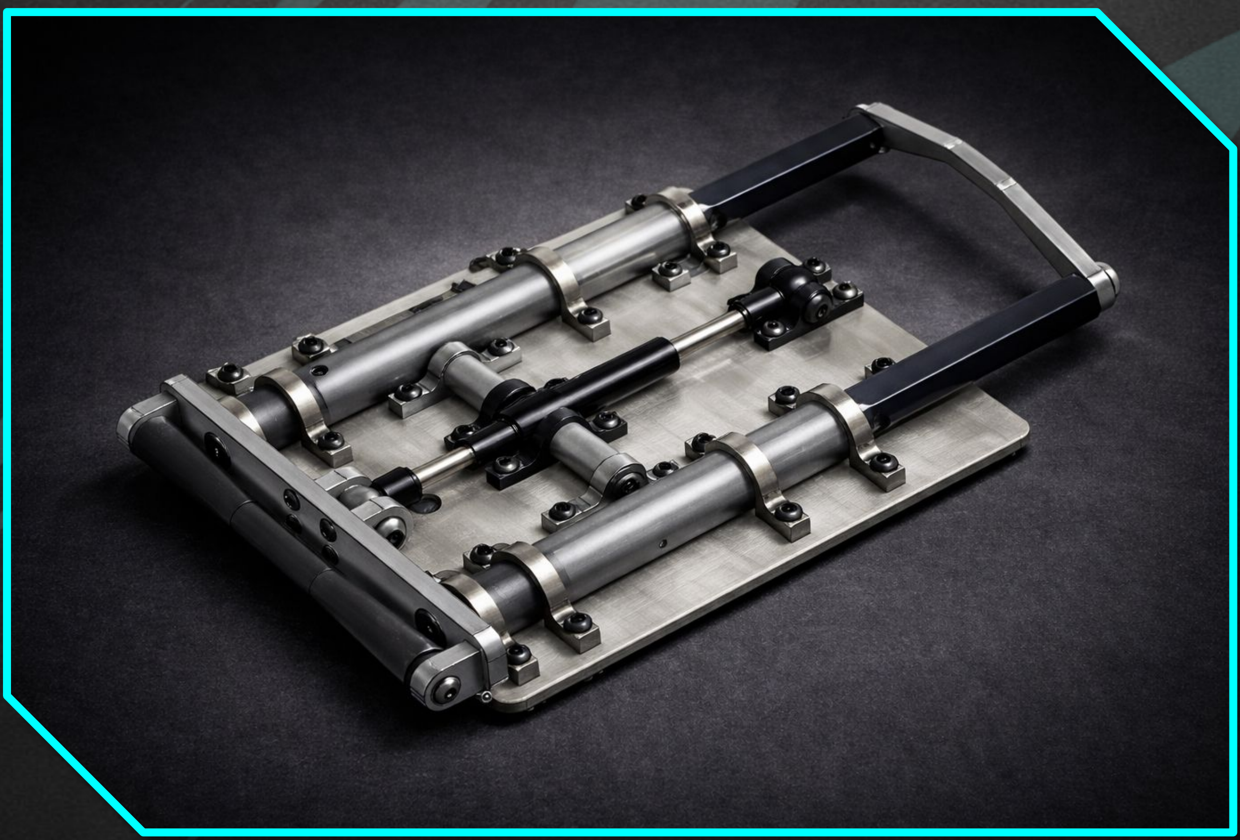
2025

Lunzer Engineering

Project: Climber Roller



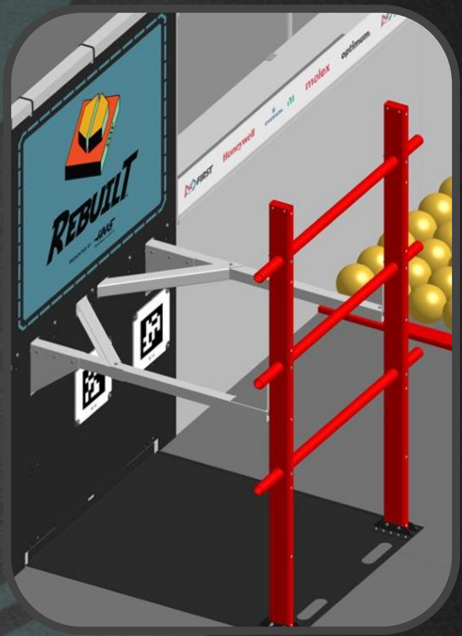
CAD +Mechanical Design
Solidworks
Bambu Labs H2D

Graham Lunzer

Project Overview

Objective

This project focused on designing a deployable roller system to control robot orientation during climbing. The goal was to prevent the robot from rotating downward and catching its bumpers on the climbing structure.

