

ME, ECE, BE Capstone Design Programs

LSU Eceaux-Car Team #33

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Background

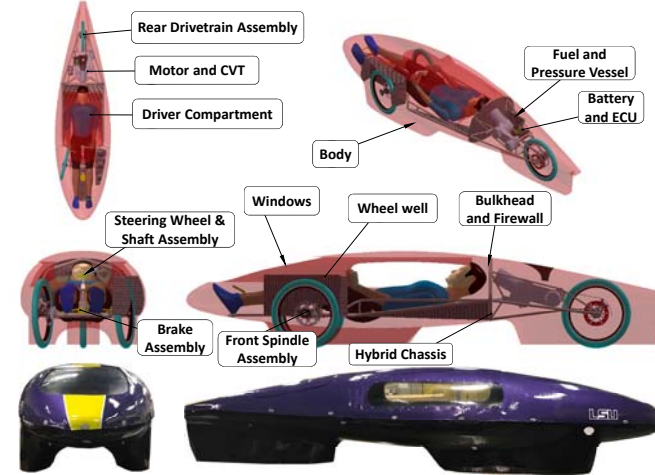
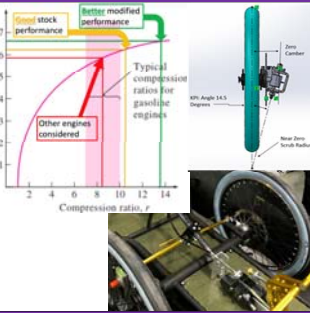
- Track will be the streets of downtown Detroit, Michigan
- Competition held April 27-30, 2017
- Must travel 6 miles in 24 minutes
- Focus on fuel efficiency, not speed

Critical Engineering Specifications

- Maximum prototype weight: **308 pounds**
- Minimum driver weight: **110 pounds**
- Brakes: independent front and rear –chose hydraulic
 - Must remain static on a **20% incline**
- Maximum turning radius of **26.25 feet**
- Roll bar must withstand a **158 pound force**
- Safety harness: support **1.5 times the driver's weight**: 165 pounds
- Fuel pressurization: translucent compressed air bottle with **5 bars** maximum
- Engine necessities:
 - Fuel inject (no carburetor)
 - Clutch system
 - 2 emergency shutdowns** & Deadman's switch
- Electrical system:
 - Voltage **48 V** nominal, **60 V** maximum
 - 1,000 Watt-hour** maximum battery capacity
 - Short circuit protection device **≤ 30 cm** away from positive terminal

Project Objectives

- Goal: minimize weight to increase fuel efficiency
- Engine: increased size to **50 cc** class
 - Determining factors:
 - Weight
 - Compression ratio
 - Torque
 - Horsepower
 - Cost
 - Brake specific fuel consumption
 - Further increased chosen engine's compression ratio to **13.5:1** to maximize thermal efficiency
- ECU: upgraded to higher resolution data acquisition and better fine tuning
- Steering System: fully adjustable to minimize losses and improve handling by
 - Reducing scrub radius to near zero
 - Aligning the wheels
- Body: Improved design for less drag
- Competitive goal: achieve **1000 MPG** or greater



Manufacturing Processes



Frame

Frame CAD drawings → Jig drawings to ensure proper placement when welding → Fabricate jigs from steel sheets and tubing → Frame tubing cut to size → TIG weld

Extreme Welding Solutions performed an inspection (all 120 welds were visually inspected, 5% were dye penetrant tested) of all the welds and all were deemed acceptable.

Body

Drawing of the body was redone by bisecting into drawings of foam layers.

- Male foam mold:
 - Water jetted foam layers
 - Stack foam layers
 - Sanded edges prime
- Female fiberglass mold:
 - Laid up fiberglass with epoxy
 - Separated from male mold after drying
 - Used Bondo and sanding to fix imperfections
 - Primed and applied wax and release agent
- Carbon fiber body:
 - Layered epoxy, carbon fiber, perforated Teflon film, and breathing cloth
 - Envelope in vacuum bag
 - Separate from female mold
 - Cut excess, windows and driver hatch, engine access hatch



Engine

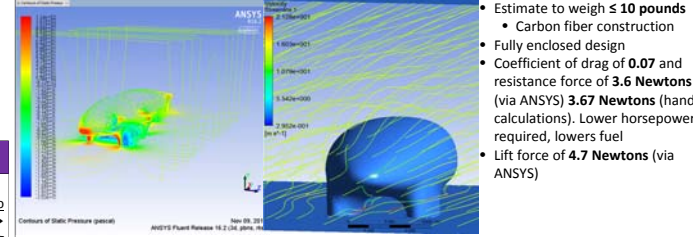
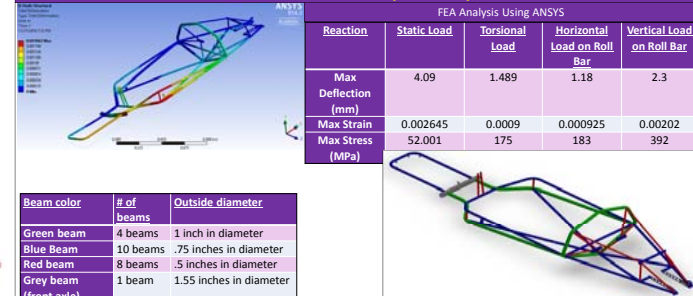
Additional improvements applied:

- Electronically tuned and controlled by a **Megasquirt III** Engine Control Unit
- Convert from carbureted to **fuel injected**
- Component specially coated to **improve thermal efficiency and lower friction**

Weight (lb)	25 (originally 44)	Displacement (cc)	49.5
Max Horsepower (hp)	3.2 @ 8,000 RPM	Ignition System	CDI
Compression Ratio	13.5:1 (originally 10.5:1)	Starting System	Electric
Brake Specific Fuel Consumption (lb/hp-hr)	0.5480	Constantly Variable Transmission Gear Ratio	2.0:1



Frame and Body Analysis

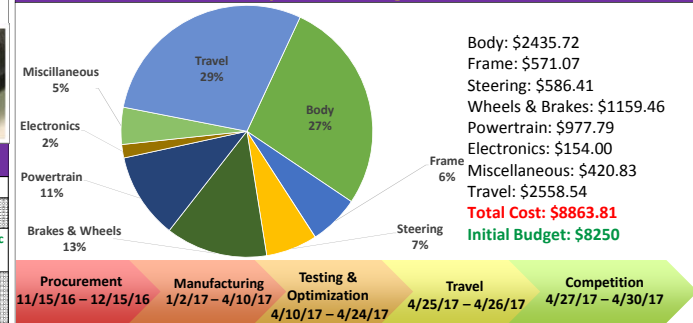


- Estimate to weigh **≤ 10 pounds**
 - Carbon fiber construction
- Fully enclosed design
- Coefficient of drag of **0.07** and resistance force of **3.67 Newtons** (via ANSYS) **3.67 Newtons** (hand calculations). Lower horsepower required, lowers fuel
- Lift force of **4.7 Newtons** (via ANSYS)

Testing and Validation

- Complete prototype currently weighs **107 pounds**, ~40 pounds less than last year's design
- Brakes successfully stopped vehicle on **20% incline**
- Steering assembly adjusted to allow turning radius **25.50 feet**
- Roll bar supported **160 pound** in multiple locations and different axis with **no major elastic or any plastic deformation of tabs or frame**
- Safety harness supported **>1.5 times the driver's weight of 192.5 pound**
- Driver egress test resulted in an average of **8 seconds**
- Engine Control Unit has successfully ran under simulation load, pending completion of engine to do more realistic testing
- Miles per gallon/driving pattern testing is pending completion of engine
- Engine start testing is pending the completion of the tone wheel fabrication

Project Management



Material Selection

Pursued lightweight, strong, minimal packaging, and loss reducing materials

Ceramic (vs others)

- ↓ density, 58% lighter
- Overall ↓ rolling resistance due to:
 - >2.3 times harder (↓ wear)
 - >4 times smoother, ↓ coefficient of friction expansion, ↓ coefficient of friction
 - Does not corrode /cold weld
 - >operating temperature
- ↑ initial cost

Lithium Battery (vs others)

- ↑ energy density
- ↑ safety
- ↓ weight

Chromoly Steel Frame (vs Aluminum)

- ↑ in house manufacturability
- ↑ stiffness (better shock absorption)
- ↓ brittle, ↑ durability
- +3 times ↑ strength
- +2 times ↑ density

make Chromoly frame weigh ≤ as Aluminum

Carbon Fiber Body (vs PETE)

- ↑ stiffness
- ↑ strength
- ↓ weight
- ↓ manufacturability

Other components made of carbon fiber:

- Bulkheads
- Floor panels
- Chain/pulley guard
- Steering wheel
- Hatches
- Battery platform

Other material used: 3D printed plastic, titanium, magnesium, and aluminum

Rear wheel hub:

- Aluminum
- Proprietary design
- Lightweight
- Compact
- Left hand, one way ratcheting gears

Safety Considerations

- Fireproof safe battery charging bag
- Bulkheads isolating driver from wheels and engine
- Safety harness to withstand 1.5 x driver's weight
- Onboard ABC rated fire extinguisher
- Fire retardant full racing suit/shoes and helmet
- Ergonomically designed to prevent discomfort/numbing limbs
- Hands-free communication, GPS, and water dispensing devices
- Audible horn