D-12 Rack To The Future
X-Hab Lunar Habitat Payload Rack

Department of Aerospace Engineering

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Problem Definition

Design an adaptable, human-centered payload rack system that supports diverse payloads across microgravity, 1/6g, and 1/3g environments, prioritizes ergonomic maintenance and repair, maximizes operational efficiency through replaceability and minimal crew time, and ensures sustainability by repurposing for lunar and Martian mission needs.

Rack production done in collaboration with NASA via the X-Hab Challenge

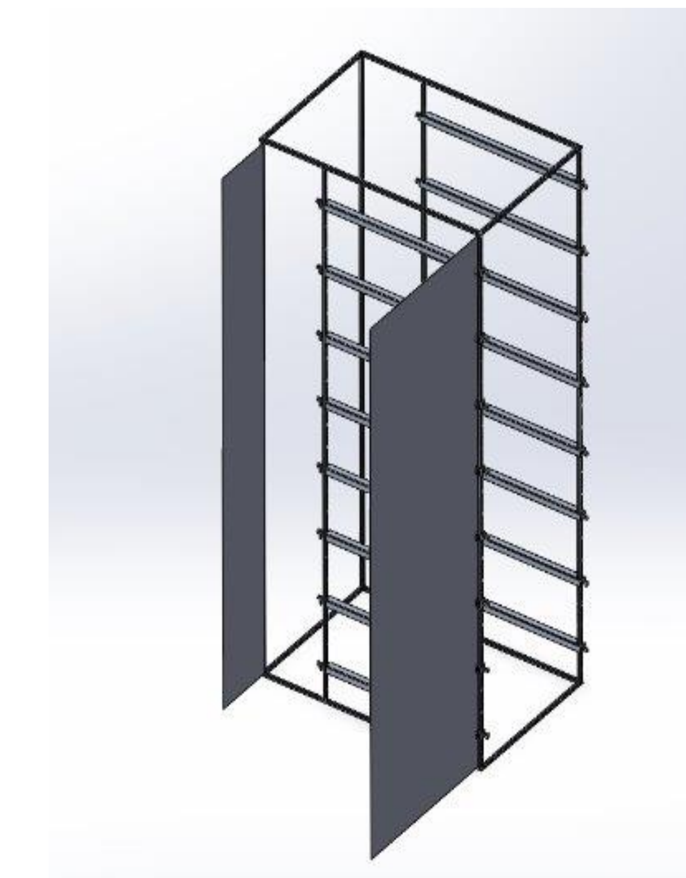
Final Design

Rails for easy front slide-in of payloads, removable side panels, adjustable rail heights through spring loaded pins

Material for rack will be AL-7075T6

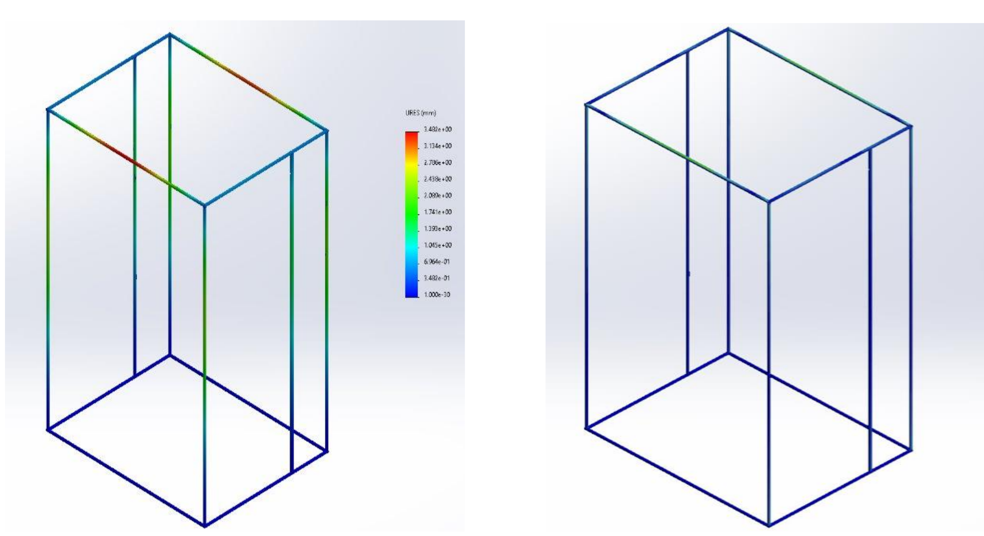
Single Rack:
- 0.90 x 0.59 x 1.91 [m]
- 0.68 m^3 of payload volume
- 0.25 m^3 of maintenance volume
- Empty mass (configured to fit 8 standard payloads not including rails) of 20.6 kg

Double Rack:
- 0.90 x 1.16 x 1.91 [m]
- 1.39 m^3 of payload volume
- 0.51 m^3 of maintenance volume
- Empty mass (configured to fit 8 standard payloads not including rails) of 21.5 kg



