



# Design Solution Stage

Team Wheelders

Rice Robotics Club | University Rover Challenge

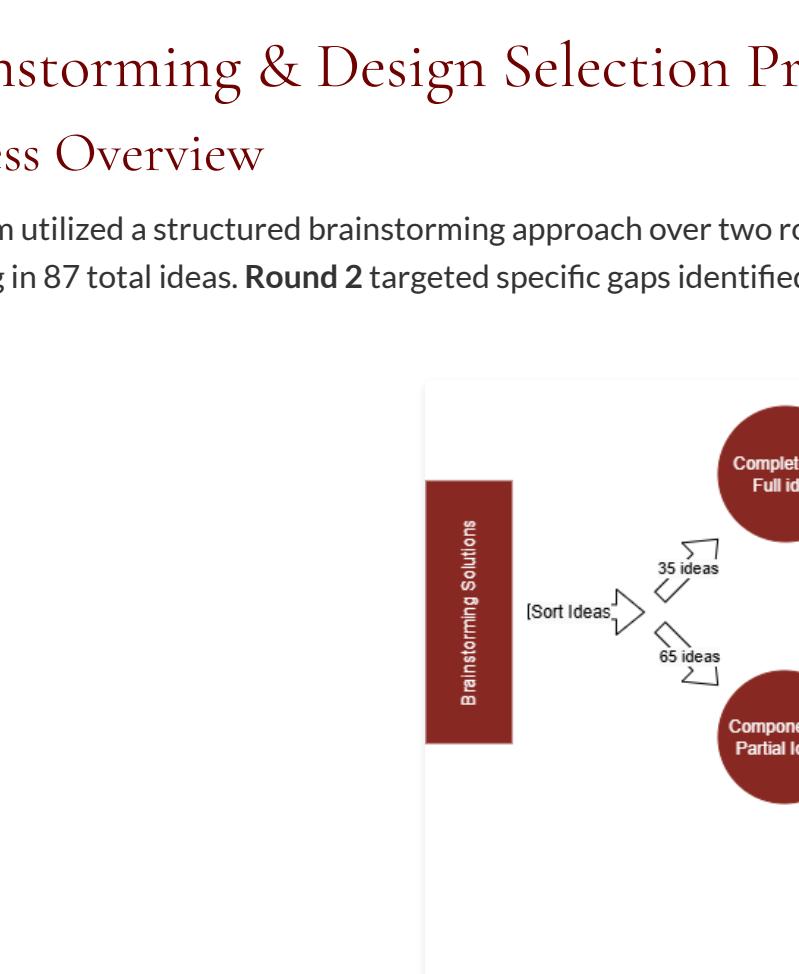


Figure 1: 2026 URC Poster

## Key Functions & Features

Our design must satisfy the following core functional blocks:

**Traction Interface:** Must grip soft sand and rock surfaces (Grousers/Tread).

**Structural Support:** Support 50kg rover load without deformation (Core/Spokes).

**Mounting Interface:** Securely attach to rocker-bogie suspension (Hub).

## Brainstorming & Design Selection Process

### Process Overview

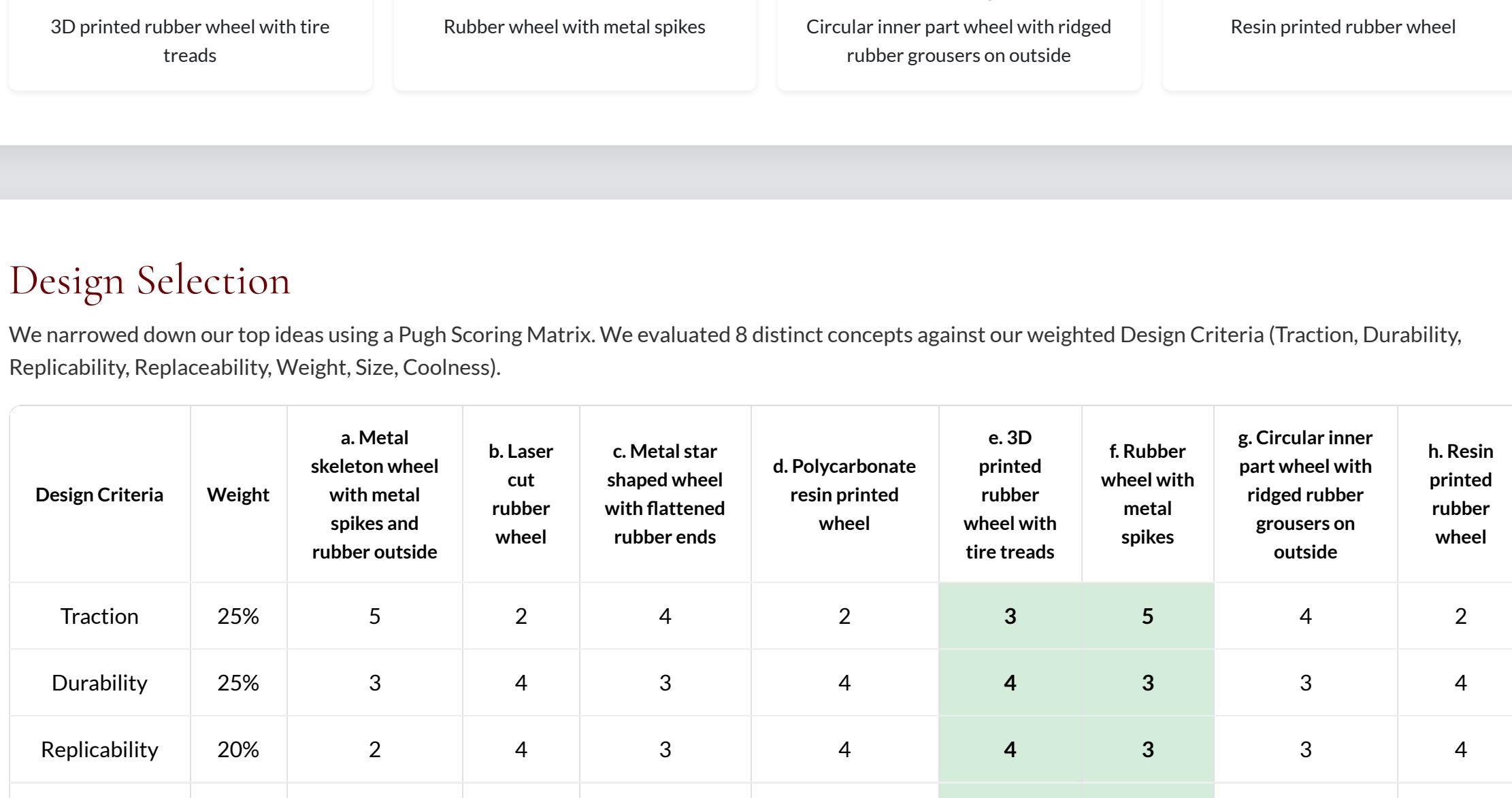
Our team utilized a structured brainstorming approach over two rounds. Round 1 focused on generating a high volume of diverse ideas using the "slip method," resulting in 87 total ideas. Round 2 targeted specific gaps identified in the first round, specifically manufacturing methods and material selection.



Figure 2: Engineering Decision Making Flowchart

### Categorized Ideas

We categorized our 80+ unique ideas into five main groups: Feature Design, Alternative Concepts, Movement Modes, Materials, and Manufacturing.



