EML 4551 Senior Design Project

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REQUIREMENT FOR THE DEGREE OF
BACHELOR OF SCIENCE
IN
MECHANICAL ENGINEERING

FIU Eco-Friendly Shallow Draft Boat

Domingo Malve
David Neer
Sebastian Lopez
Jose Arrautt

Advisor: Professor Dr. Claudius Carnegie

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This report is written in partial fulfillment of the requirements in EML 4511. The contents represent the opinion of the authors and not the Department of Mechanical and Materials Engineering.

Ethics Statement and Signatures

The work submitted in this B.S. thesis is solely prepared by a team consisting of Jose Arrautt, David Nee, Domingo Malave, and Sebastian Lopez and it is original. Excerpts from others' work have been clearly identified, their work acknowledged within the text, and listed in the list of references. All of the engineering drawings, computer programs, formulations, design work, prototype development, and testing reported in this document are also original and prepared by the same team of students.

Jose Arrautt Team Member	David Neer Team Member	Domingo Malave Team Member	Sebastian Lopez Team Member

Dr. Claudius Carnegie Faculty Advisor	Dr. Ibraham Tanzel Faculty Advisor

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Abstract

The continued use of fossil fuels as a primary source of energy has a harmful impact on both the environment and ecosystems. It is therefore becoming increasingly necessary to find and utilize more environmentally and eco-friendly objects which utilize alternative, renewable sources of energy.

The goal of this project is to design and create an eco-friendly shallow draft boat that will be used to transport people to and from a small island in Biscayne Bay. The concepts of using a renewable energy source as the primary means of energy addresses the environmental impact, while the shallow draft design and enclosed propulsion system aids in conserving the local ecosystem. The major issues with building the boat are the regulations and requirements that are implemented by the government. One such regulation protecting the seabed is the one foot allowable depth of the boat hull during low tide.

One of the most important parts in achieving a successful outcome of this project done is finding the optimal combination of materials, choice boat and hull type, and the propulsion system that will adhere to all rules and regulations while still being an attractive and functional for its desired intent. We have chosen three conceptual designs for the hull, of which one is the most promising to use to begin designing the eco-friendly boat.

1 Introduction

1.1. Problem Statement

The main purpose of this project is to properly design an environmental friendly ferry capable of transporting residents from a condo association to an island in Biscayne Bay area.

One of the main restriction this team will face is that this task needs to be accomplished complying with all rules and regulations established by all local and governmental agencies involved. All this information is needed in order to successfully develop an effective design. From this point forward all required calculations will be made in order to select the most efficient boat hull.

It is important to take into account that speed is not an issue in this design, which would be based on a vessel able to transport ideally from 20 to 25 people at a cruise speed not higher than 5 mph. For this reason a tentative goal is to power this boat with solar energy. In order to accomplish this, the design would have to include solar panels that could be part of the roof able to create enough energy to power an electric motor. With this goal, the team would be trying to achieve the design of a free carbon dioxide emission vessel.

1.2. Motivation

The Senior Design Team is very exciting and passionate to work in a very innovative project, because it will give the chance to all team members not only to demonstrate the knowledge obtained throughout all the classes taken at Florida International University all these years, but also it will show to society that students become engineers when they are able to demonstrate their abilities to analyze problems and find solutions through research, calculations, mathematical procedures, the use of other engineering tools like computer programs, etc. This ability will be shown on the development of this project, which gives the necessary motivation to design and build every part of a water vessel from scratch.

1.3. Literature Survey

1.3.1 History of Boats

The ocean has always caused fascination in humans since the beginning of time. Likewise, it has always provided food for their livelihood. Since the beginning of civilization, humans have had the necessity to move, and to transport from one place to other. That is why more than 10 000 years ago, man used a properly carved trunk as a means of transportation in the waters.[1]

The Egyptian was one of the ancient civilizations that were pioneered in the development of river crafts. They built many types of boats for different uses. Some of these uses were Agricultural produce, troops, cattle, stone and funeral processions, hunting and to travel around rivers. These first boats were made of bundles of bound papyrus reeds (Papyrus is different from paper because papyrus is a laminated material made from thinly cut strips from the stalk of Cyprus Papyrus plant) and were all carried on the Nile river and its canals. This boats where water power, provided by the current of the river and by the wind. They were steered with oars. These kinds of boats were built 4000 B.C.[1]

After that, around 2500 B.C. Egyptian replace the papyrus for wood or canifers from leabanio. They made of short blocks of timber and wood other to be more stable and be able to sail across the ocean.

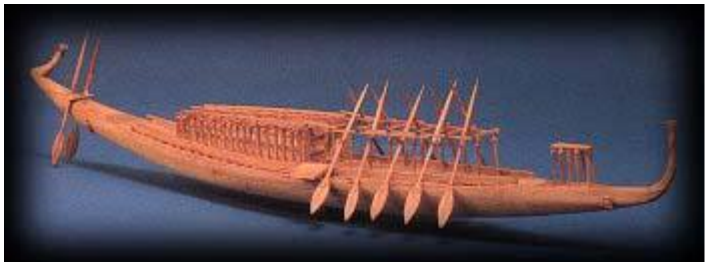

Figure 1 - Egyptian First Wood Boats replica [1]

In 1200 B.C., another civilization that started the development and construction of boas where the Phoenicians . Their ships were built to go around the sea. They were one hundred feet long and capable to support between one hundred to two hundred tons. Similar as the Egyptians, the source of power of these ships was man and wind power. [2]

By 500 B.C., they started building ships with two biggest masts, the mast in the middle had a square sail, and the other one a triangular, and it supported the main sail.[2]

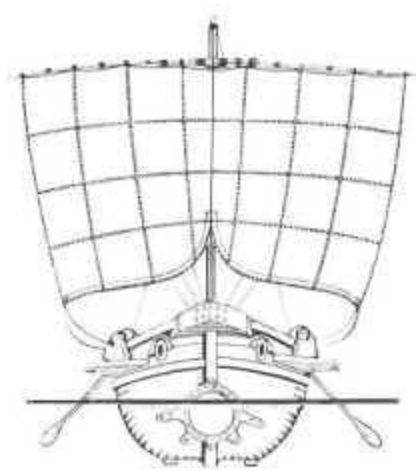

Figure 2 Phoenician Boats designs [2]

