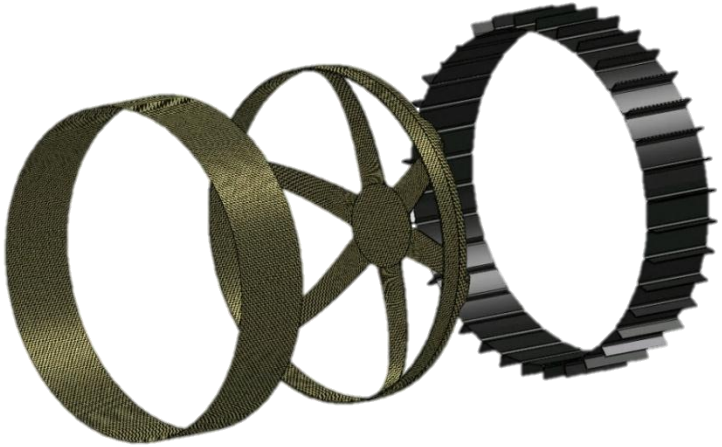
Composite Wheels
for Lunar Mobility



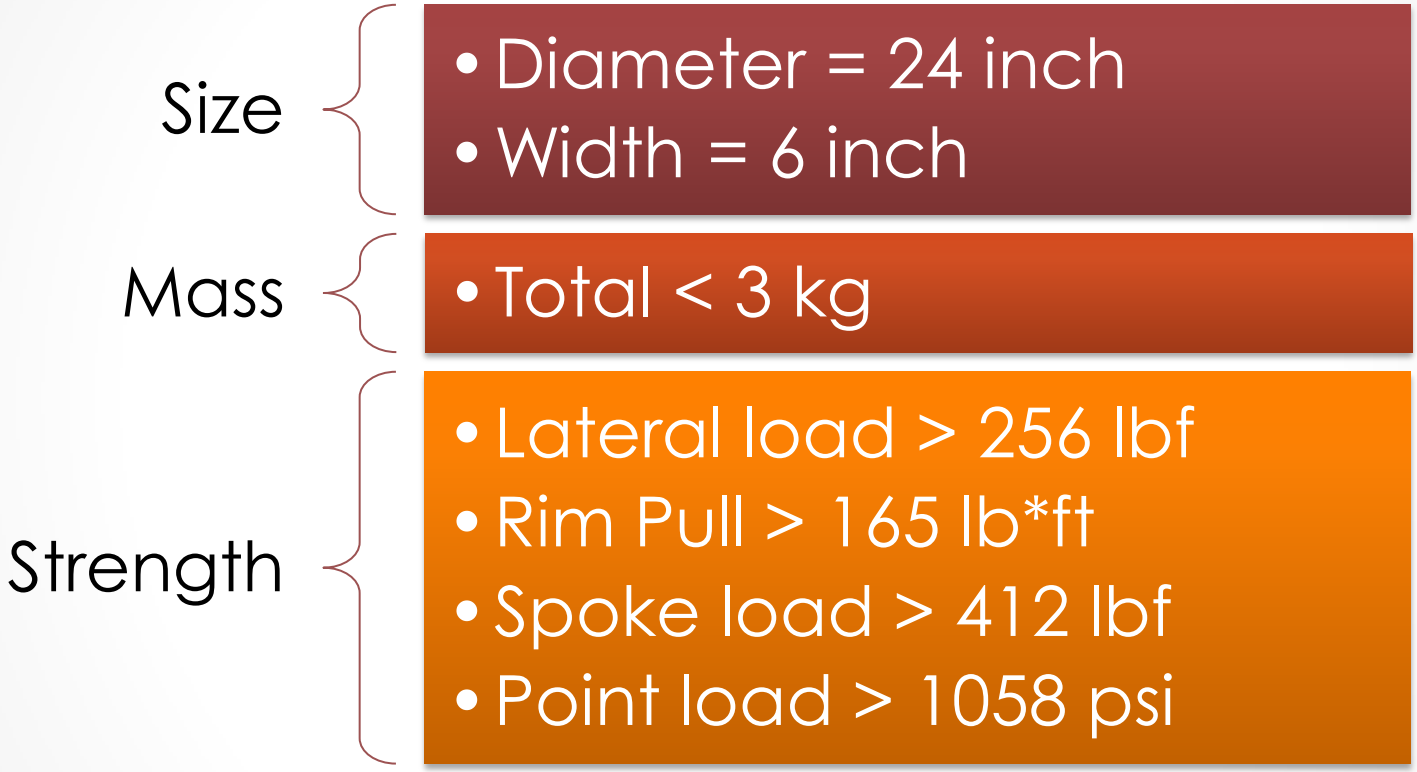
Joshua Chen
Natalie Mark
Zack Morrison
Jackie Yang

Outline

- Requirements
- Design
- Fabrication
- Assembly
- Test

Requirements

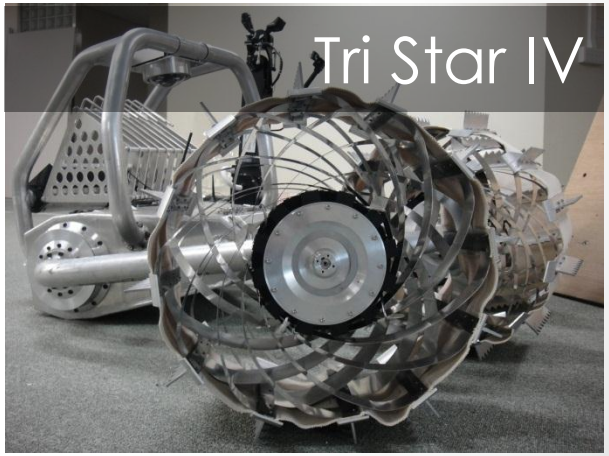
Size, Mass, and Strength


Size
• Diameter = 24 inch
• Width = 6 inch
Mass
• Total < 3 kg
Strength
• Lateral load > 256 lbf
• Rim Pull > 165 lb*ft
• Spoke load > 412 lbf
• Point load > 1058 psi