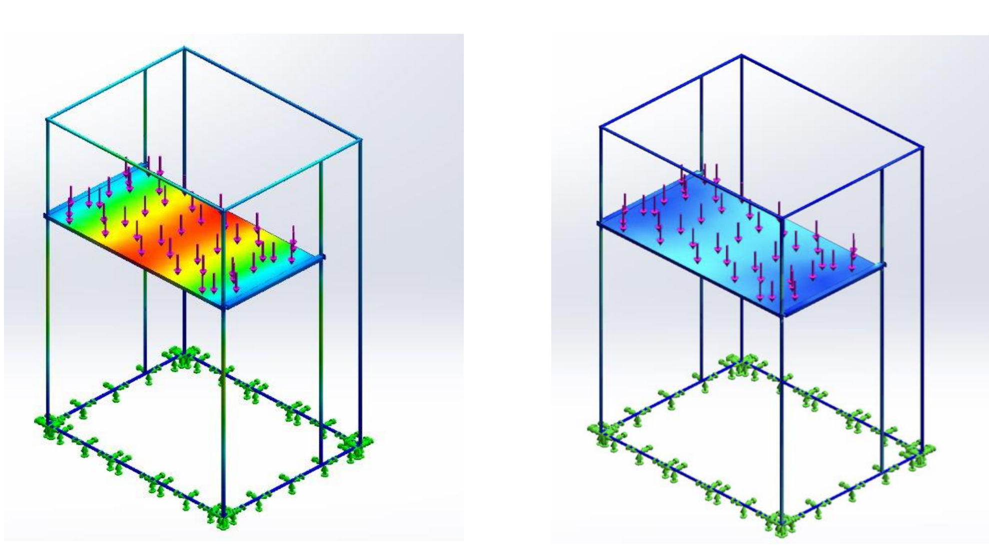
Design Calculations and Analysis

Model 1



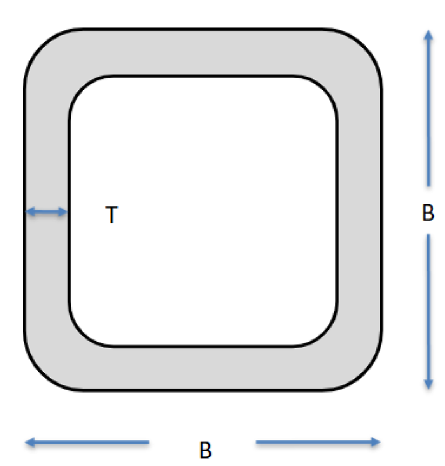
- Applied 6 g's to the racks frame excluding payloads. Fixed bottom
  - Max displacement: 3.482 mm
  - Max stress experienced: 27.41 MPA

Model 2

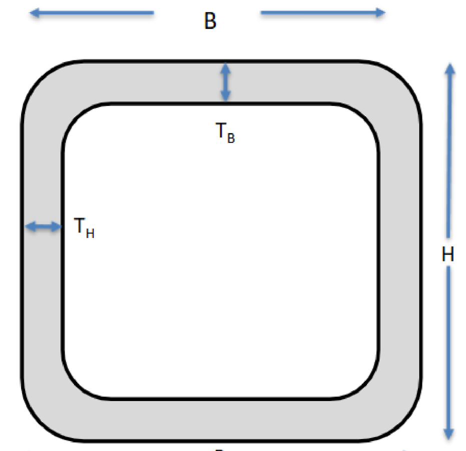


- Model "shelf" attached to rails. Uniform load of 80kg * 9.81m/s^2 = 784.8N
  - Max displacement: 0.464 mm
  - Max stress experienced: 8.921 MPA

Beams



- Square cross-section so critical stress is independent of orientation
  - B: 13.5mm
  - T: 4.2mm
  - Filet radius: 3mm (NASA STD 3001)
  - Ultimate Margin of Safety: 12.3



- B: 28.9mm
- T: 27.3mm
- T_B: 4.9mm
- T_H: 4.9mm
- Filet radius: 3mm (NASA STD 3001)
- Ultimate Margin of Safety: 0.96

Payload Dimension Analysis

Comparison to Express rack payload dimensions

	Express Rack	No Data PL	Data PL
Height (mm)	253.24	311.9	238.2
Width (mm)	440.44	548.2	548.2
Depth (mm)	516.13	660.4	660.4
Volume (m^3)	0.06	0.11	0.09

Data/Power Hub Details

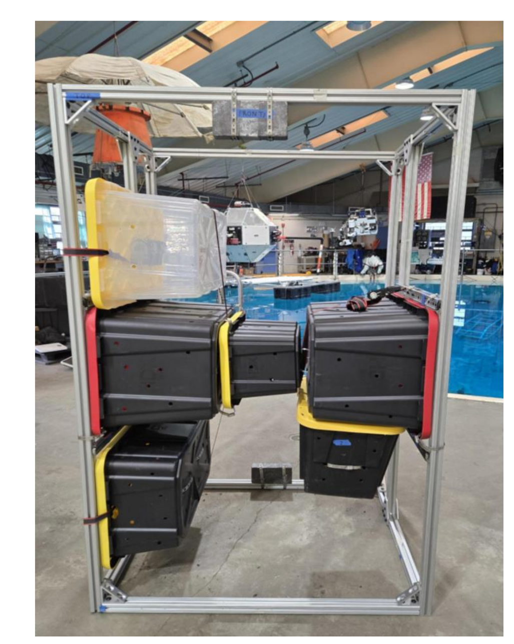
- Power: 28V DC
- Data: Ethernet, Serial, Analog, Discrete, Fiber-optic

