AquaScooter2

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Concept Generation and Selection
Document

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ABSTRACT

The objective of this proposal is to present the problem definition and schedule of the Aqua Scooter capstone project. The Aqua Scooter has a two cycle gas powered engine that, as of January 2010, the EPA's regulations prevent future sales. The capstone team needs to design and engineer a new engine which meets current and immediate future EPA regulations.

This report gives the background information pertaining to the emissions along with the current technology and some possible solutions. The constraints provided by the client to the Aqua Scooter team are given and some particular. A decision matrix was constructed by the group to assist in selecting possible solutions for the project. Finally, a schedule of deliverables is provided for the first semester of the project.

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1. INTRODUCTION

1.1.1 Product and Client Information

Aqua Scooter is a portable, submersible, gasoline powered water craft for individual use. Aqua Scooter is family owned and operated out of Sedona, Arizona. The client for this project (R.S.W. /D.I. Inc) is the owner and CEO of Aqua Scooter. The current device design is shown in Figure 1 and Figure 2. The numbered component descriptions are found in the Appendix of this report. The design incorporates a 2-stroke engine which provides approximately 2HP of power to the user. The scooter provides around 5 hours of operating time with a 2 L fuel tank capacity.

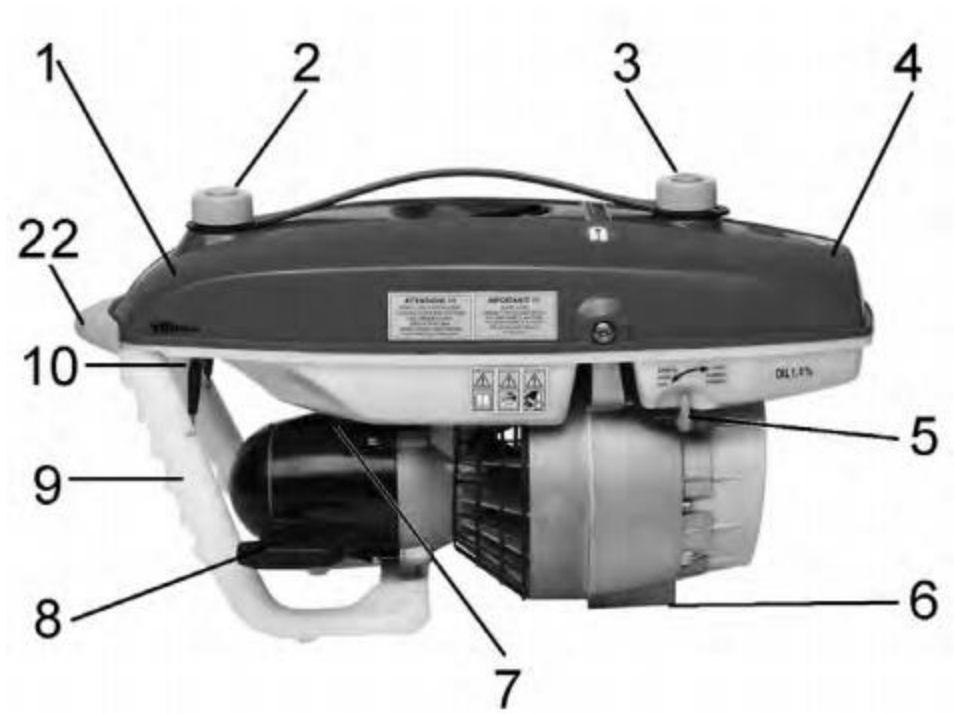


Figure 1: Aqua Scooter side view with designated components

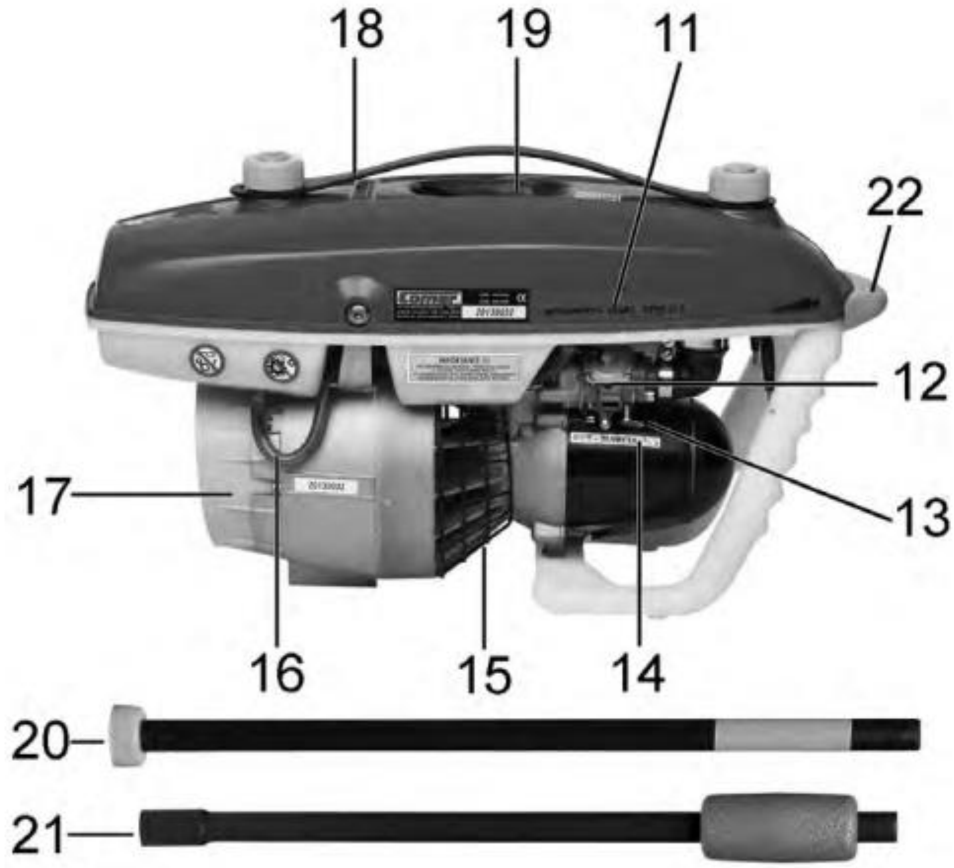


Figure 2: Aqua Scooter with designated components and snorkel extension

1.1.2 Background

A chemical technician by the name of Bernd Boettgers wanted to escape from East Germany, but he knew he would need some type of machine to help pull him through the sea. His first attempt to test his "water-machine" resulted in an arrest and jail time of three months. He was convicted of an illegal attempt at border crossing. After he was released, he decided to work on a second machine, and after a year of building, he entered the sea in September of 1968 for his second attempt. He traveled by water for six hours, two of which were done fully submerged under the sea, until he was finally spotted by the Danish Lightship, named Gedser. His successful escape broke into the European Press, and by the end of January in 1978 the "Aqua Scooter" had been brought to the United States and the first commercial prototype was successfully tested.