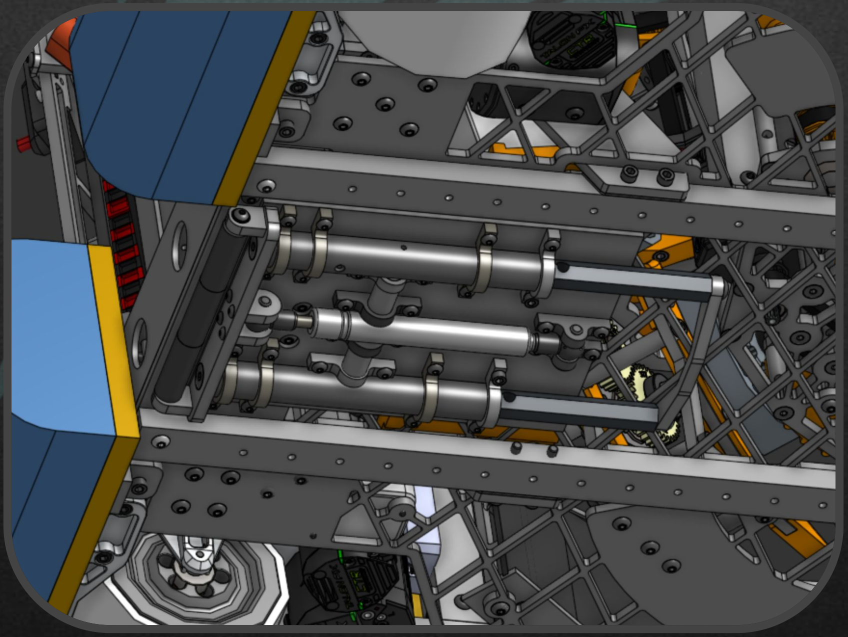


Key Features

- Deployable roller mechanism
- High-strength axle system
- Gas spring actuation
- Self-centering hourglass roller geometry

Applications

Designed for competitive robotics climbing systems where controlled engagement with horizontal bars is critical for successful traversal.



Design Problem

Background

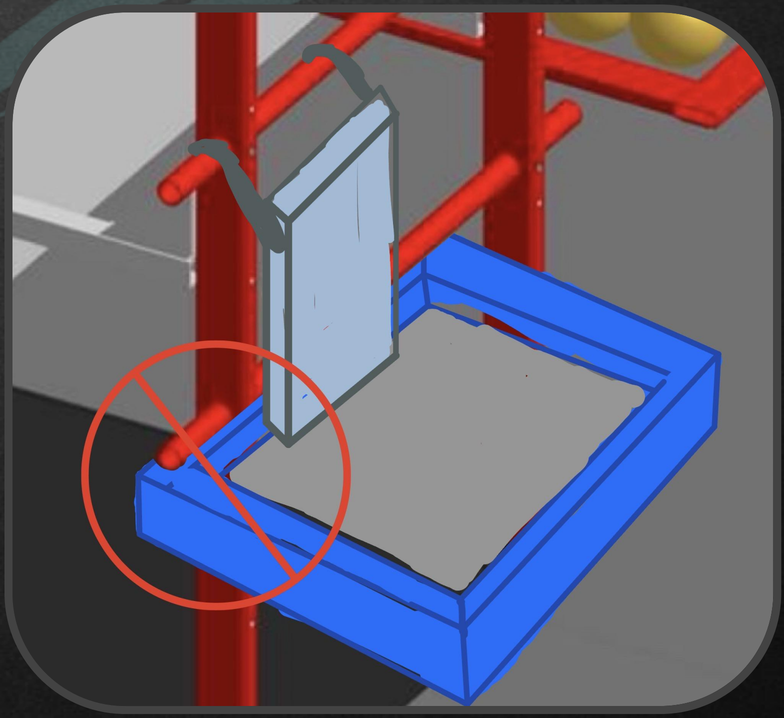
During climbing, the robot’s hooks allowed excessive rotation, causing the frame to tilt downward. This resulted in the bumpers catching on the horizontal climbing bars and preventing smooth ascent.

Constraints

- Must remain within frame perimeter until deployment
- Must withstand high dynamic climbing loads
- Limited space and weight constraints
- Must deploy reliably every attempt
- Must tolerate driver alignment error

Success Criteria

- Maintain optimal climbing angle
- Prevent bumper interference
- Reliable deployment every time
- Factor of safety > 1 on all critical components



Design Process

1 — Concept Development

Initial concept explored a fixed roller to maintain robot angle.

