# Aqua Scooter 2.0

Dylan Cannon, Darin Gilliam, Eli Palomares,
Elizabeth Tyler, Jiyan Wang, Tyler Winston

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# Overview

- Client Introduction
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# Client Introduction

Aqua Scooter is a portable, gasoline 2-stroke powered personal water craft that can propel the user up to 5mph.

Aqua Scooter is a company based in Sedona. The CEO, Robert Witkoff, approached us, asking to design a new Aqua Scooter.

The client's current model is unable to be sold in the United States due to EPA regulations.

www.cnet.com

# Need Statement and  Project Goal

**Need:**

- Current Aqua Scooter model does not meet EPA regulations

**Project Goal:**

- Design a hydrodynamic, inexpensive, aesthetically pleasing Aqua Scooter, with a marine engine that complies with EPA regulations

# Objectives

- Should be lightweight
- Must be buoyant
- Must not exceed 30 g/kWh of Hydrocarbons
- Must not exceed 490 g/kWh of CO
- Must be safe for a child to use

# Constraints

- ½ gallon, plastic fuel tank
- Internal combustion powered
- Metal engine and muffler housing
- Starter assembly is plastic and metal
- Production cost of less than $450
- Plastic propeller protection
- Control handle included
- Throttle control
- Exhaust valve
- Must be 18 pounds or less
- Must provide at least 50 pounds thrust

# Quality Function Deployment

| **Aqua Scooter QFD Matrix** | Weight | Byuoancy | Fuel Ccapacity | Thrust | Exhaust emission | Operating Life | Warranty | Cayago Seabob | Seadoo Seascooter |
|---|---|---|---|---|---|---|---|---|---|
| Aesthetically pleasing | X | | X | | | | | O | O |
| Child safe | X | X | | X | X | | | | O |
| Lightweight | X | X | X | X | | | | | |
| Floats | X | X | X | | | | | O | O |
| Propels operator through water | | | | X | X | | | O | O |
| Runs for extended period | | | X | | | | | | |
| Meets current EPA regs. | | | | | X | X | X | O | O |
| units | lbf. | lbf. | gal. | lbf. | g/kW-h | Hours/Years | Hours/Months | | |
| | ≤ 18 | ≥ 18 | ≥ 0.5 | ≥ 50 | ≤ 30 of Hydrocarbon, ≤ 490 of Carbon Monoxide | ≥ 350/5 | ≥ 175/30 | | |

- Customer Needs
- Engineering Requirements
- Engineering Targets
- Bench Marks

Table 2: QFD matrix relates customer needs and engineering requirements.

# House of Quality

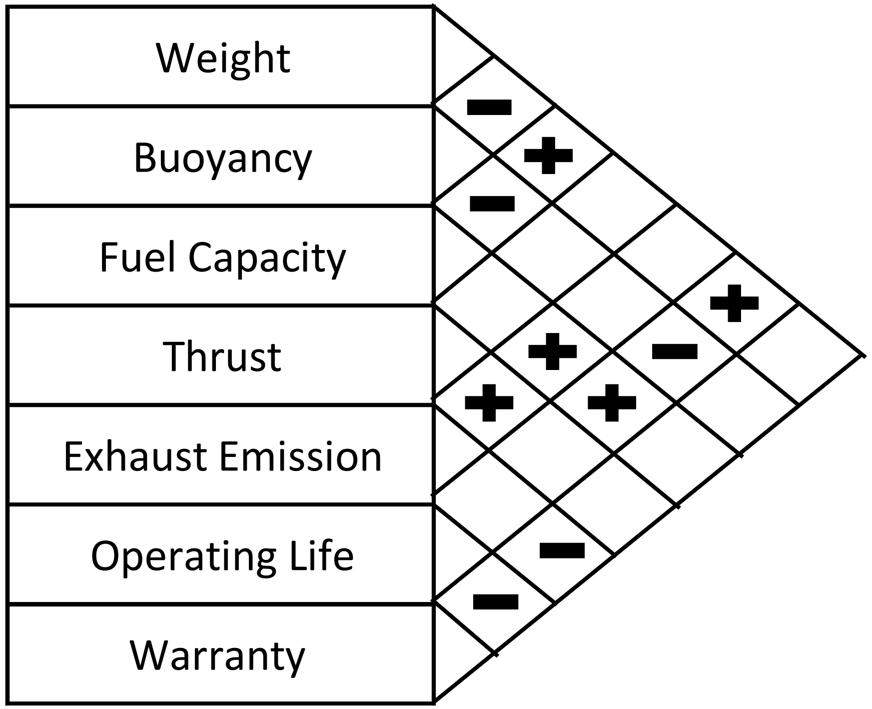



Table 3: House of quality correlates engineering requirements.

# Concept Generation

- Boomerang
- Octopus
- Duck Scooter
- 2 Propeller
- Adjustable Jet
- Tank Housing

# Criteria

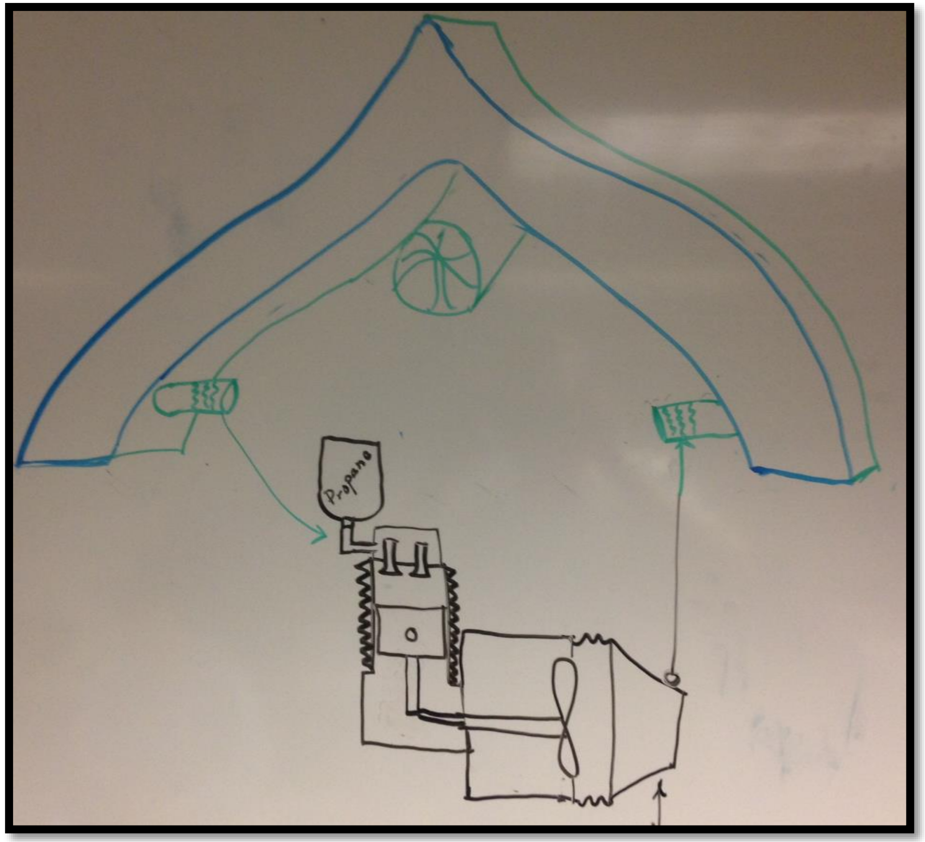
| | |
|---|---|
| • Aesthetically Pleasing | 10% |
| • Minimal Probability of Error | 10% |
| • Ease of Manufacture | 10% |
| • EPA Regulations | 20% |
| • Complexity of Design | 10% |
| • Provides Thrust | 10% |
| • Hydrodynamically Efficient | 10% |
| • Lightweight | 10% |
| • Minimal Cost of Materials | 10% |