### Top 8 Design Ideas

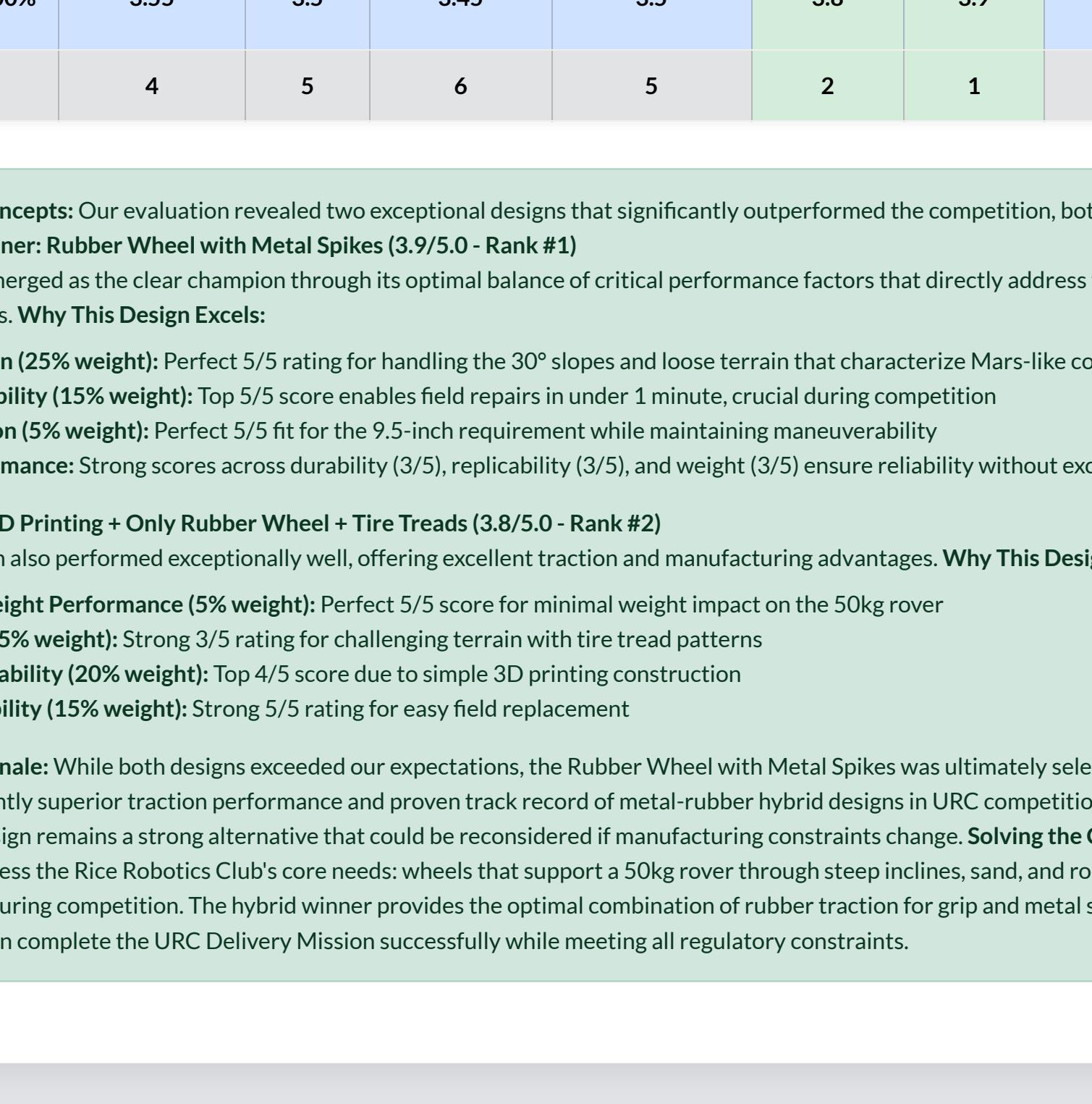


Figure 3: Top 8 Design Concepts Sketches

### Design Selection

We narrowed down our top ideas using a Pugh Scoring Matrix. We evaluated 8 distinct concepts against our weighted Design Criteria (Traction, Durability, Replicability, Replaceability, Weight, Size, Coolness).

