# Human Powered Vehicle

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NORTHERN ARIZONA UNIVERSITY

ASME
SETTING THE STANDARD

# Overview

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# Needs and Goals

- Need statement: NAU does not have a vehicle that can compete in the American Society of Mechanical Engineers (ASME) Human-Powered Vehicle Competition (HPVC).

- Goal statement: Build a human-powered vehicle that is competitive in the HPVC.

# HPVC Overview

- The HPVC is composed of three events:
  - Design presentation
  - Speed event: broken up into men's and women's brackets, each with a single qualifying run leading to double-elimination races
  - Endurance challenge: a 2.5-hour continuous event in which racers attempt to complete as many laps as possible. There are right- and left-hand turns, a slalom, speed bumps, stop signs, hairpins, chicanes, and a package which must be picked up, carried, and dropped off without damage

# Objectives

| Objective | Measurement | Units |
|---|---|---|
| Light | Weight | Lbs |
| Quick | Acceleration | $Ft/s^2$ |
| Fast | Top speed | Mi/hr |
| Inexpensive | Cost | Dollars |
| Easy to manufacture | Manufacturing time | Man-hours |
| Safe | Strength | $Lbs/in^2$ |
| Aerodynamic | Aerodynamic drag coefficient (CdA) | $in^2$ |

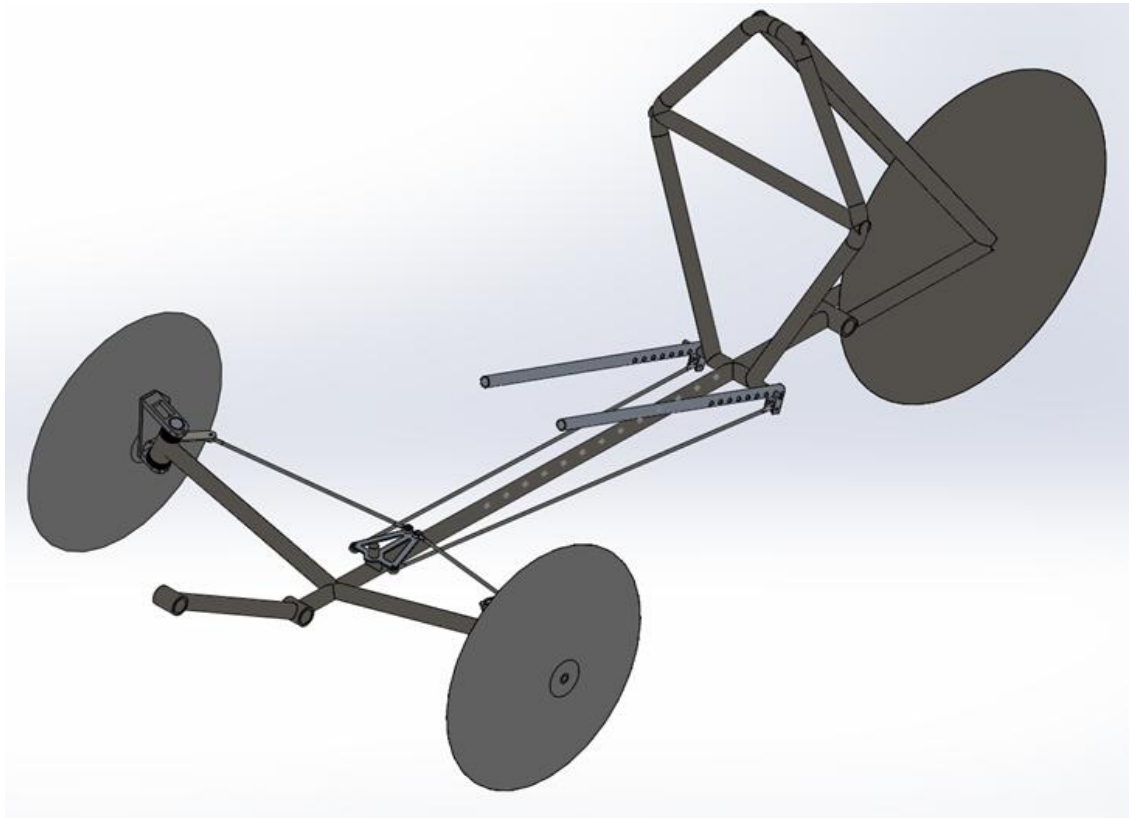
# Constraints

| Factor | Limit |
| --- | --- |
| Turning radius | Less than 8 m |
| Stopping distance from  25 km/hr | Less than 6 m |
| Roll cage top loading yield strength | Greater than 600 lbs |
| Roll cage side loading yield strength | Greater than 300 lbs |
| Front light visibility distance | Greater than 150 m |
| Taillight visibility distance | Greater than 150 m |
| | |

