Jay Kim – *Undergraduate, Mechanical Engineering*
Adelaide Yu – *Undergraduate, Electrical Engineering*
Makoa Shope – *Undergraduate, Mechanical Engineering*
Anthony Krebs – *Undergraduate, Mechanical Engineering*
Chase Lampe – *Undergraduate, Mechanical Engineering*
Ny'asia Crosley – *Undergraduate, Mechanical Engineering*
Ashle Jantzen – *Undergraduate, Electrical Engineering*
Christian Sekavec – *Undergraduate, Mechanical Engineering*
Caleb Willman – *Undergraduate, Mechanical Engineering*

Colorado School of Mines: MAST – Modular Adaptive Separation Technology

PESTO – Propellant Engineering and Storage for Transfer On-Orbit

HuLC – HUMAN LANDER CHALLENGE

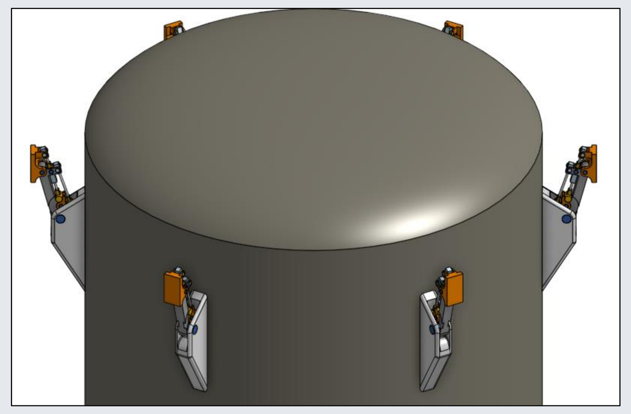
"From Icebergs to Orbit, Powered by PESTO"

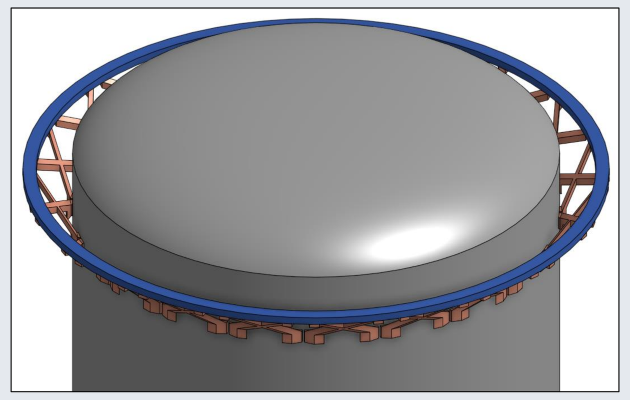
Topic and Scope

The Problem: Cryogenic Boil-off:
- Excessive heat causes vaporization
- Increases needed fuel at launch

Our Approach:
- Utilize tank retractable tank supports
- Decouple conductive elements
- Reduce heat transfer, boiloff
- Validate load-bearing capabilities

Criticality:
- Extended missions face fuel challenges
- Thermal equilibrium becomes problematic


