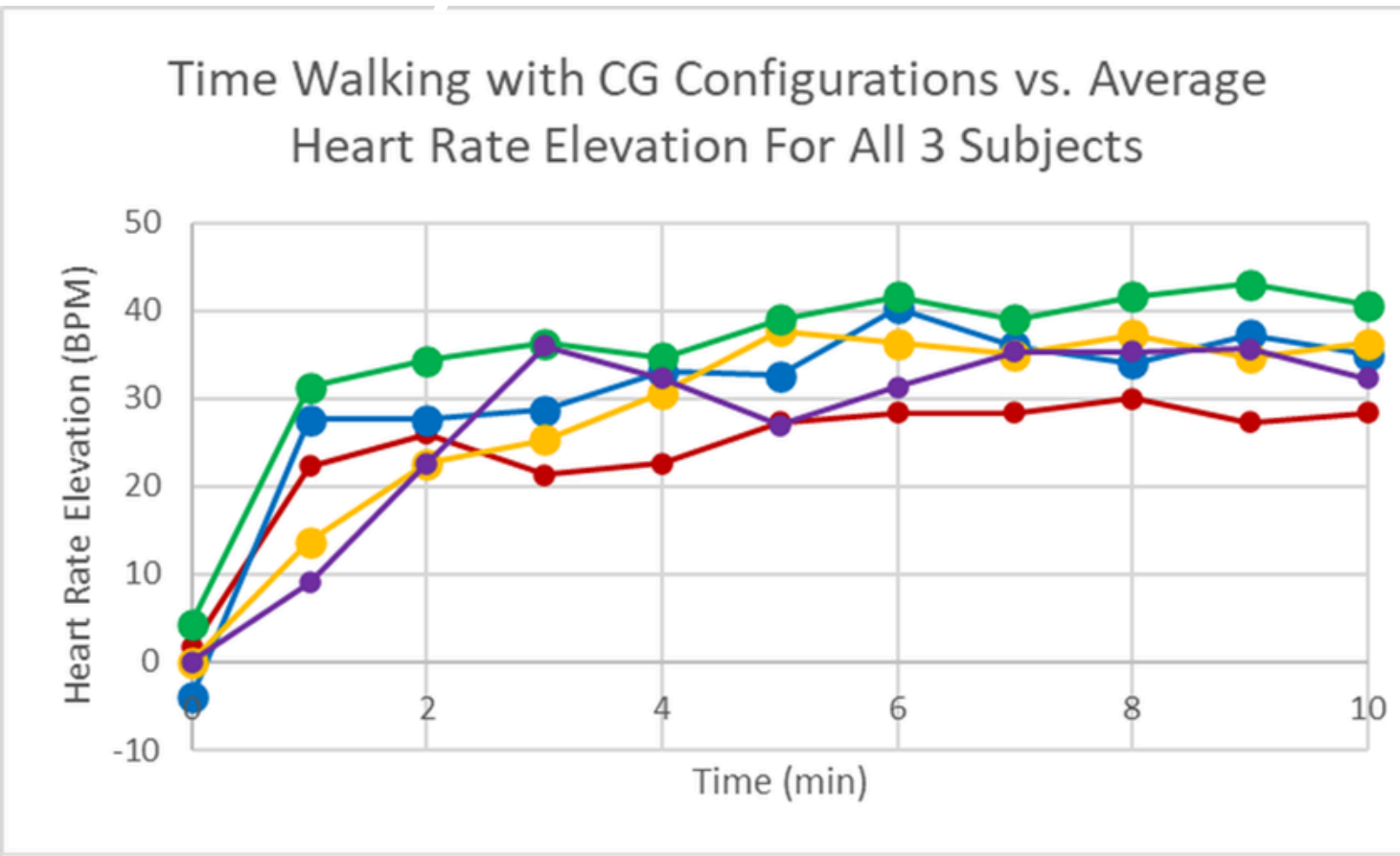
**Shielding:** Layering PEEK with tungsten creates Versatile Structural Radiation Shielding (VSRS), providing equivalent radiation shielding to aluminum at lower mass [1].

