

### Abstract

The 2021 – 2022 Trine University Shell Eco-Marathon Prototype Gas team’s goal was to build a gas-powered fuel-efficient vehicle to compete in the national competition held in Indianapolis, IN in April of 2022. The team had a goal to achieve 600 MPG while passing the competition’s technical inspection. To accomplish this, the team made a completely new shell body designed for compatibility and rigidity. Additionally, the engine was tuned to be more fuel efficient, and the electrical system was organized and updated.

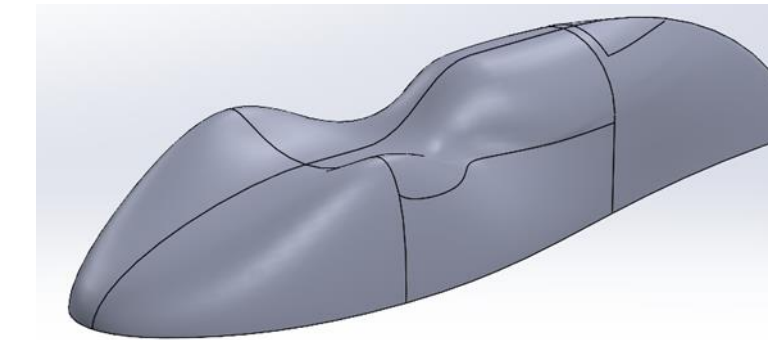
### Customer Needs and Requirements

- Complete a valid scoring run at the Shell Eco-Marathon Competition to reflect Trine University’s engineering prestige.
- Meet all technical requirements as defined by Shell
- Achieve 600 MPG
- Place in the top 15 vehicles in the gasoline prototype class
- The vehicle weight needs to not exceed 15% of the 2020-2021 vehicle weight of 95 lbs.

### Concept Selection

#### Final Body Design:

- Material: 2 oz fiberglass with Soric honeycomb, fabric, and foam reinforcement
- Fixed design from last year's model to properly fit the frame
- Hatch locations selected



Final Shell Design

#### Engine Tuning and Clutch Rebuild:

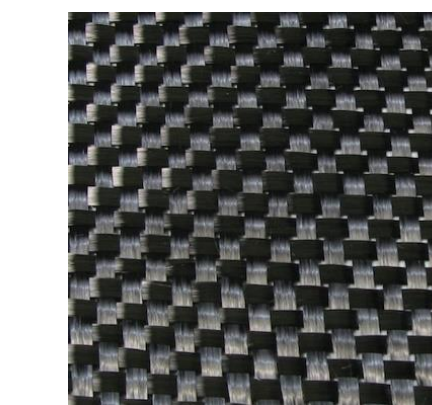
- Engine tuning to increase fuel efficiency
- Clutch rebuilt for faster engagement



Engine Modifications

#### Firewall / Seat

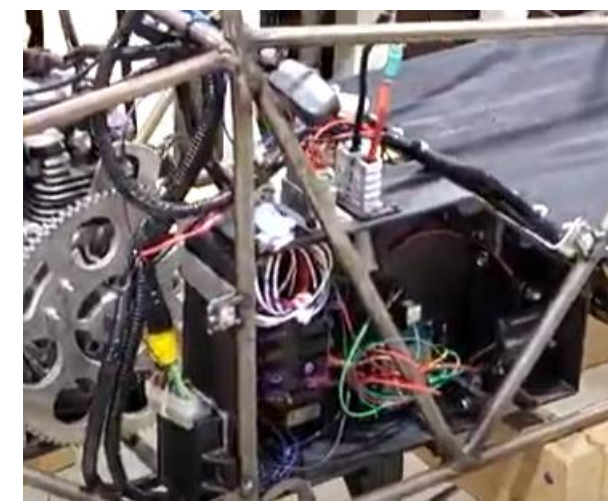
- Carbon fiber, foam reinforcement, and gold foil backed
- Improved rigidity
- The firewall was designed to be the seat back of the car as well