MAST tank structure

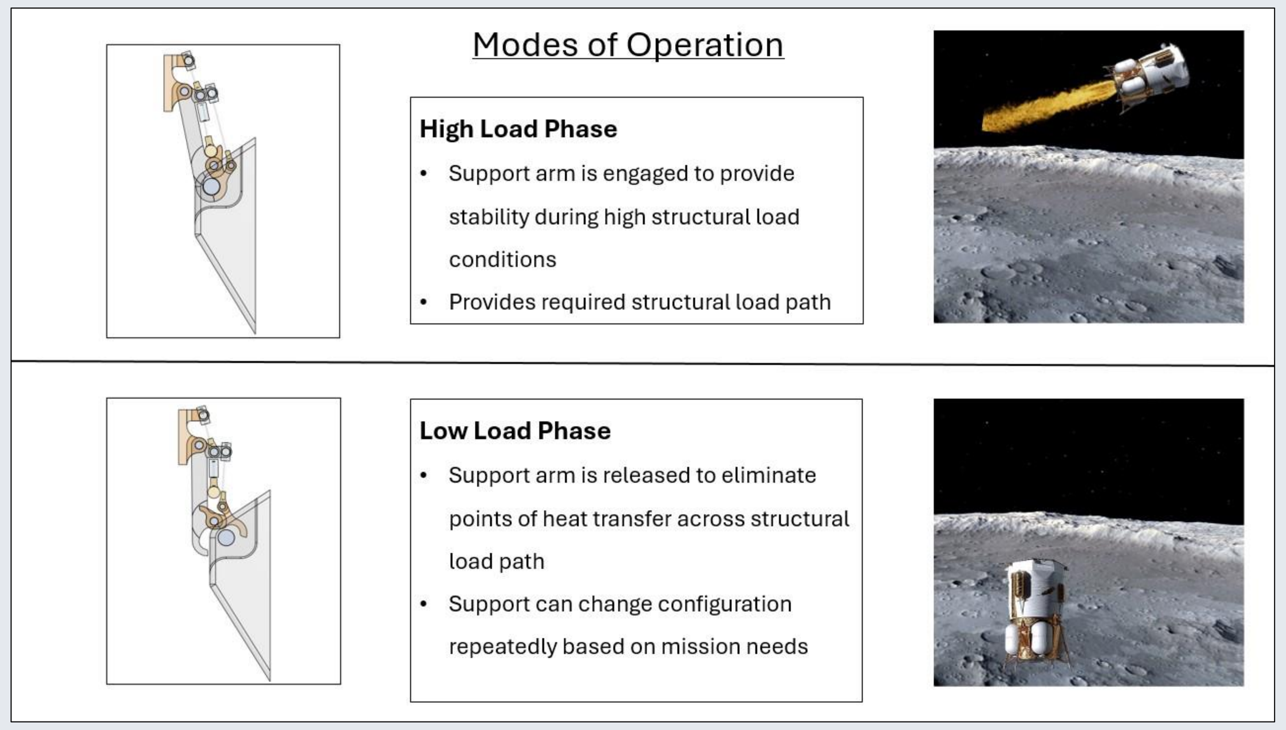

Typical tank structure

Requirements

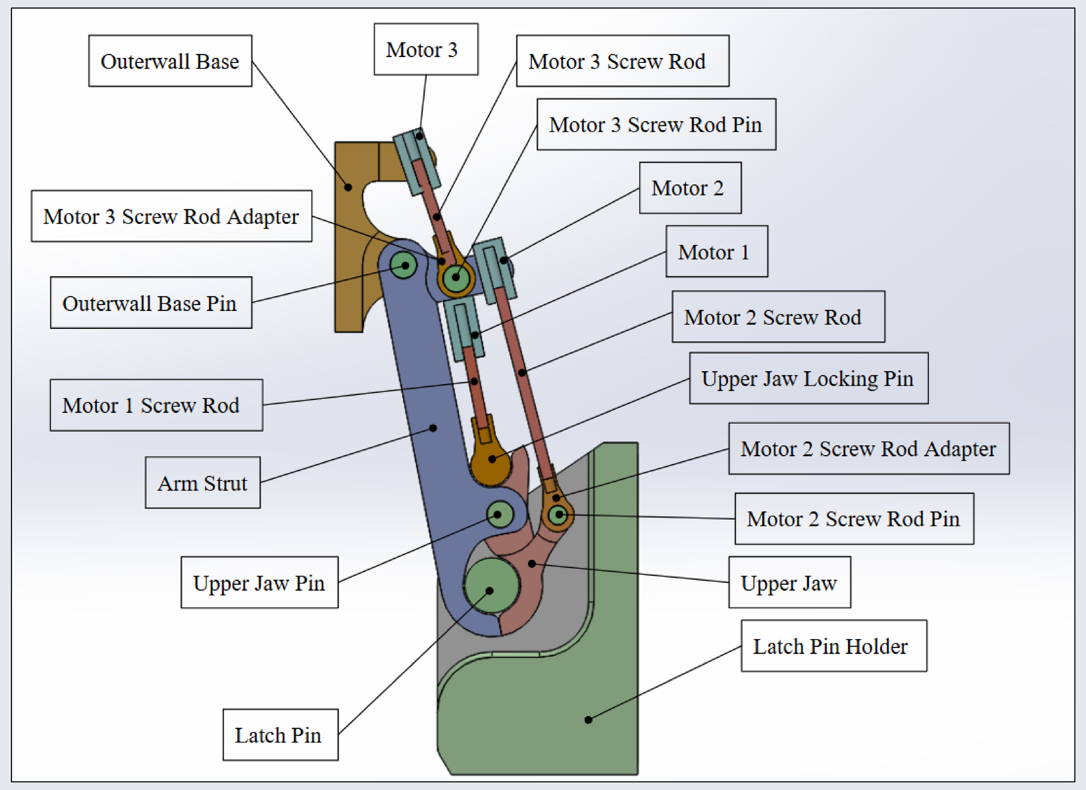
Major low-level:
- TRL Level of ~4
- Justify low TRL
- Prevent kilowatts of heat transfer
- Support 290 kN at launch
- Survive launch vibrations
- Minimum FoS of 1.5
- Weigh at most 25 kg