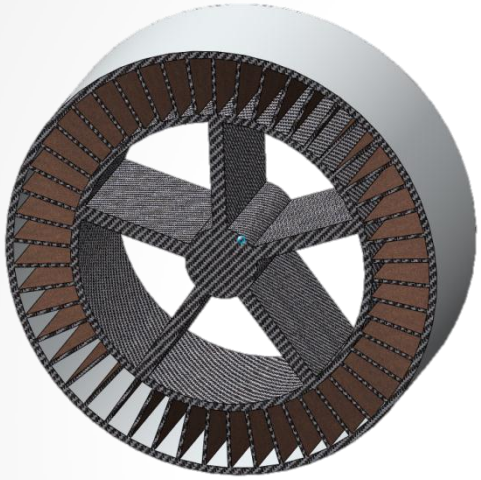
Design

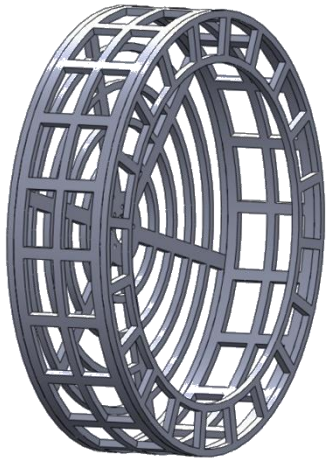
Research, Analysis, and Comparison

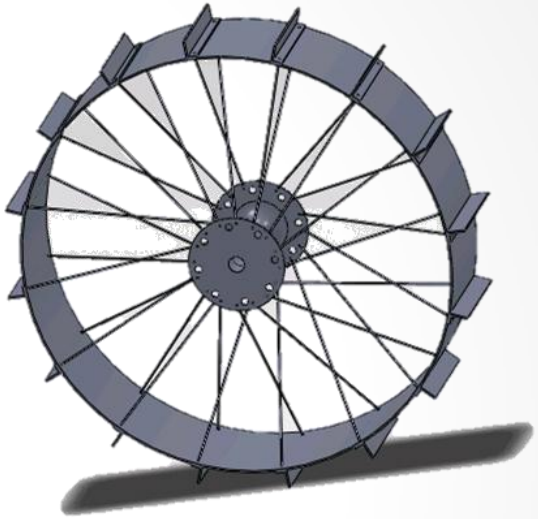
Previous Work

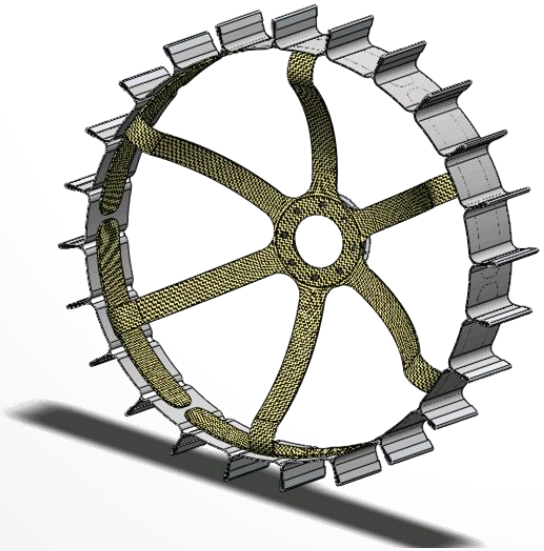


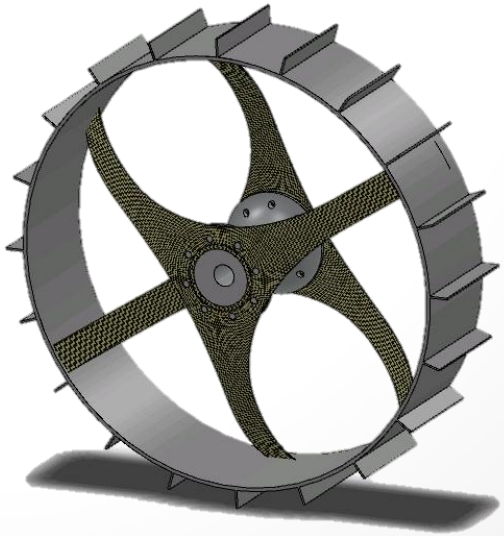
Our Concepts







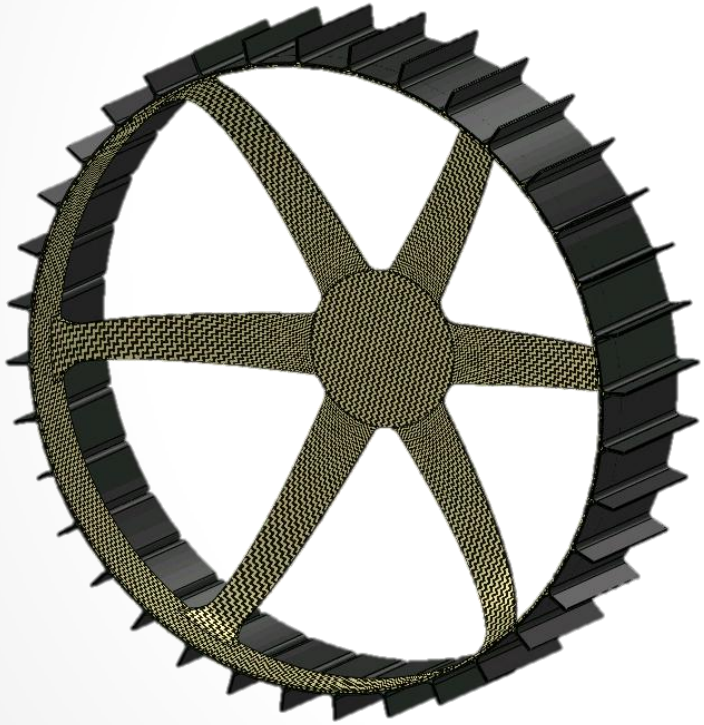


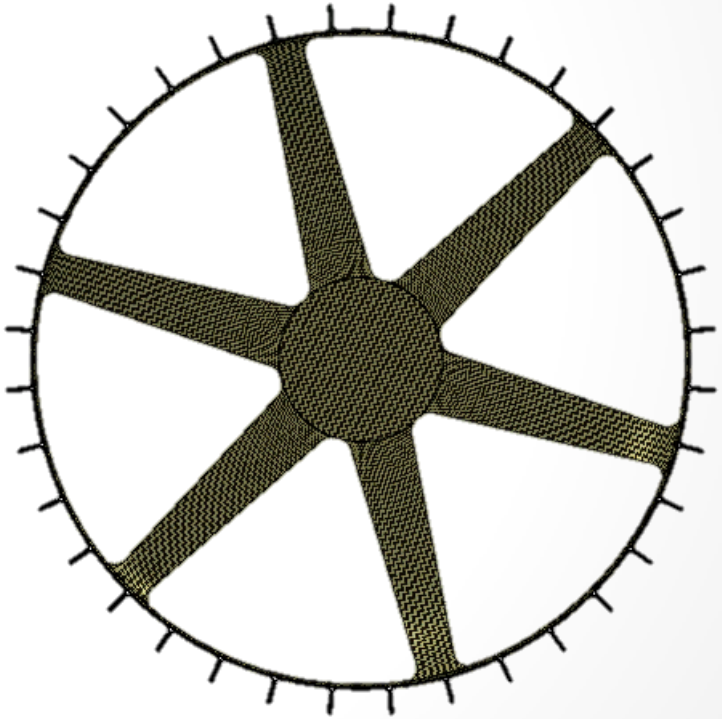


Design Comparison in Weighted Matrix

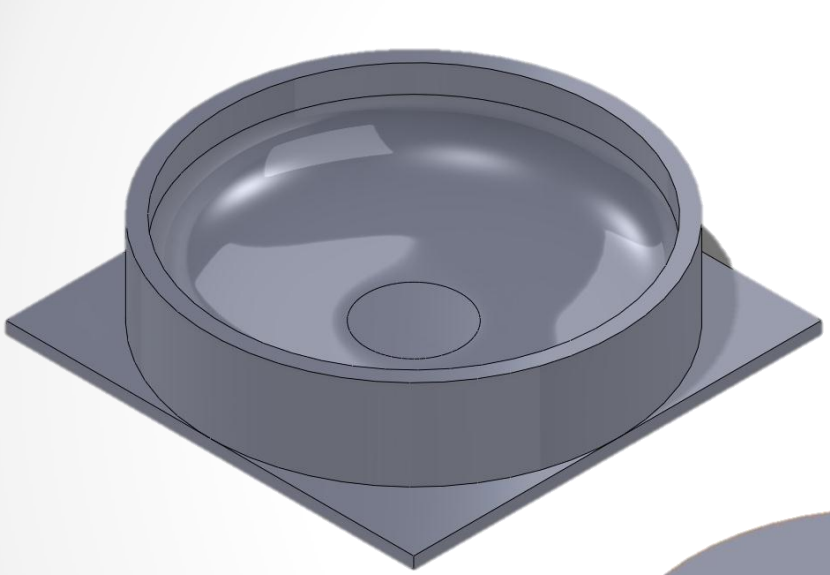
CRITERIA	WEIGHT	Spiral	Single Curved Composite	2-Curved Composite	Tweel	Spring Spokes	Straight Spokes	Mesh
Mechanical Reliability	5	3	4	4	2	2	5	2
Strength	4	3	3	4	2	2	5	2
Weight	5	3	5	3	2	4	5	4
Ride Smoothness	2	4	3	3	5	2	2	5
Obstacle Performance	3	3	3	3	4	3	3	3
Stability	3	3	3	2	4	2	3	3
Wear Resistance/ Durability	3	3	3	4	2	2	4	2
Flexibility/ Ground Compatibility	4	3	2	2	5	4	1	5
Feasibility	4	2	5	4	1	2	4	2
WEIGHTED TOTAL		97	118	108	92	87	124	100