# Requirements

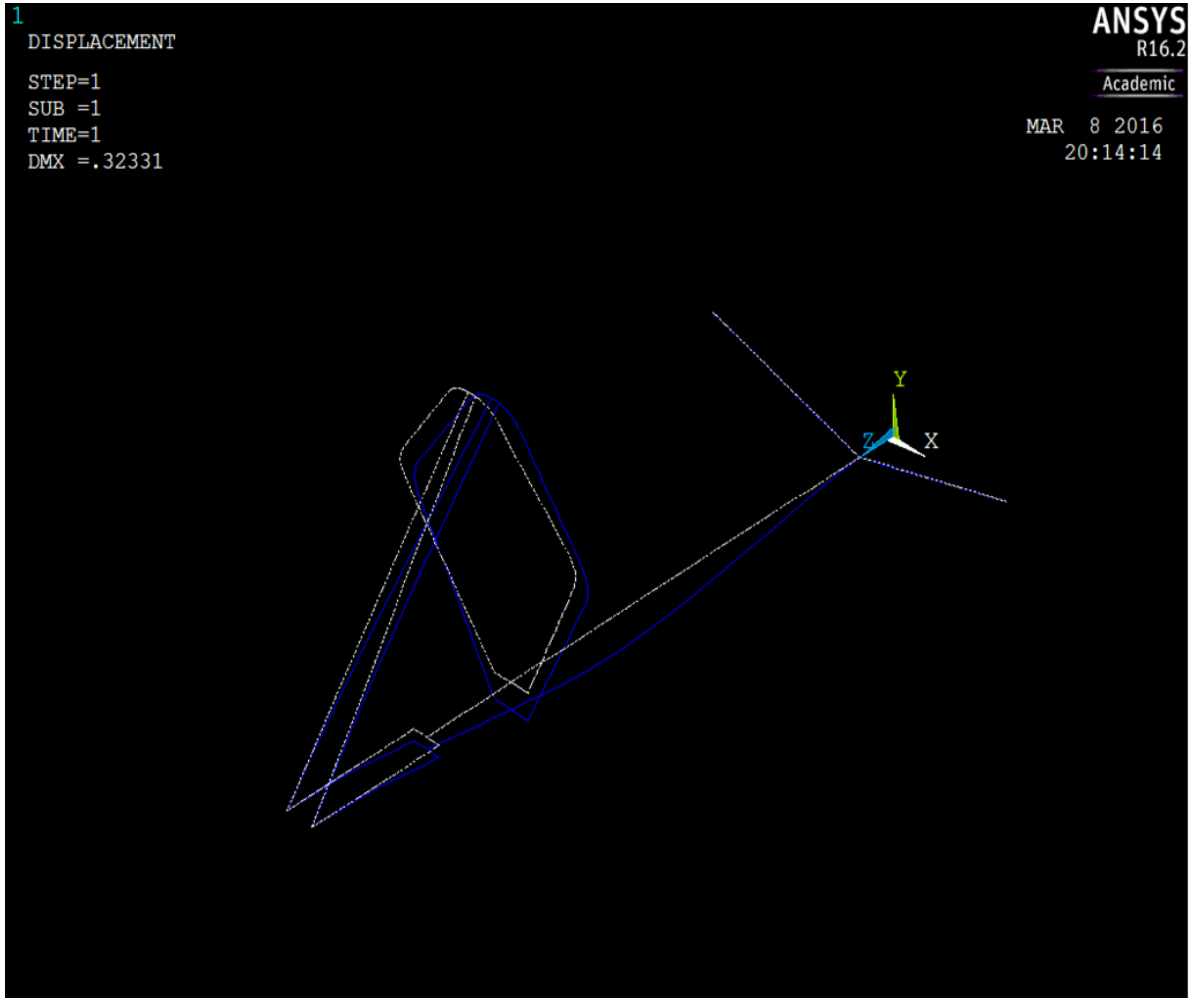
- The vehicle may not have any sharp edges on an exposed surface
- Bolts must be cut within three threads of their nut
- The vehicle must have the following:
  - Operational rearview mirrors
  - A commercially manufactured seatbelt
  - A roll bar which extends above the rider's helmeted head
  - Amber side reflectors
  - Some method of cargo carriage and containment