2 — CAD Modeling

Multiple configurations were modeled to evaluate strength, deployment, and packaging constraints.

3 — Prototyping

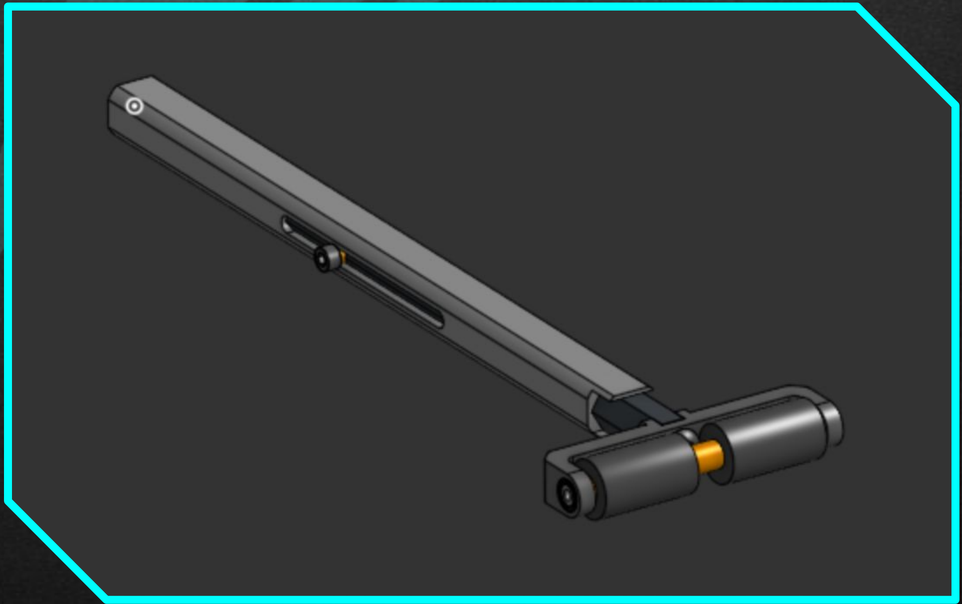
Several physical versions were built and tested under simulated climbing loads.

4 — Testing & Iteration

Failure points were identified in axle strength, deployment reliability, and structural support.

5 — Final Design

A reinforced deployable system with improved materials and actuation was developed.