Design Requirements

- The rack shall be liftable by two individuals under lunar gravity and should be compatible with a lifting device to facilitate safe and efficient handling.
- The rack shall fit within the dimensions of the NASA standard 40" x 60"(1.02 x 1.52m) hatch.
- The rack shall be designed to interface with habitat data and power systems.

For mission requirements, visit: https://go.umd.edu/Requirements

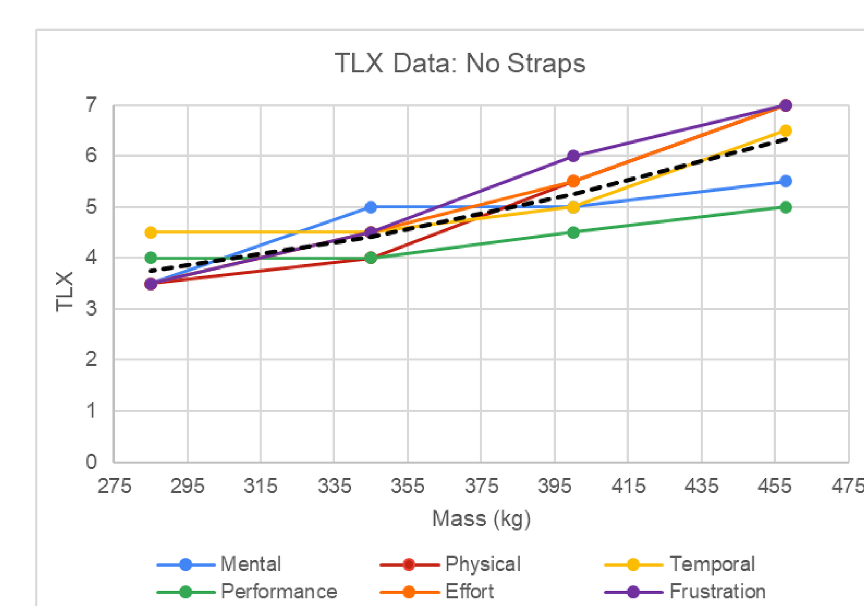
Prototype and Test Results

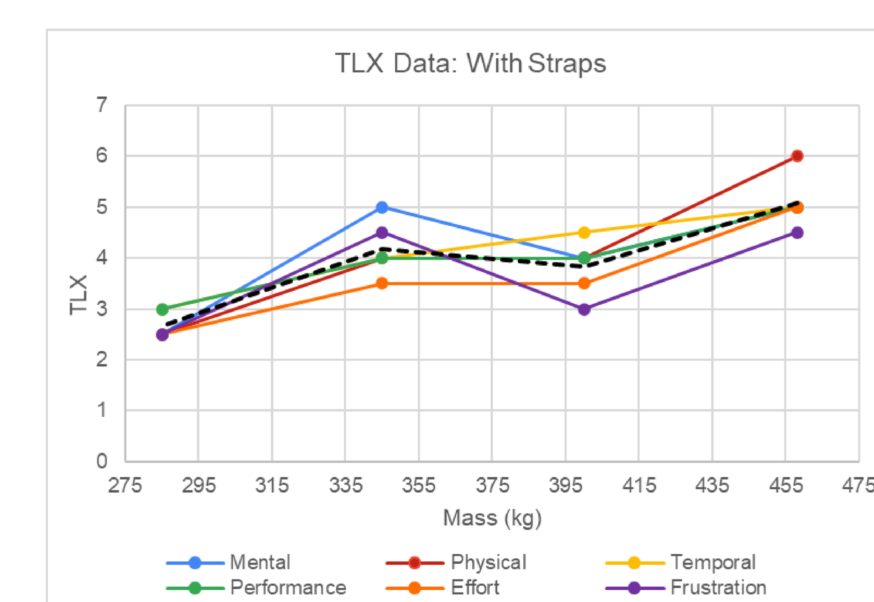


Prototype
- Built utilizing AL-6061 beams via 80/20
- Cost: $925.60
- Utilized for simulated gravity environments in NBRF

Mass Testing with SSL and NBRF

Simulated Lunar Mass Testing





- The maximum feasible mass two astronauts can safely carry in the lunar gravity environment is 375 kg under IVA conditions
  - Rack and preinstalled payloads may not exceed this mass prior to launch
  - Lifting straps recommended
- ~ 60% of payloads can be launched preloaded
  - Additional payloads must be installed after rack is in its desired location