1.1.3 Aqua Scooter Emissions

The current 2-stroke, direct drive engine does not comply with EPA regulations. As a result, the client is unable to sell the Aqua Scooter in the United States. The current emission standards that the Aqua Scooter must meet are as follows:

- It must have less than or equal to 30 g of hydrocarbons
- Less than or equal to 490 g of carbon monoxide per kilowatt hour.

Emissions testing will be done by either the Arizona Department of Transportation, or Arizona Game and Fish Department.

1.1.4 Why Test for Emissions

A good questions one might find themselves asking, is why test for emissions? What benefits does it bring to the customer, if any, and why is it important to pass? It turns out that passing an emissions test and just taking the test in general, brings several advantages. Here are three reasons why emissions testing are very important:

1. It identifies necessary repairs to improve vehicles performance and fuel economy
2. It improves air quality by reducing carbon monoxide, hydrocarbons, and nitrogen oxides
3. If emission controls are not working properly, testing ensures that owners make the appropriate repairs to aid in the reduction of ground level ozone

Although testing for emissions improves the air quality for everyone around you, it also turns out that emission testing also brings several benefits to the customers themselves.

1.2 Current Technology

The group researched two and four stroke engines for this project. The current technology on the market is available to implement in a possible solution for our client. Options available in the current market are conventional gas models or alternatives such as propane or compressed natural gas.

1.2.1 Material Properties

The materials for the new design need to be lightweight so that the Aqua Scooter can float. The new scooter should also have materials strong enough to support its own weight and handle the pressure exerted when submerged to maximum operating depth. The manufacturing of the device will also need to be considered when selecting the materials so that the cost of making the new design is still feasible.

1.2.2 Possible Solutions

Current solutions to the problem are either a four stroke internal combustion engine or a fuel injected two stroke internal combustion engine. The issue with the four stroke solution is implementing an engine that is light enough to meet the weight and thrust constraints. Research to resolve this issue has been focused primarily on compressed fuels contained in cylinders. There may be an advantage in losing the weight of a gas tank to lighten the overall weight of the machine. As for the two stroke solution, current technology is available that monitors and controls fuel intake to minimize the unburned amounts of fuel that enter the atmosphere as seen with previous two stroke models. Fuel system modification, along with implementing biodegradable two stroke oils that are also recently available, can be a viable solution in designing a product that meets current EPA requirements.

1.2.3 Summary

The Aqua Scooter is a machine that has been useful for over four decades. The power system that the machine has used since its origin is obsolete based on current environmental regulations. In order for the Aqua Scooter to keep fulfilling the legacy it has created, the team has been tasked with redesigning the device. This will be accomplished through testing and implementation of state of the art technology in the field of materials, as well as internal combustion engines.

2. PROBLEM STATEMENT

The current design for the Aqua Scooter does not comply with the most recent Environmental Protection Agency's regulations on two-stroke engines for recreational use. In order to have a marketable product, this team will design a hydrodynamic, inexpensive, aesthetically pleasing Aqua Scooter, with a marine engine that complies with EPA regulations.

2.1 Constraints

The prototype needs to meet certain constraints the team has determined based off communication with the client. The constraints are the following:

- Gasoline powered
- Engine housing must be metal
- Muffler housing must be metal
- Throttle control
- Exhaust valve
- Starter assembly made of plastic and metal
- Plastic propeller protection
- Control handle
- Plastic fuel tank, with minimum volume of ½ gallon
- Must have a dry weight of 18 lbs. or less
- Must be buoyant enough to float itself
- Must provide at least 50 lbs. thrust
- Must cost no more than $450 per scooter manufactured

2.2 Quality Function Deployment (QFD)

Table 1: Quality function deployment showing the engineering requirements and customer needs.

Aqua Scooter 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 regulations					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		

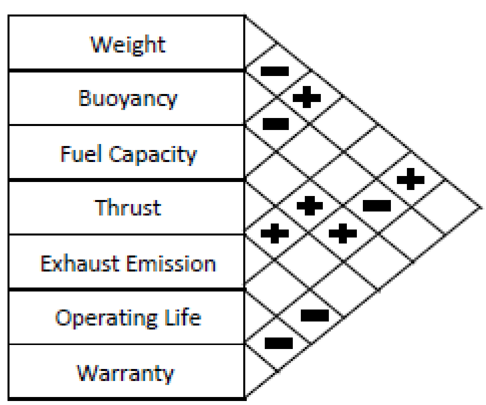
2.3 QFD Summary

The QFD matrix (Table 1) above is useful for correlating the needs of the customer to the requirements that the team can quantify. The requirements that need the most attention based on the matrix are exhaust emissions, fuel capacity, weight, buoyancy, and thrust. The exhaust emissions carry a significant amount of weight due to the fact that without falling below the constraint, the new design will not meet EPA regulations. This is not a desirable outcome because that is the main problem the current Aqua Scooter design is facing. Secondly, the weight of the machine is important because that affects the buoyancy, as well as how much exhaust gas the engine emits. For example, the heavier the device is, the harder the engine will have to work to propel the device and operator through the water. Moving forward, keeping the needs, requirements and constraints in mind will be crucial in developing an effective alternative to the current Aqua Scooter model.

2.4 House of Quality

The house of quality (Table 2) correlates the engineering requirements that are listed for this particular project. If the requirement is positively correlated, indicating that the increase of a particular item produces the same effect on another requirement, a (+) symbol is shown. If the requirements are negatively correlated, a (-) symbol is shown. If there is no correlation the space is left blank.

Table 2: House of quality, which correlates engineering requirements



3. TESTING ENVIRONMENT

Since the Aqua Scooter will need to be completely submerged in water, it is only fitting to test the prototype in a body of water large enough to assess the functionality. All the aspects of testing (i.e. thrust, weight, and functionality of all parts, fuel efficiency, and buoyancy) will take place in Lake Mary. Additionally, final testing will be conducted in a saltwater environment that is identical to the environment where our product will be marketed for use. The team will plan to test the design in the Pacific Ocean in San Diego.

To insure that the prototype engine will meet EPA regulations, emissions testing will take place at the facilities of Arizona Department of Transportation, or Arizona Game and Fish Department. They engine will be attached to a device where the results will validate the condition of emissions and whether the engine will comply with EPA requirements.

4.0 CONCEPTS

Each team member was required to develop two ideas individually. The concepts generated needed to address one of the two main client needs: EPA regulations and streamlined design.

4.1.1 Catalytic Converter with Heating Element

Using the existing Aqua Scooter design, a catalytic converter would be added to the current 2-stroke engine. Adding a catalytic converter would mean creating an exhaust system that does not currently exist on the Aqua Scooter. An exhaust system would need to be safely located so the user does not unintentionally interact with the hot exhaust system (Figure B1, Appendix B). The catalytic converter will have a heating element in order for the redox reaction within occurs spontaneously while in an environment where convection will constantly cool the craft. The catalytic converter should effectively reduce the output of nitrous oxides and unburned carbon groups, which is the current problem with using a 2-stroke engine to power the Aqua Scooter.