Engineering Details

Specifications

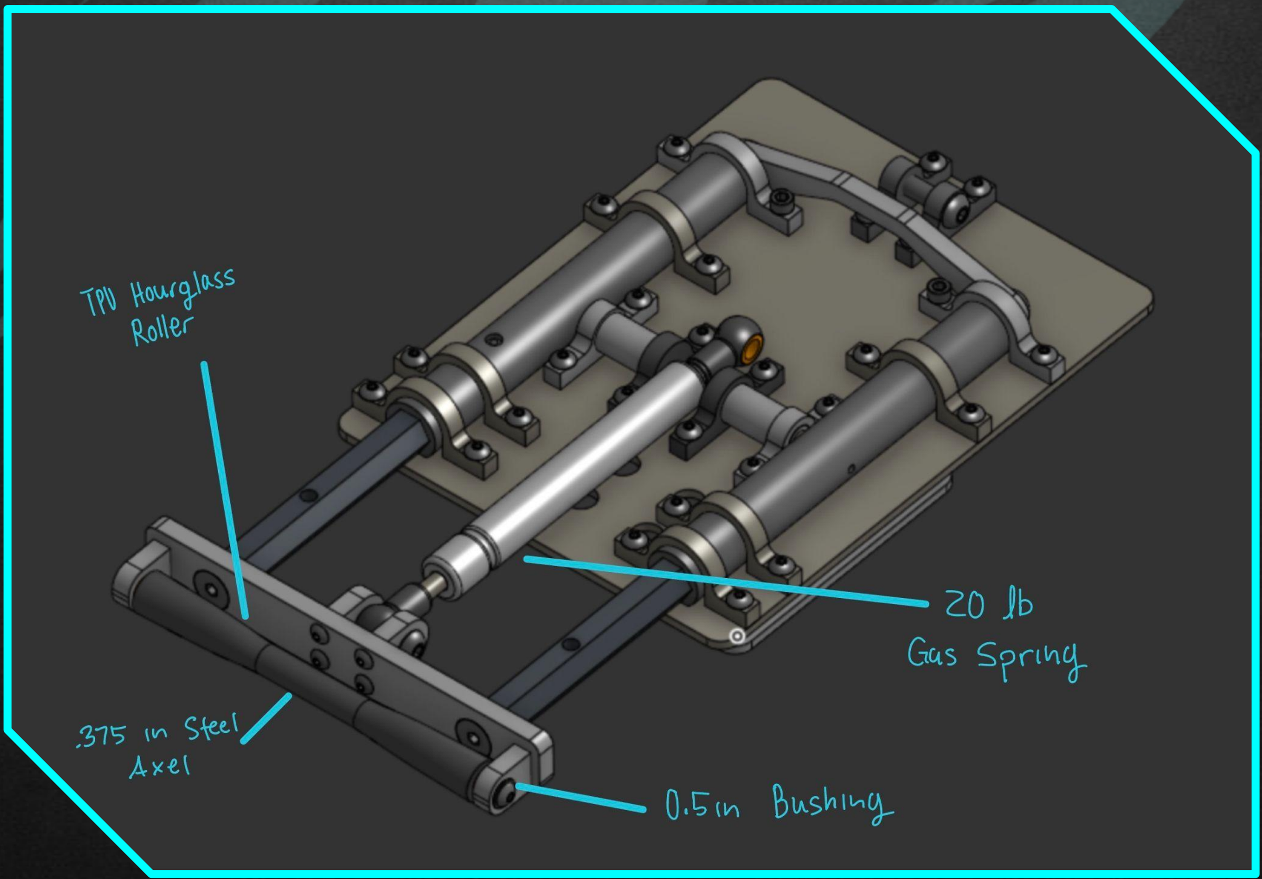
Axle:
3/8 in steel

Roller:
Aluminum body with TPU outer wheels

Bearings:
Replaced with 0.5 in steel bushing

Actuation:
20 lb gas spring

Structure:
Dual hex shafts with reinforced supports



Mechanism Overview

Step-by-Step Operation

1. Roller remains within frame perimeter before climb
2. Pin releases deployment mechanism
3. Gas spring forces roller outward
4. Roller contacts climbing bar
5. Robot angle is stabilized during ascent

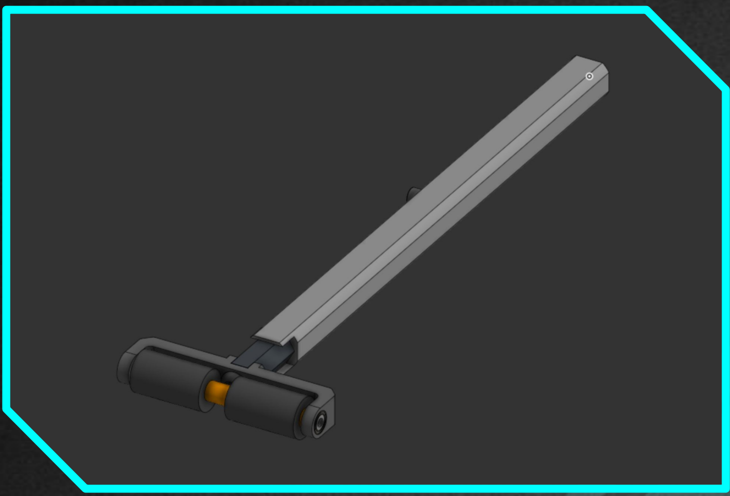
Key Mechanical Features

- Gas spring deployment system
- Dual-shaft reinforced axle design
- Hourglass roller profile for centering
- High-strength bushing interface

Motion Description

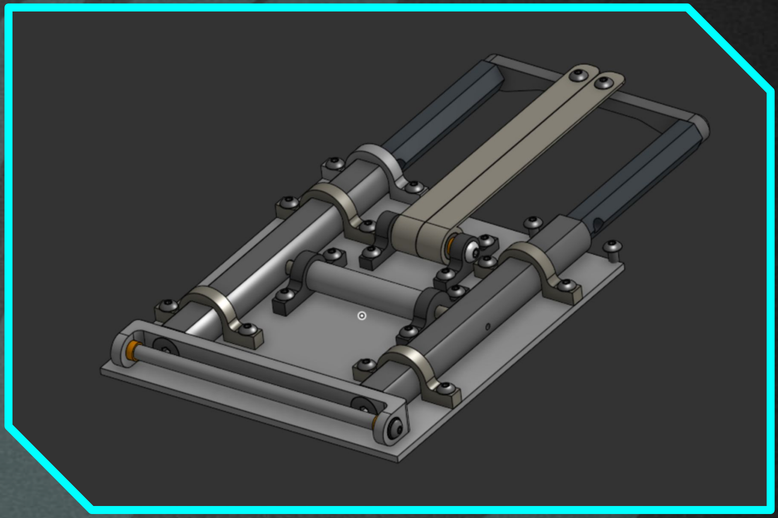
The roller deploys outward and maintains continuous contact with the climbing bar, stabilizing the robot and preventing downward rotation.

