Project Number: IQP ES3011_MQF_A10__01

The First Response EMS Vessel

by

Michael Brouwer Ryan O'Hara John Rynkar

An Interactive Qualifying Project

Submitted to the Faculty

of the

WORCESTER POLYTECHNIC INSTITUTE

In partial fulfillment of the requirements for the

Degree of Bachelor of Science

in Mechanical Engineering

______________ ______________ ______________

Michael Brouwer Ryan O'Hara John Rynkar

APPROVED: APRIL 2011

____

Professor M. S. Fofana, Major Advisor
Mechanical Engineering Department

Abstract

The objective of the First Response Medical Catamaran project is to develop a high speed medical rescue vessel that utilizes a catamaran-style hull and has the capability to stabilize and treat multiple patients at once. In order to accomplish this, three main goals need to be achieved. (1) Our vessel will have to be able to meet or exceed the maximum speed for current major rescue vessels. This is to ensure that our vessel can always be relied on when time is a crucial factor during the transport of a patient in critical condition. (2) The vessel must be very stable at sea relative to any other sea-based medical vessel. By having such a stable boat, doctors and EMTs will be able to perform procedures that were not previously impossible at sea due to the constant random movement of the vessels. (3) Our vessel will have to be very efficient but still large enough to carry medical equipment and supplies needed to treat multiple patients at once. We researched many different types of watercraft in order to find out which type of vessel would best suit our needs for size and speed, paying special attention to the style of hull that would result in the smoothest ride. We researched other medical vessels to form a general idea of how current emergency rescue vessels at sea perform, and how they need to be improved. We also researched ground ambulances, as the section of our vessel devoted to patient care should have very similar capabilities to those of typical ambulances on land. This also included methods for optimizing storage space in the ambulance, and for dealing with the prevention of contamination of patients and EMTs by contaminants left behind by previous patients. After completing this research, we developed several CAD drawings of our vessel, showcasing the shape of its hull, the size of the vessel, and the layout of the medical block. The result is that our vessel should theoretically be faster than most other emergency rescue watercraft currently employed in any part of the world, while providing an extremely smooth ride and having the capability to treat several patients at once.

TABLE OF CONTENTS

List of Figures

List of Tables

Acknowledgments

We would like to thank Professor M.S. Fofana for all of the motivation that he instilled in us that drove us to push this project to completion. In particular, the Professor's suggestions and guidance assisted us greatly in our improvements of our final products.

We would also like to extend a warm thank you to Commander Matthew B. Stuck, whose assistance was invaluable to us by providing us with the opportunity to visit the USCG station at Merrimack River. Along with this, we would also like to thank Station Operations Petty Officer Benjamin Molnar, and all of the USCG officers at the Merrimack River Station, for providing us with warm hearts and hospitality during our visit to their station, along with more key information than we had ever expected to collect.

Last but not least, we would like to extend thanks to our fellow students whose personal research directly aided us in the design of our vessel. This is including but not limited to: Joshua Bernier, Michael Haas, Kenneth Hough, Steven Knapp, Yun Qiao, and Talha Riaz. Without your assistance our research would have been significantly more strenuous, and our final product much less effective.

CHAPTER 1: EMS AND SERVICE AT SEA

The Emergency Medical Service Ambulance has been saving lives across the world since the late 1800s. The current land ambulance is a top of the line unit that provides both stability and speed in transporting an endangered patient from a point of origin to a hospital, where full medical treatment can be provided. Over the last two hundred years, the services of the EMS ambulance have become extremely effective while on land, but have several problems when attempting to rescue a patient in need elsewhere.

When accidents happen out at sea and EMS services are required, issues oftentimes quickly arise. Patients often need to be rescued faster than on a standard mainland call, and are oftentimes too far out to sea to make it back to a hospital in time. Even with all of the advanced EMS services we provide on land, in present day there is yet to be an efficient aquatic ambulance to perform rescues out at sea. While helicopters and certain rescue vessels are used in emergency water rescues, their usage is very limited.

There are many places in the world that have very limited means of aquatic rescue. Some only have air ambulance services; they have small helicopters that can bring people back to shore but they have no boats. This can be a problem as helicopters usually cannot hold more than a few passengers at a time. Helicopters can travel faster than boats, but in situations where many people are in need of rescue at sea, a helicopter would have to make several more trips than a boat. Due to this trade-off between speed and number of required trips, it is best to have both helicopters and boats available for rescue. In this way, rescuers can be prepared for a wider variety of situations.

Some areas do have ambulance boats in addition to helicopters, but they are not very efficient. They are slow-moving and are only meant to transport patients to hospitals on land. They are not well-equipped to treat patients and only stabilize them until they arrive at the hospital. Even if they did have the proper tools to treat patients, the boats are very rough on the water, which would make treatment for most patients very difficult to administer.

Our team's goal is to design a vessel that will act as both an ambulance and small treatment facility to aid in any offshore incident that requires EMS services. The vessel will need to be extremely stable, as most EMS practices cannot be done with perfect execution in a constantly rocking ship. The vessel will also need to be able to move at a rapid pace while maintaining its stability, as in these situations, time is always of the essence. This fast, stable first-response medical vessel will need to be top of the line to meet these standards, and if designed correctly, can easily provide care and safety to thousands of lives.

CHAPTER 2: FOUNDATIONS OF SEARCH AND RESCUE AT SEA

When designing and constructing an emergency rescue vehicle or vessel of any kind, there are many different aspects that must be considered and taken into account. There is the layout of the part of the vehicle that will be devoted to patient care, all of the medical supplies and equipment that must be carried within the vehicle at all times, and methods of cleaning the ambulance to make sure that no contaminants are transferred from patient to patient or patient to EMT. There are also many non-medical details to take into consideration. These can include the model of car or boat to be used as the basic design, the emergency lights on the exterior of the ambulance, the way in which to paint the ambulance, and many other minor design details that may be small but are still very important.

In order to construct a more efficient emergency rescue watercraft, we realized that we must obviously learn about the types of medical vehicles and watercraft that have already been designed and created. Our research can be grouped into two broad categories. The first of these categories is the basic design of the boat. Research falling into this category mostly consists of specifications of catamarans, boat engines, and other non-medical aspects of water vessels. The second category consists of research pertaining to ambulances used on land. Since people get injured and sick in many of the same ways out at sea as they do on land, it is important to have a solid grasp of the types of tasks expected of a typical ground ambulance. From this, we can draw conclusions as to how our emergency medical vessel should perform.

2.1 What Makes a Boat?

2.1.1 Powering the Ships

There are many options when it comes to marine propulsion. There are many different types of fuel that may be used by the engine. The engines can be different sizes and produce varying amounts of power. The possible combinations of all of the options are nearly endless. This can make choosing an engine a very difficult process, since all of the necessary requirements of the boat must be met.

Inboard drive is the second most common type of marine engine [20]. Inboard drive engines are when the main body of the engine is enclosed within the boat itself as seen in Figures 1 and 2. This type of drive is common on the largest cruise ships to the smallest ski boats, and provides a solid level of horizontal thrust on the bottom hull of the boat. This makes it quite efficient. This engine is typically a modified automotive engine adapted for marine use. There is usually an access panel in the boat and the shaft, propellers and rudders are beneath the boat.

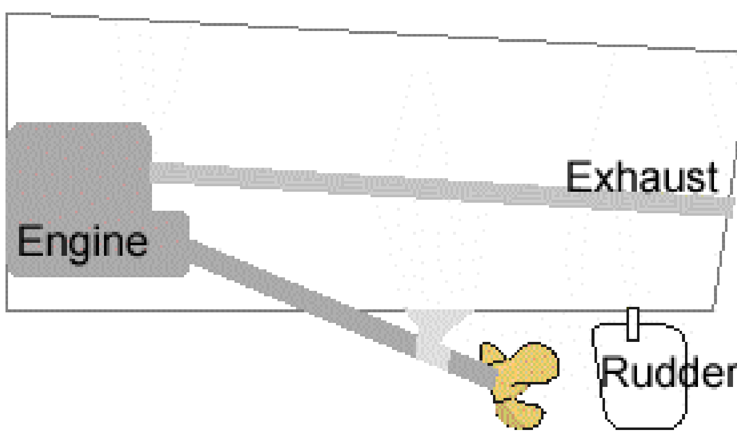


Figure 1: This is an example of an inboard-drive engine.

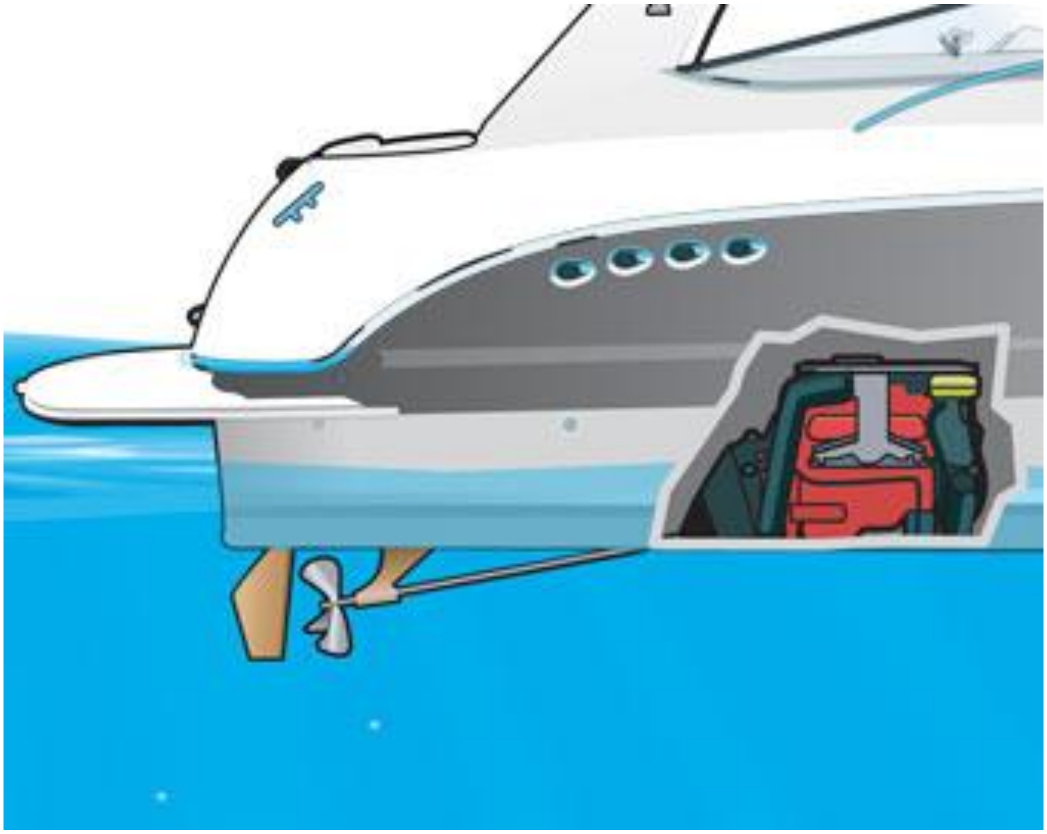


Figure 2: An alternate view of the inboard engine.

Outboard motors are the cheapest, most common, and most well-known type of marine drive. The engine is on the outside of the boat and directly connected to the propeller. These types of engines are much easier to remove and install than inboard motors, since they are easily accessible without having to deconstruct part of the aquatic vessel. Most units can be transferred from one boat to another and are self-contained units that mount to the back of the boat's hull. Each unit has an engine and a propeller, and uses the bottom of the unit as its rudder. This makes it so the entire motor unit must be turned in order to turn the vessel. An example of a common outboard engine can be seen in Figure 3. Outboard motors are typically used for smaller vessels, as there is only so much power that can be put in such a compact unit.

Figure 3: This is an example of an outboard engine.

A stern drive motor is a hybrid of both the inboard and outboard marine motors. It is similar to an inboard motor because it has the modified automobile type engine inside the boat with a shaft that goes to the propeller. However, unlike a normal inboard drive, it is not a straight shaft and it bends down like an outboard motor, as shown in Figure 4. Due to the fact that most have adjustable pitch and have dual propellers, stern drives are typically much quieter and are more fuel-efficient engines.

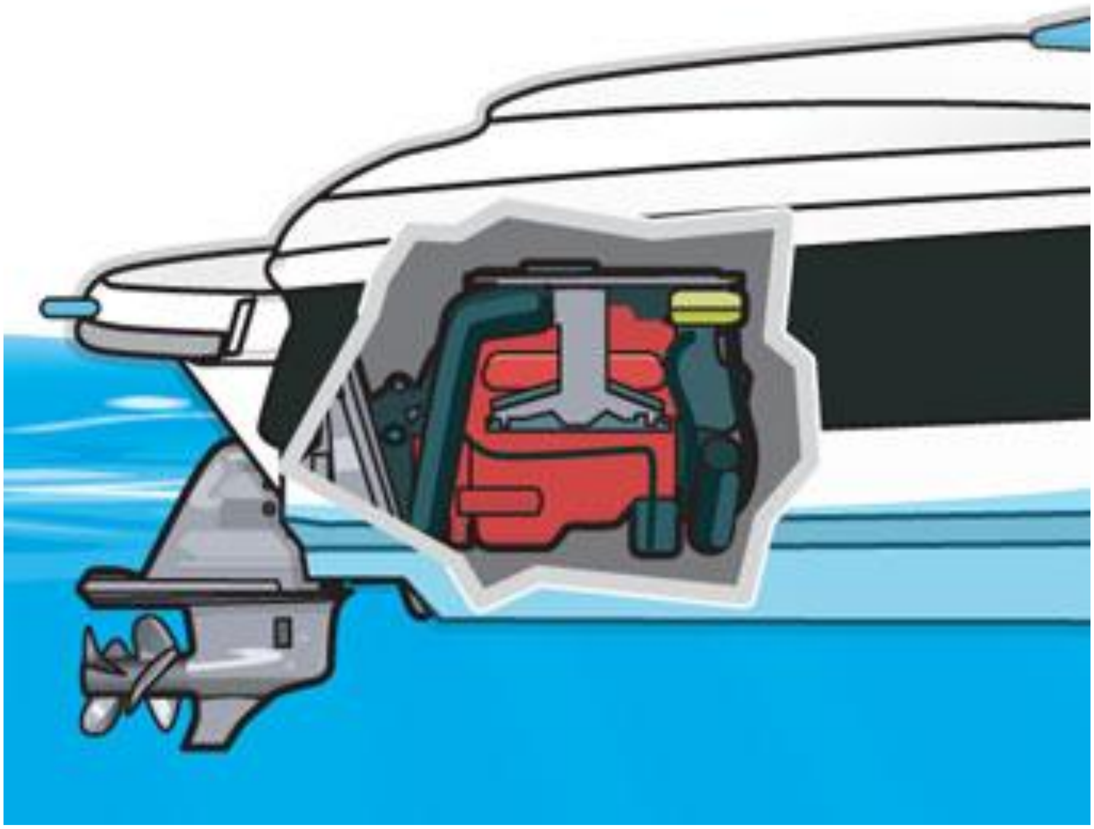


Figure 4: This is a diagram of a stern-drive engine.

Surface-piercing drives are what high-speed race boats use. They are low torque and sit half in and half out of the water so that the propeller literally pierces the surface of the water. This is where the engine gets its name. The propeller actually jets out almost horizontally from the back of the boat, decreasing losses in mechanical efficiency.

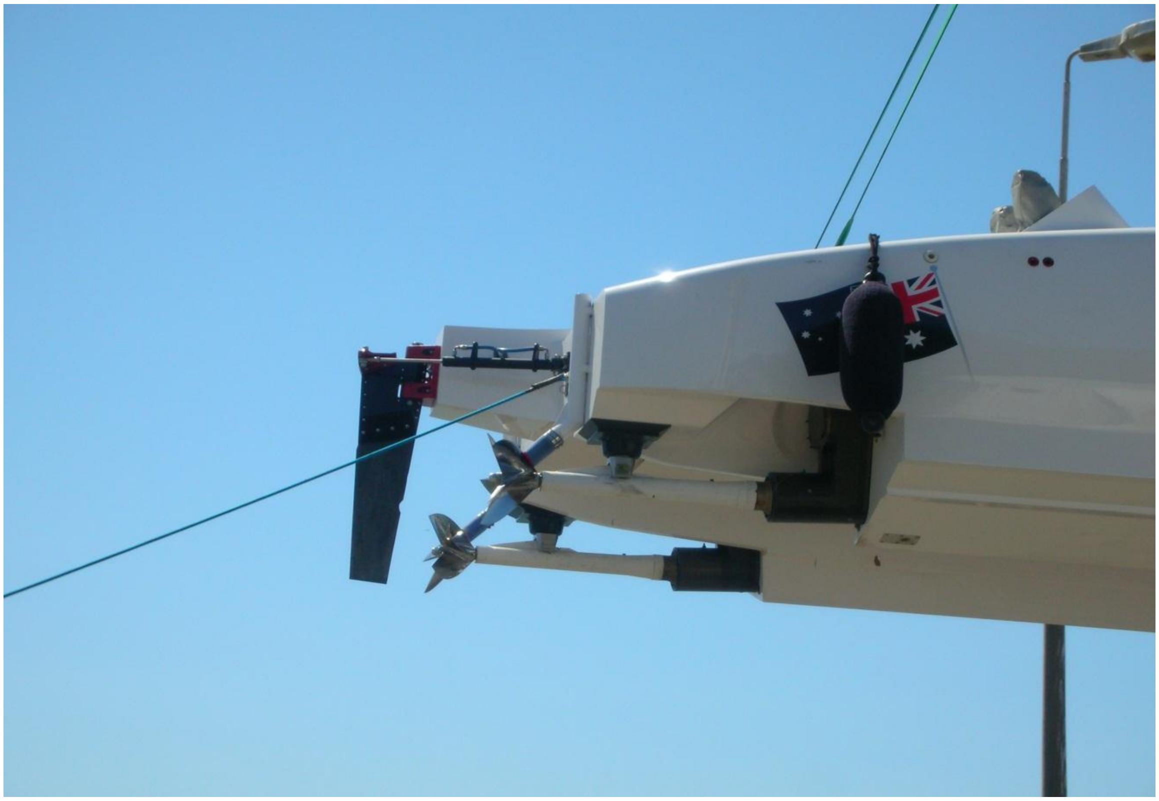


Figure 5: This is a surface-piercing style engine.

Jet drives are used on personal watercraft or on very large vessels. This propulsion system replaces the propellers and pushes the boat through the water through the use of high-pressure water. These jets draw water from the bottom of the boat into an impeller and out of a moveable nozzle that steers the boat. The nozzle can be turned to point in different directions, allowing the boat to be steered easily. This eliminates the need for a rudder.

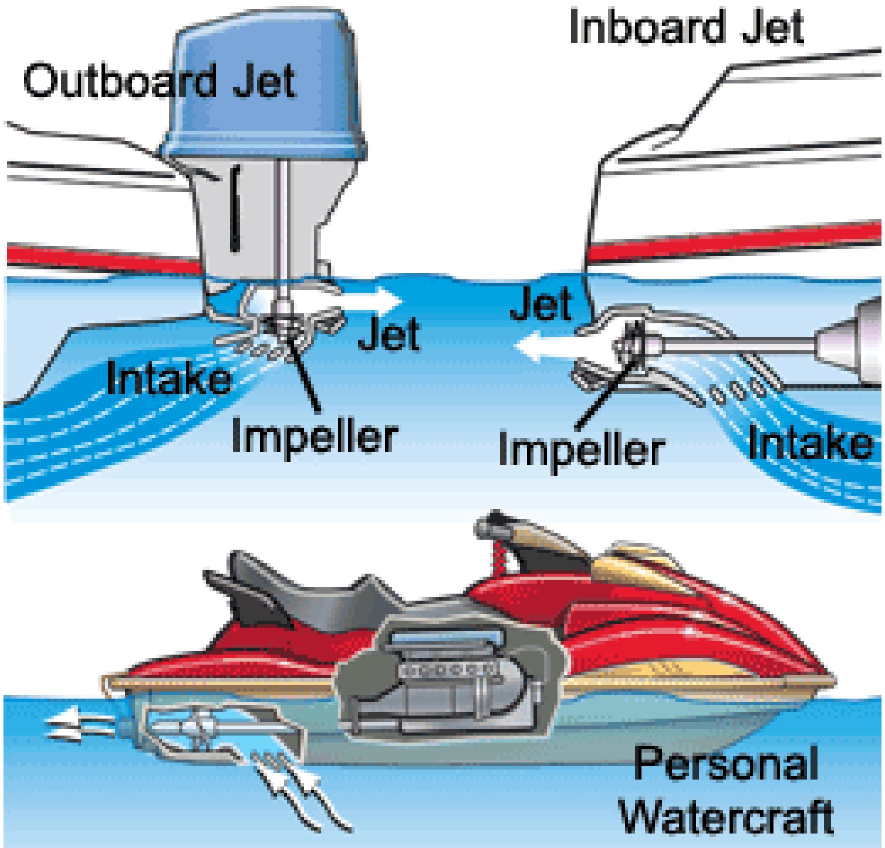


Figure 6: Here is a diagram of a jet-propulsion engine.

The newest and most advanced drive system is the Volvo Penta Inboard Performance System, shown in Figure 7. Some boat enthusiasts have even considered it the best invention in its generation. The system has the propellers set up directly beneath the engines. The propellers in the Volvo Penta Inboard Performance System actually consist of two rotating sets of blades. The two sets rotate in opposite directions, allowing the propellers to cut through the water in a very smooth manner, increasing thrust. Forward facing propellers pull on the water beneath the boat and it has been proven to increase efficiency and speed by 15-20% [9]. The IPS propulsion system has even been able to break through the 40-knot barrier easily with no stutters, which is rather uncommon for propeller units.

Figure 7: The Volvo-Penta Inboard Performance System

There are many different propulsion systems available and all have a variety of practicality based on the scenario in which they need to be used. All the options mentioned could use a variety of motors, fuels, and possibly some sort of hybrid technology. These systems, however, are hull-dependent and depending on the type of hull used, may or may not be effective in practical application.

2.1.2 Monohull vs. Multihull on Vessels

One of the defining aspects of every sea-based vessel in the world is the hull of the ship. The hull determines exactly how the aerodynamics of the ship pan out, affecting factors such as drag, maximum speed, and storage area. Typically in the nautical world, vessels are split into three distinct categories based off of hull design. These categories are monohull, dual-hull catamaran, and tri-hull catamaran (trimaran). Each type of vessel provides different strengths and weaknesses, and all three designs are used for hundreds of thousands of ships across the globe.

The most common type of vessel is the monohull. As seen in Figure 8, monohull ships are standard single-hull vessels that are prevalent in every naval facility in the world. As they only have a single point of balance in the water, monohull ships tend to have a higher draft than either of the other two types of ships. The draft of a ship is measured by the distance below the waterline of the

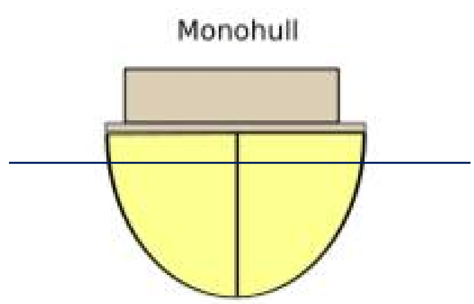


Figure 8: Diagram of a monohull vessel

lowest point of the vessel. Typically, when a ship has a larger draft, it also ends up being slower, due to the increased resistance of the submerged area. Monohull ships tend to sit very deep in the water. This is because there is only one point of contact with the water, forcing the singular hull to have a larger surface area in comparison to the size of the vessel.

Being the only type of vessel with a single point of contact, the monohull has some distinctly different strengths and weaknesses in comparison to the other two types of vessels. Due to the more tubular shape of the monohull in comparison to the two types of catamarans, if a monohull vessel is capsized by any manner, it is generically in a better situation than any catamaran would find itself in. This is because of the very small amount of resistance that a monohull has to lateral motion due to its single hull [8]. Due to this type of motion, monohull ships also tend to be much more efficient at sustaining themselves in extremely inclement weather. This can be seen in Figure 9, in which the USCG 47-foot Motor Lifeboat braves stormy seas that would be untouchable by multihull ships.

Figure 9: The USCG 47-foot Motor Lifeboat

Along with their durability and ability to handle large swells, monohulls also have the advantage of generally containing more passenger space in comparison to a multihull vessel. This is because for a catamaran, there is little to no usage of the space of the ship below the water, while a monohull provides a great deal of open space in its widened single hull.

While monohull ships do have some distinct advantages over catamarans, for many applications, a catamaran will be much more effective than a monohull vessel. For a typical dual-

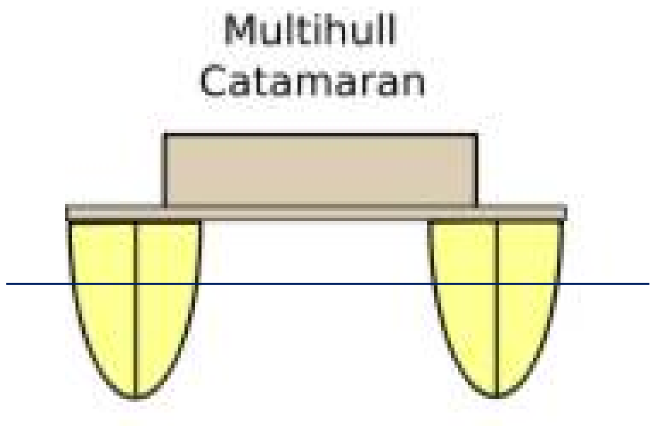


Figure 10: A standard dual-hull catamaran

hull catamaran, there will be much more stability in comparison to a monohull, due to the significantly lowered amount of lateral rocking [18]. A standard dual-hull catamaran provides significantly more balance and stability than a monohull vessel, providing a much smoother ride when the seas are calm. The most significant strength of the multihull vessels in comparison to the monohull vessel, however, is the increase in maximum speed of the vessel. This speed increase is mainly due to the large reduction in draft of a catamaran. Essentially, by adding the second hull to the vessel, you can increase the balance of the ship without using hulls that have a massive surface area under the waterline.

This being said, the stability and speed of the catamarans are extremely useful; however, the catamaran itself does pose some problems as well. Due to the wide base of a catamaran in comparison to its length, if the vessel does in fact capsize, it will be extremely hard to return to an upright position, as shown in Figure 11. Luckily, this wide base also significantly increases the amount of force needed to capsize the ship in the first place. The other major downfall to the catamaran is its

Figure 11: A capsized catamaran is extremely difficult to upright.

inability to handle well in inclement weather. Again being hindered by the wider base, the standard catamaran is very easy to pitch-pole (to capsize by flipping heal over tail) when there are high levels of surf present. This can be easily combated as a weakness by restraining from using catamarans in rough seas.

