Aqua Scooter

Final Presentation

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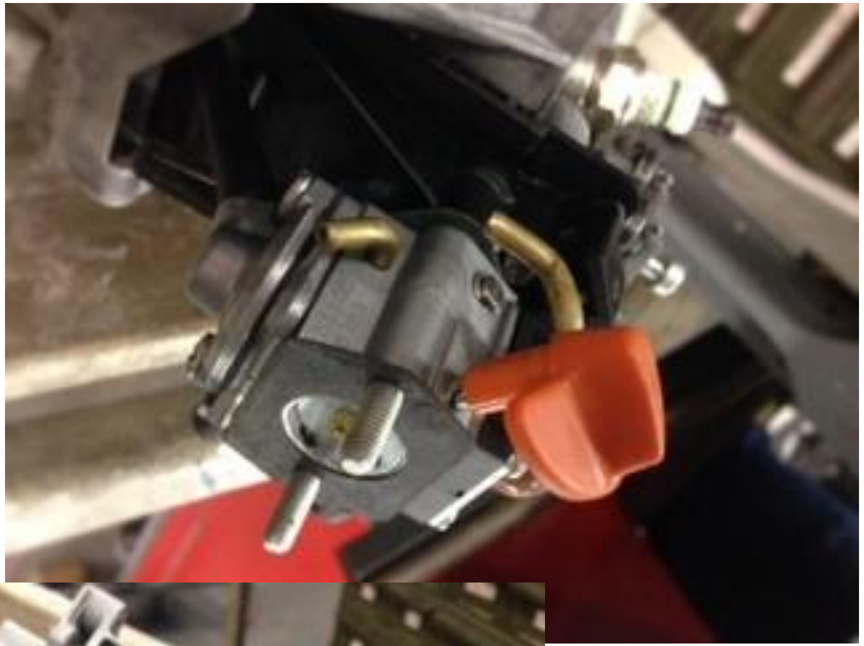
NORTHERN ARIZONA UNIVERSITY

Overview

- Objectives
- Problem Definition
- Engine Analysis
- Shell Analysis
- Final Considerations
- Conclusion
- References



Project Goal

Need

- Current Aqua Scooter model does not meet EPA regulations.

Goal

- Design an improved Aqua Scooter that exceeds EPA regulations.

Objectives

- Design an aesthetically pleasing Aqua Scooter, that complies with EPA regulations.
- The new design should be lightweight and provide similar thrust.
- The system must be buoyant and relatively cheap to manufacture.
- Must be safe for a child to use.

Objectives

- Analyze and compare gasoline, propane, and butane 4-stroke engine concepts.

- Quantify the ability for each fuel source to meet EPA regulations.

- Calculate the drag coefficients for the two final outer shell designs.

- Calculate thrust assuming a propeller that will generate a 5mph velocity.

Current Model

Two- Stroke Engine

- Used for typically greater power to weight ratio.
- Mixed oil and fuel injected into combustion chamber by carburetor.

Exhaust emissions

- Can’t meet current EPA regulations.
- Unburned exhaust emissions enter the atmosphere.

Constraints

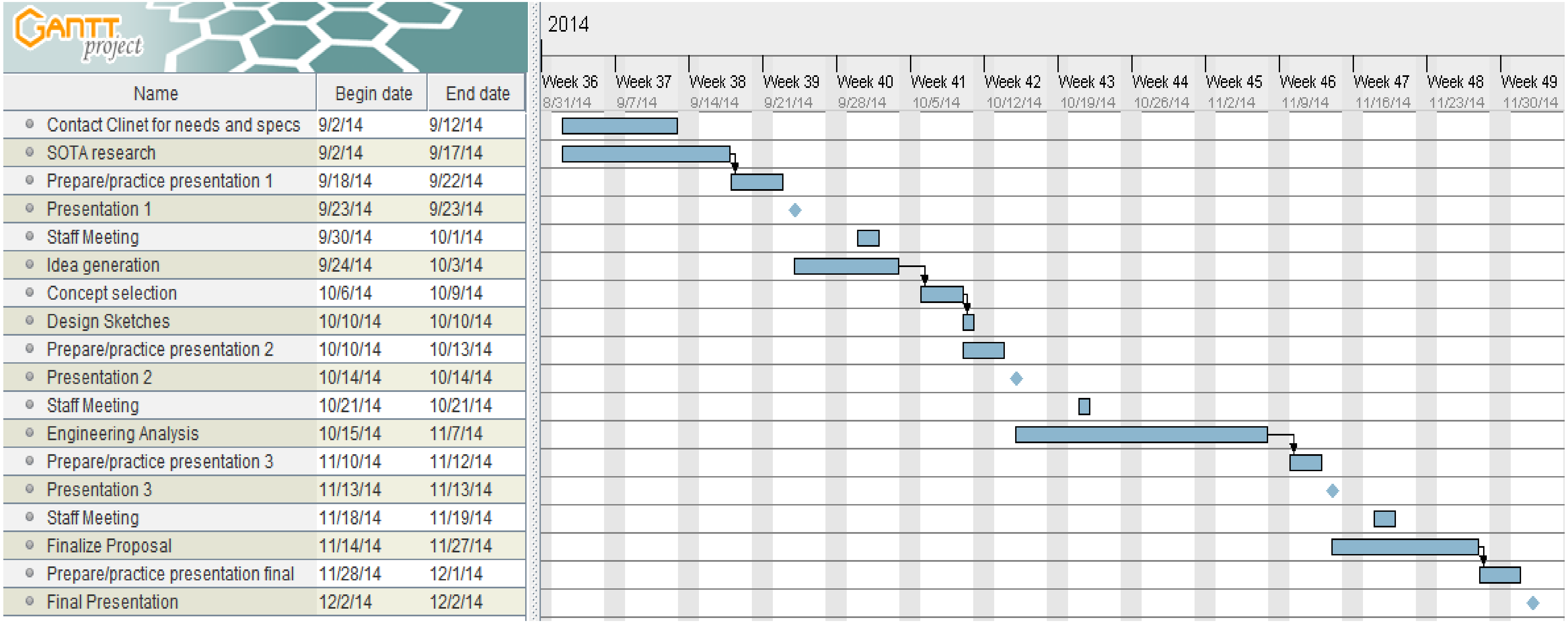
- ½ gallon, plastic fuel tank
- Internal combustion powered
- Metal engine and muffler housing
- Starter assembly is plastic and metal
- Plastic prop protection
- Control handle included
- Throttle control
- Exhaust valve
- Must be 18 pounds or less
- Must provide at least 50 pounds thrust