**Heat Transfer:** Mount electronics to aluminum plates with embedded heat pipes to carry out waste heat.

## Physical Experimentation

**Center of Gravity Test**

Objective: Test how PLSS Center of Gravity affects Perceived Exertion  
Results: Quantitatively inconclusive but qualitatively the Dispersed configuration resulted in the lowest rating of perceived exertion.



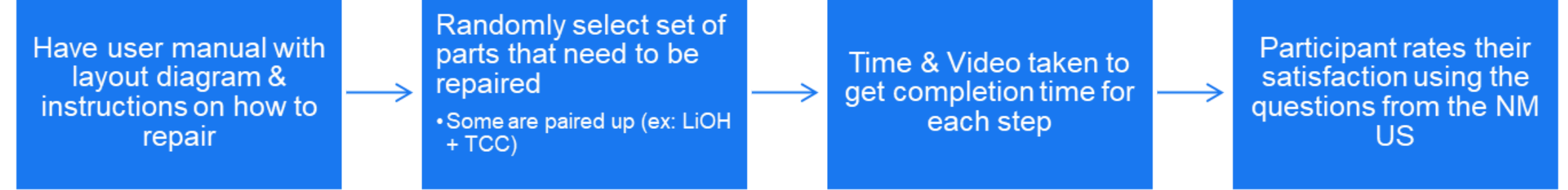
**Perceived Exertion (1-10)**

| Subject       | 1 | 2 | 3 | Avg. |