4.1.2 Enclosed Housing

The current Aqua Scooter design has the engine in direct contact with the environment. This means during operation the Aqua Scooter is submerged in water. Prolonged contact with water or saltwater causes material damage, which would reduce the functional life of the engine. To increase the functional life of the engine it would be completely enclosed in a hard, watertight polymer. There are design concepts that would require the engine to be in contact with air; the enclosed housing could be modified for these designs if need be (Figure B2, Appendix B).

4.1.3 Fuel-Injected Two Stroke Engine

This design concept is in regards to finding a solution to engineer a new Aqua Scooter that will meet the latest EPA regulations. It is a fuel injected 2-stroke engine. The reason the current Aqua Scooter model is not meeting EPA regulations is because the two stroke engine uses a carburetor to introduce the air and fuel into the engine, and ultimately into the combustion chamber. As a result, unburned fuel was escaping out of the exhaust port, leading to higher emissions and poor fuel economy. The direct fuel injected system directly injects the fuel into the combustion system, after the exhaust port is closed. In this way, no fuel escapes out of the exhaust, and this results in good fuel efficiency and very low emissions. The downside to implementing this design is the price and computational aspect. A fuel injector kit can start anywhere from $500, way too expensive to consider its use. Unfortunately, even after purchasing the kit, the setup of the computational device is very complex. In short, the electronic fuel injection computational system assists in the timing of injecting the fuel into the chamber of the engine. For these reasons, this design concept may not be considered for final application. Refer to Figure B3 in Appendix B, for a concept design sketch.

4.1.4 Magneto Hydrodynamic Propulsion (MHP) System

The MHP system is a concept primarily for thrust and emissions rather than aesthetics. The system consists of an engine, a generator, and two metal plates. The engine would be a four stroke to ensure that the system has the capability to meet EPA regulations.

The MHP system drives the Aqua Scooter with thrust created from rapid hydrolysis. This is achieved with the engine powering the generator that magnetically charges the two plates that are angled toward each other. The magnetic charge between the two plates excites the water molecules (hydrolysis) causing them to expand rapidly. The rapid change in volume forces the water between the two plates to thrust through the nozzle shape that is created by having the plates oriented at an angle. (Figure B4, Appendix B)

4.1.5 Nozzle Concept:

A conventional 4-stroke engine powers an impeller with a drive shaft. The impeller pulls water through the intake and compresses it out through a nozzle in the rear of the craft (Figure A5, Appendix A). The nozzle can be angled differently for different thrust vectors. The angle of the nozzle can be set up to be controlled one of two ways. The first way is to connect the nozzle to the handles of the craft in a way, which would allow the user to manipulate the nozzle in vertical and horizontal directions. The second way would be to have the vertical movement of the nozzle controlled by a system that could be fixed in position for the duration of use and the horizontal movement be controlled by the user moving the craft. The 4-stroke engine would be within EPA regulations for emissions, while the nozzle would add functionality to the entire Aqua Scooter system. (Figure B5, Appendix B)

4.1.6 Propane Injected 4-Stroke

The propane injected 4 stroke is also aimed at achieving EPA regulations in regards to the engine. The system consists of a conventional 4-stroke engine that is altered to allow for the use of propane, rather than gasoline, to run the engine. The reason to convert to a propane system is that propane has been proven to burn cleaner which reduces exhaust emissions when compared with gasoline engines. Cleaner emissions mean an engine that is more environmentally friendly and passes EPA regulations. (See Figure B6, Appendix B)

4.1.7 4 Stroke Mix Engine

The 4-stroke mix engine is a hybrid of both a 4-stroke engine and a 2-stroke engine. It has the emissions similar to 4 stroke engines, while utilizing a similar fuel mixture to a 2 stroke. A 4-stroke engine uses gasoline as fuel and then has an oil tank built into the system, which provides lubrication for the engine. The 4 mix operates with oil and gasoline already mixed together which eliminates the need for oil tanks, pumps, or any other heavy components that are normally part of a 4-stroke engine. This will allow the engine to be lighter while complying with EPA regulations. (Figure B7, Appendix B)

4.1.8 Tank Housing

This concept attempts to highlight an alternative look to the Aqua Scooter that will not only increase its speed from the hydrodynamic design, but will hopefully become more appealing to the customer. The current model is simple, it is somewhat box-shaped and its configuration makes it difficult for it to navigate through the waters. The tank-housing concept is a “sporty” look that will hopefully attract more customers. (Figure B8, Appendix B)

4.1.9 Duck Scooter

The idea of this design comes from the rubber duck that has been on the toy market since the late 1800s. In hoping to attract a younger demographic the outside shell of the Aqua Scooter would be constructed with a plastic duck shape. The design includes a larger fuel tank, which would be located in the head of the duck. The engine for the scooter would be a 4-stroke engine and a single propeller much like the current Aqua Scooter design where it would be located in the body of the duck. The design will meet the EPA regulations. As a result of this design is for child use making the additional requirement for production standards. (Figure B9, Appendix B)

4.1.10 Two-propeller design

This design concept utilizes a similar design to the current Aqua Scooter and will potentially provide more thrust and a larger fuel tank for longer use. The design consists of two propellers that are connected by a belt and pulley system to a single 4-Stroke engine. The current Aqua Scooter design has the engine pushing the water's wake into the user's face. One advantage with the two-propeller design is that the wake will circumvent the user allowing for a more comfortable ride. (Figure B10, Appendix B)

4.1.11 Boomerang

The boomerang concept is designed to allow the user to slice through the water. Marine devices have a rounded or pointed front to help be more hydrodynamic and conserve energy and fuel. The user will have handlebars that allow for the user to adjust the throttle and the angle of the adjustable jet. The system will use one 4-stroke engine and will provide enough thrust to move the user quickly. (Figure B11, Appendix B)

4.1.12 Octopus

The octopus would have engines on each end of the tentacles. Each of the engines would be a 4-stroke engine that keeps the design complying with EPA regulations. Since the design is completely new and not seen on the market, it will be marketable to a different range of customers. The device will also rotate around the user to jet them through the water much like a bullet through the air. (Figure B12, Appendix B)

5.0 DECISION MATRIX

The decision matrix is a tool used to help the group decide on the top two ideas for potential final designs. The team created decision matrix with nine criteria. Each of the criteria was given a specific percentage weight and then all concepts were rated in each category. The weight values range from one to ten, with ten being the most important and one being the least important. Each weight is then multiplied by designated percentage to calculate values. Finally, all team members combined their matrices to eliminate any favoritism and the final matrix is shown in Table 3.

Table 3: Decision matrix with group concepts and criteria.

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

The top concepts in either the engine category or aesthetics category were voted on by the team. These concepts were discussed and two final designs were selected.

6.0 FINAL CONCEPTS

Using the decision matrix above the final concepts for design of the new Aqua Scooter have been narrowed down into two categories: engines and aesthetics. The proposed engine ideas included a fuel injected 2 stroke, a 4 Mix 4 stroke, a propane 4 stroke, and the magneto hydrodynamic propulsion system. The proposed aesthetic designs included: the boomerang, the two propellers, the duck, and the adjustable jet. Through discussion and a voting process two concepts were selected.