# Decision Matrix

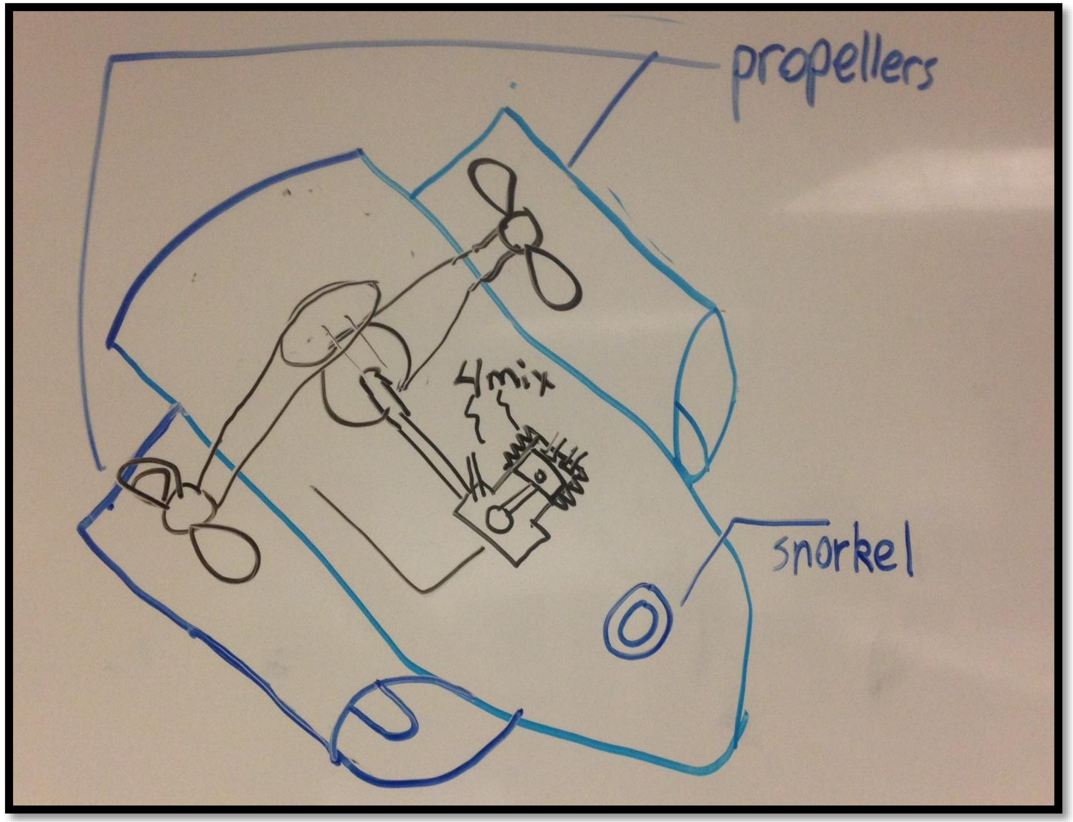
| | Requirements and Criteria | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Aesthetically Pleasing | Minimal Probability of Error | Ease of Manufacture | EPA Requirements | Complexity of Design | Provides Thrust | Hydrodynamic Efficient | Lightweight | Minimal Cost of Materials | **Total Weighted Factor** |
| **Requirement Weighting** | 10% | 10% | 10% | 20% | 10% | 10% | 10% | 10% | 10% | **100%** |
| **Boomerang** | 7 | 6 | 5 | 7 | 5 | 8 | 8 | 6 | 7.5 | **6.65** |
| **Octopus** | 6 | 3 | 4 | 7 | 4 | 8 | 6 | 6 | 5 | **5.6** |
| **Duck Scooter** | 8 | 6 | 6 | 6 | 6 | 7.5 | 5.5 | 6 | 5 | **6.2** |
| **2 Propeller** | 8 | 6 | 6 | 7.5 | 5 | 8.5 | 7 | 5.5 | 6 | **6.7** |
| **Enclosed Housing** | 7.5 | 8 | 6 | 7 | 5 | 9 | 7 | 6 | 5 | **6.75** |
| **Adjustable Jet** | 7 | 6 | 6 | 8 | 6 | 8 | 8 | 6 | 6.5 | **6.95** |
| **Tank Housing** | 7.5 | 5.5 | 6 | 6 | 5.75 | 9 | 7.5 | 7 | 5.5 | **6.575** |