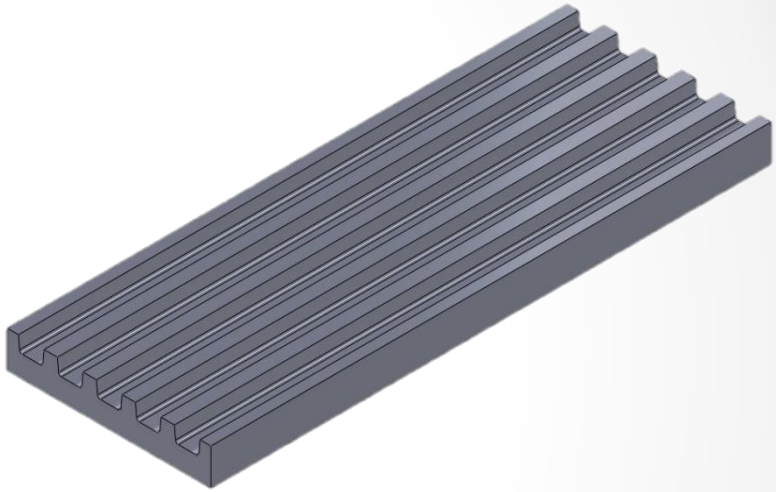
Final Design

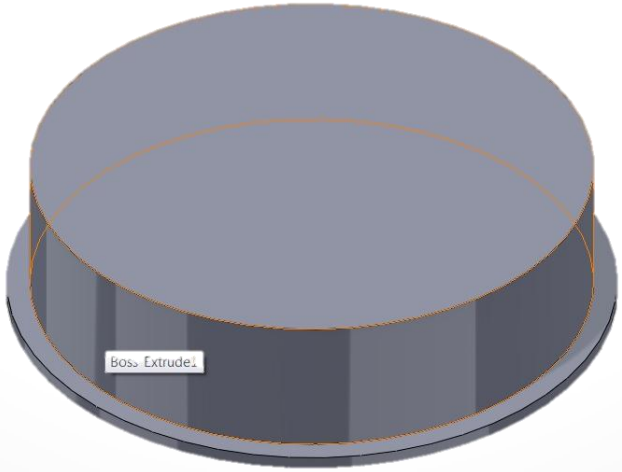




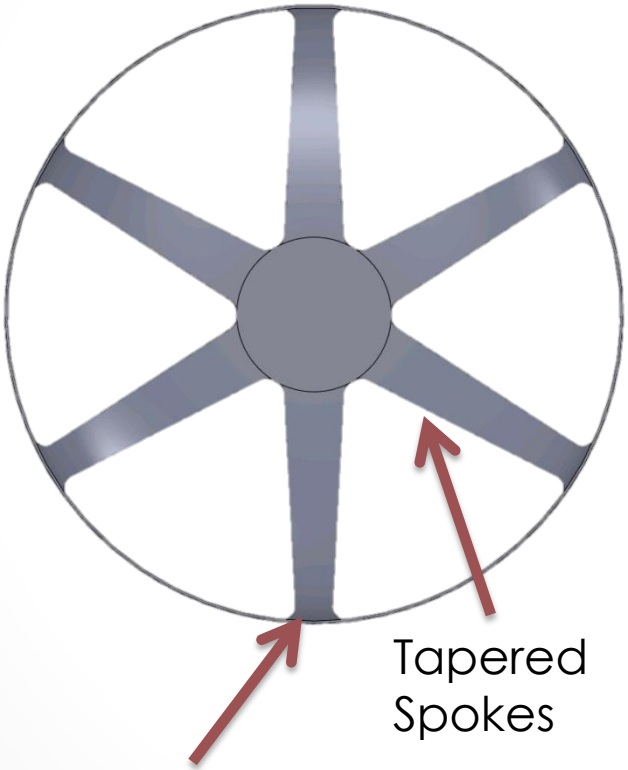
Mold Design

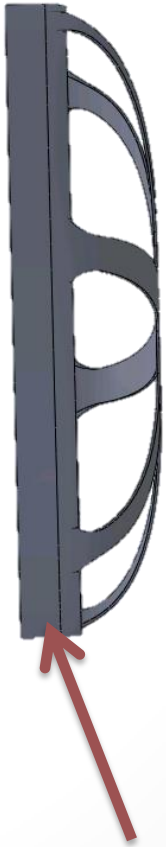






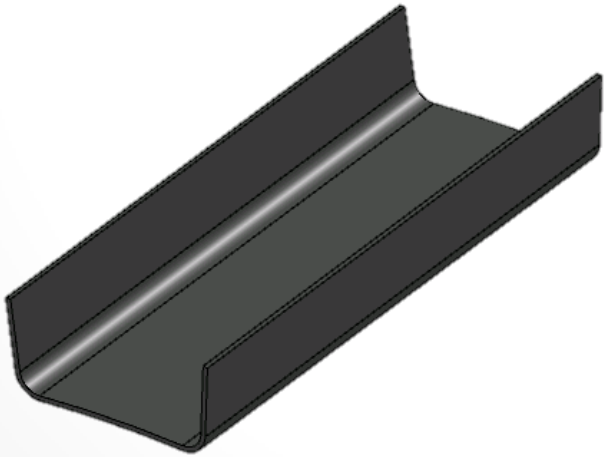
Spoke Design





Grouser Design

- 36 Grousers
- 4 Layers (2 Carbon, 2 Kevlar)
- Grouser Height ~ 0.5*Spacing
  - 0.75" Height, 2" Spacing