In 1000 A.C., The Vikings starts to play a important role in the ships construction history. This civilization is known by their famous long ships. The designs of these ships were long and narrow, between eighty by seventeen feet. The purpose of this design was to be able to travel through the sea and rivers at the same time for trading, war, and colonization. These long boats used to have around 60 oars power by man. [3]

Figure 3 The Gokstand Viking Ship ISO view [3]

Figure 4 The Gokstand Viking Ship front view [3]

Starting in the 1200's new ships designs were build. These ships had now rudders in order to steer the ship. They also had battens on the sails in to obtain more strength and watertight. Also, the sails change from square to triangular shapes. In addition to that, they had long, slim hulls and tall masts that make to seal faster. They also had fore and stern castles for people, shelter and cargo. These ships where used for battles and by explorers to carry merchandise from one country to another.

Around the 1750's a new era in the ships designs began, and the way of how the boats where powered change from wind and man power to a steam. That is how the steam engine boat idea came up. The inventor of the Steamboat was John Fitch, born in Connecticut on 21 January 1743. This watchmaker by profession was aware that steam could move gears and wheels, so he built a first prototype of the Steamboat in 1787. This boat was 40 feet in length, had a series of paddles joined together. The invention test was performed with a great success by navigating thorough the Delaware River.

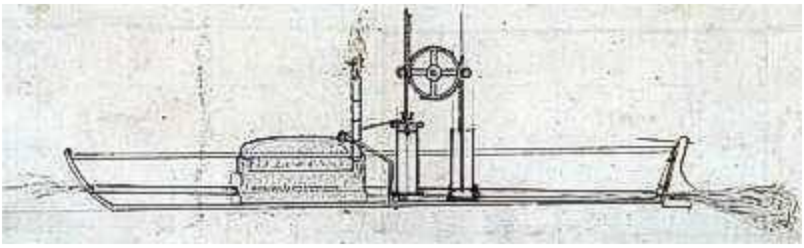

Figure 5 John Fitch Design Sketch 1787 [4]

After that in 1807, the engineer Robert Fulton was able to expand the use of steam ships by building the Clermont. This was the first steam boat that has commercial success in US waters. This new version, placed a wheel of blades in the center of the boat, and it was capable of carrying passengers and merchandise.

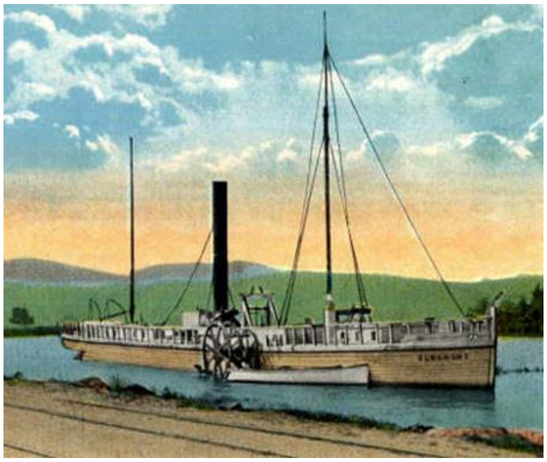

Figure 6 The Clermont -First Commercial Steam Boat in the US [5]

In 1845, the materials used for the steam boat changed from wood to iron. These ships were driven by a propeller or by huge paddles wheels located on the back or in the middle of either side of the ship.

In the 1900's stem boats engines where change into diesels power engines. Este change started a new period in the development and design of new technology in the maritime industry.

1.3.2 Why do "things" float?

The Archimedes' principle is a Physical law which establish that when an object is totally or partially immersed in a liquid, the object experience an upward thrust equal to the weight of the displaced liquid. Most of the time, this principle is applied to the behavior of objects in water, and explains why objects float and sink. The key concept of this principle is the 'thrust', which is the force that acts up by reducing the weight of the object when it is in water.

An object floats if its average density is less than the density of water. If it is completely submerged in water, the weight of water that is displaced is greater than its own weight, and the object is driven up and out of the water until the weight of the water displaced by the submerged part is exactly equal to the weight of the floating object.

Archimedes' principle can be illustrated by using the following formulas

$$Apparent\ immerse\ weigh\ = weigh - weigh\ of\ displaced\ fluid$$

$$\frac{density}{density\ of\ fluid} = \frac{weigh}{weigh\ of\ displaced\ fluid}$$

$$\frac{density\ of\ object}{density\ of\ fluid} = \frac{weigh}{weigh\ of\ displaced\ fluid}$$

For example, if a block of wood, whose density is 1/6 of the water, will float with 1/6 of its volume dipped in water, because at this point the weight of the displaced fluid is equal to the weight of the block.

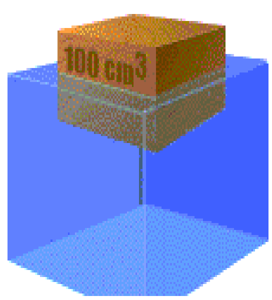

Figure 7 Archimedes' principle

By this principle, it is explained why boats and big ships do not sink in the water. Any boat will float lower in the water when they are heavily loaded because more water needs to be moved to generate the necessary force to keep it floating.

In addition to that, it is necessary to keep in mind that that if the ship is navigating in fresh water, it cannot be load as if it is going to be sailing in salt water. This is due to fresh water is less dense than sea water.

2 Project Formulation

2.1 Overview

Onyx on the Bay Condominium Association, Inc. is a non-profit organization located on the Miami side of Biscayne Bay at NE 25th Street. There is an island with a sandy beach approximately one mile from the Condo location in Biscayne Bay along the Intercostal waterway. Currently, there are very few means to reach the island, such as kayaks, jet skis, or private boats, of which one would first need to travel a distance to the marina and embark from there. The Onyx is only one of tens of thousands of condos, hotels, and apartments built east of I-95, north of the MacArthur Causeway, and south of I-195 (Julia Tuttle Causeway) over the last 10 years.

