SAE Shell Eco-marathon

Final Presentation

May 2, 2013

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Overview

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Project Background

The demand for energy continues to increase as the world population increases. Fuel and energy sources in transportation need to be optimized to meet energy demand.

Shell sponsors a competition to encourage young engineers to find innovative solutions to maximize fuel efficiency by designing and constructing a small vehicle.

Competition Information

- Location in Houston, TX
- Capstone project representing SAE NAU

Goal and Client

Goal

- Design, build, and compete with a car prototype that maximizes fuel efficiency. The car needs to follow all rules and regulations provided by Shell.

Client and Technical Advisor

- Dr. Tester and NAU SAE student chapter

Problem Formulation

Objective	Measurement Basis	Unit
Fuel Efficiency	Volume Consumed	Ounces
Lightweight	Vehicle Weight	Pounds
Aerodynamic	Drag Force	Pound Force
Rigid Chassis	Deflection Under Load	Inches

Constraints defined in Ch.1 and Ch.2 in Shell Eco-marathon rulebook

Proposed Design

6061-T6 Aluminum frame with fiberglass fairing

- Frame reinforced with Nomex honeycomb core carbon fiber panels.
- Fairing intended to mimic a teardrop shape to minimize drag and maximize fuel efficiency

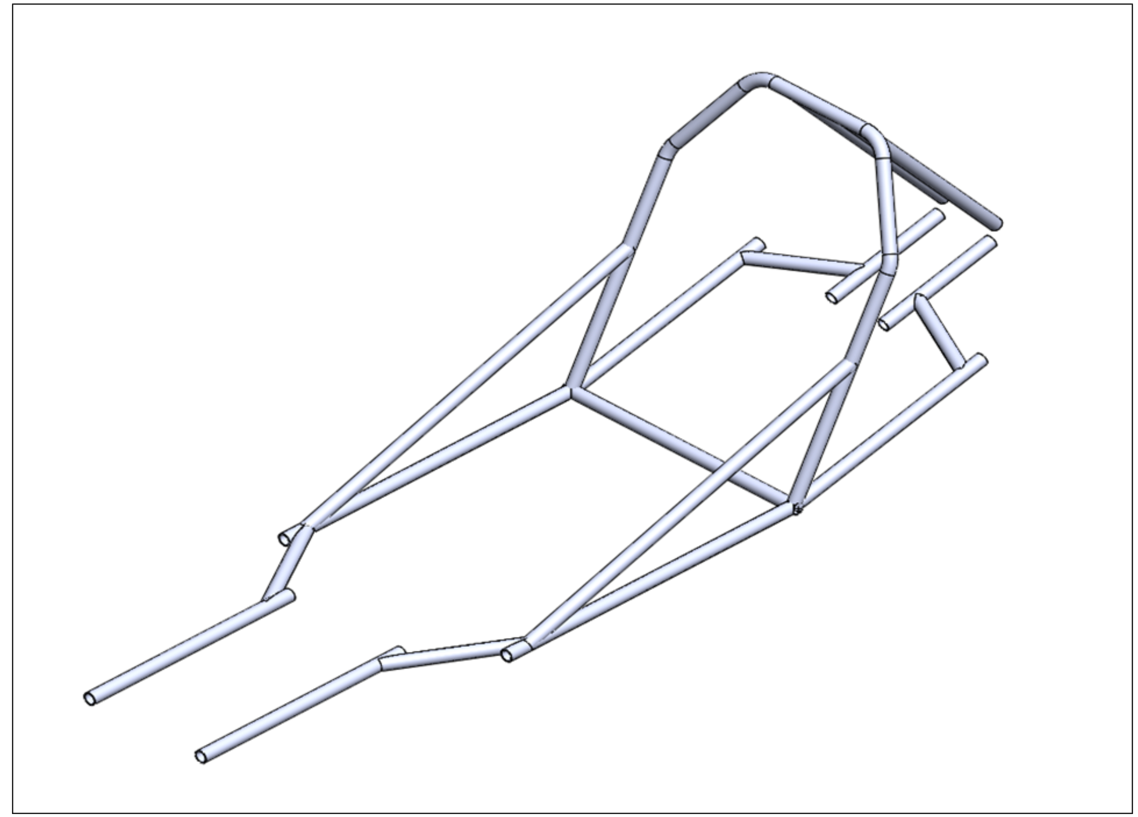

Figure 1: Proposed Frame Design

Proposed Design

Honda GY6-QMB 50cc engine

- Highly efficient motor with electric start
- Adapted to use EcoTrons fuel injection system