Similarly to the standard dual-hull catamaran, the tri-hull catamaran is also identified by a multihull base that sits very high in the water. Tri-hulls are the most modernized style of vessel, but again share many of the same issues as the standard catamaran. One of the biggest differences however, is the fact that trimarans are even more difficult to laterally capsize then standard catamarans due to their even wider base, and also provide a greater resistance to pitch-poling, thanks to the center hull having the ability to push through surf if the seas begin

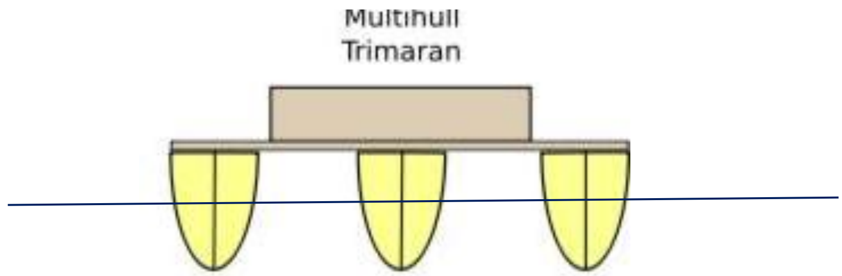


Figure 12: This is an example of a tri-hull catamaran.

to reach a level the extended hulls cannot manage. The tri-hull catamaran has the lowest draft of all three styles of ship, even to the point where the center hull sits completely out of the water. While the trimaran is generally more effective than the standard dual-hull catamarans when it comes to handling rough seas, they still do not compare to the seaworthiness of the monohull vessels in inclement weather. Another aspect of the trimaran that sets it apart from the other styles of vessels is the fact that it has an even lower draft than the standard catamarans. This allows for the center hull to generally sit above the waterline, and as the trimaran increases in size, this trait becomes more and more noticeable. In Figure 13, an INCAT Trimaran shows how low the draft of a tri-hull catamaran is in proportion to its size by easily docking right near the shore without an issue.

Figure 13: An INCAT trimaran

2.1.3 INCAT Multihull Vessel Analysis

Looking further into the multihull-style of ships, one can easily see that the Australian high-speed vessel company INCAT is leading the world in the design of new and innovative ships. The INCAT ferries rule the seas worldwide, providing fast and smooth transportation to places around the globe. The ferries produced by INCAT are generally on the larger size, but still manage to achieve speeds of up to 40 knots, which are essentially unobtainable by any large monohull vessel [4]. INCAT was one of the first companies to use the trimaran design to its fullest

Figure 14: An INCAT ferry

potential. Essentially, their ferries are designed to ride over the water, instead of through the waves, providing an extremely smooth and stable ride for all of the passengers on the ship. Their designs are so successful in fact, that they alone account for almost 40% of total vehicle-passenger high speed ferries over 50 m in length worldwide [7].

These ferries are known as “Wave-Piercing Catamarans”, a type of trimaran designed to provide passengers with the smoothest ride possible, and to provide it at high speeds as well. This is accomplished by extending the side hulls of the ship and having them take the impact of incoming waves, before piercing through it with the monohull-style wide center hull. While these ships will be easily disturbed by rough surf, in anything but the worst of weather, these ferries will provide a much better experience to any passenger as compared to even the most seaworthy monohull. In Figure 15, a close up view of the hull shows how the wave-piercing design works. The extended side hulls remove the force of an incoming wave, and allows the center hull to pass over it with little disturbance.

Figure 15: This close-up view of the hull shows how the wave-piercing design works.

2.2 Distress on Land

2.2.1 Land-Based Emergency Medical Services

In an extremely broad sense of the term, an ambulance is a vehicle used to transport patients from wherever they are injured, to a hospital or some other form of treatment facility.

Figure 16: An example of a standard ground ambulance

Figure 16 shows an example of a standard ground ambulance. There are many warning lights on the outside to alert drivers to its presence. It also has a large patient care area. This area is where the patient is treated and where medical equipment and supplies are stored. Ambulances are equipped with basic medical equipment so that they can stabilize patients until they arrive at the hospital where they can receive proper treatment. With regards to ground ambulances, their primary purpose is to transport the patient to the hospital as quickly and safely as possible from the location where the patient is encountered. They therefore are not equipped to treat many conditions or injuries, only to stabilize them and prevent them from worsening during the trip.

The manufacture of the ambulance typically consists of two stages involving two different vehicular manufacturing companies. The first stage is usually when the main body of the ambulance is constructed, often starting out as a regular commercial vehicle. Ambulances are usually converted from other types of vehicles, so the first stage tends not to involve the construction of any parts unique to ambulances. The second part of the manufacturing process involves the conversion of the vehicle into a full-fledged ambulance. This is when all of the equipment and medical devices are installed into the ambulance and its layout is organized to allow EMTs to treat a patient in the body of the ambulance. This process is analogous to the manufacture of police cars; a car is built with or without the idea of it becoming a police car in mind, such as a Crown Victoria or a Dodge Charger. The general commercial car is then converted into a police car in a separate process in which components of the police car are constructed and installed. By carrying out the process in this manner, it is not necessary to have a specific manufacturing factory for producing only ambulances; it is only necessary to have manufacturing plants that can convert already existing cars into ambulances or police cars.

In addition to all of the medical equipment and materials which must always be stocked on the ground ambulance (see Appendices A and B), an ambulance must be equipped with many other features not directly involved in treatment and stabilization of patients. One of the most important pieces of equipment that falls into this category is a radio. An ambulance must have a method of communicating with those in charge of coordination of the ambulance services. It would be very inefficient if an ambulance had to return to the hospital or the main headquarters where its services are rendered every time that it was done delivering a patient to the hospital. Oftentimes, there are several patients out at once that require ambulances to transport them to the hospital. In these cases, it is much more efficient if the ambulance driver can communicate with the ambulance coordinators so that they can be redirected while en route to a patient. In this manner, much time and fuel can be saved. For certain patients, this time could be critical in determining whether or not they will survive the trip to the hospital. Using the radio, an ambulance driver could also make it known when he or she will not be able to get to a patient in a timely manner, in which case, a different ambulance could be sent instead to make sure that the patient is received as quickly as possible and makes it to the hospital immediately afterwards.

Another important device used on many different types of ground ambulances is an automated lift or ramp. In some cases, it is difficult or unwise to try to lift the patient into the ambulance from the stretcher. This could be due to the weight of the patient or to the circumstances surrounding their injuries. In these cases, it is useful to have an automated lift on the ambulance. The lift can be deployed and lowered to the ground. The patient, on the stretcher, can then be wheeled onto the lift, which is built specifically for these instances and can withstand the weight of very heavy patients. The lift can then be raised until the stretcher on which the patient is lying can be wheeled smoothly into the body of the ambulance. Figure 17 shows an example of the type of lift used by standard ground ambulances. It is usually in an upright position to keep it out of the way. It can then be lowered and raised as needed by the crew of the ambulance.

Figure 17: This is the type of life used by most ground ambulances.

When an ambulance is navigating the streets of a town or city, trying to get to the hospital as quickly and safely as possible, it is very important to have visual and auditory warnings that allow other drivers on the road to know that an ambulance is present and that they should attempt to give the vehicle the room that it needs in order to maneuver safely through traffic. Often times, these warnings include bright flashing lights and loud sirens. The lights are designed in such a manner that they catch the eye of the typical driver on the road, without being so bright as to blind or confuse them. The auditory warnings usually consist of sirens and buzzers unique to ambulances. They are sounds that drivers are accustomed to associating with ambulances. In this way, when the ambulance uses these auditory devices, drivers are instantly aware that there is an ambulance in the area. They can then make the appropriate maneuvers to get out of the way of the ambulance and clear the way for them. Using both auditory and visual warning devices in combination yields the best results; drivers are alerted to the presence of the ambulance without being overpowered by sensory input. This can give the ambulance the room that it needs in order to quickly, safely, and effectively move through traffic in order to transport the patient to the hospital in a timely manner so that more effective treatment can be started.

The staff employed on an ambulance can be very diverse in terms of their qualifications. Some ambulance services employ drivers who are only certified to administer very basic first aid. In these cases, the driver's main function is to obtain accurate information about road closures or weather conditions that could affect the journey of the ambulance from the location where the patient is picked up to the hospital. In these situations, the driver must also be very knowledgeable about the roadways in the area so that he or she can navigate the ambulance to the hospital using an alternate route.

Another key member of the crew of an ambulance is the emergency medical technician, or EMT. The job of the emergency medical technician is to provide very basic treatment in order to help stabilize the patient until they can arrive at the hospital. This may include the administration of simple drugs, defibrillation, controlling of bleeding, or splinting of fractures and broken bones.

With more training than emergency medical technicians, paramedics can treat an even wider variety of conditions. They can administer more specific drugs such as morphine. They can also perform certain basic procedures such as tracheotomies in order to help a patient regain the ability to breathe if their airways are blocked or have closed up due to trauma or an illness. To further compare them to emergency medical technicians, paramedics can actually treat certain conditions and injuries in addition to stabilizing patients during their trip to the hospital, while emergency medical technicians for the most part can only stabilize patients and perform basic first aid. In Figure 18, a crew of paramedics and emergency medical technicians can be seen loading a patient into an ambulance. Typically, an ambulance rides with between 2 and 4 crew members on board at a given time. This number can result from any combination of emergency medical technicians, paramedics, and a driver.

Figure 18: Emergency medical technicians loading a patient into the ambulance

In addition to emergency medical technicians, nurses and even doctors may ride with the ambulances on rare occasions. These occasions are usually when the specific condition of a patient that is being picked up by an ambulance are already known. In these situations, it may be necessary for the patient to receive treatment as soon as possible; they may not have the time to be transported to the hospital before receiving treatment. However, as mentioned, these situations are very rare and, in almost all cases, a patient can be stabilized and transported to the hospital before receiving treatment, and they will not be any worse off for this.

2.2.2 The Layout of the Standard Ground Ambulance

In any ambulance, whether it is a water ambulance or a ground ambulance, there are many different supplies and pieces of medical equipment. Most of these items are required to be on the ambulance at all times. However, an ambulance can only be so big; if there are a lot of supplies and pieces of medical equipment, space cannot be easily added. Instead, optimization of storage space is necessary. By optimizing the amount of space in a ground ambulance or water ambulance that is used for storage of these supplies and pieces of equipment, much more space can be saved. This space can then be devoted to the needs of the patient. This could mean more room for treatment of the patient, or more room for supplies or equipment that could be used to improve patient care.

To get a better understanding of how storage space in an ambulance is used, we spoke with Steven Knapp and Joshua Bernier of the Ambulatory Storage Interactive Qualifying Project group [10]. The goal of their project was to research the current storage methods implemented by EMTs in ground ambulances so that they could improve upon these strategies. In doing so, much valuable space can be freed up for patient care. In some cases, this extra space could be used for the transport of extra medical equipment, extra supplies, or even extra medical personnel when necessary. Since much of the design of the medical area within our final product, the high speed medical catamaran, will parallel typical ground ambulances, any improvements that can be made to ground ambulances will be implemented in our final design. This includes the optimization of the layout of the ground ambulance and the use of better storage practices.

One of the main problems observed by the Ambulatory Storage group when they visited UMass Memorial Hospital was that there were many small creases and cracks where bodily fluids could conglomerate. These spaces, due to their size, are very hard to clean. Part of the goal of the Ambulance Storage group was to reorganize the interior of the ambulance in such a way that many of these cracks and creases could be eliminated.

Another issue was that adequate head room was required. The original ground ambulance was about six feet tall on the inside, providing enough space for most of the EMTs to stand up straight. Any modification to the space in the ambulance would have to leave this height as it was. The main purpose of having enough headroom in the ambulance is to prevent lower back injuries to EMTs. This is a common problem for them since they spend long rides standing up and constantly bending over to administer treatment or even just to pick things up off of the floor. Although it was determined that adequate headroom when standing was an important aspect of any ground ambulance design, it would be even better if the amount of time spent standing by any medical personnel could be reduced in any way possible. This idea was taken into consideration by the Ambulatory Storage group. Their proposed solution to this problem was to install a chair that would be attached to a track on the floor. The chair could move around the patient treatment area so that medical personnel would not have to stand up as often as before. This would prevent injury to the paramedics and Emergency Medical Technicians during transport of a patient. The chair could be locked into place at almost any point in the track to allow for the stable administration of treatment to a patient. This can be seen in Figure 19, which is a SolidWorks model showing how the chair and track will fit into the typical ground ambulance. A paramedic or Emergency Medical Technician sitting in the chair will have access to all parts of the patient's body necessary for treatment. The chair can be locked in place so that treatment can be administered in a stable manner.

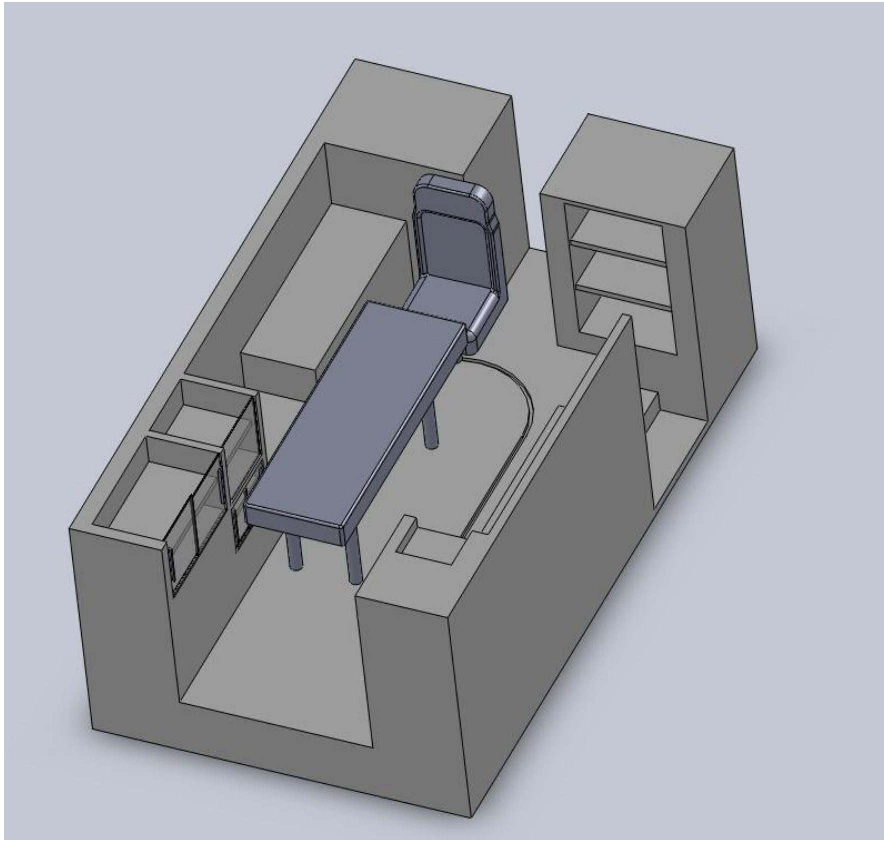


Figure 19: A SolidWorks model showing how the chair and track will fit into the standard ground ambulance, developed by the Ambulatory Storage group

The actual storage of medical supplies was also optimized by the Ambulatory Storage group. According to EMTs at UMass Memorial Hospital, most of the storage cabinets contain only a couple of shelves. Some do not contain any. For this reason, smaller supplies are kept in plastic bins in the ambulance. These bins take up space, however, so the implementation of better shelving methods in the existing storage cabinets was improved by the Ambulance Storage group. Instead of a couple of shelves running horizontally across the insides of the cabinets, a grid-like system of shelving was devised. Figure 20 is is a SolidWorks model of the grid-like shelving devised by the Ambulance Storage group. The division of the storage area into many smaller compartments allows for better organization of all of the smaller medical supplies and materials. The efficiency of the storage will also allow for more materials to be stored.

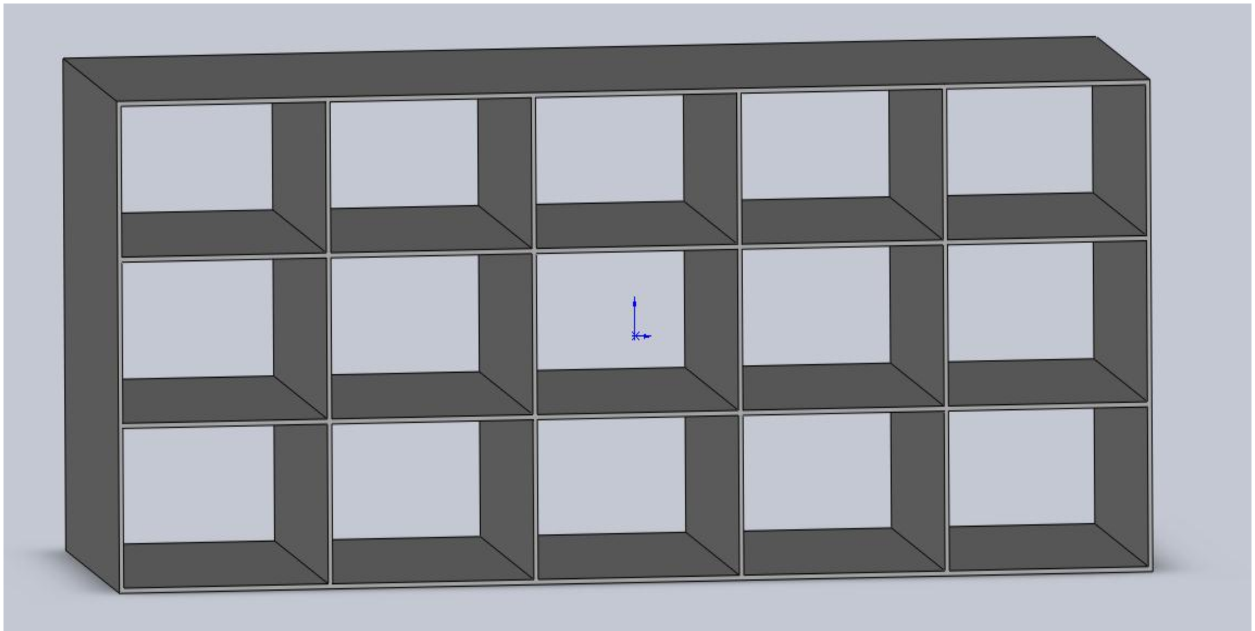


Figure 20: A SolidWorks model of the grid-like shelving developed by the Ambulatory Storage group

As shown in Figure 20, dividing up cabinet space into many more, smaller spaces would allow for better organization and storage of small medical supplies. In this way, the plastic bins previously used to store these medical supplies could be eliminated, which would free up much needed space. Also, better organization of the medical supplies means that EMTs will require less time to find these materials. When treating critical patients, every second that goes by can be crucial. It is very important to be able to stabilize or treat certain conditions as fast as possible.

Finally, another very important goal to keep in mind while optimizing the interior of the ground ambulance is safety for the patient and the medical personnel. One of the more dangerous aspects of the interior of the ambulance, according to EMTs at UMass Memorial Hospital, was that there are many sharp corners within the ambulance. Since an ambulance is usually in motion and can be very bumpy, it is not difficult to imagine a scenario in which a patient or EMT could fall over and get hurt by hitting one of these corners. For this reason, the Ambulatory Storage group also tried to eliminate as many sharp corners as they could while optimizing storage space in the ambulance. One way that they did this was by setting the grid-like shelving into the wall of the ambulance. In this way, the shelves take up even less space, while jutting out less into the ambulance. This greatly reduces the chances of someone getting injured by falling into one of the sharper corners. The elimination of corners also helps with the contamination problem. Contaminants tend to flourish in small sharp corners, since they are tiny and very difficult to clean. By eliminating these corners, the interior of the ambulance can be much easier to clean.

2.2.3 Methods of Dealing with Contamination in EMS Units

In any given day, a typical ground ambulance has many patients. Depending on the nature of the patients' illness or condition, they may be carrying contagious diseases or infectious pathogens. During treatment, it is not uncommon for the bodily fluids of a patient to get onto some of the surfaces within the ambulance. Since multiple patients will be using this same ambulance throughout the day, it is important to have a way of preventing future patients from becoming sick from contaminants left behind by previous patients.

We spoke with members of the Contamination Isolation Engineering Interactive Qualifying Project group in order to gain a better understanding of how these contaminants can be dealt with [3]. Their project goal was to devise an effective way of reducing or eliminating pathogens and contaminants from the surfaces of the interior of a ground ambulance. They researched various ways of accomplishing this difficult goal and gave us access to their research and conclusions. These methods of dealing with contamination included Ultraviolet Germicidal Irradiation, high efficiency air filters, bio-sensors, and various self-cleaning apparatuses. From their research, they concluded that two methods in particular worked the best out of these options. The first was a combination of Ultraviolet Germicidal Irradiation techniques and a high efficiency air filtration system. The problem with this proposed solution was that they were unable to find filtration systems that were designed for ground ambulance.

The second method mentioned was a self-cleaning apparatus. This method was most recommended by the Contamination Isolation Engineering group. They recommended installing a system of atomizing nozzles, shown in Figure 21, throughout the body of the ambulance. These nozzles would be connected to a small pump which would force disinfecting solution through the nozzles. The size of the particles emitted by the nozzle is so small that the particles can penetrate almost every crease and crack in the surfaces inside the ambulance. This method of decontamination should be very successful in elimination contaminants and pathogens that could potentially be transferred from patient to patient or patient to paramedic.

Figure 21: This is an example of the fine spray emitted by the atomizing nozzles.

The atomizing nozzles would produce an extremely fine spray of the solution. This spray would be so fine that it would allow the solution to cover all surfaces within the ambulance and get into small cracks and creases such as between cushions or in small openings on medical equipment. There were some drawbacks to using this system. One was that the system would require access to electricity to run. The other was the amount of time it would take for the ambulance to dry after the disinfecting spray has been used. According to the Contaminant Isolation Engineering group, the estimated cost of implementing this system would be about $1800 for a typical ground ambulance.

2.3 Methods of Distress Response

2.3.1 Aerial Rescue at Sea

Helicopters have revolutionized the way we travel and the way rescue operations take place throughout the world. However, there are some drawbacks to them. These programs can become very expensive and they can be dangerous under certain conditions. These issues can serve as a starting point for comparing aerial rescues at sea to rescues made using watercraft such as ambulance boats and other medical vessels.

The Lancet study used an expert-panel approach to determine the health outcome for patients rescued or transferred by air compared to the potential outcome if a ground ambulance had transferred the patient. It was made clear that doing a study on helicopter versus boat rescues proved to hold entirely too many variables, making it unable to be used as the main source of observations for the study. This helicopter program study was based at the University of Tromso Hospital located in northern Norway. During the study, a panel of anesthetists screened for case-specific data on 370 case-reports of helicopter evacuations from rural areas. The panels used the Delphi technique in order to reach a consensus on how many life-years were gained. One of the panels met specifically for cases of people less than 15 years old and pregnant women, while another discussed cases of older patients. The Lancet study found that 240 of 370 cases were male (which equates to 65%) and the age range of both the males and females was 0-86 years old [12]. The most common diagnoses for all cases included infection and cardiovascular disease while trauma surprisingly accounted for less than a fifth of all cases combined.

The patients arrived an average of 69 minutes earlier to the hospital than if they would have been taken by ground or a combination of ground and sea ambulances, with the range being 0 min to 615 min earlier. This was excluding 53 flights in which a doctor was not present and it was discussed that in general there were almost no health benefits gained for nearly 34% of the patients. When looking at the entire picture of helicopters opposed to ground ambulances they determined 76% of the cases gained no additional health benefits by taking the helicopter over the ground ambulance [13].

After speaking with Petty Officer BM1 Benjamin Molnar of the US Coast guard, we found that specifically in the Boston area, it takes about 60 minutes before the helicopter is even in the air on its way to the area where it would be needed, thus taking away from the speedy response time that one would normally praise [14]. The Lancet results indicated that an air-ambulance with an on-board medical attendant (which is not always available) may provide much greater benefits in terms of life-years. However, these benefits were not evenly distributed. Therefore, they determined that, since the program is so costly and such a high risk service, it should only be reserved for patients who are likely to obtain substantial benefit, such as patients with acute respiratory problems and life-threatening infections. This is backed up by the fact that in some subgroups the data implied that the risk of losing life-years of the crew members in helicopter crashes nearly outweighed the potential life-year gain. This is a large problem and in terms of larger multi-person disasters we run into another issue regarding helicopter practicality.

On October 11, 2009, a newspaper article was published about the frantic battle to save the crew of a yacht wreck, which occurred off the coast of Sydney, Australia. The 29-year veteran rescue helicopter paramedic, Peter Daniel, stated that he had seen nothing like it and the four-man rescue crew was outnumbered 4 to 1. “I’ve never had a sea rescue with this many people,” Mr. Daniel said.

Upon arrival at the yacht “Shockwave”, rescuers were shocked at the pure number of victims that needed to be rescued. The 18-member crew was forced to grab onto rocks to make their way up onto an island and two lost their lives. The yacht had been totally torn apart and other boats and crew raced slowly to assist in the rescue. Three were pulled from the water by rescue boats while the helicopter rescued the other fifteen.

The problem with this situation is that the helicopter took four trips to accomplish this and had to be refueled at one point in the middle of this process. This was completed nearly three hours after the distress call that unfortunately caused the death of two who were rescued but could not be revived. Eight ambulances waited on land, which transported the 15 injured to the local hospital. Luckily all the patients who suffered from hypothermia or minor cuts and abrasions all made a full recovery. This entire scenario leads us to question how useful emergency rescue helicopters can be at sea.

We researched many different types of rescue helicopters. Some of these worth mentioning are the Bell 47 model, the HH-65C Dolphin, and the MBB/Kawasaki BK 117. These helicopters, along with some of their specifications, are shown in Figures 22, 23, and 24.

Figure 22: Bell 47 Helicopter

The Bell 47 models are perhaps the most popular which were used during the Korean War and made famous through the hit TV show “MASH.” They contain standard piston engines which are less powerful and can only propel it at a maximum of 105 mph [5].

Figure 23: HH-65C Dolphin

The HH-65C Dolphin is the standard Chopper for the US Coast Guard. With twin turbine engines it can travel at a speed of around 184mph, which is substantial in comparison to the Bell 47 models.

Figure 24: MBB/Kawasaki BK 117

Lastly and less common among American law enforcement and military would be the MBB/Kawasaki BK 117 with a top speed of 163mph.

Although their top speeds seem high, no helicopter travels at those speeds on a normal basis; it would produce unwanted wear on the engines. Luckily the top speed is usually only 10 percent more than the actual helicopter cruising speed. The top speed is also not the same as the ground speed because there are variables such as head wind and tail wind. The instruments in the helicopters measure the speed at which air is entering the craft, which can affect the actual ground speed. Overall helicopters are significantly faster than boats, but this is not including the time it takes to run system checks and get the craft off of the ground and into the air.

In conclusion, it can be difficult to determine what is more effective when comparing surface transportation to air transportation and many variables must be taken into consideration. Instances such as the Shockwave yacht wreck would have benefitted from a high-speed boat that could have been on scene faster and rescued all of the crew in one trip. Also, while helicopters have a high top speed, this does not accurately reflect how quickly they will be able to perform a rescue. It isn’t truly their ground speed nor does it take into consideration the time it takes for rescues and safety checks on the craft.

2.3.2 The Venice Ambulance Boat

The water ambulances used by the Venetian Emergency Medical Services are equipped with much of the same equipment as the typical land ambulance, including automated respirators, defibrillators, advanced life support devices, and basic drugs. The crew typically consists of seven people. There are two emergency care nurses to stabilize the patients during their trip to the hospital. Two emergency first-level medical care technicians are also onboard. They safely move the patients onto the boat from where they are found. The seventh person is the emergency boat driver. In some cases, when the patient's injuries are potentially fatal, an emergency physician rides on the boat as well.