2.2 Project Objective

The President of the Onyx on the Bay Condominium Association, Inc. approached us with an idea for a means of transporting both residents and tourists directly from the Onyx location to the island. His idea is for a solar powered boat that would both accommodate his desires of reaching the island, and ensure the local/global environment is impacted as little as possible.

2.3 Design Specifications

The area in which the boat would function is relatively narrow waterway with a wide variety of plant and animal life. Additionally, the shore lines of both the city side and around the island have very shallow water, with its lowest water level being reached at low tide. In order to keep true to the client's objective, the boat must be shallow draft, such that the plants and sea floor remain undisturbed during docking, loading, and departure.

In order to please the client's desire for having an eco-friendly vessel, the main source of power should ultimately come by means of solar power. This shall be achieved by use of solar panels and batteries. Although this will be the primary source, conventional sources of power will still be available and used as needed.

2.4 Constraints and Other Considerations

As mentioned in section 2.3, the bay area has many forms of wildlife, including manatees, fish, and sea grass, all that give character and add to natural value of the area. This is one of the greatest considerations that must be taken into account when developing a design for the boat. In order to not disturb the wildlife or the seabed, we must take into consideration the worst case scenario, which is being located near the shoreline during low tide. This gives a maximum underwater depth of now more than one foot.

While that is on its own taking an environmentally positive approach, there are also many legal matters that govern everything from use of the waterway itself, the island, any docking that may be implemented, noise levels, and also specifics regarding aspects of the vessel itself. To ensure that all the proper permits and specifications are met, we must contact a number of different local and governmental agencies to learn of all constraints and limitations that must be strictly adhered to. The following is a list of each of the agencies that need to be contacted, along with which legal aspect of the project they are in charge:

- Biscayne Bay Aquatic Preserve Statute – *governs the use of the area in which we want to operate.*
- Fl. Department of Environmental Protection (DEP) – *owns the Island and bay bottom. Also, it has regulations for boat usage and dockage.*
- U.S. Coast Guard (USCG) – *Boat rules (Commercial vs. private) and standards.*
- Miami Dade County Department of Environmental Regulation & Management (DERM). *Regulates access rights, permitting, and usage of the area we want to operate in.*
- City of Miami – Building & Zoning (& Parks Dept.). *Dockage and access rules, regulations, and permits.*

3 Design Alternatives

3.1 Overview of Conceptual Designs Developed

The Design Project Team was approached with an idea that, in and of itself, had very few constraints based strictly on the wishes of the client. The main constraint was that the hull of the boat must remain at a depth of no more than one foot below water. The client also wished to have ease of access in both loading and departing from the boat, including making the vessel handicap accessible. Other serious constraints, ranging from noise level, to boat dimensions, to speed, are regulated by numerous local and governmental agencies. As of yet we have not been able to reach all necessary parties. Therefore, we are focusing on the client's primary constraint. One of the main factors in determining how deep a boat will go below water is the hull, in addition to the material used in its manufacturing. The Design Project Team chose as a first attempt to analyze flat bottom hulls, round bottom hulls, and pontoons. More detailed descriptions of each of these will be found in the following sections.

3.1 Design Alternate 1

Flat bottom boats can be an ideal candidate when the area of use is shallower bodies of water. The shape of the hull allows the boat to ride on top of the water, rather than through. This attribute gives the boat a very stables design. Additionally, flat bottom hulls have greater buoyancy. Therefore, boats of these types tend to have very high decks, making the rides dry.

This type of design also allows for a very smooth ride in calm waters. On the contrary, in choppier waters, the ride can become significantly rougher. Another disadvantage is that generally, flat bottom boats are less maneuverable than some other hull types. As the intent is to be used mainly in calmer waters, very low horsepower motors are needed. If the power is too great, that would also increase the roughness of the ride.

3.2 Design Alternate 2

The round bottom hull is similar to that of the flat bottom in that they are meant to be used at lower speeds, and in calmer waters. The reasoning as to why, however, is different. The round bottom boat is a displacement hull; as opposed to a planning hull such as is the flat bottom, a displacement hull moves through the water rather than on top of the water. This shape also gives the boat greater maneuverability.

3.3 Design Alternate 3

The final design alternative we are investigating is that of the pontoon. Like the round bottom hull, the pontoon is also a displacement hull. This type of hull shape allows for a larger flat deck area, which can be desirable if one wishes to carry a greater number of people. One disadvantage is that this design shape has lower efficiency, and should only be used at very low speeds.

3.4 Other Considerations

The material to be used for hull construction is another large factor to be considered. The Design Project Team needs to complete a series of studies considering all materials characteristics; choosing a material for the wrong application design could be costly. There are many options out there on the market such as aluminum, fiberglass, carbon fiber/Kevlar, and even wood. Aluminum, being less costly, can be an ideal candidate for pontoon boats. Fiberglass, being lightweight and a durability providing long lifespan, is often a first choice for boat builders. Carbon fiber/Kevlar is used by many companies in the production of flat boats in order to accomplish designs that require light weight and shallow draft. Wood, already haven proven its worth by successfully being used to construct boat hulls for centuries, is now being incorporated into the newest boat designs by getting mixed with other materials. These new composites have more desirable properties, making the construction lighter and cost efficient.

3.5 Proposed Design

The main objective of this project is to build a water vessel able to float and transport people. After analyzing several boats designs taking into account the study and building analysis of all parts, a pontoon hull was the best choice. First of all, because it is a very simple design, as explained previously, a pontoon boat is just a flat raised deck that is being held by outer typically circular hulls called pontoons. The selection of the building material depends most of the time on the kind of application the boat hull is designed for.