Type	Req	Requirement
High Level	HL1	The design shall be easily adaptable to NASA adoption.
High Level	HL2	The design shall survive in a space environment.
High Level	HL3	The design shall be fieldable in 3 – 5 years (Artemis III).
High Level	HL4	The design shall not pose additional risks to the crew.
High Level	HL5	The design shall survive launch and landing loads.
High Level	HL6	The design shall survive a mission duration of multiple months.

Operational Viewpoint

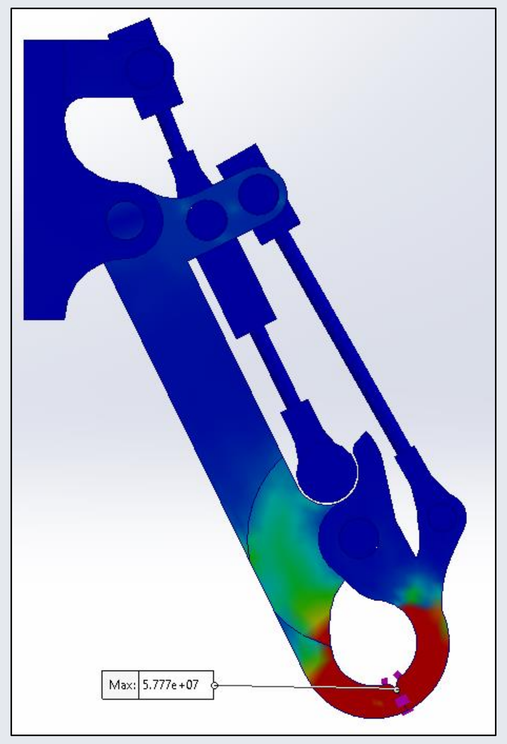


Solution Details



- Designed for 12 supports
- 23.8 kg in mass
- 55.4 x 29.9 x 10 cm
- Modular in design
- Ti-5Al-2.5Sn Alloy