Problem Definition

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

[1]

Gantt Chart



Name	Begin date	End date
Contact Clinet for needs and specs	9/2/14	9/12/14
SOTA research	9/2/14	9/17/14
Prepare/practice presentation 1	9/18/14	9/22/14
Presentation 1	9/23/14	9/23/14
Staff Meeting	9/30/14	10/1/14
Idea generation	9/24/14	10/3/14
Concept selection	10/6/14	10/9/14
Design Sketches	10/10/14	10/10/14
Prepare/practice presentation 2	10/10/14	10/13/14
Presentation 2	10/14/14	10/14/14
Staff Meeting	10/21/14	10/21/14
Engineering Analysis	10/15/14	11/7/14
Prepare/practice presentation 3	11/10/14	11/12/14
Presentation 3	11/13/14	11/13/14
Staff Meeting	11/18/14	11/19/14
Finalize Proposal	11/14/14	11/27/14
Prepare/practice presentation final	11/28/14	12/1/14
Final Presentation	12/2/14	12/2/14

Table 1: Gantt Chart and Deliverable schedule.

QFD

Aquascooter QFD Matrix	Weight	Buoyancy	Fuel Capacity	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	lb.	lb.	gal.	lb.	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

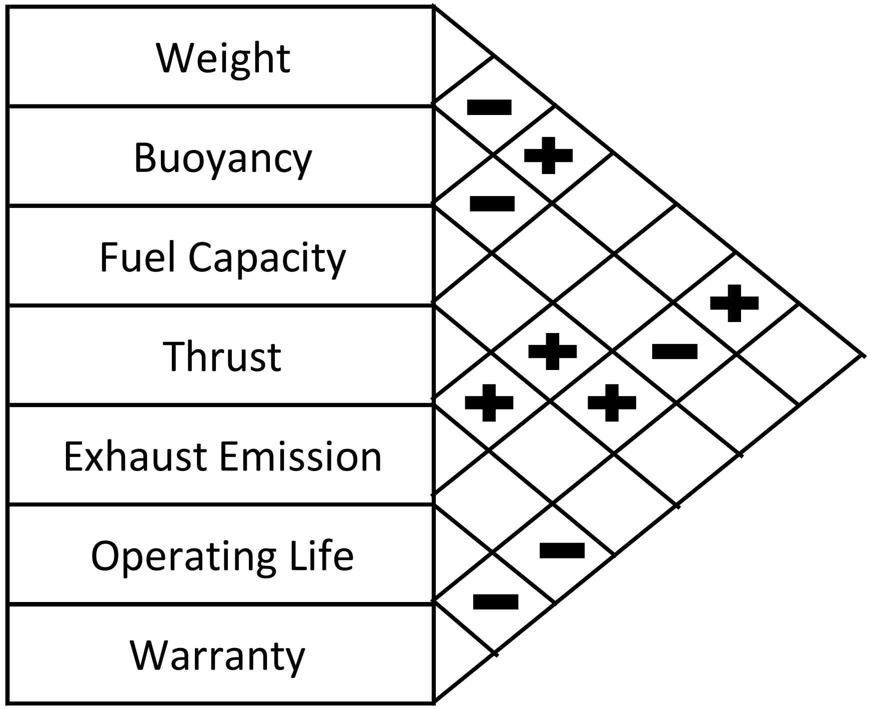


Table 3: House of quality correlates engineering requirements.

Team Concepts

- Boomerang
- Octopus
- Magneto Hydrodynamic Propulsion System
- Propane Injected 4-Stroke
- Duck Scooter
- Tank Housing
- 2 Propeller
- 4 Mix Engine
- Enclosed Housing
- Adjustable Jet
- Catalytic Converter and Coil
- Fuel Injected 2-Stroke

Decision Matrix

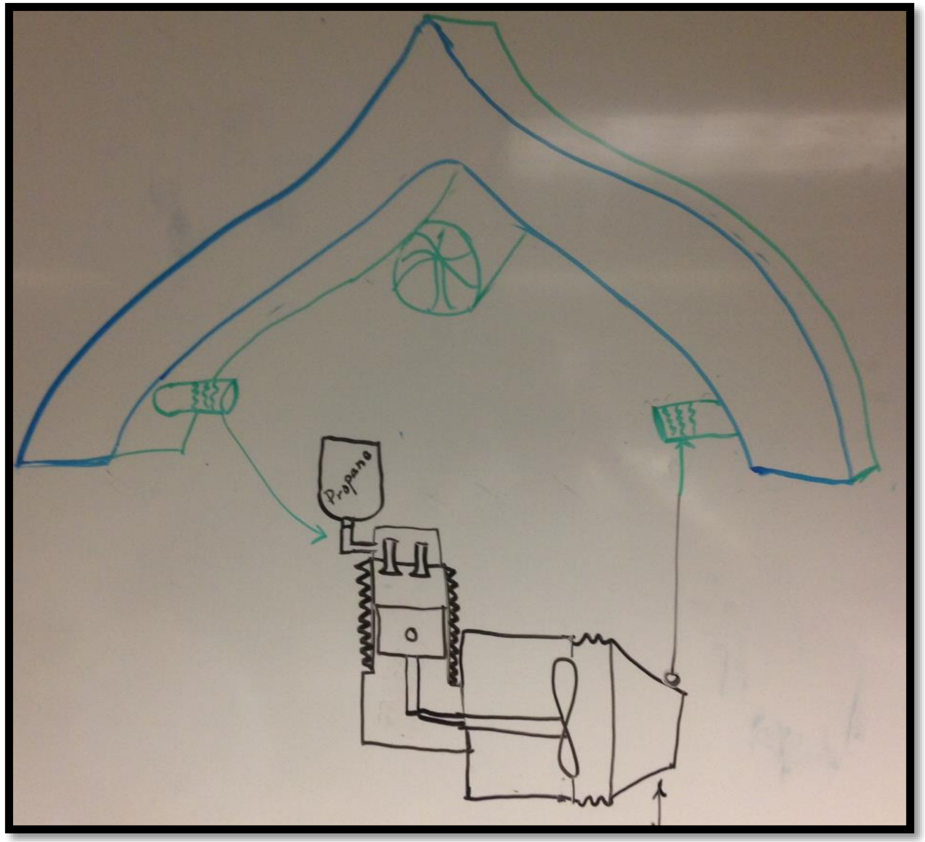
	Requirements and Criteria									
	Aesthetically Pleasing	Minimal Probability of Error	Ease of Manufacture	EPA Requirements	Complexity of Design	Provides Thrust	Hydrodynamic Efficient	Lightweight	Minimal Cost of Materials	**Total Weighted Factor**
Requirement Weighting	10%	10%	10%	20%	10%	10%	10%	10%	10%	**100%**
Boomerang	7	6	5	7	5	8	8	6	7.5	**6.65**
	0.7	0.6	0.5	1.4	0.5	0.8	0.8	0.6	0.75	
Octopus	6	3	4	7	4	8	6	6	5	**5.6**
	0.6	0.3	0.4	1.4	0.4	0.8	0.6	0.6	0.5	
Magnetohydrodynamic propulsion	5	3	3	7	2.5	9	6	4	3	**4.95**
	0.5	0.3	0.3	1.4	0.25	0.9	0.6	0.4	0.3	
Propane injected 4 stroke	7	7	7	8	7	5.5	7	6	5	**6.75**
	0.7	0.7	0.7	1.6	0.7	0.55	0.7	0.6	0.5	
Duck Scooter	8	6	6	6	6	7.5	5.5	6	5	**6.2**
	0.8	0.6	0.6	1.2	0.6	0.75	0.55	0.6	0.5	
2 Propeller	8	6	6	7.5	5	8.5	7	5.5	6	**6.7**
	0.8	0.6	0.6	1.5	0.5	0.85	0.7	0.55	0.6	
4 Mix Engine	6.5	7	8	8.5	7	9	7	6	5	**7.25**
	0.65	0.7	0.8	1.7	0.7	0.9	0.7	0.6	0.5	
Enclosed Housing	7.5	8	6	7	5	9	7	6	5	**6.75**
	0.75	0.8	0.6	1.4	0.5	0.9	0.7	0.6	0.5	
Adjustable Jet	7	6	6	8	6	8	8	6	6.5	**6.95**
	0.7	0.6	0.6	1.6	0.6	0.8	0.8	0.6	0.65	
Catalytic Converter and Coil	6	5.5	5	8	5	7	6.5	7	5	**6.3**
	0.6	0.55	0.5	1.6	0.5	0.7	0.65	0.7	0.5	
Fuel Injected 2 Stroke	7	5.5	5	8	5	9	7	7.5	4	**6.6**
	0.7	0.55	0.5	1.6	0.5	0.9	0.7	0.75	0.4	
Tank Housing	7.5	5.5	6	6	5.75	9	7.5	7	5.5	**6.575**
	0.75	0.55	0.6	1.2	0.575	0.9	0.75	0.7	0.55	

Criteria

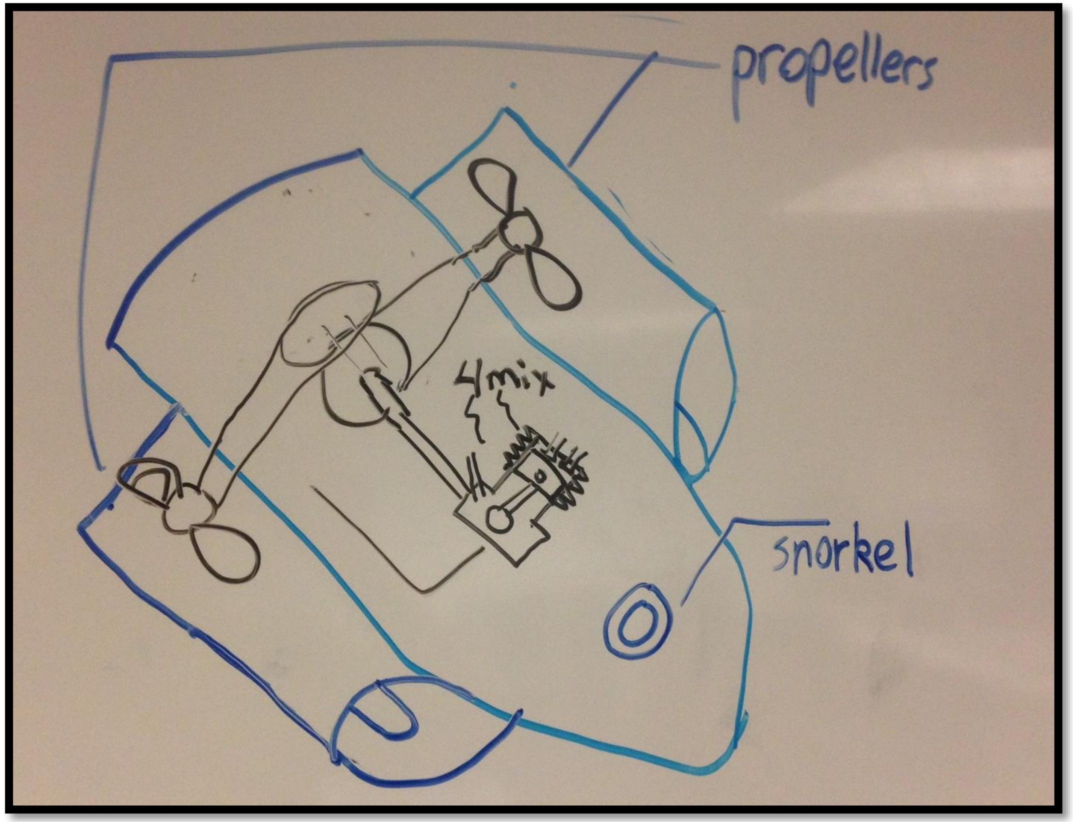
• Aesthetically Pleasing	10%
• Minimal Probability of Error	10%
• Ease of Manufacture	10%
• EPA Regulations	20%
• Complexity of Design	10%
• Provides Thrust	10%
• Hydrodynamically Efficient	10%
• Lightweight	10%
• Minimal Cost of Materials	10%

Top Two Ideas

- Boomerang with 4-stroke Propane Engine with Adjustable Jet



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



Concept Analysis

- Gasoline Analysis
- Propane Analysis
- Butane Analysis
- Shell Analysis

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Gasoline Analysis

Dimensions	Aqua Scooter 2-Stroke Engine (AS 650)	4-Stroke Engine (Honda GXH50)
Length (mm)	530	225
Width (mm)	195	274
Height (mm)	320	353
Weight (lb)	16.53	12.1
Bore (mm)	40	41.8
Stroke (mm)	39	36
Displacement (cc)	49	49.4
Power (HP)	2	2.1 @ 7000rpm
Thrust (kg)	22	22
Fuel	Mixture	Unleaded 87 Octane or Higher
Fuel Tank Capacity (L)	2	1.89271
Price ($)	(+/-) 970	420

[1]

[2]

Propane and Butane Analysis

- Assumptions
  - Calculated using Honda GXH50 converted to propane or butane.
  - Running time of 3 hours.
  - Not Adjusted for Efficiency.
- Results
  - Calculated weight of propane is 12.52 ounces.
  - Calculated weight of butane is 12.50 ounces.

Velocity Based on Thrust Calculations

Variable Values

- $V_e = 2.235 \left[\frac{m}{s}\right]$
- $T = 50lbf * \frac{4.448N}{1\ lbf} = 222\ [N]$
- $A = 0.0324\ [m^2]$
  - $diameter = 8in = .2032m$

- $T = \dot{m}V_e - \dot{m}V_o$
- $\dot{m} = \rho V_i A$
- $T = 2\rho A V_i^2$
- $T = \rho V_i A(V_e - V_0)$

Chemical Calculations

Propane Stoichiometry

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

Butane Stoichiometry

- $C_4H_{10} + 9O_2 + 33.84N_2 \rightarrow 4CO_2 + 10H_2O + 33.84N_2$

Air Fuel Ratio Calculations

AF Ratio for 87 Octane is 15:1

AF Ratio for Propane

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

AF Ratio for Butane

- $M_{air} = 28.97$
- $M_{butane} = 58.12$
- $AF_{butane} = (5 + 33.84) * \frac{28.97}{58.12}$
- $AF_{butane} = 21.36 \frac{lb\ air}{lb\ butane} : 1$

Shell Analysis

Drag Force

$F = 0.5\rho V^2 C_d A$

Where:

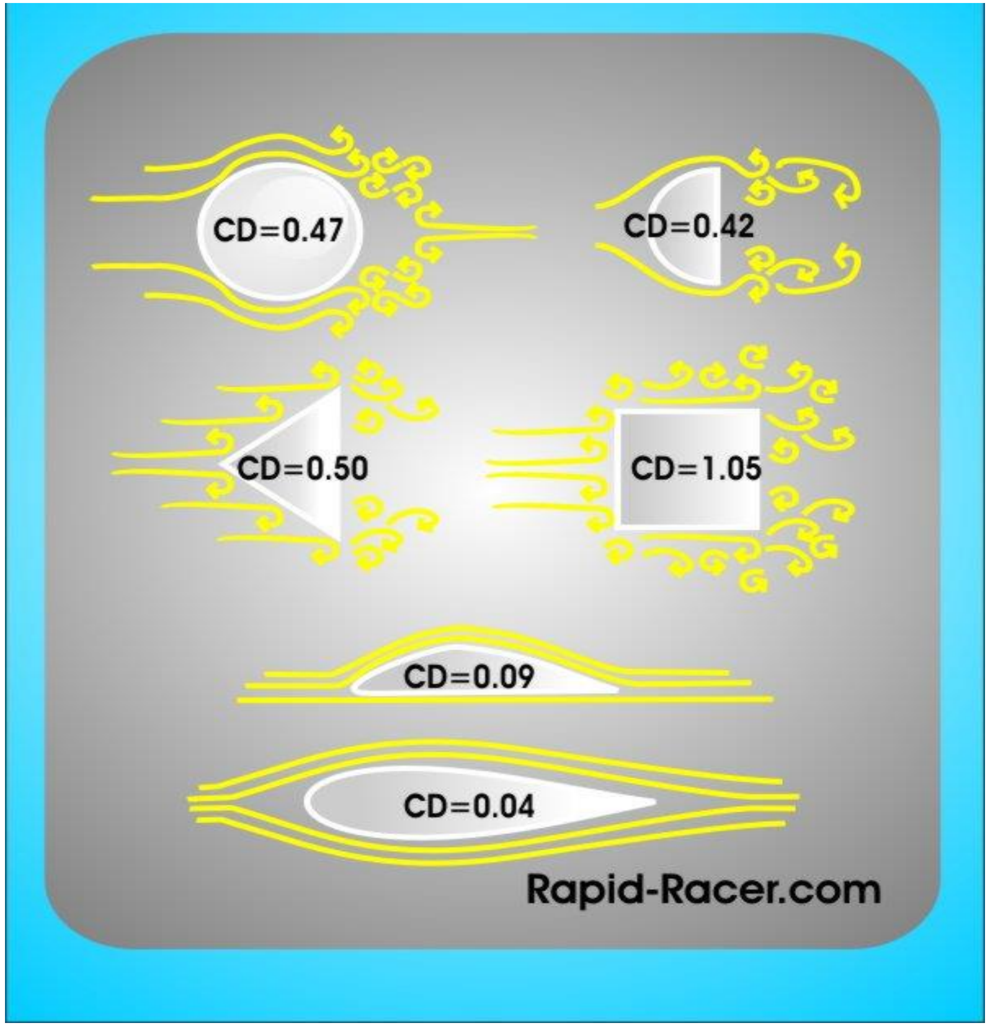
$F = Drag\ force\ [N]$

$\rho = Density\ \left[\frac{kg}{m^3}\right]$

$V = Velocity\ \left[\frac{m}{s}\right]$

$C_d = Drag\ Coefficient\ [\text{unitless}]$

$A = Area\ orthogonal\ to\ flow\ [m^2]$



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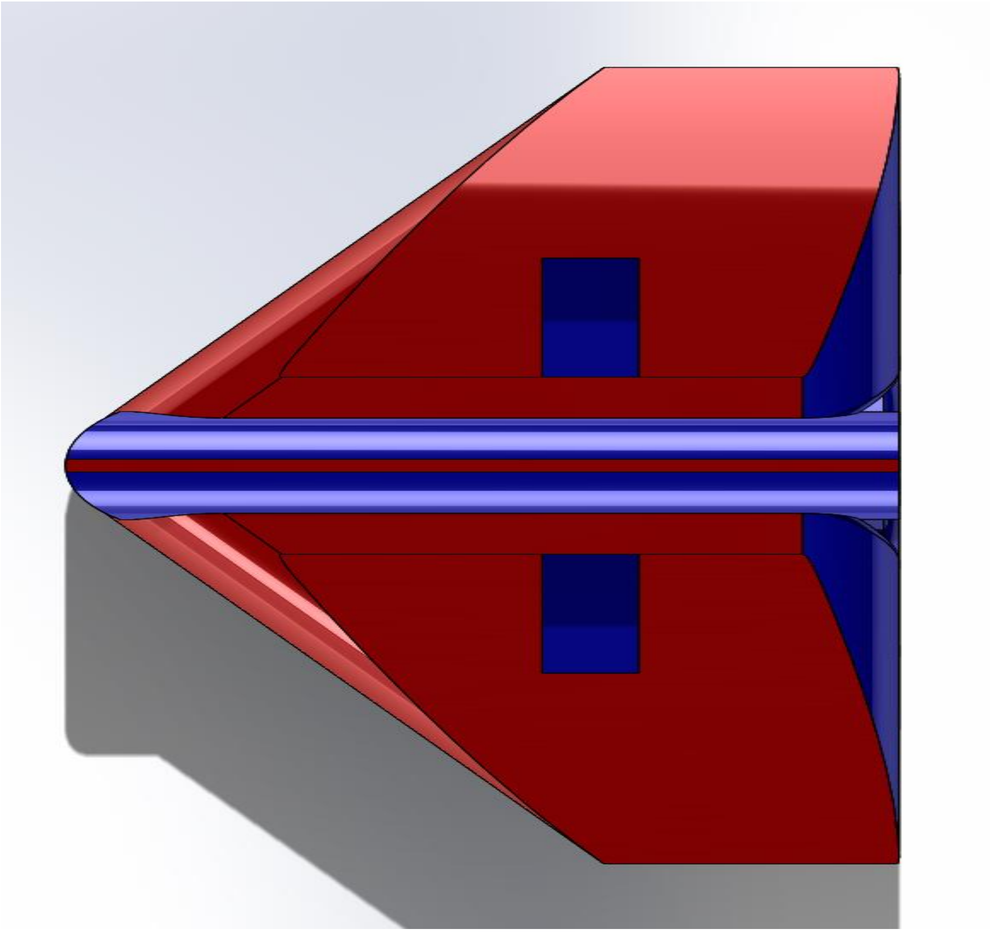
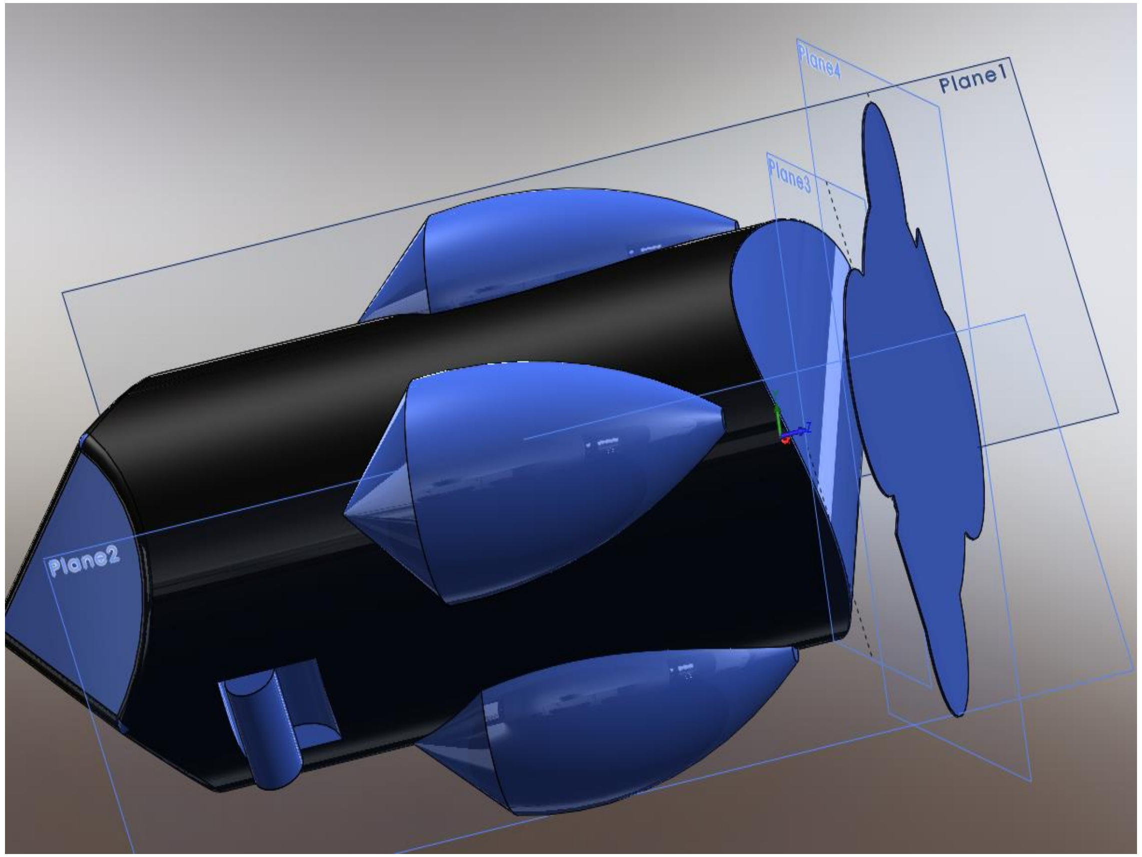
Shell Analysis- Boomerang

- **Assumptions**
  - $C_d = 0.5$
  - $A = 1106.3in^2 = 0.714m^2$
  - $\rho = 999\frac{kg}{m^3}$
  - $V_e = 2.235 \left[\frac{m}{s}\right]$
- **Drag Force**
  - $F = 0.5\rho V^2 C_d A$
  - $F = 0.5(999)(2.235^2)(.5)(0.714)$
  - $F = 890.75\ N$



Shell Analysis- Triton

- **Assumptions**
- $C_d = 0.10$
- $A = 513.20in^2 = 0.3311m^2$
- $\rho = 999\frac{kg}{m^3}$
- $V_e = 2.235\ \left[\frac{m}{s}\right]$
- **Drag Force**
- $F = 0.5\rho V^2 C_d A$
- $F = 0.5(999)(2.235^2)(.1)(0.3311)$
- $F = 82.6N$



Power Calculation

- $V_e = 2.235 \left[\frac{m}{s}\right]$
- $\mathcal{P}_d = \boldsymbol{F}_d \cdot \boldsymbol{v}$

$$= \frac{1}{2}\rho v^3 A C_d$$

- $\mathcal{P}_{d(boomerang)} = 1990.82W = 2.669hp$
- $\mathcal{P}_{d(Triton)} = 184.611W = 0.2475hp$

Final Concept Considerations

- Conversion Kits
- 2-Stroke Engines
- 4-Stroke Engines

- Emission Testing
  - Portable Devices
  - On-Site Testing
- Testing Environment
- Cost of Materials

Conversion Kits: Butane and Propane

- Alt Fuel
  - Regulators
  - Fuel Line
  - Attachment Line
  - Intake Adaptor
  - Bracket for Tank
- Propane Carbs
  - Spud-In Conversion System
    - Fuel Tube
    - Regulator
    - Vacuum Idle Needle

Husqvarna 2-Stroke Engine

- $169.00
- 9.7lbs Full Dry Weight
- 28cc Displacement
- 68.5 g/kWh

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Tanaka Two-Stroke Engine

- $200.00
- 1.3HP
- 11lbs

[17]

Briggs & Stratton 4-Stroke

- $ 199.00
- 1-HP
- 40cc Displacement
- 8lbs Dry Weight

[18]

Honda GX-25 4-Stroke Engine

- $240.00
- 1-HP
- 25cc Displacement
- 6.8lbs Dry Weight

[19]

Emissions Testing

Portable Emissions

- Enerac-500-102
  - $870.00

On Location Testing

- Carnot emission services 210-928-1724
  - Gary
  - $5000.00
- Olson-Ecologic Engine Testing Laboratories 714-774-3385.
  - David Olson
  - Currently Researching How to Test
- Deer Valley Emissions Test
  - 501West Deer Valley Road, Phoenix, AZ 85027

Campus Testing Environment

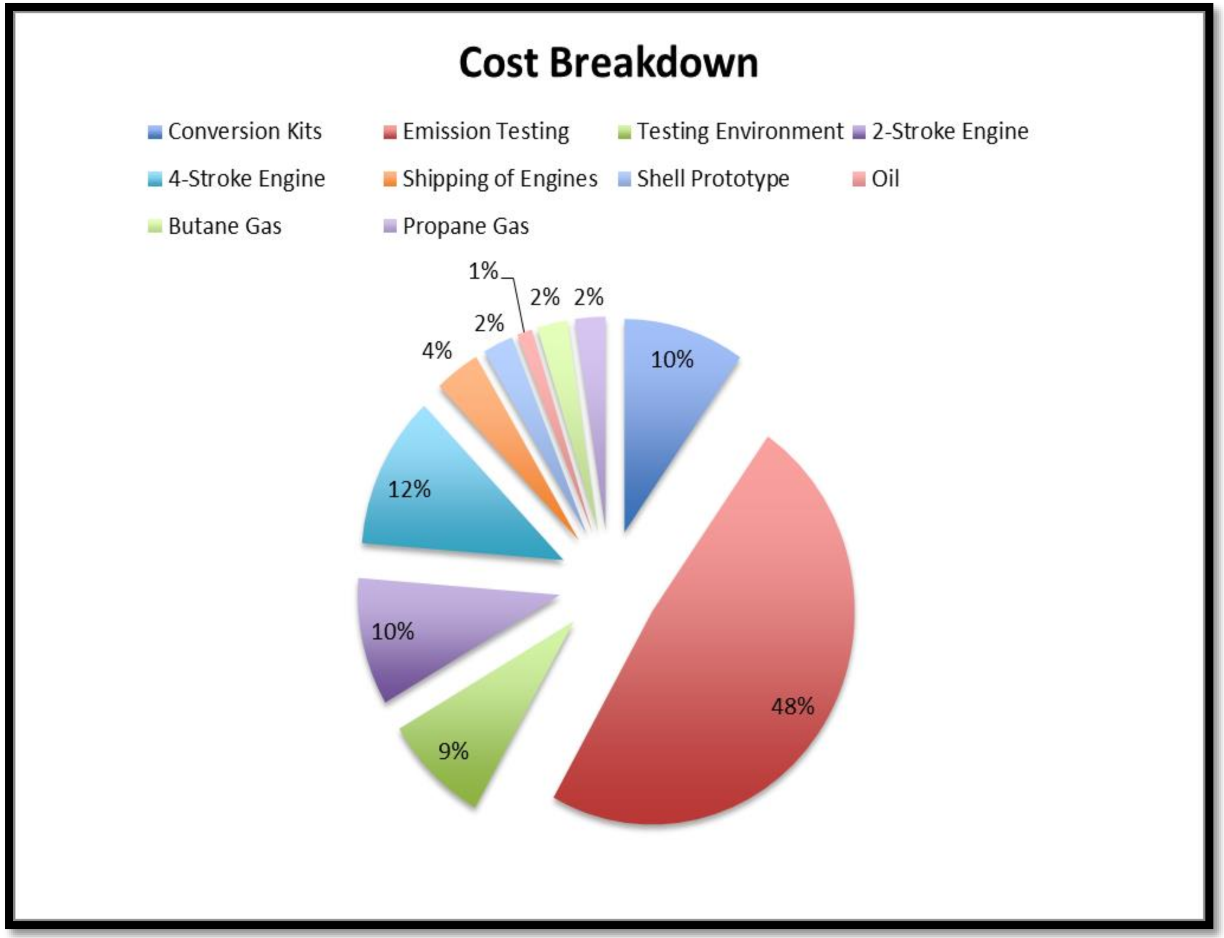
- 150 Gallon Tank
  - $175.00
  - Check with Biology

- Trough Pool
  - $104.00
  - Used stores
  - Craigslist

[1],[13]

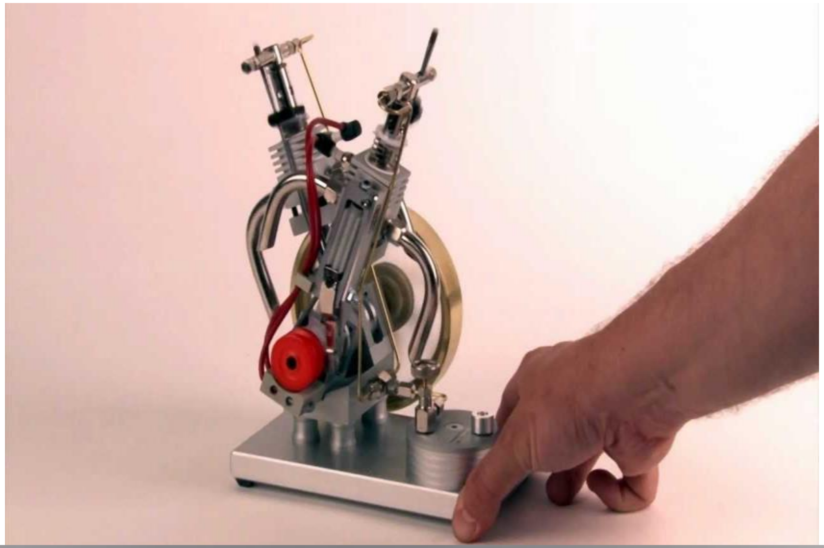
Cost of Materials

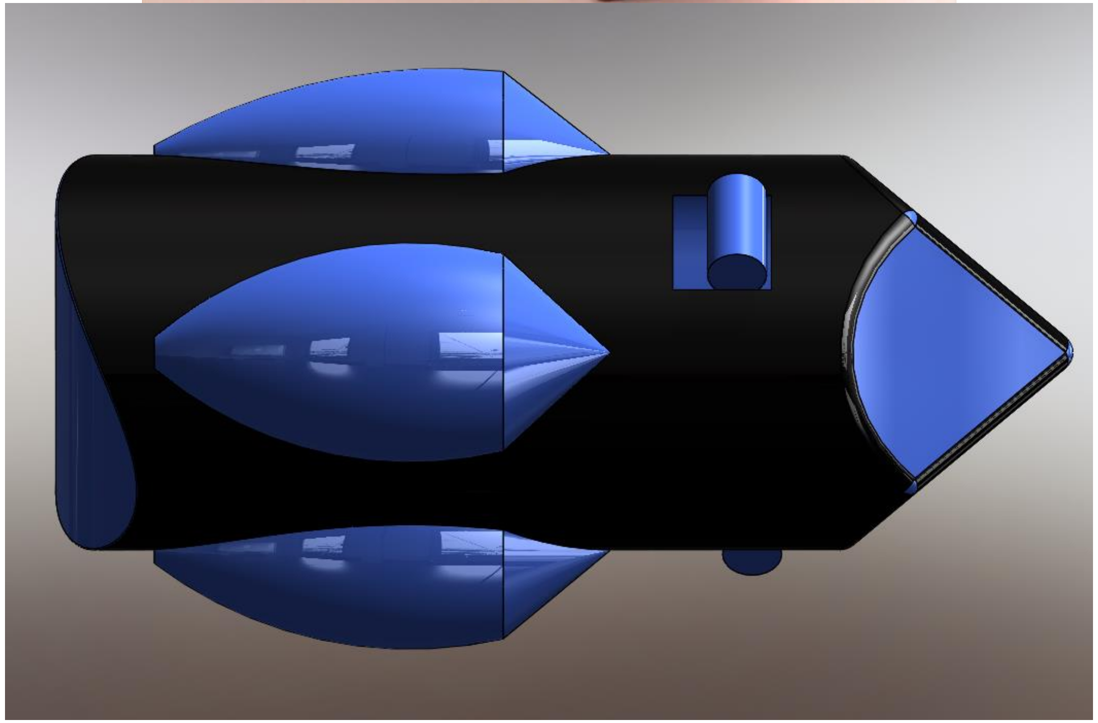
Item	Cost A	Cost B	% of Total	% of Total
Conversion Kits	$ 250.00	$ 250.00	9.69%	5.92%
Emission Testing	$ 1,000.00	$ 867.00	48.43%	51.33%
Testing Environment	$ 175.00	$ 104.00	8.47%	6.16%
2-Stroke Engine	$ 200.00	$ 169.00	9.69%	10.01%
4-Stroke Engine	$ 240.00	$ 199.00	11.62%	11.78%
Shipping of Engines	$ 75.00	$ 75.00	3.63%	4.44%
Shell Prototype	$ 50.00	$ 50.00	2.42%	2.96%
Oil	$ 25.00	$ 25.00	1.21%	1.48%
Butane Gas	$ 50.00	$ 50.00	2.42%	2.96%
Propane Gas	$ 50.00	$ 50.00	2.42%	2.96%
	$ 2,065.00	$ 1,689.00		



Conclusion

- Butane and Propane are viable options for engine fuel
- $\downarrow C_d \downarrow F_d$
- Testing Environments
  - Trough
- 2-Stroke
- 4-Stroke
- Emissions Testing
- Cost of Materials





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Any Questions?