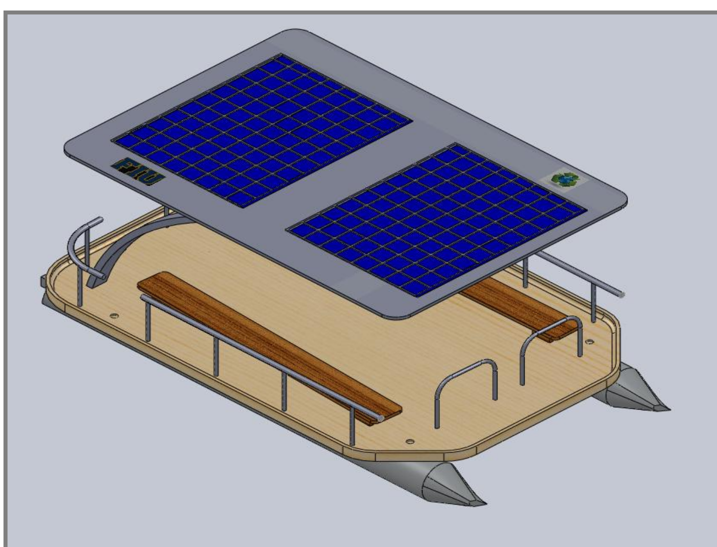

Figure 8 -– Friendly Shallow Draft Boat Design Prototype

Because pontoons are most of the time constructed on a cylindrical shape, and due to the weigh and other loads they need to hold, they are usually built of light metal. Due to being lightweight, strong, and flexible; aluminum, is considered by many to be an ideal material for boat hull building.

To build the pontoons, sheet of aluminum will be needed and throughout a rolling process they are turn into tubes and then welded, because these aluminum sheets come on standard sizes, these pontoons will be constructed on several tube sections. The pontoons are not entirely cylindrical, the pontoon's nose is built in a cone shape, which is purposely designed to help as water waive breaker. All these sections will be welded together to form a complete pontoon.

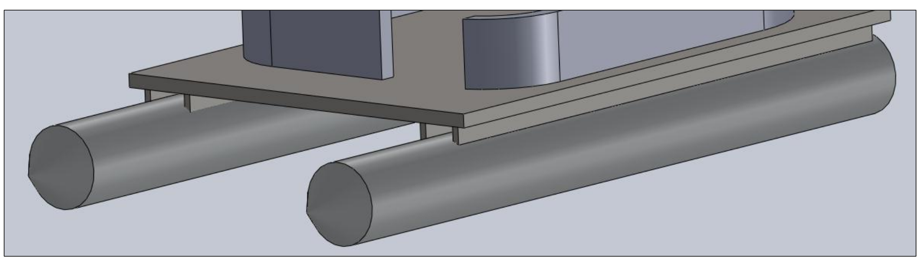

Figure 9 -Pontoon Design Prototype

Each pontoon will be constructed with several brackets welded to it, these brackets will be used to hold aluminum cross members between both pontoon to support all the weight that will be added to the top. To construct the boat floor, pressure treated plywood will be placed on top of the frame previously constructed between the pontoons forming the flat platform.

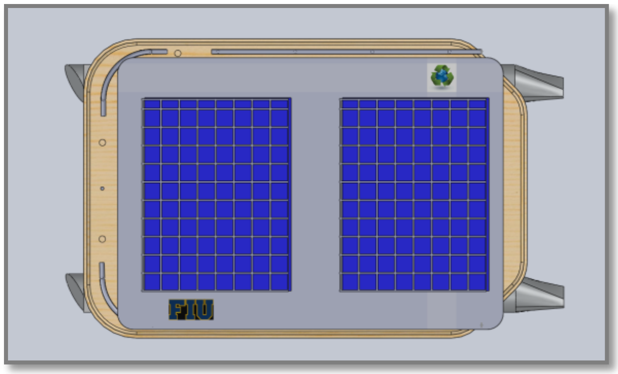

Figure 10 -Pontoon Design Prototype

Solar panels on the overhead area that also work as sun shelter will give the necessary power to move an electric motor. The team is planning on designing a hybrid system able to combine electrical energies collected from solar panels and the one collected from a regular power source. With this system the team is looking for a power system that will use battery based inverters and a battery bank to store electricity for later use. Because batteries need to be included in the system, a solar charge controller is needed to charge the battery bank and prevent over charging. The use of a backup generator can be included to continue the powering in case solar power is not present.

4 Project Management

4.1 Assigned Tasks for Senior Design Project

FIU Eco-Friendly Shallow Draft Boat

Task Name	Start Date	End Date	Assigned To
Rules and Regulations	**10/08/12**	**11/08/12**	
Site visit and meeting with client	10/08/12	10/08/12	Design Project Team
Contact agencies regarding all applicable rules specific to client specifications.	10/09/12	11/08/12	Sebastian Jose
Summary of findings	10/18/12	11/08/12	Sebastian Jose and David
Power Required	**10/09/12**	**11/08/12**	
Perform power analysis	10/09/12	11/01/12	David
Write up of relationship between power and changes in parameters.	11/02/12	11/08/12	David
Summary of findings	10/18/12	10/23/12	David
Boat Type/Hull Design	**10/09/12**	**11/08/12**	
Research boat types, hull designs, and possible materials	10/09/12	11/01/12	Domingo David
Determine design that fits both client desires and applicable rules and regulations	11/02/12	11/08/12	Design Project Team
Model design using SolidWorks	11/02/12	11/08/12	
Report	10/09/12	11/16/12	
One-page project synopsis	10/09/12	10/18/12	David
Final Report, 10%	11/09/12	11/16/12	
Cover Page	11/09/12	11/16/12	Jose
Ethics Statement and Signatures	11/09/12	11/16/12	All
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Overview of Conceptual Designs Developed	11/09/12	11/16/12	David
Design Alternate 1	11/09/12	11/16/12	Domingo
Design Alternate 2	11/09/12	11/16/12	Domingo
Design Alternate 3	11/09/12	11/16/12	Domingo
Other Considerations	11/09/12	11/16/12	Domingo and

Table 1 - Assigned Tasks for Senior Design Project

4.2 Projected Timeline for Senior Design Project

	Task Name	Assigned To	Start Date	Hours
1	**Site Visit Meeting with Client**	David, Domingo, Jose,	10/01/12	4
2	Contact local and governmental agencies	David, Domingo, Jose,	10/31/12	2
3	**Literature Survey**	David, Domingo, Jose,	10/03/12	5
4	**Design Alternatives**	David, Domingo, Jose,	10/05/12	6
5	**10% Report**	David, Domingo, Jose,	10/11/12	10
6	**Conceptual Design**	David, Domingo, Jose,	10/16/12	3
7	**Poster Design**	David, Domingo, Jose,	11/01/12	7
8	**Solidworks Modeling**	Jose, Sebastian	01/14/13	0
9	**Solidworks & ANSYS Selection**	Domingo, David	02/08/13	0
10	**25% Report**	David, Domingo, Jose,	11/02/12	19
11	**Research & Solar Panels Selection**	David, Sebastian	12/10/12	2
12	**Analytical & Structural Analysis**		01/14/13	0
13	**Purchasing Materials**	Domingo, Jose	02/08/13	0
14	**Building Process & Testing**	David, Domingo, Jose,	03/29/13	0
15	**Final Prototype**	David, Domingo, Jose,	03/28/13	0
16	**Final Report**	David, Domingo, Jose,	03/14/13	0
17	**Presentation**	David, Domingo, Jose,	04/24/13	0

