Department of Mechanical and Industrial Engineering
Faculty of Engineering and Architectural Science

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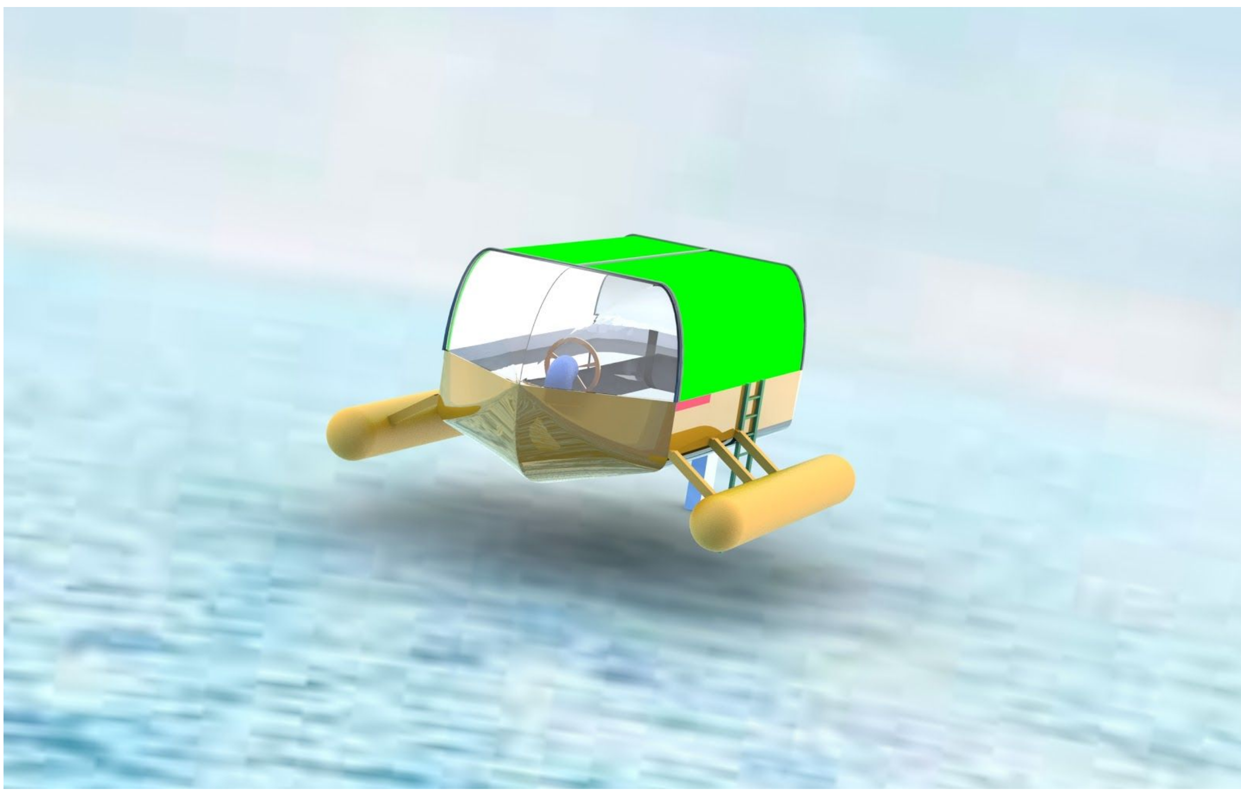
MEC325: INTRODUCTION TO ENGINEERING DESIGN
FINAL DESIGN PROJECT REPORT



The Poseidon

Department of Mechanical and Industrial Engineering
Faculty of Engineering and Architectural Science

Program: Mechanical Engineering / Industrial Engineering

Course ID:	MEC 325	Section:	08	Instructor:	Filippo Salustri
Course Title:	Introduction to Engineering Design				

REPORT:	**Final Report**

Group Number:	Group 1
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Workload Distribution Form

TEAM 0801	Report Prep	Intro & Strategy	Problem Analysis	Systems Design	Concept Generation	Concept Evaluation	Detailed Design	Discussion & Conclusions	CAD	TOTAL	SIGNATURES*
Zian Choudhury	25	25	25	25	25	25	25	25	25	225	Zian Choudhury
Vincenzo Filice	25	25	25	25	25	25	25	25	25	225	Vincenzo Filice
Sami Dib	25	25	25	25	25	25	25	25	25	225	Sami Dib
Sina Sartipzadeh Amirghasemi	25	25	25	25	25	25	25	25	25	225	Sina Sartipzadeh
Student 5	0	0	0	0	0	0	0	0	0	0	
Student 6	0	0	0	0	0	0	0	0	0	0	
TOTAL	100	100	100	100	100	100	100	100	100		

Executive Summary

Team 0801 is a group of mechanical engineering students who have set out to create an innovative design of a maritime escape/life support system. After extensive research of the current market, our team was able to analyze common designs and choose a product which we believed had superior characteristics. The product which was used as a reference design was the Viking RescYou™ ISO 9650-1/ISAF Life Raft.

Current market products are successful in meeting the requirements of life support systems, however there are aspects of many designs which can be improved. Majority of products in the current market, including our reference design, lack the ability to control their path. In this case, users can only hope that one of two things occur - they drift to shore, or are found by a rescue team, both hopefully before they run out of supplies. Another flaw of current designs is the requirement for users to physically throw the product in the water during deployment. This is typically common in inflatable rafts and puts strain on users because some rafts can weigh close to 100 lbs. Also cabin sizes lack personal space as well as lack enough headroom for passengers to sit with proper posture. These are both human factors which appear to be ignored by multiple products in the market. In addition, many products including our reference design are composed of non recyclable materials and are not environmentally friendly.

In the Poseidon, we aim to resolve this issues and create an improved version of our reference design. We want to give users the capability of controlling their own path by including an electric powered motor. We also aim to account for the strain of deploying current designs. To remove the strain of the users having to carry the product to deployment our design includes a free fall deployment which entails no required lifting. We have altered the size and shape of the hull and canopy of our design to accommodate for the 95th percentile population providing them with enough personal space and headroom to reduce effect on posture. Lastly the Poseidon is composed of a low density polyethylene which provides sufficient strength, buoyancy, cost efficiency, all in addition to being a recyclable and environmentally friendly option. We are confident our product meets all requirements and is compliant to all associated laws.

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Introduction

Design brief

Maritime Escape/Life-Support System
Overview

A conventional "life-boat" has many problems: they capsize, they can become waterlogged, they --cannot move quickly, its occupants remain exposed to the elements, and they often lack supplies or means of communicating distress to rescue agencies, to name a few. Large and complex solutions already exist, but they are all basically "scaled down ships". **Design an innovative system to help at most six people per unit escape** from the most common maritime accidents and disasters safely and quickly, such that they can survive until they are rescued, subject to reasonable limits.

Background and Details

Figure 1: Lifeboat of the Titanic.

Lifeboats have come a long way since the Titanic (see Figure 1; source), although simple wooden "mini-boats" remain the norm, especially in economically depressed regions, and for smaller vessels.

Expensive, powerful, robust designs already exist for large ships such as ocean liners and military ships. However, there remains a "gap" in maritime escape and life-support systems for smaller vessels.

An NGO, working in conjunction with a large consortium of small and medium Caribbean fishing/tour operators, is looking for a new design intervention in the area of maritime escape and life-support systems for smaller vessels. Specific goals include:

1. Ensure the safety, comfort, and dignity of users and co-users.
2. Each instance of the system should accommodate up to six persons (including any crew).
3. Be usable within a range of 50 km from major bodies of land, gale force winds, and waves up to 3m.
4. Ensure ethical practices at every stage of the product lifecycle.
5. All relevant maritime regulations and standards are observed and followed.
6. Deployment must be possible by untrained users; however, measures must be in place to prevent accidental deployment (by, for instance, a drunk tourist on a fishing tour).

Other Notes

- Preference is given to innovative solutions, so long as the safety, comfort, and dignity of users and co-users is maintained or improved.
- Preference is given to solutions that have low environmental impact.
- Preference is given to solutions that address all relevant sources of waste, including noises, smells, etc.
- Project scoping must include specifying the level of perceptual, cognitive, and physical ability required to use the intervention.

Current Situation

Situation Brainstorming

The design brief draws attention to the need of designing a maritime escape life-support system for small vessels, to fill the gap existing between expensive advanced designs, and the basic wooden mini boats. The project is to design an escape system for fishing boats in the caribbean, and to insure that the design matches standards, is reliable, and safe.

Currently, many different existing products are used around the world, however there are two main types that are most common, which are, the rigid and inflatable life rafts. Rigid liferafts are usually suspended on the side of the, or it could be attached to boat and dragged while being in the water. Due to it being exposed leads to higher chances of the raft getting damaged. Whereas, inflatable liferafts are stored inside cases that can be easily stored away, take less space, and are lighter , but take more time to deploy than rigid liferafts due to extra time required to fully inflate.

Liferafts, regardless of their type, are used as a life saving equipment in all kinds of seagoing merchants, small fishing boats, cargo, recreational boats, yachts and rescue boats. The manufacturing process of these rafts include steps like constructing the shape and body of the liferaft in the requested dimensions by the designer to accommodate a specific number of people, also the making of the floor and canopy, which by SOLAS life raft standards, are required to be an insulated floor and roof. Manufacturing could include working with cutting tools in case of rigid life rafts, and molds. Very important point to mention, maintenance of life rafts, maintenance is very important and must be done periodically, reason for the is that in case of an inflatable raft, the inflating system might not be working properly, or in general, if the life raft has been used for drills or in previous emergencies, it should be checked after and maintained to be ready in case of any emergency.

The users of the escape system vary, some would be users with experience and knowledge of boats and liferafts, like sailors, crew members, rescue personnel, or people who own yachts or recreational boats, those users are very essential in the cases of emergencies for they would most likely be able to handle such situations. While some users would lack the experience and knowledge, like tourists, which would know less what to do in these kind of situation. Some users may have mobility, vision, hearing etc disabilities, those users would probably need more help in the case of emergency from other users.

The product is required to be functional, and have the basic life raft characteristics, like floating, mobility, and reliability. The product must be safe, deploy properly, be comfortable for the users, durable to handle hard situations like bad weather and raging waters, and made of insulating materials to accommodate cold weathers. It must also be identifiable by rescuers or other boats and ships, in the case of search and rescue situations. The product should also be environmentally friendly, where the materials used in making the product shouldn't have negative effects on the surrounding environment, or in case of the use of a motor engine.

This product is designed to be used in the caribbean water and thus will be used in that region. The use of the life raft would be in the cases of emergencies where passengers are forced to leave the boat, or in case of to test the crew and the raft. The caribbean is a touristic area, which implies that high chances are that the users of the life raft are people who don't know how to use it, which demands taking that into account while designing the deployment mechanism so that it would be simple and easy to use by an inexperienced user. And since the life raft is used in the sea environment, it must be durable and tip resistant in case of rough conditions and high waves.

The product should be able to accommodate working in different locations and situations, for example if the waters were rough, the mobility and maneuverability of the product could be limited in those circumstances, or also in the case of strong winds and inclement weather, but it should still be able to withstand those natural effects and work to a certain limit.

Clients of this product will expect it to be safe, and be able to transport passengers safely to the shore (via rescue boat, rescue helicopter, or the rescue system itself etc.), and also be a safe shelter for passengers in water for as long as possible. The client also expects the product to be smaller than the boat itself, have high maneuverability, stability, and aso easy access and deployment. On the other hand, the client wouldn't want the product to contain any hazardous material for humans and marine life, or contain any allergens. It is also essential that it doesn't rip or sink.

While designing the product, it should be considered how features and functions would affect the performance of the product, for example when designing for high maneuverability and speed, it should be considered that those features affect stability. Moreover, shelter the product provides and ability to withstand sinking go hand in hand, where even a capsized vessel must still be able to shelter the users. Also, stability and safe transport insure higher chances of survival for the users. The materials used for making the product, in addition to the shape of the latter, must not negatively affect the users.

For any client or user in general, safe trans is a key feature that encompesses the main reasoning of purchasing the product, in addition to the price and features. The client would have expectations of such features and function, because in case of emergencies, the life of everyone on the boat would depend on that product and its functionality.

The attributes, features and functions of the design interrelate and interact, for example, safe transportation interacts with all aspects of the user's wants and needs, as a stable, sheltered and a maneuverable lifeboat will insure the livelihood of its users.

Initial Research

Different kinds of maritime life-support systems are used, in this project it is focused mainly on fishing boats and tour operators, and those usually use three main equipments, which are life rafts , lifeboats and/or life buoys.

In general, there are three main different types of life rafts:

1. Coastal life raft: are used for emergencies that occur near a coast. Coastal life rafts cost less, and commonly have single layer floors which makes it non isolating, and four low walled sides.

2. Offshore life rafts: this kind of rafts is designed for use in hard weather conditions, also includes water pockets which reduces the chances of it capsizing, and have an inflatable floor with dual-wall air chambers. Offshore rafts also have two buoyancy tubes and a canopy. They are safer and provide more protection than coastal life rafts.

3. Ocean life rafts: are designed to help users survive for a long time in water, commonly used in vessels. they include survival gear, canopy for shelter, double layered floors and ballast bags to prevent capsizing.

Other types of safety equipment would be the life buoy, which is very common and can be found on almost all boats.

These safety equipment are used by all kinds of boats, vessels, small fishing boats, rescue teams etc. They can be used by experienced sailors or boat owners, or it also be used by inexperienced users like tourists.

Inflatable life rafts are contained in hard cases, or in waterproof bags. They are either equipped with an auto inflation devices which allow the raft to inflate automatically when it is deployed to water, or they can be inflated before being deployed. They are commonly used on private, recreational, and commercial boats, unlike rigid lifeboats.It is essential that life rafts go through a periodic inspection done by a certified facility to insure reliability of the raft in any sudden emergency.

Rigid lifeboats on the other hand, are used on larger vessels. They can be fully rigid or of a rigid hull, and an inflatable side. They usually include a motor unlike inflatable life rafts. Open lifeboats, which have no overhead protection are becoming out of use and now it is mostly depended on closed lifeboats because they provide more protection, except for old ships and poor environments. Rigid lifeboats unlike inflatable rafts, are periodically inspected by crew members to insure safety, reliability and proper deployment of the lifeboat.

Both liferafts and lifeboats are equipped with survival equipment, such as food and water, flash lights, flares, sea sickness pills, pedals, a hand pump, a rescue quoit that is thrown to people in the water to help them get in the raft and can be used by rescue, and leak stoppers like rubber patches.

It is important that the life raft/boat capacity matches the carrying capacity of the boat. It is also important to wear the life jacket before abandoning a sinking boat into a lifeboat.

Some important functions and characteristics of life rafts are ballast pockets that fill with water after the raft inflates, to reduce the chance of the raft to capsize. Also, rafts are equipped with sea anchors that provide steadiness to the raft in case of strong winds and to prevent it from spinning. As well as insulated floor and canopy to keep the heat inside, and made from strong fabric to resist strong winds and waves. It is also mandatory for life rafts to have two stacked buoyancy tubes, where each tube should be able to withstand the maximum load of the raft on its own. They are also equipped with retroreflector tapes and commonly two lights one from the outside (orange or white) and one from the inside (white). Finally, standard colors of liferafts outside surface must be orange, yellow, or other similar colors..

Current market

Viking RescYou™ ISO 9650-1/ISAF Life Raft

Figure 2: Viking RescYou™ ISO 9650-1/ISAF Life Raft [9]

Table 1: Viking RescYou™ ISO 9650-1/ISAF Life Raft specifications [9]

Features		Pros	Cons
Cost	$4229.99	-Durable material -Automatic inflating canopy -Large capacity -Water weights make it tip resistant -2 Flotation tubes -Integral inflatable floor -12 years waranty -compact stowage -multiple versions of product with different capacities and prices	-Expensive -Heavy for inflatable design
Material	Natural rubber / Acrylic silicon-coated nylon		
Capacity	6 persons		
weight	106 lbs		
Rigid or inflatable	Inflatable		

Portland Pudgy

Figure 3: Portland Pudgy [10]

Table 2: Portland Pudgy specifications[10]

Features		Pros	Cons
Cost	$2995.00 + add ons	-Durable material -Extremely tip resistant -Option for 2 HP motor, sail, or canopy -has manual propulsion system (rowboat) -Multiple add ons which allows the Pudgy to be used for recreational use as well -Rain catcher and spout -Four SOLAS approved reflective strips -Anti nausea canopy	-Expensive -Heavy compared to other inflatable lifeboats -non-compact stowage
Material	polyethylene		
Capacity	4 persons		
weight	128 lbs		
Rigid or inflatable	Rigid		

JIM BUOY - Standard Life Float with Net Platform

Figure 4: JIM BUOY standard life float [26]

Table 3: JIM BUOY standard life float specifications [26]

Features		Pros	Cons
Cost	$1489.99	-tough/resilient vinyl surface -easily boardable -lightweight -No exposed sections of metal hardware -Double webbing - weather doesn't reach supporting beckets -Solid closed cell plastic throughout	-no protection from weather/elements -no canopy -not user friendly -expensive
Material	Vinyl Outer Shell Solid Closed Cell Plastic Inner Core		
Capacity	10 persons		
weight	30 lbs		
Rigid or inflatable	Inflatable		

Ocean ISO

Figure 5: Ocean ISO[11]

Table 4: Ocean ISO specifications [11]

Features		Pros	Cons
Cost	$2204.41	-Insulated floor Hermetically sealed -Highly visible in yellow and orange -Rain water collection -4/5 x 75ltr ballast pockets for increased stability -External and internal lighting system -Retro reflective tape -3 Year service interval -compact stowage -Fully inflates in 30s	-Slightly expensive -canopy is non inflatable
Material	PU nylon laminate		
Capacity	4 persons		
weight	62 lbs		
Rigid or inflatable	Inflatable		

Crewsaver Rescue C.A.S.E Buoyancy Aid

Figure 6: Crewsaver Rescue C.A.S.E Buoyancy Aid [12]

Table 5: Crewsaver Rescue C.A.S.E Buoyancy Aid specifications [12]

Features		Pros	Cons
Cost	$999.99	-5 100 lb ballast pockets, boarding ladder and multiple lifelines -Six-sided construction -Raft uses CO2 inflation system -Packed in high visibility lightweight, waterproof and durable valise -light weight -inexpensive -compact stowage	-No canopy -Only 1-Year limited warranty
Material	Polyurethane proofed nylon fabric		
Capacity	6 persons		
weight	25 lbs		
Rigid or inflatable	Inflatable		

SAR Single Person Life Raft

Figure 7: SAR Single Person Life Raft [13]

Table 6: SAR Single Person Life Raft specifications [13]

Features		Pros	Cons
Cost	$999.00	-Fully Reversible -Quick and easy boarding -Weather-tight canopy protection with viewing window -Stowage pockets for personal safety items -Compact bailer and sea anchor included -Easily transportable between aircraft -Optional inflatable floor for enhanced thermal protection -compact stowage	-Only capable of carrying one person -Very little space to move freely -part of body sits below sea level -person who's claustrophobic may not be able to use this raft
Material	Polyurethane proofed nylon fabric		
Capacity	1 person		
weight	5.4 - 6.2 lbs		
Rigid or inflatable	Inflatable		

User Groups

Manufacturing

- work with tools and machinery needed for the manufacturing process
- lift 60-110lb

Prototyping

- access to 3d printing and rapid prototyping technology
- knowledge of generating computer models
- be aware how different or similar the prototyping material will be to the final manufactured product

Supply Chain and Distribution

- Able to transport products in mass amounts
- Able to lift 60-110 lb on average

Implementer

- work with the necessary equipment, machine and tools in implementation
- know general life raft implementation mechanisms (hanging or inflatable)
- knowledgeable about important boat regulations

Salespeople and Marketers

- knowledgeable of the product and customers interested in the product
- knowledgeable of law around the product to assure customer's the product meets all legislation
- knowledgeable of other products on the market to compare and explain why this product is better
- ability to strongly communicate and persuade customers

Management

- knowledgeable of the product and industry
- experienced in the field of lifeboats and safety evacuations
- knowledgeable of end-users
- knowledgeable of laws and regulations around the product

Maintenance worker:

- -Must know general failure and inspection methods.
- Be aware of general cleaning methods and have knowledge of how different cleaning

product will react with each material.
- Know what needs continuous care in a product and be aware of how such maintenance should be performed.
- Be able to carry moderate to heavy loads (70-90)lbs.

End User

- Be able to interact with other people (verbally/physically).
- Follow instructions (excluding people with disabilities and people who need accommodations).
- Perception of space and barrier (excluding paralyzed).
- Operate basic controls (using sight or hearing), (excluding users with disabilities).
- Be able to handle hard situations (operators and crew at least).

Co-user

Rescuer

- able to see in order to search and identify the stranded users on the raft
- extract passengers from the raft to safety
- be able to use the necessary equipment as well as proper procedure in a rescue
- lift 90-130lb
- perform first aid

Marine life

- remain stable/ calm and undisturbed
- needs to breath in clean water

End of life User group:

- Knowledge of the available material in products.
- work with appropriate machines in dealing with waste.
- have access to a proper environmentally friendly (to the extent reasonably possible).

Personas

Manufacturing/Implementer

Isaiah

Isaiah is 55-year-old, stands 5 ft 10’’ tall, weighs 195 lbs, and works full time at a small life boat manufacturing company with 20 workers. Monday to Friday from 9-6 and oversees the melding and assembly of the boat. He has been working at the company for over 20 years and is familiar with the process as well as passionate about his job. His focus in the assembly is the melding of the joints of the fabric as leakage prevention is key to the raft. He can carry about 100 lbs however can get tired after prolonged and continuous lifting but still assists others in lifting despite his pain.

Caroline

Caroline is a new part time worker at the same company where Isaiah works. She is 25 years old, 5 ft 6’’, and weighs 145 lbs. Hired about 2 months ago, she is new to the job but has a bit of experience with the machines used in the assembly process. She can carry about 70 lbs. While she focuses on doing her job she can get nervous when melding due to Isaiah watching so carefully and sometimes can make mistakes but always makes sure to fix it.

Kylila

Kylila works at a dock for loading and unloading cargo. Occasionally there are boats that need their emergency boat lifted to the holder. While she has been working at the dock for about 4 years, she still does not like tying knots because to her it always seems to be too loose. Kylila usually lives an active life and goes to the gym every other day. She is 34, 5 ft 8’’, weighs 155lbs and can usually deadlift 100 lb and continues to improve little by little.

Prototyping

Marcos:

Marcos is 30 years old, 6 ft 2’’, 220 lbs and works as a materials scientist. Marcos has high experience in polymer and composite materials. He is familiar with metal but has only studied them in university. Marcos does have experience boating.

Sam:

Sam is 47, stands 6 ft tall, weighs 180 lbs, and is a CNC operator. He can work with many metallic materials. He can create very accurate models. He does not know much about boating or maritime systems. Sam requires detailed drawings of what he needs to create on the CNC machine.

Jason:

Jason deals with Human factors issues in designs. He is 35 years old, 5 ft 6’’, and weight 150 lbs. He will prepare the prototypes for testing. Jason need detailed information of how the design will be used and in what conditions. He also needs to know if he has access to potential customers for questioners. Jason determines what sort of testing should be done on potential designs. He has done sailing in order to prepare for this job.

Supply Chain and Distribution

Amir

Amir is 38 years old and works for an industrial distribution company. He has been working with the company for little over a year and enjoys the aspect that he deals with different products regularly. He has experience driving commercial distribution vehicles and has delivered up to one thousand products in one shipment. Amir is 5 ft 9’’ and weighs roughly 170 lbs. He is able to do heavy lifting up to 90 pounds when necessary but usually doesn’t have to. Pump Trucks and dollies make his life a lot easier.

Nathan

Nathan works for a life raft manufacturing company and is 24 years old. He is responsible for taking products which have completed the assembly process and passed quality assurance and preparing them for shipment. Nathan is in charge of ensuring each customer shipment is completed and out the door on schedule. Nathan may deal with multiple shipments a day and each shipment could contain hundreds of orders. Nathan is 6 ft 2’’ and 205 lbs and capable of moving and lifting heavy loads up to 100 lbs if necessary.

Matt

Matt works at a boating equipment sales store. He is 5 ft 5’’, and 120 lbs at age 45. Matt requires proper safety gear such as a lifting belt. Matt prefers handles for products he has to move onto the sales floor for easy transport. Matt has suffered many injuries to his shoulder and this is why he is so cautious.

Management

James

James worked as a mechanical engineer for 11 years before entering management for a life raft manufacturing company. James switched his occupation because he decided it was time for a change and that he didn’t want to deal with the headaches of design anymore. James is 37 years old, 5 ft 11 in, 185 lbs, is married and has three kids. James’ background in engineering has helped him understand his products and better manage his workers. With his background he is constantly working to suggest way to improve the manufacturing process. He does not like following the manual and usually goes based on intuition rather than a set of rules. James enjoys karate on his spare time teaches karate on weekends at his family’s dojo.

Serena

Serena supervises a test lab facility in which her team undergoes routine tests on functionality and life cycle durability of products. She is responsible of scheduling tests and ensuring all testing is up to date with the customers requests. Serena is extremely particular in terms of how testing is done. She expects her test technicians to validate every tool they use and log all information gathered. This way she maintains the integrity of the testing process and no product will enter the market without passing her testing process. Serena is 52 years old, 5 ft 7’’, and is slightly overweight. Retirement is approaching and she plans on spending her summers at her family cottage where her and her husband enjoy boating, bonfires and barbecue.

George

George is 43 years old, 6 ft 1 in, and weight 215 pounds. He works in motorized life boat company and is the manager of the company’s prototype shop. Him and his crew develop prototypes based off designs made by engineers. They make these prototypes using 3D printers and high-end shop tools and machines. George starting working for the company on the assembly line and worked his way into prototyping and now is the man in charge. George’s years of experience with tools and products allow him to lead his crew and assist where needed in finishing projects on time. When George isn’t working, he enjoys playing hockey and fishing with his son.

Salespeople and Marketers

Allison

Allison has a degree in business marketing, is 29 years old, 6ft tall, 165 lbs and has been working as a Sales Representative for VIKING Life-saving equipment for 4 years. Allison is very personable and likeable, these qualities make her an effective sale rep. Alongside of her likeable qualities, she is very competitive and has won awards such as “Top Sales Rep” for her company. Alison assures she knows her company's competition so when she is pitching to customers, she can never get thrown off her game. On a less serious note, Allison chooses to live an eco-friendly life and tries to contribute in little ways as much as possible. For example she rides her bike to work during the months she is able to.

Jason:

Jason is a 32 year old male, stands 6ft 3’’, and 210 lb with a bachelor of commerce degree. He has a long history working with different companies as a business development representative, and recently he got hired by Viking Life-Saving Equipment company to work as sales branch manager in the Caribbeans. Throughout his work experience, Jason has gained the knowledge of working with people from different cultures and backgrounds and has developed the flexibility to live in different environments and communicate effectively with the different cultures that he interacts with.

Mark

Mark is 50 years old, 5 ft 9’’, and 170 lbs. He has little understanding of maritime systems and is not tech savy. Mark was employed for his many years of sales experience. Mark cannot lift and set up any of the on sale products. He leaves the customer to do the exploring and inspection of products. He is not too familiar with “high tech” designs and tends to overlook features he doesn’t understand and does not present them to the buyer.

Maintenance worker:

George

George has little experience with boats and their general operation. He is middle aged and well-off. George is 55, 6 ft 1’’, 205 lb and has a few age related conditions such as back pain and knee problems. George thinks his age makes him experienced enough to ignore reading instructions. George spends most of his time on his vessel relaxing. He does not usually go very far out to sea (this is due to his inexperience).

Sara

Sara is an experienced sailor, but she is not a caption. She is 5ft 10’’, 170 lb and does regular maintenance on the vessels engine, body controls when it is needed. She has learnt most of her knowledge through experience and mentors. She may not know the theory behind every component but she is very handy with her tools and is confident in her work. Her hard work has left her with some injuries at the age of 46. Her injuries include hard hearing in one ear and moderate pain in her hand (around the joints), so she prefers not to grip anything with a lot of force.

Joe

Joe is a janitor on a boat. He does not have many responsibilities that need an education or specialized skills. Joe however does help out with some small maintenance work when everyone is busy. His duties will include small repetitive tasks that will not need an expert to perform. Joe is 5 ft 5’’, 115 lbs in weight and 23 years of age.

End Users

David

David is 55 years old, 185 cm tall and weighs 85 kilograms, he suffers from heart problems and has been on medication for the past 2 years. David is a businessman that owns a company which sells yachts. He is a very social person and good with handling people, he also loves making small conversations with people around him wherever he goes. He also has a great ability of working under pressure and handling difficult situations. David loves going out, but due to his heart problems he can’t do any activities that require hard work like running swimming or climbing. He also has a passion for marine life due to his field of work and reads a lot of books about it, his favourite hobby is fishing, he goes fishing every weekend on his personal boat to relax and get his mind off of work and the city life.

Nadia

Nadia is 40 years old, 160 cm and weighs about 65 kilograms, she is a housewife and a caring mother of two, she loves her sons. Ten years ago, Nadia injured her spinal chord which made it not possible for her to walk. Ever since then she uses a wheelchair to move around. Her family helped her to go through the incident. Now, Nadia and her family go on vacation once a year to relax and have some family time.