|---------------|---|---|---|------|
| Unloaded      | 1 | 1 | 1 | 1    |
| Top           | 3 | 2 | 3 | 2.67 |
| Bottom        | 2 | 2 | 5 | 3    |
| Dispersed Old | 1 | 2 | 2 | 1.67 |
| Dispersed New | 1 | 2 | 1 | 1.33 |

Rated on the Bedford Scale

**Maintainability Test**

Objective: Test ease of components replacement  
Results: TBD but the mock-up designed with maintainability in mind

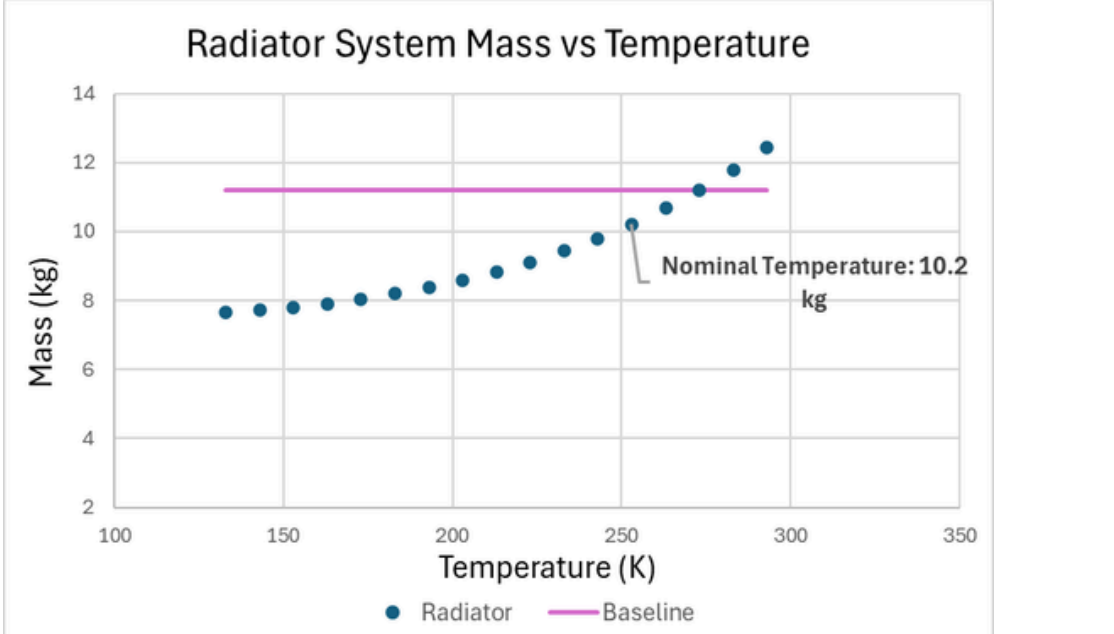
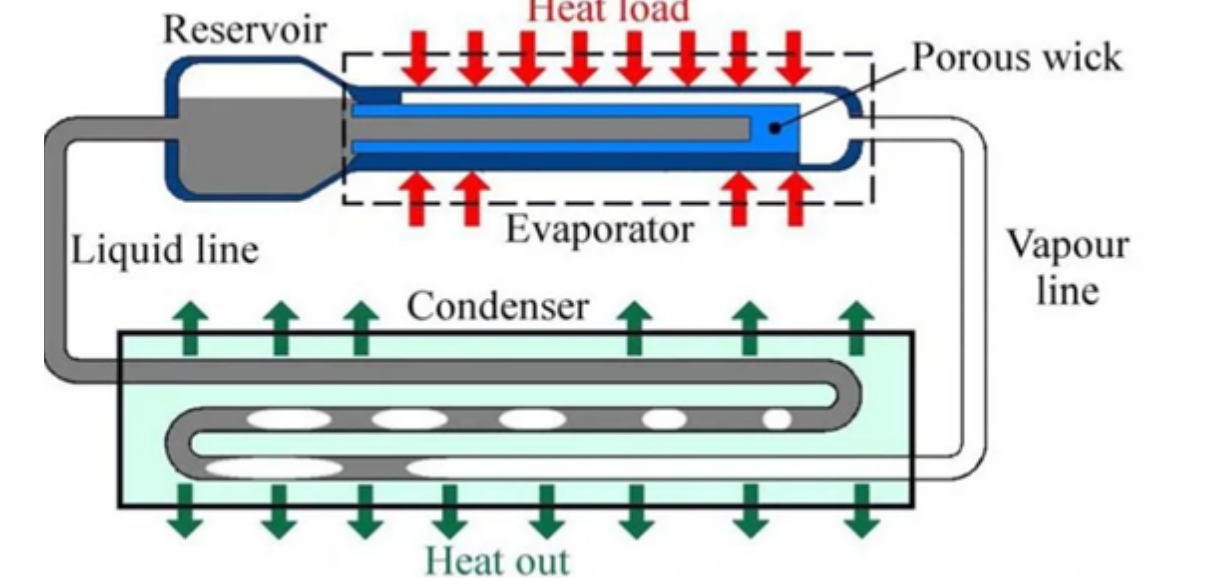