# Top Two Ideas

- Boomerang with 4-stroke Propane Engine with Adjustable Jet

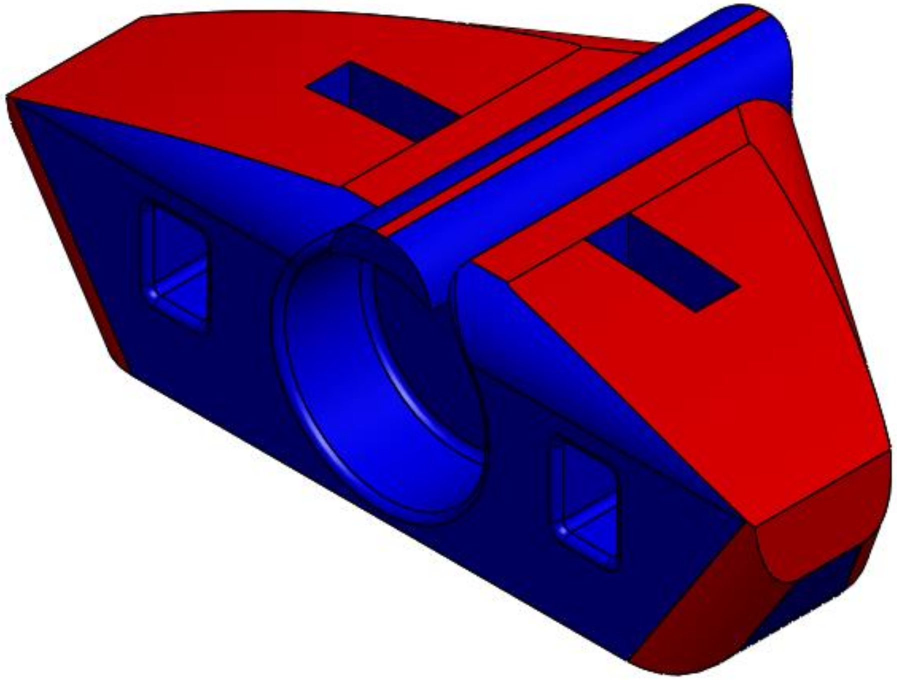



- Two Propeller with 4-stroke 4-mix Engine with Adjustable Jet

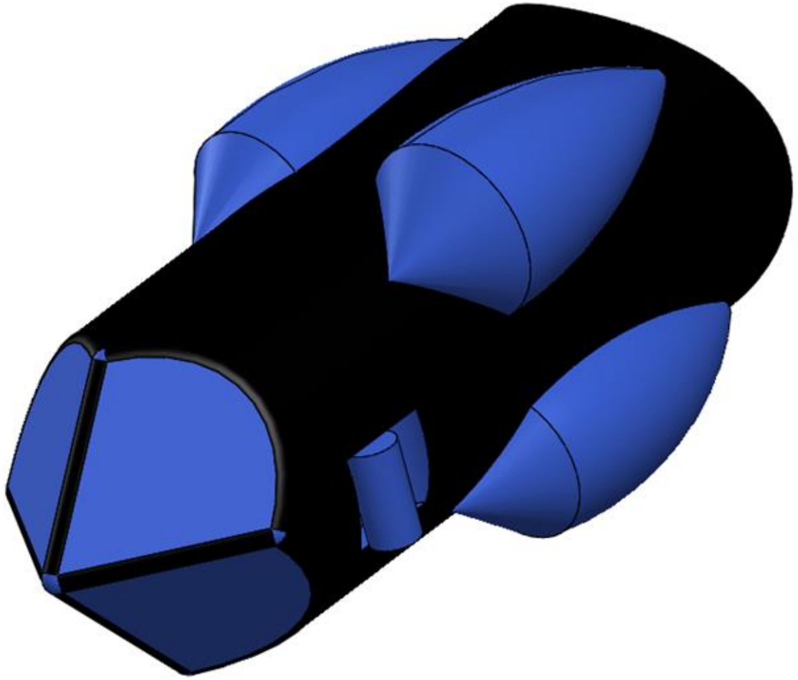


# Drag Analysis

**Drag Force:** $F = 0.5\rho V^2 C_d A$



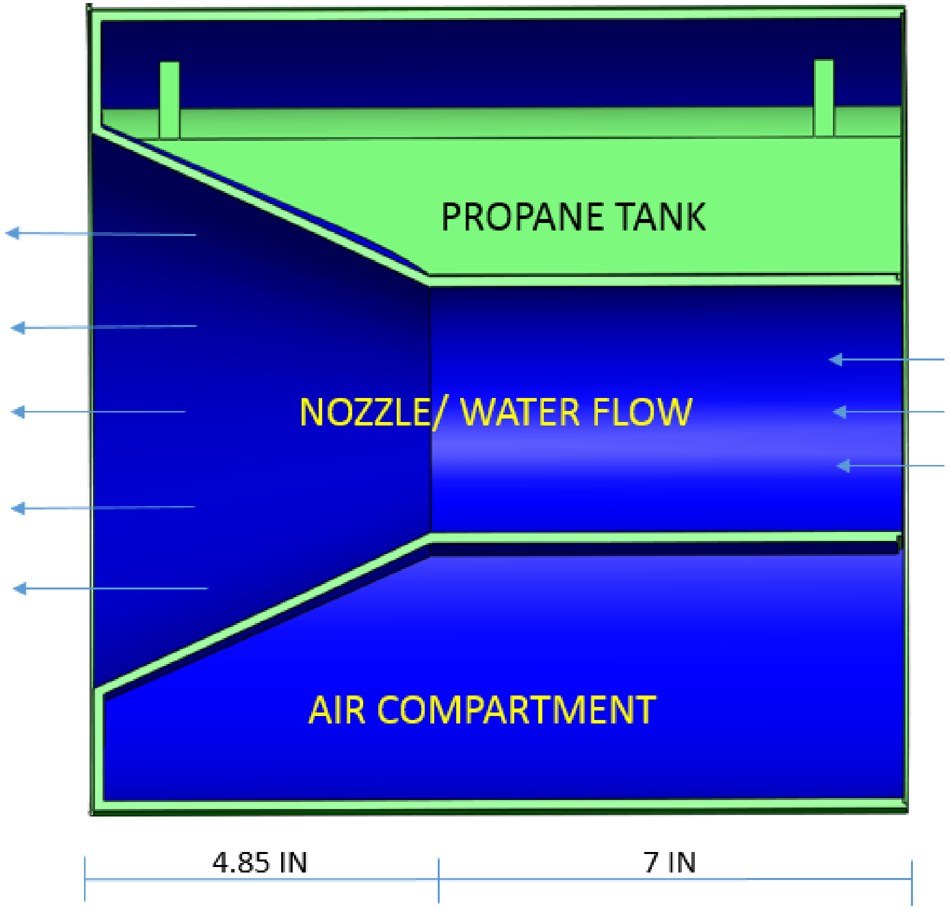