Grouser Thickness Test

Sample Detail

C: Carbon Fiber
K: Kevlar
0/90 +-45

3-Ply
- KCK | KCK

4-Ply
- KCCK | KCCK

4-Ply
- KCCK | KCCK

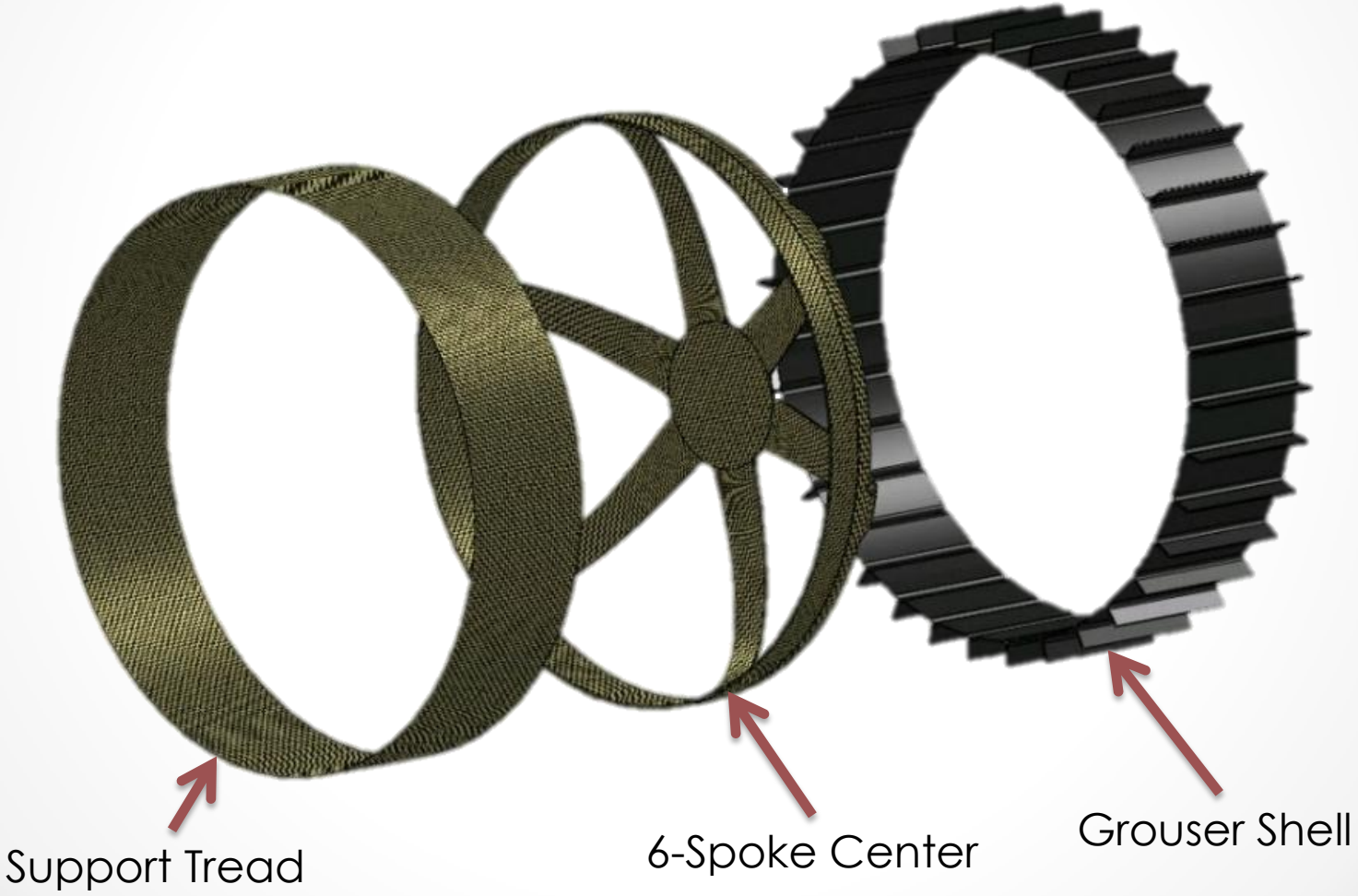
5-Ply
- KCCCK | KCCCK

Test Results

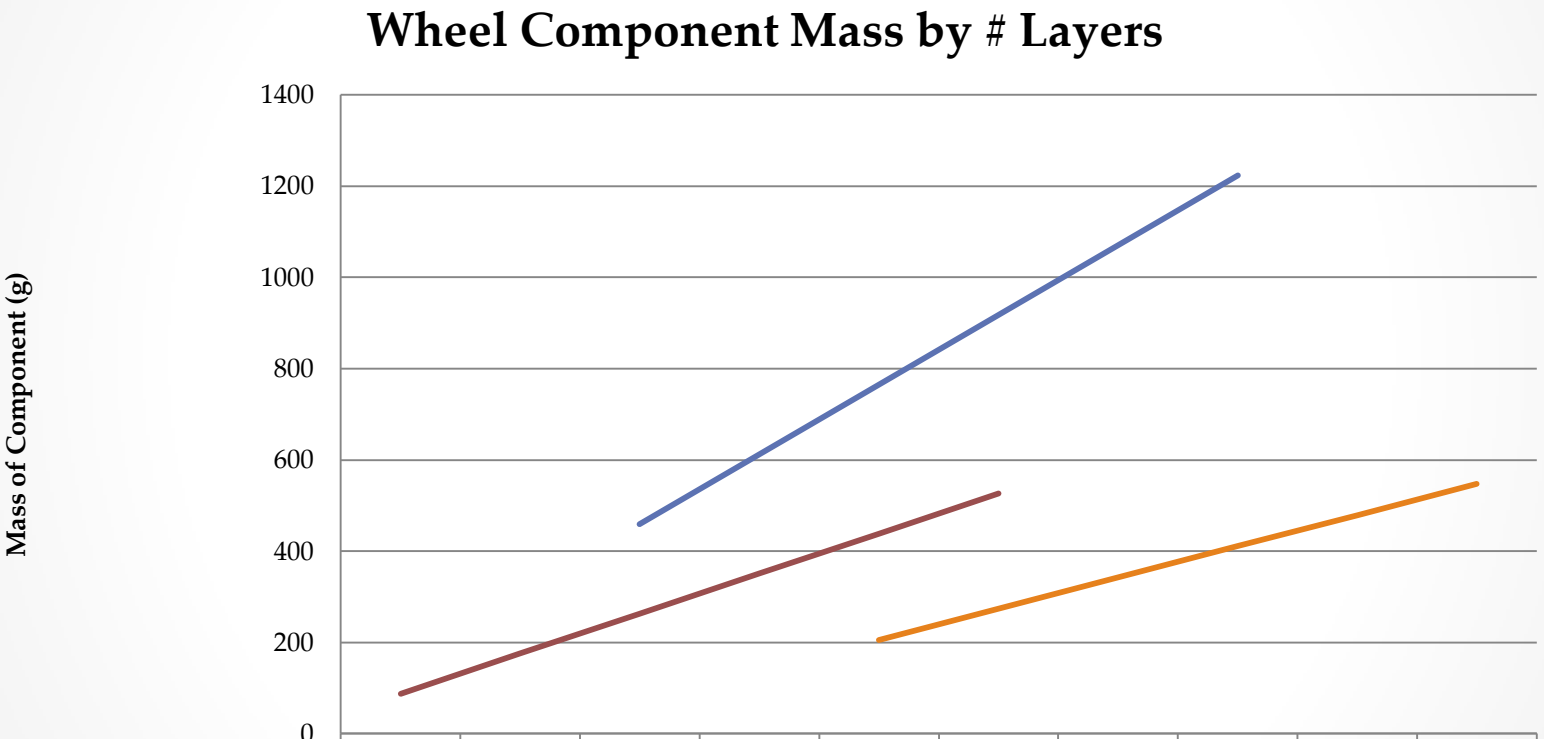
- Rim pull calculated load: 165 lb

	Test #1	Test #2	Test #3	Test #4	Test #5
# of layers	3-Ply	3-Ply	4-Ply	4-Ply	5-Ply
Width	¾″	1″	¾″	1″	¾″
Test max load	170 lb	170 lb	390 lb	310 lb	> 470 lb
Real max load	167 lb	167 lb	381 lb	303 lb	> 459 lb

Exploded View



Mass Analysis



	1	2	3	4	5	6	7	8	9	10
Total Gouser Mass (g)			458.8	611.7	764.6	917.6	1070.5	1223.4		
Suppport Mass (g)	87.7	175.4	263.2	350.9	438.6	526.3				
Spoke Mass (g)					205.4	273.8	342.3	410.8	479.2	547.7