Jake

Jake is a 13 year old boy, 164 cm tall and weighs around 43 kilograms. He is a very hyper kid, loves sports and plays baseball on the school team. Jake is a very kind and loving child but he is shy with new people he meets, He also goes with his dad every now and then for fishing, he loves spending quality time with his dad. Jake suffers from claustrophobia so he never hangs out with his friends in their tree house, and can't be in tight and closed places. Jake is very interested in biology, it's his favorite subject in school, he also loves animals and reads a lot about them, he dreams of becoming a zoo keeper.

Ravi

Ravi is a 28 year old male, he is 183 cm tall. Ravi works as a crew member on a fishing boat that works on the coasts of the caribbean, which also does tours for tourists, he has been working there for a year and he loves his job. Ravi has suffered from pain in his feet and back due to being born with flat feet, which sometimes after long hours of work, the pain becomes stronger and require him to rest his feet and back.Ravi is a short tempered person, and likes to do everything his way. But he enjoys the company of his friends on the boat and having some drinks every now and then.

Dakar

Dakar is a 42 year old male, he is 175 cm tall and weighs 110 kilograms. Dakar is an ex military person and in combat lost his right leg, now living with a prosthetic leg. He has gotten used to the leg and now works with ravi on the fishing boat. When the boat is out fishing he helps everybody with random tasks, but his main job is to ensure the safety of the crew and the tourists when the boat is having a tour. Dakar has a bad eye sight and is highly dependant on his medical glasses to see and can barely see if he loses them. He is also very knowledgeable of the safety procedures, and has done CPR training due to his previous occupation.

Agwe

Agwe is a 55 year old male, weighs around 105 kilograms and is 168 cm tall. He works as a captain in the same fishing/tourist boat. Agwe is a native caribbean who has spent his whole life working on boats and has been a captain for over 20 years. Agwe knows everything about boats and how they work, and knows how to handle and operate all the equipment due to his long experience. Agwe has been suffering from back pain for a while, and since he started gaining weight 5 years ago his knees started to feel weaker, which made it more difficult for him to move around. Agwe is very passionate about the sea and feels more comfortable being there than being on land, he truly loves his job.

Co-users

Rescuer

Ailee

Ailee is 38-years old, 5ft 9’’,160 lbs, and has been working as a navy rescuer for a little over 5 years. She takes pride in her job as a rescuer and has done several search missions over her career. However, in her first year one of her missions ended tragically as the stranded raft with the passengers was never found. Ever since then she has always had a sort of impatience because the thought of overlooking the life raft in a search worries her. Upon a rescue, she always inspects the raft itself and as a side hobby reviews and educates other about her experience on her blog. This acts as her own self relief in that she knows that people are using safe products and know the proper procedure for evacuation.

Kevon

Kevon is an crew member of a patrol team for the local area, working usually at night while in patrol. He is 5 ft 10’’, 140 lbs and 31 years old. Due to the lighting of the cabin in contrast to the darkness of the sea it is sometimes difficult to see the boats if not illuminated or is nearby. Occasionally, he inspects the boats on sea to test boat driver and check the condition of the boat making sure all rules are followed, especially the boat is found far from land. To him it is crucial that a first aid is available in the case of an emergency and is near the emergency life raft.

Marine Life

George

George is a flying fish that lives offshore of a popular harbor. To avoid predators, it flies out of the water, often without looking in the headed direction. Furthermore, in sight of a bright and colorful objects can get curious and come close. Like all other fish pollutants can harm or even kill it and avoids these areas as much as possible.

Lawyers

John

John is a company lawyer. He has a degree in engineering and law. He understands technical aspects of products. He may need clarification sometimes. John does not know every product by heart. John has not used every product the company makes. John is 35, 5 ft 8’’, and 175 lbs. His experience is mainly in patent lawsuits.

Sam

Sam writes the legal documents for terms of agreements in products. Sam is 50 years old, 5 ft 11’’, and 180 lbs. She does not have a background in engineering. Sam also cannot test the products she is writing terms of agreement for.

Jason

Jason is a litigator. He is 26 years old, 5 ft 9’’, 170 lbs and deals mostly with product research in preparation for cases. Jason needs access to both technical data and general legal documentation. Jason also spends most his time in a library performing research.

End of life users

Daniel

Daniel is a 39 year old male, stands 6 ft 4’’, and 230 lbs. Daniel is very strong and in good shape. He enjoys working out on his free time and competes in weightlifting competitions often. Daniel works on the Marine Recycling Corporation team that is responsible for recycling of all kinds of marine vessels. Is familiar and comfortable to work with heavy machinery due to years of experience.

Alice

Alice is a manager for A company responsible for a fleet of boats. She supervises what parts on a boat are old enough to dispose of and how to correctly dispose of them. Alice is 35 years old and weighs about 80 lbs. she is petite in stature and only stands 5 ft tall. Alice is an experienced employee that has studied waste management. As a busy manager however she relies on co workers under her to actually perform the tasks of disposal. Alice relies on material safety data sheets, on technical specifications on product websites and labels and laws and codes in waste management where the fleet she is working on is located. Materials she is not personally familiar with or are not in any of the specified sources state above will generally go to a landfill.

Jack

Jack has a personal yacht. It is on the larger side. Jack does his part to be responsible in waste management, but he does not go out of his way to look up proper disposal of every component. He will rely on anything that is clearly labeled or will just give the full product to his local recycling centre for them to deal with. Jack drives a luxury sedan. He has a fair amount of disposable income. He weighs 120 lbs, is 5 ft 6’’, and is 55 years old.

Reference Design

Throughout research of the current market, it is clear that the most common solution to evacuation of a small aquatic vessel is an inflatable life raft. The majority of these inflatable designs have canopies with the exception of a few. Another common feature in most life rafts are water weights underneath the raft. These are designed to weigh the raft down and keep it from being blown into the air due to high winds. There were a few unique designs such as the Portland Pudgy which had a rigid base unlike most other life rafts. The Pudgy still had a canopy similar to other rafts but no water weights.

The design which appealed most to the group was the Viking RescYou™ ISO 9650-1/ISAF Life Raft due to its reliable and vibrant design. The Viking RescYou is made of natural rubber / Acrylic silicon-coated nylon which makes this raft completely waterproof and resistant to punctures and slashes. This is extremely important as if the raft were to be punctured, there is a chance the raft would sink along with the passengers. In order to keep the maintain or improve the strength of materials, our solution design will either contain the same materials, or have a rigid hull similarly to the Portland Pudgy.

Unlike other inflatable life rafts, the RescYou has an automatic inflating canopy which is extremely convenient during deployment. The automatic inflating feature makes this raft hassle free and offers complete protection of the elements such as wind, rain, sun, etc. This canopy design has window openings on either side of the raft for a complete 360 degree view. These features can be seen in figure 8 below. Due to the large canopy in the Viking RescYou, it needs the four 16-gallon water weight bags beneath the raft to keep it on the water and out of the air. These are features which are important in terms of safety of the users and will be included or slightly altered in the final design.

The water weights are crucial in keeping the raft on the water but due to these weights, a propulsion system is out of the picture for the viking. The weights will produce a too much drag to have any manual or small motor propulsion system. In future designs, we wish to implement some sort of propulsion system. Hence, the water weights may be removed to support the implementation of a propulsion system and supplemented with another downforce system. This way the passengers would not be stranded at sea and could attempt to reach shore themselves. Although the Viking RescYou has no propulsion system, its highlighter yellow and black colour scheme makes it clearly visible to rescuers and search parties. The final design will include a similar vibrant colour scheme to increase visibility of the product.

The Viking RescYou has a capacity of up to 6 people and is extremely compact while not in use. It is folded into a container until its use is required. At that point, the user would simply deploy the raft from its container and wait until it is fully inflated. This raft inflates in under a minute, and in future designs we would like to decrease deployment time so users of the product may get to safety as fast as possible if an inflation system is used in the final product design.

A few drawbacks of the viking is its price, and its lack of a source of propulsion. The price of the RescYou is well over four thousand dollars including add-ons, making it an expensive option for a life raft. In order to make the final design more appealing to customers, we will work to reduce the price and have it more easily attainable. Also, the Viking RescYou is a passive vessel, meaning the users have no control over its path. Due to this, passengers may be forced to live in this vessel for up to days. In the final design, we plan to include a propulsion system to allow users to “save themselves” and reduce the time spent within the product.

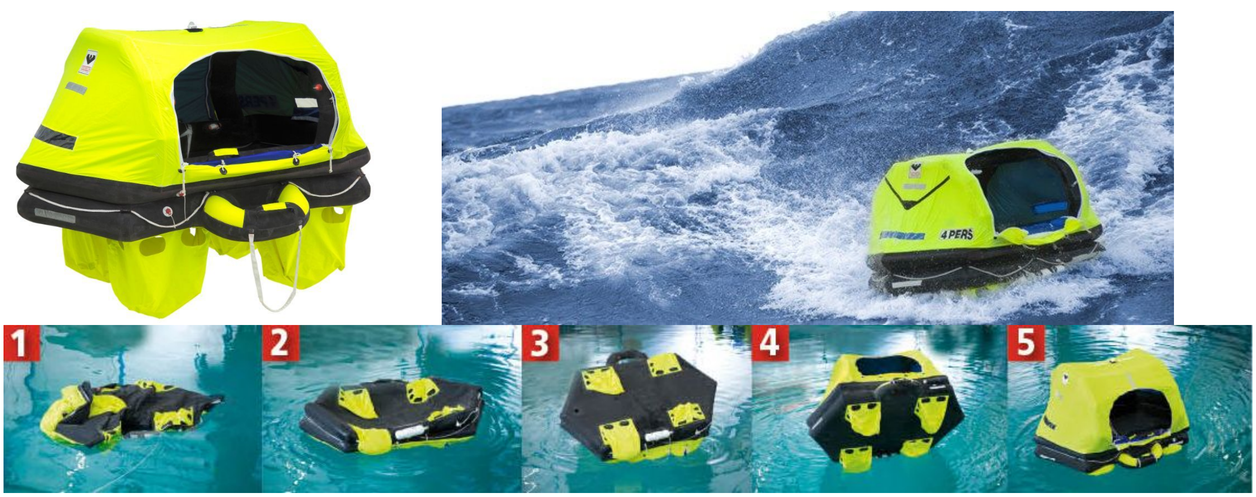


Figure 8: Viking RescYou™ ISO 9650-1/ISAF Life Raft [14]

Current System Model

Input output of the system and how they relate with flow diagrams

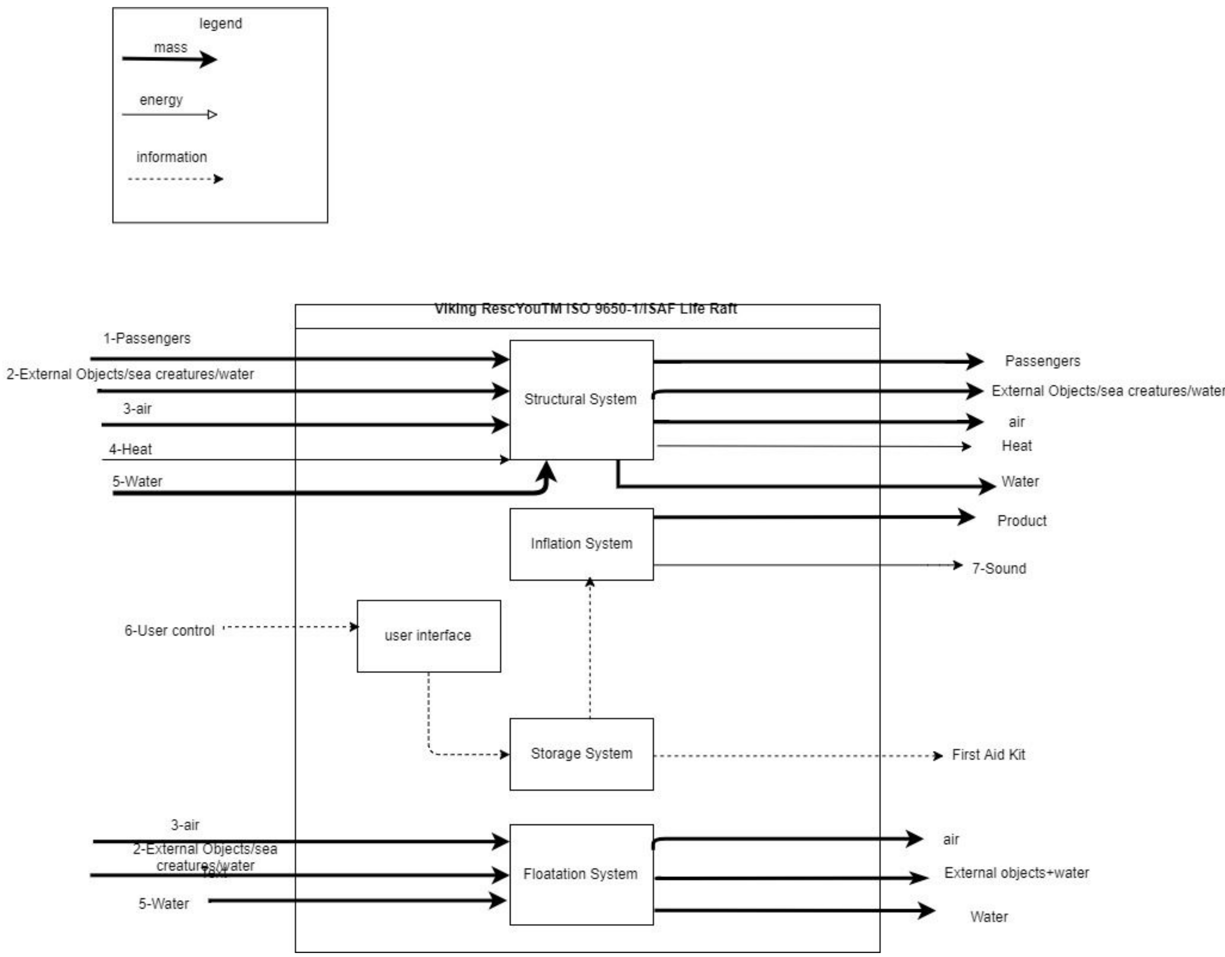


Figure 9: Initial System Diagram

Interfaces

1- Maximum passenger capacity of 4 Persons.

2- External objects/ sea creatures/ water into Flotation system which could cause puncture.

3- Air interacting with structural system, and air into flotation system to inflate the buoyancy.

4-Heat interacting with the system.

5- Water includes rainwater and seawater interacting with the structure and floatation system.

6- User controls through user interface and into storage system to access first aid or to request for deployment of product..

7-Sound of compressed air during the inflation of the raft.

Current Usage Scenarios

Usage scenario 1: Maintenance usage scenario

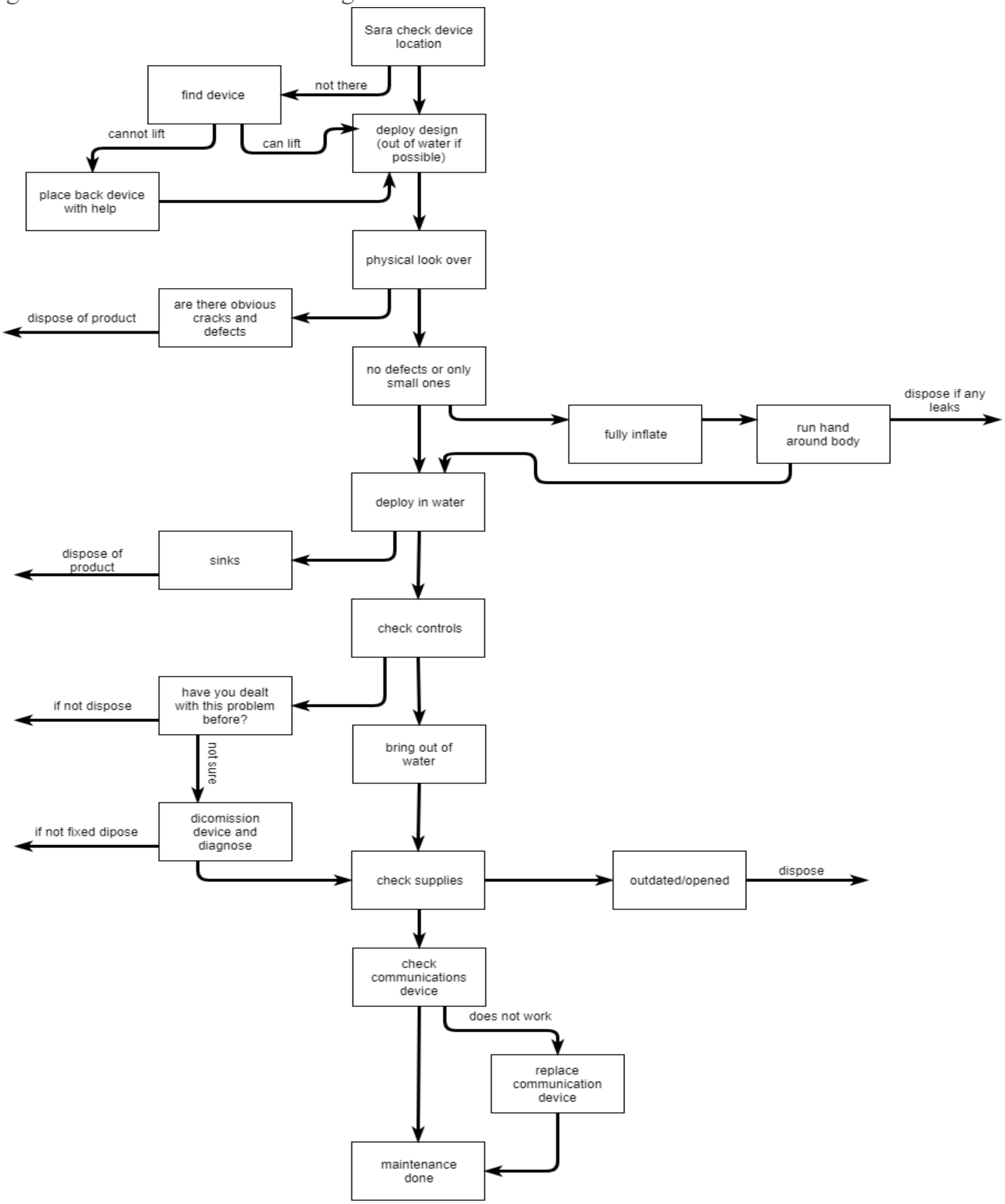


Figure 10: Maintenance Usage Scenario

Usage Scenario 2: Sinking boat and injured person

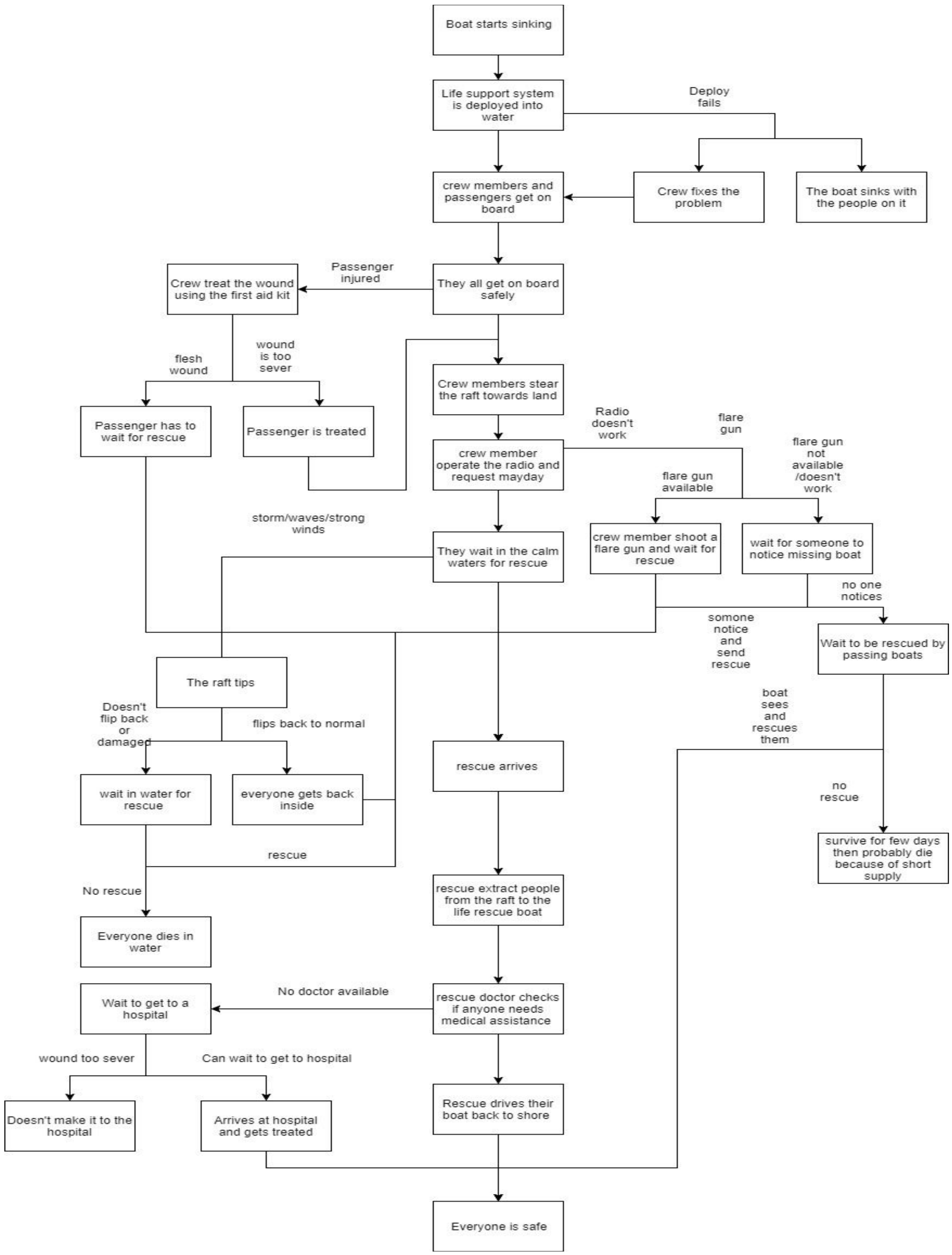


Figure 11: Usage scenario sinking boat and injured person.