Carbon Fiber

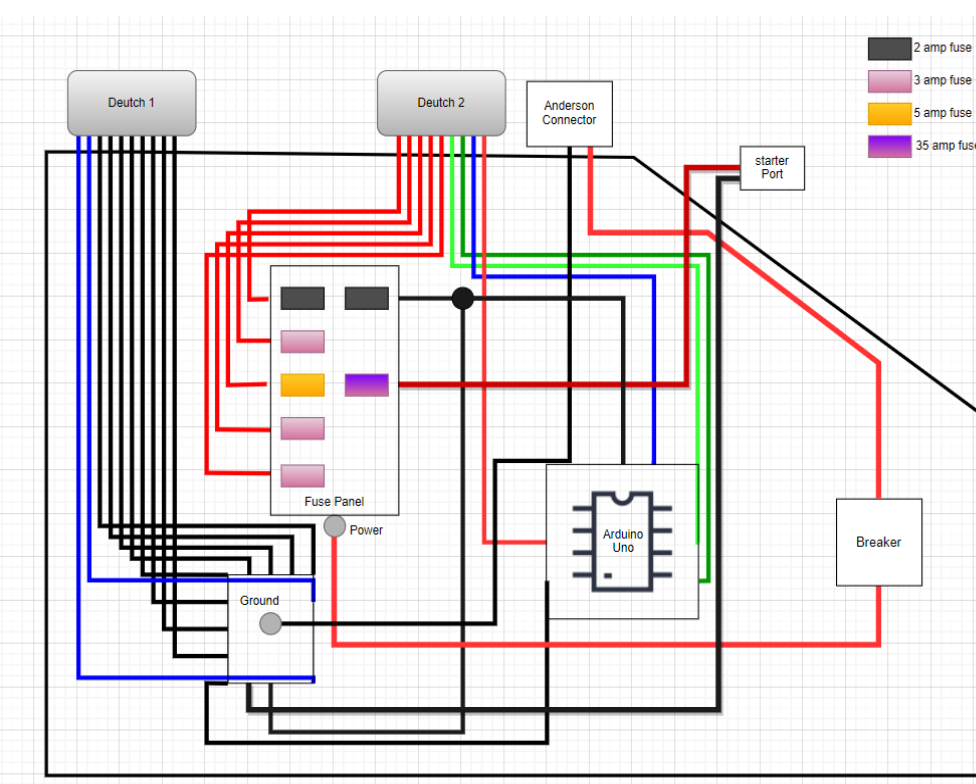
#### Electrical

- Removable electric box design
- Clean layout for easy maintenance
- Location selected behind firewall for safety

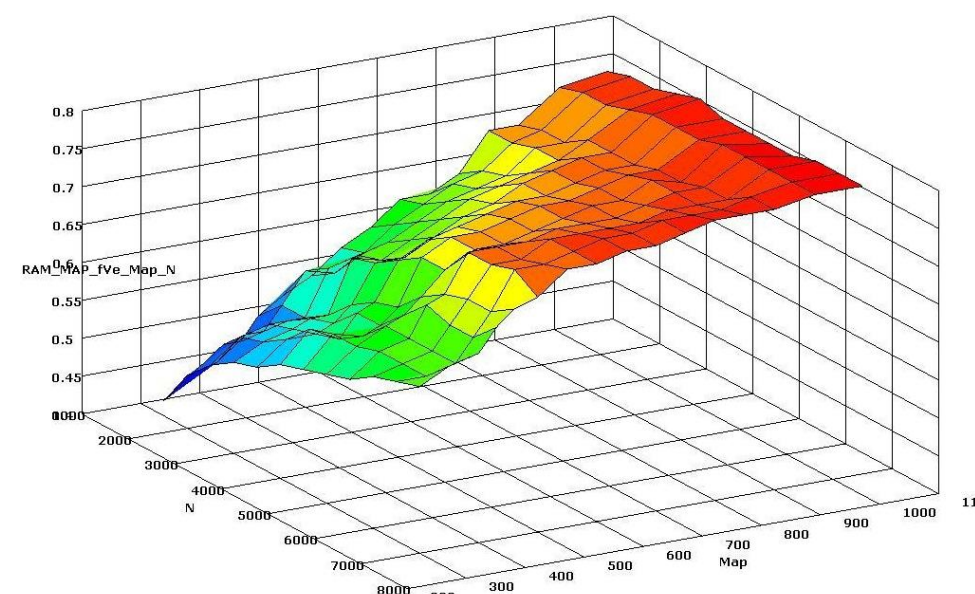


Box Under Seat

### Design Solution



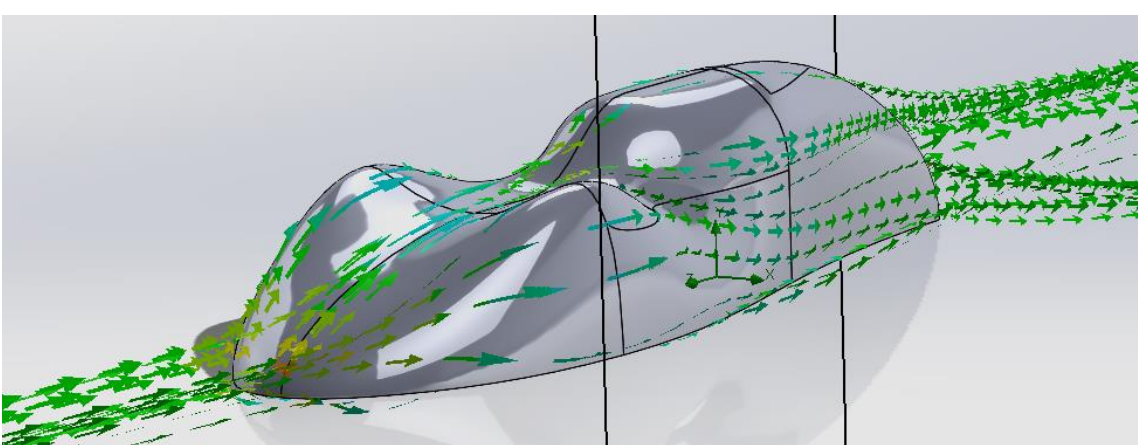
Electrical Box Wiring Diagram



Engine Tuning



Finished and Installed Firewall



Shell with CFD lines

### Manufacturing

#### Electrical



- 3D printed protective casing
- Reorganized, protected, and properly routed the wiring
- Added required safety components