6.1.1 Boomerang with Propane and 4-Stroke Engine

The first concept selected utilizes the aesthetics of the boomerang design and combines the propane 4-stroke engine with an adjustable jet. The boomerang design allows for both an aesthetically pleasing design that has good opportunity to create a buoyant vessel, which has appropriate area to include necessary fuel tanks and geometry to create an effective steering system. The nozzle coupled with a propane modified 4 stroke will allow the design to have the necessary thrust required while still meeting EPA emission regulations.

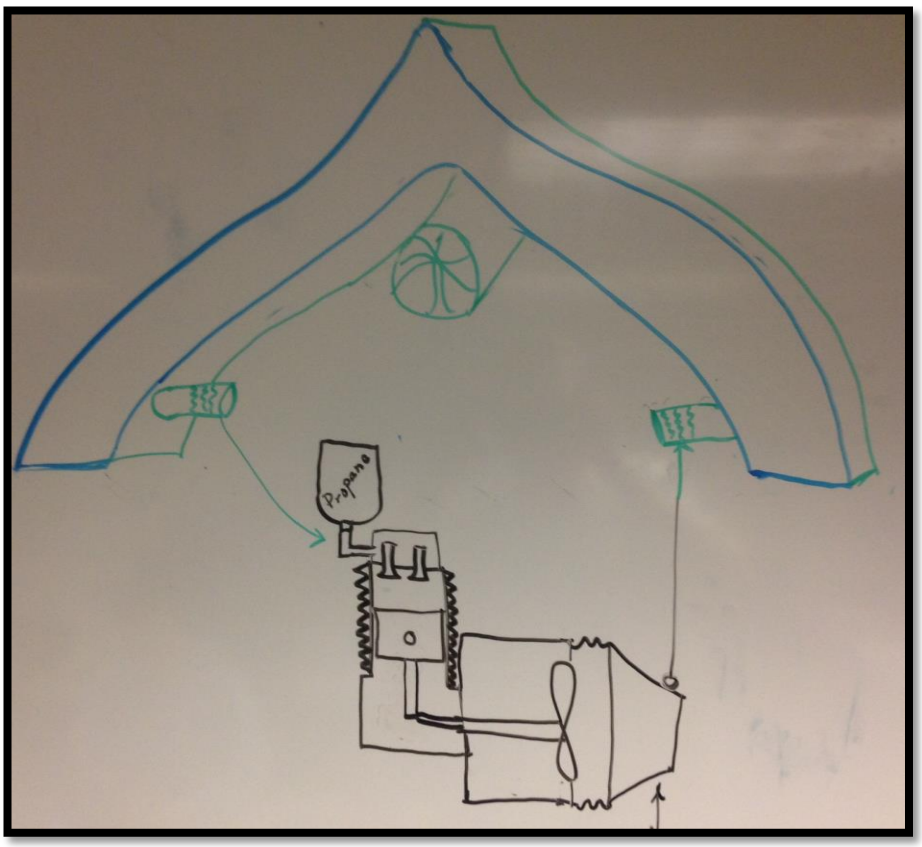


Figure 3: Boomerang with Propane Injected 4-Stroke Engine

6.1.2 2-Propellers with 4-Stroke 4-Mix Engine

The second concept selected utilizes the aesthetics of the two-propeller design and combines the 4 Mix 4 stroke engine and adjustable jet. The two-propeller design is an aesthetically pleasing design, which can house all necessary components for the new

Aqua Scooter while being a more modern design, which should allow the design to be marketable and desired. The use of two propellers that push water through two nozzles will allow the thrust requirement to be obtained by the design. In addition to meeting the thrust requirement the dual nozzles, which are set on either side of the craft, creates thrust on either side of the user rather than pushing water into the user like the current Aqua Scooter. The 4 Mix engine will be able to be housed completely in the two-propeller design and designed such that a single drive shaft from the engine will drive both propellers.

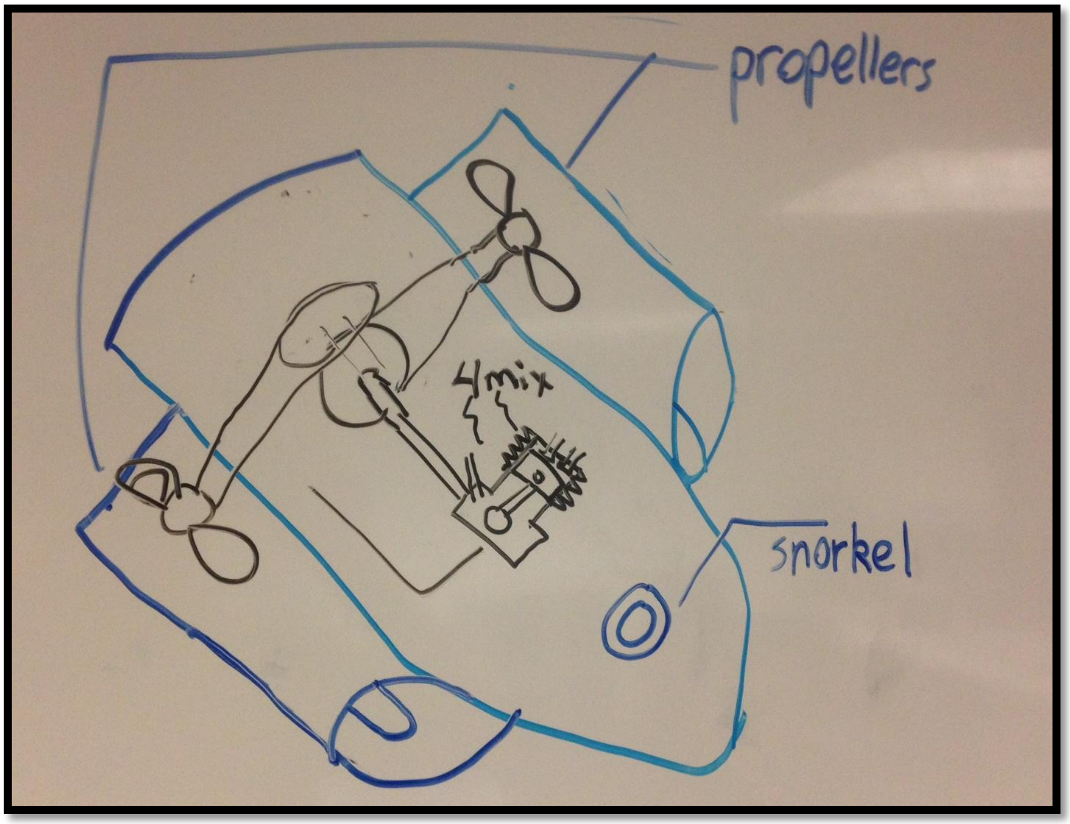


Figure 4: 2-Propeller with Belt and Pulley system Including 4-Stroke 4-Mix Engine