Usage Scenario 3: Product use during a storm

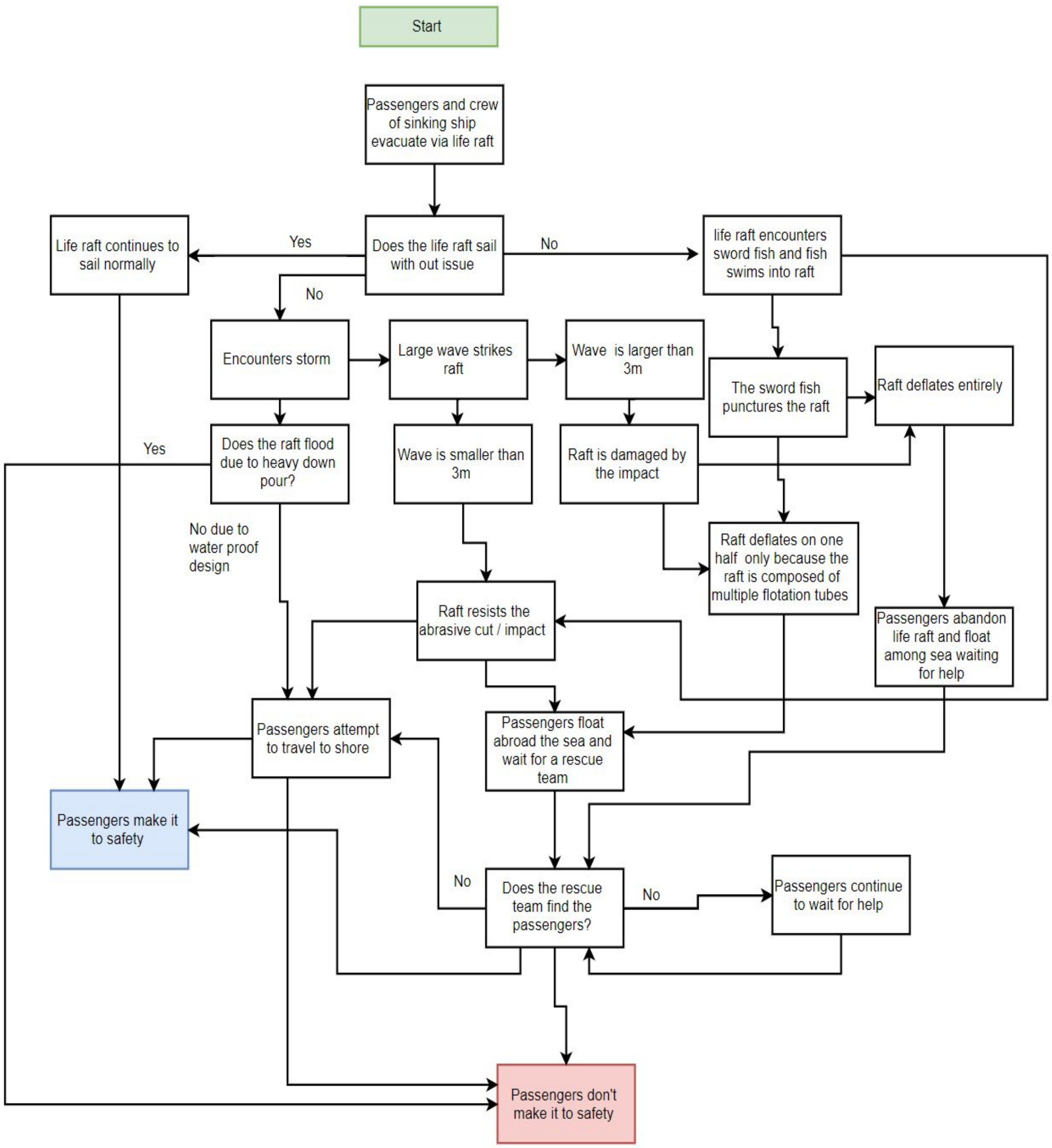


Figure 12: In Storm usage scenario

Usage Scenario 4: Product use during sinking ship

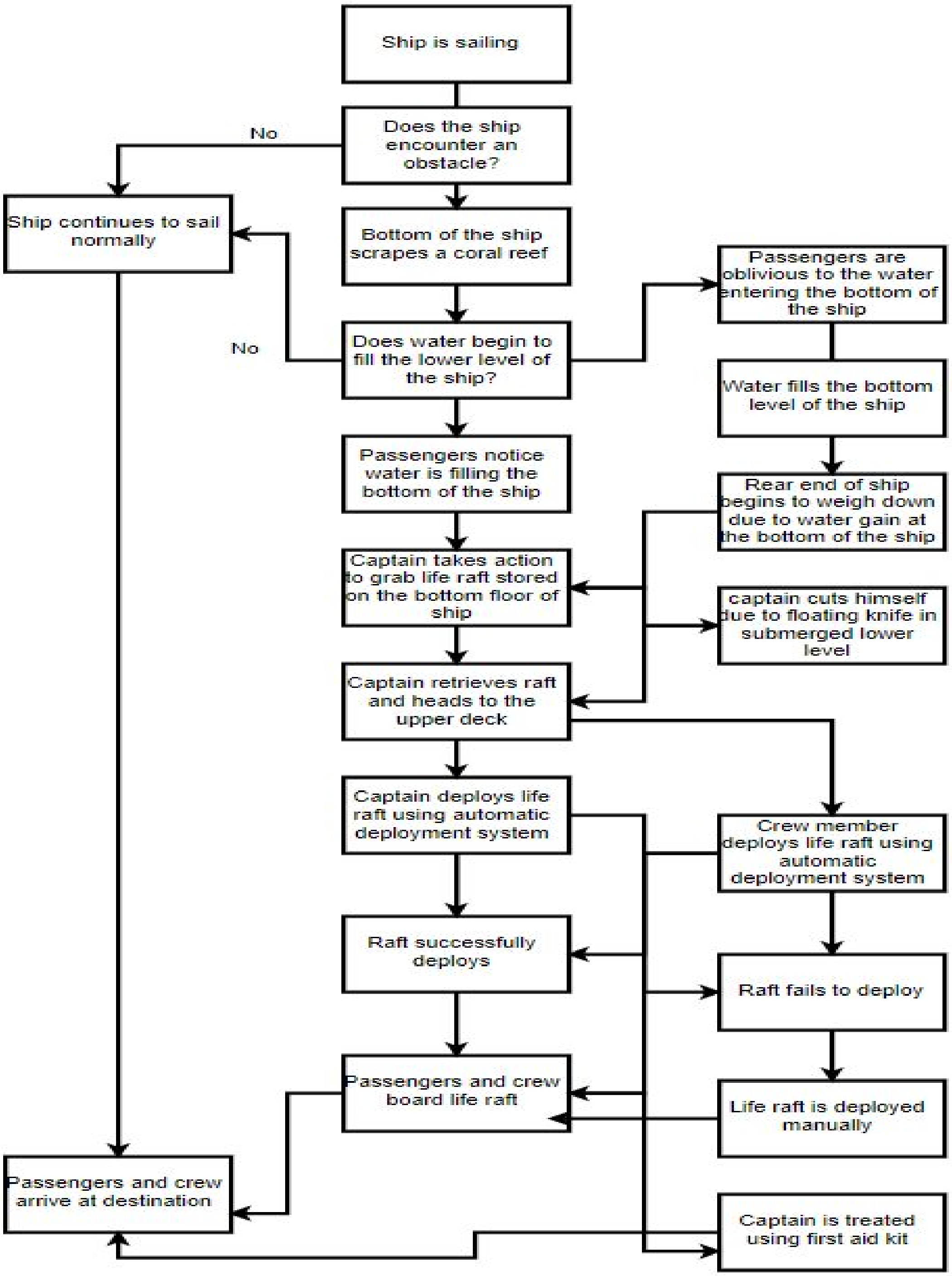


Figure 13: Sinking ship usage scenario

Usage Scenario 5: Drunk end-user interacting with product

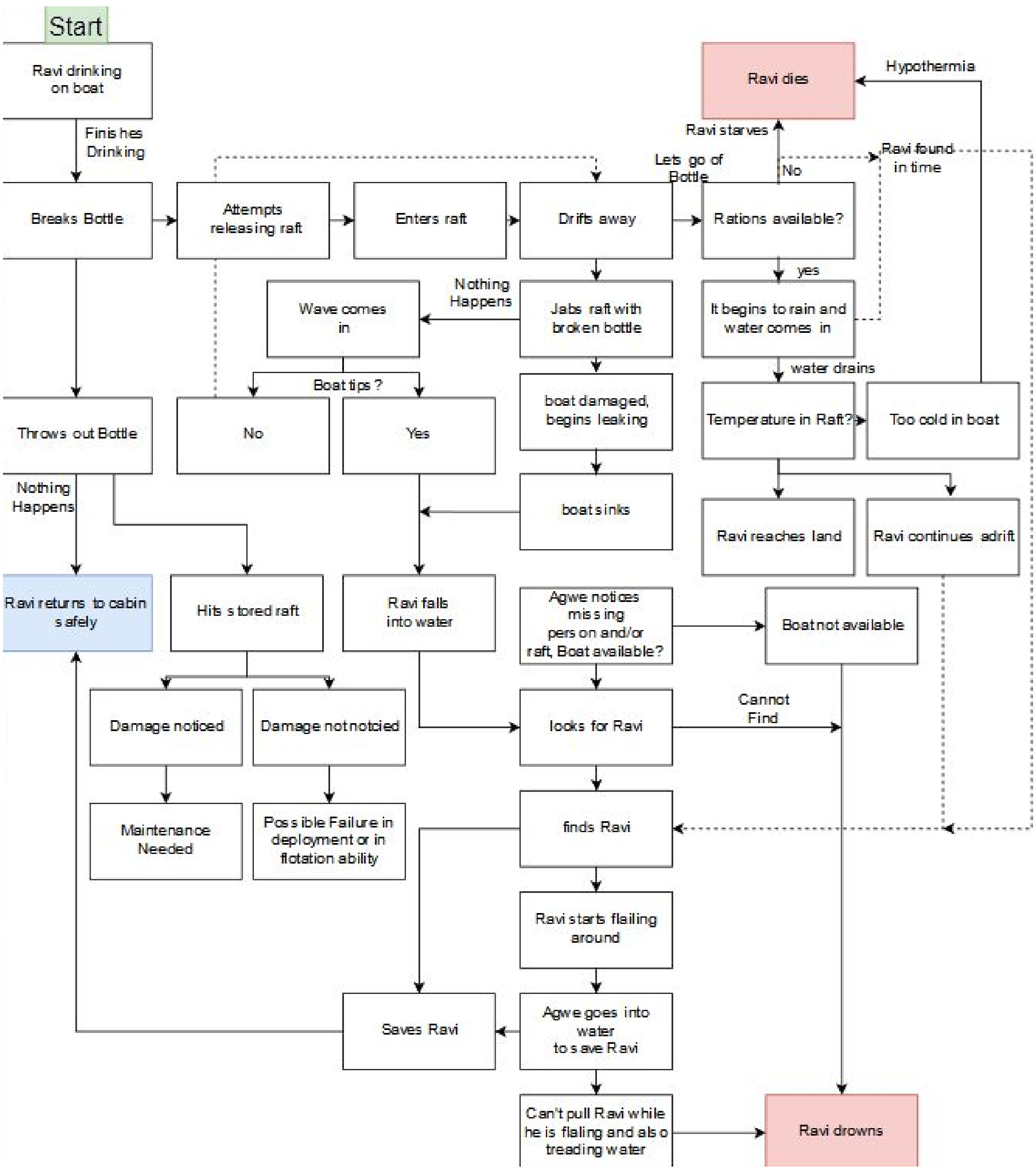


Figure 14: Drunk user using boat Usage Scenario

Usage Scenario 6: Product storage after use

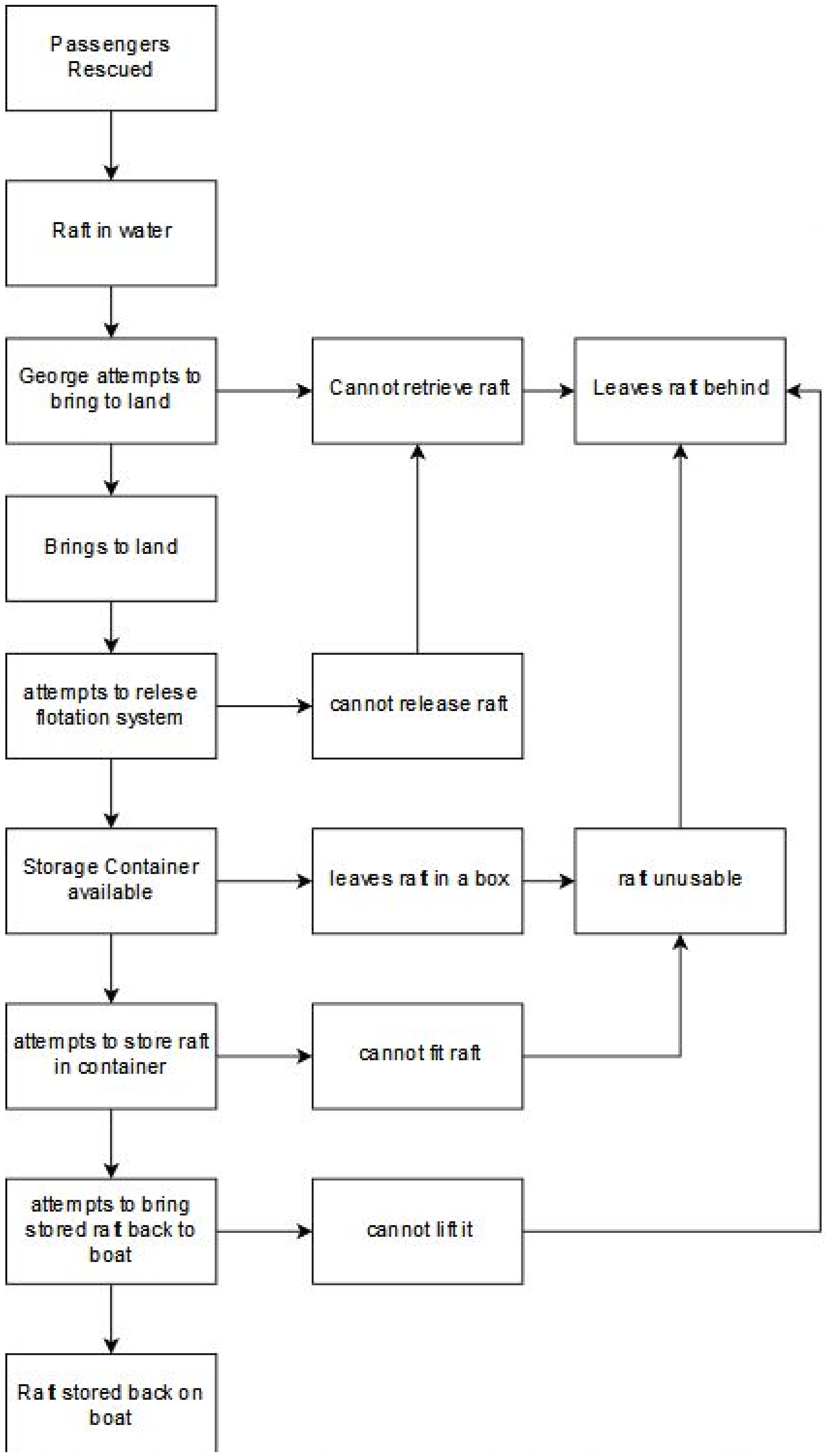


Figure 15: Storage of Raft after Use Usage Scenario

Product Strategy

The lifeboat is an important safety feature that is need on a boat. Our design is focused on smaller vessels. According to Transport Canada, a small is categorized as carrying no more than 12 passengers [1]. The design was restricted to carry no more than 6 users at a time as well as the smaller size of the boat, it was decided that we go with a design that can be collapsed rather than one that is hung on the side of the boat.

Determining the specific users and demographic is difficult because the range of users is large, there is no specific restriction on going on the boat. Thus, it is crucial that all sorts of end users are covered as there is very little of the population that can be left out. The users that are left out are those who cannot be on boat due to some sort of physical or emotional restriction for example extreme seasickness or aquaphobia as the likeliness of them being on the boat is reduced significantly but the possibility is not eliminated. However, amongst the users that are on the boat, there is a separation in the responsibility of the user. One set of users is expected to have some experience in the procedure in the case of emergency for example the captain, that has the licence and is aware of the rules. The other category is the general users that may or may not be able to use the raft. This set of users is wide and is difficult to flush out all possibilities as this group is practically anyone who is on the boat as a tourist or for recreation. This can include those who can and cannot swim, different sets of emotional control in the case of emergency and different requirements. Within this set of users, it is important to consider those with special needs or disabilities which need to be accounted for. An example is a child which in most cases cannot take care of themselves and on top of the possibility of being less aware of the situation, can be unpredictable. Another example of is a user that is in a wheelchair or in crutches. For these users it is important to design to make it easier for the user to get in or someone to assist the user in the raft.

The target market is within the caribbean which is difficult because upon research there are no specific rules that apply to the caribbean, rather there are international one that applies. We want to design a water life support system that is of minimum price so that is affordable to the people of the caribbean. One thing that we want to improve on is that the reference design does not have some sort of mobility system. The materials of the raft should be inexpensive and light so that the motor will be able to power the raft. For the mobility we would like to design it so that it uses a renewable power source. While the mobility does not fixed to an electric motor the gasoline motor is the most commonly used type of motor due to its higher power output for the cost.

Figure 16: Fishing Boats in the Caribbean

The ideal goal for our design is that we want to create something that is different from the current market. The market has several expensive alternatives already exist and we would like to work on that. One feature that we would like to incorporate is the inclusion of first aid and provisions that are ready on the life raft in the case of injury and preparation in the situation of being stranded for a longer period. Furthermore, the boat needs to be simple and reduced in the number of controlled needed because the time that this is used is usually in the panic which decreases the problem-solving ability of the user. This in turn may result in accidents, thus the need to reduce the complexity.

We do not intend to get the design into the market too fast as there are currently robust products that exist. Taking this into consideration we want to thoroughly make sure to the design meets our standards before it is put into the market to prevent a recall or flaw of some sort by spend time refining the design. The number sold will be less because for boats that already have a raft there is no real reason to change as well as that it is not used often. However, considering that one small vessel can get 1-2 and that medium sized can still get it which can come up to 3-4, our goal is to sell about 1000 products as an initial run. By the end we do not expect much of profit with an approximate profit of about 10-15%. Due to the market being the Caribbean we do not want to mark up the product too much because we want to make sure user get proper safety equipment.

Lastly, we would like to reduce the waste produced by the materials used to a minimum. Our goal would be using as little material to not only reduce the cost but also the amount of material that is left at the end of its life. The materials that are used are either reusable or easily disposable (can be broken down by the environment easily). Furthermore, for the propulsion system, we would like to use renewable energy sources to reduce the pollution of the product. This is especially crucial to the location that it is in as there is an abundance of flora and fauna in the local area from coral reefs to exotic sea life that is a critical part of the area's ecosystem. This is not only for the environment but as this is a tourist area, preserving the wild life also plays a factor in tourism. Additionally, the sealife is also strong part of the local exports as the Caribbean accounts for 130 billion of global market share in the seafood market[7]. Damaging the sealife would therefore greatly damage the local economy as it is one of their primary exports.

Figure 1:Sea life in the Caribbean [2]

Problem Analysis

Requirements

Safe

- Follow safety guidelines
    - The product must comply to the International Maritime Organization (IMO) requirements on International Convention for the Safety of Life at Sea (SOLAS) [27].
        - Includes requirements for life saving appliance which entails lifeboats, life jackets, etc depending on the ship. All appliances must comply with the International Life-Saving Appliance (LSA) Code.
- Insulating
    - Must be able to keep temperature approximately constant for at least 24 hours using approximation of distances from appendix 1.1.
- Resist leak and flood
    - Max possible water level leaked of 8 cm.
        - Level of take on water based on approximated ankle height measurements.
    - As stated in the movable constraint it should be able to withstand an.approximation of 22 hours of 10mm/h downpour which is classified as heavy rain [20].
            - Based on volume determined using a storm rainfall calculator provided by USGS Water Science School.
- Withstand waves and tides
    - Keep upright in waves that are at least 3m height.

        - Based on design brief requirements.

- Withstand strong winds
    - Be able to be in winds of at least 62-74 km/h.
        - Gale force wind speeds (8 on Beaufort scale) as required by design brief [22]
- Safe Deployment
    - Be able to deploy without harming the user by either remote deployment or at a speed that can be used safely.
- Provide first aid
    - Product will contain a first aid kit with contents based on red cross standard first aid kit contents [25].

Environmentally Friendly

- Uses non polluting material.
    - To reduce the end of life waste by using material that can be recycled or can be disposed of properly (ex biodegradable).
- Renewable power source (if any)
    - Must use solar, hydro, wind, electric, or human power source to power electric equipment.
        - These are all forms of renewable energy which do not leave negative environmental footprint.

Durability

- The product must be able to remain in water for extended periods of time.
    - Must be able to remain in water a maximum of the product's useful life.
        - If the product is a rigid base lifeboat, then the boat may be in water its

entire life and thus must be durable enough to do so.

- The product must resist impacts and abrasive cuts.
    - The product should withstand small impacts from external objects including rocks, fish, etc.
        - A puncture in the product could lead to a chance of the product sinking and which endangers the life of the users.
- The product must be reusable
    - Have a product life of minimum 12 years [9]
        - Same product life as reference design or better
- The product must be usable in far distances from shore
    - 50 km from shore
        - Based on the design brief.
- Non abrasive

Identifiable

- The product must contain retroreflective material
    - According to Legal Information Institute, retroreflective surfaces must be capable of being attached to any lifesaving equipment [32].
- The product must be audible
    - 105-120 db [15] - Average sound level of a whistle (users will have access to whistles in safety kit provided)
- The product must be detectable to satellite
    - The product would include a GPS system which makes it easier for rescuers to find it.

Maneuverable

- moveable(back and forth speed)
    - Travel at least 2.88km/h
        - The Yucatan current is the strongest current in the caribbean at 2.88

km/h[3]. Most fast current in this sea tend to move towards the shore with swirling patterns[3].

- Buoyant
  - 1250 lb to 2000 lb load
    - The portland Pudgy has stated its craft can take A USGS approved 577 lbs.[5] as with two extra max passengers in this design we have scaled up weight to take into account their own weight around 225lb each plus personal stuff brought with users from the boat [29].

Convenience/Comfort:

- Easy accessibility entering and exiting the product
  - Provide a step maximum of 2 ft under water
    - The hip height of the 5 percentile female is 2.4 ft, which means the step should be a bit shorter to make it possible for the users to push themselves into the product . [29]
- Provide personal space.
  - 0.372 m^2 per person based on ISO standards. [28]
    - Personal space is important in such stressful situations, especially for people with asthma, claustrophobia, etc.
- Stored on boat.
  - Hanged on the sides of the boat or in vacuum packing.
    - Having the product vacuum packed protects it from being deteriorated by water over time. Using either way of storage, the rescue system should be stored on the boat in a way that would allow the fastest and most convenient boarding to the product.
- Non-irritating material.
  - It is not decided yet what kind of materials are going to be used in the product, but it is necessary to avoid using irritating materials: irritating materials may cause irritations in the skin, or allergies (ex: latex), or in case of contact with eyes.

Which will cause more stress and uncomfort to the users.

- Easy to extract people by rescuers.
    - Minimum entry/exit opening width of 50.5 cm [29].
        - 95th percentile male shoulder width.
- Available in the case of an emergency
    - Product must be ready for use in 25s $\pm$ 5 s [23]
        - This is based of a test conducted for six ISO liferafts, including our reference design. Inflation time was 25 seconds.
- Passengers must be able to sit upright within the product.
    - Height of the canopy from floor of the product must be a minimum of 97 cm [29].
        - 95th percentile male sitting height.

Affordability

- Must be cost effective
    - Total cost less than $4, 159.99 [9].
        - Price of the reference design.

Discussion

HF Notes

The environment that the users will be using the device will generally be in a high stress situation resulting in generally lower cognitive abilities. For these reasons the design of the controls need to be intuitive and act within skill based or rule based decisions minimizing the need for knowledge based decisions. To further simplify the controls, the design of the actual controls should be simple and easy to use, utilizing methods of control design like location, mode of operation, shape, size etc, to make it easier for the user. Furthermore the age group of the life raft may vary there for those with less eyesight for example the elderly, the control should have sufficient contrast to see it and for night use should use larger controls.

The manufacturing process should only incorporate simple and familiar tools which can be used without straining the manufacturers body. Also the materials used should be light and easily maneuverable to relieve strain from the manufacturer’s back and knees. In addition to manufacturing, all aspects of the product which may require maintenance should be easily accessible. This is important so the maintainer of the product won’t have to work in awkward or difficult positions.

Product Architecture

Overall Product

SYSTEM IDENTIFICATION MATRIX

Table 7: system identification matrix

FR	Mobility	structure	storage	UI	Power
Follow safety guidelines	X	X			X
Insolating		X			
Resist leak and flood		X			
Withstand waves and tides	X	X			
Withstand high winds	X	X			
accessibility		X		X	
Safe deployment			X		
Provide first aid			X		
Uses non polluting material	X	X			
Provide personal space		X			
Contain users		X			
Renewable Power					X
Remain in water	X	X			
Resist cuts and impact		X	X		
reusable			X		

Used at a far distance from shore	X	X			
visual/audible		X			
movable	X		X		
Radar visibility		X			
Store on boat			X		
Stay above water	X	X			
Non irritating material		X			
Accessible in the case of an emergency			X		
Must be cost effective	X	X	X	X	X

SYSTEM DIAGRAM

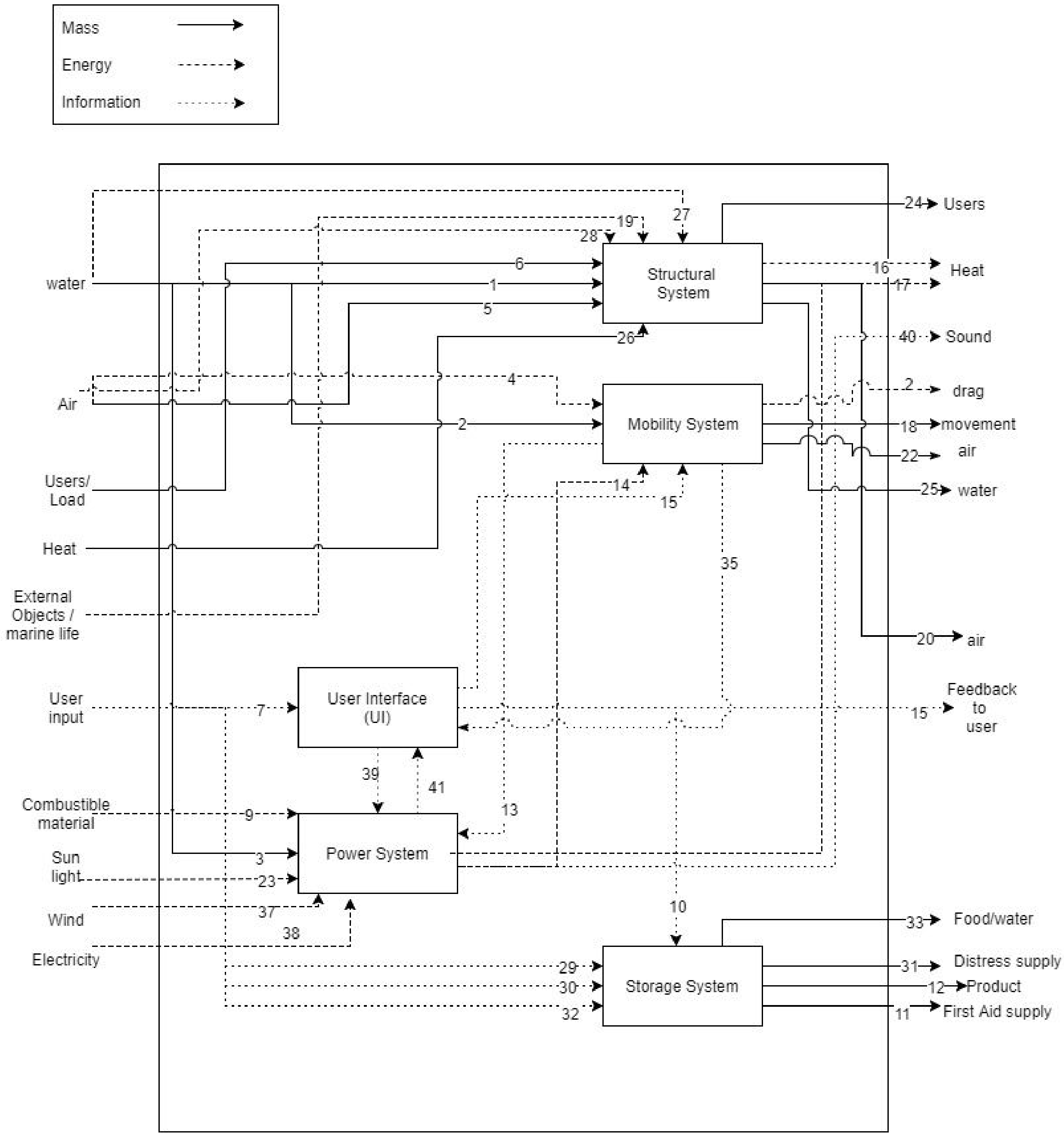


Figure 18: Main System Diagram

SYSTEM INTERFACES

1. Water to Structure a function of the volume of water: $P = \rho g h \text{ and } F = \frac{P}{A} \rightarrow F = \frac{\rho g h}{A}$ where h is the depth of water in the product and A is the containment area (assuming a flat containment area)
2. Water to mobility (drag): action and reaction forces between the steering components and water creating directional movement (user requested or otherwise). The behaviour is out of user's hands as it deals with a component outside the system boundary.
3. Water to power (exposure): Using a water turbine it is possible to convert the energy from the moving water into work.
4. Air to mobility (drag/wind): effects the ability to control the mobility system properly.
5. Air to Structural - The average person breathes about 8L/min + 4 (uncertainty). For 6 people, there needs to be at least 48 + 20L/min of air in the cabin[21]
6. User/load to structural upper float requirement of maximum 2000 lb of buoyancy required based on the requirements.
7. User input to user interface: this is the input from the user to change a parameter of the product.
8. ~~Removed due to incorporation into the user interface. User input to mobility (request to move): User will command the system to make appropriate action course adjustment. The control sub-sub system will read the command and decode appropriately.~~
9. ~~Removed due to requirements of renewable energy. Combustible material (input of energy to power system): Depends on the type of engine that would be used.~~
10. UI to storage (request access to product) - product ready for use within 25s $\pm 0.5s$ based on requirements
11. Storage to first aid: the interface is the physical separation line between the storage location and outside the physical system: contents based on red cross standard first aid kit contents [25]
12. Deployment to product (product deployed): the physical boundary between the storage compartment and reaching the water.

13. Mobility to power (request power): the control sub-sub system requests power from power sub system to perform user requested mobility adjustments .
14. Power to mobility (power sent): The power subsystem will receive power request and as feedback give power to required subsystem.
15. UI to mobility (feedback to perform new commands with data): The UI will use the given sensor inputs to adjust the course of action of each subsystem; this is communicated to each control system as needed.
16. Structural to heat: heat loss to the water, because of the relatively high heat capacity of water and that it is a large body, which leads to a high potential of heat loss/dissipation
17. Power system to heat (heat waste): interface includes any exhaust or cooling ports around the power system.
18. Mobility to movement (Resulting movement): boundary between where the movement controls make contact with water and result in movement, required speed specified in requirements.
19. External objects or marine life to structural: any sort of collision or physical damage that ranges between cuts, scrapes and impacts.
20. Structure to air: exhaust of air from product (similar to 5).
21. ~~Removed and incorporated into storage User input to supply~~
22. Mobility to air system (Air exhaust output from mobility system)
23. Sunlight to power system (exposure): Sunlight could be a major source of energy due to large exposure to sun in the caribbean.
24. Structural to users: users getting off the product, generally when getting rescued
25. Structural to water: removal of water from product.
26. Heat to structural: User body heat that is released as well as environmental heat.
27. Water to structure (waves): Resist tipping due to waves of up to 3 meters as by the design brief. A possibility is by the use of stability bags that would be attached to the bottom of the product, which according to SOLAS should be able to contain 22 L of water and be filled within seconds of inflation to increase stability.[24]
28. Air to structural (Wind): Resist tipping due to winds of at least 74 km/h as by the

requirements, possibly by making the center of gravity of the product closer to the bottom, and by using sea anchors which increase stability. [24]

29. UI to storage system (UI to buoyancy system within structural system - request to use product (throwing raft into water))
30. UI to storage system (UI to Distress system - request to access distress equipment)
31. Storage system to use of distress equipment (distress system to use of distress equipment - 2 paddles, 1 whistle, 6 hand flares, 2 parachute flares, 1 signalling mirror and 1 repair kit, based on Six ISO 9650 liferafts tested (C. Beeson)[23])
32. UI to Storage system (UI to Supply system - request to access survival supplies)
33. Storage system to use of survival supplies (Supply system to use of survival supplies) - 5L drinking water per person, rainwater collection device, 10,000 calories of food per person, based on Six ISO 9650 liferafts tested (C. Beeson)[23])
34. ~~Removed (does not exist) Sensor outputs to UI~~
35. Mobility to UI - Feedback to UI whether or not the requested change has been completed
36. ~~Removed due to to specific Control system to gps data: .~~
37. Wind (input to power system): if powered by wind the interface between any sails would and the force from wind is considered the interface.
38. Energy input to power system (Electricity): Using an electric motor that is powered by a battery, a turbine, or electromagnetics.
39. Information form UI to power system: Requests from user to turn on/off the power system.
40. Power system to sound: audible energy emitted due to the operation of converting input energy sources into power. (ex: combustion of fuel in a fuel engine).
41. Power System to UI: Request for power processed in user interface which ultimately provides feedback to the user.