# Final Design



# Frame Design

- Material selection:
  - Steel chosen over aluminum due to stiffness, manufacturability, and availability
- Testing
  - ANSYS FEA simulation to simulate load testing
  - Assumed a load of 400 lb, resulting in a maximum deflection of 0.323 inches

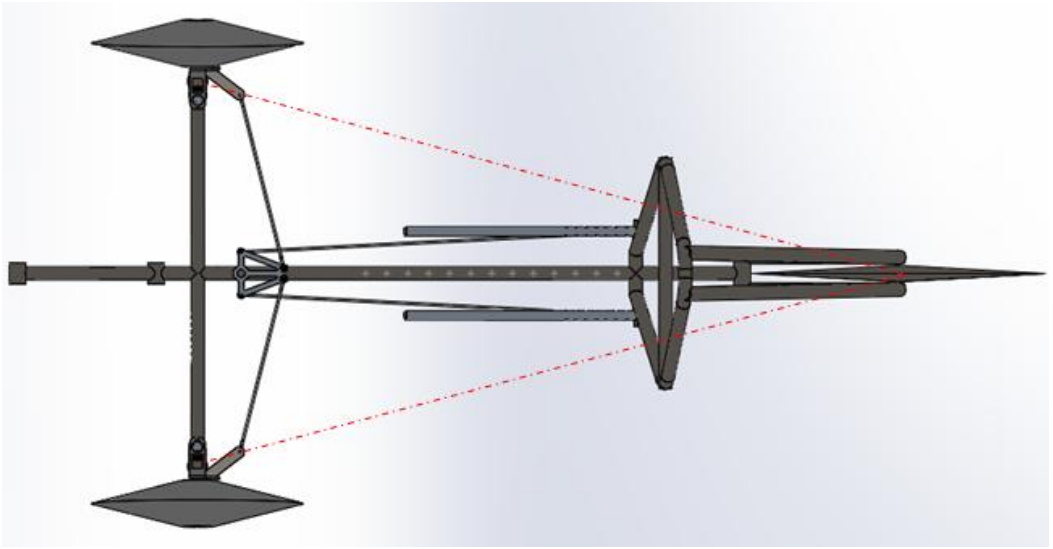


# Frame Fabrication

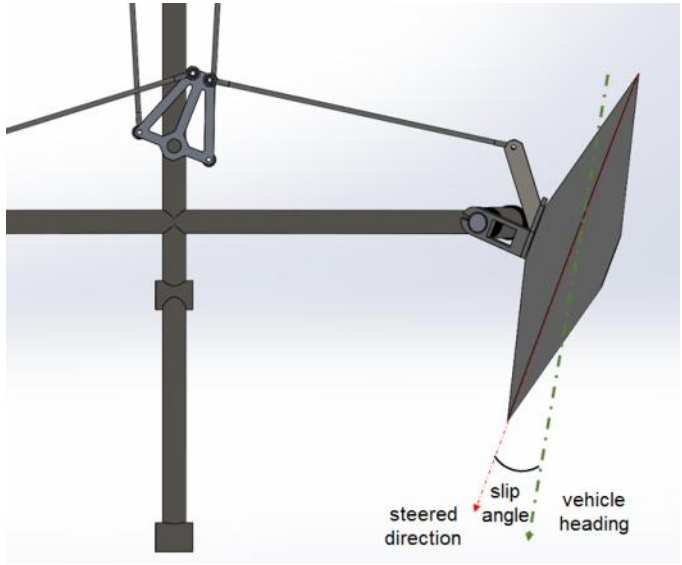
- Manufactured to tight tolerances to ensure correct geometry and proper component fit
- Constructed entirely in-house by the team

# Steering Geometry

- Steering linkages based off of Ackermann geometry
- Zero-degree slip angle is assumed
- Zero camber or toe-in for minimal friction
- 12 degrees of caster for approximately 2 inches of trail