The boat itself is designed to function efficiently on the canals of the Venetian waterways, which are very smooth waters. It has a single hull and is very small. It is therefore not fit for riding on rough waters in the ocean. It is not designed to hold that many patients at a time. Overall, the Venetian Water Ambulance is much more similar to typical ground ambulances than the medical boats used on the ocean, by the Coast Guard for example.

Figure 25: The Venice Ambulance Boat

2.3.3 The Virgin Islands Ambulance Boat

The newest and most suitable ambulance boat in the world was launched in 2011 to support and serve the entire St. Thomas and St. John District of the US Virgin Islands. It has a top speed of nearly 30 knots and has a catamaran-style hull. It also has the patient capacity for 6 littered patients, several ambulatory patients, and a total of 4 to 8 EMTs [6]. With all of these specifications, there is no other vessel quite like it. It is the Gold Coast GC50A custom-designed composite catamaran ambulance vessel and it truly is state-of-the-art (See Appendix for full details and Schedule A specifications manual.)

Below (in Figure 26) can be seen a preliminary design drawing of the 50 foot long and 20 foot 2 inch wide vessel. The 6 patient beds can easily be seen as well as the cushioned seating for the EMT's and Paramedics. In Figure 27, you can see the ambulance boat's width and understand the stability that the catamaran-style hull would create as opposed to current mono-hull rescue boats.

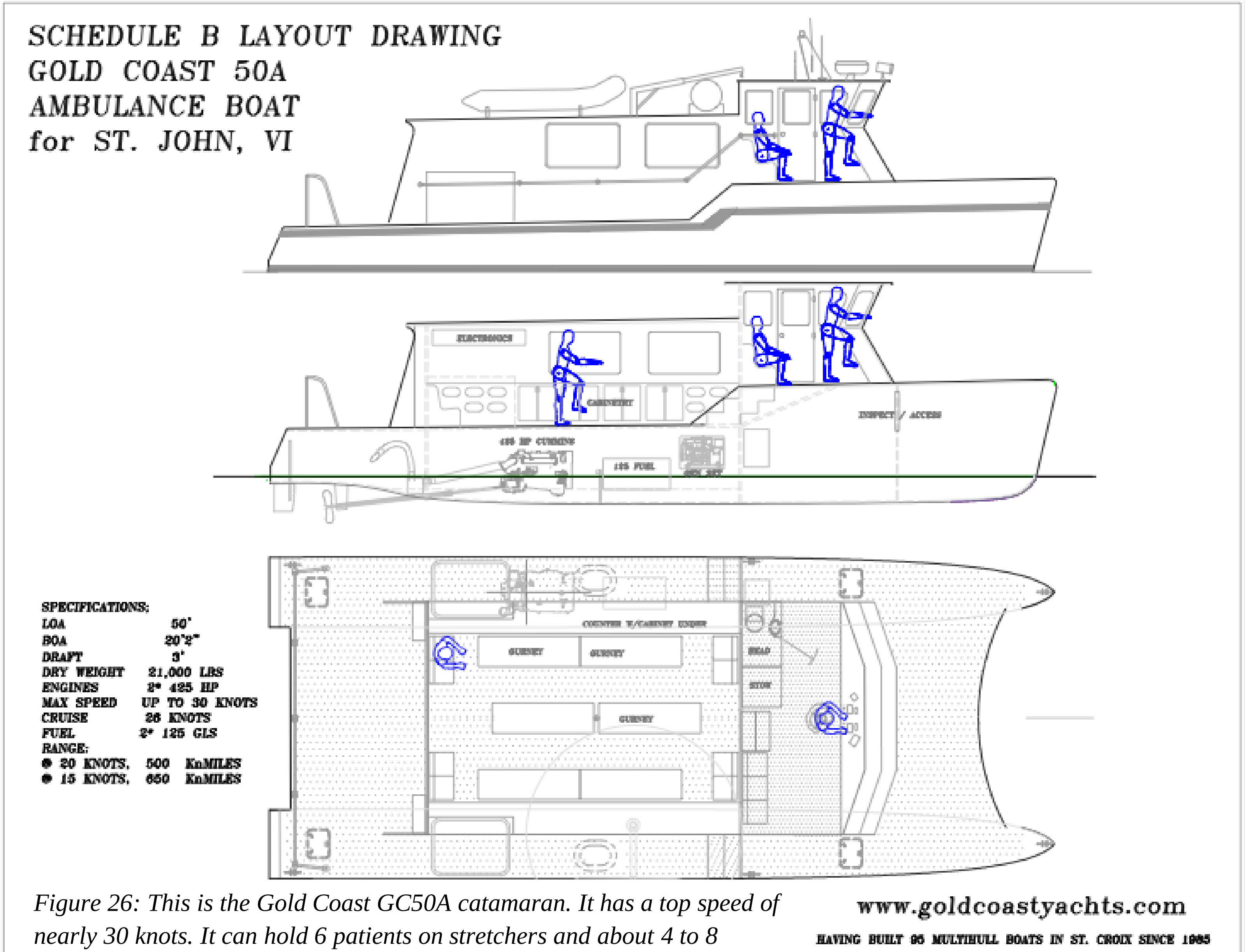


Figure 26: This is the Gold Coast GC50A catamaran. It has a top speed of nearly 30 knots. It can hold 6 patients on stretchers and about 4 to 8 paramedics.

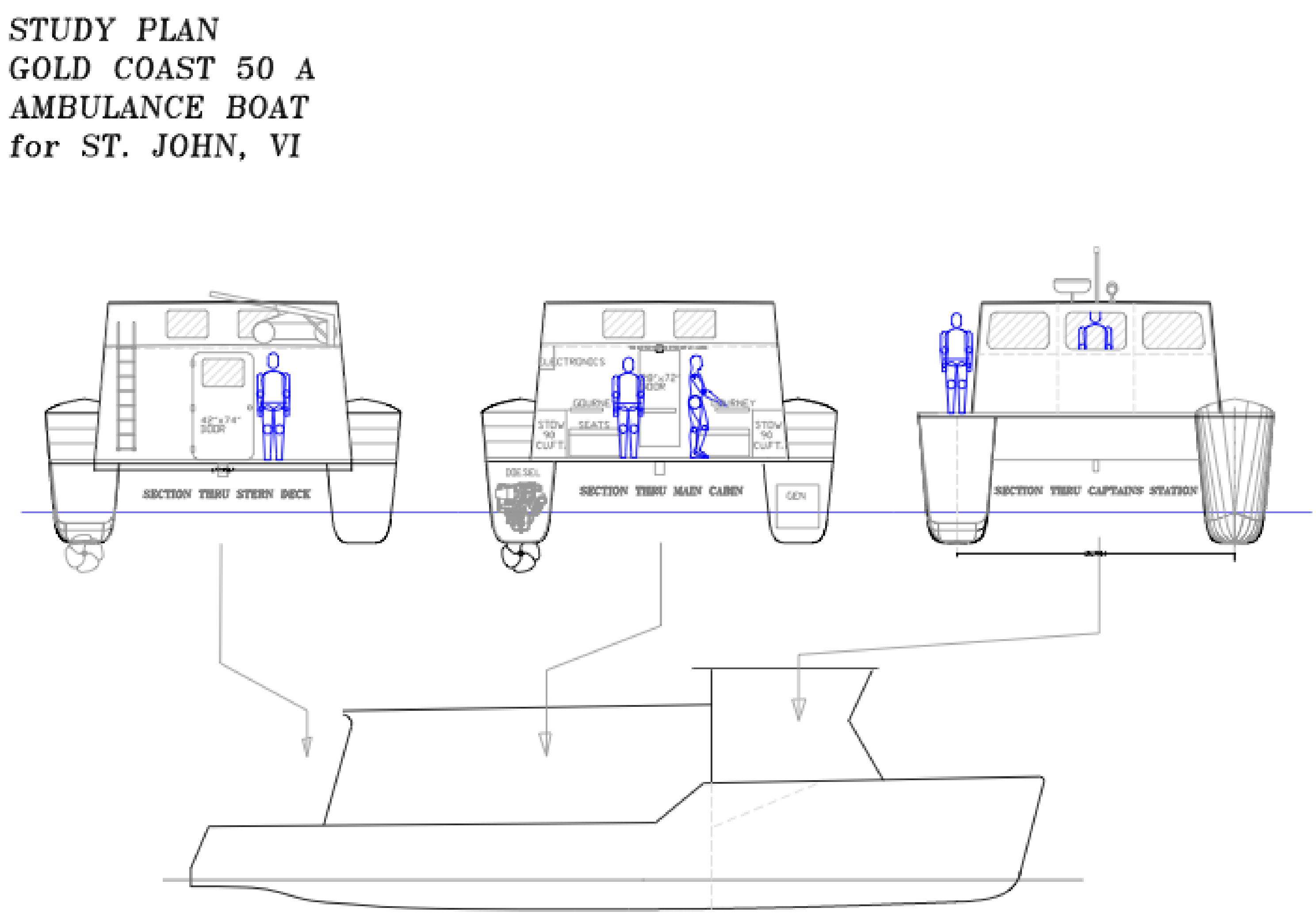


Figure 27: This is a view of the vessel from behind. Due to its catamaran-style hull, the boat is very stable.

The GC50A is equipped with emergency lights, ambulance style markings, and a separated captain's area, much like the modern ground ambulances of today. The entire boat has its own automatic fire extinguishing system as well as sound insulation around the patients' area for a smoother and quieter ride.

Figure 28: The exterior of the GC50A

The open hatch in the rear view pictured below is the access hatch for one of the two 425hp QSB engines that powers the GC50A. The boat also boasts two 125-gallon fuel tanks, a 100-gallon fresh water tank for its two sinks, and a 35-gallon waste tank for its bathroom.

Despite being more of a short range and fast response vessel, the GC50A is loaded with all the modern navigational and remote engine control systems that you would find on today's most advanced vessels.

Figure 29: An alternate view of the GC50A

The patient compartment (Figure 30) is extremely sleek with all the same compartments and ambulatory equipment that one would find in a ground ambulance. This includes oxygen masks, waste and sharps biohazard disposal, litter retention, padded seating for EMT members, and storage for much more. The rear door to the patient compartment is larger than the other doors and slides to the side for the loading and unloading of littered patients.

Figure 30: The patient compartment of the GC50A

Overall there is nothing else on the market today like the GC50A. It has superior patient care and is a sleek well-rounded vessel with speed to match its comfort. With a $787,000 price tag, the vessel is also reasonably priced for the services it can provide. This is the first of its kind and since it is has just entered commission, everyone is anxious to see just how well it performs.

2.3.4 The 47-foot Motor Lifeboat

Currently in the field of medical rescue, the Coast Guard houses a vast majority of the country's dedicated personnel. This branch of the military houses hundreds of thousands of vessels across the country, including hundreds of medical rescue units. While hosting a few varieties of vessels, the leader of the pack in the field is a monohull ship known as the 47-foot Motor Lifeboat. Back in 1991, the vessel was designed to replace the aging 44-foot MLB as the primary inshore and surf and bar rescue craft around the country, and was built with the intention to improve on both the speed and durability of older models.

Figure 31: The 47-foot Motor Lifeboat used by the US Coast Guard

In terms of sea keeping and survival in rough seas, the 47-foot Motor Lifeboat is one of the best vessels available on the market today. Due to the ship's well-engineered design (easily seen in Figure 32), the vessel has the ability to upright itself after completely capsizing in a matter of 10-12 seconds. It is unmatched by many other vessels in the industry, and allows for any rescue venture to continue to completion with few issues or interruptions. This self-righting

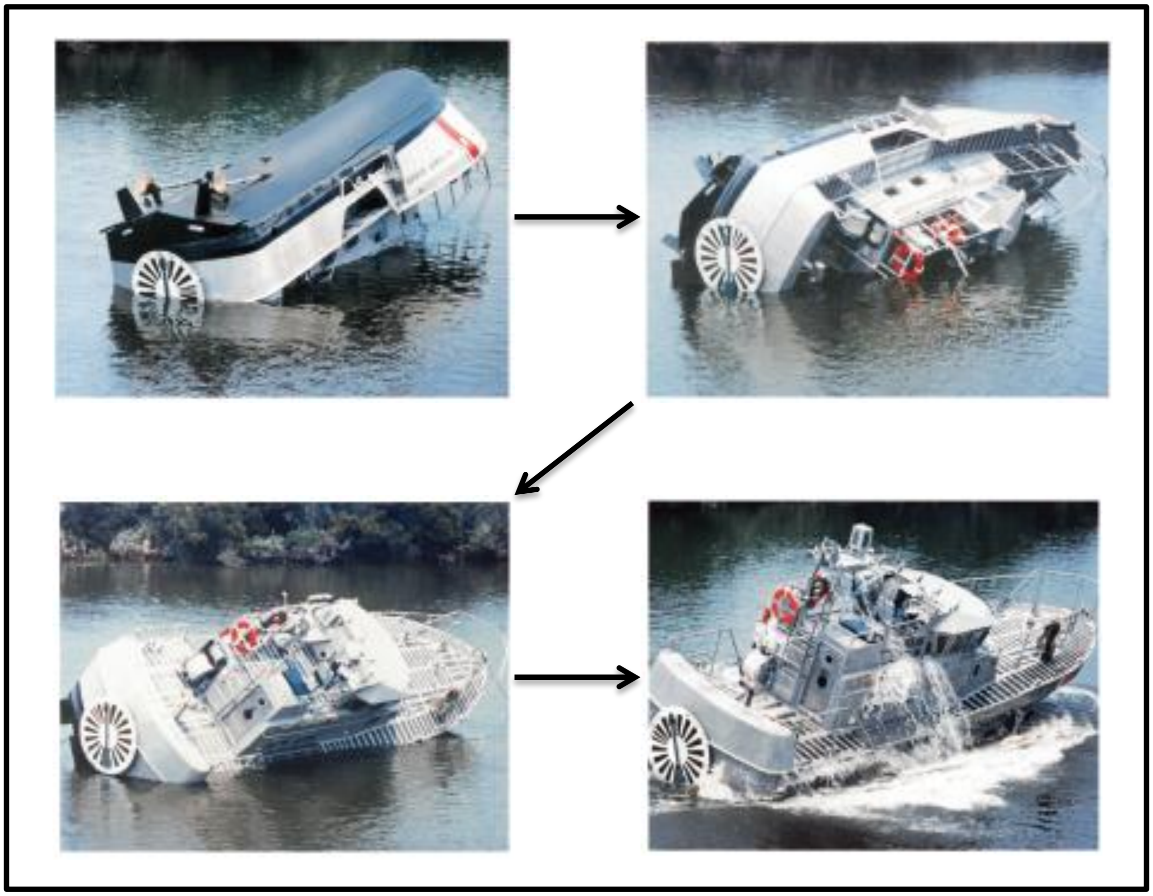


Figure 32: A 47-foot Motor Lifeboat rights itself in about 10 seconds.

process will occur whether the ship has been pitch-poled or rolled over, allowing it to have a very high level of prowess in any type of weather. However, the ship does not only boast this self-righting ability, but the marine grade aluminum hull of the ship allows for a wave-piercing design. Due to the shape of the ship, it can successfully withstand impacts from twenty-foot breaking waves at three times the force of gravity, without needing to worry about capsizing at all [19]. Even if the vessel does find itself in a position where it has capsized, all of the electrical twenty-foot breaking waves at three times the force of gravity, without needing to worry about capsizing at all [19]. Even if the vessel does find itself in a position where it has capsized, all of the electrical equipment of the ship has been built internally in waterproof pockets, allowing it to continue working in all situations.

The specific designs of the ship have been engineered to give it the abilities of extreme durability in the worst of weather (hurricanes, etc.), along with the ability to quickly retrieve imperiled individuals from the nearby water. This ship contains two “rescue wells”, or depressed sections of the main deck, that allow the crew to operate as low as one foot above the adjacent sea level. This allows the crew to have extreme ease in rescuing individuals in distress.

Figure 33: A close up of the vessel’s “Rescue Well”.

Figure 34: The engineered multi-bridge system of the 47-foot MLB

Along with the deck depressions, the deck is also ridden with safety harness equipment. This allows for any crew member intending on rescuing distressed individuals to be safely fastened to the ship. Using the same harness mechanisms, the lower watertight cabin also provides safety lines for rescued victims. This is to protect both the rescued individuals and the crew from being thrown around the ship during inclement weather. Another factor that greatly aids in the ship's efficiency is the multi-bridge system it contains. The open upper bridge "allows for superior

Figure 35: The closed bridge of the ship provides full protection, while the open bridge provides a 360 degree view.

visibility to negotiate obstacles" [21], along with granting the ability to more precisely maneuver in order to rescue those in distress. The lower watertight bridge is equipped with full windshield wipers and window heaters, and is designed to protect the crewmates from the harsh weather conditions, and provide additional protection in the chance of the ship capsizing during the mission.

Figure 36: The medical supplies provided to the crew of a 47-foot MLB.

While many successful aspects of the ship have been designed to provide ease in the retrieval of distressed individuals from the water, once the victims are pulled inside of the ship, there are several issues that arise. The ship is also only stocked with a single stretcher, so in instances where multiple persons are rescued and unconscious, problems appear quickly. Another major issue with the 47-foot Motor Lifeboat is the extreme lack of medical supplies provided with the vessel. Since a majority of the vessels are simply stocked with life vests and a first aid kit, if any major injury has been sustained at sea, treatment for the ailing person(s) will be extremely limited until the vessel safely arrives on land. While the standard Coast Guard procedure is very effective in having a medical ambulance ready to go as soon as the vessel docks, if the patient could be stabilized en route to the ground ambulance, there would be a much higher rate of survival in vessel-based accidents.

Another thing holding back the 47-foot Motor Lifeboat is the extremely small overall size of the vessel. While the small size allows it to be manned by a mere 4 people (Cocksman, Engineer, and 2 Crewmen), it also inhibits the ship from taking on more than 6 distressed victims [14]. This being said, if 2-3 of those victims are unconscious, the space will be limited even further. Due to the small size of the ship, it becomes very difficult to maneuver unconscious individuals to the inside of the vessel. The difficulty in maneuvering is generically caused by the sharp angles of the ship between the rescue well and the stairwell into the inner area (where the medical supplies are located). The inner chamber of the ship is also extremely limited in space. It is actually limited to the point where it is difficult to find an area large enough for a single individual to be placed on their back. This oftentimes results in the already distressed individual being further exposed to the elements outside on the lifeboat's main deck, and if there are multiple unconscious victims, there is no other option.

Figure 37: The 47-foot Motor Lifeboat has very limited options due to its small size. (Also to be noted, you can easily see the sharp angles that one would need to overcome in order to move a patient to the inner chamber if the ship.)

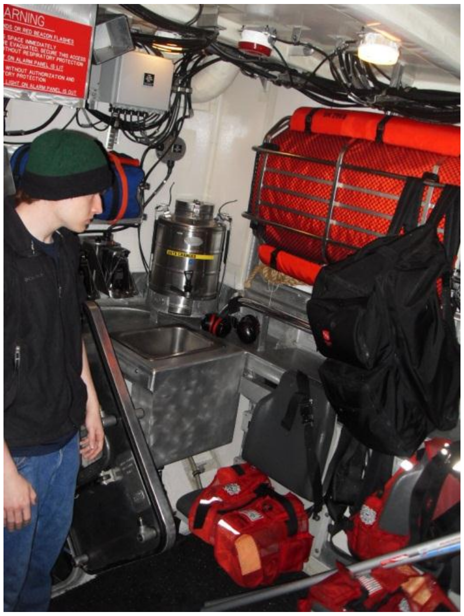


Figure 38: The inner chamber of the 47-foot MLB provides protection from the elements, but only to the few that can fit inside.

Moving at a sustained speed of 23 knots, the 47-foot Motor Lifeboat is rather quick in comparison to other vessels of its type. However, in comparison to other vessels on the market that are not built to withstand the harshest of conditions, the unit is sluggish. Along with the issue that the vessel can only hold 6 victims at most, there is much that can be improved with respect to the vessel's efficiency in ideal weather conditions.

2.3.5 Other USCG Vessels

Not limiting the Coast Guard to specifically the 47-foot Motor Lifeboat, it can be seen that there are a wide array of units available to this branch of the military. Ranging from 20-feet to over 400, the Coast Guard has hundreds of vessels built into the fleet, all with different uses and strengths. Other than the 47-foot Motor Lifeboat, there are two other vessels typically used in a quick response situation.

On a larger scale in comparison to the 47-foot Motor lifeboat, the USCG has a 110-foot cutter, known as the 110-foot Island Class Patrol Boat. This cutter is often used for search and rescue, as it is very sturdy, and has a long out-of-port lifespan. Unlike the 47-foor motor

Figure 39: This 110-foot patrol boat, departing from its homeport

lifeboat however, the 110-foot patrol boat was not designed for the sole purpose of responding to emergency calls. These cutters are very often used to combat illegal drug trafficking, which they are extremely proficient at due to their ability to remain out of port for a long period of time [21]. Generally, if an incident happens rather far out to sea, the 110-foot cutters will be chosen for the rescue mission over the 47-foot Motor Lifeboats, as they are slightly faster (29 knots), and are certified for deeper waters and longer trips.

Stepping up from the 110-foot cutters, the Coast Guard also has 270-foot Medium Endurance Cutters to patrol the water even unreachable by the 110-foot patrol boats. These ships are very large in size, and are generally only deployed for deep ocean patrols and extremely

Figure 40: The large 270-foot Medium Endurance Cutter

large scale missions. When looking at standard search and rescue calls, these ships tend to be a little on the larger side. Another drawback to these vessels, is the fact they can only travel at about 20 knots, making them the slowest of the response vessels [15].

In the opposite direction, stepping down in size from the 47-foot Motor Lifeboat, the USCG also has hundreds of smaller, 25-foot Defender Class boats. These little boats sacrifice size and longevity at sea for a very high operating speed. Moving at over 40 knots at max speed, these little vessels can get to their destination extremely quickly. However, due to the small size, only 2-3 individuals outside of the crew can be squeezed into the already crammed vessel [16].

These ships are usually used by the Coast Guard for functions such as beach and shoreline patrol, as well as accidents near shore that need a rapid response.

Figure 41: The 25-foot Defender Class Vessel

2.3.6 The USNS Comfort

Currently in the world, the Goliath of medical rescue vessels is a member of the U.S. Naval Forces, and is known by the name of the “USNS Comfort”. The ship itself is one of the largest vessels actively used, and is easily recognized as nothing short of a “floating hospital”.

Figure 42: The USNS Comfort, one of the largest vessels in the world

The vessel itself is over 70,000 tons, making it larger than even the Navy’s largest battleships. It also is just 100 feet shot of the standard length for the U.S. military aircraft carriers [17]. The vessel itself is painted pure white with scattered red crosses, a worldwide representation of medical care. This, along with the vessels sheer size, allows it to be used for its ideal purpose: the quintessential floating hospital.

The vessel itself can house over 1000 patients [2], and the ship itself is stocked with what it needs to handle a full capacity of individuals. With over 75 ICU beds fully equipped with everything a doctor needs to stabilize a patient, the USNS Comfort is equivalent to a U.S. Military tertiary care facility [1]. This level of care can easily be noted by many aspects of the ship that provide extreme efficiency with respect to medical care. Features of the ship such as the helicopter pad provide the needed transportation for emergency supplies and deathly critical patients.

Looking past the medical equipment provided by the vessel, the real gem of the unit is the care that can be provided by the personnel on board. The USNS comfort has nearly every medical specialist in its ranks, which allows the care facility to provide extremely efficient levels of treatment in nearly every situation [2]. Due to the medical staff the vessel boasts, the surgeons and doctors can perform nearly every procedure possible in the ICU/surgery beds, with the exception of organ transplants and open-heart surgery. Working alongside these medical professionals are the 480+ members [11] of the U.S. Navy who, along with aiding in the functionality of the vessel, provide massive manpower and assistance when it comes to managing the hundreds of patients that can quickly board the Comfort in a state of emergency.

Medical Staff	Surgical Specialties	Pediatrics	Miscellaneous
General internal medicine: 2	General: 2	General: 4	Anesthesia: 11
Cardiology: 1	Otolaryngology: 1	Cardiology: 1	Certified registered nurse anesthetist: 13
Critical care: 3	Neurosurgery: 2	Critical care: 2	General medicine: 2
Gastroenterology: 1	Obstetrics/gynecology: 2	Developmental: 1	Dentistry: 3
Infectious disease: 1	Oral/maxillofacial: 1	Endocrine: 1	Dermatology: 1
Nephrology: 2	Ophthalmology: 2	Emergency medicine: 1	Emergency medicine: 2
Neurology: 1	Orthopedic: 12	Infectious disease: 1	Family practice: 4
	Pediatric: 1	Neurology: 1	Nursing: 165 Medical/surgical, ED, ICU, postanesthesia care unit, pediatrics, PICU/NICU, wound care
	Plastics: 1	Advance practice nursing: 3	Optometry: 2
	Urology: 2		Psychiatry: 1
	Vascular: 1		Psychology: 1
	Wound care: 1		Social work: 2

Table 1: The table above shows the specialties of the personnel aboard the USNS comfort during Operation Unified Response. With such a large array of doctors to lean on, it is not much of a surprise that the vessel and its crew are considered to be as effective of a medical facility as a U.S. tertiary care facility.

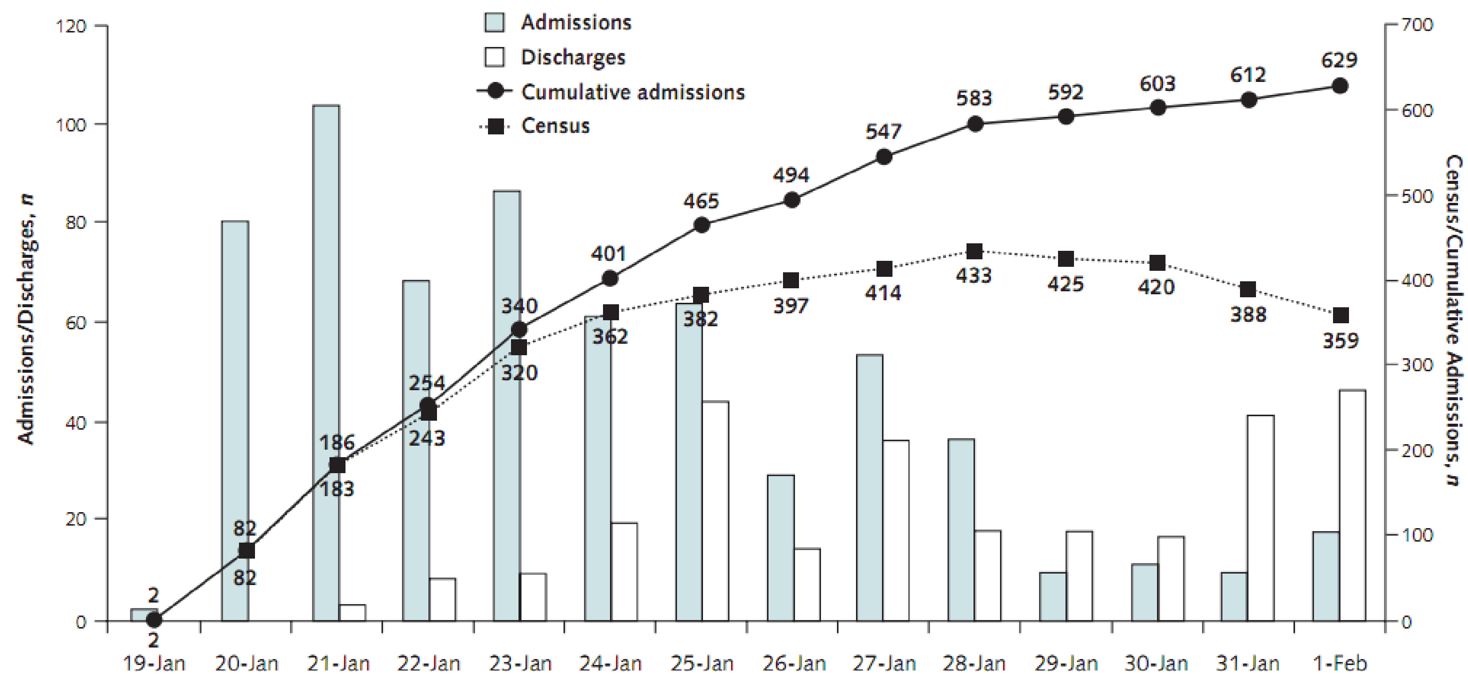
Over the vessel’s lifetime, it has been sent on many missions around the world. One of which, Operation Unified Response, was a response mission given on January 12, 2010 intended to provide support to the country of Haiti after the earthquake-related disaster. The ship was directed to remain in Haiti for roughly two weeks, and in that time treated nearly 700 patients.