\*Repeat steps first for each trial and then for each participant allowing for variability + more data\*

## Thermal

Our design reduces water mass by employing a radiator in conjunction with the current system.

- The liquid cooling ventilation garment and heat pipes transport heat under the backpack surface.
- AZ-93 coating on the outer textile surface functions as a radiator.
- **Mass reduction: 1.6kg.**



[3] Motter, L., Coquard, T., and Prat, M., "Heat and Mass transfer in the porous wick of a capillary evaporator," 5th International Conference on Porous Media and its Applications in Science and Engineering, 2014.

## Power

Use solid state batteries as a rechargeable, low mass, high energy density alternative to the current lithium-ion battery.

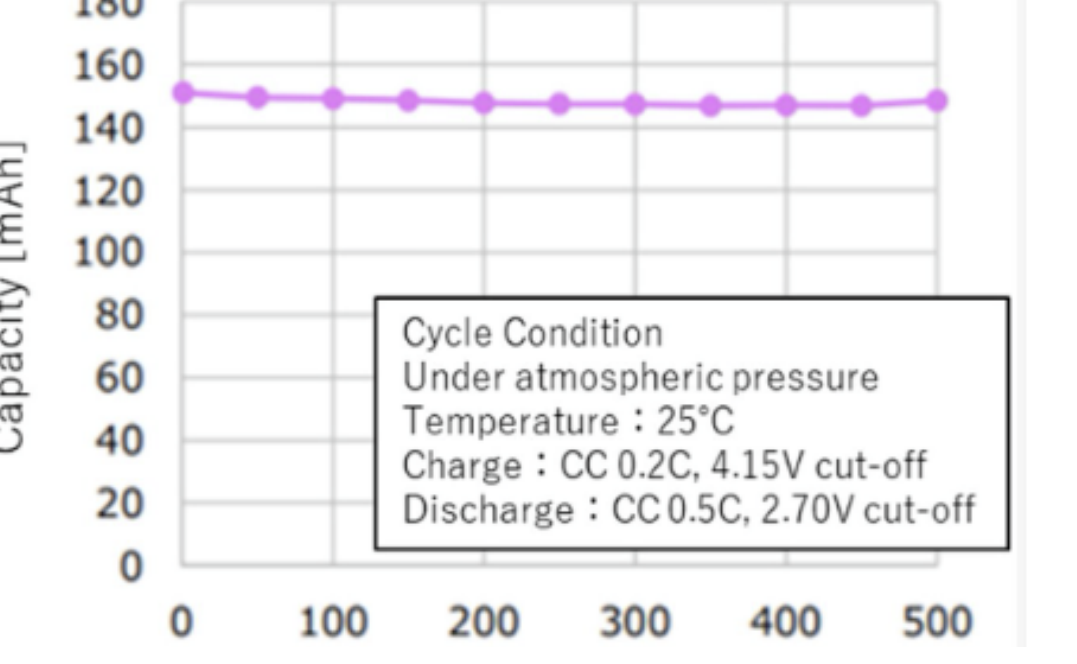
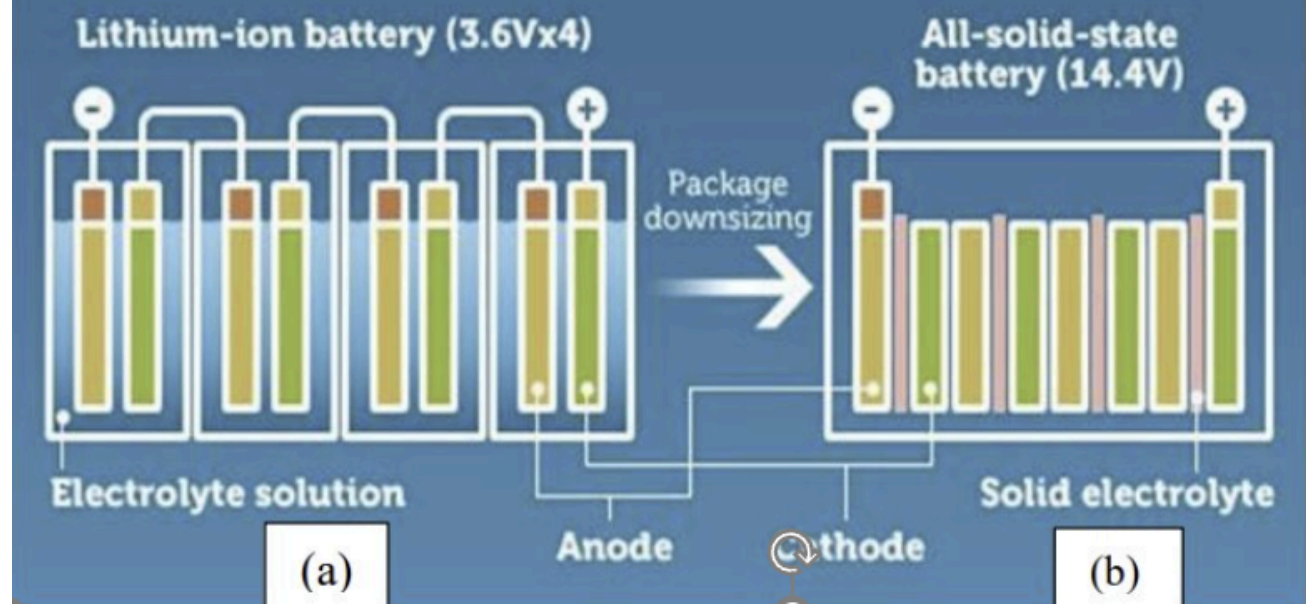


Figure 2. Diagram of (a) Lithium ion Battery; (b) All Solid State Battery [4].  
[4] Kartini, E. and Genardy, C., "The Future of All Solid State Battery," IOP Conference Series: Materials Science and Engineering, 2020.

[5] Miyazawa, Y., Shimada, T., Fuse, T., Shimada, S., Nishiura, S., Okamoto, H., Okawa, T., Hoshino, T., Kawasaki, O., and Naito, H., "Space Demonstration of All-Solid-State Lithium-Ion Batteries Aboard the International Space Station," Aerospace, 2025.

**Mass reduction: 2.1 kg + 2.7 kg of water saved**