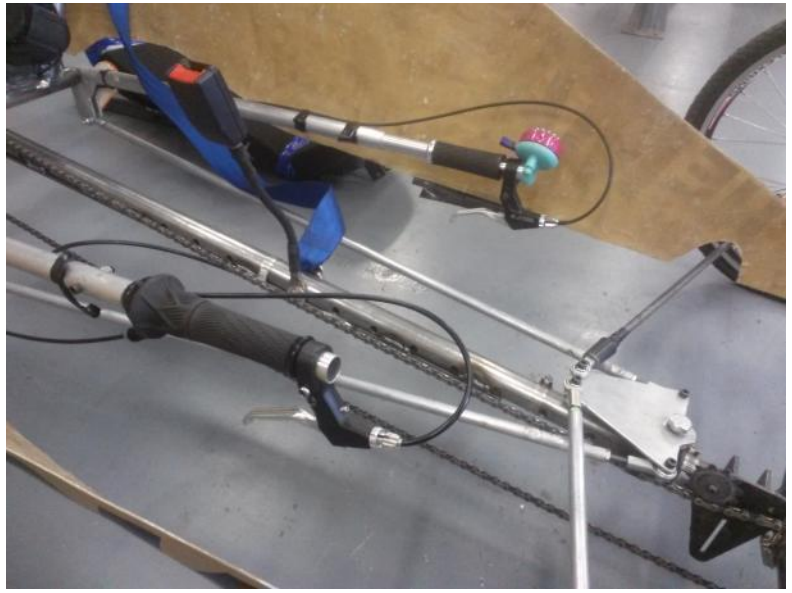
Ackermann approximation




Slip angle

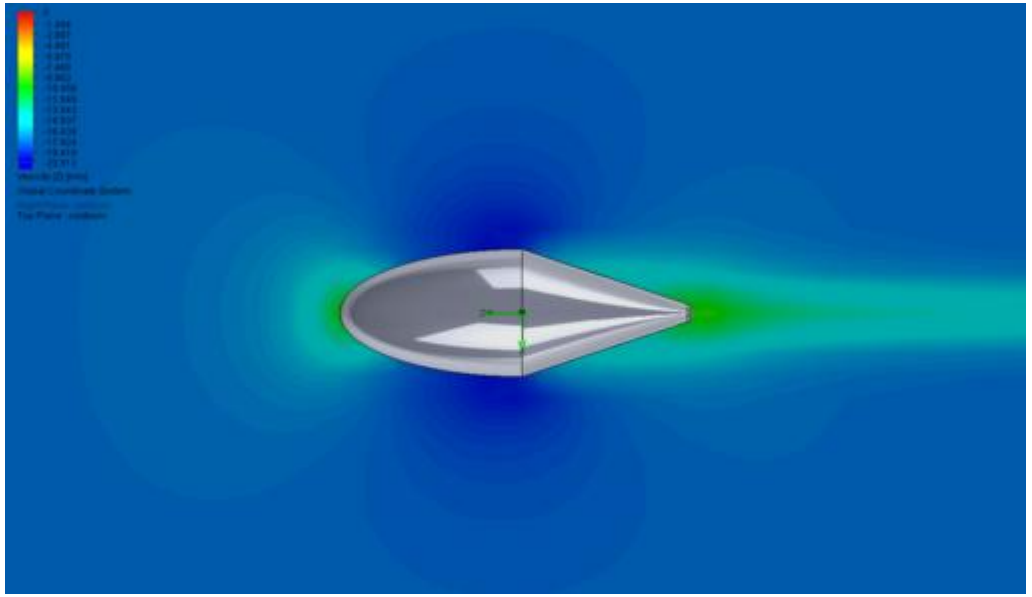
# Steering and Braking

- Steering input received through handles placed at the rider's sides
- Handles house all vehicle controls
- Front brakes are mechanical discs
- Rear is a dual-pivot caliper rim brake