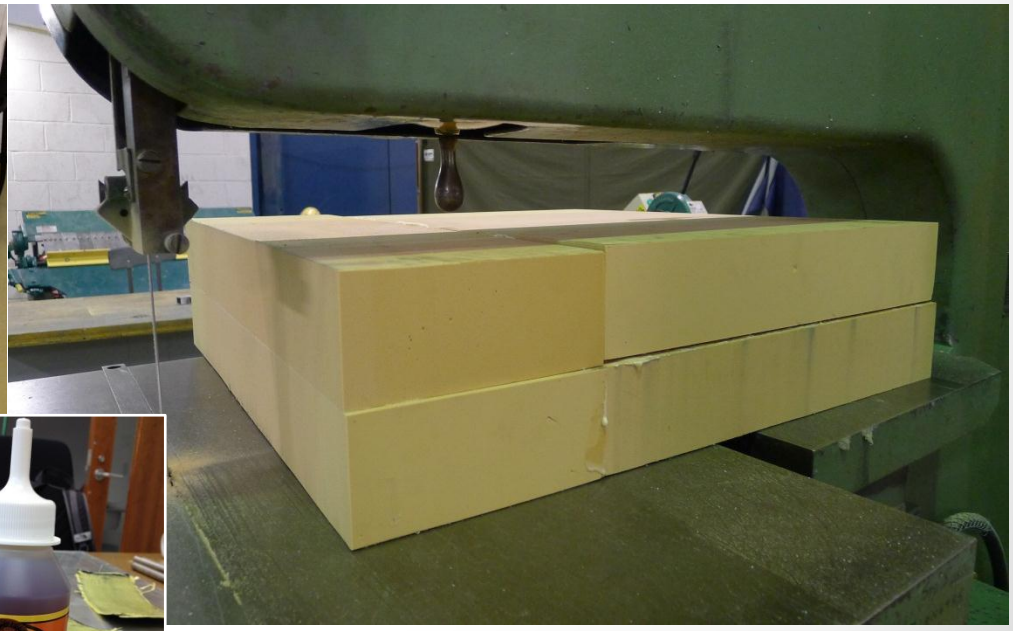
Fabrication

Mold & Component

Foam Block → Machined → Sand & Epoxy → Surface Cleaning → Layup Ready

Mold Fabrication

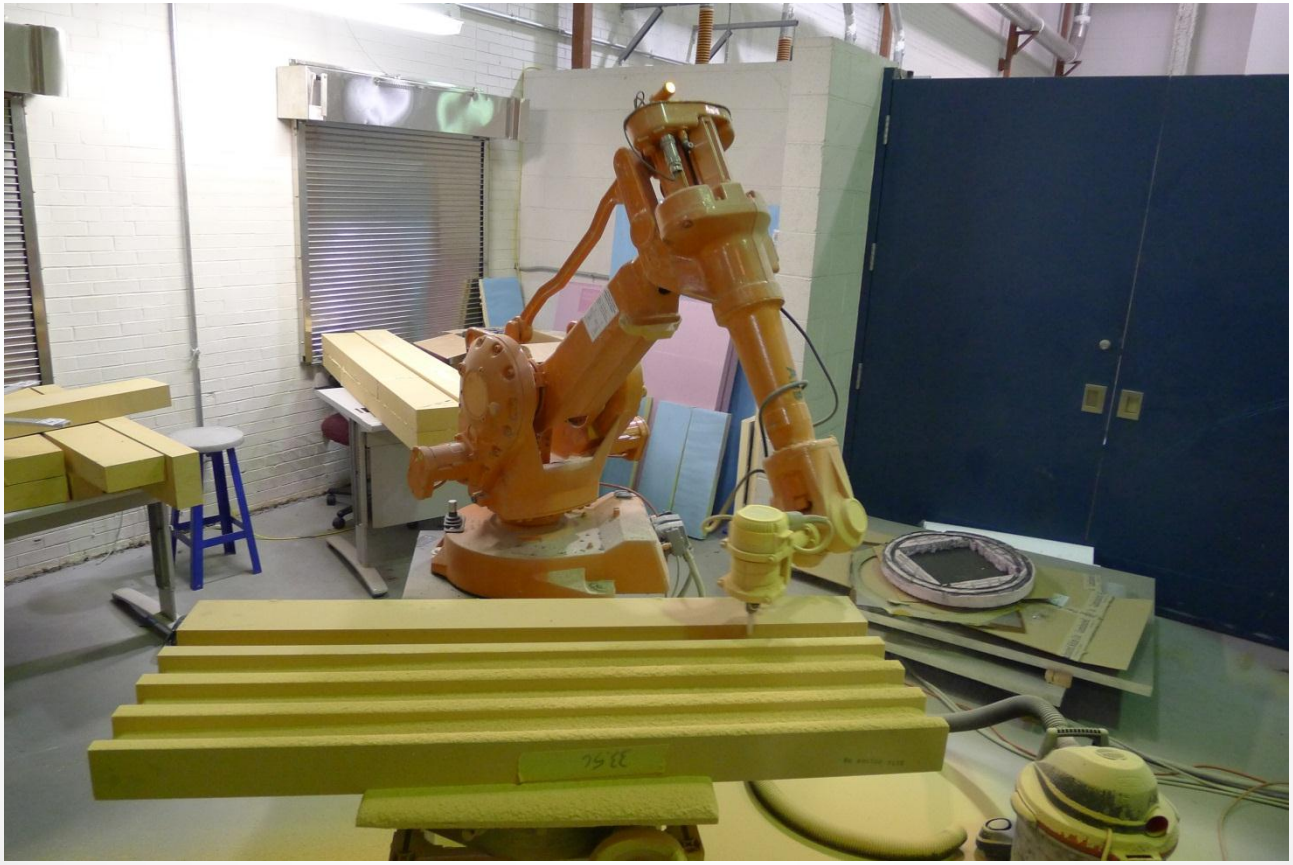
- Foam blocks were cut and glued together to make appropriate size for mold



Foam Block → **Machined** → Sand & Epoxy → Surface Cleaning → Layup Ready

Mold Fabrication

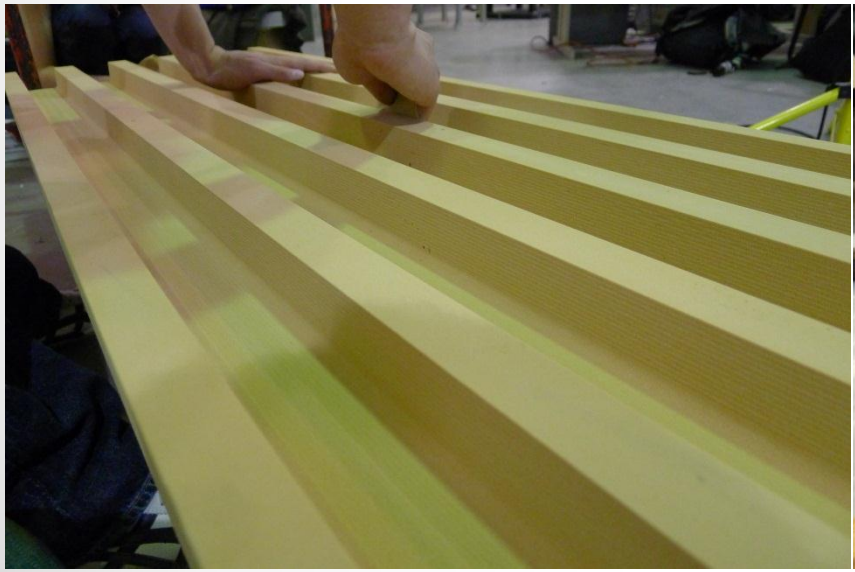
- Foam mold blocks were machined by robot arm in NSH Highbay



Foam Block → Machined → **Sand & Epoxy** → Surface Cleaning → Layup Ready

Mold Fabrication

- Each mold was sanded and epoxied two times to ensure smooth and sealed surfaces for layup



Mold Fabrication

- Clean and seal each mold multiple times to further ensure separation from mold after layup