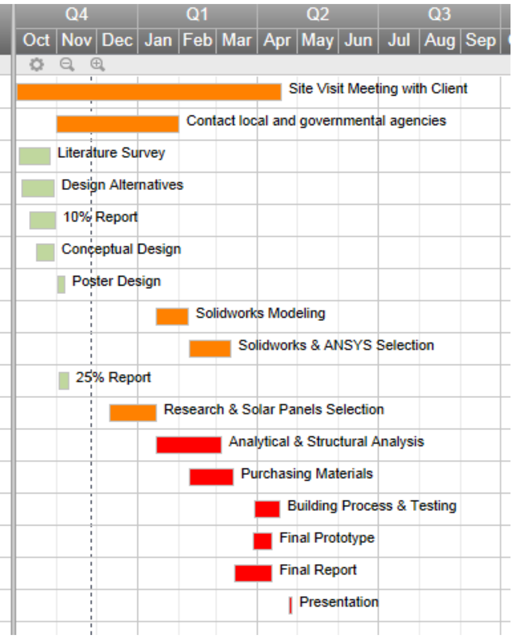


Table 2 - Timeline

Green color = Tasks completed

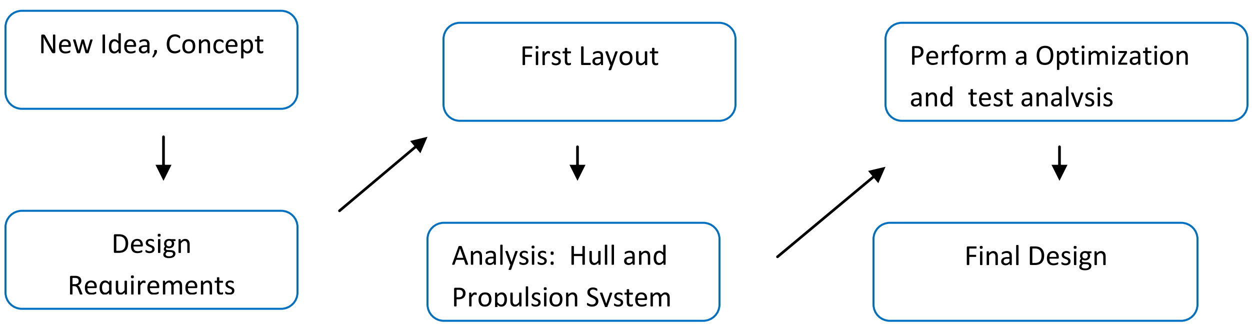
Orange Color = Tasks in progress

Red Color = Next Step

5. Analytical Analysis

Vessels and ships designs are a very huge and complex process. The first step in the construction and fabrication of any kind of vessel or ship is to have a conceptual design. In addition to that, it has to define what will be the purpose of the vessel. This could be for cargo, sporting, fishing, purposes or as a ferry.

The following diagram shows an idea of the flow and the steps that it takes to design a boat.



For purpose of this project the team has decided to use a Pontoon Boats design as initial and most convenient design. In addition to that, the requirements and standards established by the state need to be follow in order to have a safe design and be able to be approved by the state and federals Laws.

The next step is to calculate the capacity or amount of water that the vessel will displace. This is known as the buoyancy force. This is very simple process which is retrieved by finding the volume of the boat or ship hull, and multiplying that total volume by the weight of the water which is 62.4 pounds per cubic foot.

The easiest way to find the total volume of the vessel is by dividing the hull in individual boxes. Mostly, these boxes turn into really simple geometric shapes such as triangles, squares or rectangles. The following picture represents an example of this method.

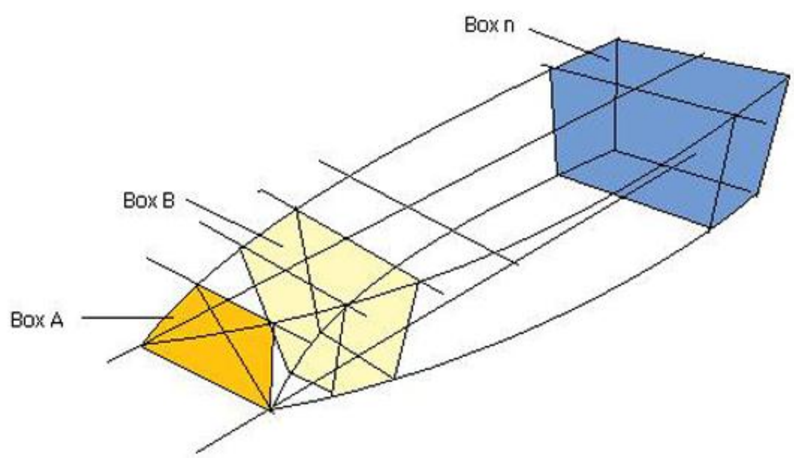


Figure 11 -Volume of Boat hull [9]

As mentioned before, for purposes of this report, the selected design was a cylindrical pontoon type. This allows us finding the volume of the pontoon that is submerged into water easily and faster.