Figure 43: The top of the line equipment in the 75+ ICU units of the USNS Comfort

The conditions of many of the patients were extreme, as the country of Haiti has a very weak medical system. Infections were extremely common because of the outside environment, and strain was quickly put on the blood bank of the Comfort. Diseases such as HIV were a constant

Figure 44: The USNS Comfort is large enough to support a full-scale landing pad on its main deck.

threat, and multidrug resistant bacteria sprouted up extremely quickly [1]. However, despite the many troubles that quickly arose, the well-trained crew and the top of the line materials provided to them were able to handle the issues. In the end the Comfort and its crew were able to provide this top of the line care to a group of distressed people that otherwise would have received little to none.



	19-Jan	20-Jan	21-Jan	22-Jan	23-Jan	24-Jan	25-Jan	26-Jan	27-Jan	28-Jan	29-Jan	30-Jan	31-Jan	1-Feb
Admissions	2	80	104	68	86	61	64	29	53	36	9	11	9	17
Discharges	0	0	3	8	9	19	44	14	36	17	17	16	41	46
Census	2	82	183	243	320	362	382	397	414	433	425	420	388	359
Cumulative	2	82	186	254	340	401	465	494	547	583	592	603	612	629

Figure 45: The graph above shows the effect of the USNS Comfort over its first 14 days station in Haiti for Operation Unified Response. In the first 14 days alone, the crew of the vessel managed to treat nearly 700 registered patients. Remembering that some of the crew ended up stationed there for over 6 months shows the true depth of the United States endeavor to assist in the disaster response.

Other than the response mission to the disaster in Haiti, the USNS comfort has proven that it is truly a part of a “Global Force for Good”, through its Continued Promise missions carried out over the last 6 years. From 2007 to 2009 the USNS Comfort has managed to treat over 200,000 people in over 14 countries. Continuing to push forward, the USNS Comfort departed from Baltimore, Maryland on March 18th 2011 toward its “Continued Promise 2011”. The vessel will be heading to countries in Central and South America, and the Caribbean in order to carry out its work.

The Comfort is the prime example of what can be accomplished when top of the line equipment and well-trained operators are combined with a state of the art vessel. Using the vessel’s ability to traverse the waterways and be uncongested by land-based limitations, a great deal can be achieved.

Figure 46: The USNS Comfort docked at home in Baltimore, Maryland.

2.4 Watercraft and Equipment Requirements

2.4.1 The Standards of a Sea-Based EMS Unit

The following is a list of requirements that must be met in order for a watercraft to be considered a water ambulance. This list is specifically from the North Carolina Administrative Code, but these are the same general specifications that are required by most areas of the United States. This list of regulations and requirements can be found in Appendix E.

1. The watercraft shall have a patient care area.

The area of the water ambulance where the patient will reside must be designed or organized in such a way that adequate access to the head is available. EMTs must also be able to access the torso and lower extremities of the patient. This area must also provide sufficient working space in order for EMTs to be able to properly administer the necessary course of treatment to the patient.

This area must be covered so as to protect the patient and the EMTs from the elements. In other words, this area must either be indoors or have a covering that will keep the patient and EMTs dry and warm in inclement weather conditions. If this is not the case, the patient's condition could worsen, or it could simply make treatment of the patient too difficult to properly administer. This covering must be sturdy enough so that patient and EMTs will be protected until they can arrive on shore or at a hospital boat, where the patient will receive full treatment.

The opening of this area must be able to permit the safe loading and unloading of patients. The opening must be large enough to accommodate a stretcher. Obviously, it must be possible to get the patient into and out of the area in which they will be stabilized and possibly treated. The opening must also be in a reasonable location. For example, having a long, steep set of stairs leading from the opening to the basic treatment area will make it difficult for a patient to be loaded and unloaded by the EMTs. This sort of inefficient design should be avoided.

2. The watercraft must have all of the necessary supplies onboard that may be necessary for the treatment of the patient.

Just as in a traditional ground ambulance, there are many devices and many pieces of equipment that must be kept on board in order to stabilize and sometimes treat patients. These include first aid kits, bandages, splints, stretchers, gauze, adhesive tape, oxygen tanks and masks, etc. For a complete list, see Appendices A and B. It is very important to make sure that these materials are always restocked whenever the boat returns to shore. If the EMTs run out of any of these materials, it could prove fatal for a patient brought onboard the boat depending on their conditions and circumstances surrounding their injuries. It is also very important to run scheduled tests on all of the equipment to make sure that it is in working order at all times. If a patient is brought onboard and some of the necessary equipment is not in good working order, it could be devastating for the patient.

Depending on the area in which these water ambulances are intended to be used, some regulations may differ slightly. For example, antidote kits contained on board will contain antidotes to different poisons depending on the region in which the boat is being used. It is important to make sure that the construction of the water ambulance complies with all of the specific regulations in place in the area in which the boat is intended to be used.

3. The name of the EMS provider to whom the ambulance belongs must be printed on the side of the water ambulance.

It is very important that an ambulance be identifiable based on the company running the service. If something happens to the water ambulance while it is out at sea, boats passing by can radio the shore and identify the company in charge of that boat. This company can then be contacted and can determine which boat is in the area and try to contact them. They can also arrange for rescue operations if needed.

If for some reason, it is necessary for another boat, such as a Coast Guard boat or a Police boat to locate one of these water ambulance boats, it can be very helpful to know what the name of the ambulance service responsible for the boat is named. This can make it much easier for the boat to be located.

4. Water ambulances must have a 360 degree warning beacon.

In order for any boat to be allowed in the water, it must have warning lights that will allow for it to be seen at night or during inclement weather. Different regions have different regulations for what lights are and are not allowed on a water craft. In addition to these standard lights required for all boats, water ambulances in particular must also have a 360 degree warning beacon. The purpose of this warning beacon, aside from making the boat more visible in poor weather conditions or at night, is to help identify the vessel as a water ambulance. Just as when a person driving a car and observes the lights of a standard ground ambulance, boats who observe this warning beacon will know to stay clear of the ambulance and make sure to give it room to maneuver. It is also helpful because it can alert other emergency boats in the area, such as police boats, that there is an emergency.

5. Water ambulances must carry the following equipment.

In addition to the materials listed in Appendices A and B, there are several other pieces of equipment and tools that water ambulances must carry on board at all times. These include floatable and rigid long backboards for securing patients and stabilizing them, a floatable litter (stretcher), a fire extinguisher, a lighted compass, radio navigational aids, a marine radio, and a pediatric restraint device.

In cases where a patient has an injury to their back, neck, or head, it is important to be able to stabilize them in such a way that their movements are restricted and they cannot compound their injuries further. A rigid backboard is usually what is used in these situations. The backboard is a sturdy surface to which the patient is strapped. This prevents the sections of their spine that are injured from moving freely before they can be treated or set properly. In case of an accident, it is important that these backboards be able to float in the water. Otherwise, if a patient is strapped to one and slides overboard, they could sink and drown very easily.

A floatable litter is necessary for transporting patients to and from the water ambulance. The litter is similar to the rigid backboard, except that the backboard has extra straps for making the patient much more secure. However, these extra straps are only necessary when the patient has an injury to their back, neck, or head. In most cases the floatable litter would be used. The litter is similar to a typical stretcher in an ambulance or hospital.

A pediatric restraint device must also be carried on board the water ambulance. The pediatric restraint device is used to safely transport young children that weigh less than 40 pounds. Children this small cannot be adequately secured to typical adult-sized litters or backboards. For this reason, it is important to have an appropriately sized restraint device that will fit them. This device must also be able to float in the water.

In rare cases, there may be a fire on board the water ambulance. Although this is a very uncommon occurrence, it is nevertheless important to be prepared for it and to have a fire extinguisher on board the water ambulance at all times. A fire extinguisher can keep a small fire from growing too big and engulfing the boat.

Navigational devices are very important, especially in a water ambulance. In a typical ground ambulance, street signs and familiar landmarks can be used to easily navigate between the hospital and the location of the patient. If the drive of the ambulance is familiar with the area, as he or she most likely is, it can make navigation even easier. Out on the sea, however, it is not uncommon to only observe water and the sky in all directions. For these reasons, it is very important to have working navigational devices. A lighted compass is necessary for operators of a water ambulance to determine what direction they are facing and heading towards.

A compass, however, will not always be able to help them navigate to a specific location along the coast. In these situations, it is important to have some sort of satellite GPS installed on the boat. A global positioning system can tell the operator of the water ambulance where they are within a small margin of error, and can tell them the relative locations of any places where they need to be. For example, GPS can be used to help a water ambulance find a specific drop off point along the shore where a patient is supposed to be transported from the water ambulance to a ground ambulance that will take the patient to a hospital.

Navigational radar is also very important for a water craft of any kind to have. It allows boats to know if there are any other boats in the nearby area. This is important, especially at night or in low visibility weather, as these conditions can make it hard to spot other boats. This can lead to accidents at sea. Since a water ambulance is used when there are injuries and accidents at sea, it is especially bad if a water ambulance itself is involved in an accident, as there is now one less ambulance at sea.

A marine radio must also be on the water ambulance. This radio is how members of the crew on the water ambulance can communicate with the shore. There are many situations in which a water ambulance that is already out at sea must be redirected to the site of an accident or the location of a patient that must be brought in from the sea. It would be very inefficient for the water ambulance to have to return to shore every time it is sent out, only to get sent out immediately after returning. This would also be a waste of fuel, which would be a waste of money that could be better spent on medical equipment or supplies. In emergencies, the radio can also be used by the water ambulance to contact the shore to let them know of the circumstances surrounding their predicament. In some situations, the radio could even be used to alert other emergency water craft, such as police boats, that their services will be required at a specific location.

6. The water ambulance shall not have any functional or structural defects that could adversely affect the patient or the EMTs on board the water ambulance, or that could inhibit the administration of necessary treatment and procedures to the patient.

The water ambulance must be in near perfect condition whenever it is sent out to sea to attempt the rescue of a patient. Aside from restocking any missing materials or pieces of equipment, this means that the ship itself must be in good working order. All instruments must be tested regularly to make sure that they function efficiently. The structural integrity of the ship must be assessed as well. If there is ever any damage to any part of the boat, it must be repaired in a timely and efficient manner. According to Petty Officer BM1 Benjamin Molnar, they have a main boat used for distress calls and a secondary boat. While the main boat is being used, the secondary boat is maintained and repaired. If the main boat ever needs repairs, it is brought in to dock and the secondary boat is then used as the main boat. In this way, there is always at least one boat that is in perfect working condition. The USCG station at Merrimack River is a small area and only has a few boats. As such, for larger Coast Guard areas, there are always enough boats in near perfect condition to have out at sea and a single boat getting damaged and needing repairs is not a big problem.

7. Water ambulances shall have a copy of the Emergency Medical Services patient care treatment protocols.

Every water ambulance out at sea must have a copy of the EMS treatment protocols on board at all times. It is very important that EMTs be able to treat a wide variety of conditions and injuries that could be sustained by a patient. It can be difficult, however, to remember all of this information and to memorize exactly when to apply it. While perfect memorization of these guidelines would be ideal, it is always important to have a copy of the proper protocols and procedures that must be followed for specific illnesses and injuries on the boat. This can be used as a reference to verify that proper treatment is being administered to the patient by the EMTs on board the water ambulance.

2.4.2 Distress Calls at Sea

In order for any water ambulance to be able to be of assistance out in the water where it is needed, there must be a way for alerting this water ambulance that their services are required in the first place. This communication between the ambulance boat and those who require its services must be quick and efficient. One method used to achieve this is to have a radio communications system. A radio communications system allows for near instant communication between both parties and functions similarly to phone call; a call over the radio can go directly to the radio of the party intended or can be redirected from other sources if the people at the location where the ambulance is needed do not know how to directly contact the ambulance service.

After speaking with Petty Officer BM1 Benjamin Molnar, we learned that these are usually the two methods by which the Coast Guard is contacted when they are needed to pick up injured or sick patients out at sea. They are usually either contacted directly by the injured parties, or people passing by who observe the injured parties contact the police or any other major service on land in the area who can then redirect their call to the Coast Guard, or who can simply relay the location of the patient to the Coast Guard. Inside the main building for the Coast Guard is a radio control room, where incoming calls and signals are received. Since the medical boat is usually already out at sea in order to speed up the rescue process, the members of the Coast Guard who work in this room can then contact those who are on the rescue boat. Once the people on the rescue boat have received the call, they can then travel to where the patient is and rescue them. If they cannot make it in time, they can use their radio to contact any other medical boats in the area and alert them, or they can make those in the radio control room aware of their situation, in which case the members of the Coast Guard working there can contact a different boat.

Figure 47: The radio control room in the 47-foot Motor Lifeboat.

CHAPTER 3: THE FIRST RESPONSE MEDICAL CATAMARAN

There are many reasons why people might require rescue at sea. Of these numerous possibilities, there are three major categories of situations in which rescue by medical personnel would be required. The first possibility is that there may be an accident on board a ship that results in injuries to one or more crew members. An example of this would be if a piece of heavy machinery were to malfunction and hurt a crew member. The second is that a crew member may simply fall ill due to events that are not directly related to being at sea or on an aquatic vessel, for example, if a member of the crew on board a ship had a heart attack. The final situation is easily the most notorious, as if a ship is ever to gain a breach in the hull due to striking an object under the waterline, or simply due to bad engineering, it can begin to sink, causing the crew and passengers to abandon ship. This can easily put individuals into the cold ocean water, where hypothermia and other serious issues can arise. Regardless of how someone on a boat out at sea became injured, medical services will be required in order to attempt to restore the patient's good health.

Currently, the way this is done in most of the world, is that a relatively small rescue vessel is sent out from the coast, or is already at sea and is redirected to the location of the patient. However, the main purpose of these boats is usually of the "search and rescue" type; most of them are not as well-equipped to administer treatment as a typical ambulance on land would be. Most are mainly designed to be quick to rescue the patient and bring them to the shore, where they can be transferred to a ground ambulance which will bring them to the main hospital.

In some cases, they are even transported to larger vessels that are essentially massive ships designed to function as “floating hospitals”.

In places such as Venice and the Virgin Islands, there are boats that function as water ambulances; they have most of the same medical equipment and tools on board that a ground ambulance would have. However, these boats are not designed for speed. This is especially true of the Venetian water ambulance. It is very small and is only designed to navigate the canals of Venice. It is not made to handle the rough water of the open seas. It is efficient for the job for which it is required, but, similar to the rescue boats mentioned above, it is not a high-speed ambulance. In order to design such a thing, a combination of the two forms of aquatic rescue and treatment are required.

Our team has created a high speed medical catamaran. Using the research we have gathered on the various types of medical rescue boats currently being employed throughout the world, and on the specifications required for these vessels, we have designed a catamaran that is a balance of speed and medical treatment. It is fast like the boats used by the Coast Guard for rescues at sea (faster in fact), and it has the medical equipment, tools, and resources necessary to treat a patient with the level of care that they would receive in a ground ambulance. Since the catamaran hull design means that it is a multi-hulled boat, the vessel should move very smoothly over the water. This is important because it will make for a much more comfortable ride for the patient. This will also allow for easier administration of treatments by paramedics and medical personnel on board the boat. Since the boat will obviously be much larger than a typical ground ambulance, it will also be able to hold more patients at once if necessary, along with all of the extra medical equipment and tools that would be required to treat multiple patients.

By combining the best aspects of the various types of sea vessels that we have researched, the high speed medical catamaran should be able to respond to a wide variety of emergency calls. It should be able to effectively treat multiple patients at once and transport them quickly and safely to the proper caring facilities. In this way, the high speed medical catamaran should be able to save many lives that would otherwise be lost without it.

3.1 Design of the Medical Catamaran

3.1.1 Vessel Engine Specifications

Due to the size of our vessel and the need for quick response time and high-speed cruising, we need a lot of power. We have chosen to go with the jet drive system found on many of the large high-speed catamaran systems. The Caterpillar Marine Legacy 3606 will pump out around 2300 horsepower and will give us the speed we need to be efficient in the water.

3606

RATINGS AND FUEL CONSUMPTION

	mhp	bhp	bkW	rpm	U.S. g/h	l/hr	EPA regs.	EU regs.
CS	2352	2320	1730	900	107.4	407	T1	NC
CS	2515	2481	1850	1000	118.9	450	T1	NC
MC	2583	2548	1900	900	118.6	449	T1	NC
MC	2760	2722	2030	1000	131.7	498	T1	NC

Additional ratings available for the above engines. Consult your Caterpillar representative.

	LE	H	WE
min.	158 in/4013 mm	108 in/2743 mm	71 in/1803 mm
max.	158 in/4013 mm	108 in/2743 mm	71 in/1803 mm

In-line 6, 4-Stroke-Cycle Diesel

Aspiration	TA	
Bore x Stroke	11.0 x 11.8 in	280 x 300 mm
Displacement	6773 cu in	111 liter
Rotation (from flywheel end)	Counterclockwise or clockwise	
Engine dry weight (approx)	34,496 lb	15 680 kg

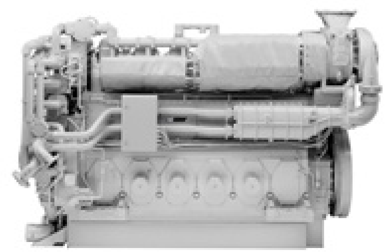


Table 2: The engine we will use is the Caterpillar Marine Legacy 3606. It is a jet drive system and is a 2300 horsepower engine.

To power the vessel we will use a combination of a Caterpillar Marine C18 ACERT Genset system and, when the engines are running, we will use the propulsion engines for power as well. The practicality of having a generator separate from the engines creates a safety net in case a major system on the vessel should fail.

C18 ACERT Genset

RATINGS AND FUEL CONSUMPTION

	Gen Set ekW @ .8pf	EPA kV•A	rpm	U.S. g/h	l/h	EPA/ IMO	EU regs.
60 Hertz	340	425	1800	25.4	96.0	T2C	NC
60 Hertz	425	531	1800	31.5	119.1	T2C	NC
60 Hertz	500	625	1800	35.2	133.2	T2C	NC
60 Hertz	550	688	1800	38.3	145.1	T2C	NC
50 Hertz	275	344	1500	19.9	75.3	T2C	CC2
50 Hertz	350	438	1500	25.2	95.4	T2C	CC2
50 Hertz	400	500	1500	28.7	108.6	T2C	CC2
50 Hertz	450	563	1500	32.3	122.3	T2C	CC2

	LG	H	W
min.	119.7 in/3040 mm	61.3 in/1557.5 mm	45.3 in/1150.9 mm
max.	121.1 in/3075.5 mm	61.3 in/1557.5 mm	51.2 in/1300.9 mm

In-line 6, 4-Stroke-Cycle Diesel

Aspiration	TA, TTA	
Bore x Stroke	5.7 x 7.2 in	145 x 183 mm
Displacement	1106 cu in	18.1 liter
Rotation (from flywheel end)	Counterclockwise	
Generator set weight (approx)	9280-10,275 lb	4209-4661 kg

Click image for larger view of the C18 ACERT Generator Set

Table 3: To power the engine, we will use a Caterpillar Marine C18 ACERT Genset System. Separating the generator from the engine can prevent damage to one from affecting the other.

Both of these, however, are very highly fuel-consuming products and as such, our fuel tank will need to be massive and set evenly throughout the hull to provide stability when the ship is out at sea.

3.1.2 Hull Design of the Medical Catamaran

The goal of our vessel was simple: design a Medical Sea-Based EMS unit that will provide both rapid rescue and transportation for patients, but also provide a very stable environment for paramedics to treat distressed individuals. Based off of the research we gathered for Chapter 2, our team decided to use the multihull design approach for our vessel and created our hull using the INCAT wave-piercing catamaran design. This will allow our vessel to provide the smoothest ride possible, and in times when very delicate procedures need to be executed on board, such as minor incisions, the extreme stability will be needed. This will limit our vessel to generally function in calm to moderate seas, but seeing as that will encompass all but the worst storms, there shouldn't be an issue, as the Coast Guard will retain their monohull vessels for these instances.

Our team chose to design the vessel to be roughly 130 feet in total length, as that will provide us with plenty of room for the designed medical block to hold our intended number of patients (see Section 3.2.1 for more details), and gave us plenty of space for maneuvering distressed individuals as well. The wave-piercing trimaran will also allow us to have a significantly higher speed than any other method of design.

Additionally, as can be seen in Figures 48 and 49 on the following pages, we added the "Rescue Well" from the 47-foot Motor Lifeboat into the ship. This will allow paramedics to be significantly closer to their distressed victims without putting themselves at any additional risk.

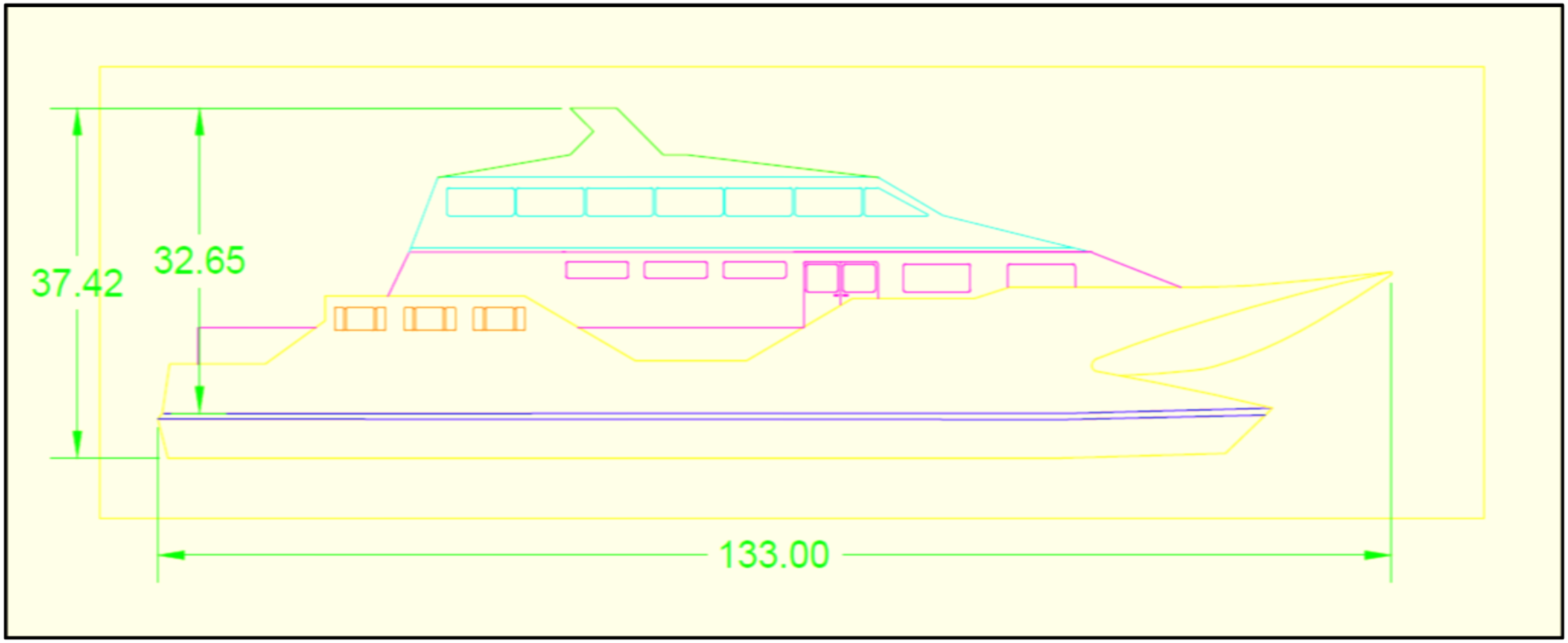


Figure 48: Above is the AutoCAD Design for the First Response Medical Catamaran. The vessel has a total length of 133 feet, and was designed around the INCAT wave-piercing catamaran layout.

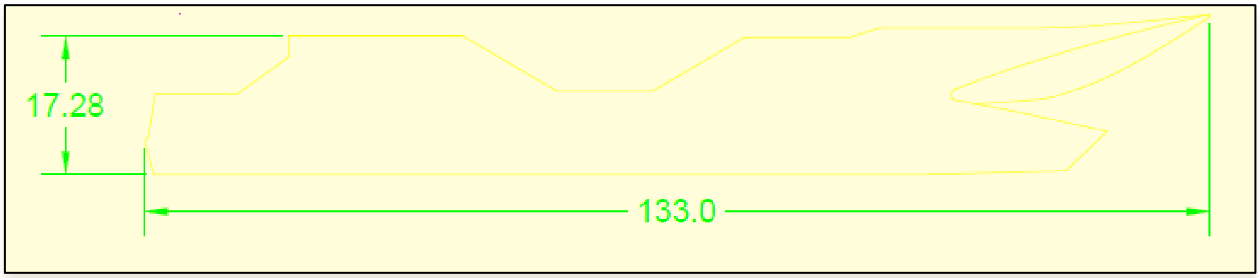


Figure 49: AutoCAD drawing of the hull of the trimaran

As seen in figures 48 and 49, the hull of the catamaran is designed to place the main deck roughly 10 feet above the waterline, assuming a draft of 5 feet for a trimaran. This will cause the 7 foot depressed rescue well to be a mere 3 feet above the waterline, aiding in the rescuing of distressed individuals greatly. The 133 foot length will also allow the ship to have plenty of space for landing docks, and coupled with the extremely low draft of the vessel, there will be little to no problems landing the ship and transferring a distressed patient to the land-based EMS teams.