DISCUSSION

Sub-System Diagrams

major system #1:

Structural System

Table 8: structural sub-system matrix			
	Floating System	Containment System	Loading System
Follow safety guidelines	x	x	
Insolating		x	
Resist leak and flood	x	x	x
Withstand waves and tides	x	x	
accessibility			x
Uses non polluting material	x	x	x
Provide personal space		x	
Contain users		x	
Remain in water	x	x	
Resist cuts and impact	x	x	
Used at a far distance from shore	x		x
visual/audible		x	
Radar visibility		x	
Stay above water	x		
Non irritating material	x	x	
Must be cost effective	x	x	x

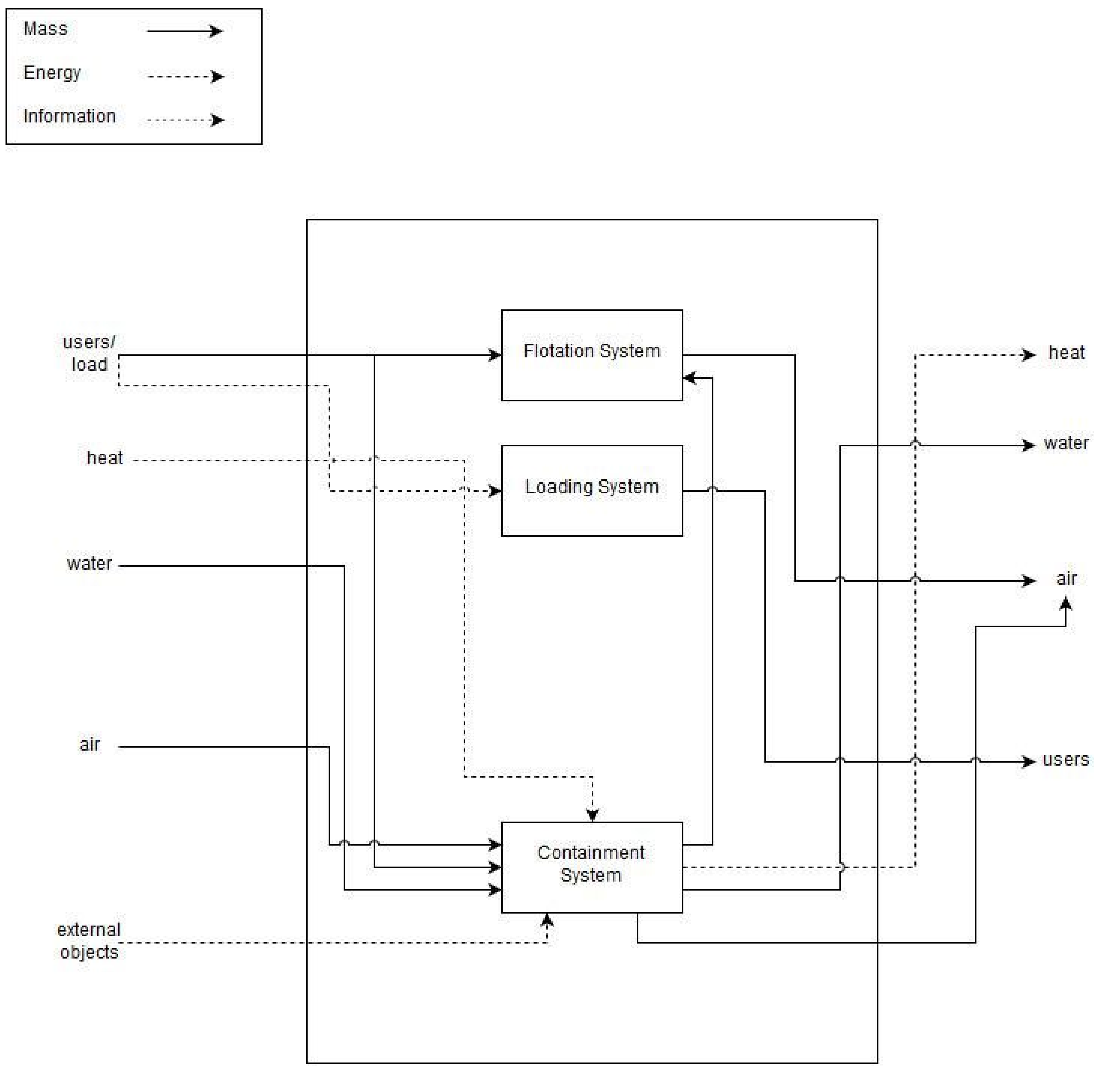
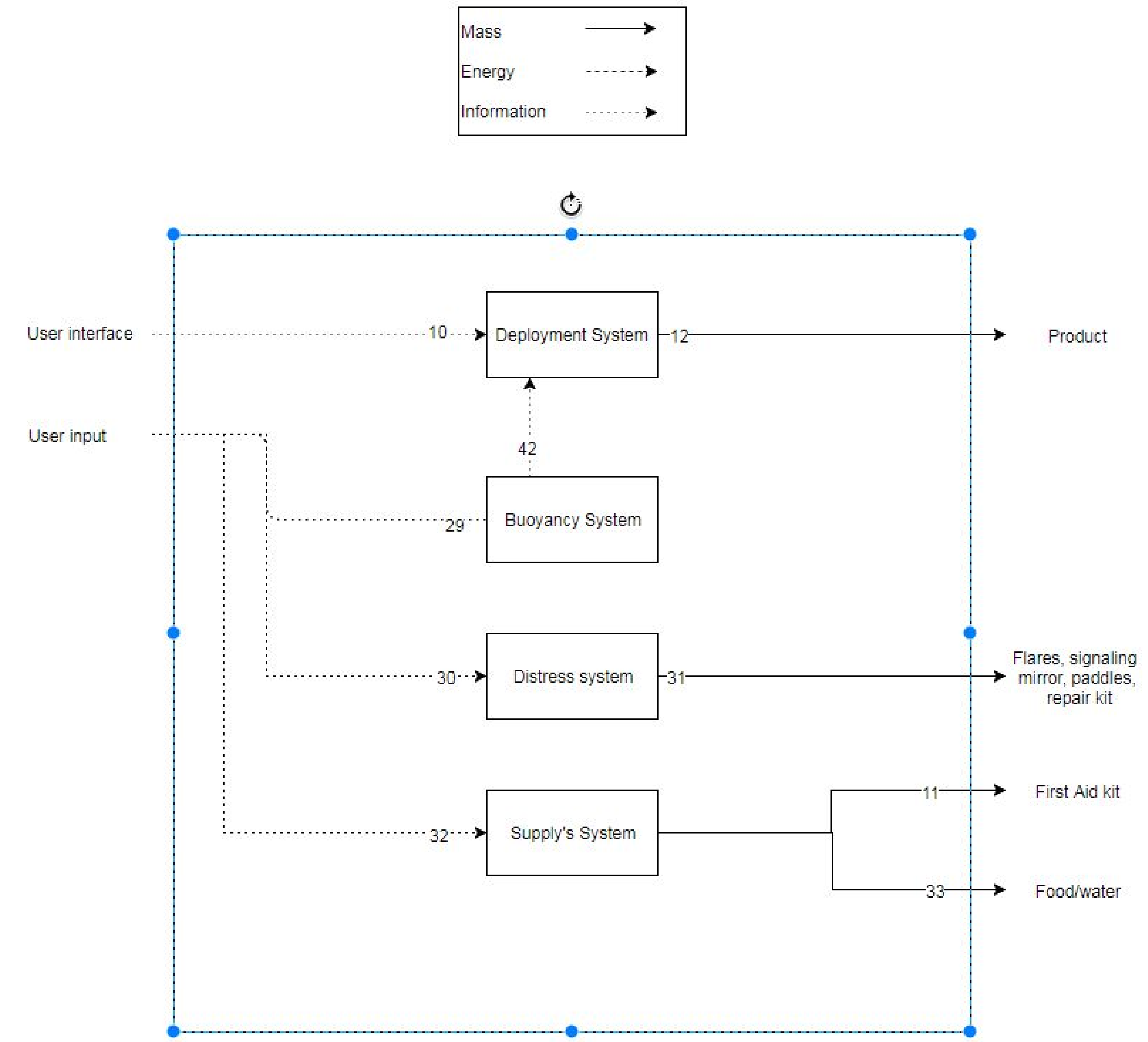


Figure 19: structural sub-system diagram

major system #2:

Storage System

Table 9: storage sub-system matrix				
	Deployment System	Buoyancy System	Distress System	Supply System
Follow safety guidelines	x	x	x	x
Resist leak and flood	x	x		x
Withstand waves and tides		x		
accessibility	x		x	x
Uses non polluting material	x	x	x	x
Remain in water		x		
Resist cuts and impact		x		
Used at a far distance from shore	x	x	x	x
visual/audible	x		x	x
Stay above water		x		
Non irritating material			x	x
Reuseable	x	x		
Safe deployment	x	x		
Provide first aid				x
Accessible in case of emergency	x		x	x
Must be cost effective	x	x	x	x



interfaces:

42. Buoyancy to deployment system (floating to inflation) - after a 30 min float before inflation time, inflation times should 60s $\pm 5s$ based on Six ISO 9650 liferafts tested (C. Beeson)[23]

Major system #3:

Mobility system

Table 10: mobility sub-system matrix			
	Control system	Steering system	Gps system
Follow safety guidelines	x	x	x
Withstand waves and tides		x	
Withstand high winds		x	
Uses non polluting material	x	x	x
Remain in water		x	
Use at a far distance from shore	x	x	x
Movable		x	
Must be cost effective	x	x	x
Stay above water	x	x	x

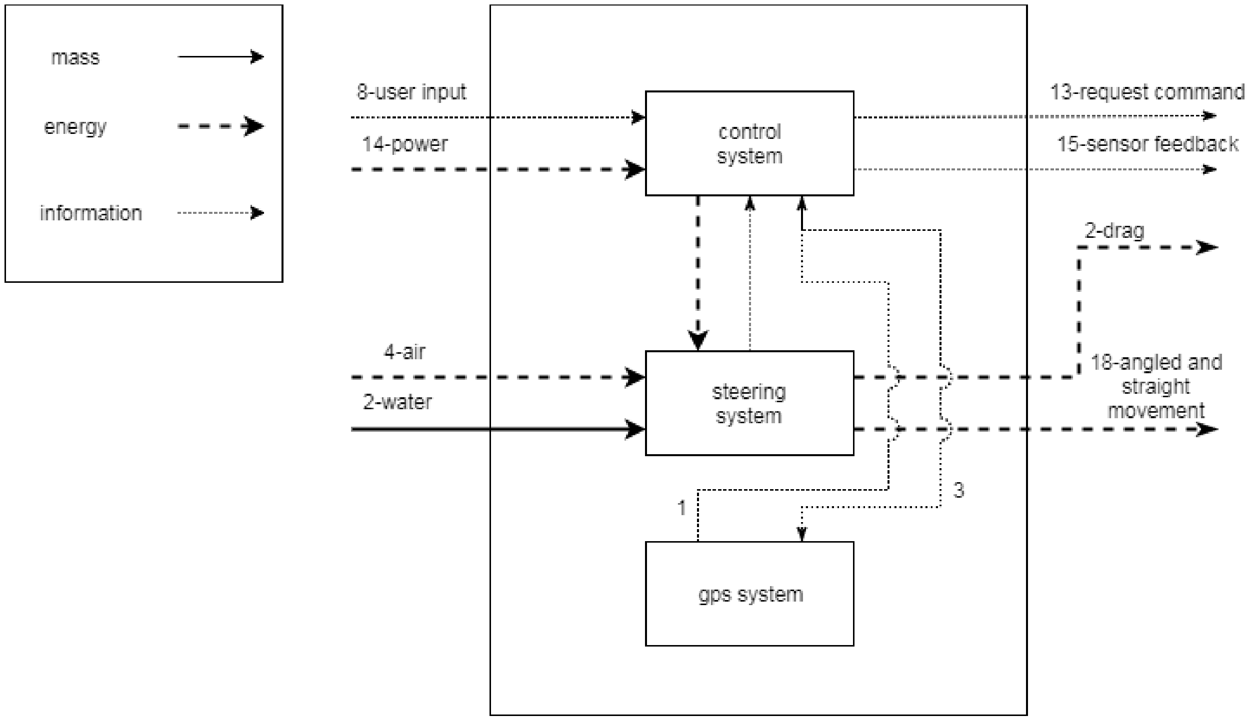


Figure 21: Mobility sub-system diagram

Interfaces:

1-control system gps data: control system asks the gps for location data and other gps functions such as heading and asks for update in data.

3- gps to control system: satellite data is decoded and sent to the control system.

Major system #4:

Power System

Table 11: power sub-system matrix			
	Converting System	TRANSFER SYSTEM	Control System
Follow safety guidelines	x	x	x
Must be cost effective			
Renewable Power **	x		

**For the embodiments we kept it if a renewable source was costing the design to be compromised and left as a last resort

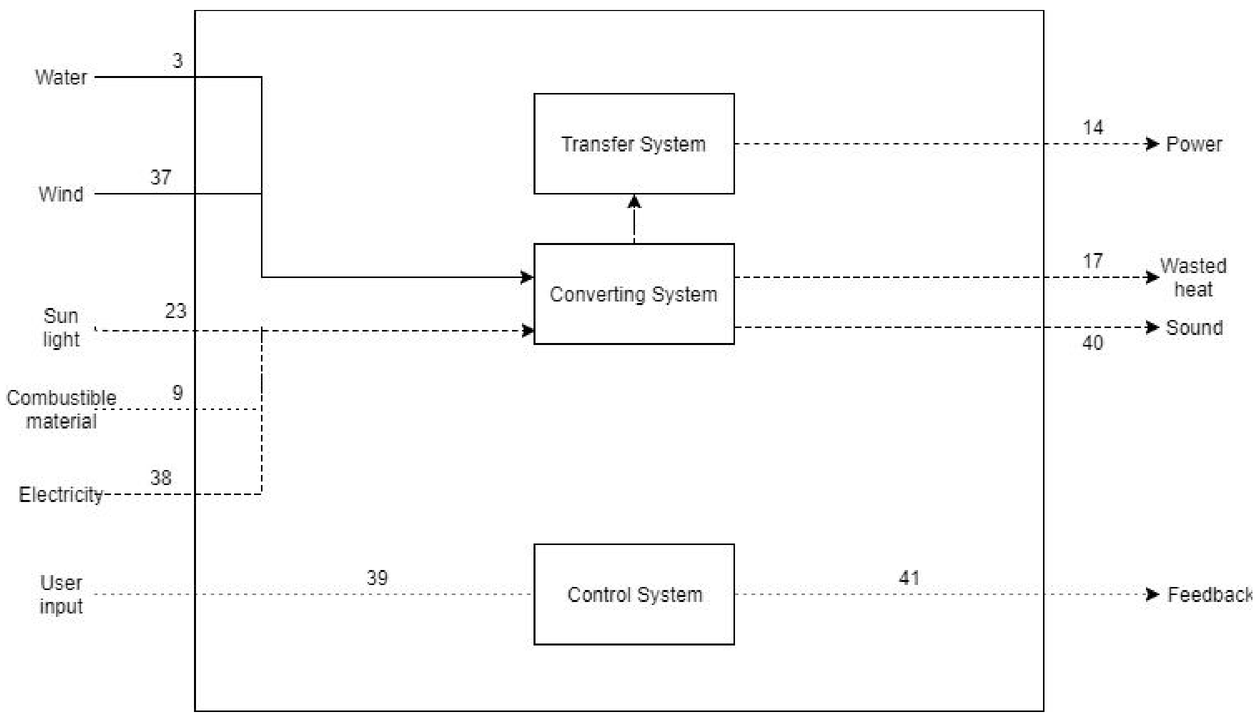


Figure 22: Power sub-system diagram

Concept Design

Pairwise Comparison

ATTRIBUTE		A	B	C	D	E	F	G	TOTALS	WGT
Safe	A		A	AC	A	A	A	A	6	25.00%
Environmentally Friendly	B			C	D	E	F	G	1	4.17%
Durable	C				C	C	C	C	6	25.00%
Identifiable	D					D	DF	G	3	12.50%
Maneuverable	E						F	G	1	4.17%
Convenience/Comfort	F							G	3	12.50%
Affordable	G								4	16.67%

Justifications

Safety - All other Attributes

Safety is the most important aspect of the product other than durability which is of equal importance because they are dependant on each other.

Environmentally friendly - All other attributes

Environmentally friendly was decided to be less important than all other aspects, considering that the product will not be used very frequently since it is used in cases of emergencies, which means that the environmental effects - if any exist - would be minor.

Durable - { Identifiable - maneuverable - convenience/comfort - Affordable)

Durability is most important between the three mentioned attributes, because if any system fails to operate properly or fails completely, it could endanger the lives of the users which conflicts with the primary purpose of a life raft.

Identifiable - Maneuverable

Identification of the life vessel in an emergency situation takes priority over maneuverability. Rescue teams being able to locate and identify the users is more importable and a more realistic goal then being able to travel to shore.

Identifiable - Convenience/Comfort

Identifiable and convenience/comfort are equal in importance because even though identifiable is a requirement to the end goal of the users being rescued.The vessel must be convenient to deploy and control, or users may not make it to the point of rescue.

Maneuverable - Convenience/Comfort

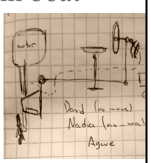
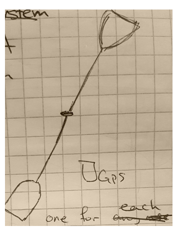
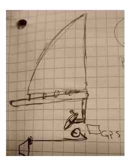
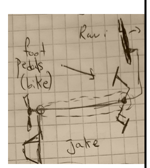
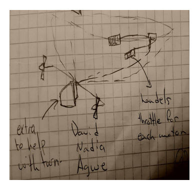
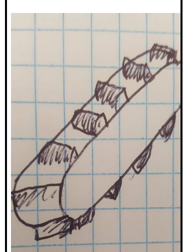
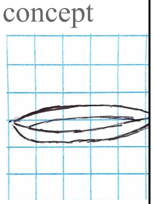
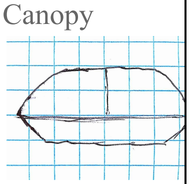
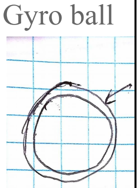
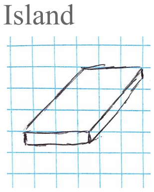
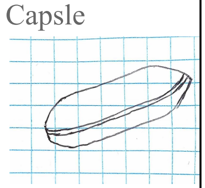
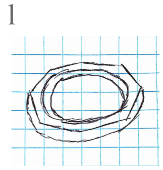
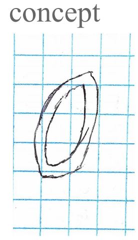
Convenience/comfort takes importance over maneuverability because the unit must be convenient to deploy and control. If maneuverability comes after deploy therefore, convenience takes priority.

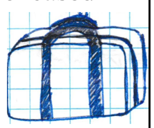
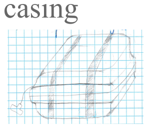
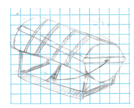
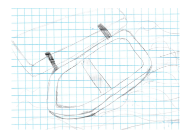
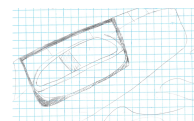
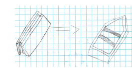
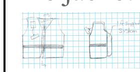
Affordable- All Except Safety and Durability

Affordability is of more importance because we need to the users to be able to afford the raft before considering the design

Ideation

Table 13: Morphological Chart

		Embodiment Number						
System Index	System	1	2	3	4	5	6	7
A	Mobility *pictures below	boat motor with rudder design with GPS in boat 	Two sided padel with GPS in boat 	Sail and rudder connected to controls with GPS in boat 	Bike like foot pedal for propeller and rudder controlled with a handle (not steering wheel) with  GPS in boat	propeller design (outside of body) Includes rudder and GPS in boat 	belt driven design wrap around body with flaps 	Passive movement (with waves/wind)
B	structure	Rigid open concept 	Canopy 	Gyro ball 	Island 	Capsle 	Symmetrical 	inflatable open concept 
C	Loading	ladder	Stairs on raft	Pully (pull up user)	“Wall climb” (built into body groves to climb up)	platform/opening	Pre loading/ deploy with person	

D	stabilization	Water pockets	Weights above water	Weights under water	Adaptive fluid			
E	Power	Solar Panels	Water Turbine	Wind powered	Human Powered	Fuel Engine	Battery (pre-charged)	
F	storage	Fabric encased 	Hard plastic casing 	Mounted on deck 	Docked on side of vessel 	Suspended out of water 	Folded 	Stored in life jacket 
G	deployment	Inflatable (compressed air)	Undocking	Freefall	Crank	Manually unfold		

Total concepts = $7 * 7 * 6 * 4 * 6 * 7 * 5 = 246960$

Inconsistent Embodiments

	A1	A2	A3	A4	A5	A6	A7	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	C5	C6	D1	D2	D3	D4	E1	E2	E3	E4	E5	E6	F1	F2	F3	F4	F5	F6	F7	G1	G2	G3	G4	G5
A1																												X			X	X					X					
A2									X			X																														
A3										X																				X							X					
A4												X													X	X	X		X	X							X					
A5										X																											X					
A6								X			X		X								X																	X				
A7																													X													
B1																															X	X					X	X				
B2																																										
B3																																										
B4																				X											X	X					X	X				
B5																	X														X	X					X	X			X	
B6																																										
B7																	X																									X
C1																																										
C2																																					X					
C3																																										
C4																																					X					
C5																																										
C6																																										
D1																																										
D2																																										
D3																																										
D4																																				X						
E1																																					X					
E2																															X	X					X					
E3																															X	X					X					
E4																																					X					
E5																															X						X					
E6																																										
F1																																										
F2																																										
F3																																										
F4																																						X		X	X	X
F5																																						X	X			X
F6																																							X	X	X	
F7																																							X	X	X	
G1																																										
G2																																										
G3																																										
G4																																										
G5																																										

Figure 23: Inconsistent Embodiment Matrix

B1 - {F1, F2, F3}

A rigid open concept life support system would be too large to be stored within a fabric or hard plastic casing, or within a life jacket. The system is larger than a person making it impossible to store in a hand-held casing or life jacket.

Concept reduction = $(7 * 1 * 6 * 4 * 6 * 3 * 5) = 15120$

B1 - G1

A rigid open concept life support system does not support an inflating deployment system as it has no effect on the life support system. A rigid body system consists of a buoyant material which does not required inflation during deployment.

Concept reduction = $7 * 1 * 6 * 4 * 6 * 7 * 1 = 7056$

B4 - {C6}

The island concept is a rigid design which makes for preloading of the user difficult and impractical.

Concept reduction = $7 * 1 * 1 * 4 * 6 * 7 * 5 = 5880$

B4 - {F1, F2, F7}

The Island design is too large to be stowed in a fabric or hard plastic casing or a lifejacket.

Concept reduction = $7 * 1 * 6 * 4 * 6 * 3 * 5 = 15120$

B4 - G1

The Island design must be rigid in order to have the required strength to contain and protect users due to its size. This design does not support inflatable deployment.

Concept reduction = $7 * 1 * 6 * 4 * 6 * 7 * 1 = 7056$

B5 - C3

A pulley loading system is not feasible on a capsule structural system, because the load applied upward on the capsule from pulling on the pulley. In addition to the user pushing down on the opposite end of the system, will create a coupled force producing a moment which will flip the system.

Concept reduction = $7 * 1 * 1 * 4 * 6 * 7 * 5 = 5880$

B5 - {F1, F2, F7}

The capsule cannot be stored in a fabric or hard plastic container because the system itself is a rigid plastic casing and storing it within another form of casing is redundant. Also, the size of the capsule is large enough to encase a human being thus, it is too large to stored within a life jacket the size of half a human being.

Concept reduction = $7 * 1 * 6 * 4 * 6 * 3 * 5 = 15120$

B5 - G1

Similarly to B1-G1, the capsule structure is composed of a buoyant rigid material which does not require inflation during deployment.

Concept reduction = $7 * 1 * 6 * 4 * 6 * 7 * 1 = 7056$

B7 - C3

Similarly to B5 - C3, implementing a pulley loading system on an inflatable structural system is not feasible due to potential to flip the system. Due to the flexibility and light weight of the inflatable concept, the load from the pulley and the user will create a couple and produce a moment which will flip the system.

Concept reduction = $7 * 1 * 1 * 4 * 6 * 7 * 5 = 5880$

B7 - G5

The inflatable concept is either inflated prior to use, or is inflated during deployment. Thus, the system cannot be deployed by manually unfolding because it cannot be folded to begin with.

Concept reduction = $7 * 1 * 6 * 4 * 6 * 7 * 1 = 7056$

F7 - { C2 , C4}

The stairs and “wall climb” loading system are not practical to be stored with the product within a life jacket. They are too bulky and would make the life jacket obsolete

Concept reduction = $7 * 7 * 2 * 4 * 6 * 1 * 5 = 11760$

D4 - F6

If the product is using an adaptive fluid to maintain stability of the system, then the system cannot be stored by folding it. The fluid cannot be compressed and makes folding the system impossible without displacing the fluid.

Concept reduction = $7 * 7 * 6 * 1 * 6 * 1 * 5 = 8820$

F7 - {E1, E2, E3, E4, E5}

These power systems are bulky and the volume of space they occupy makes storing them inside a life jacket impractical.

Concept reduction = $7 * 7 * 6 * 4 * 5 * 1 * 5 = 29400$

{A1,E2, E3, E5} - {F1, F2}

A system which is stored in a fabric or hard plastic container is packed as compact as possible. Engines and turbines cannot be manipulated to be stored compactly like the structure of the system can without disassembly and reassembly. Having to reassemble a motor or turbine in an emergency situation is not practical.

Concept reduction = $1 * 7 * 6 * 4 * 3 * 2 * 5 = 5040$

B5 - G4

The capsule design cannot be deployed using a crank because, this would mean deploying the vesle before the user can load themselves on, and then having to jump in the water afterward.

Concept reduction = $7 * 1 * 6 * 4 * 6 * 7 * 1 = 7056$

A1 - {D1,D4}

Using water pockets with a motor boat will reduce the ability of the motor to move the boat and restrict its mobility.

Concept reduction = $1 * 7 * 6 * 2 * 6 * 7 * 5 = 17640$

A1 - F7

For the same reason as A1 - {F1,F2}

Concept reduction = $1 * 7 * 6 * 4 * 6 * 1 * 5 = 5040$

{A3, A4, A5} -B3

These embodiments do not work together because the gyroball needs to rotate however the power systems listed needs to be fixated above or below the water resulting the conflict of design.

Concept reduction = $3 * 1 * 6 * 4 * 6 * 7 * 5 = 15120$

A3 - B5

A capsule is an enclosed body which makes it hard to install a sail and control it.

Concept reduction = $1 * 1 * 6 * 4 * 6 * 7 * 5 = 5040$

A3 - {E1,E2,E3,E4,E5,E6}

A sail uses the wind as a source of power, which is why other sources of power are not compatible.

Concept reduction = $1 * 7 * 6 * 4 * 6 * 7 * 5 = 35280$

A3 - F7

It is not possible to fit a sail that is large enough to move a lifeboat inside a life jacket.

Concept reduction = $1 * 7 * 6 * 4 * 6 * 1 * 5 = 5040$

A4 - {E1,E2,E3,E5,E6}

The propeller is generated by the power obtained from a person/s rotating the pedals, which eliminates the ability to power the propeller using methods other than human powered.

Concept reduction = $1 * 7 * 6 * 4 * 5 * 7 * 5 = 29400$

{A4,A5 }- F7

Due to the existence of the pedals, propeller, and rudder (and throttle control in case of A5), it is not convenient to store the system in a life jacket. Which could not fit in the jacket, make the life jacket increase in size which makes it uncomfortable for a user to wear, or obstruct the inflation of the system.

Concept reduction = $2 * 7 * 6 * 4 * 6 * 1 * 5 = 10080$

{F7-E5}

An engine is not compatible with a raft that can be stored on the life jacket due to the possibility of the raft tipping due to the weight.

Concept reduction = $7 * 7 * 6 * 4 * 1 * 1 * 5 = 5880$

G1-F4

With the raft deflated in the water it can get stuck somewhere while moving as it might not be above water at all times

Concept reduction = $7 * 7 * 6 * 4 * 6 * 1 * 1 = 7056$

{G3+G4+G5}-F4

The product cannot be deployed in free fall, manually or cranked into the water when it is already in the water.

Concept reduction = $7 * 7 * 6 * 4 * 6 * 1 * 3 = 21168$

G1-F5

An inflatable design needs to be kept on a dry surface when being deployed.

Concept reduction = $7 * 7 * 6 * 4 * 6 * 1 * 1 = 7056$

G2-F5

To undock the design cannot also be suspended. It needs to be in water.

Concept reduction = $7 * 7 * 6 * 4 * 6 * 1 * 1 = 7056$

{G5,G3}-{F5,F6}

A folded design is meant to be stored in a compact environment; being suspended defeats that purpose.

Concept reduction = $7 * 7 * 6 * 4 * 6 * 2 * 2 = 28224$

G2-F6

A uncocking design needs to be fully functional and ready for a deployment. A folded design needs to be unpacked making this impossible.

Concept reduction = $7 * 7 * 6 * 4 * 6 * 1 * 1 = 7056$

G4-F6

A crank deploy is only for ready to use design and not folded designs.

Concept reduction = $7 * 7 * 6 * 4 * 6 * 1 * 1 = 7056$

{G2,G3}-F7

A life jacket needs to be accessible to user and therefore cannot be suspended off the boat.

Concept reduction = $7 * 7 * 6 * 4 * 6 * 1 * 2 = 14112$

G4-F7

It is not likely that a design can be folded small enough that it can be inside a life jacket.

Concept reduction = $7 * 7 * 6 * 4 * 6 * 1 * 1 = 7056$

Total Concept reduction = 380604

Total remaining concepts = 246960 - 380604 = -133644

Initial Concepts

Table 14: Initial Concept by Subsystem										
Concept Index	Concept 1	Concept 2	Concept 3	Concept 4	Concept 5	Concept 6	Concept 7	Concept 8	Concept 9	Concept 10
A	7	3	3	5	5	4	1	7	1	3
B	3	5	6	4	5	2	1	1	3	2
C	6	1	5	4	1	1	4	3	6	5
D	4	4	2	2	4	1	1	3	2	1
E	4	2	2	5	2	4	1	6	3	4
F	7	5	2	4	5	3	4	4	3	1
G	1	4	1	2	4	1	3	2	3	3

Concept Selection

In order to attempt to find the best design we needed to randomize the selections of the concept designs. The way this was done is that the site *random.org* was used to generate an array of 7 digits from the numbers 1-7 with each row referring to the respective system from A-G. If one of the system embodiments that are selected overlap then the system embodiment that has already been selected is replaced with a following iteration number, this method applies to if the number obtained has no embodiment (number is to high). In the case the two have not shown in previous iterations, both are replaced and if one had an inconsistency then the one without is kept and the past one is used, else both new embodiments are used in the concept. This was repeated 10 times to obtain the initial concepts that are listed.