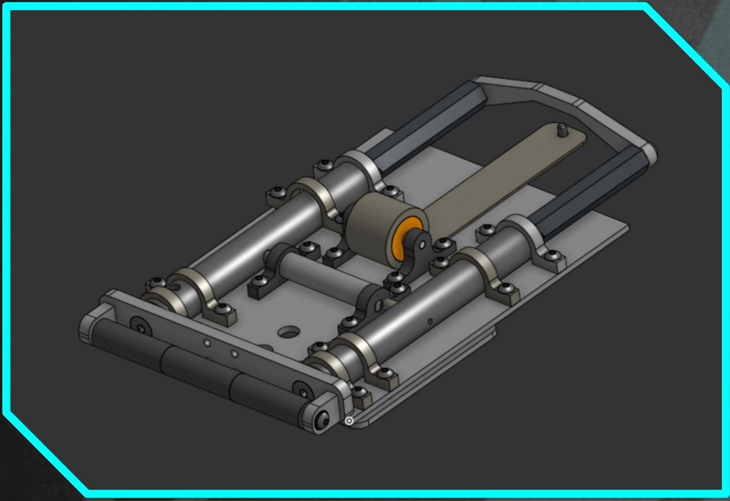
Iteration



V1

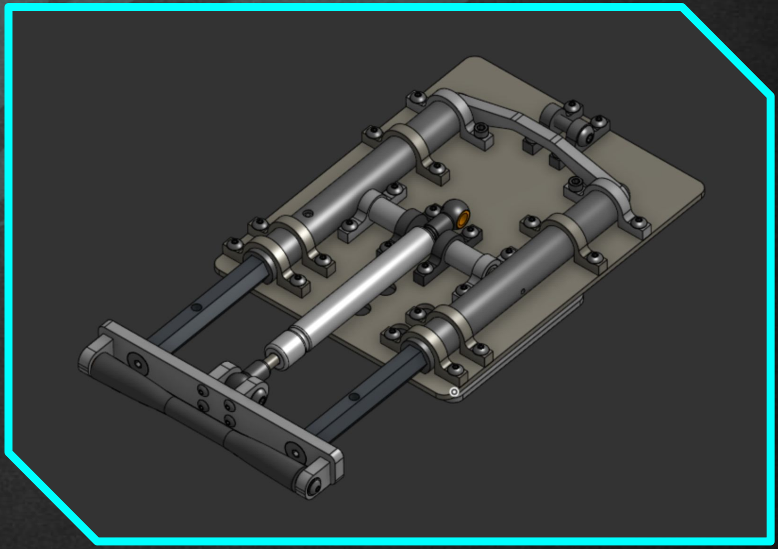
V2





V3

V4



Iteration Notes

Version 1 — Static Roller

• Fixed roller prototype
• Not legal due to frame perimeter rules

Version 2 — Single Axle + Constant Force Spring

• Insufficient axle strength
• Failed under load

Version 3 — Dual Hex Shaft System

• Improved strength and width
• Aluminum axle yielded (FOS < 1)

Version 4 — Steel Axle + Increased Support

• Still failed under load conditions
• Deployment inconsistent with 2 lb spring

Version 5 — Larger Constant Force Spring

• Improved force (7 lb)
• Created packaging and clearance issues

Final Version — Gas Spring System

• Reliable deployment every time
• Stronger materials
• FOS > 1 achieved

Project Outcome

Key Improvements

- Reliable gas spring deployment
- Increased axle strength (3/8 steel)
- Bushing replaced weak bearings
- Improved structural support
- Self-centering hourglass roller

The final design successfully maintained robot orientation and enabled smooth, consistent climbing performance.

Performance

The system deployed consistently and maintained proper robot alignment during climbing, eliminating bumper interference.

Lessons Learned

- Load distribution is critical in rotating systems
- Factor of safety must be validated early
- Deployment reliability is as important as strength

Future Improvements

- Further weight reduction
- Optimized packaging within frame
- Advanced FEA validation