Foam Block → Machined → Sand & Epoxy → Surface Cleaning → Layup Ready

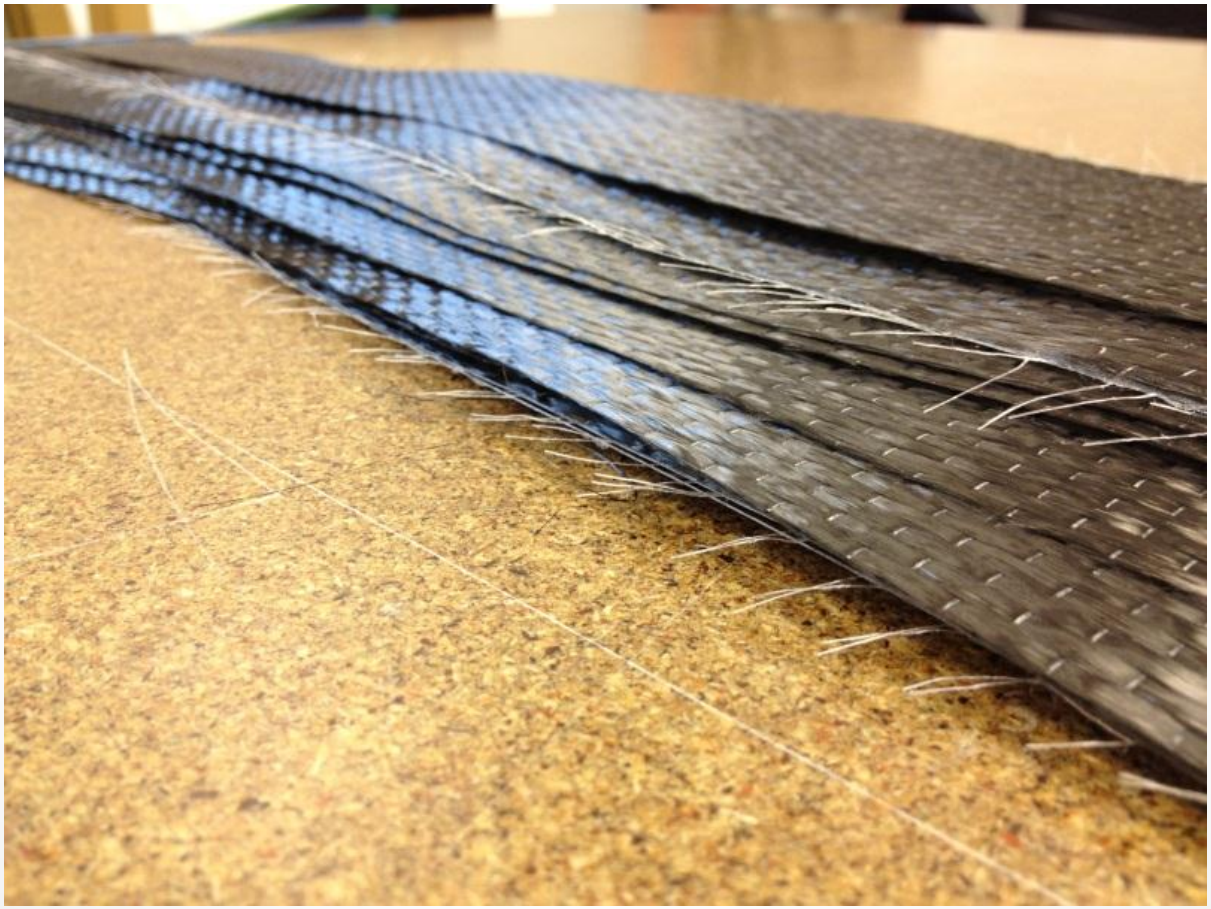
Mold Fabrication

- Mold is ready for composite layup

Material Trimmed → Epoxy Covered → Pattern Layup → Pack & Cured

Composite Layup

- Strips of carbon fiber & Kevlar were cut to size



Material Trimmed → **Epoxy Covered** → Pattern Layup → Pack & Cured

Composite Layup

- Carbon & Kevlar strips were covered in epoxy resin

Material Trimmed → Epoxy Covered → **Pattern Layup** → Pack & Cured

Composite Layup

- Carbon & Kevlar strips are laid into place over mold

Material Trimmed → Epoxy Covered → Pattern Layup → Pack & Cured

Composite Layup

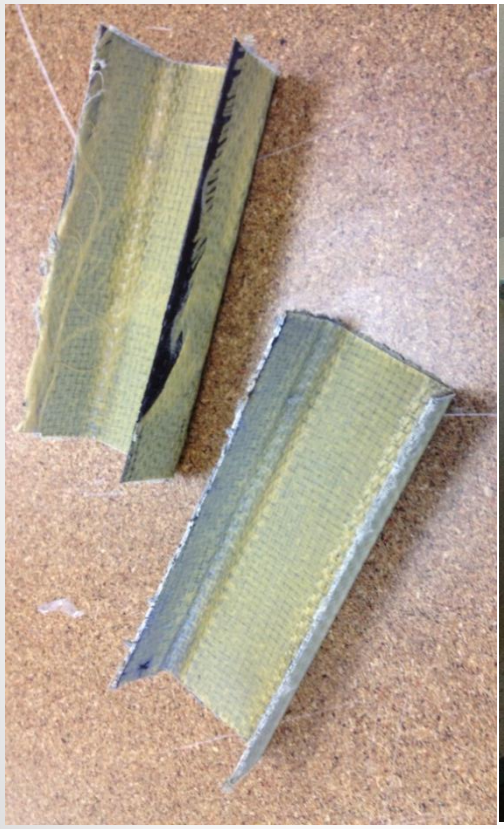
- Pack everything into vacuum bag and cure it for 8 hours in oven, then trim the parts into appropriate final shape