7.0 GANTT CHART

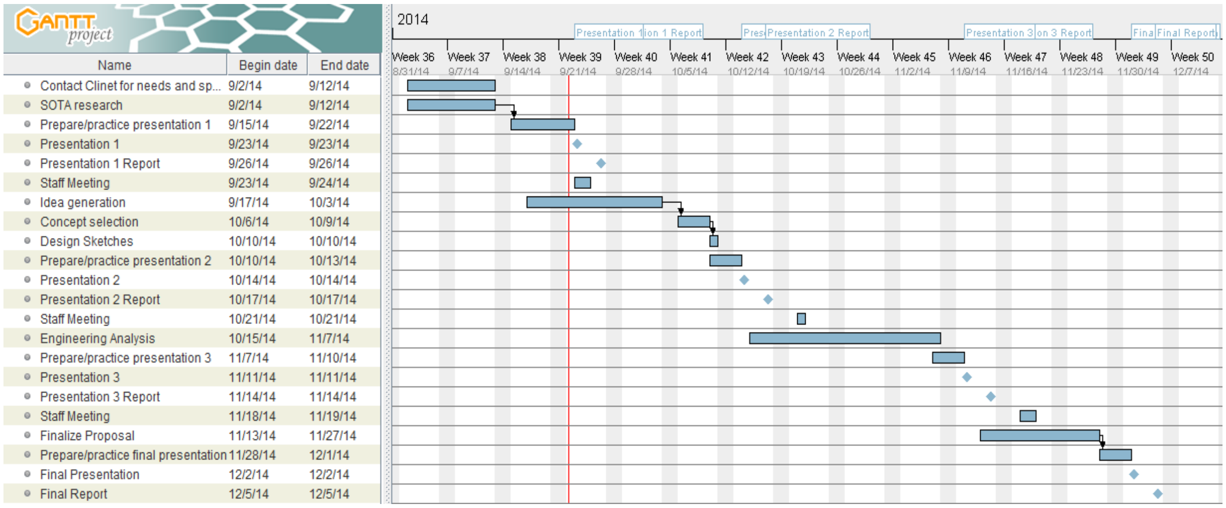


Figure 3: Gantt Chart and schedule of major deliverable and tasks for project.

Figure 3 displays the Gantt chart which illustrates an estimated timeline for the first semester of the Aqua Scooter prototype design. The timeline is broken down into tasks and deliverables. Tasks are shown as blue bars and deliverables are shown as blue diamonds in Figure 3. The deliverables include presentations and reports. Based on the materials required for the presentations, the tasks are laid out in an order such that tasks relevant to specific presentations are completed before the presentation date. This layout ensures everything is completed while also ensuring there are specific timelines for certain tasks. The Gantt chart is a work in progress and may end up changing as the semester progresses to reflect changes in due dates and newly recognized tasks relevant to the prototype design and final proposal for Aqua Scooter.

8.0 CONCLUSION

The client, R.S.W. /D.I. Inc. currently manufactures a product that does not meet current United States' EPA regulations. The objective of this project is to design, engineer, and test an engine that will exceed the current EPA regulations. The most important points to consider for the design of a prototype are to adhere to the EPA regulations, keep dry weight of device under 18 lbs. and provide a capacity of a minimum of 50 lbs. of thrust. Additionally, the team must keep the manufacturing cost per scooter under $450. The team's decision matrix assisted in providing potential solutions for the client. Two concepts were selected and will be analyzed to assess feasibility. The QFD, and House of Quality will ensure that the team complies with the needs of the client, while the Gantt chart will keep the team on track with the deliverable and milestone schedules

REFERNCES

[1] Aqua Scooter Manual. Comer SPA. Accessed 10 Oct 2014. http://www.aquascooter.it/AQUA_GB.pdf

[2] B. Douville, P. Ouellette, A. Touchette and B. Ursu, "Performance and emissions of a twostroke engine fueled using high-pressure direct injection of natural gas," in *1998 SAEInternational Congress and Exposition, February 23, 1998 - February 26,* 1998, .

[3] P. Duret, A. Ecomard and M. Audinet, "A new two-stroke engine with compressed-air assisted fuel injection for high efficiency low emissions applications," in *International Congress and Exposition, February 29, 1988 -March 4,* 1988, .

[4] H. Huang, M. Jeng, N. Chang, Y. Peng, J. H. Wang and W. Chiang, "Improvement of exhaust emissions from a two-stroke engine by direct injection system," in *International Congress and Exposition, March 1, 1993 -March 5,* 1993,

[5] W. Mitianiec, "Direct injection of fuel mixture in a spark ignition two-stroke engine," in *SAE 2002 World Congress, March 4, 2002 - March 7,* 2002, .

[6] K. Morikawa, H. Takimoto, T. Kaneko and T. Ogi, "A study of exhaust emission control for direct fuel injection two-stroke engine," in *Small Engine Technology Conference and Exposition, September 28, 1999 -September 30,* 1999, .

[7] P. Rochelle and W. Perrard, "Fuel consumption and emission reduction of a small two-stroke engine through air-assisted fuel injection and delayed-charging," in *International Congress and Exposition, March 1, 1999 -March 4,* 1999,.

[8] Sea-Doo. (2013) *RS Comparison* [Online]. Available FTP: http://www.seadooseascooter.com/RS_CMS/index.php?option=com_content&view=article&id=22&Itemid=41

[9] A. Dave, Development of a Reed Valve Model for Engine Simulations for Two-Stroke Engines, 1st ed. , SAE International, 2004.

[10] L. Arnone, M. Janeck, M. Marcacci, R. Kirchberger, M. Pontoppidan and R. Busi, "Development of a direct injection two-stroke engine for scooters," in *Small Engine Technology Conference and Exhibition, November 28, 2001 - November 30,* 2001, .

APPENDIX A: Aqua Scooter Components

1 - AIR TANK
2 - AIR TANK PLUG FOR SNORKEL CONNECTION
3 - FUEL TANK PLUG
4 - FUEL TANK
5 - FUEL VALVE
6 - EXHAUST GAS OUTLET
7 - FUEL PIPE
8 - STARTER HANDLE
9 - STEERING HANDLE
10 - THROTTLE LEVER

Figure A1: List of components of Aqua Scooter

11 - "**AVVIAMENTO - START - STOP"** POSITIONS
12 - CARBURETTOR TO CARB - EPA STANDARDS
13 - "START AND RUN" LEVER
14 - "**RUN/MARCIA"** POSITIONS
15 - PROTECTIVE GRILLE CE
16 - FUEL TANK BREATHER PIPE
17 - PROPELLER GUARD AND WATER DEFLECTOR CE
18 - CARRY HANDLE
19 - SPARK PLUG
20 - AIR INTAKE TUBE (SNORKEL)
21 - SNORKEL EXTENSION
22 - RUBBER BUMPER