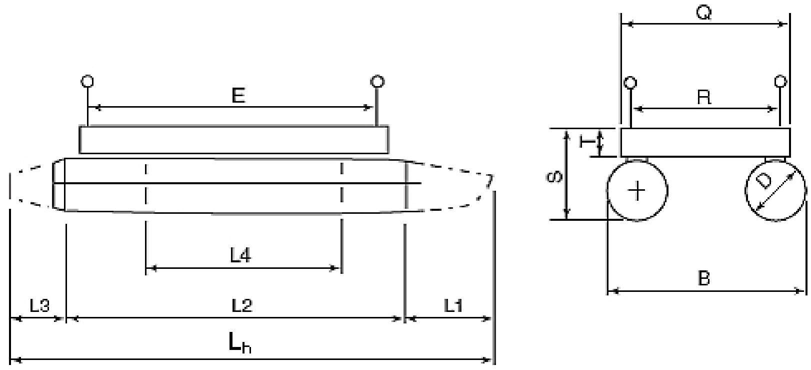


Figure 12 - Circular Pontoon Boat[8]

Q	With of the deck
B	Distance between each Pontoon tube
S	Deck Surface
D	Diameter of the pontoon
T	Thickness of the deck
Lh	Pontoon Length

Table 3 - Pontoon Boat Parts

Here are some calculations that were done in order to obtain the water displacement for our prototype designs. This calculation shows us how long and the wide in which the pontoons have to be done in order to fulfill the constraints of the project.

Total Weight	
w (lb)	180
n	15
Bw (lb)	2000
Wt (lb)	4700

Volume Sumerged	
L (ft)	26
W (ft)	3
H (ft)	1
Vs (ft^3)	78

Buoyance Force	
weight density (lbs)	62
Fb	4836

Table 4 - Weight, Volume, Buoyance Force

Fb > or = Wt	Float
Fb< or = Wt	Not Float

In order to obtain the weight, some values were assumed as the weight of the boat components such as material, solar panels, batteries etc. Also it was assumed the average weight of people to be 180 lbs.

Once the amount of displaced water is calculated, the maximum weight capacity needed to be found. The maximum weight capacity of a two tube pontoon is found by subtracting the total weight of the boat from the pontoon's volume submerged in water. One of the factors that should be included in the total weight of the boat is the weight of the engine, gasoline, batteries and the different material that the boat is made of.

The last aspect that needed to be calculated is the recommended Maximum Power. This is obtained by using the following formula:

$$HP = \frac{Volume\ of\ \ Pontoon\ (ft3) * longest\ Pontoon\ lenght(ft)}{Pontoon\ Diameter\ (in)}$$

Another way to obtain the horsepower needed for the boat is by following the next chart. This is based in the standards of glen manufacturing. There, you can see the different horsepower needed according to weight and length of the boat.

Plans are for pontoons and deck only.
See Huck Finn Cabin Plans for cabin options.

Characteristics	24'x8'	24'x10'	28'x8'	28'x10'	32'x8'	32'x10'
Length overall	23'-9"	23'-9"	27'-9"	27'-9"	31'-9"	31'-9"
Maximum deck length	20'-0"	20'-9"	24'-0"	24'-0"	28-0"	28'-0"
Pontoon weight lbs. each (approx.)	545	545	630	630	720	720
Deck unit weight lbs. (approx.)	635	870	730	1045	890	1215
Total weight lbs. (approx.)	1725	1960	1990	2305	2330	2655
Maximum load capacity lbs. (approx.)	3385	3155	4085	3805	4780	4455
Horsepower recommended	15-55	15-55	15-60	1560	20-75	20-75
Beam overall	8'	10'	8'	10'	8'	10'
Pontoon width	24" on all versions					
Pontoon depth	24" on all versions					
Draft at load capacity	12" (plus 3 1/2" when skeg used)					

Figure 13 - Pontoon Boats Characteristics [8]

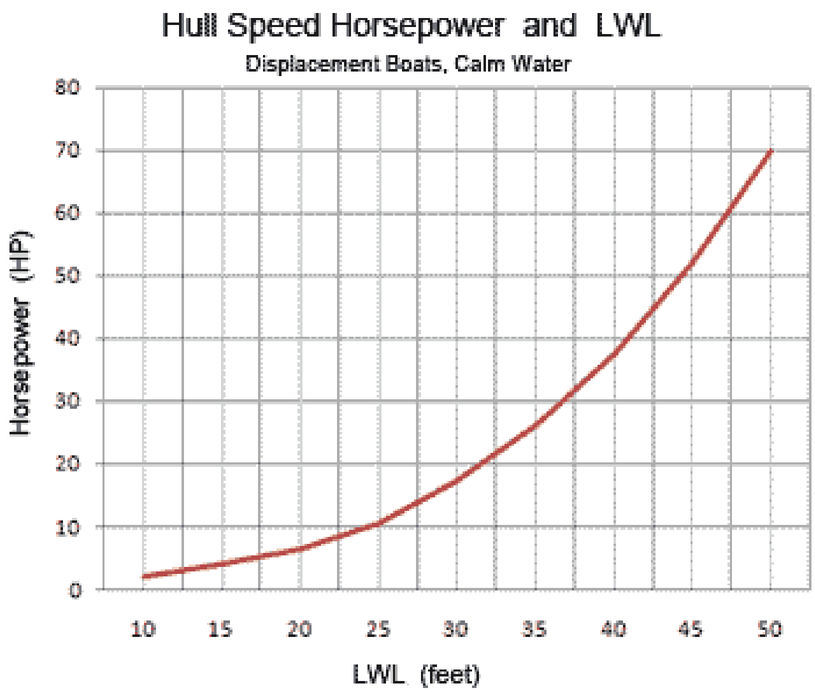


Figure 14 -- HP vs LWL graph [8]

The graph above represent s the relationship between the power and the length of the boat at the waterline (LWL) .The longer the water line, the more horse power the boat will need to move.

6. Major Components

Boats in general are composing by different parts. Some these parts depend according to the type and size of the boat. The major components of watercraft are the hull, propeller, and keel.

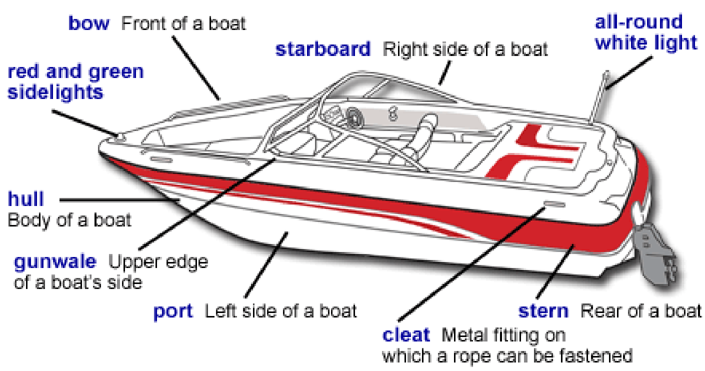


Figure 15 - Boat Components (a)[10]

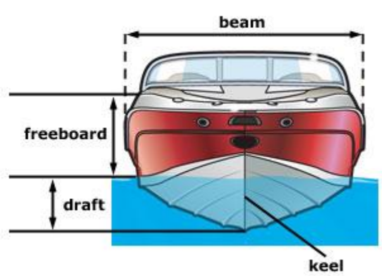


Figure 16 - Boat Components (b)[10]

6.1 Hull

The hull is one of the most important components to be design in this boat, is known as the waterproof body part of the boat. Engines, decks, rudders and mast are all installed in the hull. This part will change depending on the vessel type. There's different types of hulls that can be build, the main hulls are: smooth curve hulls, chined and hard chined hulls.[7]

6.1.1 Smooth Curve Hull

The curve hull will be rounded and most often don't have corners. This is the most common hull because it promotes planning.[7]

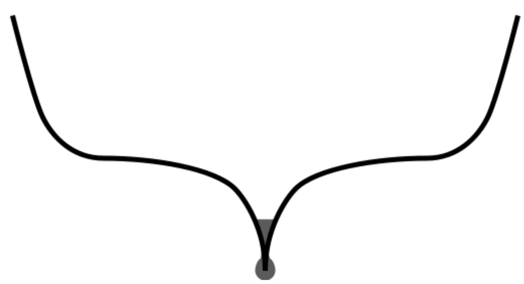


Figure 17 - Smooth Curve Hull[7]

6.1.2 Chined and Hard Chined Hulls

Chine in boating are known as a sharp angle in the hull. Hard chine is an angle with little rounding, and soft chine would be more rounded.

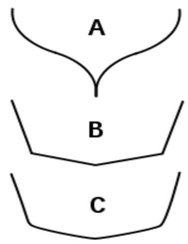


Figure 18 - (A) S bottom hull, (B) hard chine, and (C) soft chine [7]

6.2 Propeller

The propeller is also one of the main components of the boat. It transmits power by transforming rotational motion into thrust. When its rotating, the forced created by the rotation is converted into pressure and is used to accelerate the boat forward or backwards. Most propellers have their axis of rotation parallel to the fluid flow. In the past there have been some research about powering vehicles the same way they do with boat but they have been unsuccessful. There are different types of propellers: controllable pitch, skewback, and modular. [7]

6.2.1 Controllable Pitch Propeller

This type of propeller has some advantages with ships. One of them is the ability it has to move the vessel backwards, adjusting the blade pitch with this the optimum efficiency can be achieved and fuel can be save, and finally the propeller has a “vane stance” this will give the least resistance of water when not using the propeller.[7]

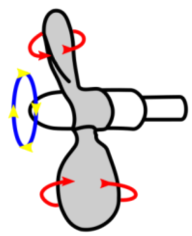


Figure 19 - Controllable Pitch Propeller [10]

6.2.2 Skewback Propeller

It is a type of propeller that was used on Germans Type 212 submarines. These skewback propellers are swept back against the direction of the rotation. The blades are inclined backward along the longitudinal axis.

Figure 20 - Skewback Propeller[10]

6.2.3Modular Propeller

It's a type of propeller that uses much different type of materials that has replaceable parts. The purpose of modular propeller is that it will provide more control of the boat at high speed. Each modular propeller it's made of the three different parts: front end cap, replaceable blades, and a rear shaft.

Figure 21 - Modular Propeller[10]

6.3 Keel

6.3.1Structural Keels

The keel is the structure that it's located underneath the hull and it's known as a large beam. Most of the ships will have it on the middle of the boat, from the bow to the stern, and it's the support of the boat, it is the major source of structural strength of the hull. Generally the keel is the first part of the ship that gets build. Keel will give longitudinal strength and effectively loading when docking a boat or ship. The most common keel is the "flat plate keel", is built in most of the ships that cross the ocean. The keel that is used in small vessels is known as "bar keel".[10]

Figure 22 - Keel[11]

6.3.2Hydrodynamic keels

6.3.2.1Non-Sailing Keels

It is a structure on the bottom of the hull that is used to give the boat or vessel greater direction control; in many vessels it will contain a very good portion of the sailing ballast. In many boat building, this type of keel will be provided by the structural keel. There's many type of fixed keels: long keels, full keels, fin keels, etc. [7]

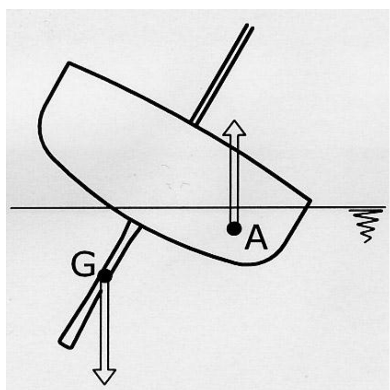


Figure 23 - Non-Sailing Keels [7]

6.3.2.2 Sailing Keels

Keels is use to help the boat be stabilize from not being move sideways by the wind, converting lateral forces of the wind to thrust. With a keel that has a high weight it will provide ballast low in the water to resist high force of wind sideways on the sails. The length of the keel depends on the different types of sailboats.[7]

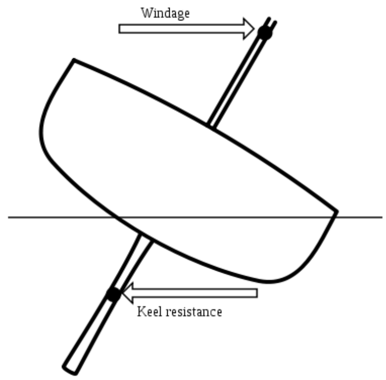


Figure 24 - Sailing Keels [7]

7 Structural Design

For the proposed design of a pontoon, there are several key components that need to be taken into consideration for structural integrity during the design process. As a pontoon uses side railings which attach directly to the deck, how the railings are attached to the supports on the pontoon deck must be closely looked at. Depending on the placement of the solar panels, which can add a considerable weight factor, a similar type of consideration needs to be addressed. Additionally, the deck itself needs considerable analysis not only as a structural member, but also for its qualities of sound and thermal insulation. These are mainly a question of type of material used.