Design Criteria	Weight	a. Metal skeleton wheel with metal spikes and rubber outside	b. Laser cut rubber wheel	c. Metal star shaped wheel with flattened rubber ends	d. Polycarbonate resin printed wheel	e. 3D printed rubber wheel with tire treads	f. Rubber wheel with metal spikes	g. Circular inner part wheel with ridged rubber grousers on outside	h. Resin printed rubber wheel
Traction	25%	5	2	4	2	3	5	4	2
Durability	25%	3	4	3	4	4	3	3	4
Replicability	20%	2	4	3	4	4	3	3	4
Replaceability	15%	4	5	3	5	5	5	5	5
Weight	5%	3	4	4	4	5	3	3	4
Size	5%	4	3	4	3	2	5	4	3
Cool	5%	4	2	5	2	3	3	3	2
Weighted Total Score	100%	3.55	3.5	3.45	3.5	3.8	3.9	3.6	3.5
Rank		4	5	6	5	2	1	3	5

**Top Two Winning Concepts:** Our evaluation revealed two exceptional designs that significantly outperformed the competition, both achieving scores above 3.8/5.0. Primary Winner: Rubber Wheel with Metal Spikes (3.9/5.0 - Rank #1)

This hybrid design emerged as the clear champion through its optimal balance of critical performance factors that directly address the URC Delivery Mission requirements. **Why This Design Excels:**

- Superior Traction (25% weight): Perfect 5/5 rating for handling the 30° slopes and loose terrain that characterize Mars-like conditions
- Quick Replaceability (15% weight): Top 5/5 score enables field repairs in under 1 minute, crucial during competition
- Size Optimization (5% weight): Perfect 5/5 fit for the 9.5-inch requirement while maintaining maneuverability
- Balanced Performance: Strong scores across durability (3/5), replicability (3/5), and weight (3/5) ensure reliability without excessive complexity

Secondary winner: 3D Printing + Only Rubber Wheel + Tire Treads (3.8/5.0 - Rank #2)

This all-rubber design also performed exceptionally well, offering excellent traction and manufacturing advantages. **Why This Design Performed Strongly:**

- Outstanding Weight Performance (5% weight): Perfect 5/5 score for minimal weight impact on the 50kg rover
- High Traction (25% weight): Strong 3/5 rating for challenging terrain with tire tread patterns
- Excellent Replicability (20% weight): Top 4/5 score due to simple 3D printing construction
- Good Replaceability (15% weight): Strong 5/5 rating for easy field replacement

**Final Selection Rationale:** While both designs exceeded our expectations, the Rubber Wheel with Metal Spikes was ultimately selected as the primary design due to its slightly superior traction performance and proven track record of metal-rubber hybrid designs in URC competitions. However, the 3D printed tire tread design remains a strong alternative that could be reconsidered if manufacturing constraints change. **Solving the Client's Problem:** Both winning designs address the Rice Robotics Club's core needs: wheels that support a 50kg rover through steep inclines, sand, and rocky terrain while being quickly replaceable during competition. The hybrid winner provides the optimal combination of rubber traction for grip and metal spikes for durability, ensuring the rover can complete the URC Delivery Mission successfully while meeting all regulatory constraints.

### Selected Design Solution

#### Initial Solutions Sketches

##### Primary Design: Rubber Wheel with Metal Spikes



Figure 4: Primary design annotated sketch

##### Secondary Design: 3D Printed Rubber Wheel with Tire Treads



Figure 5: Secondary design annotated sketch

Our initial 3D-printed TPU prototype lacked the necessary refinement, as while the material demonstrated promising traction properties, the printing process yielded unsatisfactory results. Due to our dissatisfaction with the TPU wheel's performance, we chose to concentrate exclusively on the metal-spiked wheel design. This decision was made after investing considerable time and resources into the TPU prototype, which proved to be unsuccessful. Further details regarding this prototyping process will be elaborated upon in the Prototyping Iterations page.

#### Final Refined Prototype



Figure 6: Final refined prototype