Also to be noted in the AutoCAD designs, the central hull of the ship is roughly 5 feet higher than the side hulls. This is to combat the roughly 5 foot draft of the vessel, providing us with the INCAT wave piercing catamaran design. This design can be more easily seen in the front view of the ship (Figure 50 below).

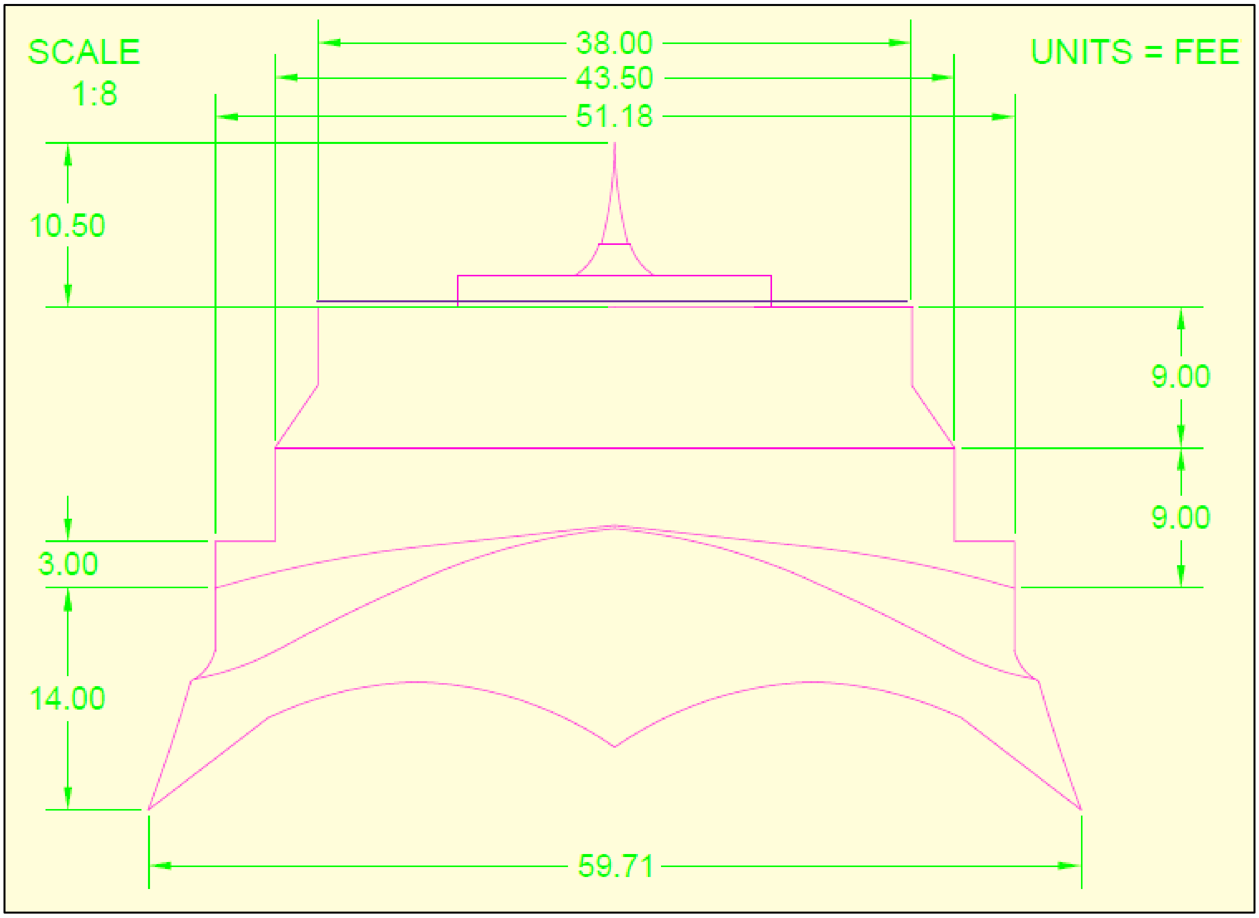


Figure 50: AutoCAD drawing of the frontal view of the catamaran

3.1.3 Full Vessel Design of the Medical Catamaran

After the design of the hull, effectively the designing factor in the layout of the ship, there were several other factors that needed to be examined in order to complete the design of them ship. Knowing the rough size of our medical block (see Section 3.2), we were able to design the outside of the ship based on the space allowed by the designed hull of the vessel.

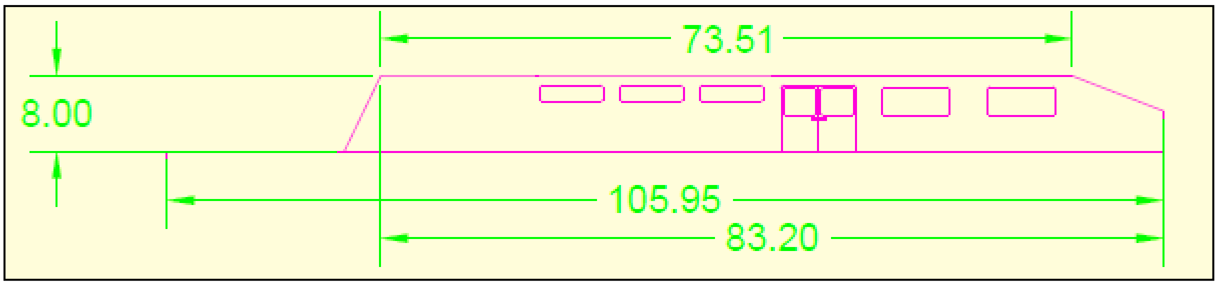


Figure 51: AutoCAD drawing of the Medical Block of the ship, not including ceiling and floor thicknes. (The width measurement can be seen in Figure 50)

The medical block was designed with the intent to hold 6 patients in intensive care units, while also maintaining the ability to treat roughly 10 more distressed individuals in a general treatment area. The block itself ended up having dimensions of 73.5ft x 45.5ft x 8ft. This block size allows for our intended capacity of patients to easily be held, without causing the ship to become too crammed. The block width in comparison to the width of the main deck also allows for space to maneuver recently rescued individuals. Using the ceiling space generated by this block, our team subsequently designed the ship's bridge atop the medical block.

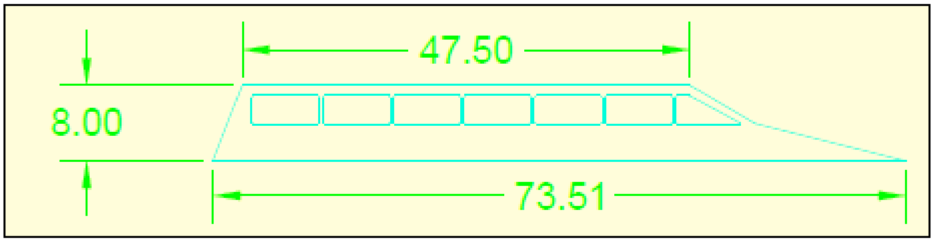


Figure 52: AutoCAD drawing of the bridge of the vessel

The bridge was designed with the intent of providing space for further storage of emergency medical supplies, as well as providing space for crew and uninjured passengers to be free from the medical block. The bridge is slightly smaller than the medical block, resting on top of it (as can be seen in Figure 52).

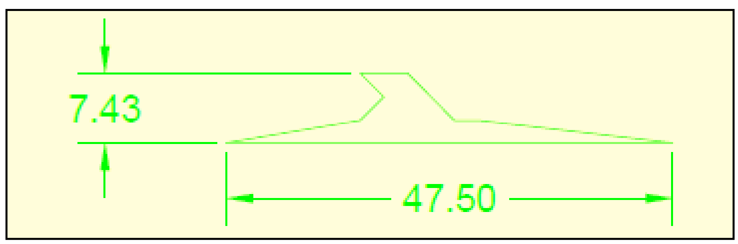


Figure 53: AutoCAD drawing of the mast of the ship

Atop the bridge lies the mast of the ship. The mast is simply a large hub of electronics that provides the ship with all needed means of communication, and is 100% vital to any search and rescue vessel. The main mast extends about 7.5 feet off of the ceiling of the bridge, with antennae extending an additional three feet past that point (see Figure 50).

3.1.4 Components of the Medical Catamaran

Up until this point, we have covered most of the important parts of the high speed medical catamaran. We have gone into detail explaining the layout of our ship, the type of engines we will use, the shape our hull will have, and the medical supplies and equipment that we will have on board. However, there are many finer details to our vessel that must be considered in order for our analysis and design to be complete. Some of these smaller, yet vital details include the method for loading and unloading patients between the high speed medical catamaran and the shore, and the way in which the vessel should be painted, the exterior emergency lighting that must be installed, and the inclusion of emergency life rafts on our vessel.

Loading Dock

While we plan on being able to treat many minor conditions on the high speed medical catamaran, it is still essentially a water ambulance; its purpose is to rescue patients from wherever they may be out at sea, treat and stabilize them in the best way possible, and transport them to a hospital or some other type of facility that will be able to administer proper treatment in a more controlled setting. For this reason, it is necessary to have a way of transporting the patient from the boat to the shore once the boat has docked at the proper location. There are many ways to accomplish this. One way is to have a lift on the boat that can raise the patient to the level of the dock so that they may be wheeled onto land smoothly. Some boats also have portable docks which they can use to help people get onto land from their boats. However, the simplest and most effective method would be to simply use a loading ramp. A loading ramp is exactly what it sounds like: a ramp used to load people or cargo onto or off of a boat. At first, we considered simply having a cutout on the guard rail on the outside of the deck at the stern. The boat could be docked in such a way that the cutout lines up with the ramp or loading area on land, as seen in Figure 54.

Figure 54: An example of how many ferries dock.

However, there is a major difference between our high speed medical catamaran and the ferry pictured in Figure 54. This ferry only docks at specific locations. At these locations, ramps have been built that are the correct height for the loading area of the ferry. Our medical vessel, however, may need to load and unload patients from a variety of locations with varying terrain.

If we simply have a cutout on the edge of our deck, it may not be the correct height at every location where the boat will dock.

In order to solve this problem, we decided that it would be better if we had a loading ramp attached to the stern of the vessel. When the boat is out in the water, the ramp would be up and, in many cases, serve as part of the guard wall on the outer edge of the deck. When the boat backs up to a dock, the ramp can be lowered so that it comes into contact with the dock or other loading platform. This creates a smooth bridge between the boat and the land. Since the ramp is part of the boat, one end will obviously always be at the height of the deck. The other end can simply be lowered until it comes into contact with the surface where the patient will be unloaded. This would allow our high speed medical catamaran to be used in a much wider variety of terrain and in many different locations.

The loading ramp in Figure 55 forms a smooth bridge between dry land and the deck of the ferry. For this ferry, the ramp is on shore and is lowered onto the edge of the boat. Although this is the opposite of how we will deploy our loading ramp, the principle is still the same. In this case, the loading ramp is used to allow cars to drive right onto the deck so that they can be transported some distance across the water. The boat then docks on the other side and the cars drive off. Because of their simple design, consisting essentially of just a large piece of solid metal with few other parts, loading ramps are very sturdy. For our high speed medical catamaran, we will obviously not need such a large and strong ramp. We do not need to transport vehicles after all, but rather patients and EMTs. In our CAD drawing of the side view (Figure 49), it can be seen that the deck has been lowered and there is no guard rail at the stern of the vessel. This is to represent where the loading ramp would be placed.

Figure 55: Many ferries use non-fixed adjustable loading ramps.

In addition to the major loading ramp located at the stern of the high speed medical catamaran, we plan on being able to use portable bridges to connect either of the two side doors of the medical block to the shore. As seen in Figure 56 below, these bridges are not fixed into place. Rather, when a boat pulls up to them, they can be moved and locked into place. This would allow for a sturdy walkway for EMTs and patients who have no impaired mobility.

Figure 56: The vessel pictured above utilizes adjustable bridges.

<u>Exterior Emergency Lighting</u>

Ground ambulances, police cars, and fire trucks all have various types of flashing lights and sounds on them in order to alert drivers on the road of their presence. This allows the drivers to be aware of the situation around them and to respond accordingly. The same is true for water ambulances. Exterior emergency lights are required so that a boat can be properly and easily identified as an emergency medical vessel. These lights allow other boats in the area to be aware of their presence and to stay clear of the pathway of the medical vessel. Our high speed medical catamaran is no exception, and will require some form of emergency lighting on the outside so that it may be properly identified. The lights on a ground ambulance make it easily identifiable, even though the ambulance itself may be very difficult to see in the dark. This is why the emergency lighting is so important. We will implement a pattern of lights on our medical boat that is similar to the type of lighting used by traditional ground ambulances.

Since boats may be viewing the high speed medical catamaran from any number of directions, it is important to have emergency lighting on all sides of the vessel. Since the boat is obviously longer than it is wide, there will have to be more lights on the sides of the boat than on the front and back. Also, in order to increase visibility of the high speed medical catamaran, the lights should be placed higher up on the vessel. For this reason, most of our emergency lights will be on the exterior of the bridge, the level of our boat above the medical block.

The lights used should not be solid; they should not simply turn on and stay on. In order to make the high speed medical catamaran more noticeably, these lights should flash, just like those of typical ground ambulances, police cars, and fire trucks. Flashing lights will be more likely to catch the attention of any boats in the area so that they will understand that there is an emergency vessel nearby and they should be alert.

Figure 57: An example of exterior emergency lighting in place on a ground ambulance.

Another important detail about the lights is their colors. Red and blue flashing lights are used by ground ambulances, police cars, and fire trucks. Usually blue lights are used more for police cars, while red lights are used more for ambulances and fire trucks. Ground ambulances also tend to have white flashing lights as well. Because of this, our high speed medical catamaran will have mostly red flashing lights with some white flashing lights. By using similar lighting to ground ambulances, people who are far enough away to only be able to observe the lights of the high speed medical catamaran will be more likely to understand that it is a medical vessel and that they should make sure to stay out of its way and give it room to maneuver.

<u>Exterior Paint</u>

As mentioned previously, it is very important to make sure that the high speed medical catamaran is easily recognizable as a medical vessel. Flashing lights of specific colors will accomplish this goal to a large extent. However, it will also be necessary to paint the vessel in such a way that it can be identified correctly as a medical vessel. Flashing lights will tell observers that the boat they are looking at is *probably* a medical vessel. Painting words along the lines of “Emergency Medical Catamaran” on the vessel will tell observers that what they are looking at is *definitely* a medical vessel.

As with the emergency exterior lights, we decided that the best way to paint the boat would be to make it appear similar to a land ambulance. Everyone can recognize a ground ambulance with great ease. By painting the high speed medical catamaran in a similar fashion, people should be able to recognize it very easily. Various combinations of red and white paint with blue lettering are usually used by ground ambulances. As such, there are many different ways we can combine these characteristics when painting our boat. However, we decided that the boat would be most easily recognized if the hull were painted red with the cabin painted white. On the cabin, in blue lettering, would be the words “Emergency Medical Catamaran.” The colors and flashing lights would let observers at a distance believe that they are probably near a medical vessel. The wording would let observers who are closer know that they are definitely viewing a medical vessel.

Figure 58: This is an example of how we would plan to paint the high speed medical catamaran.

Life Rafts and Life Preservers

One last simple yet important detail of our vessel is that it must have life rafts in the event that it fails to operate, and life preservers in the event that someone goes overboard. In order to conserve space and weight, we will use inflatable life rafts. These can be made large enough to hold up to 25 people at once. Our high speed medical catamaran will have four of these on different sides of the boat. In this way, they can be deployed from whichever side is necessary. An automated electric pump can be used to inflate them fairly quickly. Orange life vests will also be stored on board. The orange color will make people who are wearing them stand out more while they are in the water. This will greatly increase their chances of being rescued.

In addition to being used when the vessel malfunctions, the life rafts could also potentially be used in certain rescue situations. If the high speed medical catamaran is called to a location where they do not have easy access to the injured or sick person, the medical personnel may find it useful to use a smaller life raft to get to the person and to bring them closer to the boat.

3.2 The Medical Block

3.2.1 The Design and Layout of the Medical Block

The main floor of the high speed medical catamaran will be the medical block. This is where injured and sick persons will be brought for treatment and stabilization. There will be three main entrances to the medical block: a set of double-wide doors through which a stretcher can be wheeled, and two regular single doors which open up to the deck, one on either side of the medical block. The double-wide doors will open to the main corridor, which will be about 15 feet wide. The two regular single doors will open to a corridor that will be about 6 feet wide.

Upon entering the double-wide doors, there will be two bathrooms next to each other on the right side, each of which will be about 7 feet 8 inches wide by 10 feet 9 inches deep. On the left side, opposite the two bathrooms, will be a storage room. A portion of this room will be dedicated to cold storage for items such as ice packs, various medications, and food. The main storage room will be 9 feet 9 inches wide by 10 feet 9 inches deep. The cold storage room will be 3 feet wide by 10 feet 3 inches deep. There will be a door from the main corridor to each of the bathrooms, and from the main corridor to the main storage room. There will also be a door leading from the main storage room to the cold storage room. Each of these doors will be about 3 feet wide. The space immediately behind the bathrooms will be where one stairwell will be set up. The stairwell will be about 15 feet 3 inches long by 3 feet wide and will lead upstairs to the bridge. On the opposite side, immediately behind the two storage rooms will be another stairwell of the same dimensions that will also lead upstairs to the bridge.

Continuing down the main corridor, past the bathrooms on the right and the storage rooms on the left, will be the main emergency unit rooms. There will be six of these in total with three on each side of the corridor. Each of these units will be similar to the interior of a ground ambulance. In other words, having these six emergency units will be comparable to having six ground ambulances worth of space and supplies. They will measure 8 feet 6 inches wide by 13 feet 9 inches deep. These emergency units will not have walls to separate them from the main corridor. Instead, they will have curtains similar to those found in the emergency rooms of a hospital. Immediately after the last emergency units, the corridor will split to the left and the right. These two smaller corridors will lead to each of the two regular single doors that lead to the deck. These two corridors will be about 6 feet wide.

The remaining space beyond these corridors will be a large general treatment area. It will measure 20 feet 6 inches deep by 42 feet 6 inches wide. This area will not have one specific purpose but rather will be adaptable. The vessel's medical personnel will be able to use this area as necessary, given the circumstances surrounding the injuries of the patients or their illnesses. It could be used for minor surgical treatments provided that the boat is currently riding smoothly over the water. It could be used for storage of special medical equipment that does not fit in the normal storage room, such as special equipment needed for specific injuries or illnesses that the paramedics know they will have to treat in advance. The room could also be used simply for standing room if the medical catamaran is sent out to rescue a large group of people from being stranded either in the water or on board a boat that is no longer functional after having been in an accident. There will be two main doors to this room. The two doors will be at opposite ends, opening up to the short corridors near the doors that lead to the deck. They will be 5 feet wide. They will each be positioned about 5 feet from the outer walls of the medical block.

The length of the medical block, measured from just outside the double-wide doors leading to the corridor to just outside the back wall of the large general treatment area will be 73 feet 6 inches. The width of the medical block, measured from just outside of the walls on either side of the block, will be about 43 feet 6 inches. Separating every emergency unit, bathroom, storage room, and corridor will be walls that are about 6 inches deep. The main exception to this will be, of course, between the emergency units and the corridor where a curtain will be used instead of a rigid wall to separate the areas.

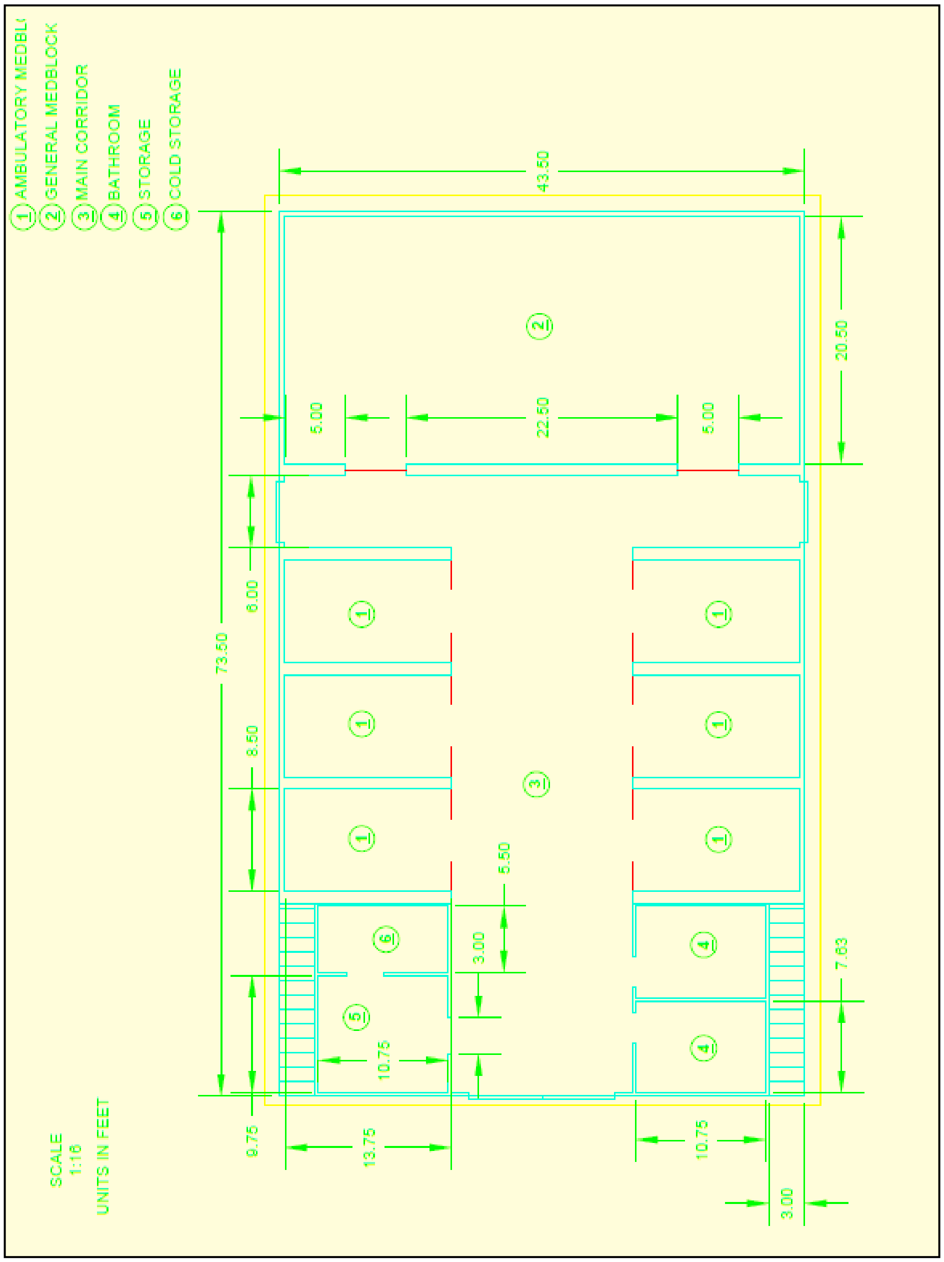


Figure 59: This is the floor layout for the medical block of the high speed medical catamaran. The six emergency units are where most of the treatment will be administered and are where patients will usually be stabilized.

3.2.2 Optimized Storage in the Medical Block

As mentioned previously, maximizing the amount of available space in the water ambulance is very important. For our project, the high speed medical catamaran, we will need to free up as much space as possible in the medical block. This will allow us to be sure that we can fit all of the medical supplies that we need and any medical equipment that we may require. More space also means more comfort for the patient and for the medical personnel that will be working on the vessel.

In order to better understand how to optimize the amount of available space within the medical block of our high speed medical catamaran, we spoke with Steven Knapp and Joshua Bernier of the Ambulatory Storage Interactive Qualifying Project group, who had researched ground ambulances and devised effective ways to increase the amount of available space inside. Since the emergency units in our medical block will each be similar to the layout of a typical ground ambulance, we can apply the strategies used by the Ambulatory Storage group to optimize the free space in ground ambulances to our high speed medical catamaran.

One of the first problems observed by the Ambulatory Storage group [10] was the difficulty in decontaminating the inside of the ambulance. The presence of many cracks and creases meant there were many tiny openings for contaminants to get into which could not easily be cleaned. Due to our research from the Contaminant Isolation Engineering group [3], however, the implementation of a self-cleaning apparatus utilizing an atomizing nozzle would emit a spray of disinfectant fine enough to enter most of these small spaces and eliminate, or at least greatly reduce, the amount of contamination.

The next problem encountered by the Ambulatory Storage group was that headroom on the ambulance could not be reduced. The height from the floor of the inside of the ground ambulance to the ceiling was six feet. However, this will not be a problem in the medical block of our high speed medical catamaran; the distance between the floor and the ceiling within the medical block will be about eight feet. By setting the height of the medical block as such, all medical personnel should be able to stand up straight without having to hunch over. This will greatly reduce the frequency of lower back pain among the medical personnel of the high speed medical catamaran compared to the medical personnel of a typical ground ambulance.

The idea of a chair that would move along a track was proposed by the Ambulatory Storage group as a solution to the problem of the prevalence of lower back pain among medical personnel. Since this is more of a problem in a ground ambulance, which is smaller and has a rougher ride, it might seem like we would not need to implement this sliding chair in our high speed medical catamaran. However, while the vessel will be large enough that it will have a fairly smooth ride, the waters could become very rough. If this were the case, it would be very important for medical personnel to be able to treat patients in a stable manner. A chair that can move along a track alongside the patient's bed or stretcher would be very useful. The fact that the person administering treatment could be strapped into the chair would make it much easier for them to treat the patients and would be much safer for them. For this reason, we have decided to put one of these chairs in each of the emergency units on board our ship.

The shelving system proposed by the Ambulatory Storage group would be also very effective in optimizing the amount of free space within the medical block of the high speed medical catamaran. As seen in Appendices A and B, there are many different types of medical supplies and equipment that must be used on board typical ground ambulances. Since most of the equipment will also be used in our high speed medical catamaran, we will also need to be able to organize all of these things well. The grid-like shelving system devised by the Ambulatory

Storage group will be very helpful for this, as various different supplies can be placed in different sections of the shelving. This will also allow us to store many more medical supplies and pieces of medical equipment within the medical block of the vessel.

In order to keep the patients and medical personnel safe in the ground ambulance, the Ambulatory Storage group had the grid-like shelving set into the wall of the ambulance. This reduced the number of sharp corners in the ambulance. In our high speed medical catamaran, however, the walls will probably not be thick enough for shelving to be set into the walls. These shelves will have to stick out of the walls at least a little bit. In order to increase safety in our case, we will have to pad these corners or make sure that they are rounded. In this way, we can gain the efficiency and organization of the grid-like shelving without having to sacrifice the safety of any of the people riding inside the ambulance.

3.2.3 Avoiding Contamination on the Vessel

In any medical rescue vehicle or vessel, contamination can be a big problem. Water ambulances are no exception to this. Since multiple patients will occupy the medical block over time, it is possible that a sick patient could contaminate one or more surfaces which will then come into contact with later patients. These patients could then become infected with any pathogens that the previous patient left behind. These pathogens could also transfer to the EMTs on board the high speed medical catamaran. It is therefore very important to have a method for dealing with contamination and keeping it to a minimum.

In order to solve this problem, we researched the methods employed by the EMS Contamination Isolation Engineering IQP group [3]. The goal of their project was to improve the methods currently used by ambulance services to decontaminate the surfaces of the ambulance. As stated previously in section 2.2.3 they concluded that one of the most effective methods of cleaning the inside of the ambulance was a self-cleaning apparatus. This device would consist of several small atomizing nozzles placed throughout the ambulance (or throughout the medical block in our high speed medical catamaran.) These nozzles would spray a fine mist of decontaminant solution. Since the atomizing nozzles would spray such a fine mist, it would be able to get into almost all of the cracks and creases inside the ambulance. These cracks and creases are where contaminants tend to reside since they are very difficult to clean using other methods.

There were some problems with this system. One was that it would require electricity to run. The other was the amount of time it would take for the ambulance (or medical block in the case of the medical catamaran) to dry after the system had been run and the decontaminant solution had settled on all of the surfaces. For the high speed medical catamaran, much more power will be required during normal operation of the boat than during normal operation of the ground ambulance. Therefore, finding a small amount of energy to power the self-cleaning apparatus should not pose any foreseeable problems. Without a proper air-filtration system, however, EMTs will still have to wait for a little while after use of the self-cleaning apparatus before the medical block has become completely dry.

As stated previously, according to the Contaminant Isolation Engineering group, the estimated cost of implementing this system would be about $1800 for a typical ground ambulance. Since our boat will be much bigger, however, this will not be the case. The high speed medical catamaran will have six emergency medical units, along with a larger general treatment area and a main corridor. Each of our emergency medical units is about the size of the inside of a typical ground ambulance. The total volume of our medical block that could potentially require decontamination is about 25 times the volume of a single emergency medical unit, and therefore, about 25 times the volume of a typical ground ambulance. To implement a self-cleaning apparatus in our medical block would cost about $45000 dollars. This is a very significant amount of money. However, it can be reduced if areas such as the storage rooms are considered to be free from contamination since patients will probably never have any reason to enter them.

Component	Quantity	Price
BEX JPL 12 Nozzle	6	$300
Compressor	1	$350
Pump	1	$275
Pneumatic Filter	1	$100
Fluid pressure filter regulator	1	$95
Tubing	1	$150
Assorted fittings and brackets	1	$200
Air cylinder	1	$150
12V Battery	1	$150

Table 4: These are the costs of the components of a self-cleaning apparatus for a single ground ambulance. The total cost comes to around $1800. Since the high speed medical catamaran will be much larger than a typical ground ambulance, the cost of implementing a similar system will be much higher.

Also, the main reason for using the self-cleaning apparatus is that the fine spray produced by the atomizing nozzles can get into the many small creases and cracks within the medical block. In the main corridors, however, there are very few of these; the corridors consist of not much more than a floor, walls, and a ceiling. This would mean that simpler cleaning and disinfecting procedures could be used instead of the self-cleaning apparatus. If the self-cleaning apparatus is instead only applied to the emergency units, the bathrooms, and the general treatment area, the volume of space requiring sanitization could be reduced to only about 15 times the size of a typical ground ambulance. This would result in an overall cost of around $27000. This is still a significant cost, but is much more manageable than $45000. Considering the total cost of building the entire boat, implementing a self-cleaning apparatus for $27000 could be very feasible.

3.3 Catamaran Efficiency

3.3.1 Points of Success

Retrospectively, our goal was to create a vessel that can provide sufficient medical treatment to individuals injured at sea, and to provide a both rapid and smooth method of transportation from the site of injury to the place of landing. Our vessel took in the strengths of many vessels from around the world and combined them into one effective unit in order to achieve our goal.

As a team, we first looked at the abilities of a medical helicopter and used that information to determine the needed size of our ship. While vessels such as the Venice Ambulance Boat and the Virgin Islands Ambulance Boat are effective at what they do, the truth of the matter is a boat that small can never compare to a medical helicopter in terms of rescue completion pace. Our ship on the other hand, due to the size difference, has the ability to excel over medical helicopters in several cases. In cases where more than 4-5 individuals are injured, units such as the Venice Ambulance Boat and the Virgin Islands Ambulance Boat, along with any type of medical helicopter, will simply not have the sheer size needed to handle all of the distressed individuals. Our vessel, on the other hand, will be able to quickly reach the location of the scene, will be able to take over 15 patients for treatment, and will be able to easily fit significantly more passengers that are uninjured. In many cases, the time difference between getting retrieved on the first or second helicopter flight could easily be the difference between life and death, and with a vessel designed like ours, this would never be an issue.

In further comparison to units such as the medical helicopter, Venice Ambulance Boat, and Virgin Islands Ambulance Boat, our unit has a few other distinct advantages. While some of these units may be slightly faster than the First Response Medical Catamaran (e.g. the medical helicopter), our vessel can easily boast a superior level of treatment to people in distress. Due to the sheer size of the other units, there is not only very little space to put more than three victims, but there is also very little space to store any sufficient amount of medical equipment. The catamaran designed by our team will be stocked with 6 fully equipped ambulance style units, and any seriously injured patient can be attended to with EMS level care immediately. Had any of the other units mentioned recovered the individual, treatment would be significantly less effective. In situations such as hypothermia, strokes, and heart attacks, the patient can easily be placed in a life or death situation, and having the proper medical equipment in a more stable environment can easily be the difference between saving a life and letting a victim die.

Another aspect that can be considered successfully achieved is the stability needed for the vessel. Other than ships over ten times its size, the First Response Medical Catamaran will provide a transit environment that has a much less bumpy ride than any of its search and rescue predecessors. Ships such as the 47-foot Motor Lifeboat and the USCG cutters have the ability to hold a decent amount of distressed individuals. However, even in calm seas, there will be constant turbulence in the ship from the moving vessel. Our vessel remedies this issue. The wave-piercing hull design will provide this much needed stability to the catamaran, and because of that, the paramedics aboard the ship will have an environment uninterrupted by constant turbulence from the waves. This environment is extremely important to saving the life of a patient because if emergency procedures need to be done during the trip towards the shore, an environment consisting of a rocking ship will cause any type of procedure to become countless times more difficult.

In comparison to many of the current ships however, the First Response Medical Catamaran has one major aspect that puts it leagues ahead of its competition: speed. The vessel designed by our team will function with a maximum speed of about 36 knots, which is 13 knots faster than the most similar USCG vessels when it comes to emergency response-type vessels. This speed is essential when it comes to life-or-death situations as, when heading out to deep sea, it can often be quite a long trip before help can arrive.

3.3.2 Points of Inefficiency

Looking back on the design of the First Response Medical Catamaran, it can easily be seen that the design and theoretical aspects of the ship were a great success. However, by no means is the ship perfect. While the First Response Medical Catamaran will be extremely effective at the things it was designed to do, there will be certain situations where it is outshined by other vessels.

One of the biggest initial concerns during the design of the First Response Medical Catamaran was the fact that trimaran-style ships are generically less suitable for inclement weather in comparison to nearly all larger monohull vessels. However, while our ship is undoubtedly less seaworthy in large surf than the 47-foot Motor Lifeboat, there is no reason to deem the ship as useless. This view is based off the fact that many Coast Guard calls come in during the weekends of the warmer summer months in nicer weather [14]. This is mainly because more people will take out their vessels for a spin during the calm warm days, as they are the more ideal.

Another point where our vessel came up short with respect to our initial plans was the maximum speed at which the ship will cruise. While 36 knots is significantly faster than many other rescue type vessels, by no means is it the fastest one available. The initial goal for our ship had been 10-12 knots faster than our final result. This, however, is counterbalanced by the size-effectiveness and the stability of the ship, two things which most similarly sized vessels do not have whatsoever. In the end, we found that a safe, balanced vessel would be more effective than one that simply moves at ridiculous speeds, and we designed the First Response Medical Catamaran accordingly.

The only other major issue with our vessel to be found was the issue of its difficulty with docking, as many passengers on the boat will need to be removed via stretcher. While backing into the port is a viable method of solving this problem, the technology that would need to be added in order to achieve this could end up being rather expensive. This is mainly due to the fact that a ship design like ours will have a decent amount of trouble in the maneuvering department. Most smaller monohull-type units will have a much easier time turning on a dime in comparison to the medical catamaran.

Lastly, it can be noted that none of these problems really give rise to a complete weakness of the vessel, as the positive aspects brought by this vessel (such as extensive medical equipment) heavily outweigh any minor weaknesses in the design. In the end, the biggest real-world issue with the vessel will be fronting the cost to build it and to hire the crew to man the ship. If this can be accomplished, the vessel will serve its purpose extremely well, and has the potential to save countless lives.

3.4 Regulations and Standards

In the section 2.4 of our paper, we introduced our research on the regulations and standards generally require for watercraft to meet the criteria of being considered water ambulances. It is important to make sure that our high speed medical catamaran follows all of these standards and regulations so that it will be a safe vessel that complies with legal requirements. As stated previously, this specific list of regulations is from the North Carolina Administrative Code, but these are the same general specifications that are required by most other places in the United States as well. However, when building the high speed medical catamaran, it will be important to take into account any other additional regulations that may be imposed by the specific location where the boat will be intended for use. In this section, we will review these guidelines and indicate how our vessel has been built in order to make sure that these regulations are followed.

1. The watercraft shall have a patient care area.

Obviously, for a watercraft to be considered a water ambulance it must have a patient treatment area. In our high speed medical catamaran, this is the medical block. The medical block has been designed in such a way that adequate access is available to all areas of the patient's body so that proper treatment can be administered. This area is indoors so that the patient and the medical personnel are protected from the elements. The opening to this area (to our medical block) is large enough to permit the safe loading and unloading of patients on stretchers. The medical block also does not contain any major obstructions that would hinder this process, such as stairs or narrow, winding corridors.

2. The watercraft must have all of the necessary supplies onboard that may be necessary for the treatment of the patient.

We have researched the medical supplies and equipment typically stored in a ground ambulance, and have ensured that they are included in the medical block at all times. This complete list can be found in Appendices A and B. The high speed medical catamaran will also be restocked on a scheduled basis in order to ensure that these supplies are always available when needed. Emergency medical equipment will also be tested periodically to make sure that it is in top working condition and will not be broken when it is needed for treatment.

3. The name of the EMS provider to whom the ambulance belongs must be printed on the side of the water ambulance.

We have already discussed how we will paint the high speed medical catamaran. The hull will be red while the cabin will be mostly white. Any words that must be printed onto the side of the vessel will be printed in blue lettering. During this whole process, it will be necessary to make sure that the name of the EMS provider is painted onto the side of the vessel as well. This would be a very simple thing to add to our design.

4. Water ambulances must have a 360 degree warning beacon.

As we have already discussed, emergency lighting is very important to have on the high speed medical catamaran, and indeed, on any emergency vessel or vehicle. It is this lighting which easily allows observers to realize that they are in the presence of an emergency vehicle and should be alert. One of these exterior emergency lights will be a warning beacon that can be seen from all directions. It will be place on top of the bridge, since there will be no obstructions to prevent it from being viewed by onlookers from any direction.

5. Water ambulances must carry the following equipment

In the list of regulations and standards, it is required that all medical ambulances carry floatable and rigid long backboards, a floatable stretcher, a fire extinguisher, a lighted compass, radio navigational aids, a marine radio, and a pediatric restraint device. All of the medical equipment listed has already been considered and will be placed within the medical block. However, originally, we simply envisioned the usage of typical ground ambulance equipment. We must also ensure that all of this equipment is floatable. Although some of this equipment is not intended to be used in the water, accidents can happen and it is important that anything that the patient could be attached to be able to float in the water.

Aside from the medical equipment, we must also make sure to include fire extinguishers on all floors of the high speed medical catamaran. This could mean the difference between minor damage to a small area of the vessel, and the complete destruction of the vessel. Navigational aids such as Global Positioning Systems and compasses will be implemented in the high speed medical catamaran, as well as a marine radio. As discussed in section 2.4.2, marine radios are very important because they allow communication between members of the crew on the vessel and people on land.

6. The water ambulance shall not have any functional or structural defects that could adversely affect the patient or the paramedics on board the water ambulance, or that could inhibit the administration of necessary treatment and procedures to the patient.

There is no specific design specification that can fulfill this requirement. Rather, all our specifications put together fulfill this. We have made sure that there are no obvious flaws to our designs; the high speed medical catamaran is relatively aerodynamic, is not extremely top heavy, and will contain emergency equipment such as life vests and water rafts just in case something should go wrong. However, in order to completely satisfy this requirement, it will be important to inspect all of the parts of the high speed medical catamaran after it has been built in order to ensure that they were manufactured correctly and that no faulty equipment will be implemented. This must be done before the boat is used as a life-saving vessel.

Periodic checks will also have to be made on the high speed medical catamaran in order to make sure that it remains in good condition. Performing these checks will take some time, so it will be important that any medical services that plan on using our high speed medical catamaran also have other life-saving vessels and water ambulances (possibly even other high speed medical catamarans) that can be called out while the main high speed medical catamaran is being serviced.

7. Water ambulances shall have a copy of the Emergency Medical Services patient care treatment protocols.

According to this requirement, all watercraft considered to be water ambulances must have copies of patient care treatment protocols on board the vessel at all times. These copies are used as references for medical personnel in order to make sure that they administer the correct treatment to a patient and that it is appropriate for their specific form of illness or injury. Since some of these practices vary from location to location, we will not be able to fulfill this requirement until we know exactly where our high speed medical catamaran will be implemented. However, simply placing a book onto our vessel is no difficult task and can be easily taken care of once the boat has been built and is in its proper location.

CHAPTER 4: CONCLUDING REMARKS

In the last hundred years, technology around the world has improved at a near unfathomable rate. This rapid increasing of the world's technological prowess has caused many things to be left behind when it comes to optimal design. Our team felt that the current state of sea search and rescue vessels were just that, suboptimal. Due to this perspective, our team planned to improve the search and rescue scene at sea, by designing a vessel that was fit to exist in today's standards, without taking away any needed aspects of a search and rescue vessel. In order to accomplish this, our team needed to meet a set of goals. (1) We needed to design a vessel that could match/improve the maximum speed for current major rescue vessels. This would ensure that in the race against time, our vessel will always be an effective choice for deployment. (2) The vessel needed to ensure a level of stability at sea that has never been before achieved by a medical rescue vessel. This stability will allow doctors and paramedics to proceed with many procedures that normally could not be done on a rescue vessel due to the constant ebbing and flowing from the sea below. (3) The final product also needed to be of the correct size to provide maximum efficiency when compared with other rescue units available, so that in certain conditions, the unit will always be the go-to vessel, making it an invaluable addition to any fleet.

Since our emergency medical catamaran is essentially a combination of a watercraft and an ambulance, we decided that a good place to start was to research boats and ground ambulances, and then to try to combine the two. The major aspect of the design of the vessel itself was its hull. We concluded that, by using a trimaran-style hull, our vessel would have an extremely smooth ride, better than any medical vessel currently in use. We then shifted our focus to the engines. For our vessel, we chose the Caterpillar Marine Legacy 3606, which is a jet drive system and is used by many large high-speed catamarans.

We then researched all of the basic elements of a typical ground ambulance. Since our vessel would need to be able to treat and stabilize patients at least as well as a ground ambulance, it was important to understand the capabilities of ground ambulances. We determined what medical supplies and equipment are usually required to be on board ground ambulances at all times. We also learned some of the methods that EMTs currently use to try to decontaminate ambulances between uses. This led us to the conclusion that a self-cleaning apparatus using atomizing nozzles to spray an extremely fine mist of decontaminating solution was the best way to deal with contamination on our vessel.

Our final major branch of research was on the current vessels in the fleet of the U.S. Coast Guard. Our main focus was on the 47-foot Motor Lifeboat, as the USCG typically employs the 47 as the major “response-type” search and rescue vessel. Additionally, we analyzed the larger and smaller boats of the USCG as well, providing us with detailed information the current state of search and rescue response. Our greatest source of information on this subject was Stations Operation Petty Officer BM1 Benjamin Molnar, who allowed us to interview him and get a hands-on tour of the vessels stations at the USCG station at Merrimack River. The information received from this trip allowed us to integrate the successful aspect of the Coast guard vessels into our ship’s final design.

After completing most of our research, we made CAD drawings of how our catamaran should be built. We generated views from the sides and front, paying particular attention to the shape of the hull. We also created a layout of the medical block, the part of the vessel where the patients would be stabilized and receive treatment. All of these CAD drawings can be found in Sections 3.1.2 and 3.1.3, and in Appendix F.

The result of all of our research and designs is that we have created a model of a vessel that satisfies all of our goals. Our vessel is very fast, very stable, and able to carry many patients at once when necessary. There is definitely no other boat quite like it. We believe that, if the Coast Guard or any other organization were to decide to build the vessel which we have designed, it would become their most useful vessel and would save countless lives that otherwise may have been lost.

REFERENCES

[1] Amundson, Dennis. et al. "Practicing Internal Medicine Onboard the USNS COMFORT in the Aftermath of the Haitian Earthquake." *Annals of Internal Medicine* 1 June 2010.

[2] Ashton, Jennifer. "Aboard the USNS Comfort in Haiti" *CBS News Report* 20 January 2010

[3] Haas, Michael. Hough, Kenneth. Qiao, Yun. and Riaz, Talha. *EMS Contaminant Isolation Eng.* Rep. Worcester: WPI, 2011. Print.

[4] Hallenbeck, Tom. "INCAT Identifies Top 21 Challenges Using Autodesk Inventor." *CAD/CAM Update* Nov. 2008.

[5] Hane, Steve. "How Fast Can the Air Ambulance Fly at Top Speed?" *Your Source for Knowledge - Emergency Health.* 2011.

[6] Hatfirld, Roger, and Jeff Bisson. "St. John Ambulance Boat GC50A." *Gold Coast Yachts*. Web. 6 Mar. 2011. <goldcoastyachts.com>.

[7] Henderson, Hartley. “Australia’s High-Speed Ferries Rule the Waves.” *Manufacturer’s Monthly*. Feb. 2007.

[8] Howard, Jim J. *Handbook of Offshore Cruising: The Dream and Reality of Modern Ocean Cruising*. Sheridan House, 2000. Print.

[9] Jones, Tony, and David Marsh. "Volvo Penta IPS Revealed - MBY." *Motor Boat News.* 1 Dec. 2004.

[10] Knapp, Steven T., and Joshua D. Bernier. *Ambulatory Storage IQP*. Rep. Worcester: WPI, 2011. Print.

[11] Kremer, Valerie A. “USNS Comfort to Support Continuing Promise”. Bureau of Navy Medicine and Surgery Public Affairs. *American Forces Press Service.*18 March 2011.

[12] Kristiansen, Hotvedt R Et Al. "Which Groups of Patients Benefit from Helicopter Evacuation?" *The Lancet* 18 May 1996: 1362-366. *LexisNexis Academic*. 18 Feb. 2011.

[13] McKenny, Leesha. "Rescuers Tell of Frantic Battle to Save Crew of Wrecked Yacht." *The Sun Herald* 11 Oct. 2009: 4-6. Print.

[14] Molnar, Benjamin Station Operations Petty Officer BM1. Personal Interview. 13 April 2011.

[15] Moore, Captain J.E. "Coast Guards: The New Breed." *Defense & Foreign Affairs* Apr. 1998: pg 8.

[16] Scheina, Robert L. *U.S. Coast Guard Cutters and Craft, 1946-1990.* Annapolis, MD: Naval Institute Press, 1990.

[17] Sternberg, Steve. "Haiti's "Floating Hospital": Tough Questions on USNS Comfort." *USA Today* [Baltimore] 2 Feb. 2010. Print.

[18] Task Group AVT-112. *Seakeeping and Habitability in the Design of Vessels with Novel Hull Forms*. Tech. Neuilly-sur-Siene Cedex, France: North Atlantic Treaty Organization, 2008.

[19] Textron Systems. *47' MOTOR LIFEBOAT: EXCELLENT STABILITY, STRENGTH AND SURVIVABILITY*. Tech. Print.

[20] Watson, Ericka. "Boat Marine Engines Basics - Boat Drive Systems." *Boating - Information About Powerboating*. Aug. 2010.

[21] Wilkinson, William D., and Timothy R. Dring. *American Coastal Rescue Craft: A Design History of Coastal Rescue Craft Used by the United States Life-Saving Service and the United States Coast Guard*. Gainesville: University Press of Florida, 2009.

APPENDICES

Appendix A: Ground Ambulance Medical Supplies and Equipment

A/R 5-401

OFFICE OF EMERGENCY MEDICAL SERVICES
Administrative Requirements Manual

Effective: 6/30/2002 Authorization: Page: 1 of 10

A/R Title: Ambulance Equipment List
Basic Life Support

Supersedes: BLS List Effective March 1, 2000

General Principles

A. **AUTHORIZED EQUIPMENT:** Ambulance services must carry equipment and medications as required by Statewide Treatment Protocols. Ambulance services should not equip ambulances with equipment that is outside of scope of practice of its EMT employees, or outside of the service's level of licensure.

B. **PERFORMANCE STANDARDS**: All equipment must be designed and constructed to meet medical performance objectives and must not endanger patients.

C. **MAINTENANCE**: All equipment and supplies must be maintained according to manufacturers' specifications with regard to maintenance, storage, expiration date, replacement, etc.

Item # Name	Class	Description & Quantity
1 Ambulance Cot	I, II	• One 4-wheeled, multi-level ambulance cot. • Standard cot mattress with waterproof cover. • Patient restraining devices at chest (commercial shoulder harness or equal) hip, and knee to prevent lateral or longitudinal displacement of the patient during transport. • Dual I.V. holder, capable of being cot mounted. • Padded wrist and ankle restraints, minimum one complete set.
2 Bag Valve Mask Ventilation Unit	All	One (1) hand-operated bag/mask ventilation unit with adult mask(s), capable of use with oxygen supplies (disposable, single use units recommended). Unit must be accessible within the patient compartment, and include, at minimum: (a) One (1) each child and infant size bag/mask ventilation units with Appropriate mask(s), capable of use with oxygen supply (disposable, single use units recommended); (b) Two (2) oxygen connector tubes, minimum 84 inches long; (c) One (1) oxygen supply reservoir for each bag/mask ventilation unit.
3a Portable Oxygen Unit	All	Portable positive pressure resuscitator/inhalation unit designed to operate in conjunction with external cardiac compressions and deliver nearly 100% oxygen. All components must be stored together. Unit must be equipped with: (a) One (1) bag/valve/mask ventilation unit. The Addition of a flow restricted, oxygen powered ventilation device (demand valve) is optional; (b) Oxygen cylinder with minimum capacity of 300 liters; (c) Oxygen cylinder pressure gauge and regulator capable of delivering a range of zero (0) to fifteen (15) liters per minute;

Item # Item Name	class	Description and Quantity
3a Cont'd (Port. Oxygen Cont.)		(d) Two (2) different sizes of resuscitator face masks; (e)Two (2) Each child and adult size transparent, disposable, high concentration oxygen masks with delivery tubes. (f) Two (2) adult nasal cannula with delivery tube; (g) Oxygen connecting tubing; (h) Cylinder wrench or wheel secured to unit; One (1) full spare oxygen cylinder, minimum 300 liters. All spare cylinders to be maintained in vehicle, but not part of the kit. All spare cylinders must be stored in a crash stable devices per KKK-A-1822, and any amendments thereto.
3b Installed Oxygen System	I, II	An installed oxygen system conforming to Applicable sections of the Federal Specification for Ambulances KKK-A-1822, and any amendments thereto, and equipped with the following: (a) Two (2) Flowmeters_capable of delivering a range of zero (0) to 15 liters per minute, at minimum; (b) Unbreakable oxygen humidifier, disposable, for single use only; (c) Sterile water for use with oxygen humidifier; (d) Four (4) each adult and child size, transparent, disposable, high concentration oxygen masks with delivery tubes; (d) Four (4) Each adult and child sizes of disposable nasal cannulae with delivery tubes;
4 Installed Suction	I, II	[required by KKK-A-1822 s.3.12.3; but not previously itemized on equipment list] Electrically powered suction aspirator system shall be furnished with an illuminated switch, and panel mounted, to include: (a) One (1) non-breakable, transparent collection bottle or bag, minimum 1,000 ml capacity; (b) One (1) suction rinsing water bottle; (c) Two (2) semi-rigid pharyngeal suction tip with thumb suction control port; (e) Two (2) transparent or translucent, non-kinking suction tubing min. 1/4 inch in diameter; (f) Two (2) Each 5, 8, 14 French suction catheters; and ten (10) spare collection bags when bag type system is furnished.
5 Portable Suction Unit	All	One (1) adjustable gas or battery powered portable suction apparatus, capable of delivering a minimum vacuum of 600 millimeters of mercury and equipped with the following: (a) Wide bore, non-kinking tube;

Item # Item Name	class	Description and Quantity
5 Cont'd		(b) Pharyngeal suction tip; (c) Non-breakable, transparent collection bottle, minimum capacity 550 cc (disposable container recommended); (d) One (1) pair disposable exam type gloves; (e) One (1) combination face mask/eye shield or one (1) each facemask and protective eye wear.
6 First Aid Kits	I, II	Two (2) portable first aid kits.
	IV, V	One (1) portable first aid kit.
		Kits may be incorporated into other kits (i.e., portable oxygen kit.) Each first aid kit to be supplied and equipped with the following equipment: (a) Three (3) wrapped oropharyngeal airways, one (1) each, infant, child and adult sizes; (b) Twelve (12) small dressings (sterile gauze pads, minimum size 4"x4"); (c) Four (4) medium dressings, sterile, minimum size 5" x 9"; (d) Two (2) large dressings (sterile universal dressings, minimum size 10"x 3 0") (e) Six (6) rolls soft roller, self-adhering bandage, minimum 4" x 5 yrds; (f) Four (4) cravats or triangular bandages, minimum 40" wide; (g) Two (2) arterial tourniquets for control of arterial bleeding, commercial or equivalent; (h) Two rolls 2" adhesive tape, minimum 5 yards; (I) One (1) 7" bandage scissors or equivalent; (j) One (1) adult size sphygmomanometer; (k) One (1) stethoscope; (l) One (1) penlight-type flashlight; (m) One (1) unbreakable container of sterile water or saline solution, minimum one pint (500 cc); (n) One (1) wrapped 3 ounce bulb syringe for irrigation purposes; (o) Two (2) cold packs; (p) One (1) tube glucose based paste or equivalent; (q) Two (2) wrapped tongue depressors for glucose administration; (r) Six (6) band-aids, minimum 3/4"; (s) One (1) mouth-to-mouth resuscitator mask with one way valve and an oxygen port (disposable type recommended); (t) Two (2) combination face mask/eye shield or two (2) each facemask and protective eye wear; (u) Two (2) pair disposable exam type gloves.
7 Traction Splints	I, II	• One (1) hinged Thomas-type half ring lower extremity splint or equivalent; • One (1) child-sized hinged Thomas-type half ring lower extremity type with ankle hitch and leg ties or equivalent, with ankle hitch and leg ties. All accessory items to be stored with splints.

Item # Item Name	Class	Description and Quantity
8 Padded Board Splints	All	Covered padded board splints or equivalent impervious to saturation by fluids, minimum two (2) each of the following sizes: (a) 3 feet by 3 inches; (b) 15" inches by 3 inches; (c) 4 1/2 feet by 3 inches.
9 Spine Boards and Accessories	All	• One (1) half spine board meeting AAOS standards, with three (3) torso straps and head strap (2" tape or functional equivalent), or equivalent (i.e., KED); • One (1) full spine board meeting AAOS standards; • Accessories for each full spine board carried, stored together, as follows: (a) Four (4) straps of 9 foot length or functional equivalent; (b) Four (4) adult rigid cervical collars of various sizes (e.g. no-neck, small, medium, and large), or one (1) adult adjustable collar, and three (3) child size rigid cervical collars of various sizes (e.g. infant, toddler, and child), or one pediatric adjustable collar, at a minimum; (c) Sufficient padding material to maintain in-line head and cervical spine support and stabilization (i.e., foam blocks, rolled blankets, and/or towels).
10 Stair Chair	I, II	One (1) stair chair with patient restraint straps
11 Auxiliary Stretcher	I,II	One (1) auxiliary stretcher with patient restraint straps, or equivalent (i.e., orthopedic "scoop" stretcher, "Reeves" type stretcher, long spine board)
12 Transfer Sheet	I, II	One (1) transfer sheet with a minimum of six (6) handles, or equivalent.
13 Airways Revised 12/00	I, II	Six (6) Wrapped oropharyngeal airways (2) Each infant, child, and adult [in addition to those listed in the first aid kit]; (a) Eight (8) adult size nasal airways, one (1) each 20F, 22F, 24F, 26F, 28F, 30F, 32F, and 34F; (c) Four pediatric nasal airways, One (1) Each 12F, 14F, 16F, 18F; (d) One disposable package water soluble lubricant per nasal airway.
14 Small Dressings	I, II	Twenty-four (24) sterile gauze pads, minimum 4" x 4".
15 Medium Dressings	I, II	Twelve (12) sterile, individually packaged dressings, minimum 5" x 9", or equivalent (i.e., sterile sanitary napkins)

Item # Item Name	class	Description and Quantity
16 Large Dressings	I, II	Six (6) sterile, individually wrapped universal dressing, Minimum 10" x 30".
17 Soft Roller Bandage	I, II	Twelve (12) rolls soft roller, self-adhering bandage, either 3" or 4" size.
18 Triangular Bandage	I, II	Twelve (12) triangular, commercial or equivalent, of unbleached muslin, minimum 40" wide.
19 Adhesive Tape	I, II	Four (4) rolls of 1"x 5yd, one of which must be hypoallergenic.
20 Bandage Shears	I, II	One (1) pair bandage shears.
21 Burn Sheets	All	Two (2) sanitary, wrapped burn sheets, linen or disposable.
22 Obstetrical Kit	All	One (1) sterile commercial obstetrical kit; OR One (1) sterile obstetrical kit containing the following: (a) One (1) large towel; (b) One (1) receiving blanket, or equivalent; (c) One (1) pair sterile disposable plastic or rubber gloves; (d) Six (6) sterile gauze pads, minimum 3" x 3"; (e) Two (2) Kelly clamps or sterile ties; (f) Six (6) sanitary napkins; (g) One (1) infant bulb syringe; (h) One (1) pair scissors (bandage or surgical blade); (h) One (1) container with lid for carrying placenta; (i) One (1) newborn swaddler system, i.e. space blanket, foil swadler, or equivalent to retain body temperature.
23 Poison Antidote Kit	All	One (1) poison antidote kit, containing: (a) Activated charcoal; Measuring device.
24 Irrigation Fluid	I, II	Three (3) liters of sterile water or saline solution, in unbreakable containers, in a minimum of three (3) containers.
25 Aluminum Foil	I, II	One (1) roll of aluminum foil, minimum 12 inches by 25 feet, or adult size space blanket.
26 Polyethylene Film	I, II	One (1) roll of polyethylene film.

Item # Item Name	class	Description and Quantity
27 Bed Pan	I, II,	One (1) adult bed pan.
28 Motion Sickness	I, II, IV	Two (2) motion sickness bags, or equivalent , capable of being sealed.
29 Pillows	I, II IV, V	Two (2) pillows with waterproof plastic covers, and four (4) pillow cases. One (1) pillow with waterproof plastic cover, and two (2) pillow cases.
30 Sheets	I, II IV, V	Eight (8) sheets, disposable or linen; Two (2) sheets, disposable or linen.
31 Blankets	I, II IV, V	Four (4) blankets. Two (2) blankets.
32 Towels	I, II	Four (4) towels.
33 Tissues	I, II	Two (2) packages of disposable paper tissues.
34 Drinking Cups	All	Two (2) or more disposable drinking cups.
35 Cold Packs	I, II	Four (4) cold packs
36 Glucose	I,II	Two (2) glucose based paste or equivalent, and wrapped tongue depressors for glucose administration. (*other than what is in first aid kits.*)
37 Infection Control Kit	All	One (1) infection control kit, containing two (2) each of disposable, fluid resistant gowns, masks, caps, protective eye wear, and two (2) different sizes of gloves.
38 Ring Cutter	I, II,	One (1) ring cutter.

Item # Item Name	class	Description and Quantity
39 Adult Sphygmomanometer	I	One (1) adult, sphygmomanometer.
40 Large Adult	All	One (1) large adult, or thigh size sphygmomanometer.
41 Child Size Sphygmomanometer	I, II, V	One (1) child size sphygmomanometer.
42 Infant Sphygmomanometer	All	One (1) infant size sphygmomanometer.
43 Stethoscope		One (1) stethoscope to be a component of patient compartment stocks. (other than what is in first aid kits.)
44 Plastic Bags	I, II	Two (2) large plastic bags with ties.
45 Contaminated Trash Container	All	Two (2) disposable "Bio-Hazard" bags, with ties.
47 Eye Shields	I, II	Two (2) combination face mask/eye shield or two (2) each face mask and protective eye wear.
48 Gloves	I, II	Six (6) pairs of disposable exam type gloves in three (3) different sizes.
49 Hand Cleaner	I, II, V	One (1) dispenser antiseptic hand cleaner, or 25 individually wrapped antiseptic hand wipes.
50 Latex-free Equipment	ALL	One (1) commercial latex-free kit; OR one (1) labeled latex-free kit containing the following: (a) latex-free examination gloves, two (2) pairs each, small, medium and large; (b) latex-free tourniquet; (c) latex-free adult BVM and masks; (d) latex free high concentration, disposable, oxygen masks with delivery tubes, two (2) each, adult and child; (e) latex-free nasal cannulae and delivery tubes, two (2) each, adult and child; (f) latex-free B/P cuff; and (g) latex-free stethoscope.

51 CPR Board	I,II	CPR board or functionally equivalent (i.e., short board) hard surface for patient torso accessible to patient compartment.
52 Automatic Defibrillator	I,II,V	One Automatic external cardiac defibrillator (AED) appropriate to ambulance staffing configuration, with appropriate accessories. Effective date: March 1, 2002
53 Epi-Pens	ALL	Two (2) each, child and adult Epi-Pens. Effective June 30, 2002
54 Aspirin	ALL	30 tablets of chewable pediatric-strength (81 mg/tablet) aspirin, or 30 tablets of adult-strength (162-325 mg/tablet) aspirin. Effective June 30, 2002

EQUIPMENT TO GAIN ACCESS

Item # Item name	class	Description and Quantity
1 Equipment to Gain Access	I,II	(a) One (1) screwdriver, minimum 8" regular blade (b) One (1) hacksaw with six (6) wire (carbide) blades (c) One (1) pair of pliers, 10" vice grip (d) One (1) short handled sledge hammer, minimum 3 pounds (e) One (1) rope, synthetic, minimum 50 feet by 1/2 inch diameter or functional equivalent (f) Two (2) pairs of gloves (leather gauntlets) (g) Two (2) pairs of goggles (clear eye protective)

Appendix B: Ground Ambulance Medical Supplies and Equipment Descriptions

Ambulances of any sort must be able to treat a wide variety of conditions and injuries, and to be able to stabilize patients with immediate, life-threatening conditions. In order to accomplish this, they must have the equipment and supplies necessary for all of the different types of tests and treatments that they may have to administer. The following is a list of these items obtained from UMass Medical.

<u>Basic Life Support</u>

1. Ambulance Cot

The ambulance cot is where the patient resides during transport. They must have wheels capable of moving over pavement and must be able to be locked in place inside of the ambulance. They have a soft but sturdy cushion covered by a cheap cloth that can be disposed of if contaminated.

2. Bag Valve Mask Ventilation Unit

The bag valve mask ventilation unit is a hand-held device used to assist a patient who is not breathing or is breathing poorly. It is placed over the mouth and squeezed to force air into the patient's lungs. In some cases, an O_2 tank can be attached to the device to pump pure oxygen into the patient's lungs.

3. a. Portable Oxygen Unit

The portable oxygen unit is an oxygen tank containing essentially pure O_2 gas inside. This is used for patients who are having trouble breathing and allows them to inhale more oxygen at a time than if they were inhaling normal air. This is useful if their lungs are not functioning efficiently enough for them to get enough oxygen on their own.

3. b. Installed Oxygen System

As a part of the oxygen tanks and oxygen systems in place in the ambulance, humidifiers are sometimes needed to make sure that the oxygen delivered to the patients is of comparable humidity to that of the air in the atmosphere. In certain situations, the patient should not receive dry air.

4. Installed Suction

Aspirators are required to assist with patients who are vomiting and are unable to keep their own airways clear. They can also be used when a patient is choking. Collection bags are also necessary to isolate the substances withdrawn from the patients' throats either for testing or simply to isolate them for sanitation purposes.

5. Portable Suction Unit

The portable suction unit is essentially a battery powered aspirator used when EMTs are unable to get the patient within range of the installed suction. It functions in much the same way as the installed aspirators but is simply smaller, portable, and battery operated.

6. First Aid Kits

The first aid kits contain many of the valuable tools essential for primary treatment of a patient's symptoms before they can be diagnosed and treated either on the ambulance or more likely in the hospital. First aid kits must contain all of these basic tools while remaining portable so that patients may be stabilized for transport, or at least so they can be moved to the ambulance safely where proper, more effective treatments may be administered and their situation can be accurately assessed. Whenever supplies are used in the first aids kits, paramedics must make sure that they are replaced before they expect they will be needed again.

7. Traction Splints

Traction splints are usually used to treat damaged bones in the legs. They often consist of metal rods attached to the leg parallel to the bone. These metal rods are attached to straps that go around the waist or hips as an anchor. The purpose of these splints is to keep the leg positioned correctly.

8. Padded Board Splints

Padded board splints are used for support for patients who may have spinal trauma or damage to the muscles in their back, abdomen, or chest. These splints restrict the movement of the patient's torso, preventing any more potential damage to the injured areas. The patient can then be safely transported either to the ambulance or from the ambulance into the hospital where they can be treated.

9. Spine Boards and Accessories

Sometimes, board splints the length of the body are required to totally immobilize a patient. These are referred to as spine boards and are usually the length of human body. They prevent a patient from moving around too much and further injuring themselves, and help stabilize the patient's body in transport to keep their injuries from worsening.

10. Stair Chair

The stair chair is a small chair that a patient can be strapped in to. It is used in place of an ambulance cot/stretcher in confined places where there is no room to maneuver large, cumbersome transport devices.

11. Auxiliary Stretcher

It is important to have an extra stretcher available in case the stretcher that is normally used breaks or if it is necessary to transport two patients who both require a stretcher in order to be transported.

12. Transfer Sheet

A transfer sheet is simply the sheet that is on top of the stretcher. It is made to be sturdy so that paramedics can simply grab the edges when a patient is lying on top and lift them by lifting the sheet underneath them. This allows for easy transfer of patients from one stretcher to another or from a stretcher to a bed or an operating table, etc.

13. Airways

Oropharyngeal airways prevent a patient from being unable to breathe, especially if they are unconscious, by preventing the tongue from covering the trachea which could prevent the patient from breathing. Nasal airways also prevent an unconscious patient from being unable to breathe by simply keeping their nasal passages open.

14. 15. and 16. Small, Medium, and Large Dressings

Gauze is used to cover open wounds and burns. Its loose weave and smooth fibers make it unlikely to adhere to the wound, preventing the wound from healing around the gauze. Due to the severity of the patient's injuries, it may be necessary to have several rolls of gauze on the ambulance.

17. 12 Rolls Soft Roller Bandage

Adhesive bandages are often necessary to cover open wounds on a patient. The fact that they are rolled up makes them simple and quick to apply to a patient when necessary. Adhesive bandages are very useful because they can be used to cover and treat many different types of wounds of varying sizes. For this reason, it is important to have several rolls of these bandages on the ambulance at all times.

18. 12 Triangular Bandages

Triangular bandages are mainly used, due to their shape, for injuries to the knees, elbows, feet, or head. Their shape allows for more comfort than a traditional square or rectangular bandage due to the high degree of curvature of these parts of the body.

19. 4 Rolls Adhesive Tape, 1 of Which is Hypoallergenic

Adhesive tape is necessary to apply bandages to patients' wounds. The tape is used to secure the bandage or gauze to the patient so that it does not need to be held in place. A small percent of people have an allergy to the material used in the bandages, so it is important to always have at least one roll of hypoallergenic adhesive tape.

20. Bandage Shears

Bandage shears have a different shape from regular scissors. They have a longer, blunt bottom edge that can get under bandages without causing any discomfort to the patient. They can be used to quickly and easily remove a bandage from a patient's body without risking cutting the skin of the patient

21. 2 Burn Sheets

Burn sheets are applied to areas of a patient's skin that have been burned. They are made of a lint-free fiber to provide a smooth and sterile environment in which the wound can heal. They are designed with the sensitive skin of the burned area in mind.

22. Obstetrical Kit

The obstetrical kit is used for dealing with pregnant women. Because they are pregnant, there are many more complications that can arise depending on the circumstances surrounding the patient's injuries. It is designed for situations in which a mother must give birth in an emergency. The kit is used to deal with any of the problems that could arise before, during, or after treatment of the patient.

23. Poison Antidote Kit

These are simply antidotes to common poisons. For example, if a certain species of poisonous snake is indigenous to the area in which the patient and ambulance service reside, the kit would probably contain antidote to the poison of this specific species of snake.

24. Irrigation Fluid

Irrigation fluid is used when a specific area on a patient's body must be wetted or washed.

25. Aluminum Foil

Aluminum foil is used as a heat reflective material. In some cases this can be useful, such as shielding a newborn.

26. Polyethylene Film

Polyethylene film can be used as a sterile surface, or to cover certain surfaces to prevent them from becoming contaminated by any substances that have come from a patient. In an ambulance, as in a hospital, maintaining a sterile environment is a very high priority, as it can be the determining factor as to whether a patient will recover or whether their injuries will worsen.

27. Bed Pan

A bed pan is necessary for when a patient is either unconscious or unable to move and has to use the bathroom. The bed pan is important because in most cases it will keep the sheets from being soiled and will make for less contamination within the ambulance. This will also prevent the patient from making a mess that will take time to clean up.

28. 2 Motion Sickness Bags with Seals

If a patient becomes ill while riding in the ambulance, either from simple motion sickness or from an underlying illness or injury, it is important to have at least two motion sickness bags with seals for them on the ambulance so that any vomit may be contained in a sanitary fashion and disposed of properly. This makes it so that there is less to clean up within the ambulance later on and improves the sanitation of the ambulance.

29. Pillows

When patients are lying on the stretcher, it is important that they are comfortable. It is especially important to try to prevent the vibrations of the ambulance from compounding any injuries, especially ones to the head and neck.

30. 8 Sheets, Disposable or Linen

An ambulance gets several calls a day and transports several different patients. For this reason, it is important that the stretcher always have clean sheets that are either disposable or very easy to clean. These are necessary to prevent patients from being exposed to contaminants still present in the ambulance from previous patients who rode in that same ambulance earlier in the day.

31. 4 Blankets

Patient comfort is very important in the ambulance, as soft surfaces obviously lessen the risk for injury or for the compounding of injuries already sustained by the patient. Because of this, it is necessary to always have four blankets on the ambulance. Some patients may also be feverish or need to be kept warm. It is important to have more than one so that contaminants remaining on the blankets from previous patients do not affect patients that are currently being transported.

32. 4 Towels

Towels are necessary on the ambulance to clean up spills, whether they are bodily fluids from a patient or simply a spilled beverage. A patient may also be wet when brought into the ambulance, in which case it would be very important to keep them dry and clean so that treatment may be properly administered.

33. 2 Packages of Paper Tissues

If a patient has a bloody nose or if one of their symptoms is nasal congestion or excess mucus production, tissues will be necessary to have in the ambulance in order to dispose of these bodily fluids in a sanitary manner.

34. 2 Disposable Drinking Cups

If a patient is dehydrated, they will obviously require fluids. A drinking cup is a very simple way of delivering fluids to the patient.

35. 4 Cold Packs

If a patient has an inflamed joint, or an aching or swollen muscle, an ice pack can greatly reduce swelling and the severity of the pain for the patient. Also, if a patient has an especially high fever, ice packs may be necessary to help bring their temperature down or to simply keep it in check until it can be treated properly at a hospital.

36. Glucose

If a patient has a low blood-sugar level, the ambulance must have a form of glucose on board that can be ingested to raise their blood-sugar levels to the correct amount.

37. Infection Control Kit

The infection kit is used in situations where a patient has a communicable disease that could be spread to the paramedics working on him or her. They consist of gowns, caps, face masks, eyewear, and gloves so as to prevent the paramedics from making direct contact with the patient, minimizing their chances of catching what the patient may have.

38. Ring Cutter

It may be necessary to remove a patient's rings or jewelry to prevent them from cutting off circulation to their hands and fingers. In these cases, it is necessary to have a ring cutter at hand in order to safely remove these personal items. Most importantly, a ring cutter can do this without harming the patient in the process.

39. 40. 41. and 42. Sphygmomanometers (infant, child, adult, large adult size)

A sphygmomanometer is a device used to measure a patient's blood pressure. Since it consists of a blood pressure cuff that is placed on the arm of the patient, it is important that an ambulance contain enough different sized cuffs to fit any sized patient whether they are an adult or a child.

43. Stethoscope

The stethoscope allows the paramedics to listen to the heart beat of the patient and to determine if certain anatomical structures are functioning correctly within the heart. Other sounds inside the patient's body may also be observed using a stethoscope.

44. 2 Large Plastic Bags with Ties

In the course of attempting to stabilize a patient and treat them, it may be necessary to discard some materials which may not be contaminated, such as wrappers for bandages or packaging for certain medical devices. For this reason, it is important to always have a few plastic bags with ties for them. It may also simply be necessary to have a bag in which to put the patient's belongings and personal effects.

45. Contaminated Trash Container

Not all trash generated in the ambulance may be safe to dispose of normally. Some may be contaminated and will have to be disposed of appropriately. In these situations, it is necessary to have a container specifically for trash that is unsanitary. In this way, the trash can be separated from typical waste materials and can be disposed of efficiently in the manner designated for such materials.

46. 2 Eye Shields

When attempting to stabilize or treat a patient in the ambulance, there may be a chance of contaminants coming into contact with the eyes of either the paramedics or the patients. In these situations, it is necessary to have eye shields in the ambulance which can be used to prevent injury to the eyes. They can also prevent the spread of contaminants from one person to another through contact with the eyes.

47. 6 Pairs Rubber Exam Gloves

When a paramedic is attempting to either stabilize or treat a patient in the ambulance, it is important to make sure that no contaminants are transmitted either from the patient to the paramedic or from the paramedic to the patient. One way that this could happen is through contact between the skin of the patient and the skin of the paramedic. This contact can be greatly reduced and often eliminated completely through the use of rubber examination gloves. Several pairs should be kept on the ambulance at all times.

48. Antiseptic Hand Cleaner

In order to maintain proper sanitation, it is necessary for paramedics to wash their hands before they attempt to stabilize or treat any patients on the ambulance. For this reason, it is important to have antiseptic hand cleaner on the ambulance at all times. By keeping the hands of the paramedics clean, the risk of contaminants being transmitted from patient to paramedic or paramedic to patient is greatly reduced.

49. Latex-Free Equipment

A large number of people have allergies to latex. For this reason, these patients cannot be treated by equipment with latex on it. Special latex-free equipment has been developed and must be carried on ambulances in case they encounter patients who have this allergy.

50. CPR Board

A CPR board provides a flat surface that is rigid which aids in the administration of CPR. It helps the paramedics correctly position the head and torso of the patient so that CPR may be performed efficiently and effectively on them when necessary.

51. Automatic Defibrillator

An automatic defibrillator is a device that can detect certain conditions in a patient's heart based on the rhythm of its heart beats and then administer electrical shocks as therapy to restore the correct rhythm of the different parts of the heart. This can stop cardiac arrest.

52. 2 Child and 2 Adult Epi-Pens

Epi-pens are necessary for patients with severe allergies to certain substances. The epinephrine in the Epi-pen can effectively avoid or treat anaphylactic shock. It is important to have these on an ambulance, as reactions to allergies must be treated immediately. If they are not, the patient may not make it to the hospital in time to receive proper treatment.

53. 30 Tablets Aspirin

Aspirin is a very simple yet effective pain killer. Due to the circumstances surrounding a patient's illness or injury, it may be useful to administer aspirin to the patient to help manage their pain and make them more comfortable.

<u>Additional Equipment</u>

1. Equipment to Gain Access

Before paramedics can treat patients, they need to be able to get to them. If a patient is in a car accident, the paramedics may need to clear through the debris of the accident. The patient might also be trapped in the car and need to be safely removed without exacerbating the injuries they already have. There are several other situations in which the patient may be difficult to reach.

Appendix C: Specifications for the Virgin Islands Medical Rescue Vessel

SCHEDULE A
AMBULANCE VESSEL FOR ST. JOHN, USVI
GOLD COAST 50A
DESIGN BRIEF

A custom-designed “state-of-the-art” composite catamaran ambulance vessel (Vessel) built for the U.S. Virgin Islands Department of Health (DOH) provides medical support and transportation for patients on the island of St. John as well as water-based emergency response to the entire St. Thomas - St. John District.

Amenities include a 260 sq ft. climate-controlled fully enclosed Patient Compartment with custom cabinets for supplies and equipment for four patients on stretchers and four or more EMT‟s. Equipment includes supplied oxygen, waste and sharps disposal, litter retention, ample storage, two sinks with „widespread‟ levers, padded seating for EMT‟s and more. The Captain‟s compartment is be separated from the patient treatment area and features excellent visibility in an elevated wheel house, deck entrance/ exit doors, remote engine controls, independent air conditioning, helm seat, cushioned seating for four passengers, complete marine navigation array, emergency frequency mobile radios, sirens, intercom and public address systems, compact refrigerator, closet and storage under helm as well as a bathroom with sink and toilet.

The Vessel is equipped with flashing emergency lights, Star of Life markings, scene lights for nighttime operations, a 6-person inflatable hard bottom dinghy with outboard engine and a rotating lift boom. Sound insulation and an automatic fire extinguishing systems with remote closing air vents are provided in the hulls.

Also included is a 3-ring binder Reference Notebook with instructions for the operation, care and maintenance of the vessel. The Notebook contains mechanical, electrical and plumbing diagrams and equipment manufacturer operation and warranty manuals.

SPECIFICATIONS

LOA 50‟
BOA 20‟2”
DRAFT 3‟
LIGHT SHIP WEIGHT 22,000 lbs
PATIENT CAPACITY 4 Stretchers plus 2 Body Boards
CREW Captain and 1 crew
EMT/PARAMEDICS 4 to 8
PASSENGERS 25 Total people (including patients) allowed on board
ENGINES 2 X QSB 425 hp
TOP SPEED 29.5 knots
CRUISE SPEED 26.5 knots
RANGE 331 KNM @ 20 knots, 780 KNM @ 10 knots
TANKAGE 2 X 125 gal. fuel, 1 X 100 gal. water, 1 X 35 gal. waste
STEERING Hydraulic
AC ELEC 13.5 KW Onan/Cummins generator, 2800/5000 Outback inverter
HVAC 18,000 BTU – helm, 48,000 BTU – patient compartment
ELECTRONICS Complete setup (see details below) p. 2/5

HULLS ANDSUPERSTRUCTURE

Construction:

Hulls, decks, roof and cabin built of Corecell foam, glass and CPD epoxy resin using resin infusion and vacuum-bag. All primary structural components and amenities built using West System construction methods.

Interior/Exterior Finish:

Dupont polyurethane paint over Dupont epoxy primer--commercial yacht finish

Paint & Graphics:

Gloss white hulls and superstructure
Reflective Blue Star of Life and Ambulance markings on exterior of cabin
Orange belt stripe with Blue pinstripe edges
2 - Coats of Micron 66 bottom paint – Blue

.

DECK FITTINGS AND EQUIPMENT

Cleats:

6 - 12" Stainless
6 - 18" S.S. rub strakes

Liferails/Posts:

2 - 1.5" aluminum cabin side rails
1 - 1.5" aluminum stern deck rail
2 - 1.5" aluminum upper deck rails
2 - 1.5" aluminum interior ceiling handrails
1 - 1.5" aluminum fwd seat guard/ handrail
3 - 1" Stainless Steel safety handrails

Deck Hatches:

4 - Bomar aluminum engine room access hatches
2 - Custom composite engine removal hatches
2 - Lewmar 50 hull access hatches

Windows/Doors:

13 - 3/8" tempered glass American Marine Windows, 2 of which open (one is in the head)
2 - American Marine locking helm station doors w/ windows
1 - American Marine extra wide sliding locking cabin entrance door w/ window
2 - Teak Isle interior doors

Steering and Rudders:

30" Edson Destroyer wheel, Hynautic H-41 hydraulic pump, Teleflex HC rams in series driving Bronze tiller arms
Custom composite rudders on 2" 316 Stainless Steel rod w/ UHMW bearings

GROUND / MOORING TACKLE/FENDERS

1 - FX 55 Fortress anchor, 15'-3/8" chain and 200'-3/4” rode, mounted and ready forward
1 - 44 lb Lewmar Claw anchor, 15'-3/8" chain and 200'-3/4” rode, stowed in aft hull.
1 - Stainless Steel Bow roller and 10” anchor cleat
4 - 50'-3/4" dock lines
4 - Scanmarin fenders
Full length commercial duty rub rail port and starboard
p. 3/5

ELECTRICAL

115 V AC

13.5 KW Onan/Cummins generator
Outback VFX 2812 inverter/battery charger
AC/DC Master panel with AC Source selector
Four 110V outlets in Patient Compartment
6 - flood scene lights
1 - 18,000 BTU HVAC
2 - 24,000 BTU HVAC

12V DC

2 - 8D house bank battery system
2 - 8D engine starting batteries
3 - Dynaplate ground plates
1 - Port and starboard bow light, sternlight, steaming and anchor lights
2 - Emergency flashing lights by Wheeled Coach
1 - 400,000 cp roof mounted search light
7 - Fluorescent lights for bathroom and hull interior
9 - LED Patient Compartment ceiling w/ dimmers
2 - Red/ White LED lights for Capt. station
3 - LED Courtesy lights
4 - 12V Receptacles
2 - Hella fans in engine room

Navigation and Communication System

2 - Raymarine VHF radios with intercom and PA horns
1- Raymarine E- Series 125 GPS, 2KW Radar, Chart plotter, depth sounder w/ multifunction display
1 - 4 ½” Hi Speed Compass
1 - Motorola 800 MHz emergency radio with repeater in patient compartment

PLUMBING

Piping:

Water supply hosing is rigid PVC, nylon and reinforced vinyl. PVC and nylon fittings.
1 - Henderson MKV emergency manual bilge pump
6 - Rule 1000 electric bilge pumps
2 - High water bilge alarm systems

Fresh Water System:

1 - 100 gal water tank w/ Jabsco Ultra Max pressure pump, accumulator and deck fill
1 - Sink spigot in head, 2 – „Widespread‟ spigots in patient compartment

Black Water System:
1 - 35 gal polyethylene black water tank w/ deck pump out discharge.

Toilet:
1 - Jabsco Flush Back 12V marine toilet, w/ Marelon thruhulls and seacocks

ENGINE
2 - QSB 425 hp Cummins diesels with ZF 280A straight drive transmissions, 4 bladed fixed bronze props, 2 1/4" Aquamet 22 shaft, PYI shaft seals. ETS electronic controls plus secondary electronic controls, 6" Vernatone wet exhaust, (2) 125 gal. aluminum fuel tanks with fuel filters. Copper fuel lines. Elec fuel sender and gauges. Instrument panel w/ oil pressure, water temp, alarms, tachometers and engine hour meters. Fixed FE-241 fire suppression system with manual pulls and air vent closure pulls located in helm station. Sounddown soundproofing. p. 4/5
ACCOMMODATIONS
Patient Compartment
Large rear sliding access door
260 sq ft patient compartment
High capacity independent control HVAC system
Custom cabinets
2 large cushioned squad benches double as storage for Life Jackets and oxygen
Space for four stretchers with ability to carry two more patients on boards
Removable stretcher retention devices lock into structural bonded floor plates
Four 110V outlets along cabin edges
Ceiling light dimmers
2 – 12V outlets
2 – full length ceiling handrails
Waste and sharps disposal compartments
Overhead oxygen supply system
Door to Captain‟s Compartment
Easy wash painted interior with wet deck drains

Captains Compartment
Interior Captain‟s Compartment entrance door
2 - Exterior entrance/exit doors
Elevated wheel house
Excellent peripheral window viewing
Primary and secondary engine controls
Custom helm station with dual helm seats, AC/DC electrical panel, Raymarine electronics, emergency 800 MHz mobile radio, VHF marine radio w/ intercom and public address system, spotlight, 2 - 12V outlet
Independent climate-control
Captains helm seat
Cushioned squad or passenger bench

Bathroom with sink and toilet
Stowage in open closet, under seats and in helm station
Private compact refrigerator for refreshments

VESSEL SAFETY EQUIPMENT/FEATURES
Three watertight bulkheads per hull
Composite construction provides positive buoyancy and makes vessel unsinkable.
1 - 24" Ring buoy (orange) w/ bracket
25 - Adult Type 1 PFDs
10 - Child's Type 1 PFDs
6 - Red hand-held flares
6 - Orange smoke hand-held flares
3 - 10 lb ABC (B II) Fire Extinguisher w/ holder
Watertight container (flares, flashlight & whistle)
Caribe 10X Dinghy w/ 15 hp outboard motor
1000 lbs+ lift boom
EPIRB
Star of Life and Ambulance graphics
Flashing emergency lights
PA system
Reference handbook

MISCELLANEOUS
Buckets, scrub brush, sponges, toilet paper holder, Oil/Garbage discharge plaques, teak trim
p. 5/5

Appendix D: Trip to Merrimack River USCG Station

On Wednesday April 13, 2011 the First Response Medical Catamaran team went on a trip to the U.S. Coast Guard Station at Merrimack River. The ability to achieve access to the USCG station was heavily based off the assistance of Commander Matthew B. Stuck, who we all thanked greatly for the help with our endeavor. The first part of the trip consisted of an interview with the Station Operation Petty Officer BM1 Benjamin Molnar, a USCG officer who works extremely close to the vessels stationed at Merrimack River. Following the interview, we were allowed access to one of the stationed 47-foot Motor Lifeboats, where we gathered further information and took numerous photographs. The interview questions were posed as follows:

<u>Specific Vessel Based Questions:</u>

1) What are the technical specifications of the recue vessels? (engine specs./storage areas)
    a. How often does the vessel need refueling?
2) What is the estimated manufacturing cost of this vessel?
3) What medical equipment is provided on the vessel for patient care?
4) How many distressed patients can this vessel handle?
5) How many crew members does it take to man the vessel?
    a. How many doctors/paramedics are included in this total?
6) What is the maximum cruising speed for this vessel in calm seas?
7) In what circumstances would this vessel be chosen over other methods of rescue? (e.g. helicopter/other vessels/etc.)
8) In what conditions is this vessel NOT optimal?
9) What about these vessels separates them from the other rescue vessels, and do it have any components that should be made standard in all similar vessels?
    a. Does it have any components that should be added?
10) Are there any specific aspects of the vessels that cause problems during rescues?

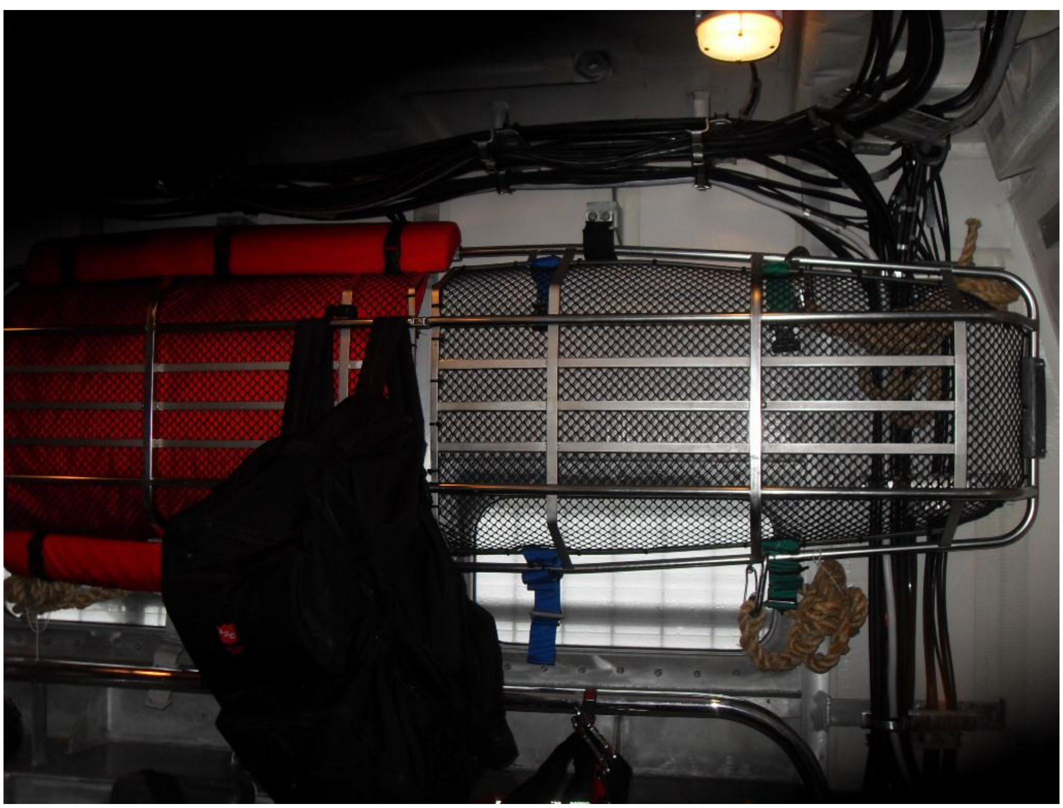
<u>General Questions:</u>

11) What is the protocol for incoming distress calls?
12) Other than the Coast Guard, who handles these calls?
13) What is the protocol for handling patients once they arrive on land?

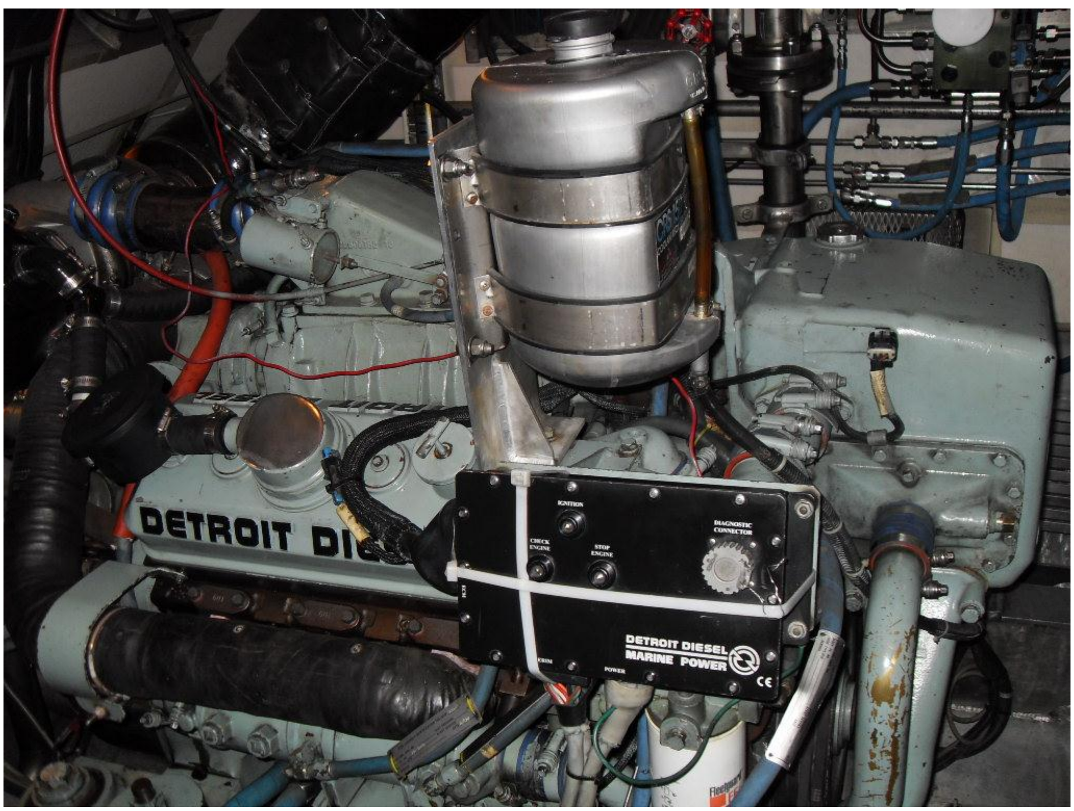
While several of the interview questions could not be effectively answered, most questions were quickly and assuredly answered, and can be seen in section 2.3.4. The photos from the vessel tour can be seen below.

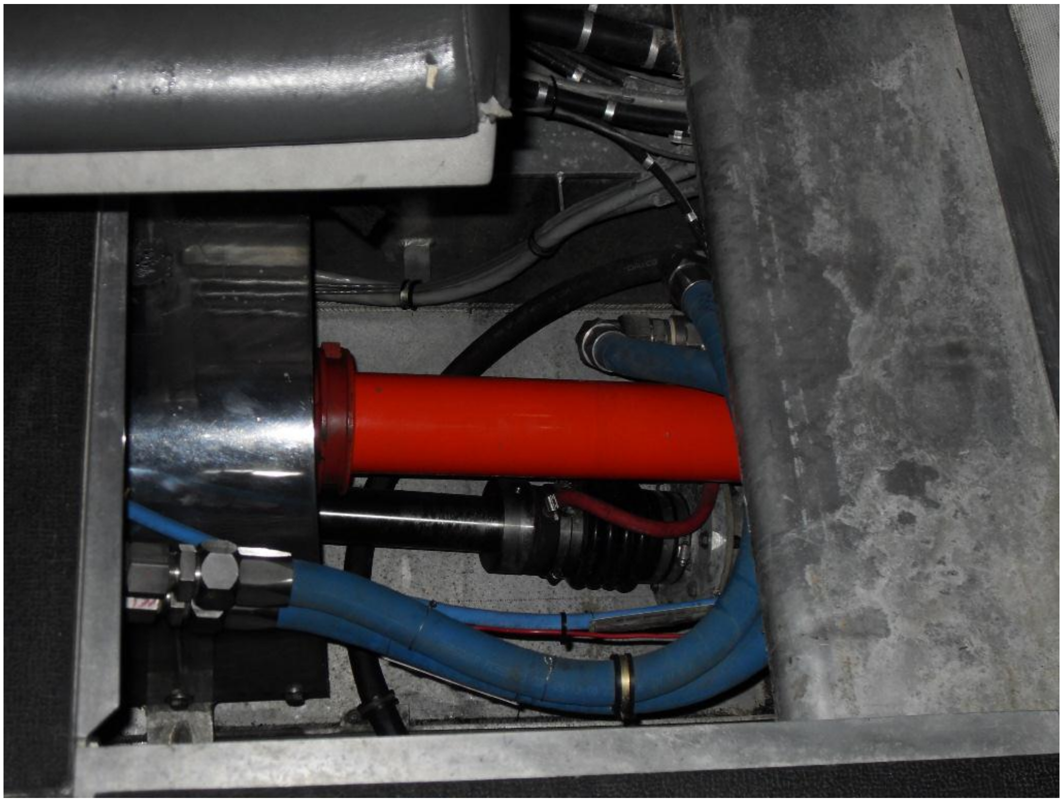

TOOLS
AIRWAY
WOUNDS
WOUNDS


WARNING
WHEN ALARM SOUNDS OR RED BEACON FLASHES
LEAVE THIS SPACE IMMEDIATELY
WHEN RED LIGHT ON ALARM PANEL IS LIT
DO NOT ENTER SPACE WITHOUT AUTHORIZATION AND
RESPIRATORY PROTECTION




TOOLS
AIRWAY
WOUNDS
WOUNDS


IGNITION
CHECK ENGINE
STOP ENGINE
DIAGNOSTIC CONNECTOR
DETROIT DIESEL
MARINE POWER




U.S. COAST GUARD


U.S. COAST GUARD


WARNING
WHEN ALARM SOUNDS OR RED BEACON FLASHES
LEAVE THIS SPACE IMMEDIATELY
AFTER ALL PERSONNEL ARE EVACUATED, SECURE THIS ACCESS
DO NOT ENTER SPACE WITHOUT RESPIRATORY PROTECTION
WHEN RED LIGHT ON ALARM PANEL IS LIT
DO NOT ENTER SPACE WITHOUT AUTHORIZATION AND RESPIRATORY PROTECTION
DO NOT ENTER IF WHITE LIGHT ON ALARM PANEL IS OUT
DANGER-NOISE HAZARD AREA
HEARING PROTECTION
MUST BE WORN

Appendix E: North Carolina Water Ambulance: Watercraft and Equipment Requirements

10A NCAC 13P .0210 WATER AMBULANCE: WATERCRAFT AND EQUIPMENT REQUIREMENTS

To be permitted as a Water Ambulance, a watercraft shall meet the following requirements:

(1) The watercraft shall have a patient care area that:

(a) provides access to the head, torso, and lower extremities of the patient while providing sufficient working space to render patient care;

(b) is covered to protect the patient and EMS personnel from the elements; and

(c) has an opening of sufficient size to permit the safe loading and unloading of a person occupying a litter.

(2) The watercraft shall have on board patient care equipment and supplies as defined in the "North Carolina College of Emergency Physicians: Standards for Medical Oversight and Data Collection," incorporated by reference in accordance with G.S. 150B-21.6, including subsequent amendments and editions. This document is available from the OEMS, 2707 Mail Service Center, Raleigh, North Carolina 27699-2707, at no cost. The equipment and supplies shall be clean, in working order, and secured in the vehicle.

(3) Water ambulances shall have the name of the EMS Provider permanently displayed on each side of the watercraft.

(4) Water ambulances shall have a 360-degree beacon warning light in addition to warning devices required in Chapter 75A, Article 1, of the North Carolina General Statutes.

(5) Water ambulances shall be equipped with:

(a) two floatable rigid long backboards with proper accessories for securing infant, pediatric, and adult patients and stabilization of the head and neck;

(b) one floatable litter with patient restraining straps and capable of being secured to the watercraft;

(c) one fire extinguisher mounted in a quick release bracket that is either a dry chemical or all-purpose type and has a pressure gauge;

(d) lighted compass;

(e) radio navigational aids such as ADF (automatic directional finder), Satellite Global Navigational System, navigational radar, or other comparable radio equipment suited for water navigation;

(f) marine radio; and

(g) the availability of one pediatric restraint device to safely transport pediatric patients under 40 pounds in the patient compartment of the ambulance;

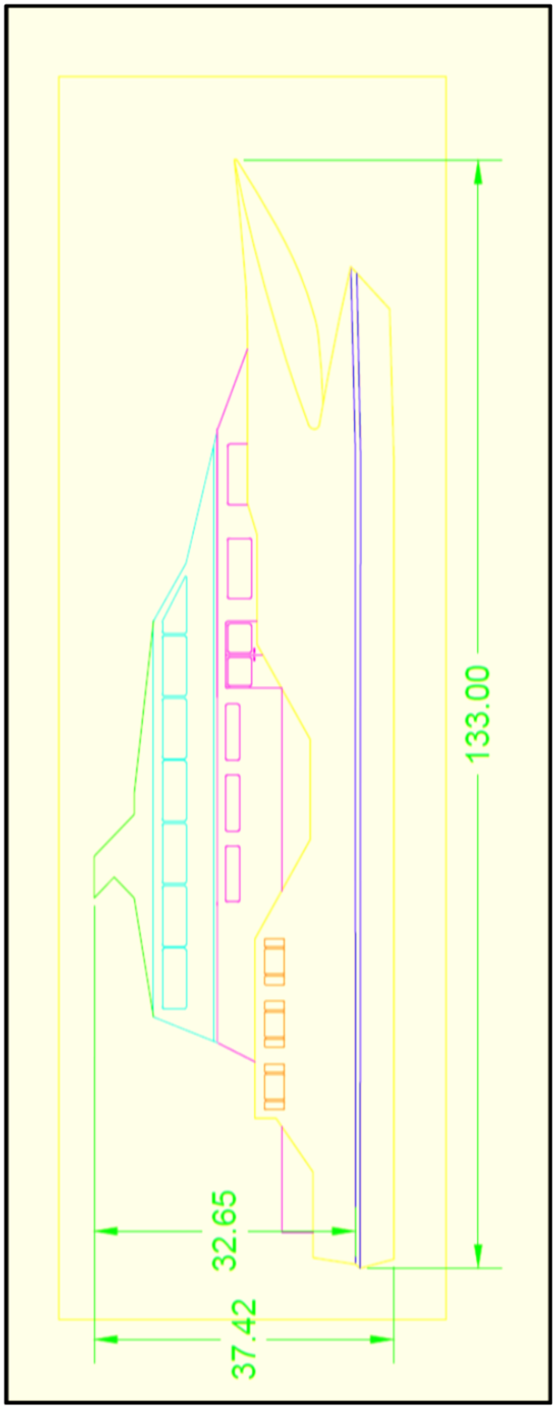
(6) The water ambulance shall not have structural or functional defects that may adversely affect the patient, the EMS personnel, or the safe operation of the watercraft.

(7) Water ambulances shall have a copy of the EMS System patient care treatment protocols.

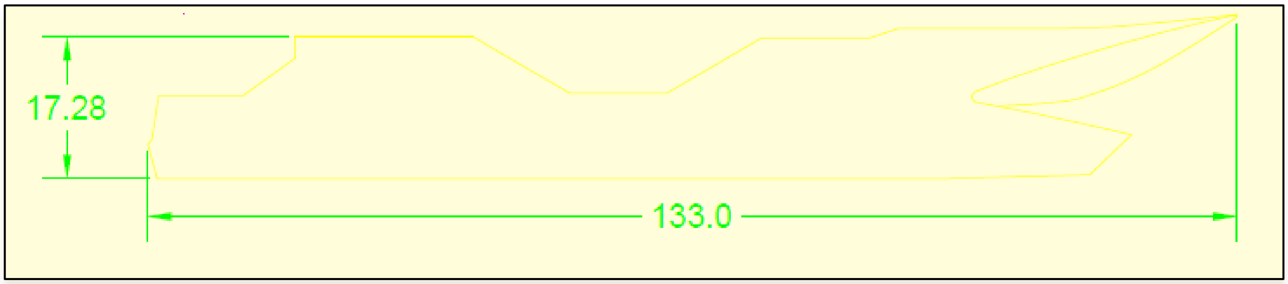
History Note: Authority G.S. 131E-157(a); 143-508(d)(8);
Temporary Adoption Eff. January 1, 2002;
Eff. April 1, 2003;
Amended Eff. January 1, 2009; January 1, 2004.

Appendix F: AutoCAD Drawings

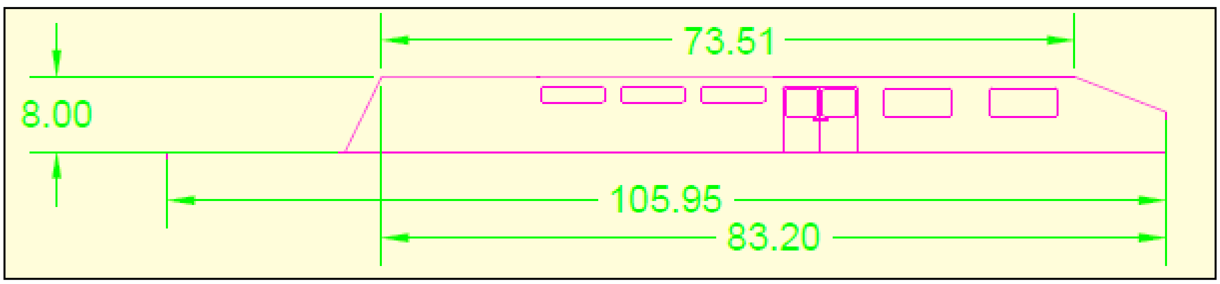
Side View - Full



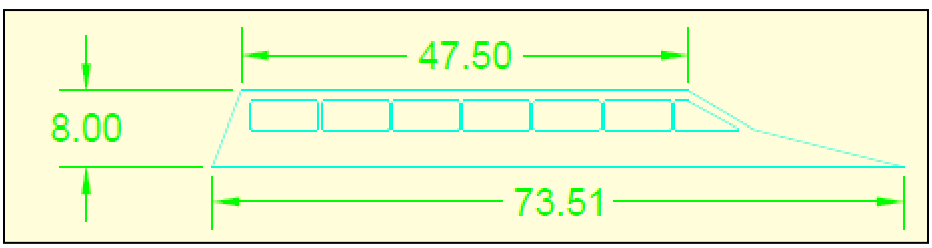
Side View - Hull



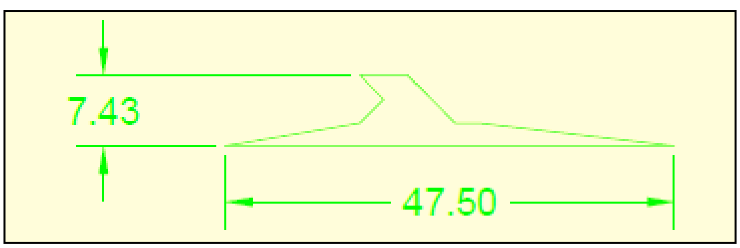
Side View – Medical Block



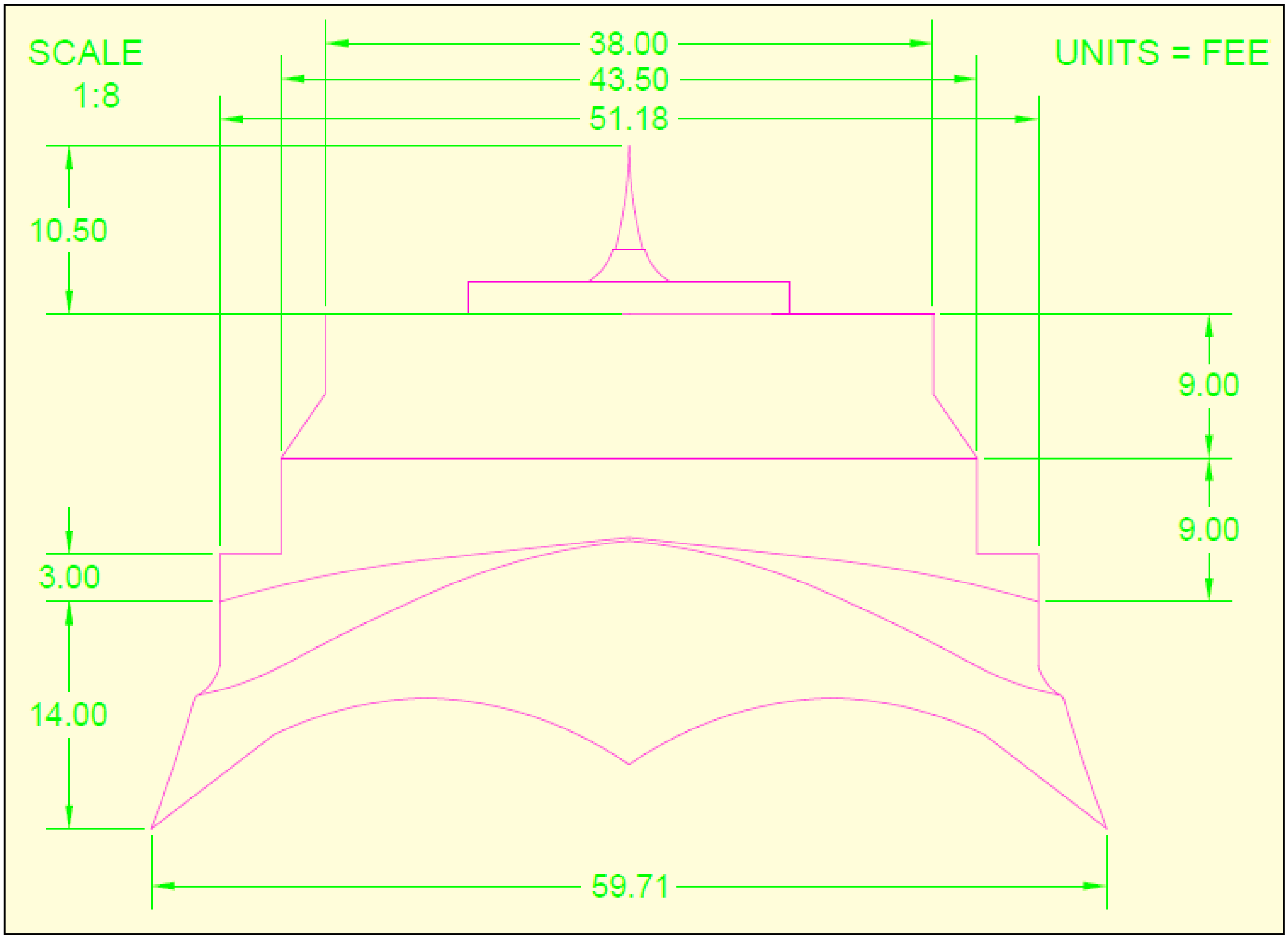
Side View – Bridge



Side View – Mast



Frontal View – Full



Medical Block – Full