Brake splitter

# Fairing



Original fairing design

Foam shaping

Smoothed foam shape

# Fairing continued

Foam coated
in body filler

Sanding the filler

Fiberglass laid over mold

# Fairing continued


Final fiberglass panels

# Additional Features

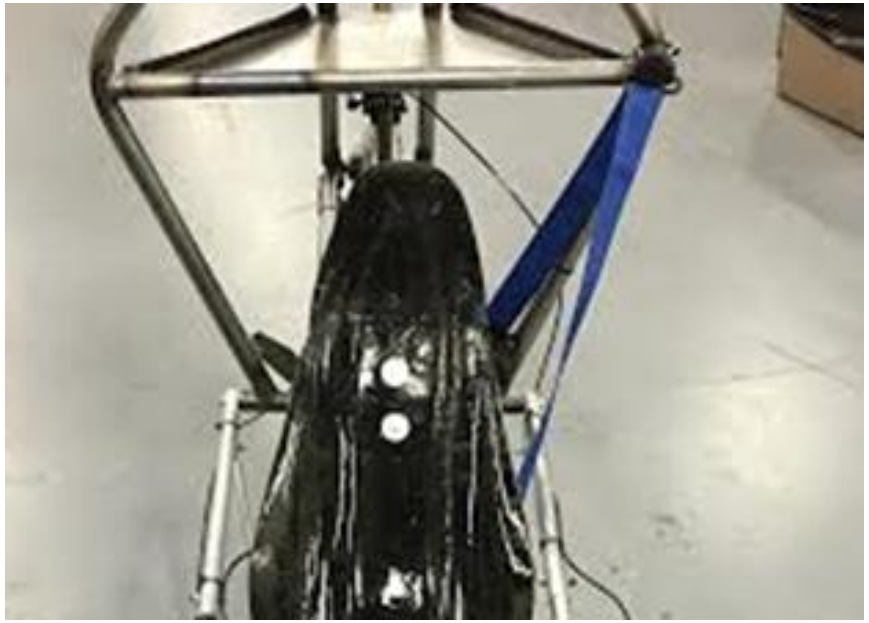
Cargo area

Front and rear lights

# Additional Features continued

Rearview mirrors

Side reflectors



Seatbelt

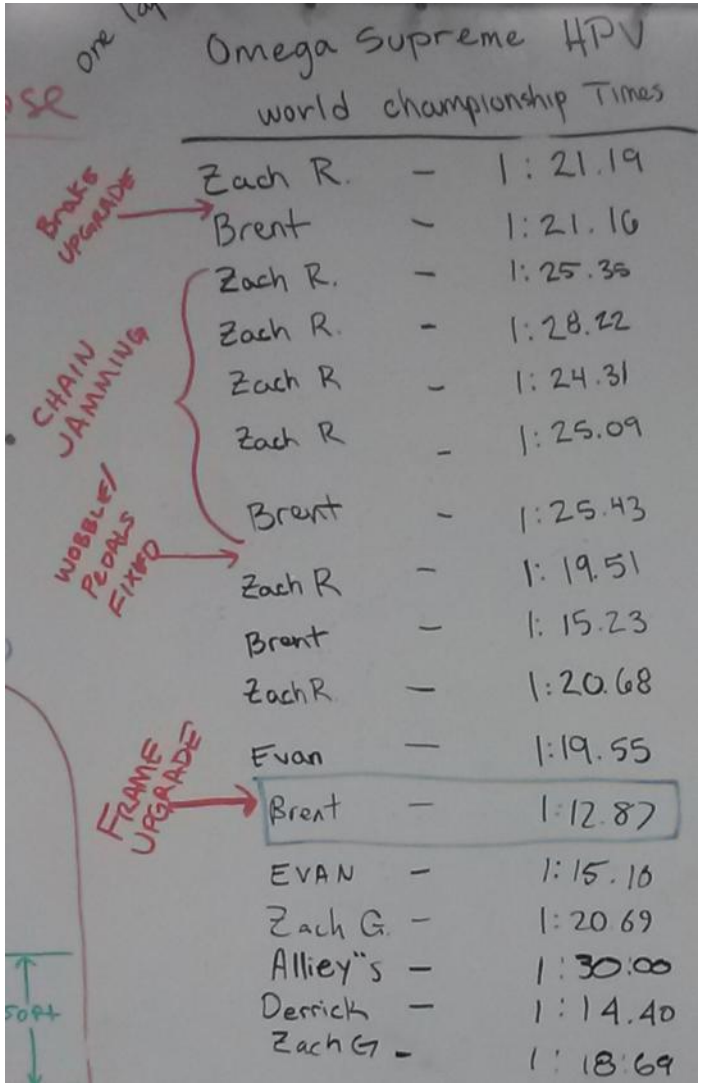
# Feature Testing

- Welds
- Chain routing
- Chain tension
- Idler pulleys
- Tie rods

# Performance Testing

- 100 foot drag race “from a dig”
- 50 foot speed trap
- ¼ mile lap

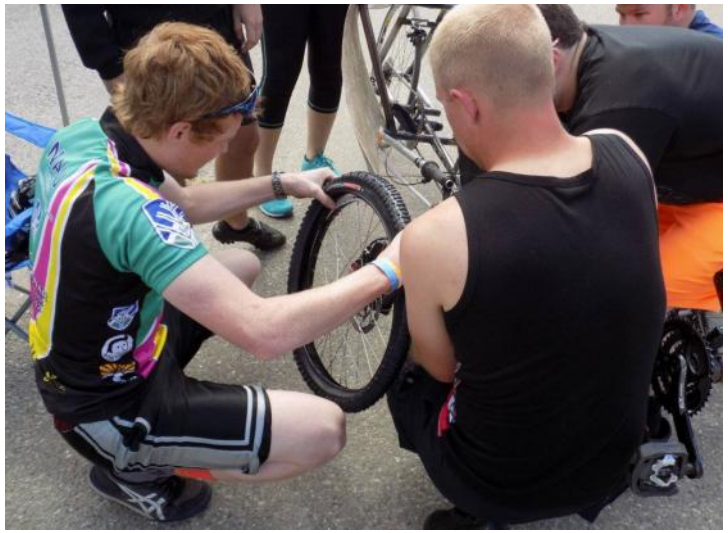
- Times logged in public space to encourage competition, maximum stress on vehicle
- Vehicle modifications tracked alongside times to demonstrate performance improvements

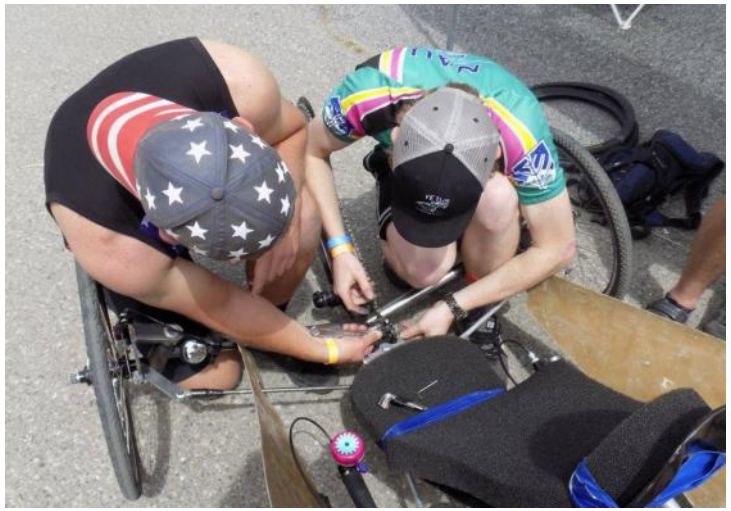



Performance log

# Issues Encountered During Competition

- Chain dropped during the men’s qualifying round in the sprint event
- Front end misalignment caused a tire failure in the endurance challenge and the spares did not fit the wheels
- Idler pulley nut self-loosened during the endurance challenge causing a loss of chain management





# Competition Results

| Category | Ranking (out of 32) |
|---|---|
| Design presentation | 21 |
| Innovation | 19 |
| Women’s speed event | 13 |
| Men’s speed event | 20 |
| Endurance challenge | 20 |
| *Overall* | *21* |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# Conclusions

- The team created a competitive vehicle that meets all requirements and constraints and which represented NAU at the 2016 ASME HPVC
- The frame of the vehicle is made of steel and is both strong and stiff enough to hold and protect any occupant
- Steering geometry is designed for stability and efficiency
- After extensive shaping and layup, the fairing was pared down to small side panels due to shipping damage
- Despite pre-competition testing, the vehicle still encountered issues at the HPVC which inhibited it from performing as hoped

# Acknowledgements


- Northern Arizona University chapter of ASME
- Perry Wood - faculty advisor
- W.L. Gore
- SolidWorks
- M.C. Gill Corporation



THE GILL CORPORATION

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# Questions