Chain drive with dual stage reduction

- Centrifugal clutch attached to motor output shaft
- Chain drive used because of low projected parasitic loss
- Dual stage reduction for 20:1 ratio while minimizing rotating mass

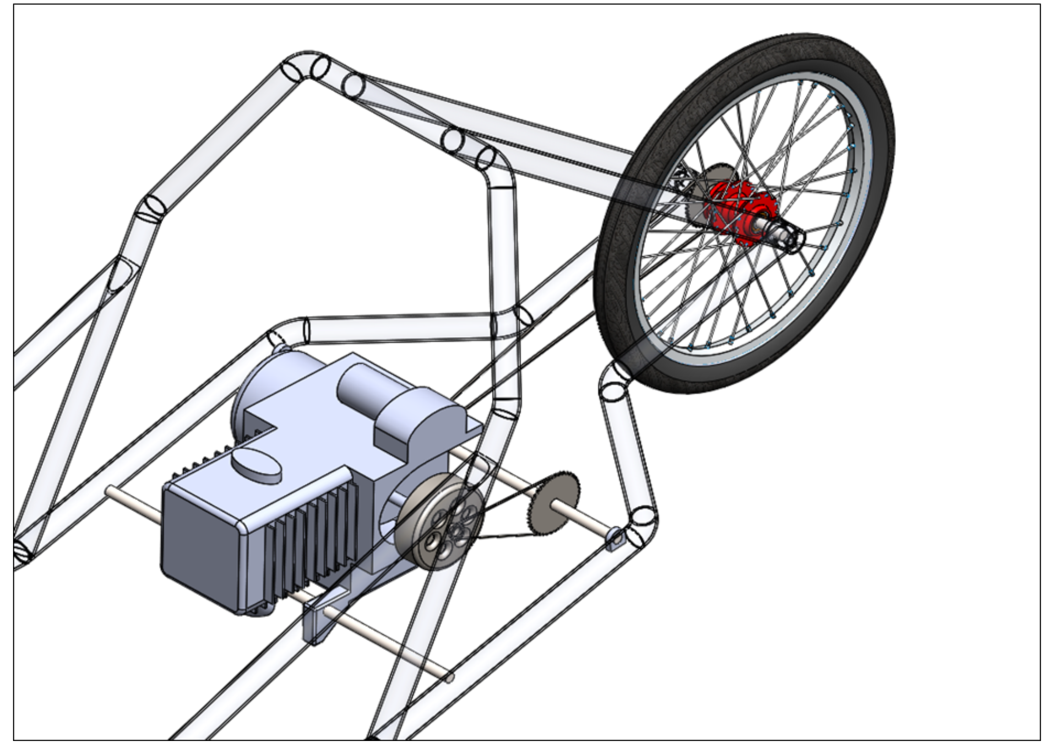

Figure 2: Proposed Drivetrain Design

Proposed Design

- Steering system utilizes a pitman arm and quick steering ratio
- 3 wheel design with 2 front and 1 rear wheel
  - Wheels taken from bicycles: 16x 1-3/8” front wheels, 20x1-1/2” rear wheel
- Disc brakes from bicycles used on each wheel
  - Independent front and rear systems

Fabrication

- Fabrication of the major components of the car, excluding the composite work, was done at the NAU Engineering Fabrication Shop
- The frame was built first
- All of the various subsystems were subsequently attached to the existing frame
- Fairing constructed from a male mold due to time constraints

Fabrication

- Frame TIG welded at on-campus machine shop
- Cross braces added to increase rigidity

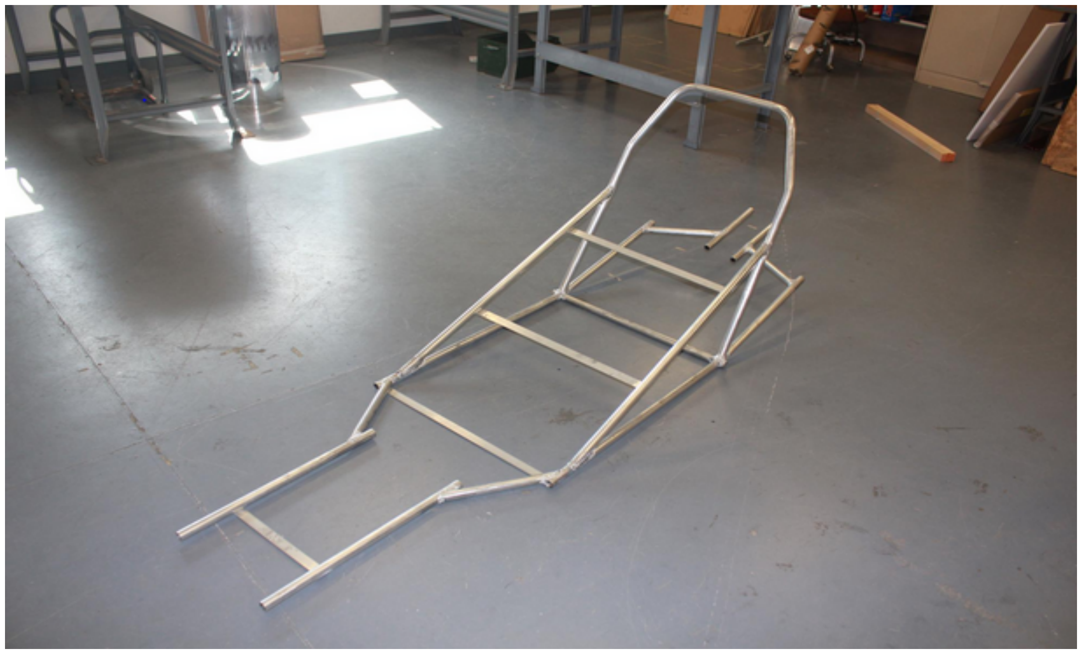

Figure 3: Frame Fabrication Process

Figure 4: Finished Frame with Other Components Installed

Fabrication

- The fairing plug was constructed from OSB sections and smoothed with multiple fillers to create a surface that could be released
- The fairing was constructed from 1 layer of carbon fiber weave, 2 layers of fiberglass veil, and 1 final layer of fiberglass weave

Figure 5: Sections and central spine of the fairing plug.

Figure 6: Layup of the fairing on the plug

Figure 7: Final fairing on the vehicle

Fabrication

- GY6 CVT removed to accommodate clutch
- EcoTrons injection kit installed
- Engine test run on bench top for break-in period

Figure 8: GY6 Initial Assembly

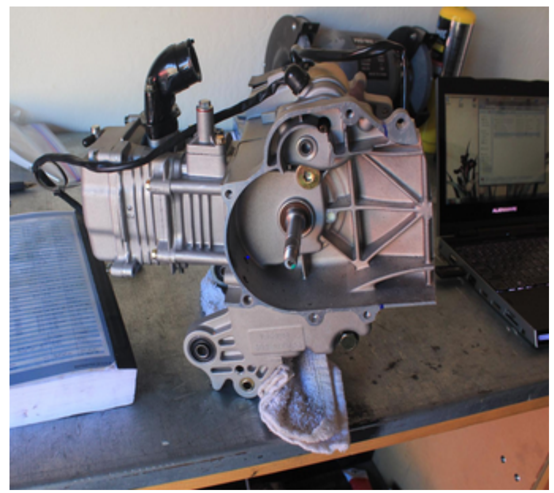

Figure 9: CVT removal

Figure 10: Benchtop Engine Testing

Fabrication

Fuel and Electrical

- A pressurized 2 liter bottle provides the pressure to pump the fuel into the fuel injector
- A valve regulates the pressure inside the fuel tank
- A 5-lb 12V battery powers the entire vehicle

Figure 9: Fuel Pressure System

Fabrication

Clutch and Drivetrain

- An intermediary shaft in the drivetrain mounted with pillow blocks to the frame connects the two chains
- The centrifugal clutch is mounted to the motor with an extended shaft

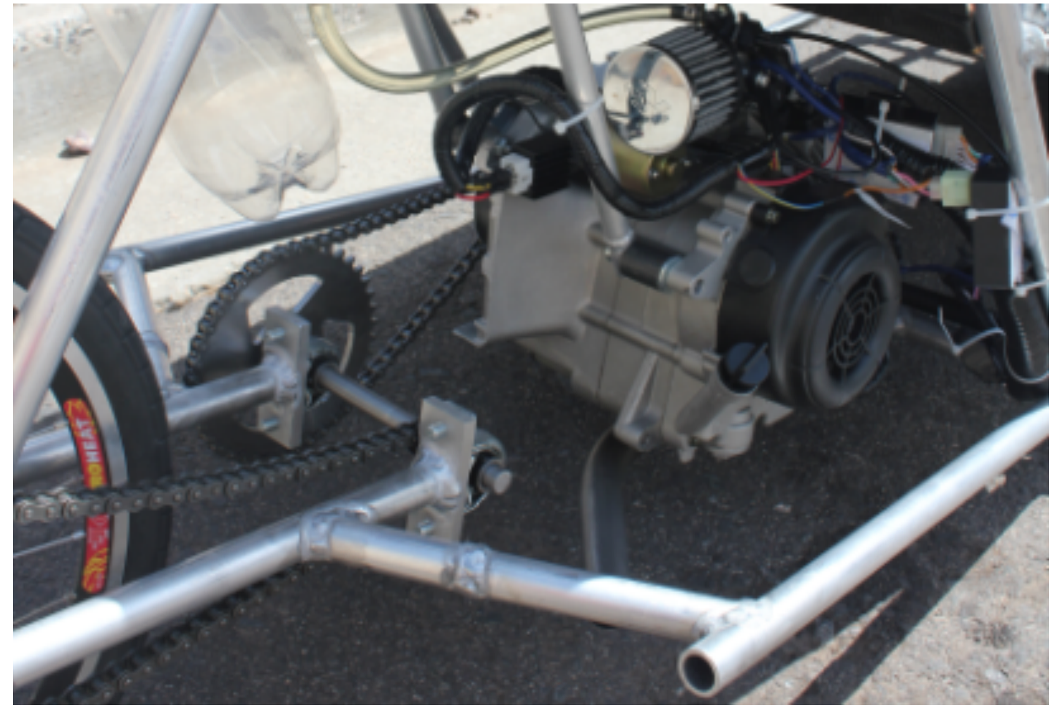

Figure 10: Engine and Drivetrain

Fabrication

Steering and Braking

- Four steering designs were fabricated before settling on the final design
- A dual cable bike lever connected both brake lines for the front brakes
- The calipers were constantly readjusted to provide grip to the rotors while eliminating rubbing

Figure 11: Steering System

Cost Analysis

- The Project budget was initially $2500 through SAE NAU
- Budget raised later through donations

System	**Cost**	**System**	**Cost**
Engine	$909	Braking	$290
Drivetrain	$190	Steering	$90
Electrical	$78	Wheels	$537
Frame	$134	Hardware	$95
Fairing	$350	Safety	$516
		Total	$3,189

Testing

Vehicle testing was performed while the fairing was being completed. Testing was done in the parking lots surrounding the NAU machine shop.

Testing parameters:

- Driver weight: 178 lbs
- Elevation: 7000 ft above sea level
- Fuel Consumed: 100 ml
- Course Description: 0.2 mi laps with long uphill and downhill sections

Testing trial results were in the range of 77 to 114 mpg. The team concluded that such low fuel efficiency was due to the fuel injection tune.

Competition and Results

Shell Eco-marathon 2014 Results:

- The vehicle passed both technical inspection and safety inspection on first attempt
- The official fuel efficiency for the NAU team was a DNF. Vehicle could not complete a full lap without a breakdown and needing to be hauled of the track.

Competition and Results

Problems the team encountered at competition:

- Driver weight increased by 50 lbs.
- Engine failed to start consistently
- Engine tune incapable of keeping the engine running after initial warm up period
- Aluminum steering crossmember fractured, replaced with wooden crossmember
- Fuel tank broke
- Fuel cap leaks/Fuel caps broke regularly
- Failure to start on starting line
- Fuse blown
- Engine performance switch taped to RICH instead of ECO

Competition and Results

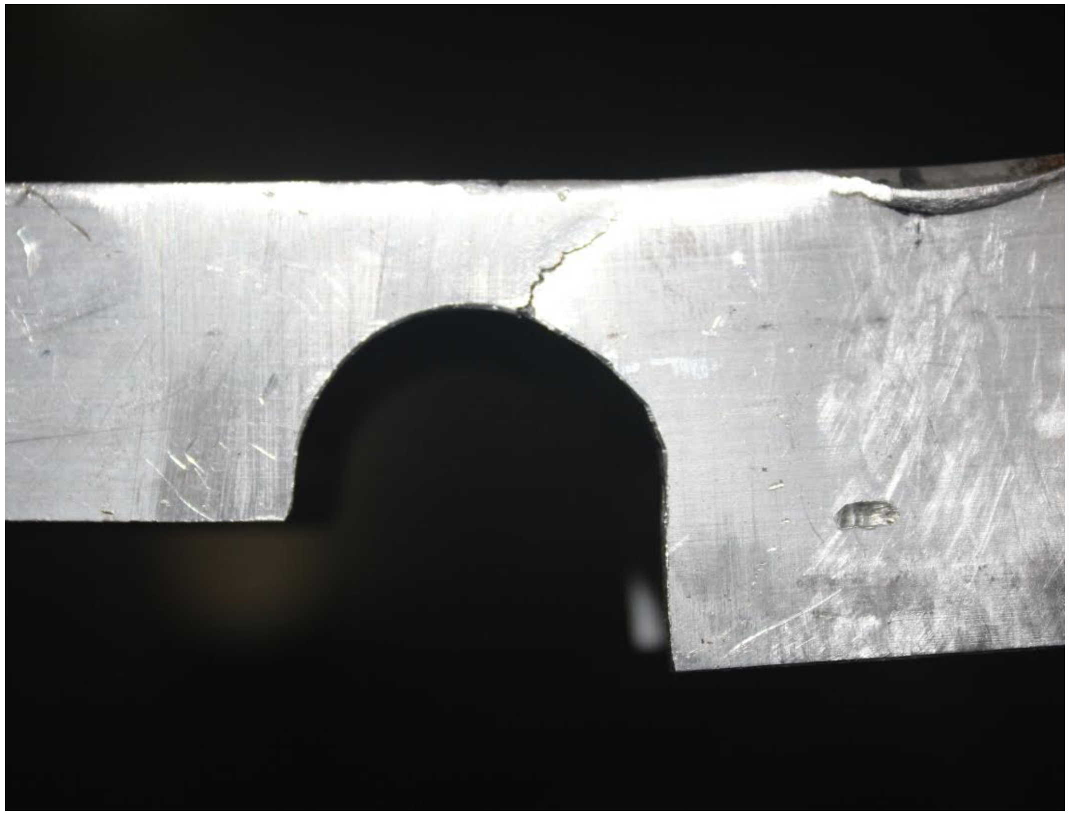

Figure 12: Fracture in initial steering cross member

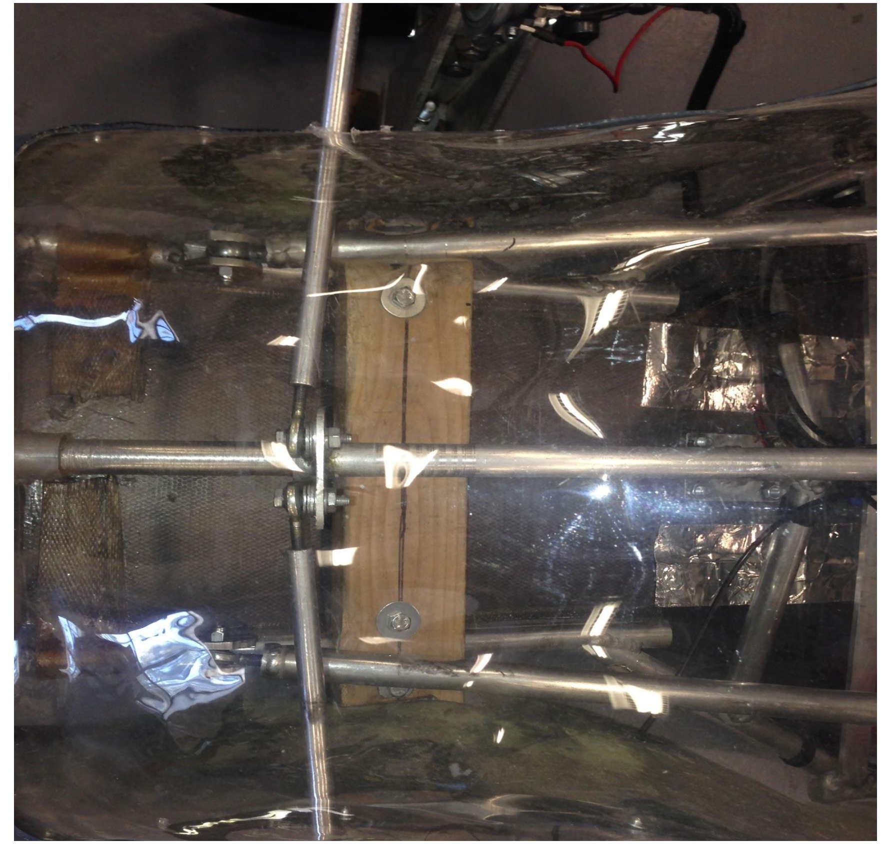

Figure 13: Replacement wooden cross member

Recommendations

- Have NAU professors supervise the construction of a well developed monocoque chassis
- Driver position in fully reclined orientation
- Have the capstone team focus on one aspect of the car per year (i.e. engine, steering, etc.); Make it an iterative project.
- Use a smaller engine
  - 35cc or smaller
- Use single gear reduction drivetrain with large sprocket
- Tow hooks and/or lift points

Recommendations

- Use a wideband O2 sensor
- Spend more time tuning the engine
- Quick release fuel and air pressure connections
- Use standardized wheel sizes
- Use a lighter driver
- Bring back-up engine/fuel system
- Bring replacement parts
- Take trailer to competition
- Increase team member accountability

Conclusions

In conclusion, the team successfully designed and fabricated a fully functioning prototype vehicle that met all of the requirements and constraints set out by the team's client.

The prototype design consists of:

- 1 in - ⅛ in wall tubing 6061-T6 aluminum and Carbon Nomex panel chassis
- 4 layer composite fairing with 1/16 in thick windows
- Honda GY6 50cc with Ecotrons fuel injection kit powertrain
- 2-stage custom freewheel drivetrain with overall gear ratio of 20:1
- Pitman arm steering system

The total estimated cost to fabricate the vehicle was $3,189.00

Conclusions

The team however did not meet the proposed fuel efficiency of 800 mpg.

Reasons for this failure include:

- Constant engine struggles
- Steering crossmember failure
- Fuel tank/fuel cap struggles
- Team member accountability

Following the recommendations made by the team, NAU should be a contender in the future Shell Eco-marathon competitions.

References

Shell Eco-marathon, "Offical Rules 2014 Chapter 1,"http://s01.static-shell.com/content/dam/shell-new/local/corporate/ecomarathon/downloads/pdf/sem-global-official-rules-chapter-1-2014.pdf, 01 Oct. 2013.

Questions