#### Shell

- Foam extensions were glued onto the sides of the existing plug
- Plug was coated and sanded smooth with many layers of Bondo



Foam Plug



Mold

- 6 oz and 4 oz fiberglass fabric were draped and wetted with epoxy which hardened and created the mold
- 2 oz fiberglass and Soric honeycomb fabric were sealed in a vacuum bag
- Vacuum applied to pump in epoxy resin
- Final shell surface finish and paint



Body

#### Engine: Clutch Rebuild



Clutch Friction Plates

- New friction plates installed
- New bearings installed
- Engagement RPM adjusted to ~2700 RPM

#### Firewall / Seat



Vacuum Bagged Firewall

- Carbon fiber and foam assembled by wet-layup process
- A vacuum was applied after the wet layup
- Gold tape backing applied



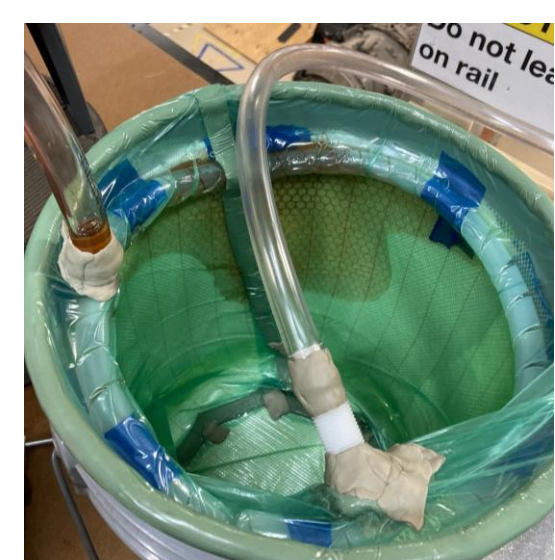
The completed '21-'22 Trine Shell Ecomarathon ICE Prototype

### Testing and Validation

#### Preliminary

##### Test 1: Vacuum Infusion Tests

- Shell process tested multiple times on challenging shaped buckets
- Final procedure altered based on these results

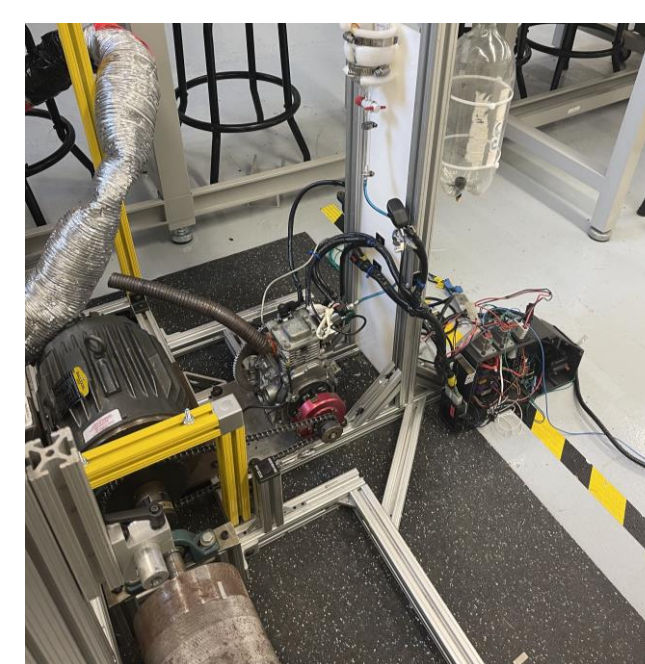


Resin infused bucket

#### Intermediate

##### Test 2: Engine Tuning

- Engine fuel and timing tables were calibrated to maximize fuel efficiency
- Torque vs RPM plots were created to find the operating range of the engine



Dyno setup

##### Test 3: Brake Test

- The car was placed on a 20% incline ramp with the driver inside
- Both rear and front brakes required to be held separately



Brake Test

#### Final

##### Test 4:

##### Pre-Competition Test Runs

- Testing all components for functionality and addressing issues
- Completed 2-hour driver experience training



First Test Run

#### Validation Competition

- Passed technical inspection
- Completed a practice lap
- Did not complete a full run due to a failed sensor
- Car weighed in at 122 lbs.
- Final test run 190 MPG



Car on the Competition Test Track

### Acknowledgments

We would like to thank our generous donors who helped fund our project and attend competition: Failure Analysis Solutions, Mr. and Mrs. McNeal, The Haug and Haskin Family, and Steven Moore. We would also like to thank Dr. Teichert, Mr. Joe Thompson II, and the entire ME Department for their continued support.