Mechanical Loading

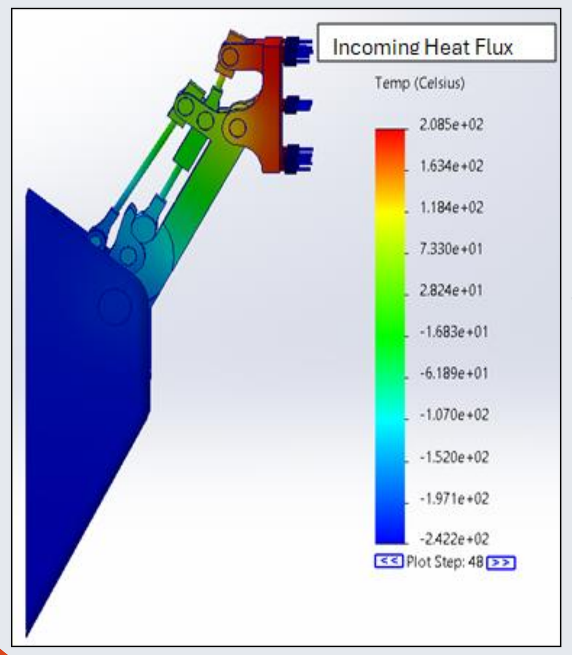

Launch Stress Plot

- Use SolidWorks Simulator

Launch Test:
- Vibrational and thrust considerations
- Launch FoS: 14.31

Drop Test (lunar):
- 3.1 ft/s
- Drop FoS: 10.3

Thermal Analysis



Heat transfer plot

- Incoming heat flux of 1410 W/m^2

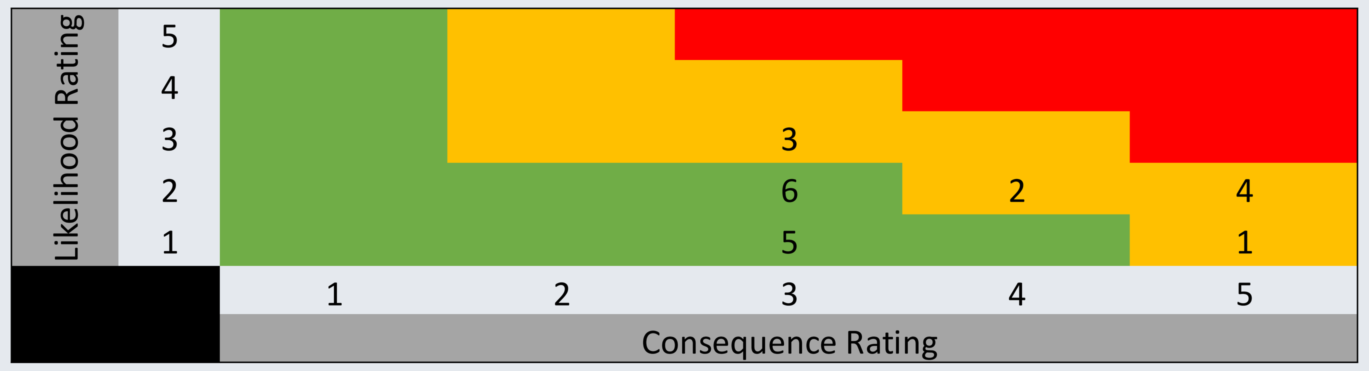
Initial Conditions:
- Arm strut: –150 °C
- Latch pin holder: –253 °C
- 28 W of transfer per support
- 0.378 g/s boiloff
- 97% reduction in boiloff

Budget and Schedule

Items	Lunar Landing Cost	Lunar (UC)	LEO Launch Cost	LEO (UC)
Resource	Cost	Uncertainty Cost	Cost	Uncertainty Cost
Material	$216,672.00	$246,412.80	$216,672.00	$246,412.80
Manufacture	$53,000.00	$70,000.00	$53,000.00	$70,000.00
Integrate and Test	$2,430,000.00	$1,611,500.00	$810,000.00	$1,611,500.00
Launch	$285,600,000.00	$357,000,000.00	$856,800.00	$1,071,000.00
Total	**$288,299,672.00**	**$358,927,912.80**	**$1,936,472.00**	**$2,998,912.80**

Phase	Estimated Time (Months)
Planning	4.5
Testing and Iteration	9.5
Manufacturing for Assembly	4
Assembly	3.5
Integration with Spacecraft	3
Safety Checks	2
Total (Months)	26.5

Risk Mitigation



Major risks:
1. Structural damage during mission
2. Spacing for MAST is too small
3. Design is too heavy
4. Structure cannot handle launch forces

Mitigation Plans:
1. Analyze and test to ensure FoS requirement
2. Use standard tank clearance (Artemis III)
3. Optimize structural mass
4. Simulate and test to replicate launch environment

Alignment

HL1 –
- Based on NASA standards
- Justifies low TRL solution with high TRL components

HL2 –
- Electronic and mechanical components verified
- Titanium alloy prevents overheating

HL3 –
- Fieldable in just over two years
- Pairs with existing NASA technology

HL4 –
- Mechanically and thermally verified

HL5 –
- Verified using SolidWorks Simulator

HL6 –
- Non-load bearing during low load phase