Concept Design 1

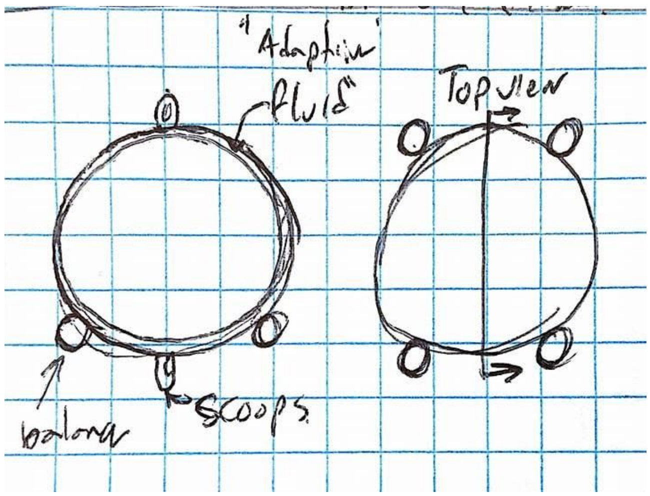


Figure 24: Concept 1

The original design was stored inside the life jacket; this is ideal as it can lead to lack of oxygen due to the design to stay afloat. The adjusted design uses a hard-shell ball that is stored at the back of the boat and pushed off into the water. Within the ball is a bearing platform that rotates independently of the outer shell keeping it upright. There are slits to allow the users to breath and the outer shell is covered in a material used is permeable to air it is not to water to make it breathable. The bottom is normally kept in the sense that it can be heat conductive to have the transfer of the internal heat into the water cooling the insides. In the case that it is cold an insulating material can be used to cover the thermally conductive area. The containers can accommodate up to 4 people each and within the cabin there is a first aid kit available in the case of an emergency. This uses a passive form of movement that means that it is mostly just using the waves as a form of movement. However, if the users need to move manually there is a crank that is connected outer shell using friction to rotate the outer shell. The shell itself contains groves to propel itself. The shell has a screwed hatch for loading that has a ladder connected to the fixed platform to get on and can split in half to expose the users to for rescue.

Concept Design 2

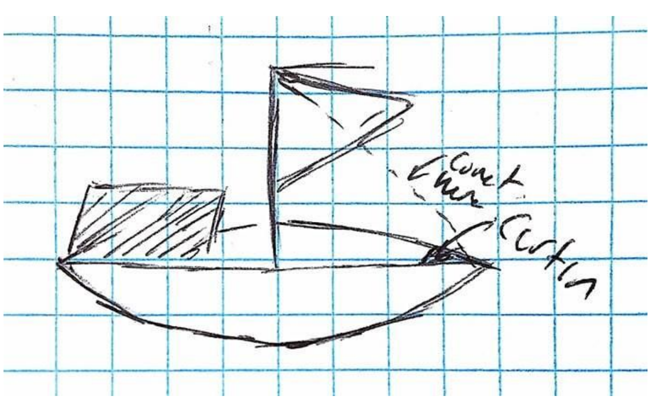


Figure 25: Concept 2

This concept uses a sail and rudder for its design and is powered by the solar panels. It is stored in a rigid casing that is put into the water and expands using the compressed air within. The solar panels are folded into strips and expands with the raft. When fully expanded it is kept at an incline because this is more efficient for the panels it can also be rotated to face the sun to maximize the power received. The sail pole is elastically compressed into the storage system and when inflating it pops out upright but uses a stiff spring to slow the expansion and locks when fully raised. It has two small rotating motors that are used to rotate the sail and rudder but in the case of being night has a manual mode with a rope and crank. The storage breaks apart to the front and fills with water to act as weights to the system to prevent tipping. Users board it with a small platform that is on the end of the raft to get themselves up and is slightly below the water to use the reduced apparent weight to the users advantage when getting themselves up. For users that cannot help themselves up it can be deflated slightly and the user attached to it and reinflated pulling them up. There are two sections that is normally part of the floor that lifts from the sail on both sides to raise the canopy to protect the users in case of a storm. Due to that larger parts of the raft, the overall design is sized to accommodate the max 6-person capacity. The top of the sail has a red light that is active in the night in order to act as a beacon. Attached to the floor of the raft is a box with a first aid kit in the case of an emergency. The shape of it is sharper at the ends so to reduce the drag due to the possibility of the design being underpowered.

Concept Design 3

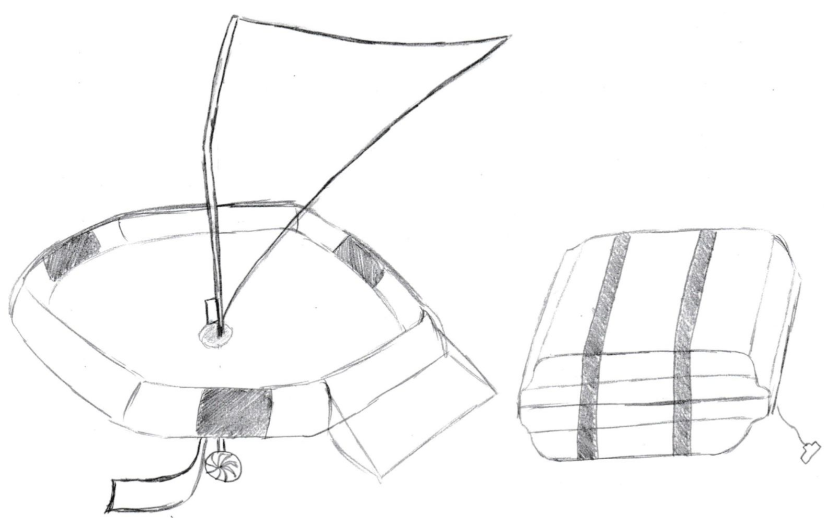


Figure 26: Concept 3

This concept is mobile due to the incorporation of a sail for propulsion and rudder for steering. It has a symmetrical design taking the shape of a hexagon. The symmetrical design allows for a larger capacity being able to accommodate up to 6 passengers. The symmetrical design is beneficial in terms of stabilization as there is no front, side, or rear of the vessel resulting in equal weight distribution in all directions. In addition to the weight of the passengers, there are stability weights to assist in keeping the vessel on the water. The weights are strategically placed above water and equally distributed (3 total). Placing the weights above water increases mobility compared to having water weights or weights hanging from the vessel. Any form of weight which sits in the water will produce drag which will oppose the motion of the product. This concept uses a water turbine to provide power to the gps system included in the user interface. The turbine is located in the water beneath the center of the vessel as is connected to the shaft of the sail by a fixed journal bearing. This is the optimal location of the turbine as the product may travel in any direction due its symmetrical design, and the fixed journal bearing allows the turbine to rotate to perpendicular to the water flow. Therefore, if the turbine was located on one of the sides of the vessel, it the product was not moving in a direction perpendicular to the side, then the turbine would not produce any power.

All of this is stored compactly in a hard plastic casing. The hard plastic casing protects the vessel from interaction with any potential rip or abrasive materials. Upon deployment, the casing is placed into the water and the product begins to inflate in response to the user pulling on a painter line. After inflation, the users may board the vessel by a platform which extends from one side.

Concept Design 4

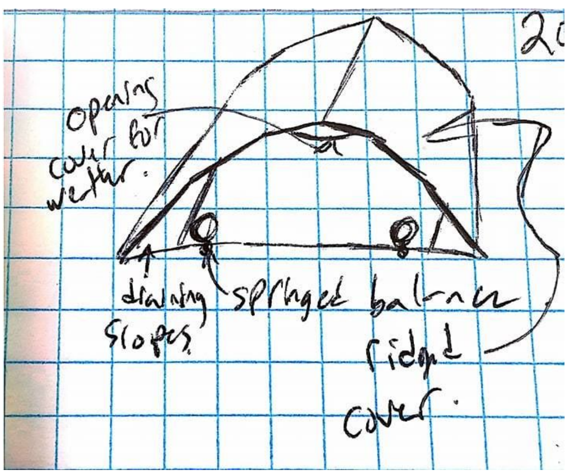


Figure 27: Concept 4

The concept is an island like structure that has a flat solid surface and a solid canopy above with opening at the front and back to allow users in. Each side contains small increasing height steps that go into the water to allow the user into the raft. For the users that may have physical disabilities there are harnesses for the users that can get on to help the disabled user on. Furthermore, at each end is a buoy on the surface of the raft to stabilize it. When one end tips it is elastically connected to the surface so that when the end gets submerged it is forced back up. The raft is docked in the water connected to the main boat and undocked to deploy. Due to the size of the overall design it is sized to take up to 6 people. The mobility is powered by a fuel engine that is centrally mounted and uses 2 separate propellers to move. The controls utilize a motor bike like throttle control with independent throttle control that is used to turn. The floor has a conductive material so that it uses natural cooling methods to cool the insides with the water below and in the case of the cold it can be covered with an insulating cover. The floor is covered in an hydrophobic coating with small drain indents and is slightly parabolic in shape to move the water away. The overall shape of the raft is triangular at the ends the opening (also the stair loading) to help reduce the drag. In the case of heavy rain the ends can be covered to contain the users with small openings to allow air in.

Concept Design 5

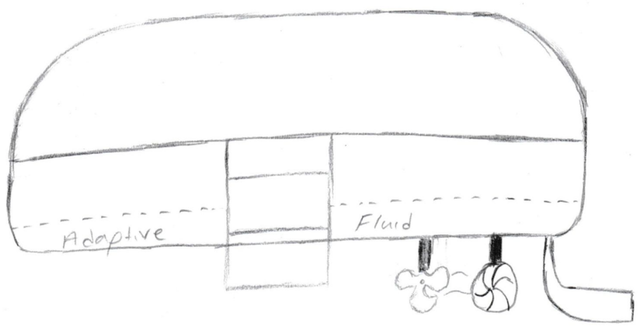


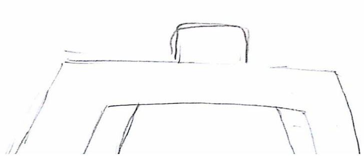
Figure 28: Concept 5

This concept has a unique pod like structure, containing the user in a capsule. The capsule has a maximum occupancy of 1 passenger due to its slender design. The capsule is composed of a hard buoyant outer shell and soft foam like interior. The interior consists of food and water supplies, as well as a gps and control system for the mobility system. The Capsule's primary method of movement is a propellor underneath the vessel. The propeller design is powered by a water turbine which is also located beneath the vessel and behind the propeller. The propeller and turbine work hand in hand in the capsule. As the propeller pushes water backward, it feeds it to the turbine which in turn produces energy to power the propeller and GPS device located inside the vessel. This cycle repeats supplying constant power to the mobility system. The movement is controlled using a joystick inside the product. The capsule is round in shape which means it requires a stability system to keep it up right. In this concept, an adaptive fluid, located in the bottom level of the capsule, is used to keep the vessel upright and level. This works by when the capsule tips to one side, the adaptive fluid flows to the opposite side to counterbalance the vessel, and return it to its equilibrium position.

This concept is to mounted to the side of the primary vessel and suspended out of water. The user can load themselves in the capsule using the rope ladder provided. When it comes to deployment, the original design was to be deployed using a crank that would slowly lower the capsule to the water. The issue with this design is that a co-user would have to lower the capsule for the user while they are inside as the user cannot turn the crank from inside the product. This means users would not be able to properly deploy this concept when alone. The altered design consists of a free fall deployment inside. In this design, the capsule can be release from the inside of the vessel by pulling the release cable inside the vessel. This design allows users to use the device without the reliance on a co-user to deploy the product for them.

Concept Design 6:

This concept has an inflatable, waterproof, and puncture resistant structure, with an insulated floor and canopy for shelter. It has an opening on two sides to provide access to the users. Users can aboard the raft



from the boat directly through the openings, or if the users are in water, two ladders are attached to the raft, one at the position of each opening, which assists the users with getting inside the raft. For mobility, two pairs of foot pedals are included to be used by one or two users, and provide rotation to a propeller to move the raft. Also, a rudder is connected to a handle inside the boat controlled by the users. As well as a GPS for directions. For stabilization, water pockets are attached to the bottom of the raft, which fill up with water after the inflation of the raft, and provide stability to the boat to resist tipping due to winds and waves. This raft is mounted on the boat deck inside a case, and deploys when the case is thrown in water by the user or after it is in water after the boat sinks, and inflates using compressed air.

Concept Design 7:

This concept has taken the following embodiments in its design: motor with rudder and gps, rigid open concept body, ladder, solar energy intake, adaptive fluid stabilization, and freefall deployment. The motor will need to be electric in order to run on the power from the solar panels. The solar panels will need to provide power for the motor and controls and the gps. The panels are set up as a roof structure to protect the users inside from harsh weather. There will be batteries inside the boat which will take up space however the batteries are under the boat floor to keep the boat bottom heavy. The overall styling is very similar to the pudgy.

Figure 29: Concept 6

The design will include a string ladder to help users get on with an extra low step to allow for disabled users to be helped up into the boat.

The adaptive fluid runs around the body of the boat and works as a counter weight. The users don't have easy access to this fluid.

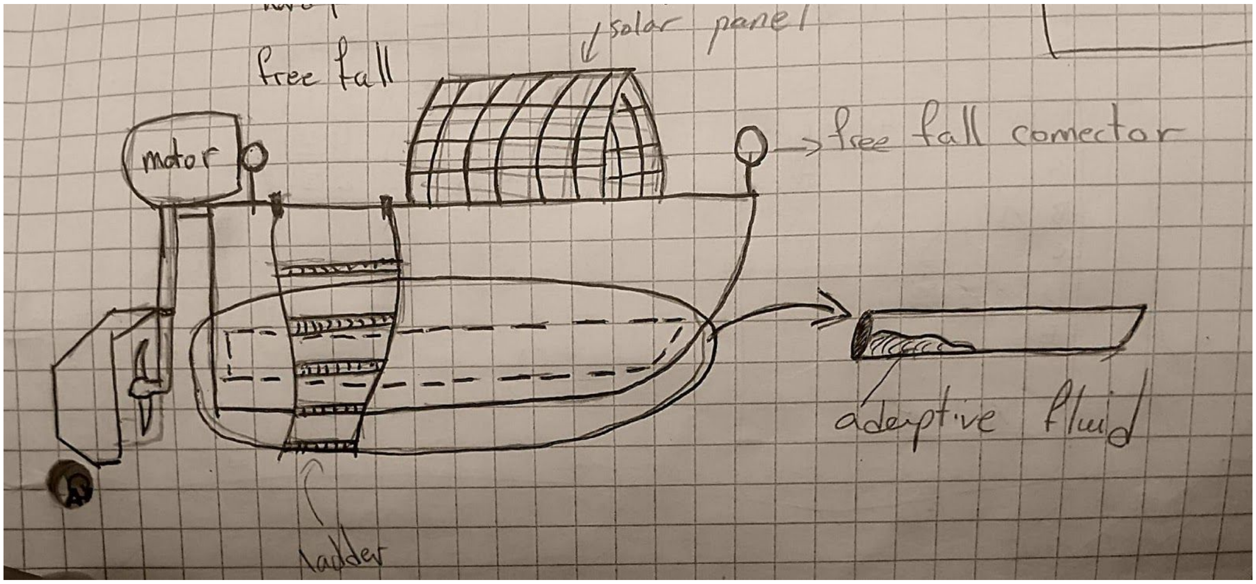


Figure 30: Concept 7

Concept *Design* 8:

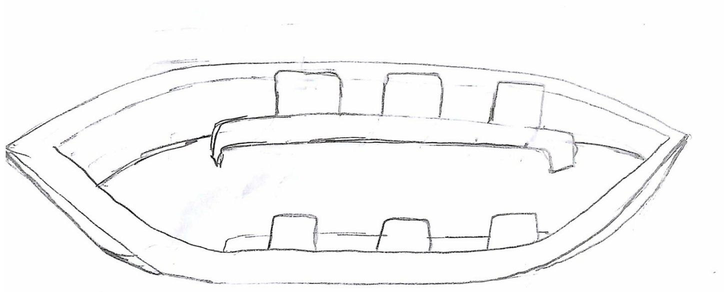


Figure 31: Concept 8

This concept is of a rigid structure, and an open top. It depends on waves and air for mobility, and is equipped with weights attached to the bottom of the structure, providing stability and tip resistance to the structure in the case of strong winds and waves. When users are boarding this concept, they can enter from any side since it is an open concept, also stairs are provided for helping the users with getting on the lifeboat from water. To provide power to the boat -for powering lights for example- it is equipped with a pre-charged battery. This concept is kept in water when in storage, as it is docked to the side of the boat carrying it, and deployed by undocking when needed.

Concept 9:

This concept includes the following embodiments: Gyro body, preloading, weight above water, wind power, on deck mounting, freefall. The design is shaped liked a submarine to fully protect the users. The entrance is a simple door and the design can be deployed after everyone has entered the design. The design generates power through a deployable rotating sail which will generate electricity for battery packs located in the back of the design. The Body is in two parts; the inner and outer. They are connected through rollers which will allow full tipping of the outside without the users inside feeling the rotation. The inside body is loaded on a rotating shaft which stops the inside body from rotating. The controls only include a steering wheel and throttle lever. The design can avoid strong jolts of movement by utilizing weights on the side.

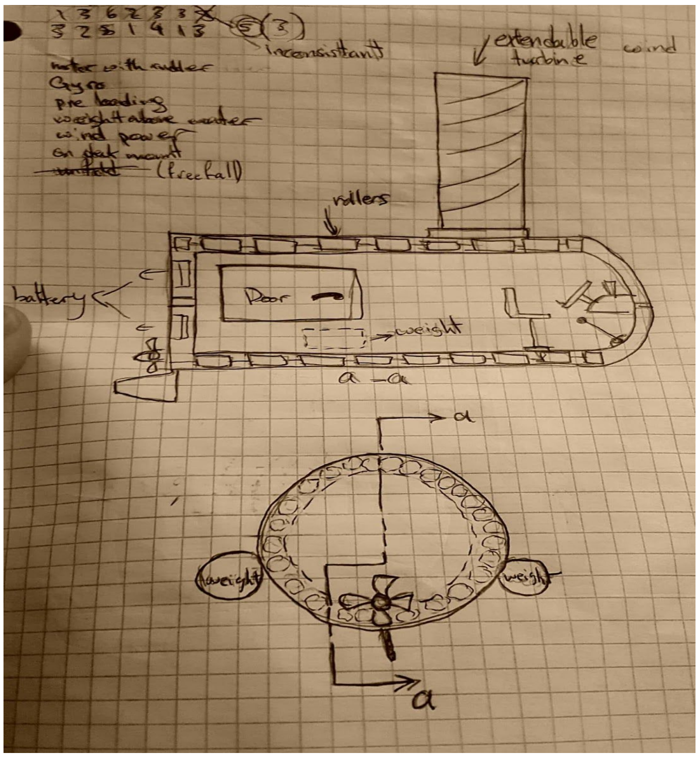


Figure 32: Concept 9

Concept *Design* 10:

This concept includes the following embodiments: canopy body, platform boarding, water pocket stabilizers, human powered, fabric case, free fall. The design closely resembles a regular boat. It includes a tent roofing which will protect the users. The sail needs to be hand controlled along with the rudder.

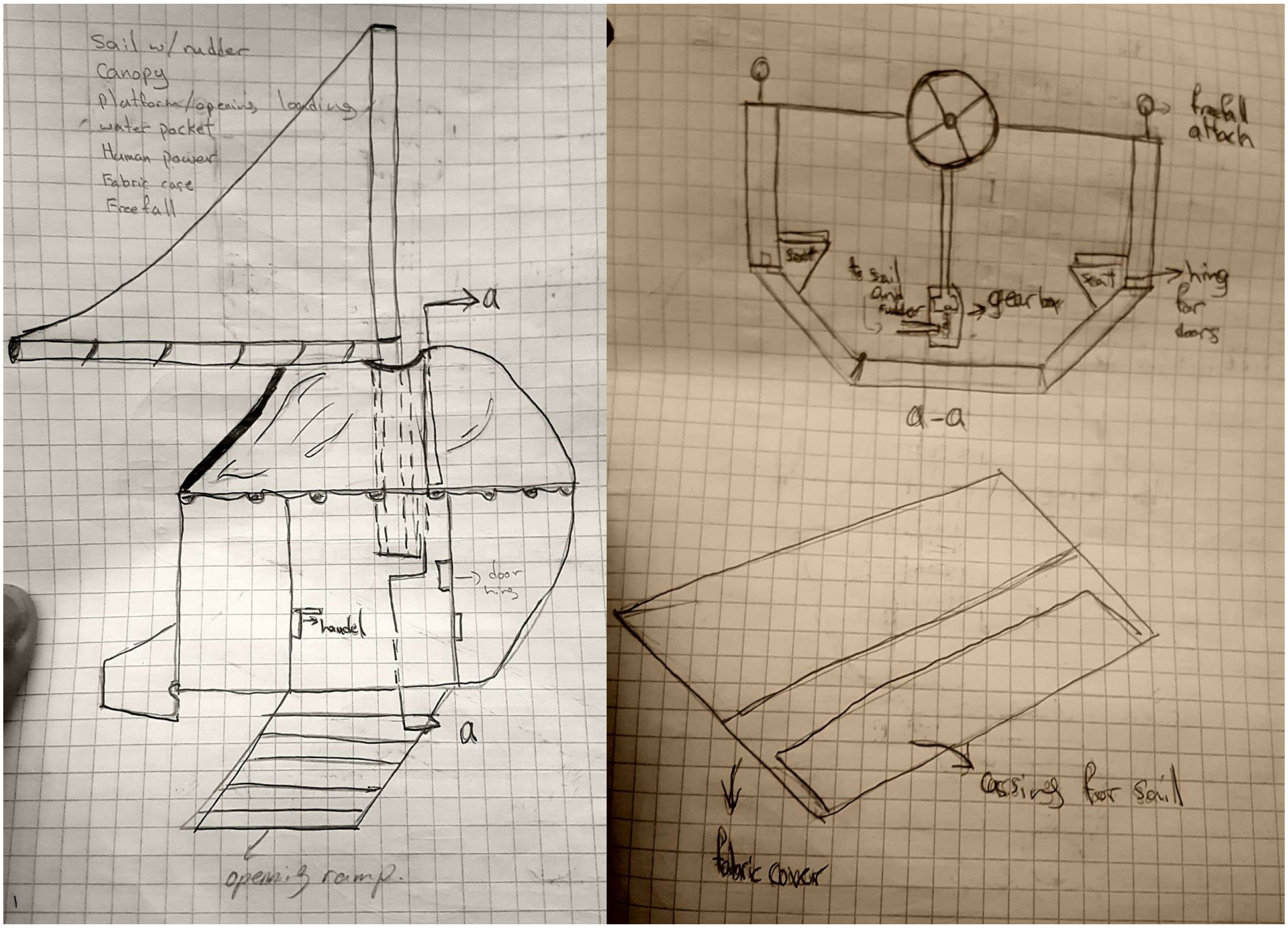


Figure 33: Concept 10

Concept Evaluation #1

Table 15: Concept Evaluation Iteration 1													
		Concepts											
		Reference		1		2		3		4		5	
PC	WGT	Rating	Score	Rating	Score	Rating	Score	Rating	Score	Rating	Score	Rating	Score
Safe	25	0	0	-1	-0.25	-1	-0.25	-1	-0.25	1	0.25	1	0.25
Env. Friendly	4.17	0	0	0	0	-2	-0.0834	0	0	-2	-0.0834	0	0
Durable	25	0	0	-1	-0.25	-1	-0.25	0	0	1	0.25	1	0.25
Manuverable	4.17	0	0	1	0.0417	0	0	2	0.0834	-2	-0.0834	1	0.0417
Conveinient/ Comfort	12.5	0	0	1	0.125	-1	-0.125	0	0	1	0.125	-1	-0.125
Identifiable	12.5	0	0	1	0.125	2	0.25	0	0	0	0	-1	-0.125
Affordable	16.67		0	1	0.1667	-2	-0.3334	-2	-0.3334	0	0	1	0.1667
Total Score			0		-0.0416		-0.7918	1	-0.5		0.4582	2	0.4584

6		7		8		9		10	
Rating	Score	Rating	Score	Rating	Score	Rating	Score	Rating	Score
0	0	1	0.25	-2	-0.5	2	0.5	0	0
0	0	0	0	0	0	-1	-0.0417	2	0.0834
0	0	1	0.25	1	0.25	1	0.25	1	0.25
2	0.0834	1	0.0417	0	0	1	0.0417	0	0
0	0	-1	-0.125	1	0.125	0	0	1	0.125
0	0	1	0.125	1	0.125	1	0.125	-1	-0.125
0	0	1	0.1667	2	0.3334	-2	-0.3334	1	0.1667
	0.0834		0.7084		0.3334		0.5416		0.5001

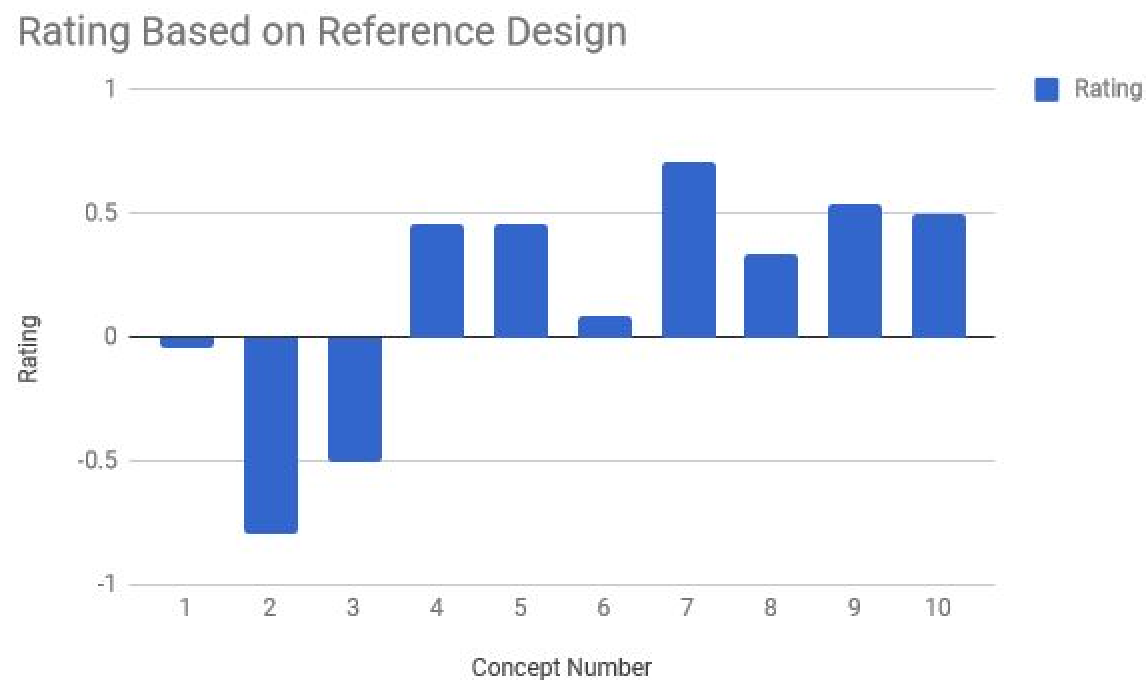


Figure 34: Graph of Concept Ratings

Concept Refinement

Best Design Refinement (Top 2)

Embodiments: Gyro, motor with rudder, wind turbine, ladder, weights above water, stored in the water and undocking for deployment.

Concept 9 and 7 were scored to be the best designs of the 10 initial concepts. From those designs the Gyro was taken as the structure due to the better durability of the design. For the design the wind turbine was chosen because it is a stronger power source to the human powered and meets the renewable requirement. Due to the larger size of the design the raft was stored in water and undocked for deployment. To stabilize the entire system the weights above water was chosen because the water pockets will add too much drag when moving.

Combination of design 4, 10 and 5

Embodiments: Capsule, battery, suspended, free fall, weights above water, ladder

These designs varied in embodiments, so we decided to choose the design that was a smaller size due to the best design being a larger raft; thus, the capsule was chosen. The power source was changed to a battery because the original power was too expensive. Due to the smaller size yet still ridged, we stored the capsule out of water to prevent drag and have the users get in after it is deployed in water because free fall in this case can be dangerous. The stabilization uses the water above water to reduce the cost and prevent leaking. The mobility of the capsule was decided to be propeller so that the user easily control the design.

Worst Design Refinement

We decided not to refine the worst design because it poor mismatches and poor selection like the broken requirement to be environmentally friendly and that it is not ideal for the personas that have disabilities along with not being sustainable. This was in the end chosen to be replaced with a random selection for the second iteration.