Figure A2: Additional list of components for Aqua Scooter

APPENDIX B: Team Concepts

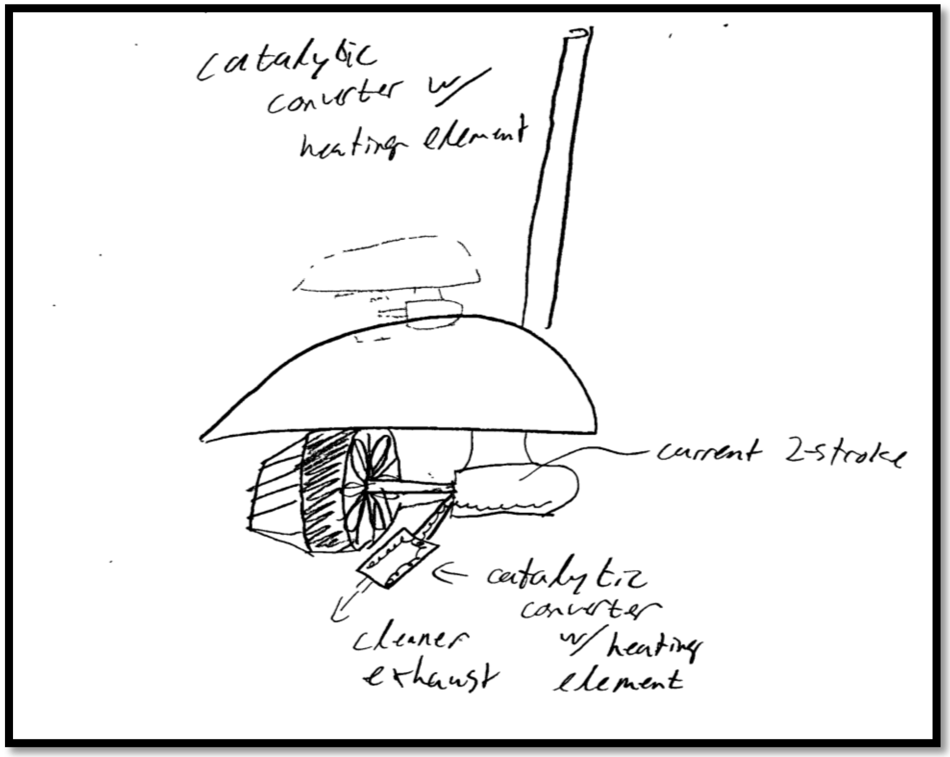


Figure B1: Catalytic Converter with Heating Element

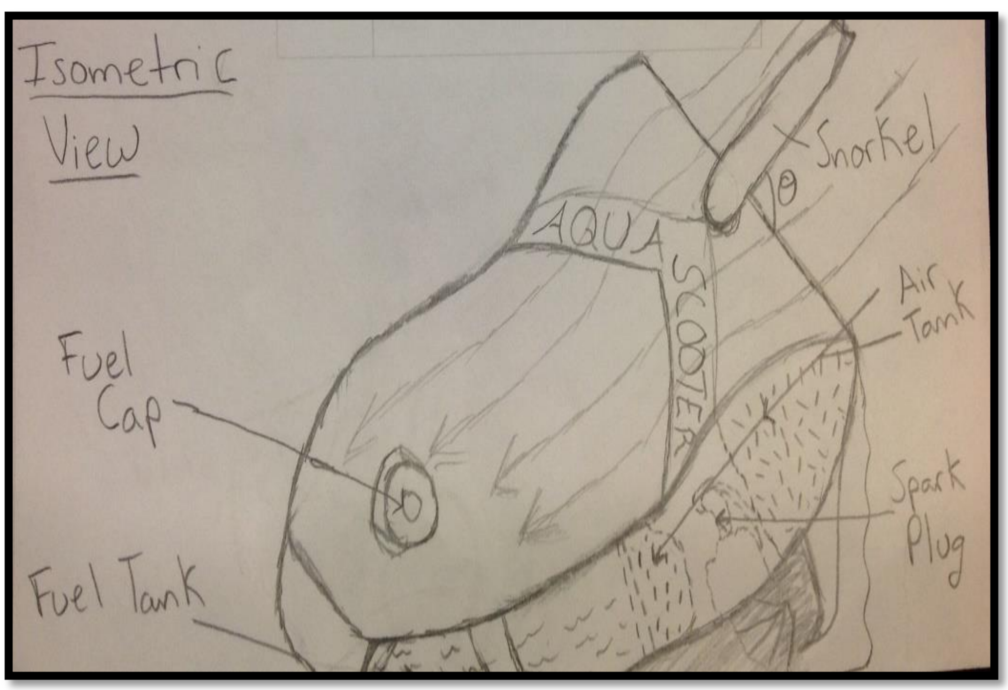


Figure B2: Enclosed Housing

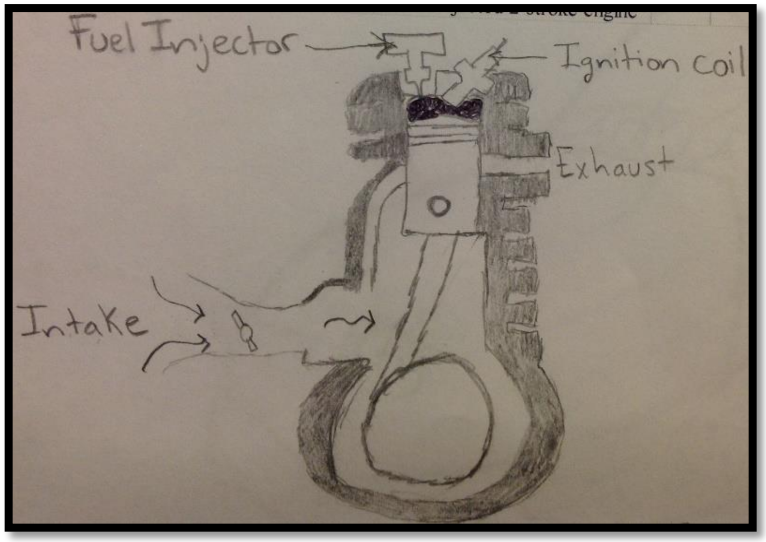


Figure B3: Fuel Injected 2-Stroke Engine

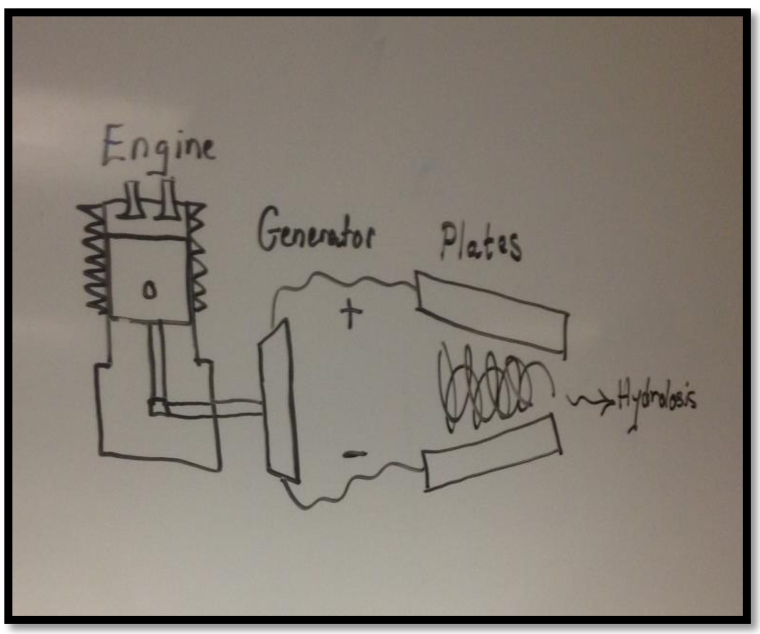