- $\boldsymbol{F = 200.25 lbf}$



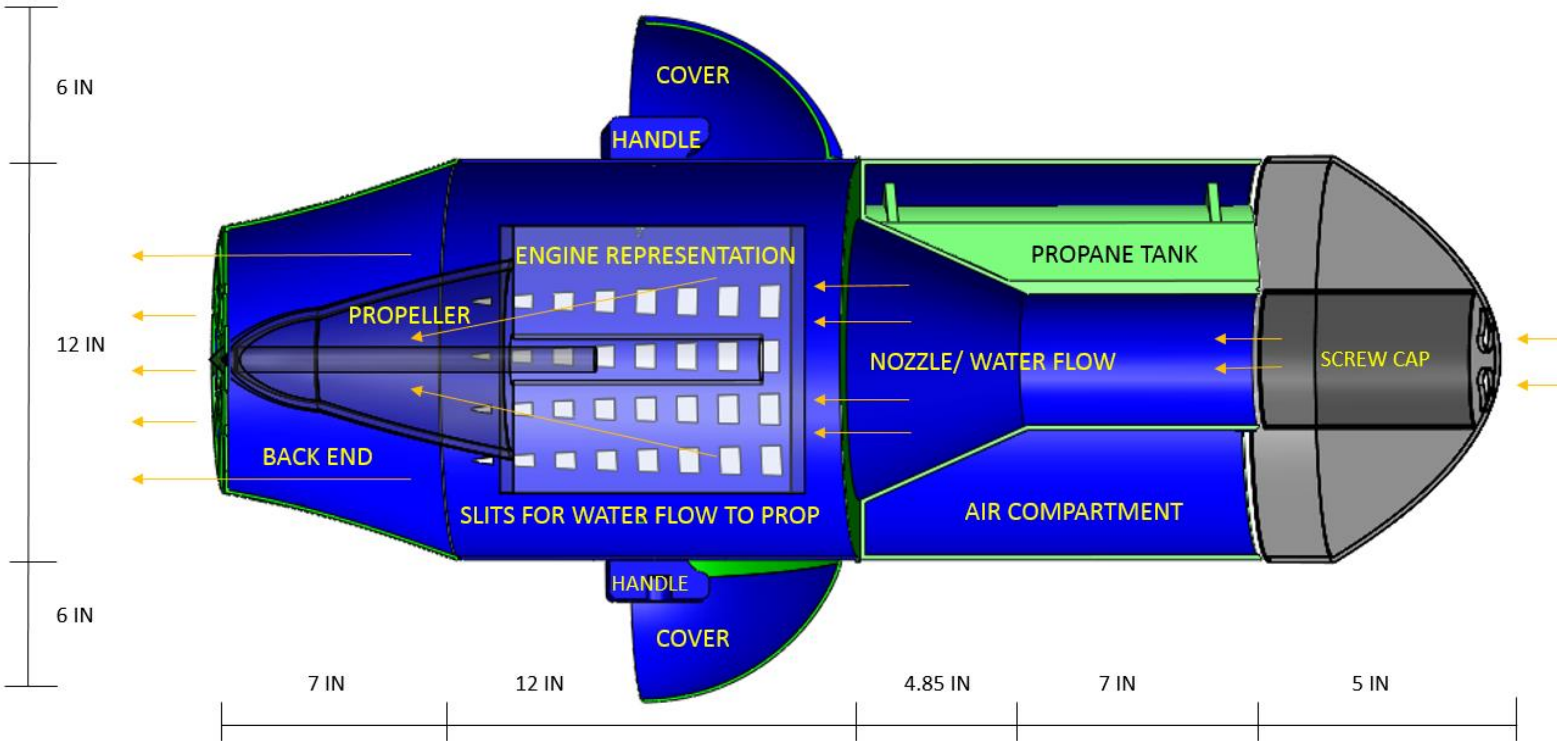
- $\boldsymbol{F = 55.72\ lbf}$

# Buoyancy Calculations

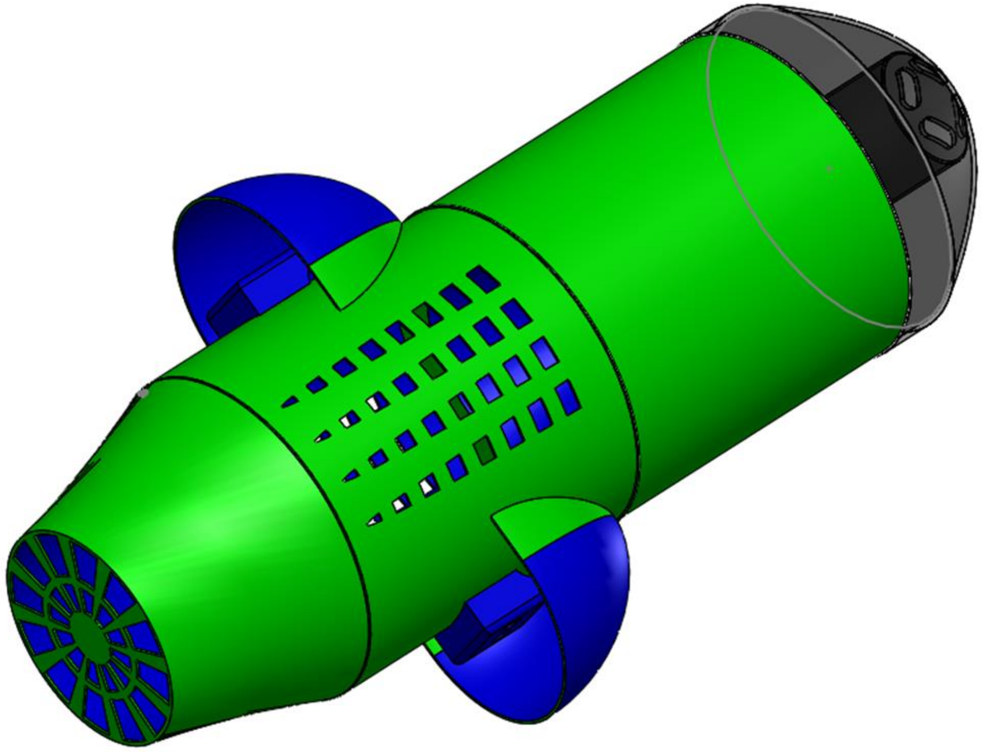
- $V_{cyl} = \pi r^2 h = 0.65\ ft^3$
- $V_{nozzle} = 0.13 ft^3$
- $V_{cyl} - V_{nozzle} = 0.52\ ft^3$
- $V_{required} = 0.54 ft^3$

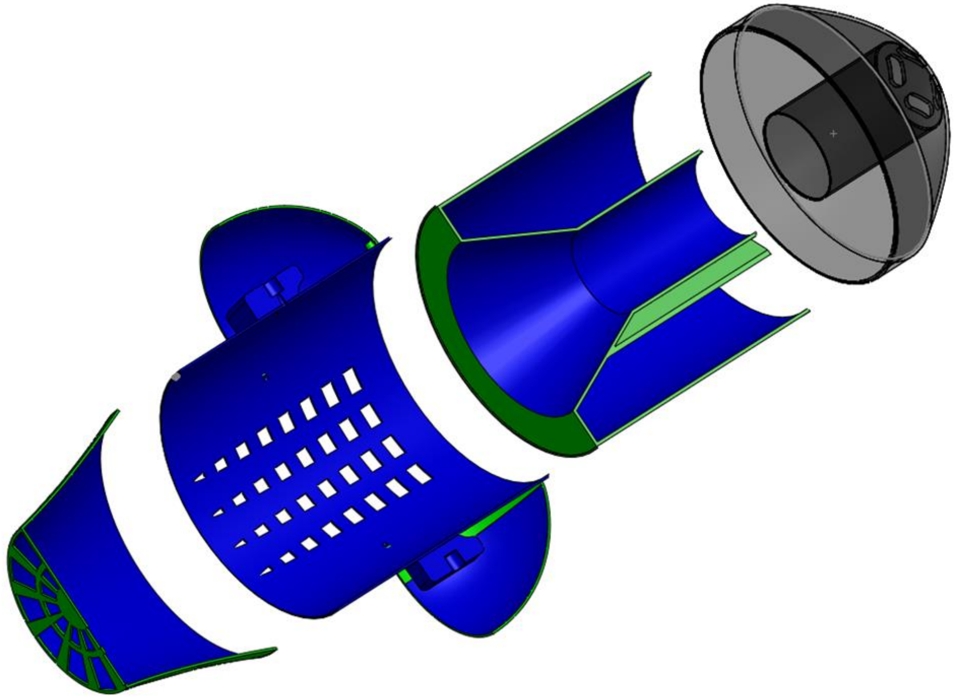


# Triton Internal Side View



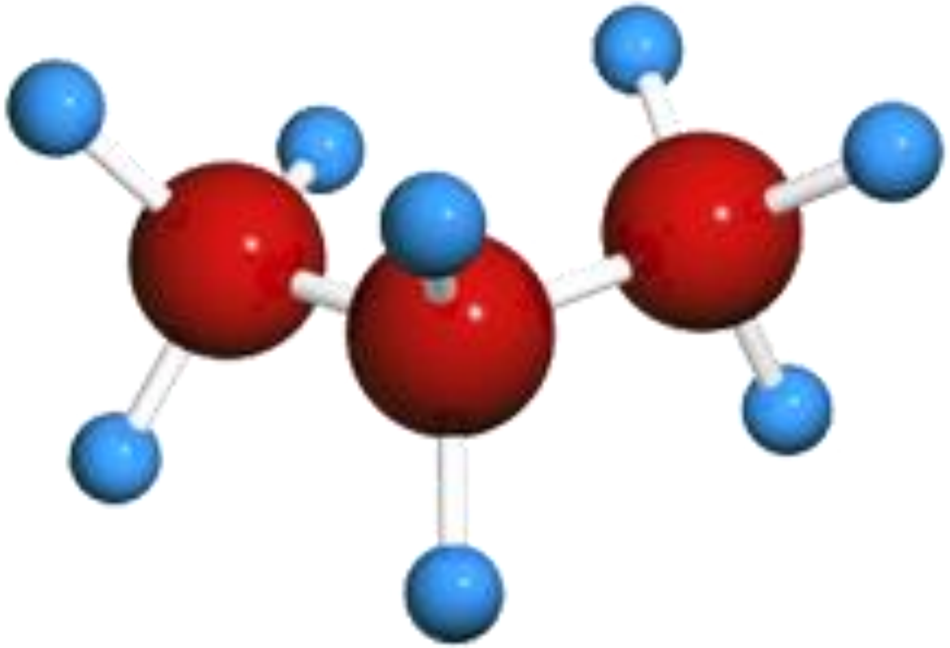
# Triton Prototype





# Fuel Analysis

- Gasoline Analysis
- Propane Analysis



suburbanpropane.com

# Gasoline Analysis

| Dimensions | Aqua Scooter 2-Stroke Engine (AS 650) | 4-Stroke Engine (Honda GX25) |
|---|---|---|
| **Length (in)** | 21 | 7.6 |
| **Width (in)** | 7.6 | 8.7 |
| **Height (in)** | 12.6 | 9.1 |
| **Weight (lbf)** | 16.5 | 6.4 |
| **Bore (in)** | 1.6 | 1.4 |
| **Stroke (in)** | 1.5 | 1.4 |
| **Displacement (cc)** | 49 | 26 |
| | | |
| **Power (HP)** | 2 | 1.1 @ 7000rpm |
| **Fuel** | Mixture | Unleaded 87 Octane or Higher |
| **Fuel Tank Capacity (gal)** | 0.5 | 0.15 |
| | | |
| **Price ($)** | (+/-) 970 | 240 |


spearfishing.de


engines.honda.com

# Propane Analysis

- Assumptions
  - Calculated using Honda GX25 converted to propane
  - Running time 3 hours
  - Not Adjusted for Efficiency

- Results
  - Required weight of propane is 12.52 ounces

# Chemical and Air Fuel Ratio Calculations

**Propane Stoichiometry**

$C_3H_8 + 5O_2 + 18.8N_2 \rightarrow 3CO_2 + 4H_2O + 18.8N_2$

## AF Ratio for 87 Octane is 15:1

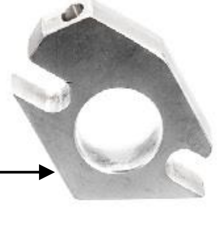
**AF Ratio for Propane**

- $M_{air} = 28.97$
- $M_{propane} = 44.09$

- $AF_{propane} = (5 + 18.8) * \frac{28.97}{44.09}$
- $AF_{propane} = 15.66 \frac{lb\ air}{lb\ propane} : 1$

# Conversion Kits: Propane

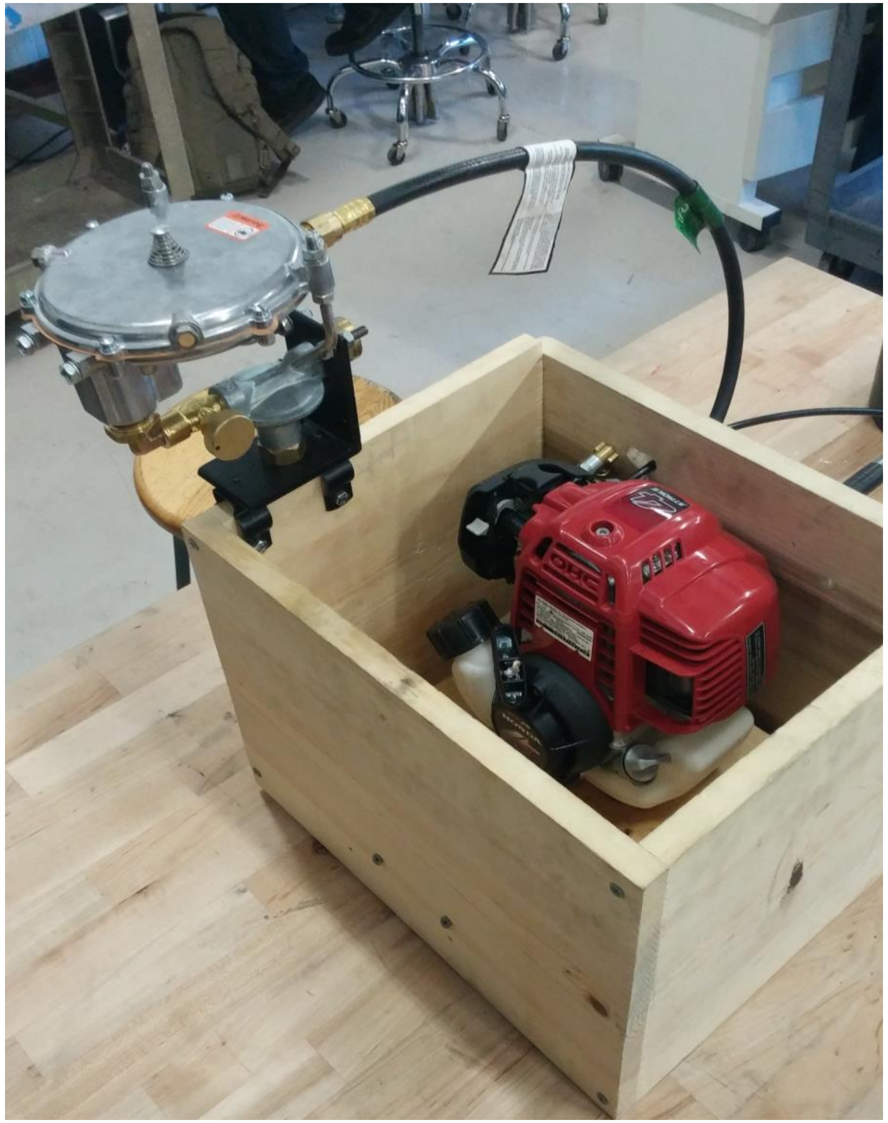
- Alt Fuel
  - Intake Adaptor
  - Bracket For Tank
  - Regulator
  - Attachment Line
  - Fuel Line


propanepowerkits.com

# Conversion Kit

- Specific to Honda GX25
- Minor carburetor modification
- Easily swap between gasoline and propane



# Engine Testing

- Horsepower Testing
- Thrust Testing
- Emissions Testing

# Engine Modifications

- Exhaust system modified to fit emission testing probe
- Shaft and flange machined in order to test engine on dynamometer
- Multiple iterations attempted to compensate for shaft vibration

# Prony Brake Experiment

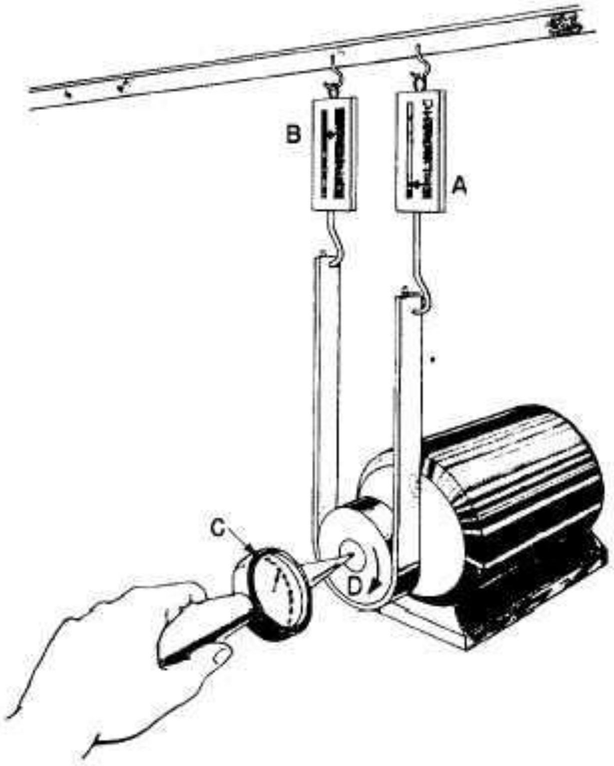
- $P = \frac{(F_A - F_B) * D}{t}$

  $P = Power$

  $F_i = Force\ measured\ from\ spring$

  $D = Distance\ Pulley\ Traveled$

  $t = time$
- $\tau = LF \quad (ft * lb)$
- $P = \tau * rpm\ (ft * lb/min)$

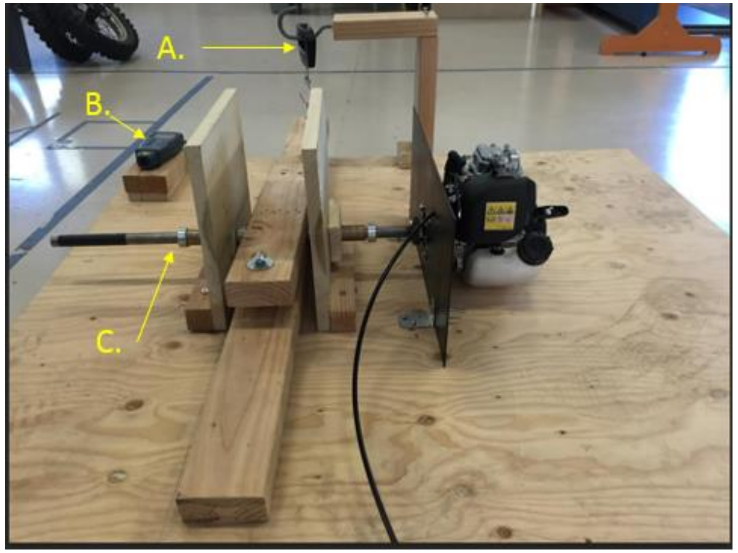



enginemechanics.tpub.com

# Prony Brake Experiment: Results

**Original Test**

- Engine did not start
- Shaft eccentricity significant
- Too much friction




A. Force Scale
B. Tachometer
C. Pulley System

**Final Test**

- Engine did start with shaft in bushings
- When brake was applied engine stalled
- Vibration moved bolts out of flywheel

# Thrust Experiment: Modifications

- Tapered shaft for propeller
- Lubricated bushings
- Wooden box constructed for housing engine
- Force scale

# Thrust Experiment: Gasoline

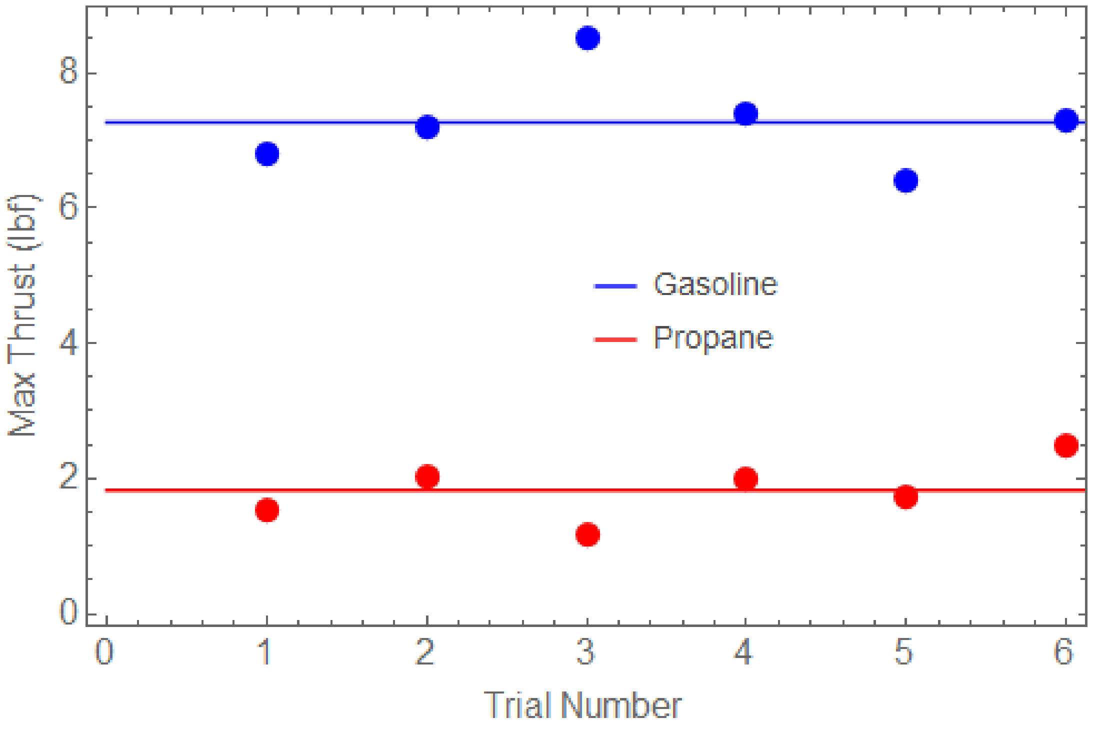
- Wooden housing attached to cart
- 6 Trials conducted of experiment
- Engine started with minimal water
- Water poured into bucket until engine stalled

# Thrust Experiment: Propane

- Engine converted to propane
- Correct air-fuel ratio
- Experiment conducted with new fuel source
- Regulator mounted to engine housing

# Thrust Experiment Results

- All max thrust data points plotted
- Average thrust line created
- Difference in thrust attributed to:
  - Additional weight
  - Warped fly-wheel



# Emissions Testing

- 87 Octane Gasoline Used

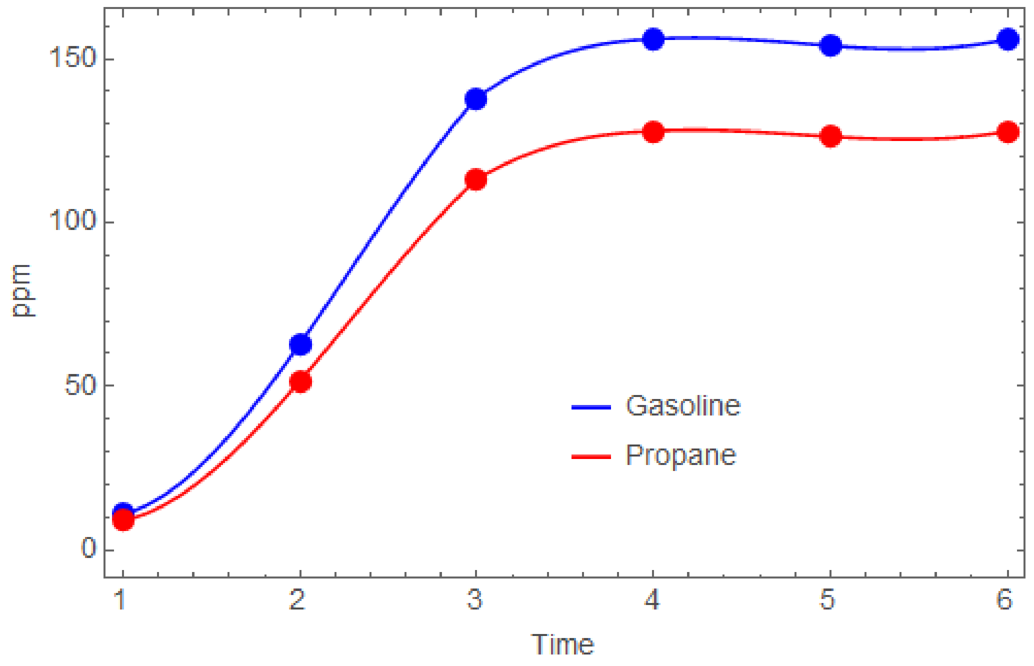
- Device: 3 Gas Analyzer
  - Hydrocarbon
  - Carbon Monoxide
  - Carbon Dioxide

# Emissions Testing

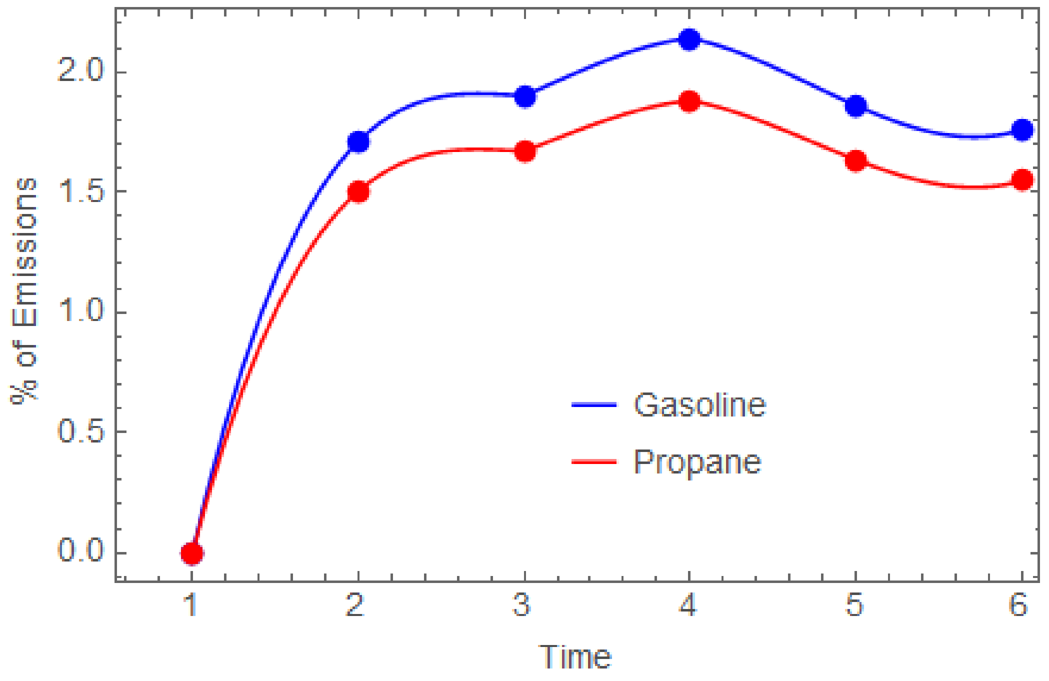
- Probe Insert Into Exhaust
- Single Test Conducted
- Several Data Points were Collected
- Goal to compare with Propane

# Emissions Testing

**Greenhouse Gases vs. Time[16]**

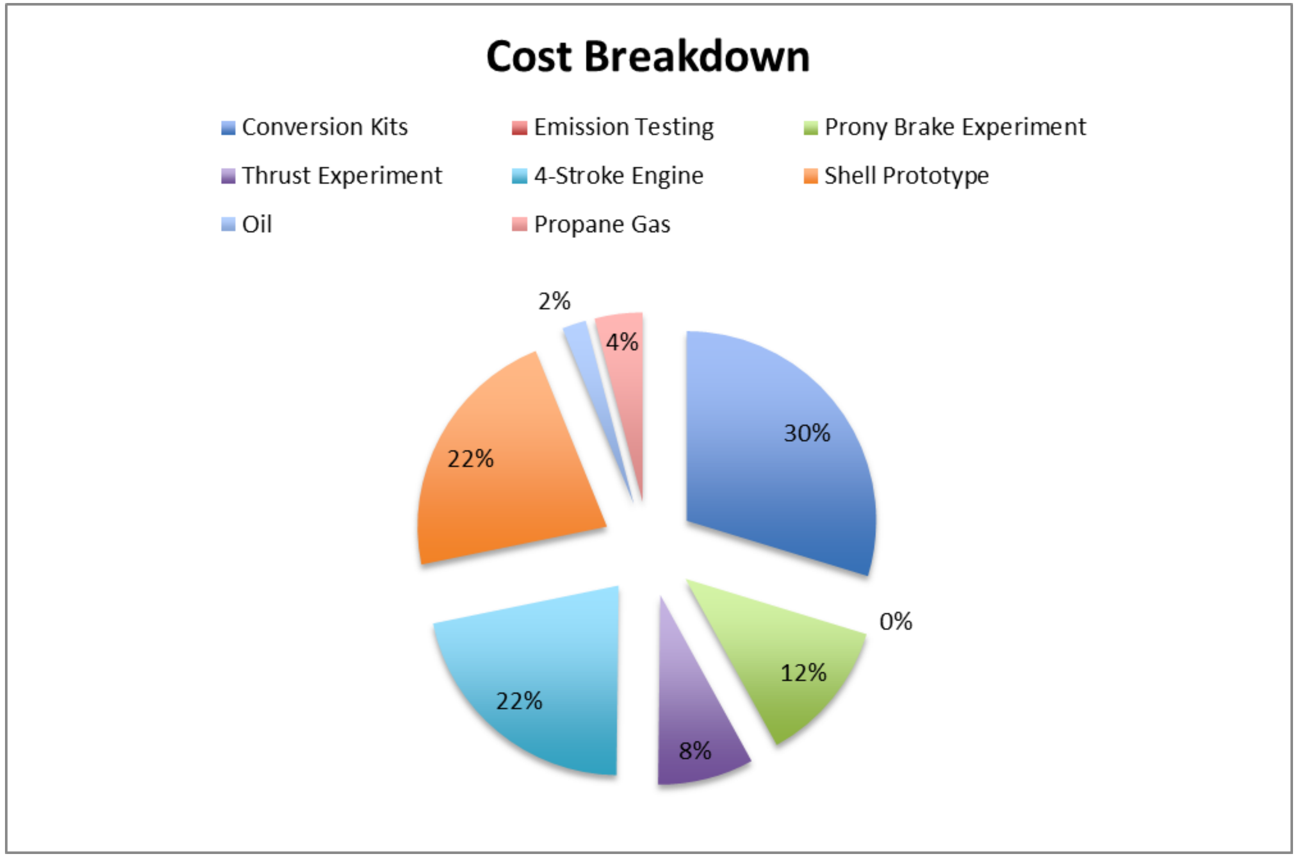



**Carbon Dioxide % of Emissions vs. Time[16]**



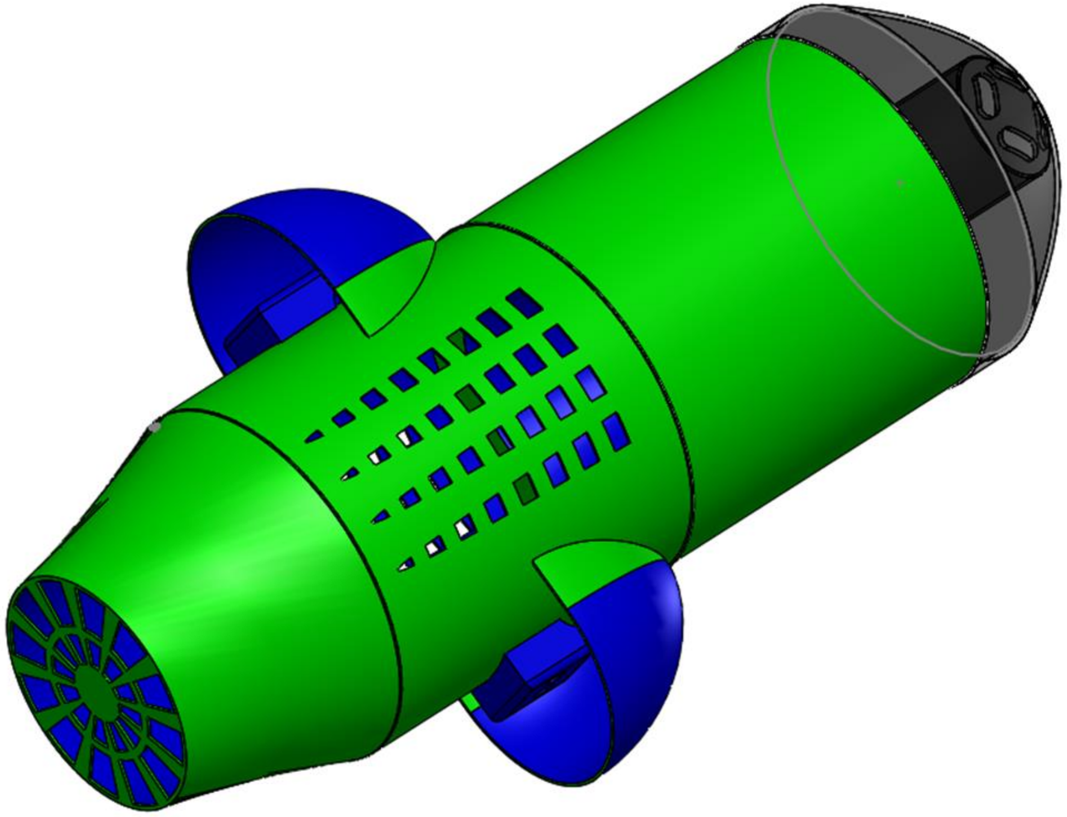
# Cost of Materials

- Emissions Cost - $0.00
- Support Material - $95.05
- Model Material- $174.60
- Conversion Kit- $363.00



# Conclusion

- 3-D Printed Prototype of Shell ½ Scale
- Propane provides comparable thrust
- Emissions for $CO_2$ are 12% less for Propane
- Emissions for Greenhouse gases are 18% less for propane



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# Any Questions?