Table 16: Second Iteration of Concepts by Subsystem										
Concept Index	Concept 1	Concept 2	Concept 3	Concept 4	Concept 5	Concept 6	Concept 7	Concept 8	Concept 9	Concept 10
A	4	5	5	6	3	6	7	1	1	5
B	2	2	7	3	1	3	6	6	3	5
C	6	2	6	1	6	1	5	2	1	1
D	3	3	2	3	4	4	3	3	2	4
E	4	6	3	6	5	4	1	2	3	2
F	3	3	1	7	5	1	2	4	4	4
G	1	5	2	5	4	2	3	2	2	2

Concept Evaluation #2

Table 17: Concept Evaluation of Iteration 2													
		Referance		1		2		3		4		5	
Product Characteristic	WGT	Rating	Score	Rating	Score	Rating	Score	Rating	Score	Rating	Score	Rating	Score
Safe	25	0	0	0	0	0	0	-2	-0.5	-1	-0.25	-1	-0.25
Env. Friendly	4.17	0	0	1	0.0417	2	0.0834	0	0	-1	-0.0417	-2	-0.0834
Durable	25	0	0	-1	-0.25	1	0.25	0	0	0	0	1	0.25
Manuverable	4.17	0	0	0	0	-2	-0.0834	2	0.0834	2	0.0834	2	0.0834
Conveinient /Comfort	12.5	0	0	-2	-0.25	1	0.125	-1	-0.125	0	0	1	0.125
Identifiable	12.5	0	0	0	0	2	0.25	2	0.25	0	0	0	0
Affordable	16.67	0	0	-2	-0.3334	-2	-0.3334	-1	-0.1667	2	0.3334	0	0
Total Score			0		-0.7917		0.2916		-0.4583		0.1251		0.125

6		7		8		9		10	
Rating	Score	Rating	Score	Rating	Score	Rating	Score	Rating	Score
-1	-0.25	-1	-0.25	0	0	2	0.5	1	0.25
0	0	0	0	1	0.0417	1	0.0417	1	0.0417
-1	-0.25	0	0	1	0.25	1	0.25	1	0.25
2	0.0834	0	0	1	0.0417	1	0.0417	2	0.0834
-2	-0.25	0	0	0	0	0	0	-1	-0.125
1	0.125	0	0	0	0	1	0.125	-1	-0.125
-1	-0.1667	-2	-0.3334	2	0.3334	-2	-0.3334	2	0.3334

-1	-0.25	-1	-0.25	0	0	2	0.5	1	0.25
	-0.7083		-0.5834		0.6668		0.625		0.7085

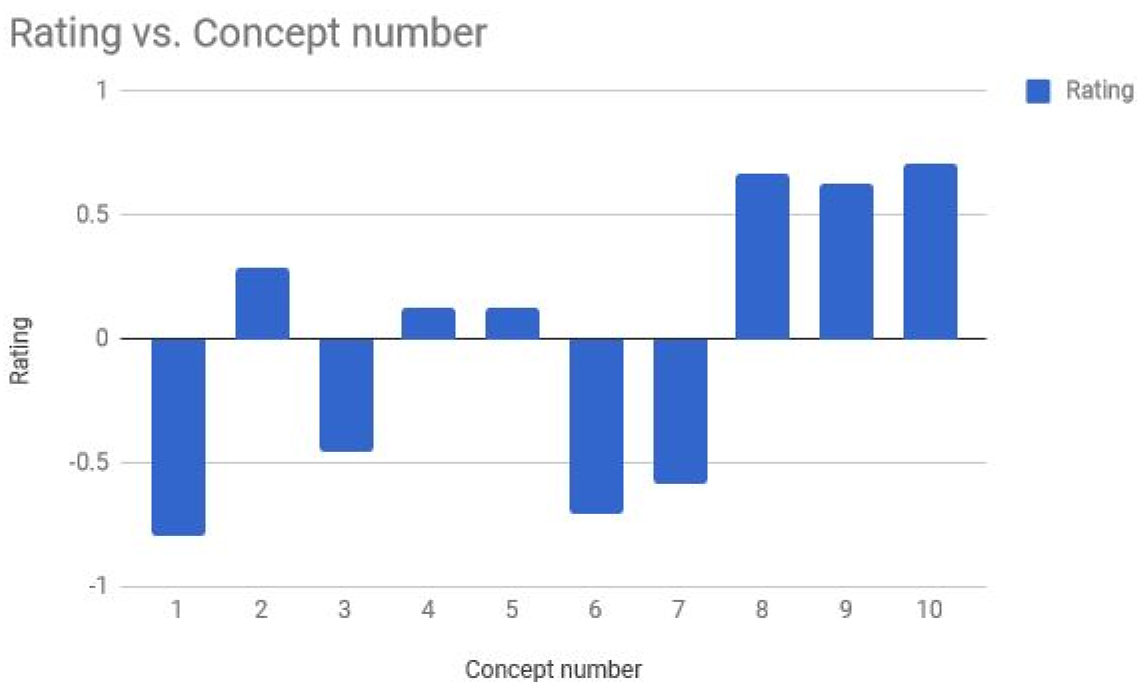


Figure 35: Ratings of Second Iteration of Concepts

Final Concept Validation

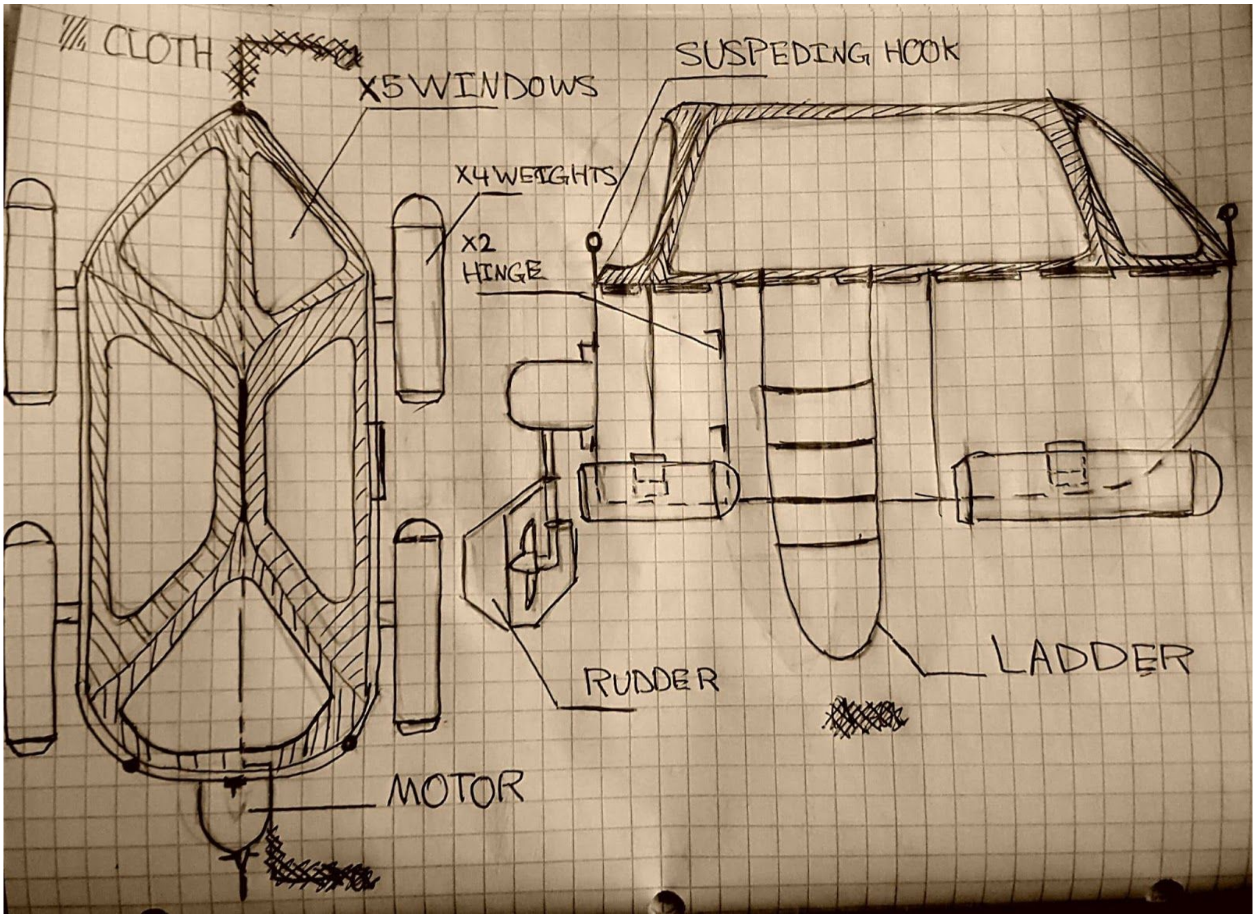


Figure 36: The final concept design.

Design Description:

The final design a canopy design with tent cover. It generates power using water turbine to charge batteries. The boat runs on an electric motor and is steered using a rudder. The controls involve a steering wheel and throttle lever. The door on the boat opens to present a ladder which can also be used to hoist disabled persons on. The boat keeps itself stable with four weights surrounding the boat. The tent includes tinted screens to see outside. The design has conductive properties to allow heat dissipation to cool the users. The canopy of it is removable and breathable while being resistant to water, allowing the users to breath and cool using air circulation. The boat is stored on the ship by hanging on the side by the hooks around the boat. The deployment uses quick releases that will drop the boat.

Requirements Validation

Safe

The final concept design will meet the ISO9650-1 standard (detail of this will be provided in the final report. Insulation is a requirement for this product. The final concept design contains insulating material to keep warm air inside the cabin, and cool air from the ocean outside. The type of insulating material used will be described in the detailed design.

Another safety requirement is the ability to resist leaks and floods. The final concept design has a built in canopy structure which gives users the option to either completely seal themselves from the effects of the environment, or having the canopy open. When closed, the canopy is entirely water and leak resistant which makes the vessel resistant to flooding due to rain and waves.

4 stability weights are strategically incorporated into the final concept design which act as counterbalance weights increasing the amount resistivity to impacts resulting from high tides. The addition of the 4 stability weights also produces downward force capable of keeping the product grounded in high gale winds.

Safe deployment of the life system is a requirement of the product. The product will be deployed from a position suspended out of water. The deployment procedure from storage position will be a freefall deployment. The height of free fall in addition to precautionary design (foam/padded material) make free fall deployment safe for users.

Lastly, first aid is the last safety requirement of the product, and within the supply system of the product, a standard first aid kit is provided.

Environmentally Friendly

A requirement of the product is to use not polluting materials in the manufacturing of the product.To satisfy this, the final concept will be composed of non pollution or recyclable materials (material composition to be determined in detailed design).

Another requirement for environmental impact is the use of a renewable power source (if needed). The concept uses a renewable energy production cycle requiring an initial power source only.

Durability

The raft must be able to remain in water for extended periods of time. The concept design is composed of a material resistant to corrosion and erosion due to prolonged water exposure (Material to be determined in detailed design).The inflatable portion and canopy of the raft must be difficult to rip/cut. The concept will resist impacts and abrasive cuts which may potentially caused by rocks and marine life. The raft must be reusable. The concept will be available for more than one time use due it durable design and material composition. Lastly, the product must be usable in far distances from shore. The concept will be useable in conditions 50km from shore including rough/choppy waters, and potential storms.

Identifiable

The final concept will be highly visible as it will use a fluorescent yellow-green color. It will also include equipment that will help with identifying it, such as a highly audible whistle, pyrotechnics, SOLAS flares, a rocket parachute flare. Also it will be equipped with high intensity external lights, as well as retroreflectors on each side of the raft. The design will incorporate a gps tracking system so users may be detected and located by satellite. All of this will help rescuers with identifying the life raft.

Maneuverable

This concept uses a motor and rudder, which provide movement back and forth, as well as the ability to steer the raft side ways. Which provide enough maneuverability to be to overcome winds and water to direct the raft in the direction the user desires. This concept also has strong rigid structure, and an effective floating system to support loads in the range of 1250 lb and 2000 lb, the specific loading capacity will be specified in the detailed design. which can accommodate passengers plus equipment and other loads brought with the passengers such as personal belongings.

Convenience/Comfort:

The concept is provided with a ladder that will help users access the raft.. It is also provided with wide opening/s on the sides to allow users in, and which can be later closed to seal the raft.

It will also provide sufficient personal space in a way that will provide comfort for users, specific dimensions will be specified in the detailed design. This concept will also provide enough space to contain the users in a safe manner, and accommodate the required number of users that will be specified in the final design along with the specific dimensions of the raft.

This concept will be suspended out of water to the side of the boat that is carrying it, which will protect it from deteriorating from being in water all the time even when it’s not used.

It will also be made of non-irritating material which will prevent any irritations and allergies which could cause discomfort to the users of the raft. The materials used will be specified in the detailed design later on.

As mentioned previously, the wide opening/s on the sides will make it easier for rescuers to extract people from the raft especially in the case of an injured or a disabled person.

The final concept will depend on free fall as a deployment method, which would provide a big advantage to deployment time, because of it being a simple and fast procedure.

Personas:

Safe deployment: It is important to reduce the impact from deployment as much a possible so users similar to David heart conditions are not startled and put at risk of a heart attack.

Easy accessibility: a ladder is included in the final design to assist users similar to Nadia who uses a wheelchair and Dakar which has a prosthetic leg, as they can hang on to the ladder while other users can help them inside

High range of load capacity: This is crucial for being able to accommodate users such as Agwe which suffers from overweight problems.

Sufficient personal space: This will help users such as Jake which suffers from claustrophobia feel less disturbed from being in an isolated structure with other people.

Visibility: It is important to make the product of vibrant material with retroreflectors as well as other identification appliances. These implications will assist with users similar to Kevon who experiences visual difficulties while working at night.

Discussion

Detailed Design

Overall Shape Justifications

When getting the dimensions of the raft we decided the proportions of the raft using the overall shape of the viking's usable space. The viking is ISO9650-1 certified, which is for the small boat life raft standards. In our research finding the exact specifications for this specification requires the purchase of the document [30]. Due to this we decided to stay with the size of the viking so that we know that the size meets the requirements by the standard. However due to the shape of the viking being different to that of our design we needed to make some adjustments. One of this is that we kept the floor space of the viking so we know that the users have enough space and used the space that the viking used for its tubes for the hull of the raft.

Interior and Size Validation

In order to make the experience in the raft easier for the user we chose to provide benches for the users. This is a suitable design than that of the viking where the users are required to sit on the floor of the raft. There is not enough space to stretch their feet but for some users crossing their legs may be difficult and uncomfortable especially since they might be in it for long periods of time. Utilising the dome like shape of the raft we can provide enough height clearance so that the users have their hip at a 90 degree angle. To determine the best height for the users is difficult and incorporating adjustable height will add extra weight that will affect the storability of the raft. Taking into account that for shorter users being able to reach the floor is of more importance as taller users will be able to reach the floor if the smaller users can we decided to use the 5th percentile female erect sitting height[29]. To validate the size of the raft we used the 95th percentile of the male shoulder width so that we know that the users can fit comfortably on the raft.

In order to decide how many persons we wanted to design for we needed to look at the number of persons that are on the boat and the general size of the boats themselves. In the tour boats they are mostly a lot smaller in size and do not have many persons on the boat itself. The users that are in the boat are generally more knowledgeable however the owner of the fishing boat may not have the funds to purchase expensive alternatives.

Material Selection

In choosing the material that the product will be manufactured from, the main focus was finding a recyclable and durable material. Low density Polyethylene was found to be a very suitable material for our requirements. Due to it being a light yet strong material. In comparing it to fiberglass, it was found that it is a bit heavier, but a major advantage was that Polyethylene is recyclable as well as less expensive compared to fiberglass, which gives it the advantage of being cost effective and environmentally friendly. Another flaw is that it is not suitable for larger boats generally greater than 20’ however this is not an issue for our design[33].

The back and side canopy are comprised of nylon and fully collapses into the top bar. The side bars use a track that guides the canopy around the raft. Nylon was chosen canopy because it is a water resistant material that is also quite cost effective and also breathable. As for the front of the raft, it uses an acrylic plastic due to the lightness of the material and its visibility. The acrylic will be covered in a UV protective spray that reduces the uv light that is exposed to the driver as in the caribbean due to its approximation to the equator can hive high exposure.

Motor Selection and Mobility

It was decided to make two versions of the boat. Both using an electric motor, but the difference being the cost and thrust each motor provides. For example, small fishing boats wouldn’t need much thrust considering that they don’t go far offshore, which reduces the need for a strong motor since being close to shore would make it easy for people and rescue to spot the lifeboat, as well as the high probability that a small fishing boat wouldn’t have a high budget to afford an expensive lifeboat. On the other hand, tour boats usually carry more people and could go further offshore, which creates the need for a strong motor, and considering that a tour boat would have a larger budget than a small fishing boat and would be able to afford a more expensive lifeboat. The advantage of having two versions of the boat is that it would not restrict the client with one product and provide the capability of choosing between two versions depending on their budget and requirements. Both of the motors are interchangeable as they both have a clamp mounting system the attaches to the back of the raft.

The mobility was decided to be controlled by a mechanical system that uses a metallic wires and pulleys that run under the seats. The overall pulley design is so that the mobility system is controlled using a typical car steering. This is because with the other users sitting in the raft, with a traditional rudder motor, it controlled with the driver at the back. In the case of our design that is difficult as other passengers may block visibility. To control the mobility the steering wheel was chosen to be as cost effective as possible, trying to avoid expensive parts and that is also lightweight so a plastic wheel was chosen. The wires are run under so that it reduces the risk of the users getting injured as the metallic wires can hurt if tripped on. The wires themselves are 4.8mm piano wires, due to its strength and a thicker wire was selected to reduce the chance of a maintenance getting cut if dealing with the wire. The length of the wire was determined using solidworks by measurin though from pulley to pulley to where the rudder is approximately. The 6m measurement is an approximation and can be slightly off. The rudder is connected to the wire in that when the wheel is turned, the direction for the turn will change the direction of the tension resulting in the turning of the rudder.

Structure and Appearance

The battery for the mobility system is stored away at the front of the boat so that it acts as a counterbalance for the motor. Furthermore due to the large empty space at the front, it utilized as a storage compartment for first aids and other equipment. The seats of the boat are all filleted so as well as any part exposed to the user to get rid of sharp edges that may hurt the user's. The hull of the boat was made with a thicker sheet of the Low Density PE (LDPE) to reduce the need for double layering the raft like a speed boat. We found that the boat was too heavy and is redundant material. The LDPE is already able to float in water, we set that the boat, from the bottom will be 30cm submerged. Using solidworks measure feature we obtained the volume of the raft submerged. Using that we were able to obtain the diameter of the side stabilization fixing the length based on the boat's size limitation so that it does not go past the flat part of the body. (Calculations and measurements shown below)

Buoyancy analysis

From Solidworks analysis: with 30cm of the boat submerged volume=.64m^3 Appendix

$F_B = V\rho_w F_g$=907.17kg*9.8=8820 (set by requirements)

$V = \frac{900*9.8}{9.8*1000} = .9 -> .9 - .64 = .267$ splitting it into the 2 tubes->.1335m^3

Tube volume $= \pi r^2 h = .1335$

We started with a 20cm diameter tube but that resulted in a 4.25m long tube.

We then tried 30cm diameter tubes and got the length we used.

In the selection of colors for the raft is we chose colors that contrasted well with blue which lead to the colors orange and green using a color wheel. The sides of the raft have reflective strips that allow for easy visibility.

Accessibility and Resources

The side of the raft has a 4 step foldable ladder that is between the side tubes and hull of the raft. The tube will provide backing for a user that is still in the water and will allow for easier entrance into the raft. The total length is 1.2m and meets the requirement for the ladder as it provides sufficient footing. Also contained with the cupboard is a food ration pack that can last up to 5 years and also a first aid kit standard with the boat both from a company called Datrex. There is also an optional gps system for the user, the *Garmin ETREX 10 Handheld,* that is powered by standard batteries allowing for quick battery change instead of charging. We left the gps system optional because if the user is not heading far from shore often, it becomes an unnecessary cost for the user with affordability being a critical factor.

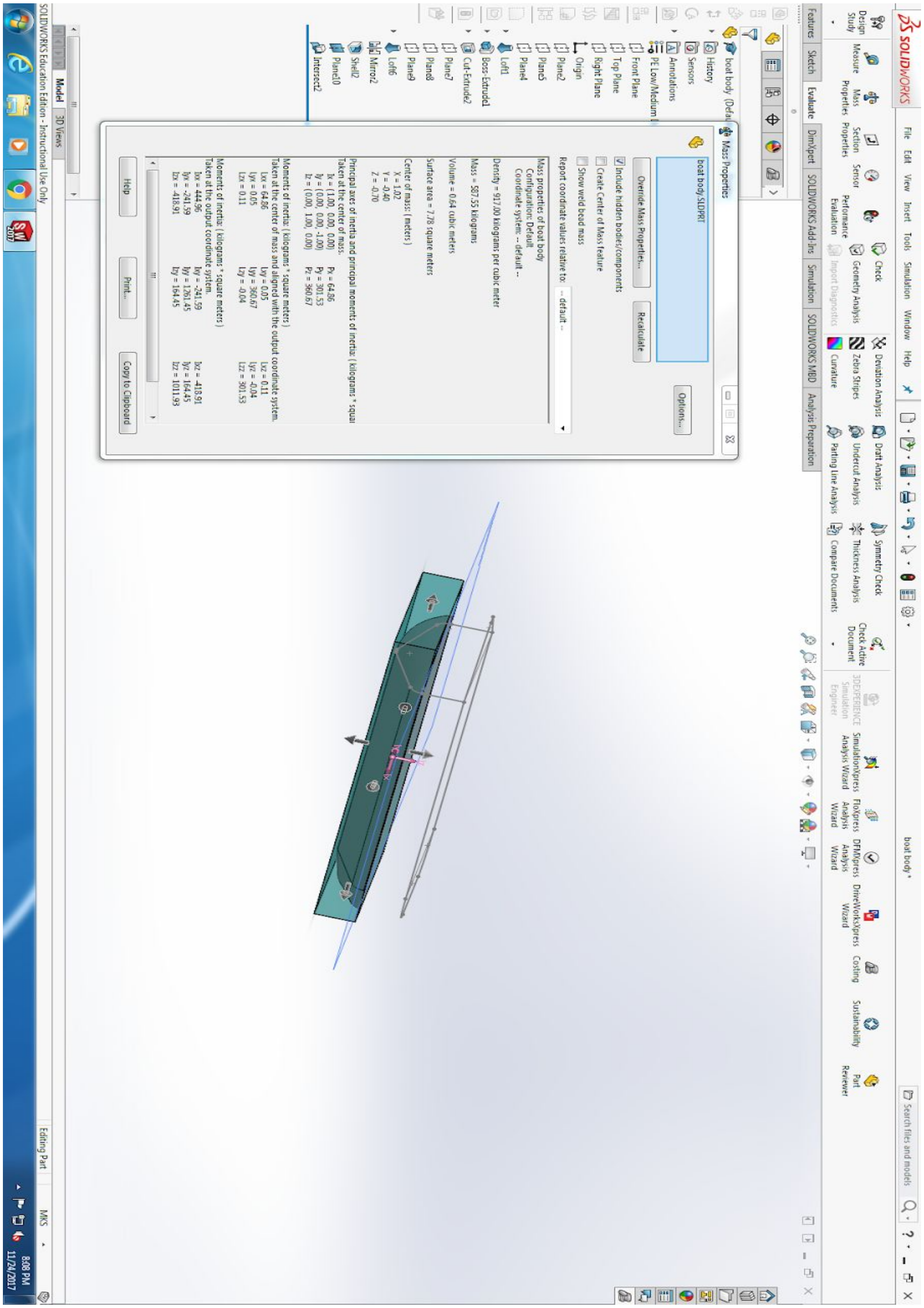


Figure 37: Volume calculation done automatically in solidworks. .

Design Discussion

Overall we are satisfied with the design as a whole. While the design is not anything new and innovative it focuses at the problem that is at hand, the design of a maritime support system for the caribbean. From the selection of the material, size of the raft or available motors for the users we had the affordability of the product in mind. Our original goal was to focus on the touring side of the problem however after research realized that there is plenty of options for expensive alternatives.

Our design also strongly focused on the environmental aspects of the overall design process. It is really easy to ignore the environmental aspect of the raft and in the design we did consider outweighing the gasoline. Ultimately, we came up with the thought to give the user the option of selecting different powered motors that varied in specs that suit the need of the users. We gave the option of a high power electric motor with a strong range however can run the user about $2000 or the lower powered motor that is about $500 that is cost effective and is sufficiently powered for shorter distances.

Another aspect that we are proud of is the mobility system that simplified the use of a traditional trolling motor. In an traditional motor the user will need to sit in the back controlling the rudder in a counter intuitive method where a right turn is for left and vice versa. While this can be quick to get used to, our design is done so that it is similar to that of a regular road vehicle and is situated at the front of the boat. This is done to not only simplify the user experience but also allow for better visibility for the user when controlling the raft.

Despite the strong aspects of the raft there are some flaws and aspects of the raft that can be considered for future reference. One of the flaws of the raft is the sustainability of the storage. While for mid sized rafts this can be stored relatively easily, smaller fishing boats may only be 13-15’ long and our design will be difficult to store for those users. Furthermore, in the design of the hanger, it would be ideal to actually see a boat so that we can appropriately find proper dimensions for the hanger as this was difficult due to the sheer variety of boats. Another possible consideration is the long term sustainability of the the raft. While we believe low density PE was a strong decision how long it will last is still a an aspect that is unknown to us. However, its property to be able to stay in salt water without corrosion, strength and that is recyclable is a strong aspect making it a good choice.

Project Discussion

At the beginning of the semester, each member of team 0801 signed a team contract stating; goals, expectations, rules and consequences if rules are disobeyed.This contract was extremely important because it would ensure each member would contribute to the best of their ability to this term long project. By signing the team contract, each member agreed to attend all meetings, contribute and communicate effectively, keep the integrity of the group, and meet all deadlines assigned by the group.

The life support system project has helped each group member improve their time management, communication, teamwork and engineering skills. Time managements skills were improved by the requirement of team member to meet project deadlines. In addition to the deadlines set by the professors, we had deadlines of our own in order to leave time for editing and formatting content. Each member had to balance other school responsibilities in addition to this project to complete tasks on time. Communication skills were improved because as a team we had to communicate effectively so all portions or the project are consistent. The means of communication used was the app called WhatsApp and was a successful tool of communication of meetings, data and questions. Team work skills of each member improved because we were forced to argue ideas, work together and provide feedback for each members input to support the group as a whole. Lastly, our engineering skills were put to the test to produce a design of a maritime life support system which is not only innovative, but is ethical and practical.

After each milestone, the TA gave feedback on how the milestone can be improved for the final report. Before the completion of this project, the team made a group effort to look back and edit the previous milestones. We worked well as a team however this methodology could have been improved by making the appropriate changes closer to when each milestone was returned. This way the comments made would be more fresh and more mistakes could have be corrected.

During the concept design process, we encountered an issue due to forgetting to consider some requirements. We forgot to consider our cost and weight constraints during this process which left us with a heavy and costly concept design. After realizing our mistake, we went back and make changes to the design to incorporate both of these requirements. This was a tedious task and if considered the first time around, would have saved a lot of time which could have been put towards other components of the report.

However, once all decisions regarding the design were finalized, as a group we were extremely satisfied with the final design. We were able to meet all previously stated requirements, and complete a design which was useable for all personas and user groups discussed. We put a large focus on our design to considering our persona's in that each would be confident in their ability to use the Poseidon. We were able to correct all mistakes mentioned along the way. We brought the cost the product down by finding an electric motor (the torqeedo 3 HP motor) which was cost effective and powerful enough to propel the Poseidon. We also were able overcome the weight challenges by deciding to use low-density polyethylene as the primary material in the hull of the Poseidon which reduced the weight and provided enough support to contain the passengers. Lastly, we were extremely pleased with the overall aesthetics of the rendering of the Poseidon and confident our design has potential to be a viable maritime life support system with further in depth engineering.

Conclusion

The goal of this project was to create a maritime support system for fishing boats and tour boats in the caribbean. In our research we found that many in the fishing boat industry do not have the funds to afford expensive alternatives like our reference design, thus we set our goal to tackle this issue. On the other hand the tourist boat users have more needs and vary in their traits as well. Furthermore the simplicity of the design of the mobility allows for more users being able to use the raft. One of the problems we faced was the weight of the raft as the larger the boat the heavier it is but also needs to carry enough persons. In analysing different boats we found that a 4 person raft was a good balance between the weight of the raft and number of persons that it can take with ample space.

In the designing process we considered different personas that each have different needs. Some users have disabilities while others had restrictions and needs that needed to be addressed. Thought the designing process these users we considered and was designed around those needs. The use of the usage of the usage scenarios allowed for us to visualize those needs and come up with requirements for the design.

Using the requirements we analyzed the system and obtained a system diagram that illustrates the inputs and outputs for the system as a whole. Embodiments for each of the subsystems was conceptualized and using those initial concepts were produced. However, if left untouched the sheer number of concepts is too large, therefore to reduce that and try to get closer to the desired design embodiments that are poorly matched were eliminated. This ultimately led us with our final design from all of the initial concepts and one set of refinements. Lastly, the concept was defined, refined and sketched to produce a model of the design in solidworks.

Overall this was a good experience as we were able to work as a team to come up with a good design which is The Poseidon.