7.1 Use of Fasteners

The pontoon design, unlike more conventional boat designs, is subjected to a higher degree of stress and twisting, since the pontoons, acting as two separate hulls, pass over waves independently. Therefore, the types of fasteners used to attach the railings to the deck play a vital role not just in passenger safety, but also in maintaining the structural integrity of the entire boat. Some options for fasteners are plated screws and steel bolts. Within these categories, there are still numerous types of plates and bolt combinations that can be used. Further analysis is needed before final decisions can be made.

7.2 Deck Materials

The deck of a pontoon plays several rolls. However, as a structural member, the choice of deck and its properties of rigidity are the most important factors to consider, as this affects the amount of stress transferred to other components of the boat. It is therefore desirable to use a deck with greater rigidity. The less rigid the deck, the greater the torsional stress will be. Common deck materials used are aluminum, composites, and wood.

7.3Pontoon Design

The design of the pontoons themselves clearly plays a crucial role in overall design. The main types of pontoon tubes used today are foam filled "U" shaped pontoons, single chamber baffled round pontoons, and round pontoons with single with discrete airtight compartments.

8. Plans for Prototype Testing

Using the proposed baffled pontoon as a base design, a scaled down prototype can be made such that we may test different components for structural integrity, motor efficiency, and length of charge from solar panels. The plan involves testing at different stages of prototype completion, with the idea being that this will ensure the final prototype has the best components. The key factor to keep in mind during the testing process test will be ensuring the maximum allowable depth of the hull is not exceeded.

Before testing external components such as motors and solar panels, the structural design must be tested to help guarantee the safety of passengers after full scale manufacturing. This type of testing will include subjecting the deck to different torsional and bending stresses that might be experiences when the pontoons pass over waves. A variety of materials can be used, from aluminum decks, composites, fiberglass, and wood. We know that a deck with greater rigidity is more suitable for use. The results therefore obtained will help determine which material would be most suitable.

With the chosen deck, pontoons can be added. The proposed design includes a round baffled pontoon, though other types will also be tested. The most common types are foam filled U shaped pontoon, and round pontoons with discrete airtight chambers. Using scaled down weight ranges, along with varying pontoon diameters, each pontoon type can be tested for its buoyancy properties. Through observation, the first criteria for selection would be the design that carries the greatest load while maintaining the proper hull depth.

Motor efficiency can be tested by measuring the ratio of output power to input power. This can be most easily performed using software such as drivecalc that measures output power for a motor's rated rpm. Using a tachymeter, we can also vary the electric power input to measure the rpms the motor gives out. Once the desired level is reached, a motor can be sized, and solar panels can be chosen that provide the necessary electrical input.

A later stage of testing, involving the length of charge from the chosen panel type can be a simple running of the motor out of water on a fully charged battery and measuring the time. It might also be beneficial to perform the same test in water to determine what effects friction and water resistance has on the panels' length of charge.

9. Research and Development Cost

An estimated summary of the tasks realized by each member is listed in the table below, indicating the hours invested and the percentage of each task among the entire project. The man-hours salary value for this project was $35.

				Domingo Malave		David Neer		Jose Arrautt		Sebastian Lopez	
Task	Days	Man-Hours	Cost ($35/hr)	Percentage	Hours	Percentage	Hours	Percentage	Hours	Percentage	Hours
Theoretical Research	60	90.2	$3,157	25%	22.55	25%	22.55	25%	22.55	25%	22.55
Theoretical Analysis	35	60.6	$2,121	25%	15.15	25%	15.15	25%	15.15	25%	15.15
Prototyping	50	100.6	$3,521	25%	25.15	25%	25.15	25%	25.15	25%	25.15
Total	145	251.4	$8,799		62.85		62.85		62.85		62.85

Table 5 - Cost Analysis

9.1 Engine Cost

We will have some regulations on how big the boat has to be, and because of this we need to choose the right engine to make the boat move. In the table below be show the three best options we found, also the prices.

Engine				
Name	Type	Specifications	Store	Price
Iron Horse Stainless Steel AC Motors		Max Horsepower: 300 Max RPM: 3600 Efficiency: 95.4 EPAact: 95	Automation Direct	$8,535.00
Marathon NEMA Premium Blue Chip XRI		Max Horsepower: 200 HP Max RPM: 3600 RPM Efficiency: 95 EPAact: 95	Automation Direct	$1,066.00
Marathon Blue w/ Enconder		Max Horsepower: 100 HP Max RPM: 3600 RPM Efficiency: 94.1 EPAact: 93.1	Automation Direct	$3,951.00

Table 6 - Engine comparison

10. Conclusions

With the design of the eco- friendly boat, we are going to be able to protect the environment from fuel engines with a more ecological engine, that it might be an electrical with the help of solar panels. Our boat will be a more expensive boat in comparison to a boat that has traditional propulsion. The cost of the boat will go up because of the cost of the batteries, the solar panels and the control systems. There will be a reduction in cost of gasoline that will benefit the owner and also benefit the environment and the wild life.

In this paper we have shown different type of boats that have been made in the past, and a brief history about the beginning of the boat. There's different type of hull that can be part of this project, from all of this hulls we chose some that will fit more perfectly the concept of an eco-friendly boat. By choosing the correct size of the boat we are able to get the exact power that the boat is required to function, with the exact size we can find out how many panels are going to use and the cost of the panels. Finally with the size of the boat we find the weight and how many people we can transport to island. Our goal is to transport more than 15 people in this boat.

Our main objective of this first part of the project was to do research about different type of solar or electrical boats that are eco-friendly, have in our mine the different types of panels that can be used in our final design, also to have a rough sketch of different type of hulls for our design. All the objectives were achieved. At this moment we don't have an exact model for the final design, but with the information that we have research we can conclude that at the end of this semester we will have the final conceptual design.

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