Assembly

Component & Wheel

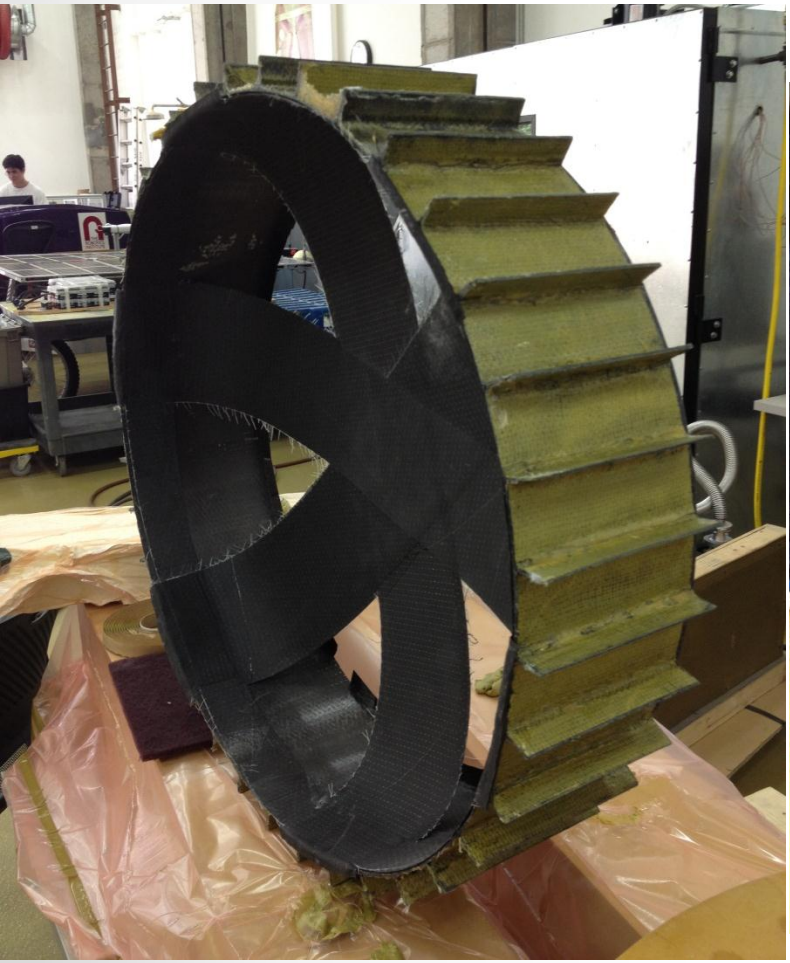
Spokes

Grousers



Rim + Grousers

Wheel



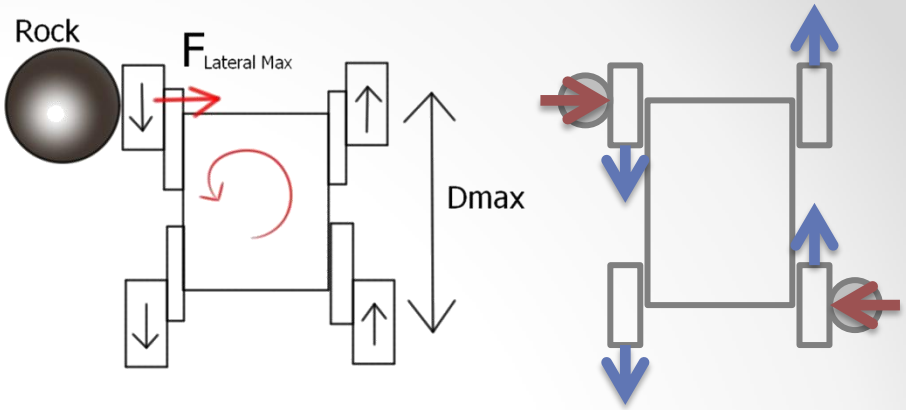
Test

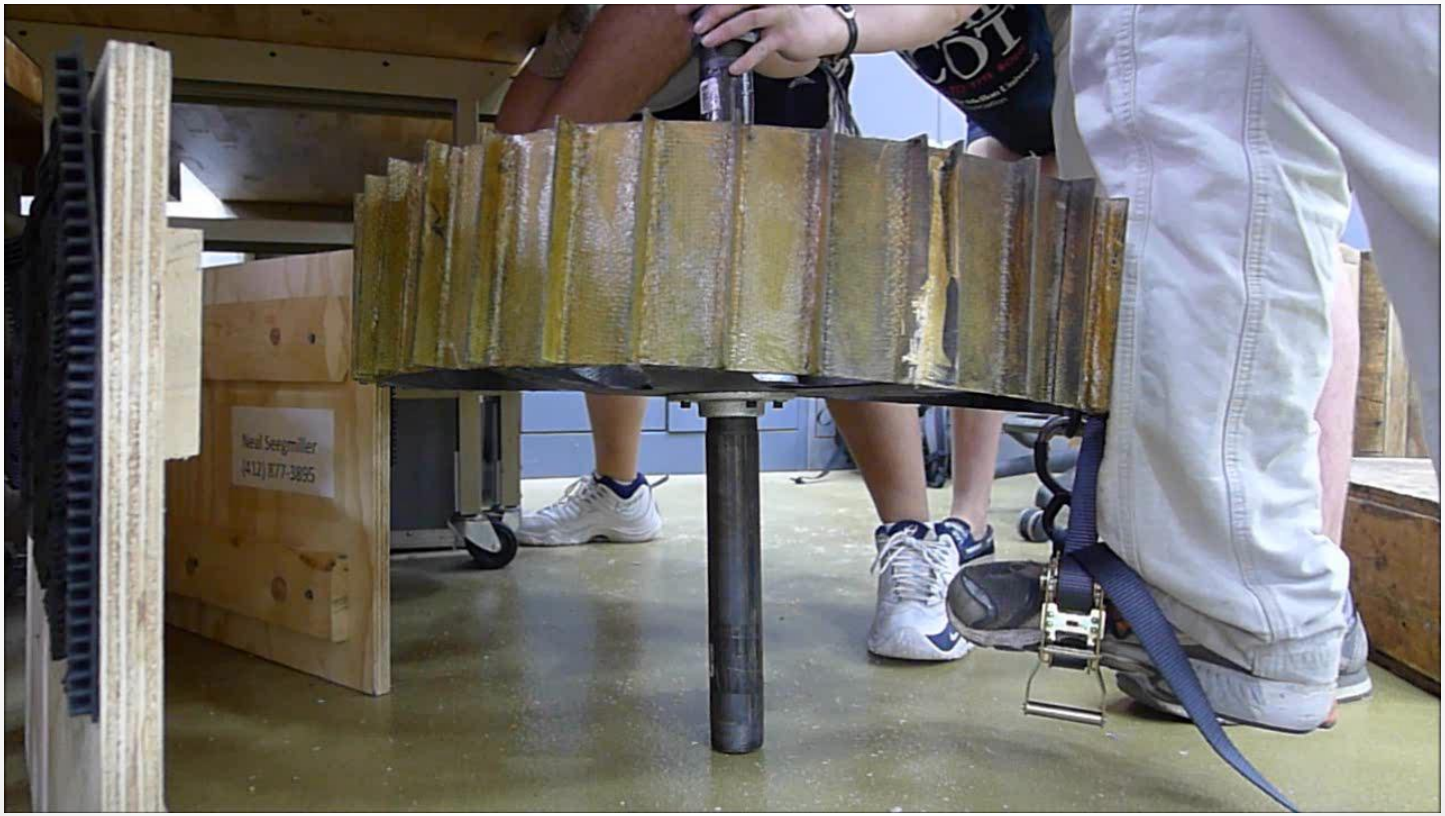
Lateral Load, Rim Pull, Spoke Load, and Point Load