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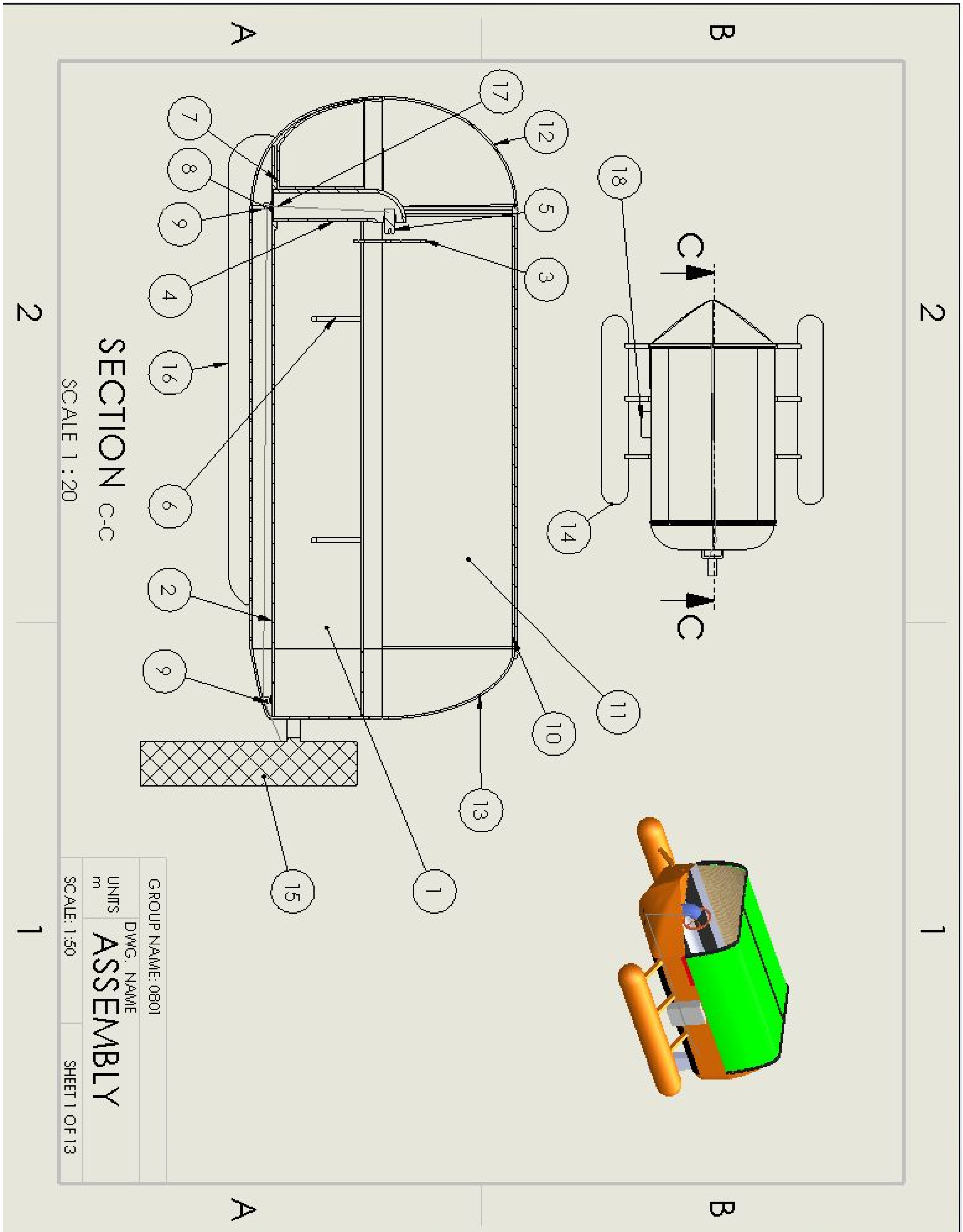
Appendix 1: drawing



ITEM NO.	PART NUMBER	Description	QTY
1	boat body	LOW DENSITY POLYETHELENE	1
2	boat floor	LOW DENSITY POLYETHELENE	1
3	wheel	Attwood 13" Soft Grip Wheel	1
4	steering holder	LOW DENSITY POLYETHELENE	1
5	steering shaft	LOW DENSITY POLYETHELENE	1
6	seat	LOW DENSITY POLYETHELENE	1
7	cubord	LOW DENSITY POLYETHELENE	1
8	Pully Support	Heightec P02	4
9	pulley	Heightec P02	4
10	canopy bar	LOW DENSITY POLYETHELENE	1
11	side canopy	Nylon	2
12	front cover	ACRYLIC	1
13	REAR CANOPY	NYLON	1
14	tube side Right	LOW DENSITY POLYETHELENE	1
15	Motor	LOW:Haswing Protruar HIGH: Torqudoo 1003C	1
16	tube side left	LOW DENSITY POLYETHELENE	1
17	Cables	EMA Steel Piano WIre 4.8mm	6m
18	Ladder	Amarine-made 4 Step	1

GROUP NAME: 0801

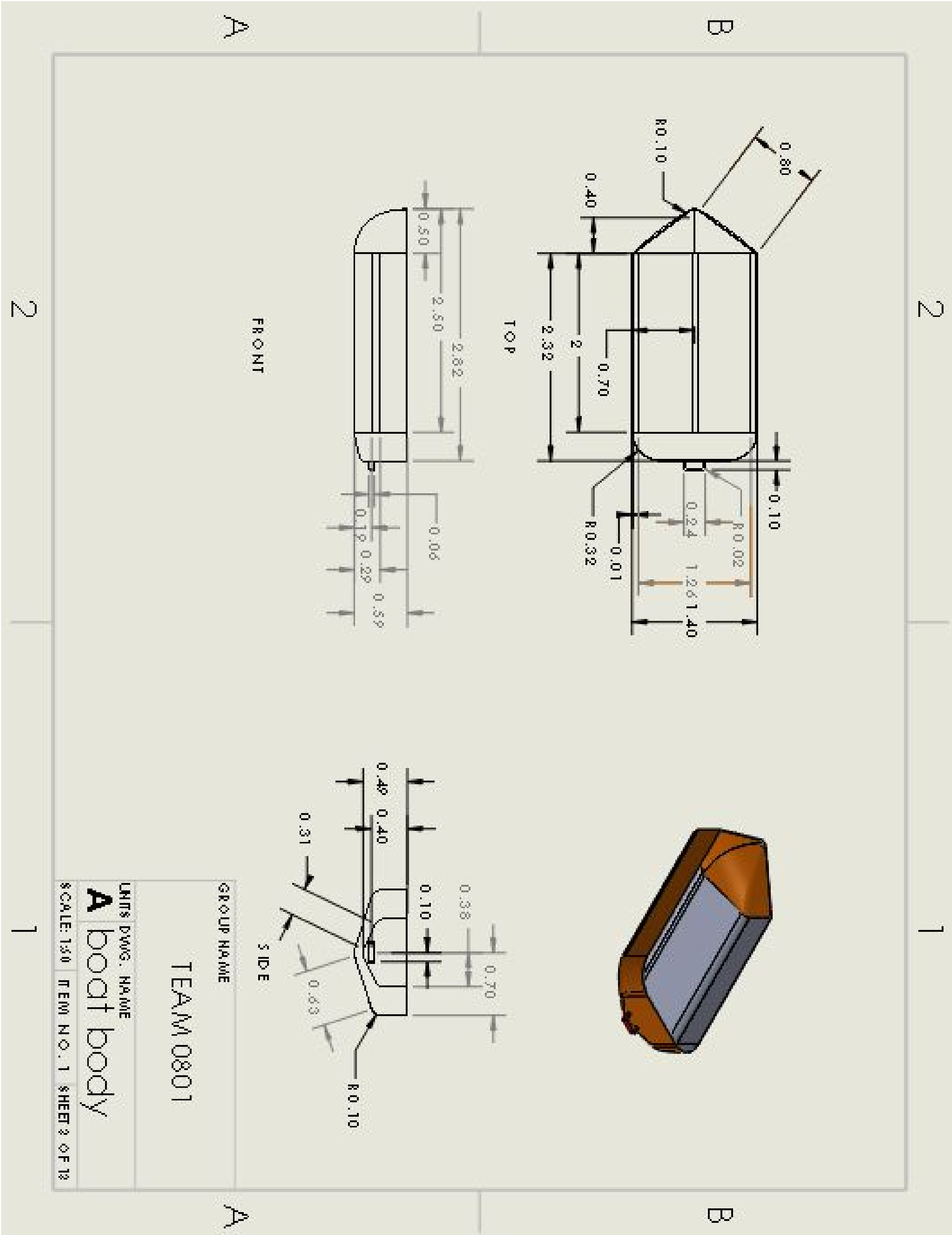
UNITS NA | DWG. NO. BOM

SCALE:NA | SHEET 2 OF 13

Off Shelf Parts

Item No	Citation	Link
3	Attwoodmarine.com. (2017). *Attwood Marine*. [online] Available at: http://www.attwoodmarine.com/store/product/Soft-Grip-Steering-Wheel [Accessed 2 Dec. 2017].	http://www.attwoodmarine.com/store/product/Soft-Grip-Steering-Wheel
8 , 9	heightec. (2017). *Aluminium rescue pulley 5cm - manufactured by heightec*. [online] Available at: https://www.heightec.com/product/alloy-rescue-pulley-5-cm/ [Accessed 2 Dec. 2017].	https://www.heightec.com/product/alloy-rescue-pulley-5-cm/
15 (high)	CS, T. and CS, T. (2017). *Outboard - Travel 1003 C - Torqeedo*. [online] Torqeedo.com. [Accessed 2 Dec. 2017].	https://www.torqeedo.com/us/en-us/products/outboards/travel/travel-1003-c/M-1149-00.html
15 (low)	Amazon.com. (2017). [online] [Accessed 2 Dec. 2017].	https://www.amazon.com/Haswing-Protruar-Transom-Electric-Trolling/dp/B01EHQ03I6
17	Ema-models.co.uk. (2017). *Steel Piano Wire 4.8mm - Steel Piano Wire - Metal - Materials*. [online] Available at: http://www.ema-models.co.uk/index.php/materials/metal/steel-piano-wire/steel-piano-wire-5534.html [Accessed 2 Dec. 2017].	http://www.ema-models.co.uk/index.php/materials/metal/steel-piano-wire/steel-piano-wire-5534.html
18	Amazon.com. (2017).[online] Available at: [Accessed 2 Dec. 2017].	https://goo.gl/qqhujX
7*	1. Datrex.com. (2017). *Datrex - FIRST AID KIT LIFERAFT USCG detail*. [online] 2. Canadiantire.ca. (2017). *Garmin ETREX 10 Handheld GPS, 2.2-in | Canadian Tire*. [online] 3. 3600C Datrex Emergency Food Rations, (. (2017). *3600C Datrex Emergency Food Rations, (Case of 10)*. [online]	1.http://www.datrex.com/index/catalogdetail/pdt_id/557 2. https://goo.gl/4J2vQU 3. https://72hours.ca/products/10x3600kcal-mainstay-food-ration-bar?variant=94469692

7* stored within the cupboard


TOP
FRONT
SIDE
GROUP NAME
TEAM 0801
UNITS
DWG. NAME
A
boat body
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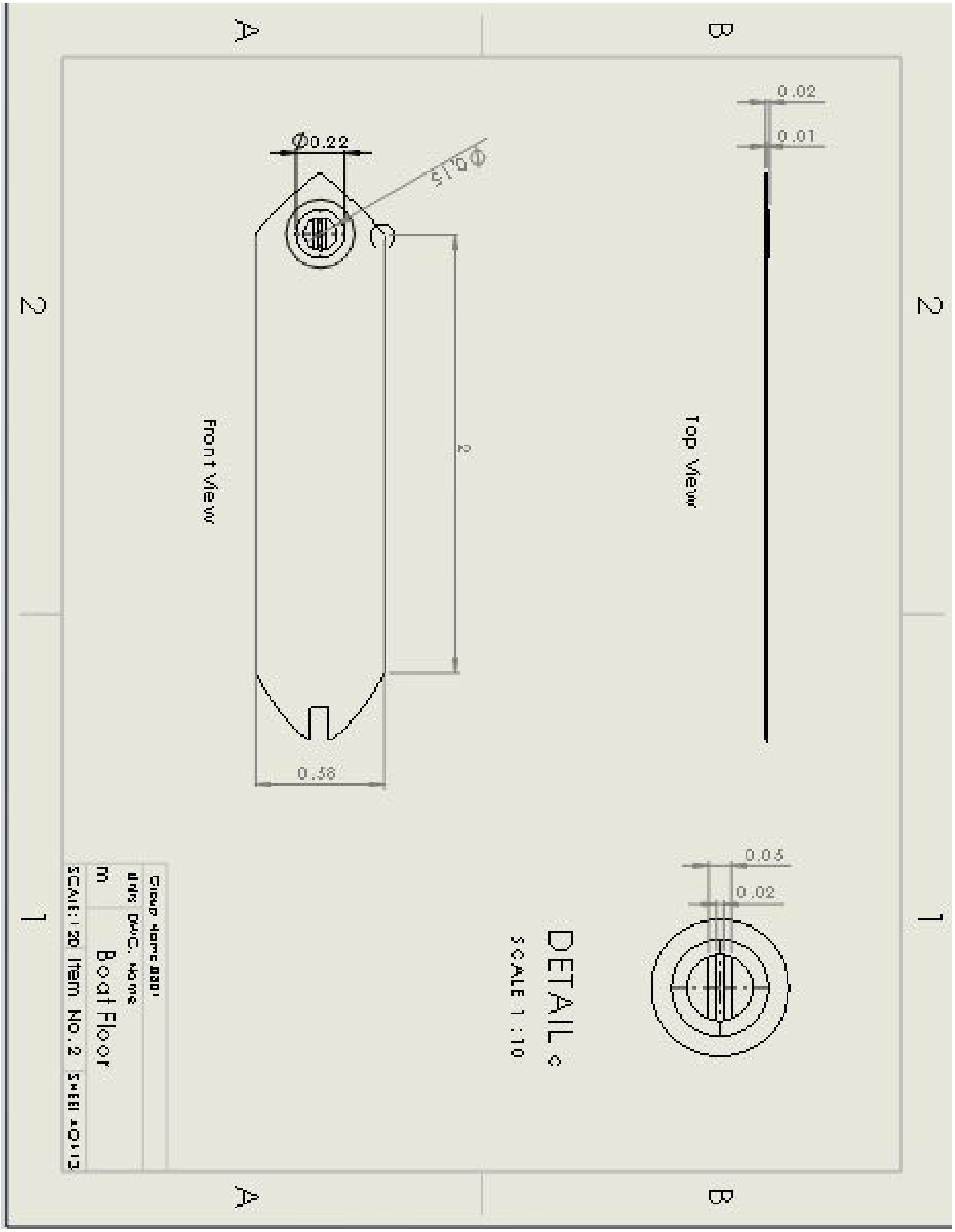
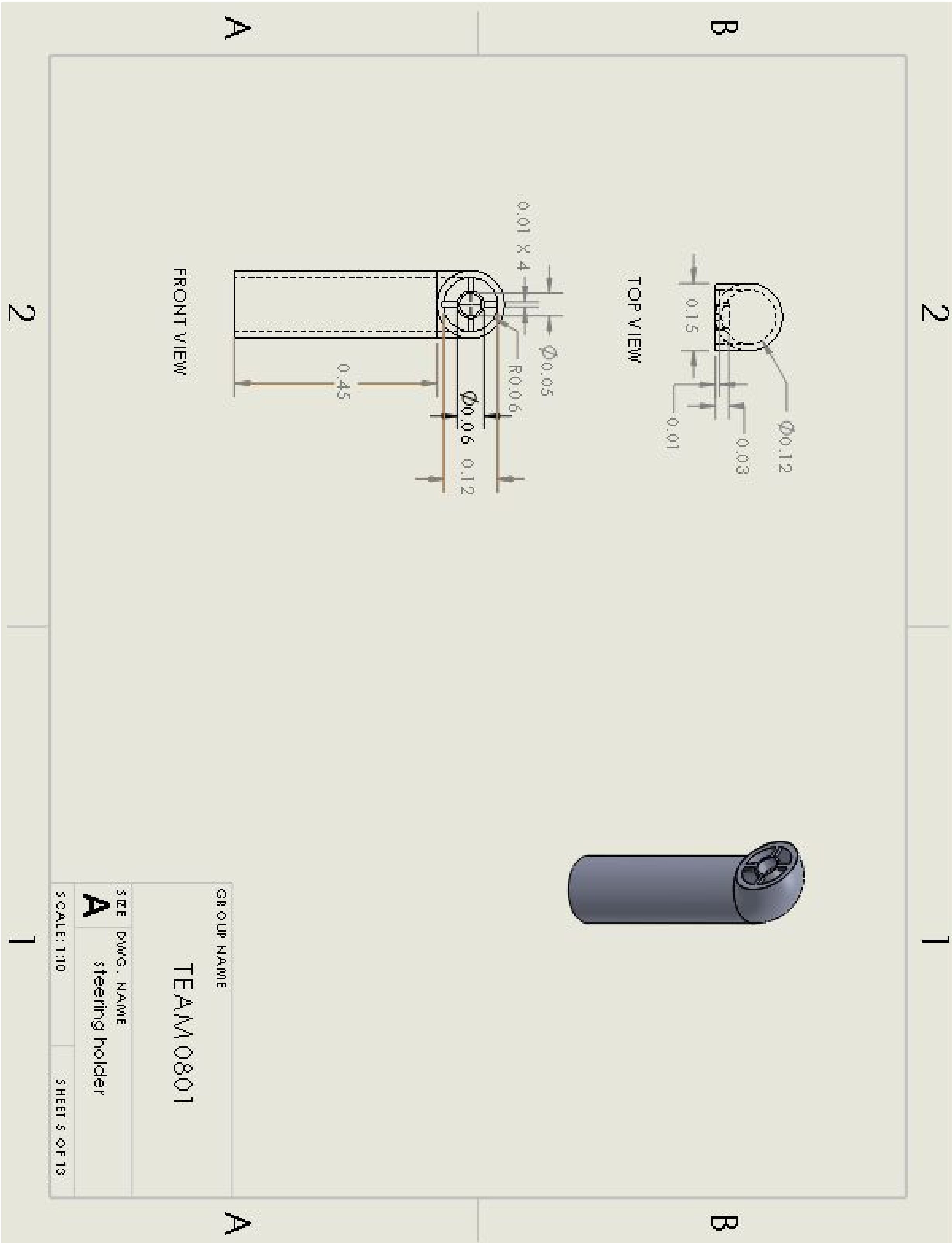
ITEM NO. 1
SHEET 2 OF 12



A
B
2
1
Ø0.22
Ø0.15
0.02
0.01
2
0.58
Front View
Top View
0.05
0.02
DETAIL C
SCALE 1 : 10
Boat Floor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FRONT VIEW
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0.01
0.15
Ø0.05
R0.06
0.01 X 4
0.45
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0.12
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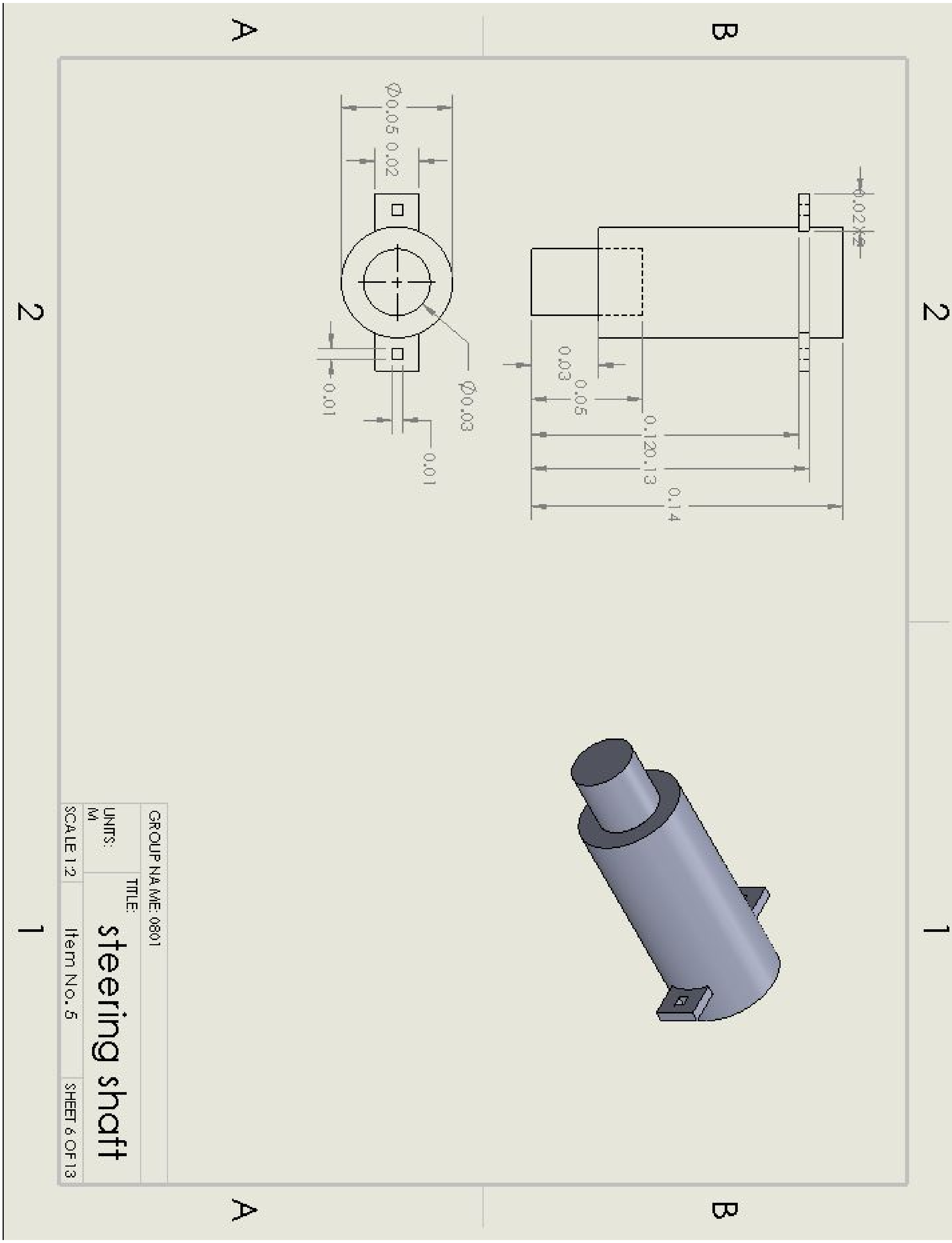
TEAM 0801
SIZE
A
DWG. NAME
steering holder
SCALE: 1:10
SHEET 5 OF 13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TITLE:
steering shaft
UNITS:
M
SCALE 1:2
Item No. 5
SHEET 6 OF 13
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Ø0.03
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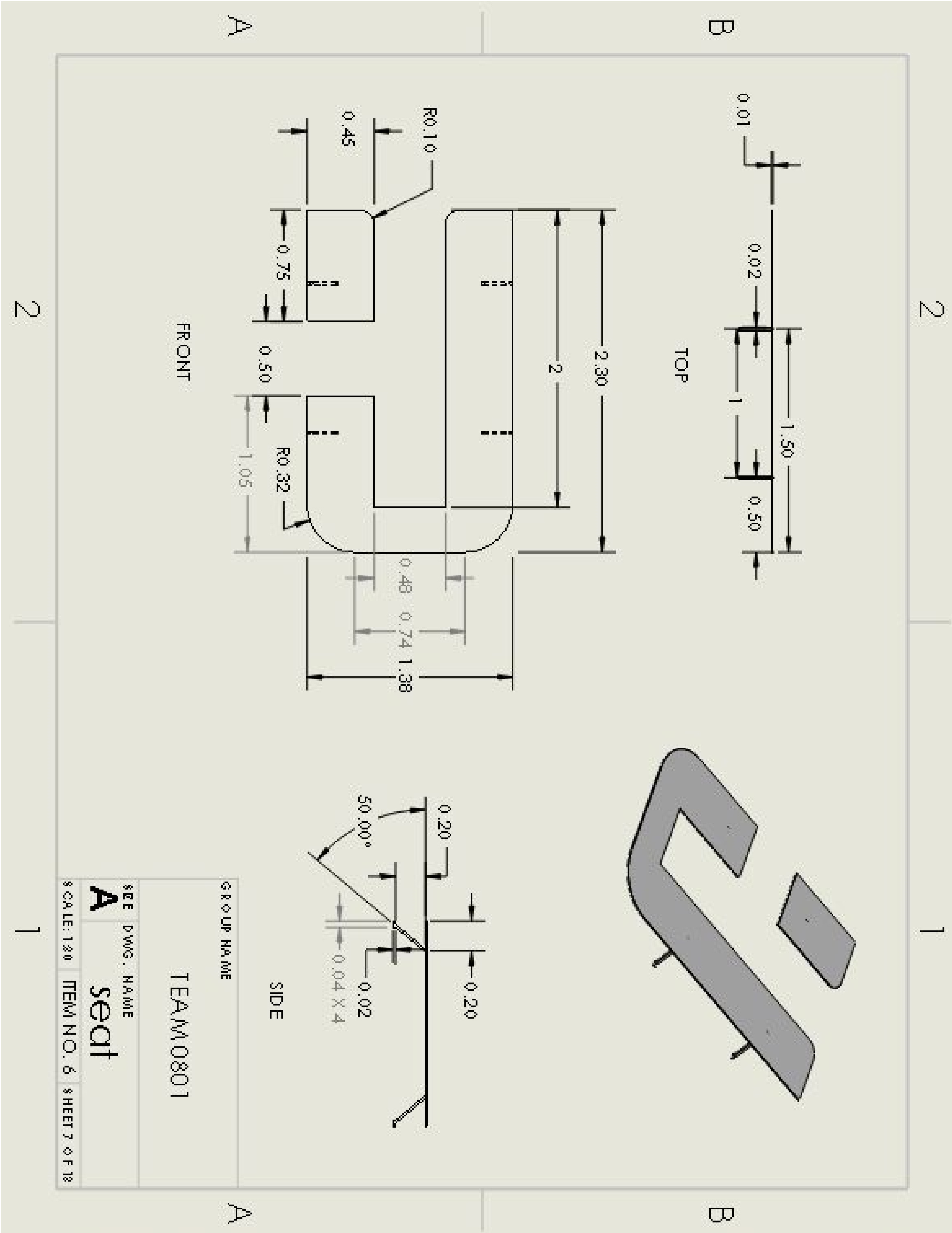
0.01
0.02
0.03
0.05
0.12
0.13
0.14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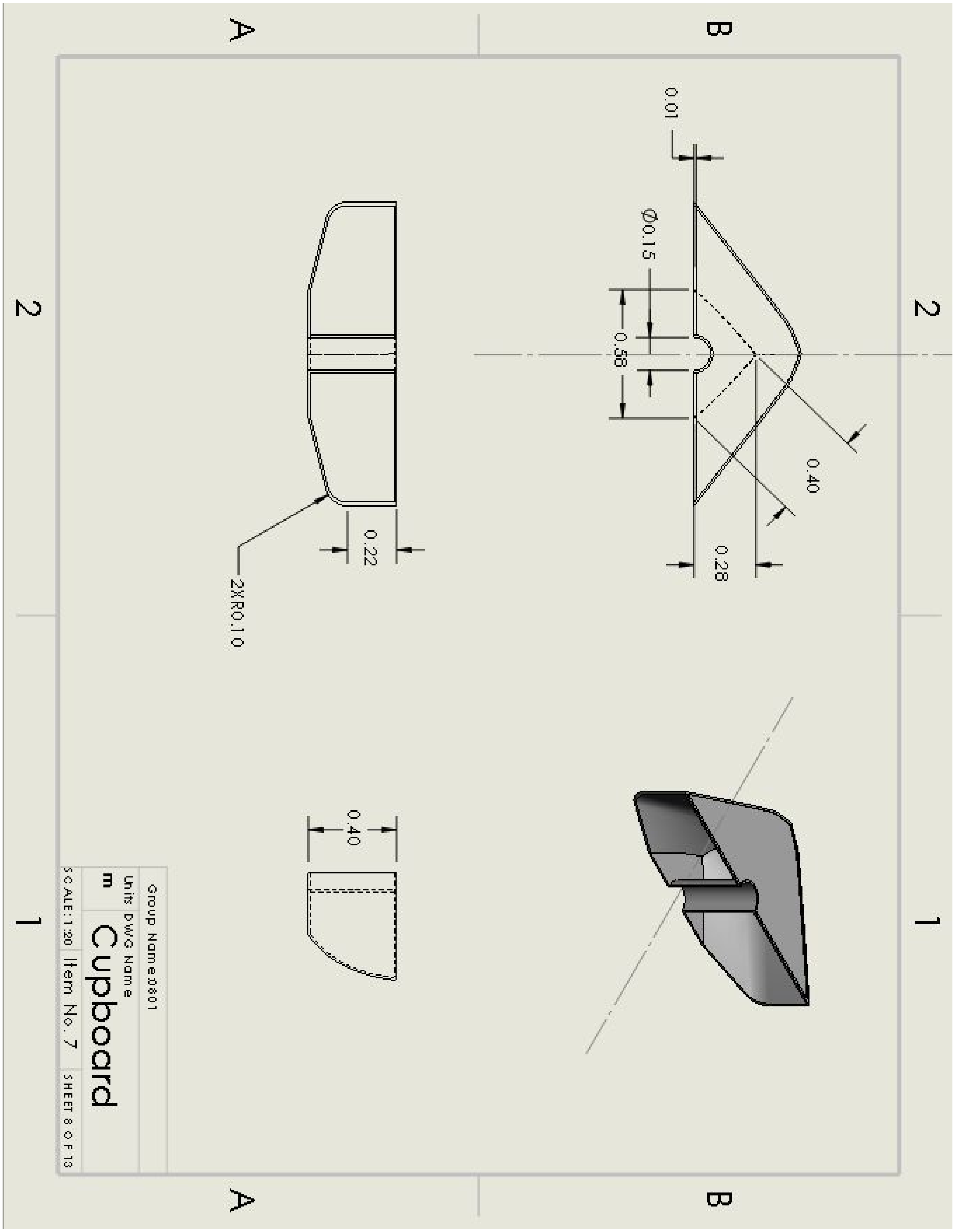
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Ø0.15
0.58
0.40
0.28
0.22
2XR0.10
0.40
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DWG Name
m
Cupboard
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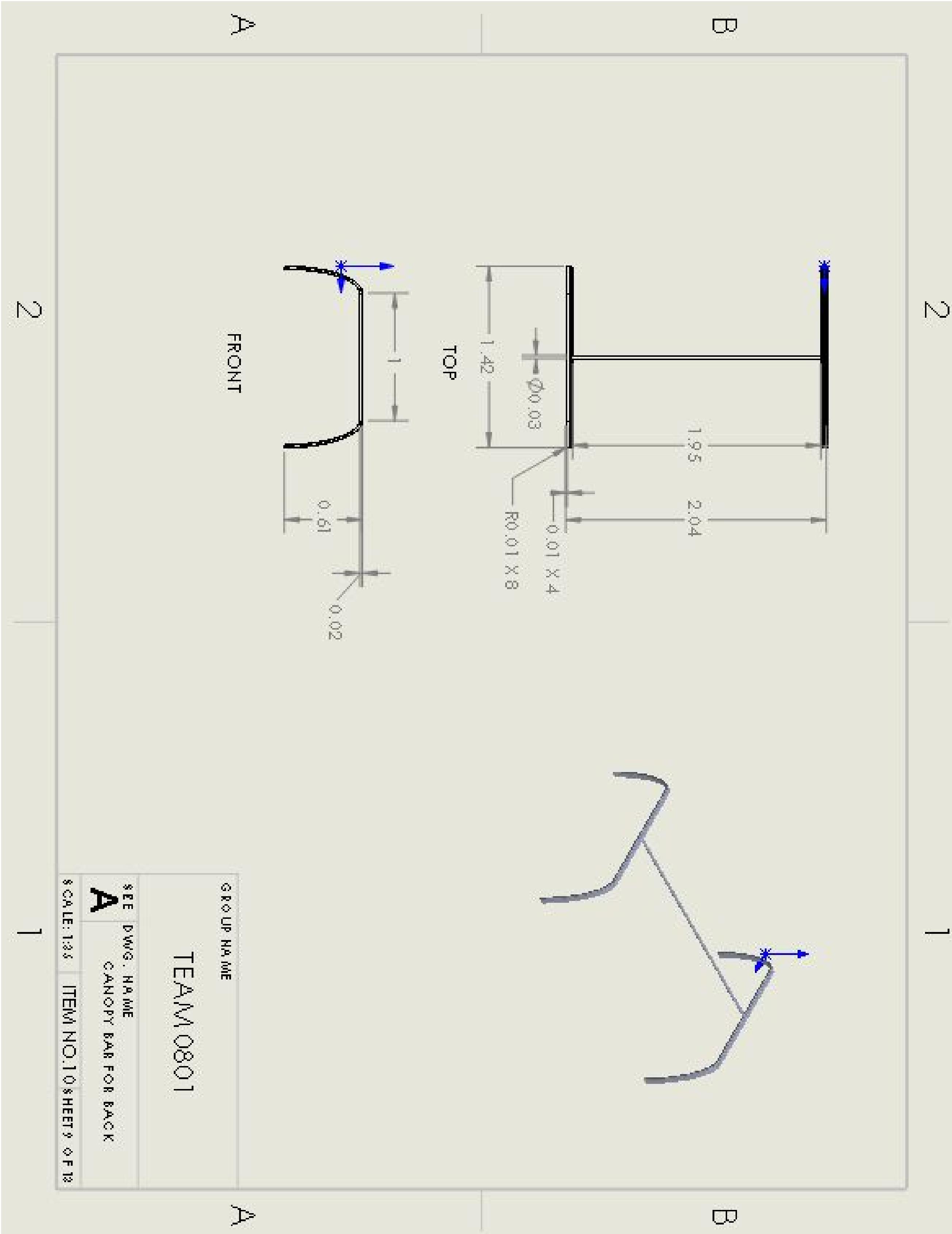
Item No. 7
SHEET 8 OF 13