Figure B4: Magneto Hydrodynamic Propulsion System

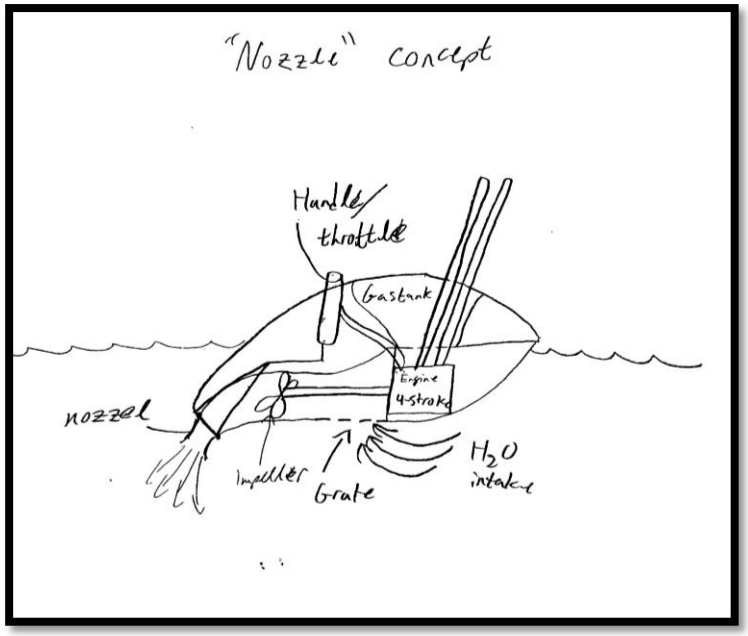


Figure B5: Adjustable Jet Nozzle Design

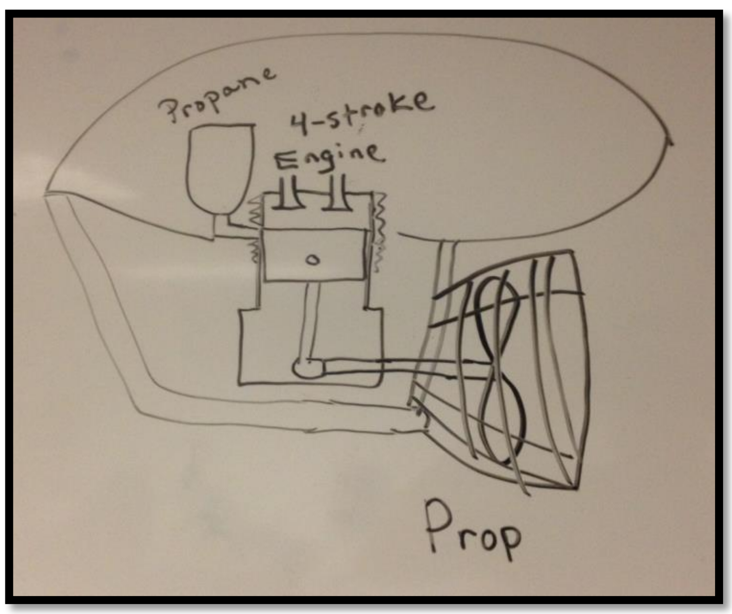


Figure B6: Propane Injected 4-Stroke Engine

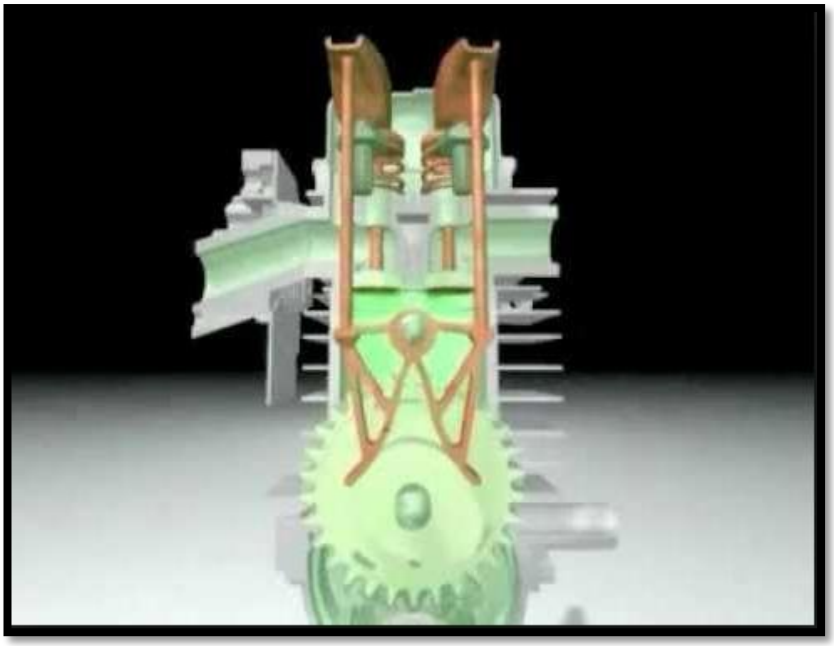


Figure B7: 4-Stroke 4-Mix Engine

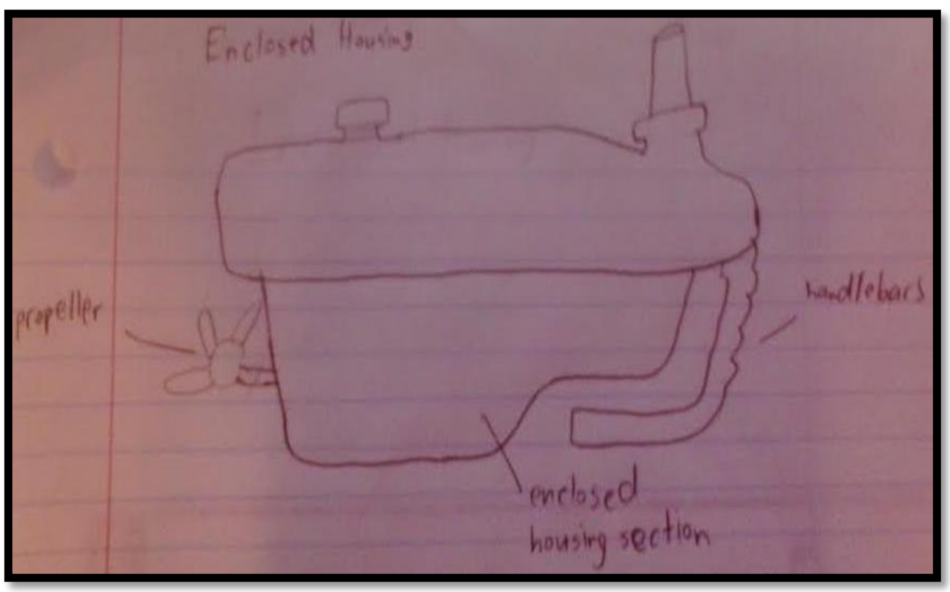


Figure B8: Tank Housing

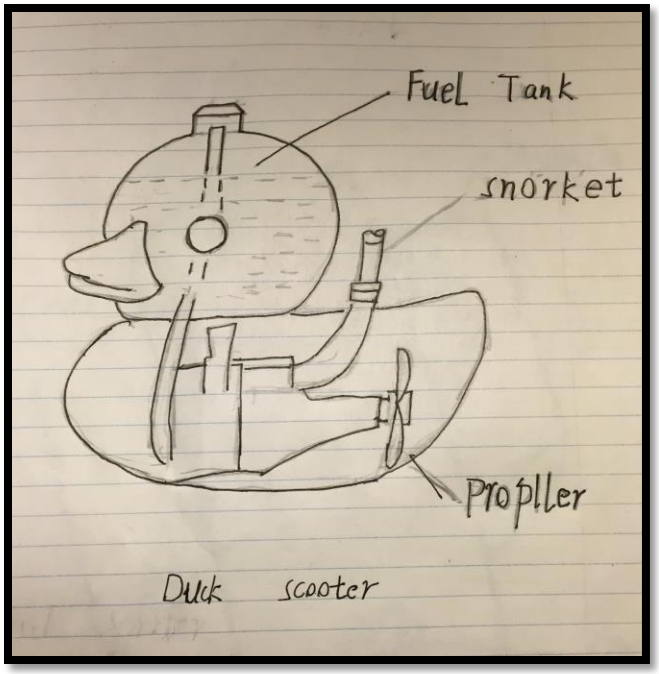


Figure B9: Duck Scooter

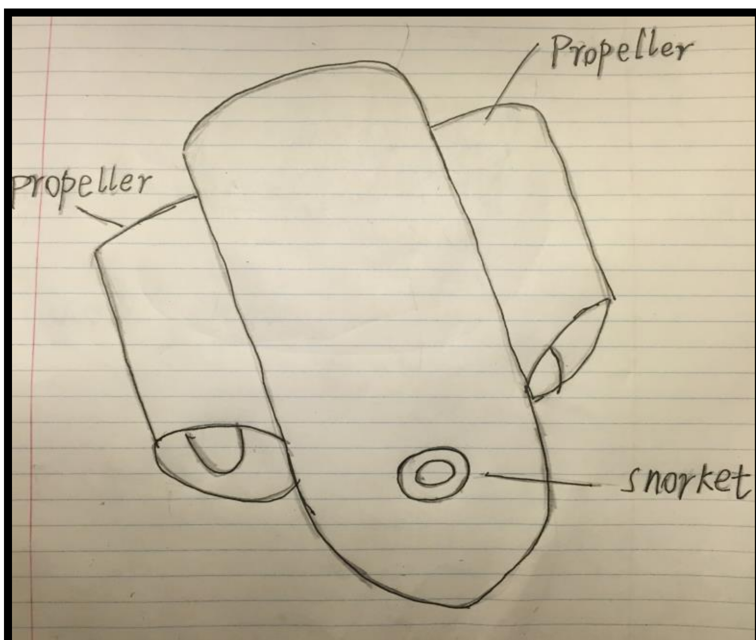


Figure B10: 2-Propeller Design with Belts and Pulleys

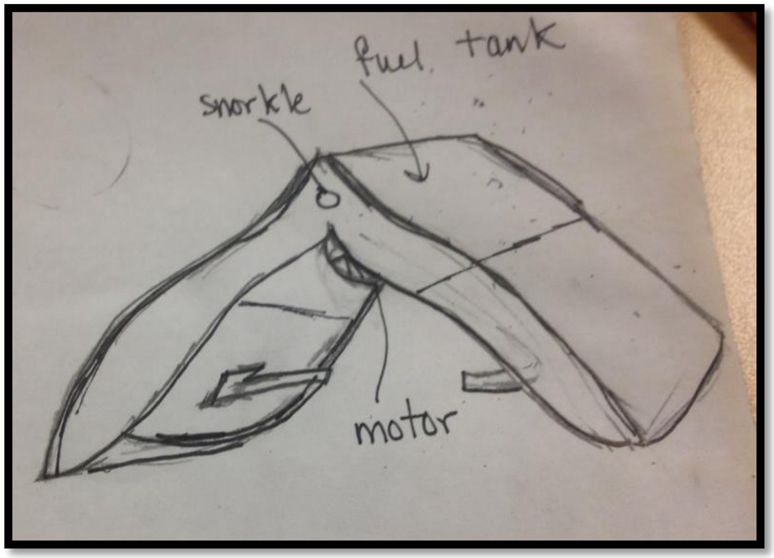


Figure B11: Boomerang with Single 4-Stroke Engine

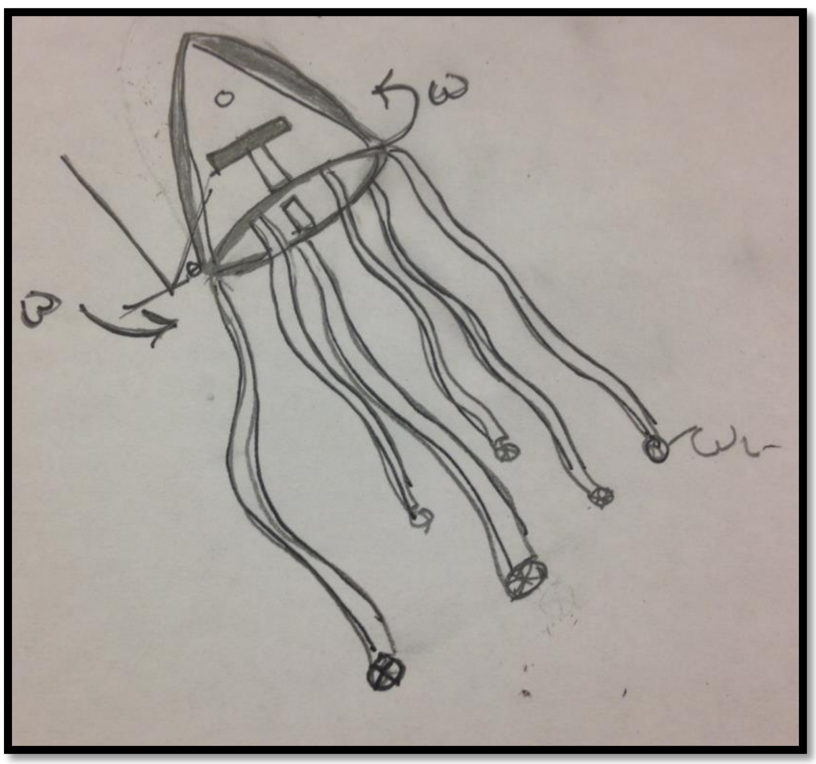


Figure B12: Octopus with Rotating Mechanism