Strength Test

Lateral Load

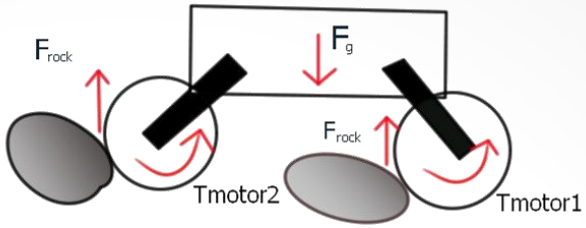
1140 N = 256 lbf

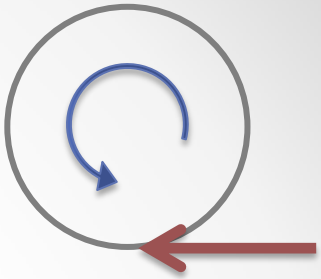




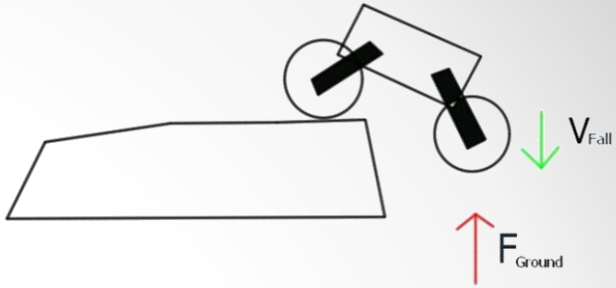
Rim Pull

735 N = 165 lbf

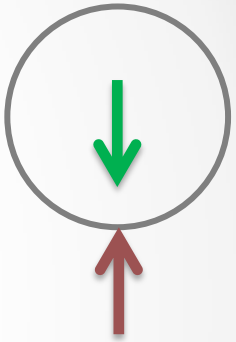




Spoke Load

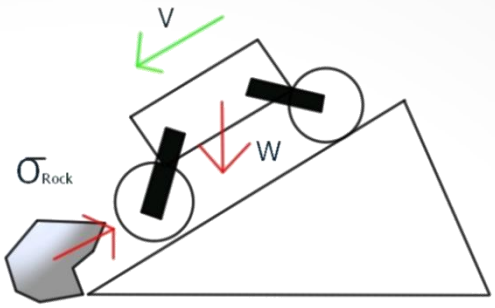


2.5*(static) = 1837 N = 413 lbf

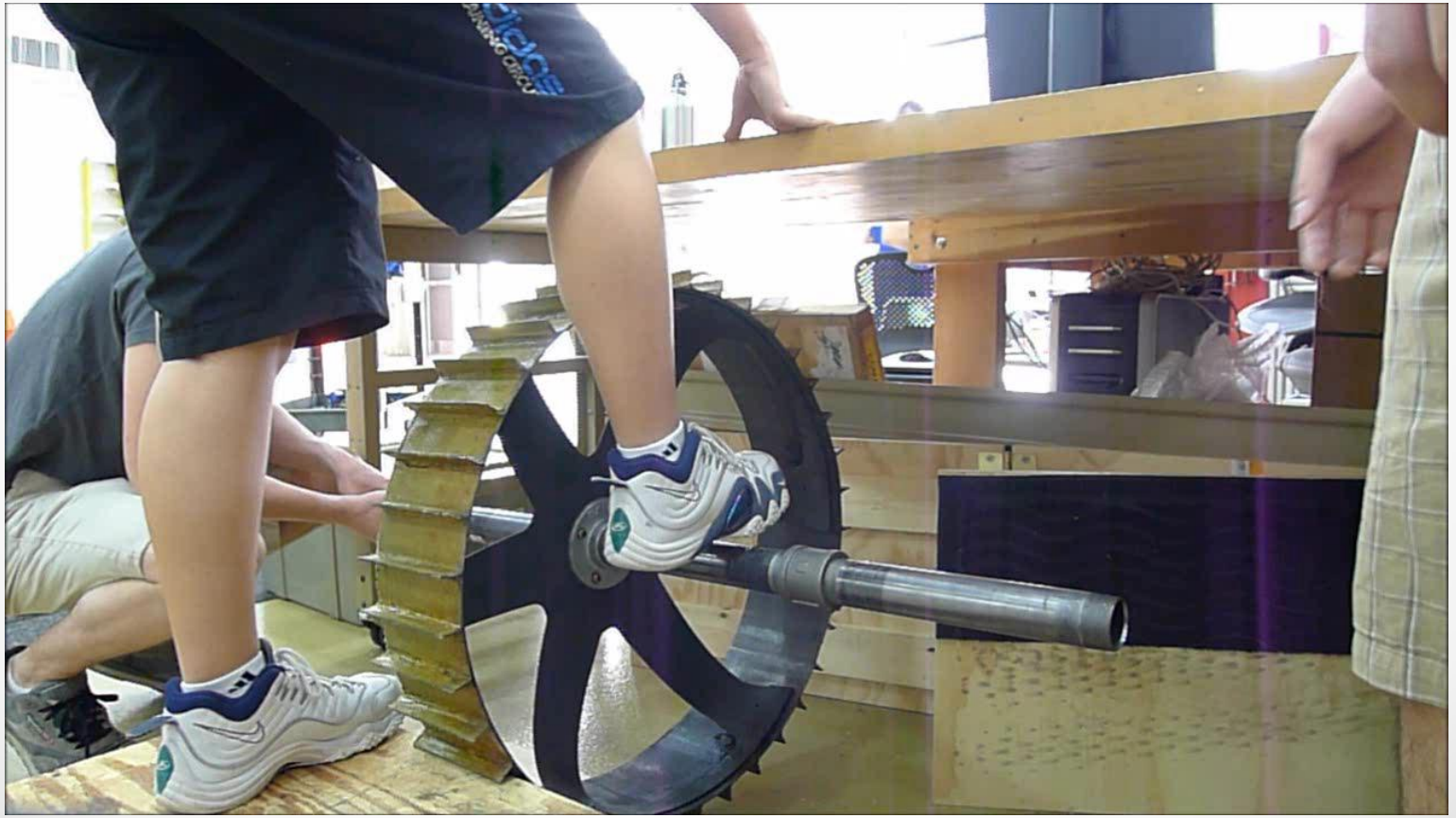


Point Load

1058 psi



Impact Area = 0.11 in^2



Conclusion

Requirements Check & Future Work

Requirements

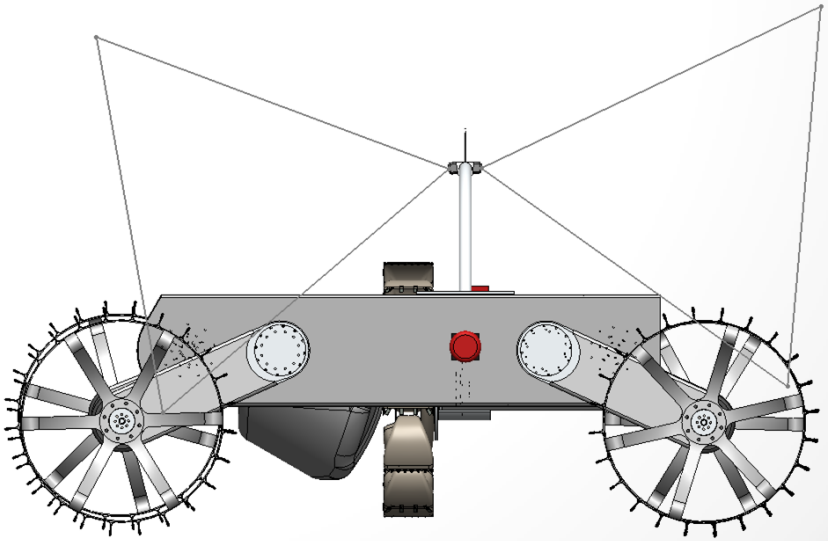
Size	Diameter = 24 inch
	Width = 6 inch
Mass	Total < 3 kg
Strength	Lateral load > 256 lbf
	Rim Pull > 165 lb*ft
	Spoke load > 412 lbf
	Point load > 1058 psi

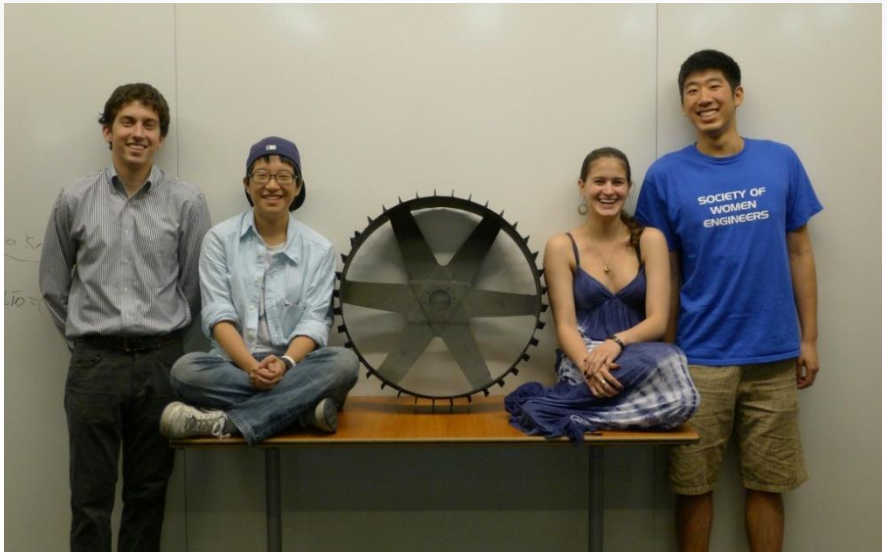
2.166 kg = 28% ↓


2166

Future Work

- Improve attachment between spoke & rim
- New mold with new foam
- Trim spokes w/o vibration
- Fabrication of 3rd & 4th wheel
- Attachment to rover
- Field testing





Q & A

• • •

Special Thanks

Wennie

John

Steve

Robert

Jessica