TOP
FRONT
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Ø0.03
1.95
2.04
0.01 X 4
R0.01 X 8
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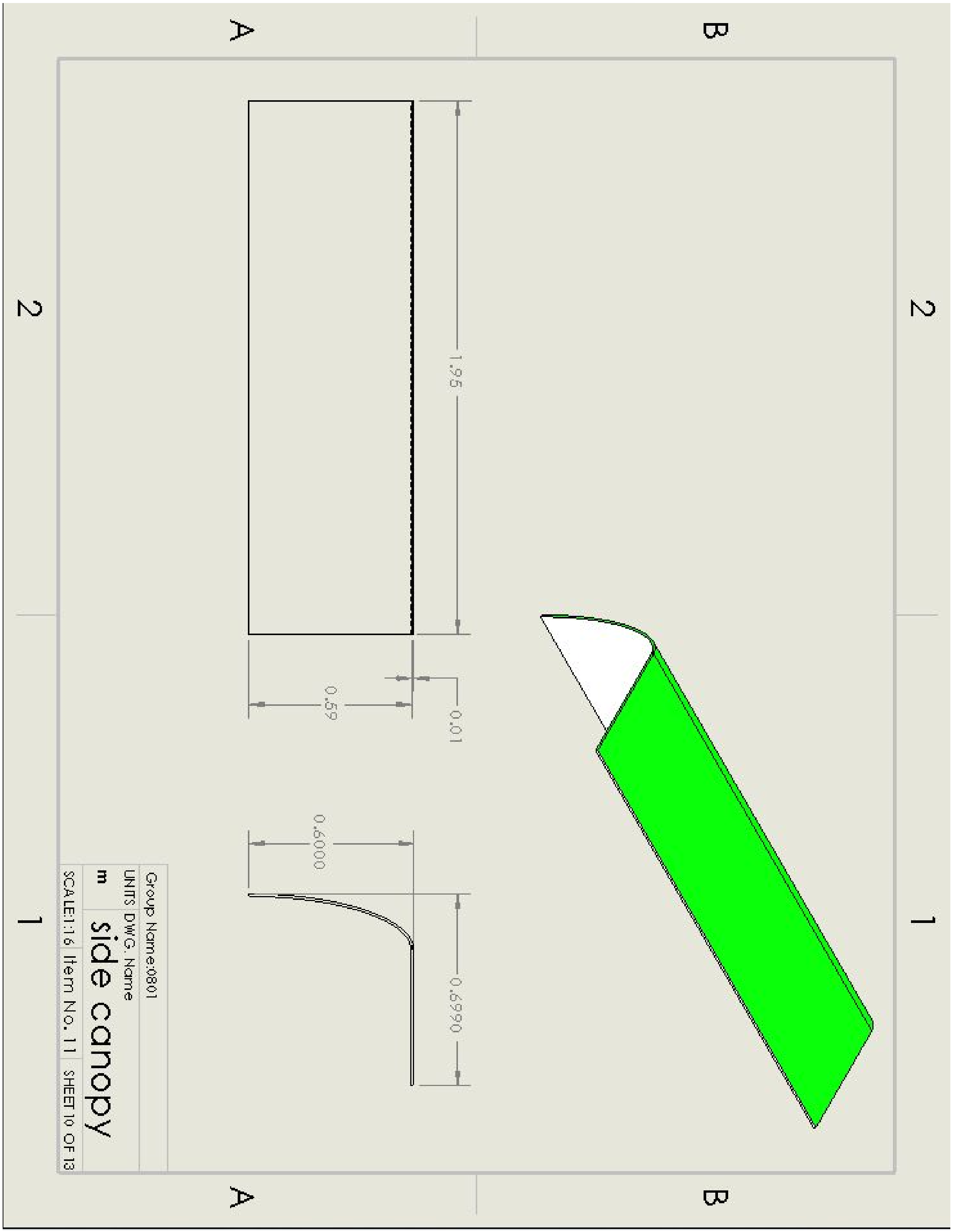
DWG. NAME
CANOPY BAR FOR BACK
SIZE
A
ITEM NO.10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UNITS DWG. Name
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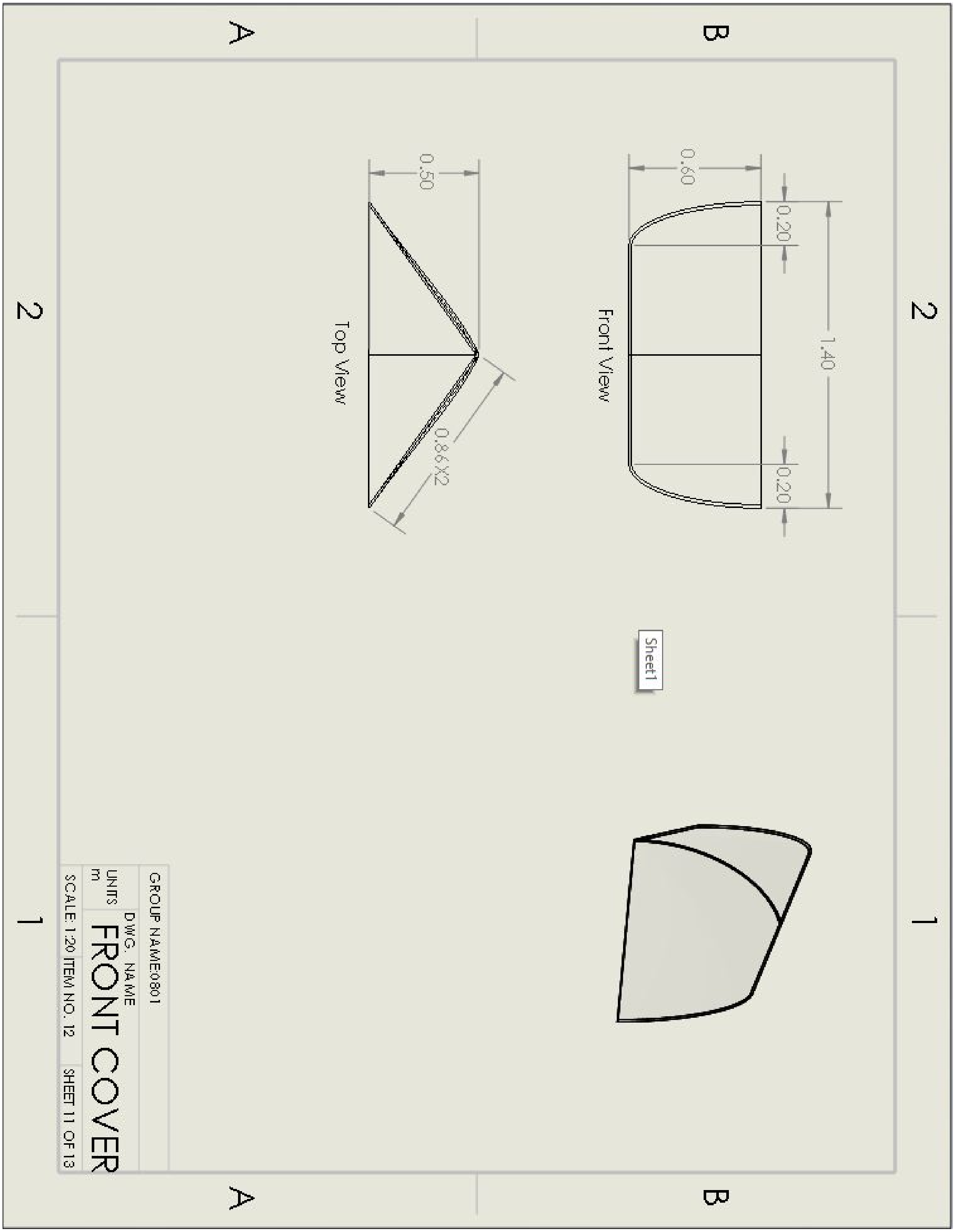
SHEET 10 OF 13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Top View
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0.50
0.20
1.40
0.20
0.86X2
Sheet1
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DWG. NAME
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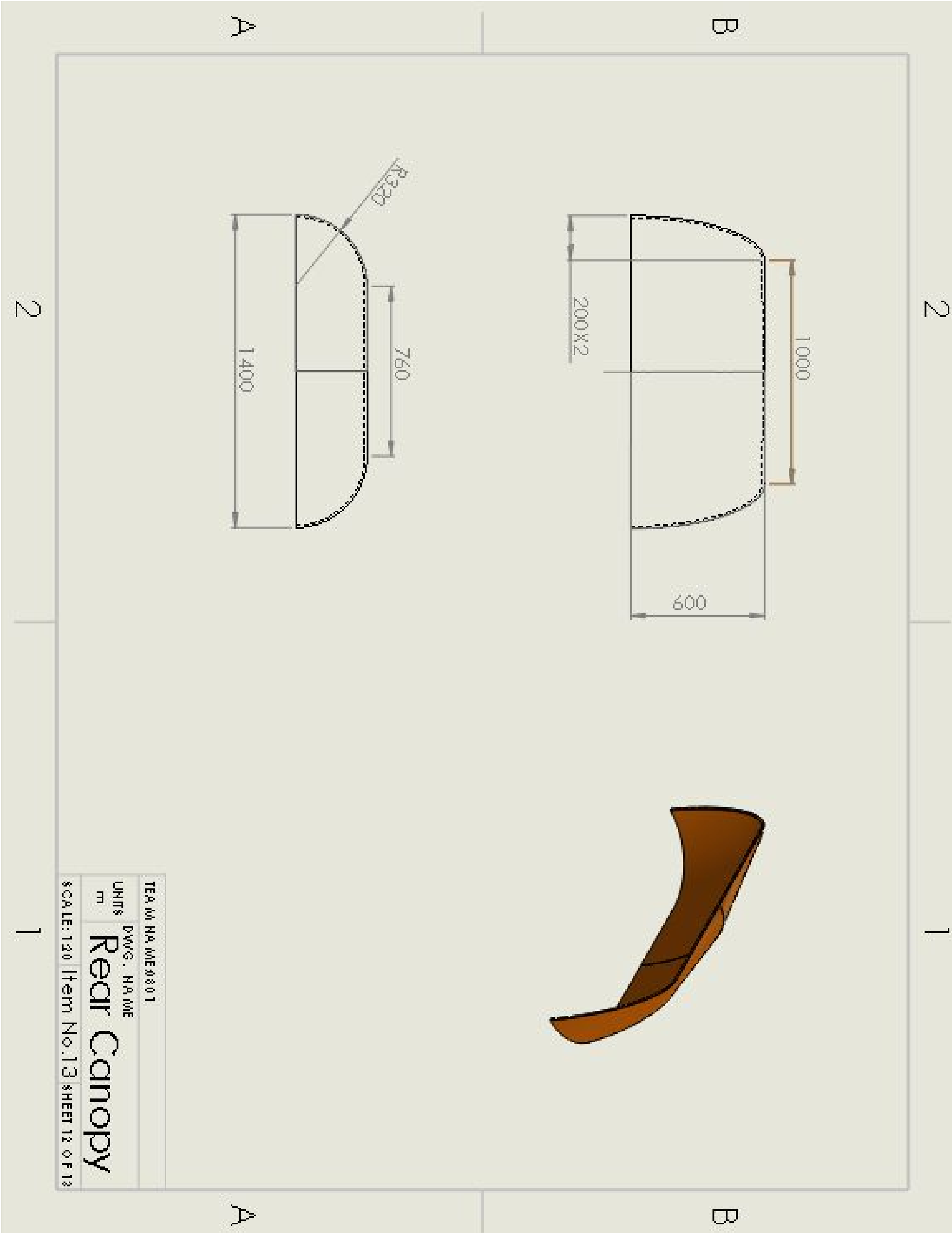
UNITS
m
SCALE: 1:20 ITEM NO. 12
SHEET 11 OF 13



A
B
2
1
R330
1400
760
200X2
1000
600
TEAM NAME ME0801
UNITS
m
DWG. NAME
Rear Canopy
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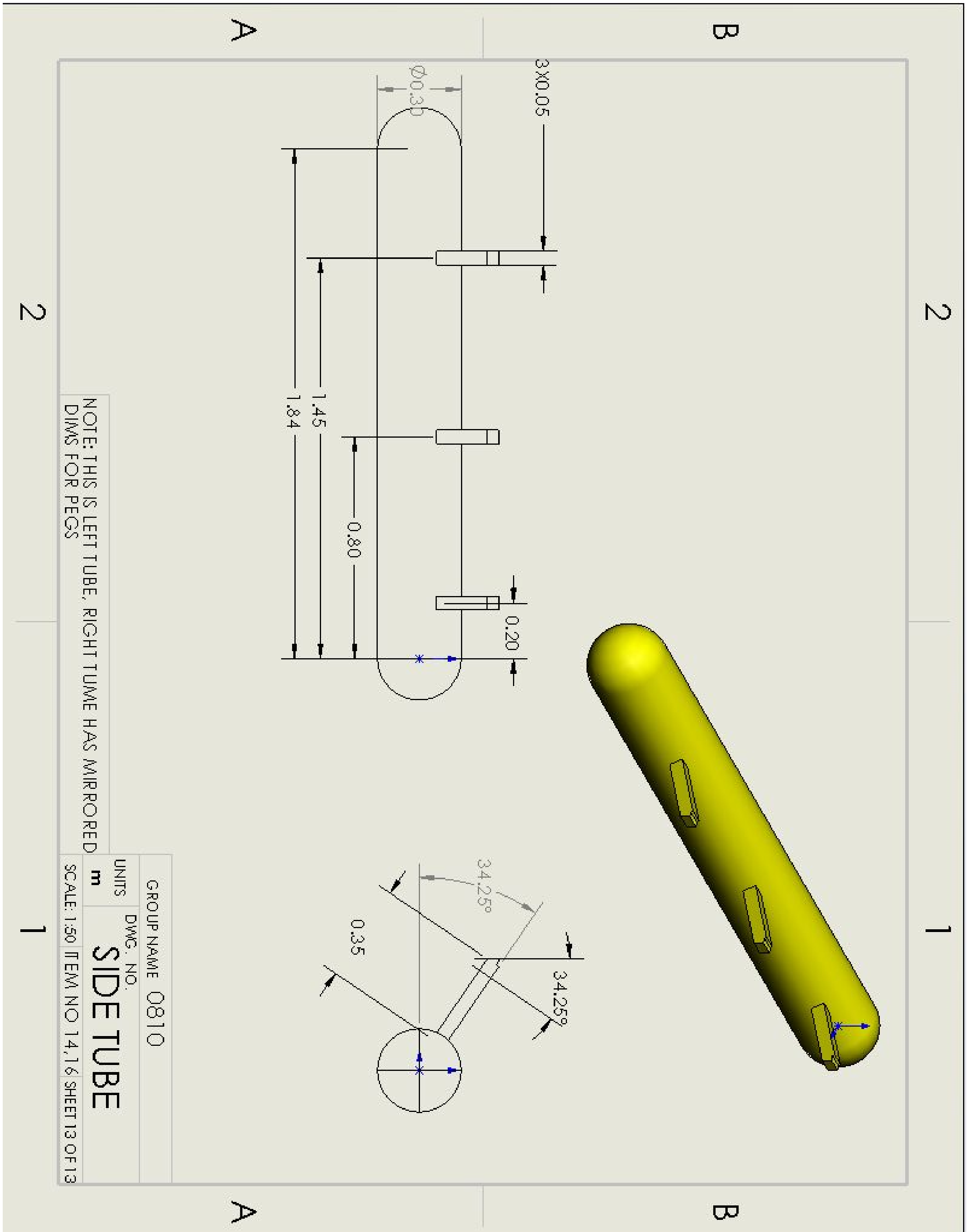
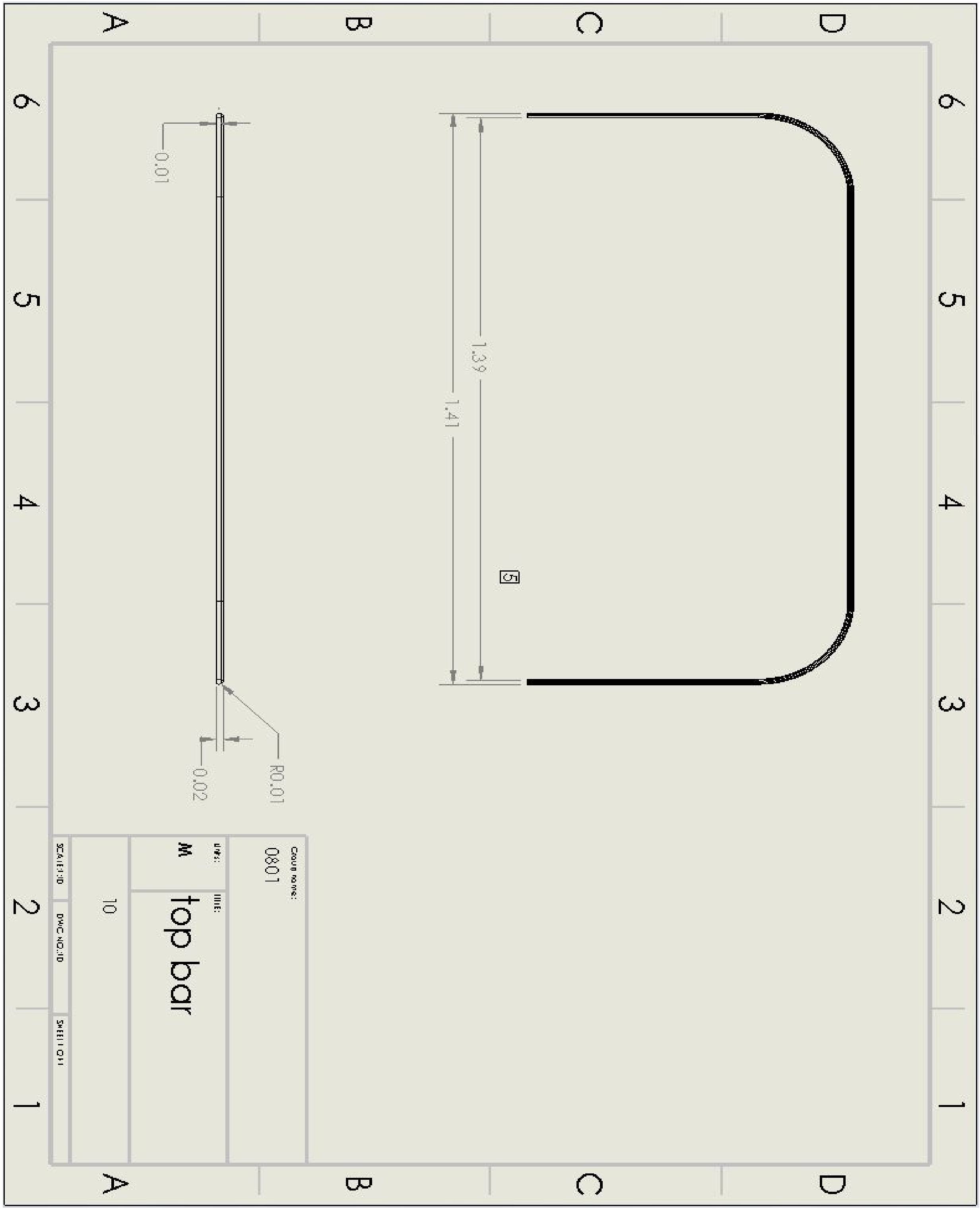
Item No.13
SHEET 12 OF 1


NOTE: THIS IS LEFT TUBE, RIGHT TUME HAS MIRRORED
DIMS FOR PEGS
GROUP NAME 0810
DWG. NO.
SIDE TUBE
UNITS
m
SCALE: 1:50 ITEM NO 14,16 SHEET 13 OF 13
Ø0.30
3X0.05
1.45
1.84
0.80
0.20
34.25°
0.35
34.25°
A
B
1
2



0.01
1.39
1.41
0.02
R0.01
0801
top bar
10

Appendix 2: brainstorming

[RAW DATA FROM YOUR INITIAL BRAINSTORMING]

Appendix 3: team attendance

DATE	LOCATION	Sina Sartipzadeh Amirghasem	Vincenzo Fillice	Zian Choudhury	Sami Dib	NAME	NAME	<-- PRINT/TYPE YOUR FULL NAMES IN THIS ROW.
09/21	Skype	Sina Sartipzadeh Amirghasemi	Vincenzo Fillice	Zian Choudhury	Sami Dib			<-- NOTE THE DATE AND LOCATION OF EACH MEETING.
09/25	Library Room	Sina Sartipzadeh Amirghasemi	Vincenzo Fillice	Zian Choudhury	Sami Dib			SIGN YOU NAME FOR EACH MEETING YOU ATTEND IN YOUR OWN COLUMN.
09/28	ENG	Sina Sartipzadeh Amirghasemi	Vincenzo Fillice	Zian Choudhury	Sami Dib			INCLUDE THIS SPREADSHEET IN YOUR FINAL REPORT.
09/30	Skype	Sina Sartipzadeh Amirghasemi	Vincenzo Fillice	Zian Choudhury	Sami Dib			
10/02	Library Room	Sina Sartipzadeh Amirghasemi	Vincenzo Fillice	Zian Choudhury	Sami Dib			
10/11	KHW LAB	Sina Sartipzadeh Amirghasemi	Vincenzo Fillice	Zian Choudhury	Sami Dib			
10/13	Library Room	Sina Sartipzadeh Amirghasemi	Vincenzo Fillice		Sami Dib			
10/15	Skype	Sina Sartipzadeh Amirghasemi	Vincenzo Fillice	Zian Choudhury	Sami Dib			
10/17	Skype		Vincenzo Fillice	Zian Choudhury	Sami Dib			
10/21	Skype	Sina Sartipzadeh Amirghasemi	Vincenzo Fillice	Zian Choudhury	Sami Dib			
10/24	Skype	Sina Sartipzadeh Amirghasemi	Vincenzo Fillice	Zian Choudhury	Sami Dib			
10/27	Library Room	Sina Sartipzadeh Amirghasemi	Vincenzo Fillice	Zian Choudhury	Sami Dib			
10/31	Skype		Vincenzo Fillice	Zian Choudhury	Sami Dib			
11/02	139	Sina Sartipzadeh Amirghasemi	Vincenzo Fillice	Zian Choudhury	Sami Dib			
11/04	Skype	Sina Sartipzadeh Amirghasemi	Vincenzo Fillice	Zian Choudhury	Sami Dib			
11/07	Skype	Sina Sartipzadeh Amirghasemi	Vincenzo Fillice	Zian Choudhury	Sami Dib			
11/08	KHW LAB	Sina Sartipzadeh Amirghasemi	Vincenzo Fillice	Zian Choudhury	Sami Dib			
11/12	Skype	Sina Sartipzadeh Amirghasemi	Vincenzo Fillice	Zian Choudhury	Sami Dib			
11/14	Skype	Sina Sartipzadeh Amirghasemi	Vincenzo Fillice					
11/15	KHW LAB	Sina Sartipzadeh Amirghasemi	Vincenzo Fillice	Zian Choudhury	Sami Dib			
11/18	Skype	Sina Sartipzadeh Amirghasemi	Vincenzo Fillice	Zian Choudhury	Sami Dib			
11/20	Library Room	Sina Sartipzadeh Amirghasemi		Zian Choudhury	Sami Dib			
11/22	Skype	Sina Sartipzadeh Amirghasemi	Vincenzo Fillice	Zian Choudhury	Sami Dib			
11/24	KHW LAB	Sina Sartipzadeh Amirghasemi	Vincenzo Fillice	Zian Choudhury	Sami Dib			
11/25	Skype	Sina Sartipzadeh Amirghasemi	Vincenzo Fillice	Zian Choudhury	Sami Dib			
11/26	Skype	Sina Sartipzadeh Amirghasemi	Vincenzo Fillice	Zian Choudhury	Sami Dib			
11/28	139	Sina Sartipzadeh Amirghasemi	Vincenzo Fillice		Sami Dib			
11/30	SLC ROOM+139		Vincenzo Fillice	Zian Choudhury	Sami Dib			

Figure 38:attendance image screenshot. Available at the shared folder.

Appendix 4: