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Technical Report

Use of Heavy Lift Ships as Modular Casualty Receiving Ships

By

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Abstract

The purpose of this report is to research and develop alternative uses for commercially viable heavy lift ships to employ as modular casualty receiving ships (MCRS). The concept revolves around a standard field hospital (FH) constructed or floated onto the deck of a commercially viable heavy lift ship for rapid deployment. Doing so eliminates the need for the U.S. Navy to construct or purchase a heavy lift ship, but rather lease any commercially viable heavy lift ship for a relatively short period of time. This concept is adaptable to any commercial heavy lift vessel configuration, and the feasibility of the proposed design will be shown through 3-D computer aided design software as well as space and weight analyses focusing on three different commercial heavy lift vessels.

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Nomenclature

EMT	Emergency Medical Technician
FH	Field Hospital
ICU	Intensive Care Unit
IMO	International Maritime Organization
MARPOL	Maritime Pollution
MCRS	Modular Casualty Receiving Ship
MCS	Mobile Causeway system
OR	Operation Room

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Introduction

Objective

The objective of this report is to explore the use of commercial heavy lift ships as Modular Casualty Receiving Ships (MCRS). This report will focus primarily on the architecture of the hospital aboard the heavy lift ship and omit the seakeeping attributes. A MCRS is more or less a floating field hospital (FH) comprised of modular ISO shipping containers. The concept is to place a FH on the deck of a commercial heavy lift ship to act as a temporary hospital in combat or disaster relief operations. This type of operation has the ability to be adapted to any type of commercial heavy lift ship.

Background

Commercial heavy lift ships typically have very large working deck spaces. These spaces can accommodate a large variety of cargo such as entire oil rig assemblies or entire ships as seen in Figure 1.

Figure 1: Heavy lift ships and payload

These ships can handle extraordinary loads and sizes. They have the ability to partially submerge beneath the water, "lift" their payload out of the water and transport it anywhere in the world. Their large working deck and payload capabilities make them excellent candidates for U.S. Navy operations. Since these vessels can adapt easily to many operations, the U.S. Navy would not need to build specialized ships saving money in the long term.

Three different commercial heavy lift ships have been chosen to meet the desired objective: the M.V. Black Marlin[1], CombiDock[2], and the Explorer[3]. These ships were chosen because they are representative of available commercial heavy lift shipping. The three ships chosen cover the following types:

- Open deck heavy lift ship.
- Combination product tanker and heavy lift ship.
- Specialist dock or yacht transport ship.

The M.V. Black Marlin, CombiDock, and the Explorer are common in the world of heavy sea lifting and transport; therefore, it is advantageous to study these three ships with the possibility of one being chosen to perform the FH mission. Table 1 lists the potential storage space of each ship and their respective weight capacities.

Ship	Length of Storage (m)	Width of storage (m)	Deck Area (m^2)	Weight Capacity of Deck (MTU)
M.V. Black Marlin	178.2	42	7484.4	57021
CombiDock	132.6	18.9	2506.1	9300
Explorer	117.4	25.2	2822.8	10763

Table 1: Heavy lift ship cargo capacity and dimensions

The M.V. Black Marlin has the largest open work area, no obstructions that would impede on the design of the FH. CombiDock contains two 350 metric ton cranes and one 200 metric ton crane as well as a 270.7 cubic meter liquid cargo tank. The three heavy lift cranes aboard Combidock can help move supplies and equipment while at sea. The liquid water storage tank within the hull of Combidock conserves deck space; extra water storage tanks on deck may not be needed. The Explorer has an open deck bounded by wingwalls and a stern door. The wingwalls and stern door adds protection from the elements.

Requirements

Listed below are provisions[4] required for a FH environment. The numbered provisions are followed by descriptions of how each provision may be achieved, and were derived from researching current Navy Hospital vessels, researching current land based field hospitals, and consultation with CISD engineers.

Physical Environment: Accommodation and hotel services.

1. Provision of accommodation and hotel services.
    - Accommodation for both casualties and medical personnel should utilize modified shipping containers due to their high strength, durability and seaworthiness for shelter while at sea. The layout of these containers will not be higher than one level as there are no spaces for elevators or equipment of that nature.

1.1. The ability to accommodate medical casualties
- Medical casualties must have their own designated units for accommodation and hotel services. Intensive care and recovery units will presumably accommodate a set number of casualties. Once a casualty is discharged, it is presumed they will be taken to another location off the ship.

1.2. Provision of accommodation and hotel services for medical personnel.
- Separate accommodations must be set aside for the doctors and other medical technicians while at sea. It is presumed no special treatment is necessary for this class of personnel, therefore lodging and other containers can be stacked in order to conserve deck space. Personnel can travel to other levels of containers by means of a simple stair infrastructure.

Physical Environment: Storage

2. Provision of storage
    - Storage should be containerized to be consistent with the total FH infrastructure. The FH can be modularized for easy loading and unloading at port.

2.1. Provision of accessible stowage for core Medical Equipment supplies, spare and equipment
    - Medical supplies will be stored within containers and have easy access for personnel to retrieve any supply required.

Physical Environment: Services

3. Provision of all medically required services e.g. electrical power, distilled and potable water; chilled water, fuel for machinery
    - Electrical power must be sufficient to power all electronic equipment utilizing one or more generators. Distilled, potable, or chilled water may be stored within the heavy lift ship water storage tanks. Fuel will be stored in separate tanks and placed onboard close to equipment requiring fuel.

3.1. Provide medical and surgical equipment
    - Medical and surgical equipment must be stored within the FH hospital component for quick access.

Physical Environment: Infrastructure

4. Provision of infrastructure
    - An infrastructure is needed to manage casualties, supplies, and communications within the MCRS.

4.1. Ability to receive general medical stores
    - In order to receive supplies from land, sea, or air, a designated reception area is needed. This area will manage the exchange of supplies on board the ship.

4.2. Provision of reception areas, wards, operating theatres, x-ray wards, support and staff facilities and ready use stores for medical applications.
    - These areas must be integrated within the FH for better operation with one or more units to accommodate casualties.

4.3. Provision of methods of recovering wounded and injured personnel from helicopters and landing craft. Internal transfer of personnel to medical facilities.
    - A helipad must be set aside (assuming permissible deck space) to receive casualties. An area for landing craft must also be set aside for quick, safe and easy discharge of casualties.

A MCRS must have an infrastructure where no part is isolated. All parts must work together allowing the operation to move smoothly and efficiently. Below are several basic requirements needed in a MCRS infrastructure.

Communications, NES/IS Environment

5. Provision of communications.
    - A communication center within the FH is needed for personnel to communicate with each other in day to day applications. Communication is also needed to communicate with the environment outside the FH to prepare for incoming casualties and supplies.

Transport capability

6. Provision of transport capability.
    - Vehicles are needed to move personnel, casualties and supplies within the infrastructure of the FH.

6.1. Ability to transport critically injured or wounded personnel, stores, and equipment to and from entitled units in the local area.
    - Vehicles must be relatively small, easily maintainable, and powerful enough to move various cargo. Ideally most of these vehicles would be electrically powered as to reduce noise, fuel consumption, storage, and pollution. However diesel may be used as long as it is universally utilized. For example, the same fuel that can be used for a fork lift can also be used for a generator. Consuming the same fuel conserves storage space.

Waste Management

7. Provision of medical waste management.
    - Medical waste must be handled and disposed of properly. Storage of medical waste is necessary until it can be removed from the ship either by various crafts or at port. Proper destruction may also be conducted onboard the ship alleviating the storage. This operation could be contained within a single container.

7.1. The ability to conform to relevant Maritime Pollution (MARPOL) and other anti-pollution regulations.
    - Pollution must be disposed of properly as set by various organizations. Pollutants include oil, noxious liquid substances in bulk, sewage, and medical waste.

7.2. The ability to safely handle, store and move liquid and solid hazardous medical waste.
    - Equipment and procedures are needed to handle and dispose of medical waste for disease prevention and sanitary purposes.

These requirements form the basis of the FH. A more comprehensive investigation on actual components comprising the FH are discussed in subsequent sections.

Concept Description and Evolution of Design

The objective of this study is to design a fully functioning mobile FH on the deck of a heavy lift ship. The configuration of the hospital is based on a standard army FH found in the FM 8-10-15 report[5]. This type of hospital can be mobilized relatively quickly to provide adequate medical care to soldiers in the field. The difference between land and sea based FHs is the aspect of area. Land based FHs have much more area to utilize, while sea based FHs have only a finite workable area useable, as in this case the deck of a heavy lift ship. The challenge at hand is to place a fully functioning FH onto the deck of a heavy lift ship where a finite amount of space is available.

In order to place a FH within the boundaries of the ships deck, the FH must be compact. To achieve this compact configuration while optimizing all useable space, the FH will comprise of 20 ft and 40 ft ISO shipping containers. The technology for these containers is developed since several manufacturers produce completely containerized hospitals for militaries and governments of the world. Using shipping containers would be advantageous because they are again compact and contain all the necessary equipment as well as service the need of the FH while maximizing the usable deck area.

The basic method of determining whether or not a FH is capable of operating onboard the deck of a ship is relatively straightforward. First the number of patients must be determined followed by the personnel that will cater, maintain, and assist the patients. The second component is the type and quantity of supplies needed to sustain a FH at sea. These supplies include food, water, medicine, blood, and fuel. The amount of these supplies is based on the number of patients and personnel within the FH. The third component is the type of services needed to treat patients such as operating rooms (OR), intensive care units (ICU), and emergency rooms. All these components combined will determine the footprint of the FH.

Once the footprint of the FH is developed, it is then placed onto the deck of a heavy lift ship to ultimately determine whether or not it will actually fit with in the bounds of the heavy lift ship deck. The process of placing a FH on board a ship is an iterative process. Multiple iterations are performed in order to fully optimize the deck space of a heavy lift ship while maintaining the ability to treat a high number of casualties for days without resupply.

There are two methods for placing a field hospital aboard a heavy lift ship. The first method would place the FH directly aboard the deck of the heavy lift ship and secure it. The second method would use an intermediary platform made of assembled mobile causeway system (MCS) units or barges. The FH would be placed and secured to MCS units or barges and then floated onto the deck of a heavy lift ship to be secured and remain for the duration of the mission.

MCRS Components

Figure 2: Containerized FH[6]

The FH as seen in Figure 2 is comprised completely of a combination of 20 ft and 40 ft ISO shipping containers. Supplies, food storage, water storage, accommodations, etc. are also comprised of ISO shipping containers. These shipping containers can suit many different needs for a ship based FH. Utilizing standardized shipping containers allows the FH to be modularized, adding flexibility in the layout of the hospital. Modularizing a hospital allows for easier modifications to the design arrangement, while maintaining a dense compact layout. Utilizing 20 ft and 40 ft ISO containers allows for ease of loading the shipping containers onto the deck since most ports can handle 20 ft and ft 40 ft ISO containers; however, if a port can only handle 20 ft ISO shipping containers then the 40 ft ISO shipping containers may be replaced with two 20 ft ISO shipping containers operating side by side mimicking a single 40 ft ISO shipping container.

Figure 3: Three in one 20 ft ISO shipping container[7]

Several 20 ft ISO shipping containers have added features as displayed in Figure 3. The container in Figure 3 is classified as a “three in one” container. The container can expand from its sides allowing for more space within a 20 ft ISO shipping container. This container can be loaded onto the deck unexpanded allowing it to be handled normally as a standard 20 ft ISO shipping container. But once on deck and secured, the sides are expanded maximizing the space within the 20 ft ISO shipping container. If more space is needed than provided by the three in one container, several 20 ft ISO shipping containers can be combined into one large unit as seen in Figure 4.

Figure 4: Three containers connected together[7]

Placing several containers close together and removing one of more sides allows the space within each container to be expanded creating essentially one large unit. Several manufacturers utilize this technology to provide a variety of services for the FH[7].

Based on information collected from various FH manufacturers and in the FM 8-10-15 report several medical facilities have been evaluated that will suit the mission of the FH on deck of a heavy lift ship. These options are the basis for FH operations, and are required for the treatment of patients. The medical facilities include the following:

- Blood bank
- CT/MRI Scanner
- Dental
- Emergency triage
- Intensive Care Unit (ICU)
- Laboratory
- Patient Wards (WARDs)
- Pharmacy
- Sterilization
- Operating room (OR)
- X-Ray

For the purpose of this study it is assumed each Emergency triage and ICU can treat a maximum of 6 patients at once and each WARD can treat a maximum of 12 patients at once. These assumptions help determine size of the FH during the layout phase of the heavy lift ship deck.

In order to support and maintain the medical facility, several support facilities are needed. The support facilities will help sustain the medical facilities in their day to day operation and will not provide medical treatment. They are needed to supply accommodations, order, power, food, water, and fuel to the FH. The support facilities include the following:

- Accommodations (Personnel)

- Administrators
- Communications
- Dining/Recreation
- Fuel Storage
- Food Storage
- Helicopter pad
- Kitchen
- Laundry
- Medical/Mechanical Maintenance
- Medical/Miscellaneous Storage
- Oxygen Storage
- Patient Process Center
- Power Generation
- Shower/Toilets
- Solid Waste Storage
- Water Treatment/Storage

Both the medical facility and support options can vary in quantity. That is not to say that there should be multiple ISO containers for each option, but rather only necessary to the mission requirements based on the number of patients and personnel. Ideally all of the medical facilities can be contained within 20 ft ISO containers with several that can expand from their sides. Details of the interior layout of the medical and support facility options can be found in Appendix A. The following sections will elaborate upon the support options listed.

Accommodations, Shower/Toilets, and Laundry

In order to determine the amount of accommodations required, the number of personnel must be determined first. The number of crew is based on a ratio of the maximum amount of patients treatable as found in Appendix B. Research into the accommodations of personnel was provided by Jennifer Gardner. Jennifer found a maximum of 20 personnel can live in one 40 ft ISO shipping container. However if loading equipment at port is not efficient in handling a 40 ft ISO shipping container, two 20 ISO shipping containers may be used as a substitute for one 40 ft ISO shipping container so long as each container can accommodate 10 personnel. Adjacent to each accommodation container will be a shower and toilet unit. This unit also consists of 40 ft ISO shipping containers, but again can be broken into two 20 ft ISO shipping containers if needed. Laundry facilities are needed for both patients and personnel. The same laundry facility can facilitate both patients and personnel needs. Patients will typically have more laundry than personnel and must have their belongings washed more frequently than personnel. However personnel must wash their belongings at least once a week[5].

Administrators, Communications, and Patient Process Center

The administrators will consist of service men and women who will handle non-medical day to day operations of the FH. These operations may include patient documentation and managing supplies. They are able to coordinate and potentially order staff on any of the operations within the FH. These individuals only need one to two 20 ft ISO shipping containers relative to the size of the FH. Communications must be maintained within and outside the FH. Communications are critical within the FH as a means to establish and maintain connections and equipment in and around the FH. Personnel in this section will coordinate patient reception from outside sources such as helicopters and other craft. The patient process center will be the first section of the FH a patient will visit. There they will be directed to the appropriate area of the hospital for treatment as well identified for clerical purposes.

Kitchen, Dining/Recreation, and Food Storage

The kitchen provides meals for both the staff and patients. The staff should be provided three meals a day while patients should be provided up to four meals a day for nutritional purposes. Adjacent to the kitchen will be the dining/recreation center. Here staff can gather and consume the meals prepared for them. They will eat in the dining area in multiple shifts as it is more sensible than fitting the entire staff into a much larger dining area. Other events for the staff can be held there since it is an appropriate common location for staff to gather. The food storage will be adjacent to the kitchen. Food storage adjacent to the kitchen will allow for better access of food supply for the kitchen staff and reduce the time of retrieval.

Helicopter pad

Of the three heavy lift ships this study acknowledges, zero have their own helicopter landing pad; therefore, area on the deck of the heavy lift ship must be set aside to accommodate helicopters. The size of the helicopter pad was determined by choosing a standard U.S. Navy helicopter, the Sikorsky CH-53E Super Stallion. At a length of 99 ft (30.2 m) and a rotor diameter of 79 ft (24.1 m), the CH-53 is one of the largest helicopters the U.S. Navy owns and operates today[8]. The area and configuration of the helicopter landing pad was determined based on the document provided by the International Maritime Organization (IMO) and the overall dimensions of the CH-53. The document clearly indicates the appropriate size for a helicopter pad as seen in Figure 5.

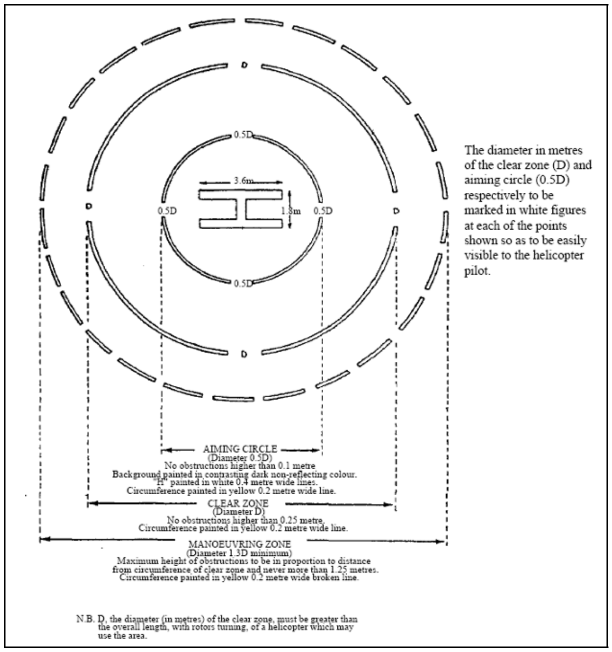

Figure 5: Helicopter landing area[9]

The landing circle has a diameter of 46.9 ft (14.3 m), the clear zone has a diameter of 96.5 ft (29.4 m), and the maneuvering zone has a diameter of 126.18 ft (38.5 m). These dimensions also meet acceptable NAVAIR requirements[10]. Choosing such a large helicopter allows for other smaller helicopters to land safely within the bounds of the helicopter landing area.

Power generation and Fuel storage

According to the FM 8-10-15 report, a 503 patient FH with a staff of 428 personnel will consume on average 1384kW of power daily[5]. In order to sustain that amount of power usage one or multiple generators are needed.

Figure 6: Generator[11]

The generator pictured in Figure 6 can produce a maximum power of 1500 kW and a continuous power of 1125 kW[11]. The entire generator is self-contained within one 20 ft ISO shipping container. Since the generator will not be operating at maximum power for the duration of the mission the continuous power consumption is a more accurate number to base power output. For the FH mentioned in FM 8-10-15 a minimum two generators are needed to provide adequate power. This generator model also contains a 180 gallon fuel tank for diesel, which is not large enough to sustain power for several days. In order to sustain the FH for the entire operation additional fuel storage is required. The fuel storage estimation was based on the fuel consumption of the generator and the duration of the mission. Fuel storage will be 20 ft ISO shipping containers since FH will be comprised of same size containers.

Medical/Mechanical Maintenance

The medical and mechanical maintenance facilities are two separate entities. The medical maintenance facility will maintain and repair any medical related equipment such as a MRI machine. They are limited to only equipment within the hospital. The mechanical maintenance facility will maintain and repair all other mechanical equipment such as a generator. They are not limited to only repairing hospital equipment.

Oxygen, Solid Waste, and Medical/Miscellaneous Storage

As stated in the FM 8-10-15 report, oxygen is required for OR table hours, ICU beds on vent, and emergency medical technicians (EMT). Oxygen is a critical supply and many units must be stored for the hospital to sustain itself while operating at sea. Oxygen will be stored in 680 liter cylinders to serve the patients and instruments within the FH[12]. These 680 liter cylinders are placed into 20 ft ISO shipping containers for storage during the mission and retrieved when demanded[13].

Solid waste would encompass waste from both patients and staff with patients producing more solid waste than the staff. Infectious waste is one of the largest amounts of waste produced in a FH on average 1,512 lbs per day of waste produced by a FH consisting of 503 patients and 428 personnel[5]. Since this hospital will be operating at sea, eliminating the solid waste is a concern. The solid waste cannot be discarded into the sea for ecological and sanitary reasons; therefore, the solid waste must be stored onboard the ship in 20 ft ISO shipping containers until it can be removed and disposed of safely or destroyed on board the heavy lift ship.

In order for the FH to operate remotely, various types of medical supplies must be stored on board the heavy lift ship. Storage space must be allocated for medical supplies and must be placed within the FH configuration to allow staff personnel to retrieve any desired item which could include sheets, syringes, gauze, etc. Other storage units not utilized for medical supplies can be placed anywhere space is provided. These containers could hold items such as spare parts, cleaning supplies, personal effects, and other unmentionables while on mission. Keeping the standard of the FH configuration, these storage containers will be 20 ft ISO shipping containers.

Water Treatment/Storage

Water is the most essential cargo consumed by the FH. Water treatment facilities would be used to convert waste water and sea water into clean usable water. Treating the water directly on board the ship will free up more space than having many more storage containers of water. The treatment facility researched is self-contained within one 40 ft ISO shipping container and can produce 33,000 gallons of fresh water per day[14]. However, water storage tanks will be needed as long as the heavy lift ship does not contain a separate tank within its hull for water storage. Water storage tanks ideally are 20 ft ISO shipping containers, keeping in line with the standard container size for the FH.

Hospital fixture methods

Two methods of bringing a field hospital aboard a heavy lift ship were explored. The first method is to have the entire hospital assembled on the deck of the heavy lift ship. This can be achieved through various means of deck fixtures. The second method is to have the FH assembled on a floating platform and floated on the deck of the heavy lift ship. This method could employ the same type of deck fixturing as in first method aboard the floating platform.

Deck fixtures for shipping containers

In order for the FH to keep itself from shifting while at sea it must be fixed to the deck of a heavy lift ship in some manner. One method places the shipping containers aboard the deck and weld them in place to the deck of the heavy lift ship. Another way would utilize twistlocks to secure the FH to the deck.

Fixed Fittings (attached to ship)

DESCRIPTION	PURPOSE	IMAGE	NOTES
Flush Socket	Locating of base twistlocks or stacking cones in the cargo hold.		Normally fitted over a small recess to ensure watertightness. Clean and remove debris before use.
Raised Socket	Locating of base twistlocks or stacking cones on deck.		Clean and remove debris before use.

Figure 7: Means of securing shipping containers[15]

Examples of standard fixed fittings are presented in Figure 7, and must be welded precisely on deck for all four corners of the shipping container to be secured in place using twistlocks. The advantage of this system would allow units to be changed or replaced easily without welding and rewelding the container to the deck. These fixtures are not limited to the M.V. Black Marlin, CombiDock, and Explorer.

Mobile Causeway System (MCS) and Barges

If the heavy lift ship were not to arrive for a lengthy period of time, but must leave shortly after arriving to conduct the mission, the FH could be loaded on to a mobile causeway system (MCS) or a barge and floated to the heavy lift ship. A MCS is comprised of two different size modules as depicted in Figure 8.

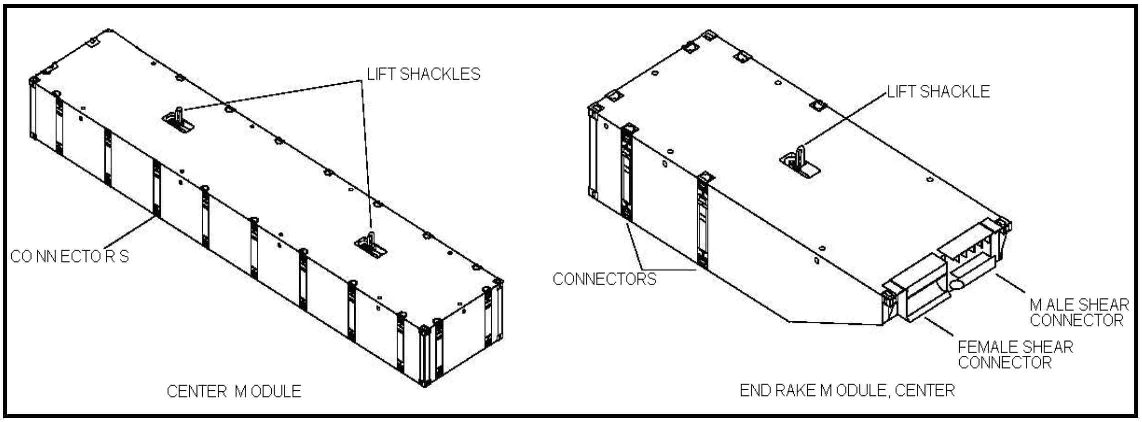

Figure 8: MCS sections[16]

The center module in Figure 8is 8 ft (2.4 m) wide, 40 ft (12.2 m) long, and has a depth of 4 to 6 ft, and the end rake module is 8 ft (2.4 m) wide, 20 ft (6.1 m) long, and has a depth of 4 to 6 ft (1.2 to 1.8 m). These two modules are assembled using built in connectors to form multiple sections providing the desirable working area. When assembled these units have a deck bearing capacity of 5000 lb/ft^2 [16].

A FH could be assembled on either barges or on a MCS system before the heavy lift ship arrives. This way the FH is assembled and prepared for rapid deployment and installation. Once the heavy lift ship arrives the entire assembly can be floated out to the deck of heavy lift ship and secured.

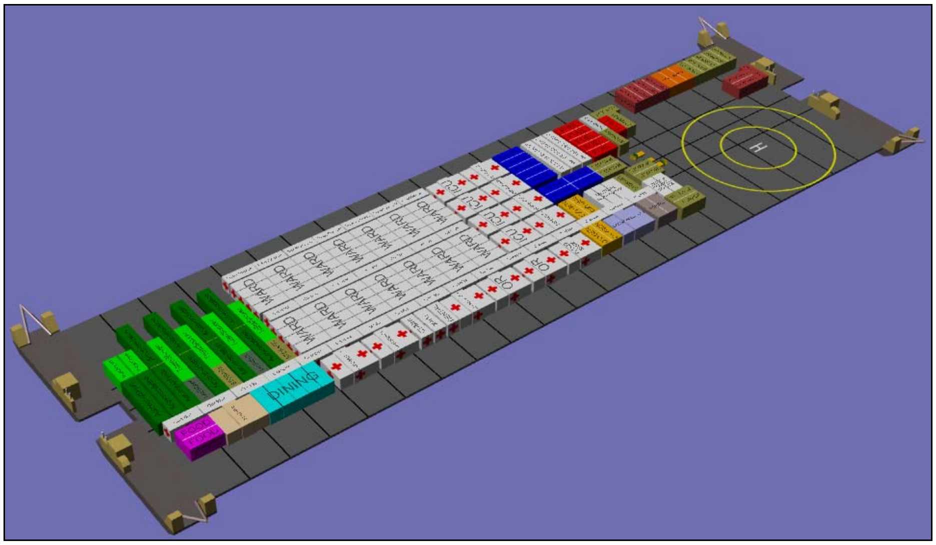

Figure 9: FH on MCS

Figure 9 depicts one example of a FH aboard an MCS for the M.V. Black Marlin. On four corners of the MCS are warping tugs. The warping tugs act as a dynamic positioning system since the MCS inherently contains no alternate type of dynamic positioning system. They also move the MCS and its cargo from one location to another.

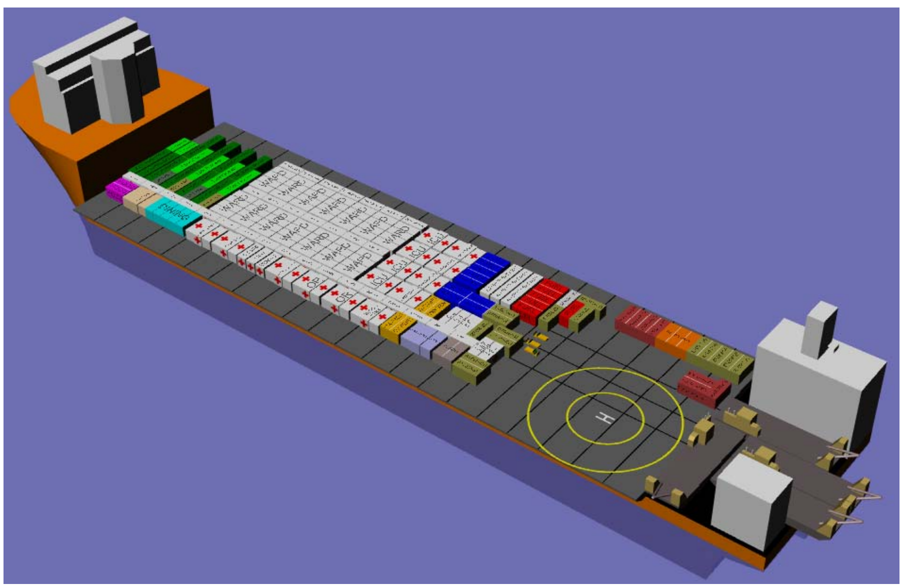

Figure 10: MCS on M.V. Black Marlin

Figure 10 displays the MCS FH aboard the M.V. Black Marlin after deballasting process. The warping tugs can be stored on the stern of the M.V. Black Marlin if the mission for the FH is to float off the deck of the M.V. Black Marlin after reaching the desired mission location. This way the M.V. Black Marlin is utilized for a shorter period of time, merely for transporting the FH.

Barges could also be used as a substitute to the MCS. If the MCS is unavailable, flat deck barges can easily replace the MCS. One example of a particularly useful barge is one supplied by Norfolk Barge Company. A typical barge supplied is 12.192 × 6.096 × 1.219 m with a flat top weighing 25.85 MT and can support a weight of 22.7 MT[17]. Within the body of the barge are tanks for storing potable water. This is beneficial when deck space is at a premium and water storage necessary.

The advantages of the MCS and barge system are efficient use of construction time before a heavy lift ship arrives, increased deck space, and the ability to store water within their structures. A disadvantage to both options are their sea keeping abilities. Both systems have a small window of allowable operation, operating in low sea states or in sheltered waters when not aboard a heavy lift ship.

Total Ship Model

The total ship models are a representation of possible MCRSs created using the 3-D CAD package Rhinoceros® for the M.V. Black Marlin, CombiDock, and Explorer ships. The purpose of these models is to provide a vision of what a MCRS could look like. Producing these CAD models also demonstrates the size and configuration of the FH. Each component of the FH is labeled within the CAD model for immediate recognition and colorized to distinguish from one unit to another.

M.V. Black Marlin

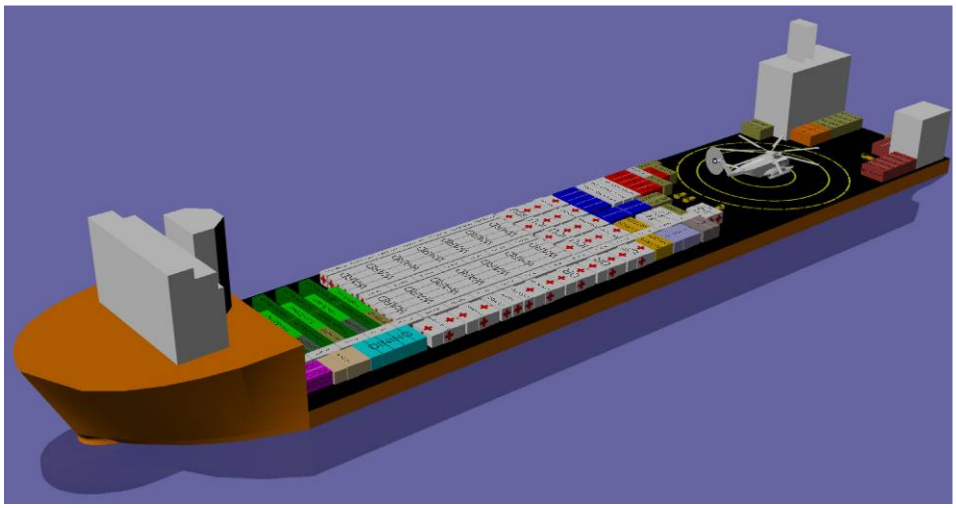

Figure 11: M.V. Black Marlin

FH Requirements	*Input*
Number of Patients (Total)	216
Number of Surgical Cases	24
Number of Bed Patients (ICU)	24
Number of Minimal Care Patients	100
Number of Decontamination Cases	10
Number of Staff	185
Number of Days	10
Generator power output (Continuous kilowatts)	1125
Generator fuel consumption (gph)	104
Daily power requirement (kW)	599

Table 2: FH inputs for M.V. Black Marlin

The M.V. Black Marlin FH requirements are chosen as the basis of all subsequent models due to its large size and large open deck space. The FH shown in Figure 11 is only one level high. The one level eliminates the need for an elevator system to move patients in and around the FH. Stairs are also eliminated so patients do not need to use them to move within and around the FH. The accommodations may have the option of having stairs since able body personnel can move much easier than a patient, but for ease of construction, design, and possible sea keeping advantages the FH is best at one level. The FH is also fully enclosed through a network of corridors. Having the hospital enclosed keeps the elements away from the patients and personnel.

Aboard the M.V. Black, as pictured in Figure 11 is a 216 patient, 185 personnel fully functioning FH. Table 2 lists the main requirements for the FH. The numbers listed in Table 2 will affect all supplies and equipment which are dependent on those values. Additional figures and detailed calculations are shown in Appendix B and C for the M.V. Black Marlin.

FH Component

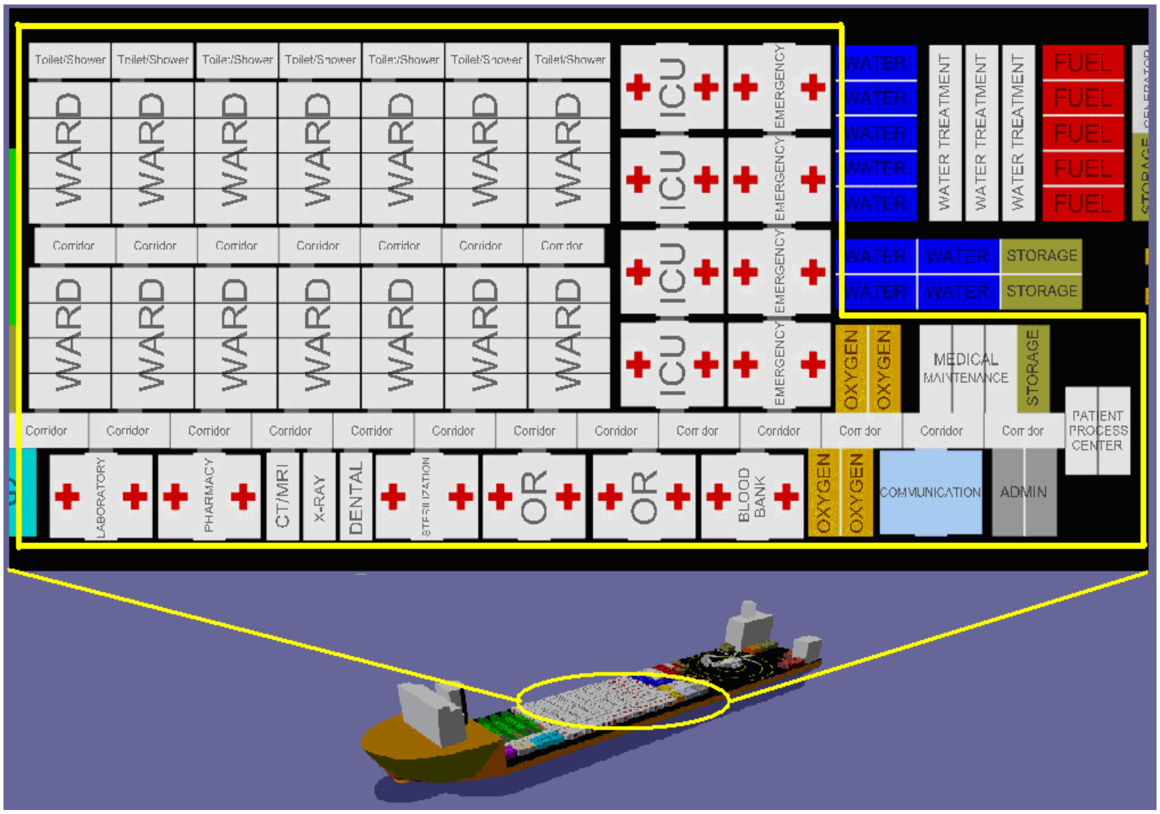

Figure 12: FH aboard M.V. Black Marlin

The hospital aboard the M.V. Black Marlin is capable of treating 216 patients/day for 10 days, and its layout is shown in Figure 12 within the yellow lines. The list of the medical units is found in Table 3.

Hospital Components	*Quantity*	*Hospital Components*	*Quantity*
Administration	1	WARD	14
Blood Bank	1	Patient Process Center	1
Communication	1	Pharmacy	1
CT/MRI Scanner	1	Sterilization	1
Dental	1	OR	2
Emergency triage	4	Oxygen Storage	4
ICU	4	Storage	1
Laboratory	1	Toilet/Shower	7
Medical Maintenance	1	X-Ray	1
		*Total Units**	*47*

Table 3: Quantized list of hospital components for M.V. Black Marlin

The patient will enter the hospital through the patient process center first. There the patient's condition is quickly evaluated and the patient is sent where needed. Nearby the entrance is the emergency triage unit of the hospital where the patient is first treated. Having the emergency triage close to the entrance will allow patients to be treated faster than rushed to the other side of the ship for treatment. Adjacent to the emergency triage unit is the ICU. Critically injured patients can be rushed quickly and easily from emergency triage to the ICU for treatment. If a patient is evaluated and determined to need surgery, the OR's are across the corridor from both the emergency triage and ICU. Two ORs are listed due to the high number of patients that can be treated. Oxygen and blood bank storage are in close proximity to the OR and emergency triage units for easy access for surgeons and doctors. All general care for patients will take place within the WARDs. There patients can continue to receive treatment in the largest section of the hospital. Seven of the 14 WARDS receive a toilet/shower unit and must share it with the other seven WARDs, two WARDs per toilet/shower unit. Each shower/toilet unit has multiple showers and toilets to accommodate more than one individual. As for the laboratory, pharmacy, CT/MRI, X-Ray, dental, and sterilization units, they are further away from the entrance of the hospital as they are least busy sections of the hospital. Their location serves those treated in the WARDs better than the ICU or emergency triage units. The administration, communication, and medical maintenance facilities are located at the entrance of the hospital as a means to process incoming and out going patients quicker.

Personnel Accommodations Component

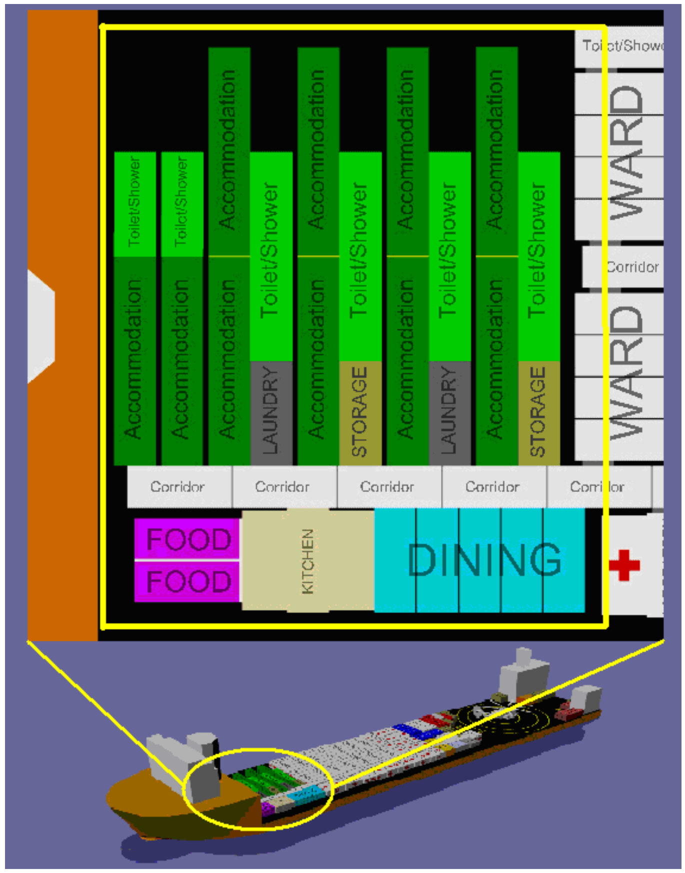

Figure 13: Personnel Accommodations Component for M.V. Black Marlin

One hundred eighty five personnel and staff are housed within the yellow rectangle in Figure 13. To the left of the yellow rectangle encompassing the accommodations section of the FH in Figure 13 is the forward section of the M.V. Black Marlin, and to the right is the hospital section. A summary on the number of components within this section are listed in Table 4.

Personnel Components	***Quantity***
Accommodations	10
Dining	1
Food Storage	2
Kitchen	1
Laundry	2
Storage	2
Toilet/Shower	6
*Total Units**	24

Table 4: Quantized list of personnel components for M.V. Black Marlin

Two of the ten accommodation units are not connected because they will house higher ranking officials or special guests. Each of those two units receives its own toilet/shower unit for added convenience and privacy. The other eight accommodation sections are connected to each other as a means to maximize deck space each housing twenty personnel. Having the accommodations connected together allows the toilet/shower unit to be shared evenly with both accommodation units. With this configuration there is enough space left for laundry and storage units. The laundry units serve the entire FH. According to a laundry machine manufacturer specification, two laundry units appear to be sufficient for the FH[18]. The storage units provide storage for hospital supplies and/or personnel supplies contained within the confines of the FH. The kitchen unit serves both the patients and hospital personnel. Its proximity to the WARDs and across from the personnel accommodation section allow meals to be delivered quickly to patients housed within the WARDs as well as quickly feed the personnel accommodation section. Naturally the dining area is in very close proximity to the kitchen as well as the food storage for easy access. The dining area is across from the accommodation unit and will only sustain hospital personnel. It is assumed that patients will eat at their bedsides rather than inside a dining facility.

Entry and main storage Component

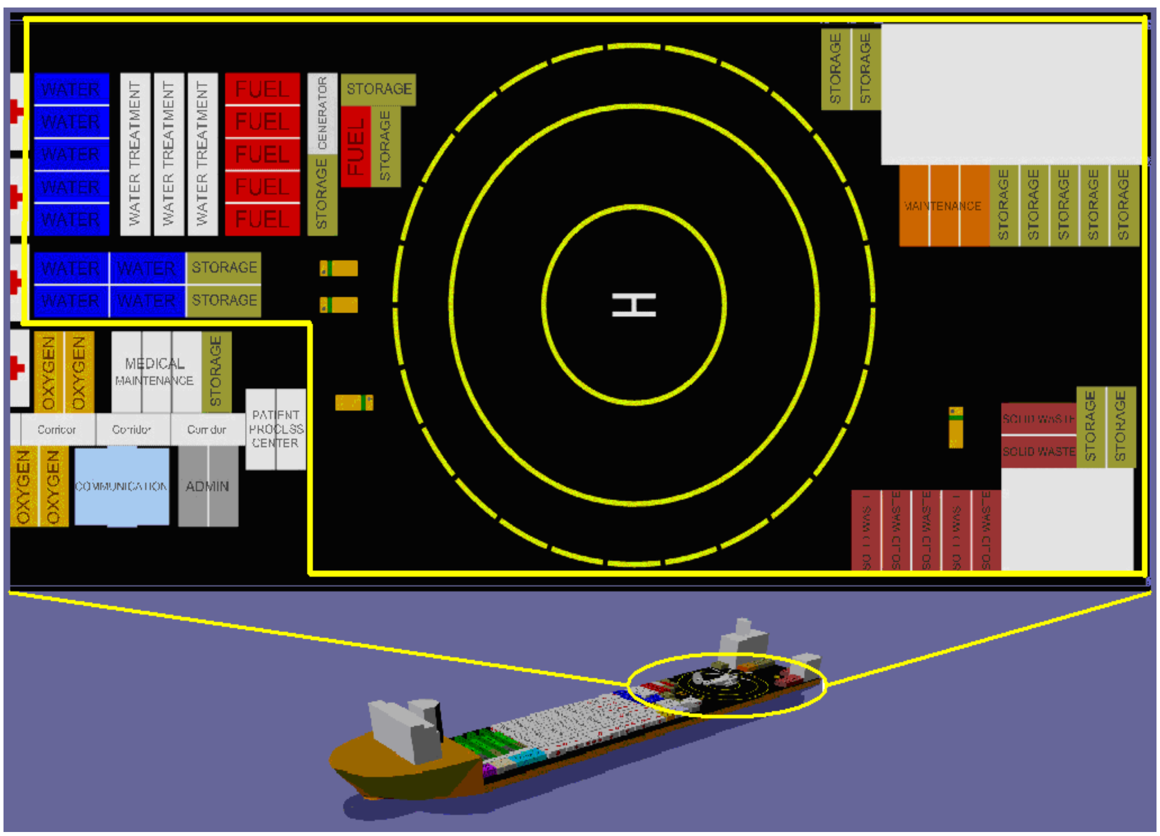

Figure 14: Entry/Main storage section for the M.V. Black Marlin

Positioned on the stern of the M.V. Black Marlin are two buoyancy towers shown in the right side of Figure 14. These towers can be removed if needed to add more storage capacity; however, removing them would add more time and cost to the FH preparation.

Since the deck of M.V. Black Marlin is large, small electric vehicles may be of service to maneuver around the FH swifter.

Figure 15: Electric Vehicle[19]

These electric vehicles pictured in Figure 15 are small, durable, quiet, and non-polluting. They may aid in the transport of patients from a helicopter or from a small craft to a desired location within the hospital. They may be used to shuttle maintenance equipment or supplies in and around the FH. These vehicles are small enough that multiple vehicles could be placed in a container for storage and retrieval. A summary on the other components within this section are listed in Table 5.

Entry/Main Storage Components	***Quantity***
Fuel Storage	6
Generator	1
Maintenance	1
Solid Waste Storage	7
Storage (Miscellaneous)	14
Water Storage	9
Water Treatment	3
*Total Units**	42

Table 5: Quantized main entry and storage components for M.V. Black Marlin

All the shipping containers in Table 5 are on the same level of the deck on the heavy lift ship. This arrangement is in accordance with the remaining FH. If the storage or other shipping containers where stacked on top of each other then extra equipment would be needed to retrieve supplies. Several storage and equipment facilities must be placed in proximity to each other. Fuel storage is placed in close proximity to the generator and water treatment facilities as they will be the largest consumers of fuel. Table 5 displays only one generator is required; however, a second generator can be added as an auxiliary. Water storage is placed near the water treatment facility allowing for easier access to place usable water generated into storage, assuming the M.V. Black Marlin does not contain potable water storage tanks within its hull. Water treatment was chosen over all water storage due to space requirements. It was estimated that 71, 20 ft ISO shipping containers, of water are needed for a 10 day mission. This number is too high and would reduce the size of FH limiting the patients and personnel available; therefore, a water treatment facility is a viable and practical option. One maintenance facility made of three combined 20 ft ISO shipping containers provides all non-medical maintenance. Solid waste storage is placed at the aft of the ship to limit the interaction between the solid waste and the FH. This placement keeps the FH more sanitary and less likely to be contaminated. If needed the solid waste can be easily removed from the ship to be disposed of properly while not interfering with hospital activities. In the aft portion of the deck, storage containers can be placed wherever possible to satisfy the needs of the mission.

CombiDock

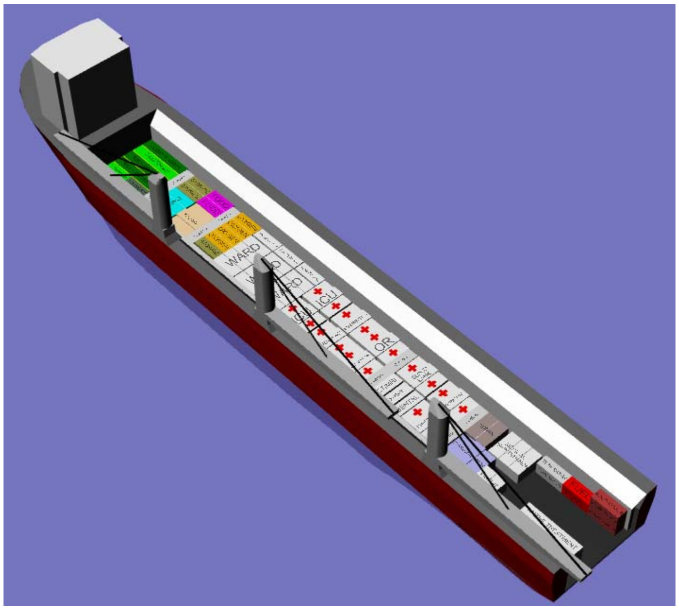

Figure 16: CombiDock

FH Requirements	*Input*
Number of Patients (Total)	60
Number of Surgical Cases	24
Number of Bed Patients (ICU)	12
Number of Minimal Care Patients	28
Number of Decontamination Cases	10
Number of Staff	52
Number of Days	10
Generator power output (Continuous kilowatts)	1125
Generator fuel consumption (gph)	104
Daily power requirement (kW)	168

Table 6: FH inputs for CombiDock

The configuration of the FH in Figure 16 aboard the deck of the CombiDock was modeled from the layout aboard the M.V. Black Marlin. However, the M.V. Black Marlin has much more deck space than the CombiDock. Therefore, portions of the FH aboard the M.V. Black Marlin were reduced, combined, or removed entirely in order for a FH to fit within the walls of the CombiDock as listed in Table 6. CombiDock has two main advantages over the M.V. Black Marlin and one over the Explorer. The first advantage over the M.V. Black Marlin is its wingwalls, shielding patients and personnel from the elements. This advantage could prove valuable when the ship experiences rough weather or seas. Another advantage of CombiDock over both the M.V. Black Marlin and Explorer are its three built-in cranes. These cranes could be used to ferry patients and personnel from one ship or craft to the CombiDock deck, or to optimize deck space by stacking shipping containers and using the three cranes to move these containers around when needed. Additional figures and detailed calculations are shown in Appendix D and E for CombiDock.

FH Component

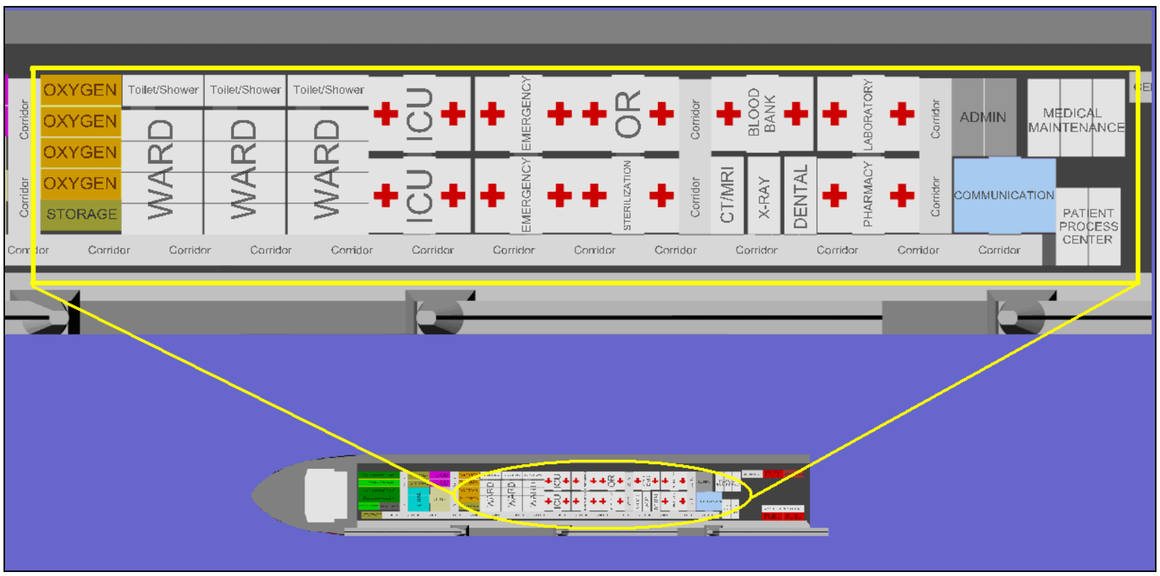

Figure 17: FH aboard CombiDock

The FH and its layout displayed in Figure 17 aboard the CombiDock is capable of treating 60 patients/day for 10 days. The list of the FH units and their amount are found in Table 7.

Hospital Components	*Quantity*	*Hospital Components*	*Quantity*
Administration	1	WARD	3
Blood Bank	1	Patient Process Center	1
Communication	1	Pharmacy	1
CT/MRI Scanner	1	Sterilization	1
Dental	1	OR	1
Emergency triage	2	Oxygen Storage	4
ICU	2	Storage	1
Laboratory	1	Toilet/Shower	3
Medical Maintenance	1	X-Ray	1
		*Total Units**	*27*

Table 7: Quantized list of hospital components for CombiDock

Much like the M.V. Black Marlin this FH has the same attributes but differs in number. Due to space constraints only 27 units of the FH can fit within the walls of the CombiDock. Patients will enter through the FH from the stern of the ship and enter through the patient process center. On a special note is the medical maintenance unit will have a dual roll as the maintenance facility for the FH as well as that of the ship. This decision is due to space constraints within the cargo area of the ship. Beyond the patient process center is the service portion of the FH. This section contains the laboratory for testing, a pharmacy, a blood bank, CT/MRI, X-ray, and dental units. Beyond the service section is the treatment section of the hospital containing the OR, sterilization, emergency triage, and WARD units. This section was placed after the service section because the center of the ship intuitively appears to be more stable than the rear of the ship. The entire FH is connected with a network of corridors, so as not to expose patients to outside elements.

Personnel Accommodations Component

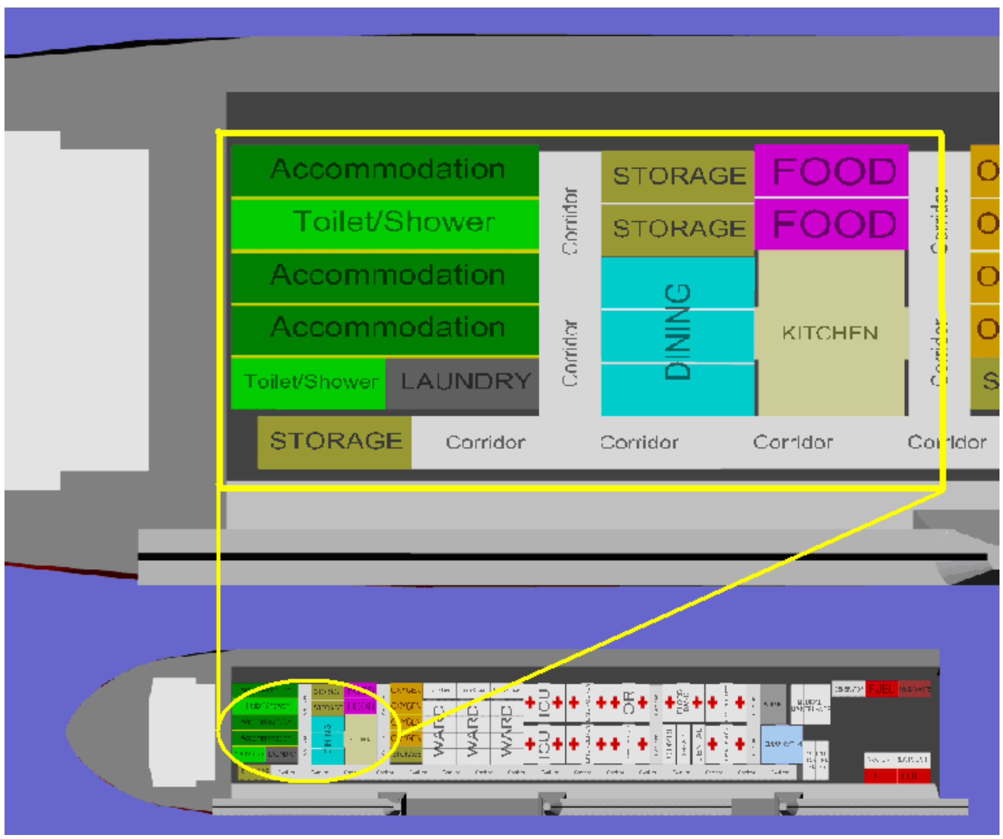

Figure 18: Personnel Accommodations Component for CombiDock

A total of 52 personnel can be accommodated. The personnel accommodation section is in the forward area of the ship, and to the right of this section is the FH as displayed Figure 18. A summary of the number of units within this section are listed in Table 8.

Personnel Components	*Quantity*
Accommodations	3
Dining	1
Food Storage	2
Kitchen	1
Laundry	1
Storage	2
Toilet/Shower	2
*Total Units**	12

Table 8: Quantized list of personnel components for CombiDock

Two of the 40 ft ISO shipping container accommodation units will share one toilet/shower unit. The other will have its own toilet and shower unit to accommodate higher ranking officials and special guests. The dining area is smaller when compared to that of the M.V. Black Marlin since there is less personnel. Personnel will eat in shifts to maximize the space of the dining area. The food storage unit will consist of two ISO shipping containers and is adjacent to the kitchen. The kitchen, as is the case for the M.V. Black Marlin, will provide all the meals for the entire FH. One laundry unit is placed adjacent to one accommodation unit and toilet/shower unit in order to share a possible connection leading to the water treatment facility. Two storage units are placed where space was not being utilized and can be used for mixed purposes.

Entry and main storage Component

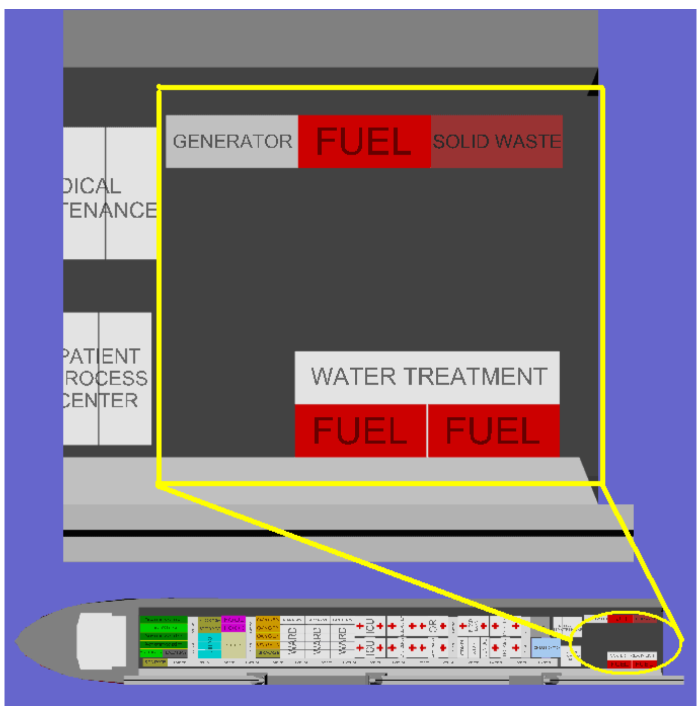

Figure 19: Entry/Main storage section for the CombiDock

In this location of the ship equipment and cargo can be stacked with the aid of CombiDock's cranes. The water treatment facility and the fuel containers are adjacent to each other in Figure 19 and are stacked on top of each other two high. The solid waste containers are stacked one on top of each other two high and are adjacent to one fuel storage container and a generator. A second auxiliary generator can be added for redundancy should one fail. Stacking two containers high allows for more space while maintaining the number of necessary equipment required for a 10 day operation. Utilizing the onboard cranes to stack the units allows them to be reconfigured while at sea without the aid of a port and the units easier to load while in port. Another use for CombiDock's cranes could be to ferry patients from ship to ship in specialized containers. These containers could (as depicted in Figure 20) store several patients for temporary transport via CombiDock's crane from ship to ship.

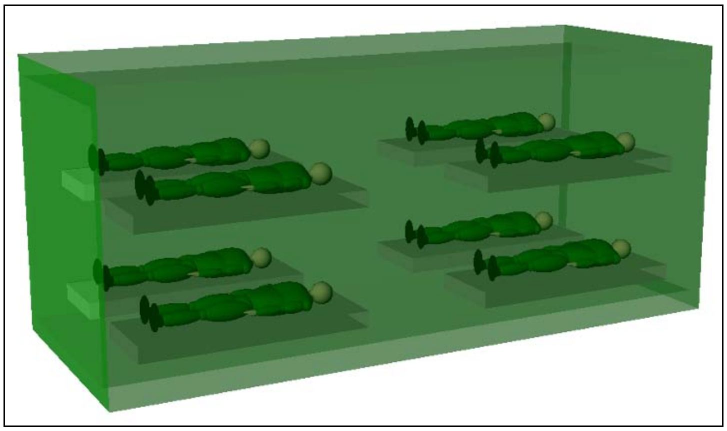

Figure 20: Specialized Ferry Container

Small craft can also dock at the stern of the ship to unload patients as another option. Unfortunately not enough deck space is available to accommodate the landing of a helicopter. The ship itself does not supply its own helicopter landing pad; therefore, the transport of patients is limited to small craft and the use of CombiDock's cranes to ferry patients from ship to ship.

The total number of units in this section are listed Table 9.

Entry/Main Storage Components	*Quantity*
Fuel Storage	6
Generator	1
Maintenance	0
Solid Waste Storage	2
Storage (Miscellaneous)	0
Water Storage	0
Water Treatment	2
*Total Units**	12

Table 9: Quantized main entry and storage components for CombiDock

In order for the generator and water treatment facility to operate for 10 days, both will require a total of six containers of fuel. These fuel containers can be stacked to maximize deck space as well as the water treatment facilities and solid waste containers. There is no separate maintenance facility since the medical maintenance unit is combined with general maintenance to save deck space. Mixed use storage is not readily available in this section of the ship due to space constraints. Should a unit be determined "stackable" then doing so would open more deck space aboard an already tight deck. Water storage aboard the deck of CombiDock is not necessary since the ship itself contains a 270.7 cubic meter fresh water tank within its hull in the bow of the ship. Any ship with a capacity to store large volumes of water is beneficial when deck space is a premium. The water treatment facilities are present to replenish the ship integrated tank over the 10 day mission.

Explorer

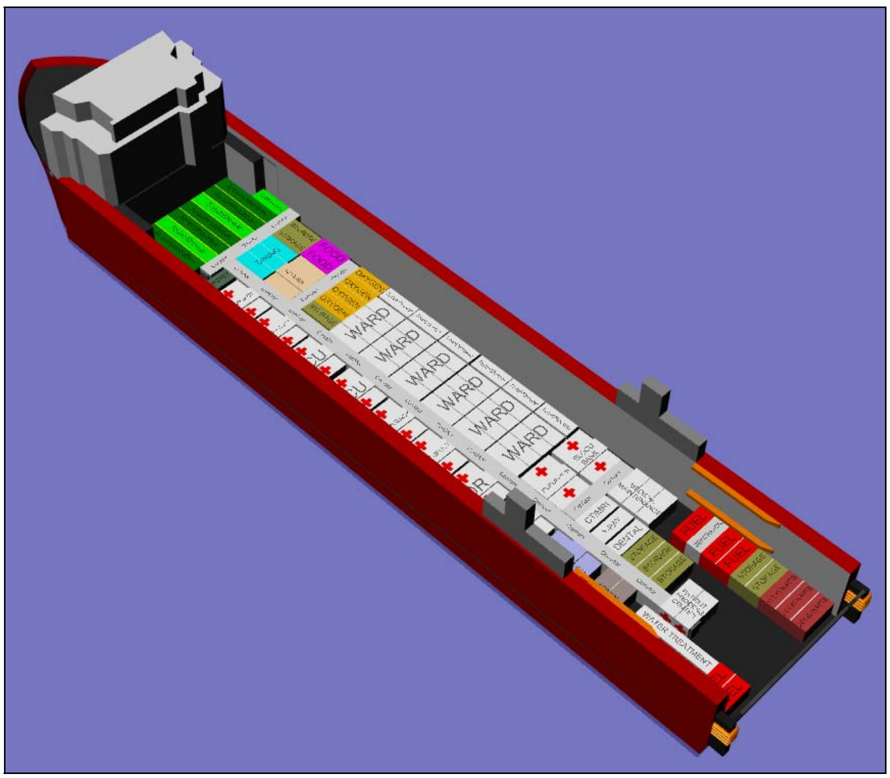

Figure 21: Dockwise Explorer

FH Requirements	*Input*
Number of Patients (Total)	96
Number of Surgical Cases	24
Number of Bed Patients (ICU)	12
Number of Minimal Care Patients	45
Number of Decontamination Cases	10
Number of Staff	83
Number of Days	10
Generator power output (Continuous kilowatts)	1125
Generator fuel consumption (gph)	104
Daily power requirement (kW)	268

Table 10: FH inputs for Dockwise Explorer

The Explorer, pictured in Figure 21, is typically used to ship yachts from one location to another, and yacht owners have the option to travel with their yachts. The Explorer will supply water and power to any yacht that requires it during the voyage[3]. This indicates their ability to provide power via an onboard generator, and potable water from within the hull via a freshwater tank. The details of these two items have not been published publicly.

Aboard the Explorer is a 96 patient FH staffed by 83 personnel. Table 10 lists the main requirements for this FH. The values within Table 10 will affect all supplies and equipment which are dependent on those numbers. Additional figures and detailed calculations are shown in Appendix F and G for the Explorer.

FH component

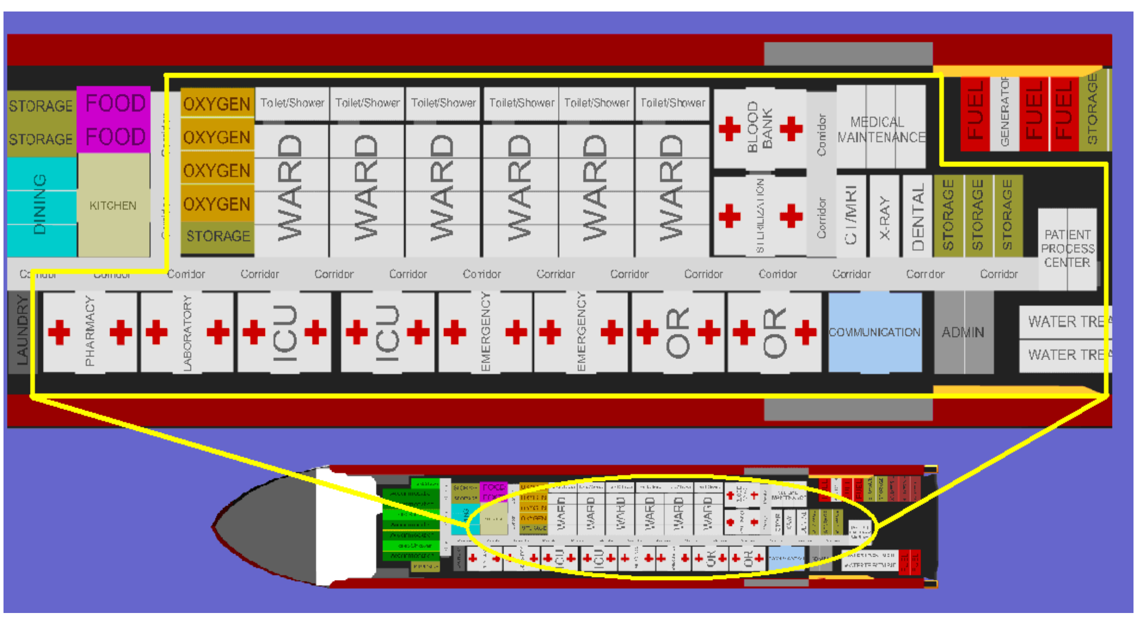

Figure 22: FH aboard Explorer

The FH depicted in Figure 22 can treat 96 patients/day for 10 days. Again the layout of this FH aboard the Explorer is based on the FH layout aboard the M.V. Black Marlin. Table 11 lists the units and their quantity within the FH.

Hospital Components	***Quantity***	***Hospital Components***	***Quantity***
Administration	1	WARD	6
Blood Bank	1	Patient Process Center	1
Communication	1	Pharmacy	1
CT/MRI Scanner	1	Sterilization	1
Dental	1	OR	2
Emergency triage	2	Oxygen Storage	4
ICU	2	Storage	4
Laboratory	1	Toilet/Shower	6
Medical Maintenance	1	X-Ray	1
		*Total Units**	*37*

Table 11: Quantized list of FH components for Explorer

The standard units that appear in this FH have appeared both in the M.V. Black Marlin and CombiDock. This ship can treat a higher capacity of patients than the CombiDock but not as many as the M.V. Black Marlin. The medical maintenance unit, just as in the CombiDock layout, will serve a duel role as both the medical maintenance facility as well as the general maintenance facility for the FH.

Personnel Accommodations Component

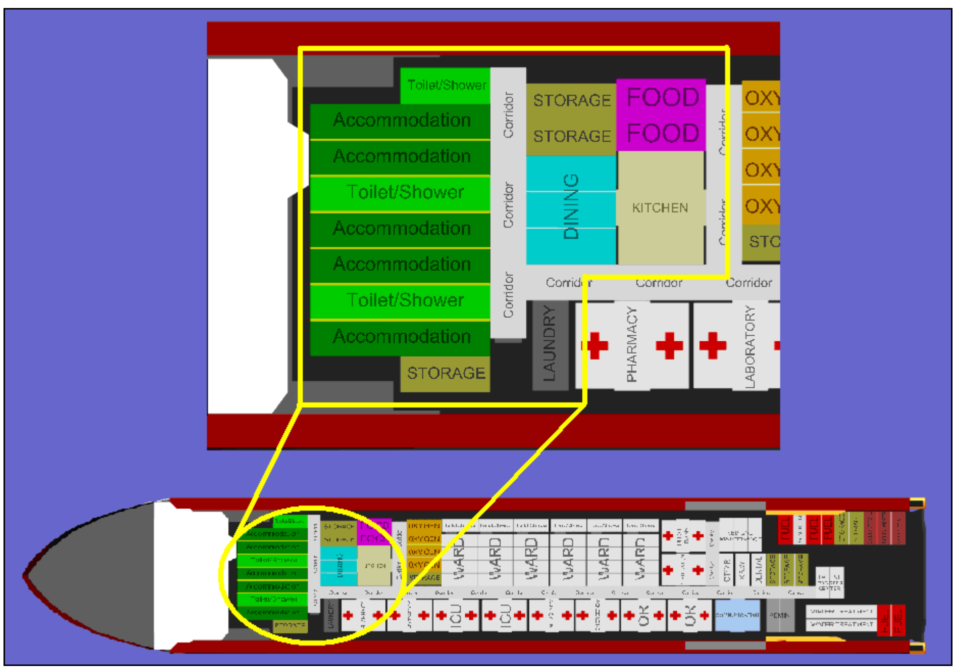

Figure 23: Personnel Accommodations Component for Explorer

The accommodations section is in the forward portion of the ship with the hospital to the right and the deck house to the left as displayed in Figure 23. This portion of the FH is capable of accommodating 83 personnel for the duration of the mission. A summary of the number of components within this section are listed in Table 12.

Personnel Components	***Quantity***
Accommodations	5
Dining	1
Food Storage	2
Kitchen	1
Laundry	1
Storage	3
Toilet/Shower	3
*Total Units**	16

Table 12: Quantized list of personnel components for Explorer

As with the accommodations in the M.V. Black Marlin and CombiDock ships, one unit is set aside for higher ranking officials and special guests. This unit is located at the top left of Figure 23 adjacent to the 20 ft ISO toilet/shower module. The kitchen, dining, and food storage are located within close proximity and connected so they can easily serve the occupants within the FH. One laundry facility is provided for serving both the personnel and patient needs. Three mixed use storage units were placed to maximize storage capacity as well as utilize the available space. However one of the storage units pictured in the lower left hand corner in Figure 23 is not connected to the network of corridors and is only accessed outside the hospital.

Entry and main storage Component

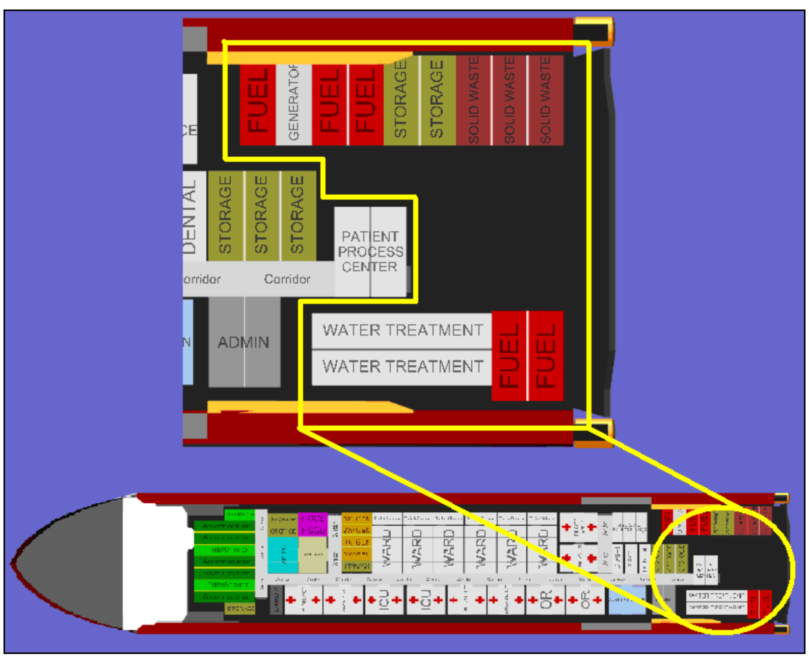

Figure 24: Entry/Main storage section for the Explorer

All the facilities depicted in Figure 24 are on the same level, not stacked, just as the M.V. Black Marlin's entry and storage component. This layout omits the location of a helicopter landing pad as there is not enough space available on deck to do so. The wingwalls on board the Explorer, just as in the CombiDock, provide protection from marine elements. The Explorer also has a large stern door that can open and close which would add to protection provided by the wingwalls. Table 13 summarizes the number of individual units as displayed in Figure 24.

Entry/Main Storage Components	***Quantity***
Fuel Storage	5
Generator	1
Maintenance	0
Solid Waste Storage	3
Storage (Miscellaneous)	2
Water Storage	0
Water Treatment	2
*Total Units**	15

Table 13: Quantized main entry and storage components for Explorer

In order to save space the maintenance facility was merged with the medical maintenance facility to conserve deck space. The storage components listed in Table 13 are standard for all three vessels. It is assumed the Explorer has the capacity for water storage within its hull, but the information regarding the volume of the tank is not publicly published. Dockwise reports yacht owners may travel with their yachts while aboard the Explorer, and if they choose to do so, the yachts will be supplied with freshwater, electricity, and berths. This Dockwise statement indicates a freshwater storage tank. For the purposes of this report, the volume of the tank was assumed to be the same size as the tank located in the bow of the CombiDock, 270.7 cubic meters. The water treatment facility will provide usable water daily as demanded for the duration of the 10 day operation.

Space and Weight Analysis

A rudimentary space and weight analysis was conducted to determine how much of each heavy lift ship deck is being utilized by the FH and whether each heavy lift ship can support the weight of the FH.

Space Analysis

Space Analysis			
Heavy Lift Ships	*M.V. Black Marlin*	*CombiDock*	*Explorer*
Total Utilized Area (m^2)	4798	1747	1854
Total Deck Area (m^2)	7484.4	2506.1	2822.8
Percent Utilized	65	70	66
Total Number of Units	189	87	89

Table 14: Space Analysis

The space analysis was conducted based on the sum of the foot prints of each container and a helicopter pad. This number was then compared to the total area of the deck of each heavy lift ship as shown in Table 14. According to Table 14, the FH on CombiDock utilizes the largest percentage of deck space. This is due to the long and narrow nature of the deck provided by CombiDock. Both the M.V. Black Marlin and the Explorer utilize roughly the same amount of deck space, 65-66%, which a reasonable number indicating extra space for other equipment. One aspect of the FH not included is the infrastructure of pipes and electrical wiring needed to allow the FH to operate. This infrastructure will require space, inflating the total utilized area of the three ships; however, given the rudimentary analysis, there appears to be ample space for the addition of the FH infrastructure.

Weight Analysis

Weight Analysis			
Heavy Lift Ships	*M.V. Black Marlin*	*CombiDock*	*Explorer*
Total Weight of FH (MTU)	3024	1392	1424
Weight Capacity of Deck (MTU)	57021	9300	10763
Percentage Utilized	6	15	14

Table 15: Weight Analysis

The purpose of the weight analysis is to indicate if all three ships mentioned in Table 15 can support the load of the FH. The weight of each container was assigned a value of 3200 kg[7] and multiplied by a safety factor of five. The safety factor of five was chosen due to the high variability in the weights of each unit and includes the weight of the infrastructure. Comparing the values to the specifications of weight capacity given by the heavy lift ship manufactures, the weight of the FH is small compared to the maximum weight capacity; therefore, it is safe to assume the weight of the FH is negligible when aboard each heavy lift ship.

Conclusions

The purpose of this report was to introduce the adaptability of three common and different style heavy lift ships that can be used to serve a single function, a FH. Of the three heavy lift ships mentioned in this report the M.V. Black Marlin, CombiDock, and the Explorer, the best candidate for FH operation would be the M.V. Black Marlin. The M.V. Black Marlin is the largest of the three heavy lift ships allowing it to sustain a larger amount of patients and personnel for ten days. Its open deck, although open to the elements, allows for more freedom in the FH layout. In the case of using a MCS or barges, they are much easier to float on and float off the FH, and also allow space for a helicopter pad, a vital attribute for any FH. However, if the most desired vessel is unavailable others can be substituted to perform the same operation indicating the adaptability of the concept.

The inherent benefit to placing a FH aboard a heavy lift ship is in the design layout. This report provides one of many possible combinations for treating casualties. Elements within the design can be substituted or cancelled if deemed necessary based on the mission requirements. If a mission requires more operating units or ICUs, a specialized FH could be constructed and deployed to service those needs. Ultimately the U.S. Navy will decide the needs and capabilities it desires without designing, constructing, or owning a heavy lift ship, but rather order one to serve a variety of functions.

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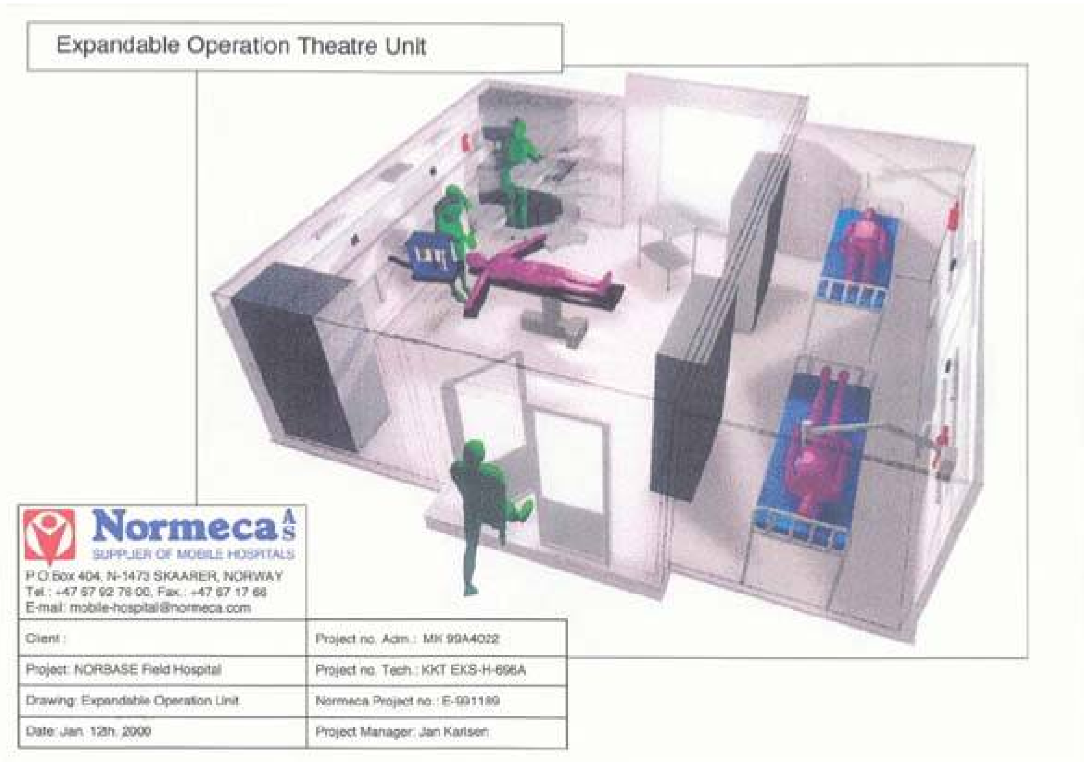
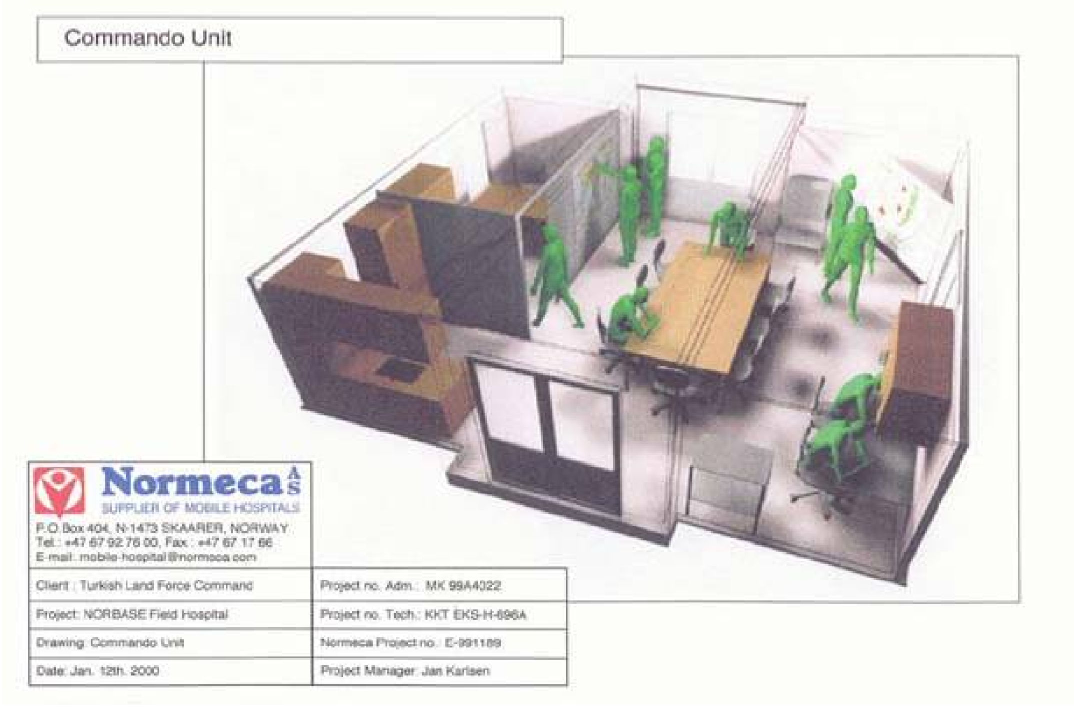
[19]Model B. Taylor-Dunn. 2005. 16 February 2007. < http://www.taylor-dunn.com/07vehiclesforyourindustry/32modelB.htm>.

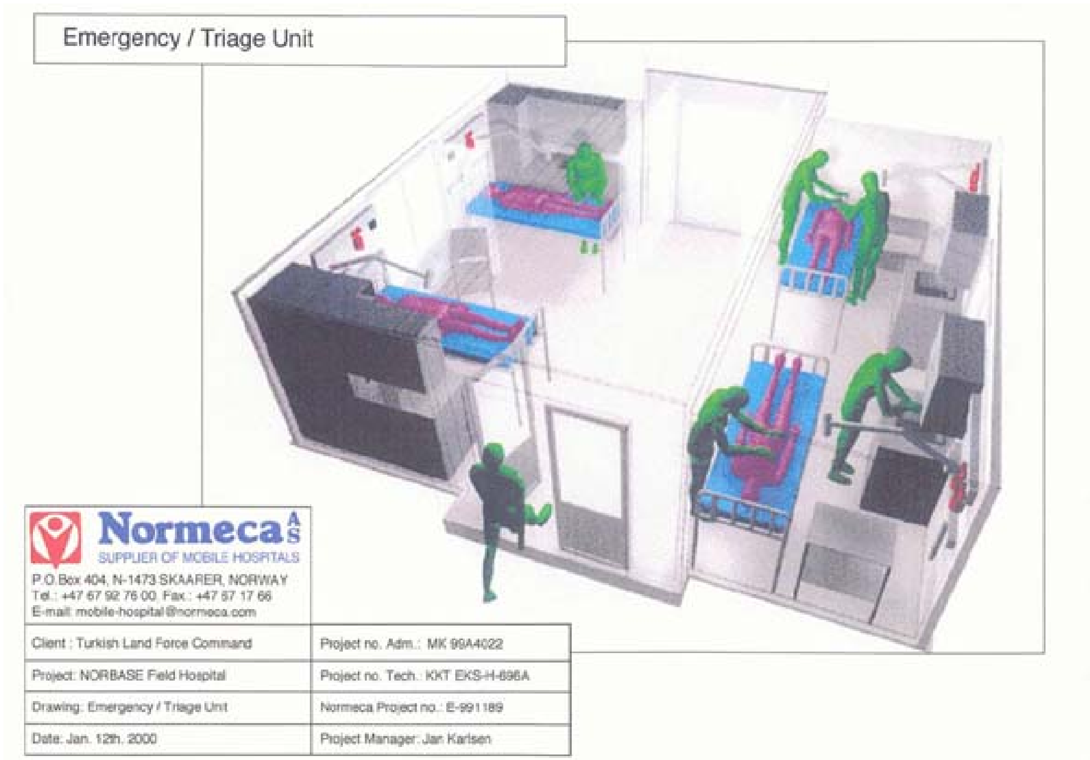
[20]The Norwegian Container Hospital (NorBase). Normeca. 22 December 2006. <http://www.normeca.com/normeca/products/norbase1.htm>.

Appendix A: Interior Layout of ISO Shipping Containers

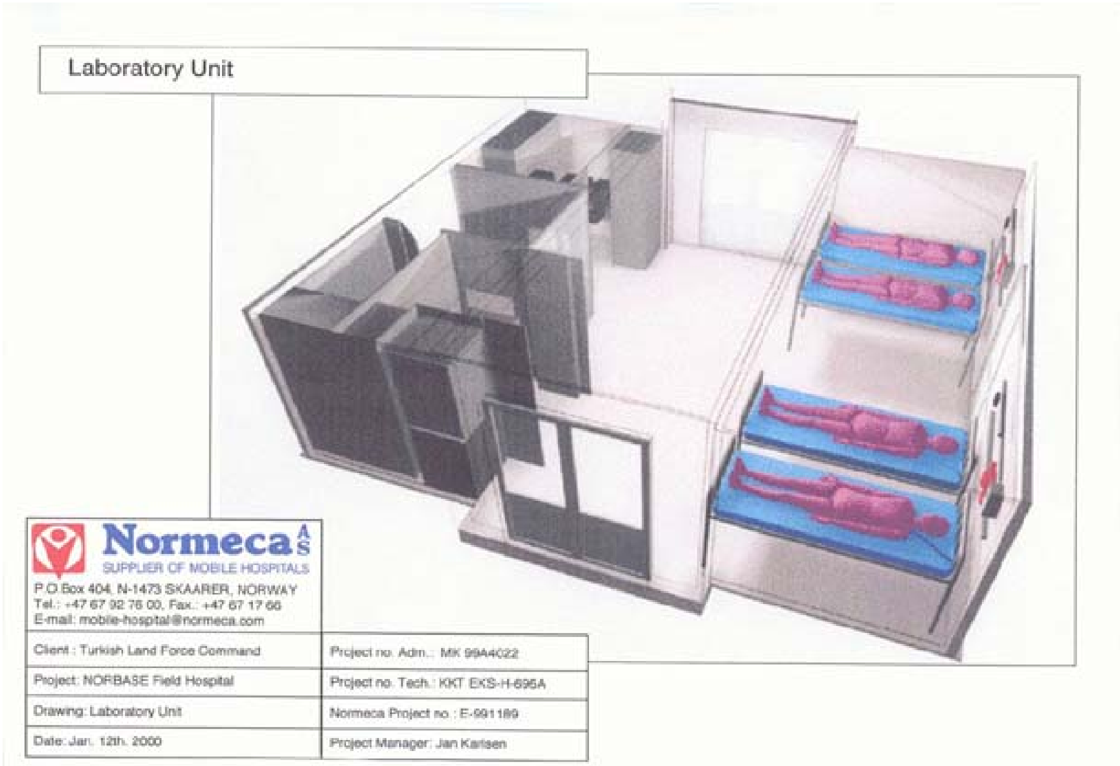
The figures below display the interior layout of several FH units. These figures are provided by Normeca and serve as examples for potential FH interior units[20].

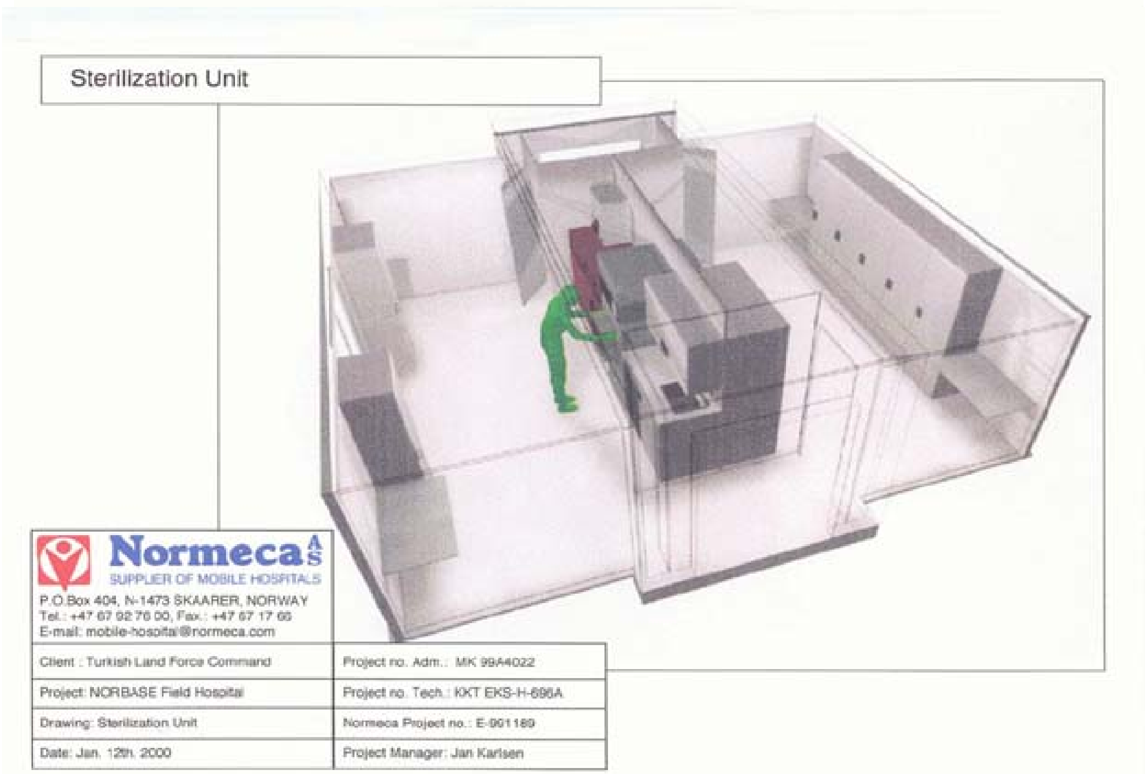


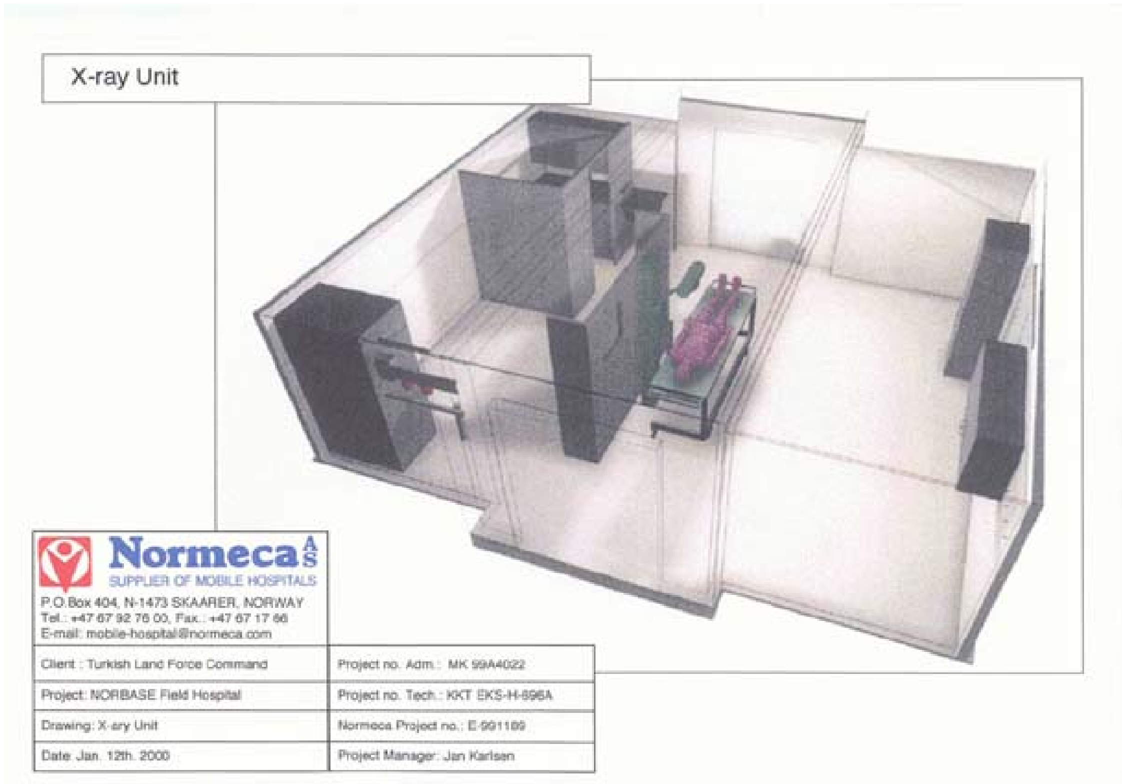



Emergency / Triage Unit
Normeca AS
SUPPLIER OF MOBILE HOSPITALS
P.O.Box 404, N-1473 SKAARER, NORWAY
Tel.: +47 67 92 76 00. Fax.: +47 67 17 66
E-mail: mobile-hospital@normeca.com
Client : Turkish Land Force Command
Project no. Adm.: MK 99A4022
Project: NORBASE Field Hospital
Project no. Tech.: KKT EKS-H-696A
Drawing: Emergency / Triage Unit
Normeca Project no.: E-991189
Date: Jan. 12th. 2000
Project Manager: Jan Karlsen


Intencive Care Unit
Normeca AS
SUPPLIER OF MOBILE HOSPITALS
P.O.Box 404, N-1473 SKAARER, NORWAY
Tel.: +47 67 92 76 00. Fax.: +47 67 17 66
E-mail: mobile-hospital@normeca.com
Client : Turkish Land Force Command
Project no. Adm.: MK 99A4022
Project: NORBASE Field Hospital
Project no. Tech.: KKT EKS-H-696A
Drawing: Intencive Care Unit
Normeca Project no.: E-991189
Date: Jan. 12th. 2000
Project Manager: Jan Karlsen


Laboratory Unit
Normeca AS
SUPPLIER OF MOBILE HOSPITALS
P.O.Box 404, N-1473 SKAARER, NORWAY
Tel.: +47 67 92 76 00, Fax.: +47 67 17 66
E-mail: mobile-hospital@normeca.com
Client : Turkish Land Force Command
Project: NORBASE Field Hospital
Drawing: Laboratory Unit
Date: Jan. 12th. 2000
Project no. Adm.: MK 99A4022
Project no. Tech.: KKT EKS-H-696A
Normeca Project no.: E-991189
Project Manager: Jan Karlsen


Sterilization Unit
Normeca AS
SUPPLIER OF MOBILE HOSPITALS
P.O.Box 404, N-1473 SKAARER, NORWAY
Tel.: +47 67 92 76 00, Fax.: +47 67 17 66
E-mail: mobile-hospital@normeca.com
Client : Turkish Land Force Command
Project: NORBASE Field Hospital
Drawing: Sterilization Unit
Date: Jan. 12th. 2000
Project no. Adm.: MK 99A4022
Project no. Tech.: KKT EKS-H-696A
Normeca Project no.: E-991189
Project Manager: Jan Karlsen


X-ray Unit
Normeca AS
SUPPLIER OF MOBILE HOSPITALS
P.O.Box 404, N-1473 SKAARER, NORWAY
Tel.: +47 67 92 76 00, Fax.: +47 67 17 66
E-mail: mobile-hospital@normeca.com
Client : Turkish Land Force Command
Project no. Adm.: MK 99A4022
Project: NORBASE Field Hospital
Project no. Tech.: KKT EKS-H-696A
Drawing: X-ary Unit
Normeca Project no.: E-991109
Date: Jan. 12th. 2000
Project Manager: Jan Karlsen

Appendix B: Calculations Based on FM 8-10-15

The FM 8-10-15 report was the primary source of calculation data for all three ship models. The report highlighted a 500 patient and 428 personnel hospital as an example of a typical field hospital size. The following Appendices D, F, and H were constructed using data documented in FM 8-10-15. Table 16 is an example input table where all subsequent calculations are based for all three ship models. The values listed under "Input" are estimated using ratios and data found in FM 8-10-15.

FH Requirements	***Input***
Number of Patients (Total)	96
Number of Surgical Cases	24
Number of Bed Patients (ICU)	12
Number of Minimal Care Patients	45
Number of Decontamination Cases	10
Number of Staff	83
Number of Days	10
Generator power output (Continuous kilowatts)	1125
Generator fuel consumption (gph)	104
Daily power requirement (kW)	268

Table 16: Appendix B Example Input Table

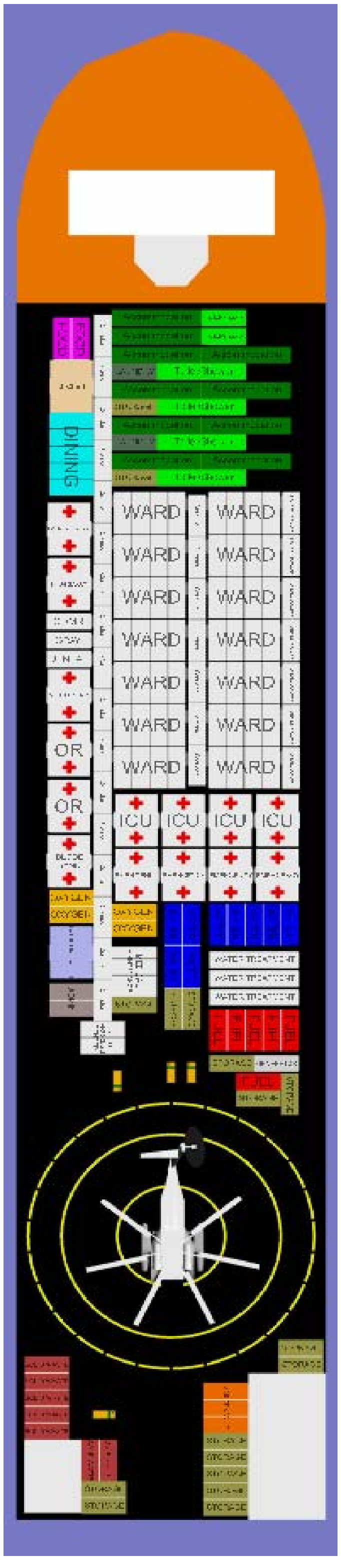
A ratio between the patients and personnel listed in the FM 8-10-15 report was developed as a function to estimate the number of personnel needed, making the number of personnel is dependent on number of patients. In this case the number of patients is divided by the value 1.16822 (500 patients/428 personnel) estimating the number of personnel. The same ratio was used to estimate the number of patients that require minimal care. For 216 patients, it was estimated that 100 will need minimal care. The value of 2.16 (216 patients/100 minimal care patients) was applied to the CombiDock and Explorer as a means to equate all three ships with the same percentage of minimal patients to the total population of patients.

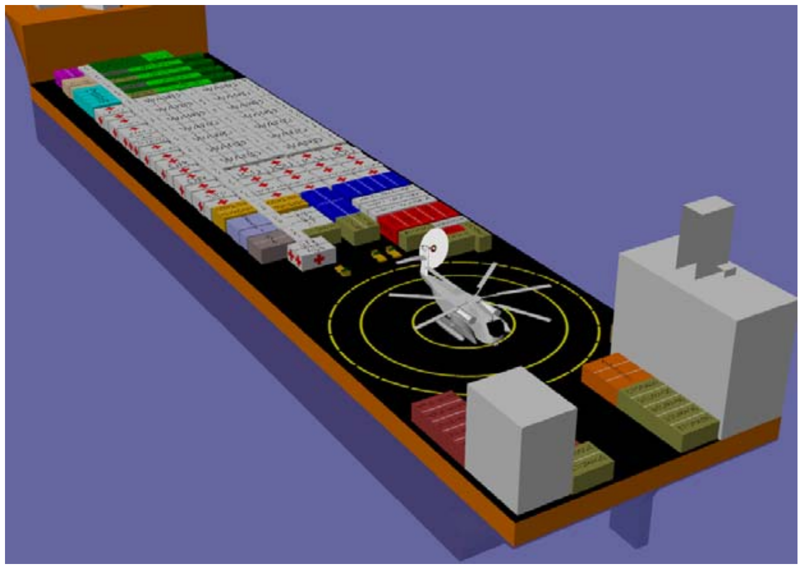
The daily power required is based off the estimated power (1384.295 kW) needed for 428 personnel and 500 patients as given in FM 8-10-15. A ratio was developed between the sum of patients and personnel needed divided by (500 + 428), the number FM 8-10-15 utilizes. The ratio is multiplied by the estimated maximum power which estimates the power needed for a particular number of patients and personnel.

All other numbers were derived based on estimates and assumptions listed in FM 8-10-15 such as the number of surgical and decontamination cases. The number of ICU patients is based on the number of beds allocated from only ICU operations, and each ICU unit can hold six patients. The values for the electric generator are the manufacturer specifications, which can be changed if a different generator is chosen. The number of days for the operation was chosen arbitrarily and can be changed easily. Changing the number of days will affect the value of fuel, water, medical, maintenance, and food storage.

All three ships have two methods of calculating water consumption, both provided by FM 8-10-15. The first method of estimating water consumption is rudimentary and less accurate than method two; however, the value of method one is used to compare the value of method two. Method two contains a detailed list of estimated every day water consumption per patient and personnel, and provides are more accurate estimate of consumption. Based on those calculations a method of water storage was developed using standard 20 x 8 x 8 ft ISO shipping containers as holding tanks. However the number of storage tanks for all three ships was too large to fit onto the deck. As a result an alternate storage method was developed utilizing a water treatment facility to manufacture freshwater rather than store a large amount. The water produced is stored in a smaller number of tanks because more water can be created if necessary. Values related to water, fuel, and food storage are found within FM 8-10-15 and placed in Microsoft Excel for FH calculations.

Appendix C: M.V. Black Marlin Views





Appendix D: FH calculations for M.V. Black Marlin

FH Requirements	*Input*
Number of Patients (Total)	216
Number of Surgical Cases	24
Number of Bed Patients (ICU)	24
Number of Minimal Care Patients	100
Number of Decontamination Cases	10
Number of Staff	185
Number of Days	10
Generator power output (Continuous kilowatts)	1125
Generator fuel consumption (gph)	104
Daily power requirement (kW)	599

Ship Characteristics	
Water Storage Capability (Gal.)	0

Food Storage Calculations

	Calculations Factor	*Total number of meals*	*Total Number of Pallets*	*Total Volume of Pallets (cu. Ft)*	*# of ISO Containers*
Patients (UGR-B type ration)	400 meals/pallet	6480	17	783.888889	1
Personnel (UGR-B type ration)	400 meals/pallet	5550	14	645.555556	1
Total		*12030*	*31*	*1429.44444*	*2*

Water Consumption Calculations (Method 1)

Personnel	*Calculation Factor*	*Gallons/Day*	*Volume(cu. Ft)/Day*	*Total Gal. for Operation*	*# of ISO Containers*
Total patients (beds) X 17.25 gallons	(# beds) x 17.25 gal.	3726	498.0937517	37260	4
Surgical cases X 19.0 gallons	(# cases) x 19.0 gal.	456	60.95833354	4560	1
Staff X 10.25 gallons (40%)	(# staff) x 10.25 gal.	1896.25	253.4917543	18962.5	2
Bed patients X 22.0 gallons (ICU)	(# beds) x 22.0 gal.	528	70.58333357	5280	1
Minimal care patients X 10.0 gallons	(# MMC) x 10.0 gal.	1000	133.680556	10000	2
Staff X 9.4 gallons	(# staff) x 9.4 gal.	1739	232.4704869	17390	2
Decontamination	*Calculation Factor*	*Gallons/Day*	*Volume(cu. Ft)/Day*	*Total Gal. for Operation*	*# of ISO Containers*
7 gallons per individual		7	0.935763892	70	1
380 gallons per major end item		380	50.79861128	3800	1

Vehicle maintenance	*Calculation Factor*	*Gallons/Day*	*Volume(cu. Ft)/Day*	*Total Gal. for Operation*	*# of ISO Containers*
1 gallon per vehicle (hot climate)		1	0.133680556	10	1
Loss/waste factor = 10 percent of total requirement		973.325	130.1146272	9733.25	2
Total Hospital Needs		*10706.575*	*1431.260899*	*107065.75*	*17*

Water Consumption Calculations (Method 2: Consumptive Factors)

Staff	*Gal/Man/Day*	*Gal/Day*	*Total Gal. for Operation*	*Total Volume (cu. Ft)*	*# of ISO Containers*
Drinking	1.5	277.5	2775	370.963543	1
Hygiene	1.7	314.5	3145	420.425349	1
Food prep	1.75	323.75	3237.5	432.7908	1
Extra showers	5.3	980.5	9805	1310.73785	2
Unit wastewater generation	7	1295	12950	1731.1632	2
Staff Total	*17.25*	*3191.25*	*31912.5*	*4266.08074*	*7*
Patient	*Gal/Bed/Day*	*Gal/Day*	*Total Gal. for Operation*	*Total Volume (cu. Ft)*	*# of ISO Containers*
Cleanup	1	216	2160	288.750001	1
Heat treatment	0.2	43.2	432	57.7500002	1
Bed bath	5	1080	10800	1443.75	2
Hygiene	1.7	367.2	3672	490.875002	1
Bed pan wash	1.5	324	3240	433.125001	1
Laboratory	0.2	43.2	432	57.7500002	1
Sterilizer	0.2	43.2	432	57.7500002	1
X-ray	0.2	43.2	432	57.7500002	1
Handwashing	2	432	4320	577.500002	1
Cleanup	1	216	2160	288.750001	1
Unit wastewater generation	12	2592	25920	3465.00001	3
Patient Total	*25*	*5400*	*54000*	*7218.75002*	*14*
Surgical	*Gal/Case/Day*	*Gal/Day*	*Total Gal. for Operation*	*Total Volume (cu. Ft)*	*# of ISO Containers*
Scrub	10	240	2400	320.833334	1
Instrument wash	4	96	960	128.333334	1
OR cleanup	5	120	1200	160.416667	1
Unit wastewater generation	19	456	4560	609.583335	1
Surgical Total	*38*	*912*	*9120*	*1219.16667*	*4*

Laundry	*Gal/Bed/Day*	*Gal/Day*	*Total Gal. for Operation*	*Total Volume (cu. Ft)*	*# of ISO Containers*
Bed patients	22	4752	47520	6352.50002	5
Ambulatory patients	10	2160	21600	2887.50001	3
Staff smocks	9.4	2030.4	20304	2714.25001	3
Unit wastewater generation	41.4	8942.4	89424	11954.25	10
Laundry Total	*82.8*	*17884.8*	*178848*	*23908.5001*	*21*
Decontamination	*Gal/Decon/day*	*Gal/Day*	*Total Gal. for Operation*	*Total Volume (cu. Ft)*	*# of ISO Containers*
Individual	7	70	700	93.5763892	1
Major end item	380	3800	38000	5079.86113	4
Vehicle 450	450	4500	45000	6015.62502	5
Wastewater generation To be determined		0	0	0	0
Decontamination Total	*837*	*8370*	*83700*	*11189.0625*	*10*
MISC	*Gal/Meal/100 Portions*	*Gal/Day*	*Total Gal. for Operation*	*Total Volume (cu. Ft)*	*# of ISO Containers*
Water usage table for food and beverage preparation staff menu (gallons per meal per 100 portions)	928	5150.4	51504	6885.08336	6
Water usage table for food and beverage preparation patient menu (gallons per meal per 100 portions).	928	8017.92	80179.2	10718.4	9
Mission Total	***1856***	***84684.42***	***846844.2***	***113206.604***	***71***

Alternate Water Storage Method

	Gal/Day	*# of 40 ft Treatment Containers*	*# of ISO Containers for Water Storage per Day*		*Total # of ISO Containers per Day*
	84684.42	***3***	***9***		***12***

Estimated Oxygen Requirements

Estimated Oxygen Requirements	*Liters/Day*	*Total Liters for Operation*	*Total # of E Storage Cylinders*	*Total # of Storage Units*	*# of ISO Containers*
OR Table Hours (HUB)	41814.62069	418146.2069	123	6	1
HUH	0	0	0	0	0
ICU Beds on Vent (HUB)	82793.10453	827931.0453	244	11	1
EMT and other Oxygen Requirements	302.0463362	3020.463362	1	1	1
Pneumatic Instruments	158510.806	1585108.06	466	20	1

Total	*283420.5776*	*2834205.776*	*834*	*38*	*4*

Estimated Fuel Consumption

Fuel Consumption	*Gal/Day*	*Weight (lb)*	*Volume (cu. Ft)*	*Total Gal. for Operation*	*# of ISO Containers*
Diesel	997.28	7,010.87	133.635	9972.8	2

Solid Waste Factors

	Calculation Factor	*Gallons/Day*	*Volume(cu. Ft)/Day*	*Total Gal. for Operation*	*# of ISO Containers*
Total patients (beds) X 15 lbs = total patient solid waste	(# beds) x 15 lbs	3240	433.1250014	32400	4
Staff X 12.5 lbs = total staff solid waste	(# staff) x 12.5 lbs	1250	167.100695	12500	2
Total		*4490*	*600.2256964*	*44900*	*6*

Blood Storage Calculations

	Calculation Factor	*Total # of Units*	*Total # of Refrigerators*	*Total Refrigerator Surface Area (sq. ft)*	*# of ISO Containers*
Red Blood Cells	4 Units / Patient / Day	8640	12	175.28125	2
Fresh Frozen Plasma	.08 Units / Patient / Day	172.8	0.24	3.505625	0
Frozen Platelet Concentrate	.04 Units / Patient / Day	86.4	0.12	1.7528125	0
Total		*8899.2*	*12.36*	*180.539688*	*2*

Power Requirements

	Gallons per hour	**Gallons per day**	**Gallons needed for mission duration**	**Cubic ft**	***# of ISO containers***
Fuel Consumption	104	2496	24960	3336.66668	3
	Generator power output (Continuous Watts)	**Daily requirement (kW)**	**#of generators needed**		***# of ISO containers***
Total	*1125*	*599*	*1*		*3*

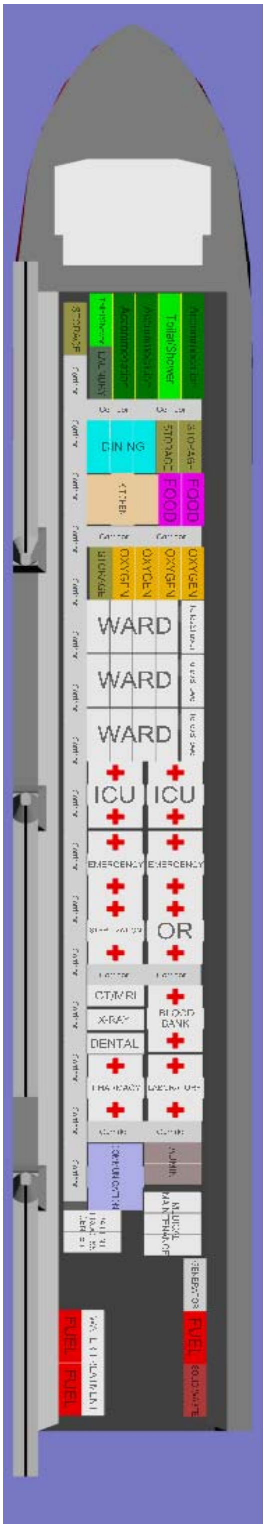
Laundry

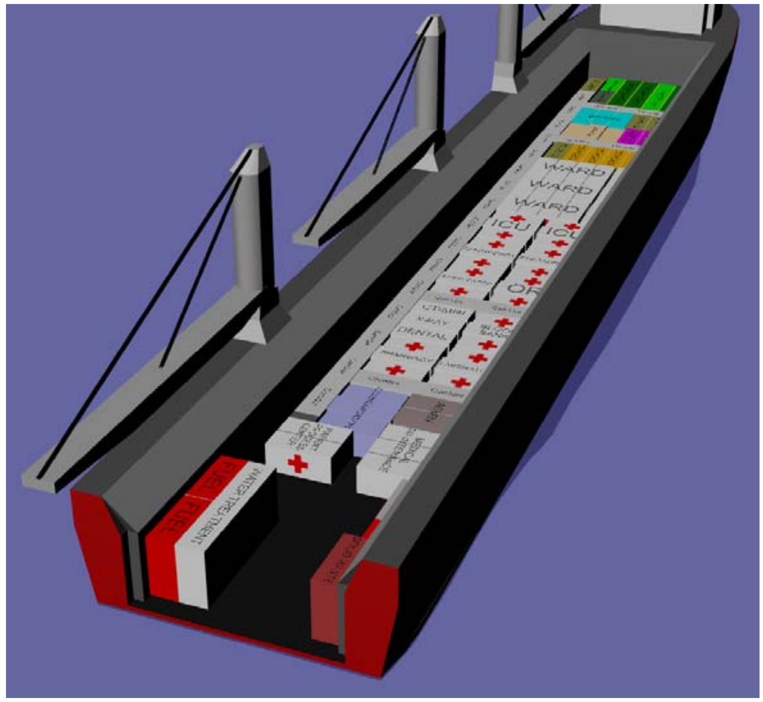
	Weight per person/day (lb)	25kg to lb	Hourly wash 25kg/hr	Estimate 4 in 20 ft ISO (x2)	# of ISO containers
Weight of clothing to be washed per day (4 lbs for personnel and 8 lbs for patients of clothing per person per day)	2468	55.1155655	1322.773572	2645.54714	1

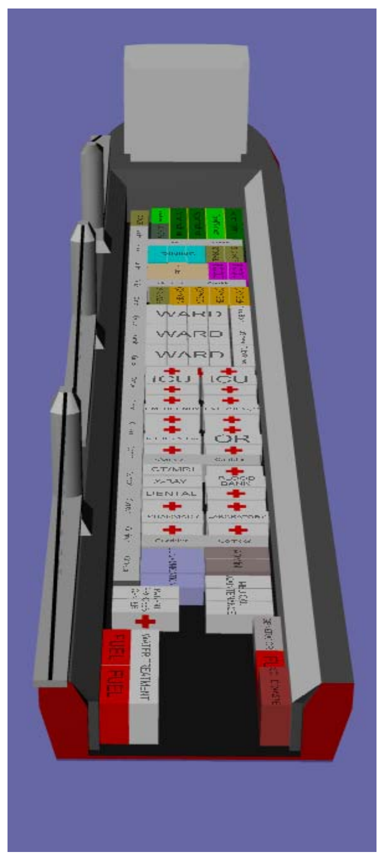
Accommodations

	Number of Accommodations for personnel 40ft containers
Total	10

Appendix E: CombiDock Views







Appendix F: FH calculations for CombiDock

FH Requirements	*Input*
Number of Patients (Total)	60
Number of Surgical Cases	24
Number of Bed Patients (ICU)	12
Number of Minimal Care Patients	28
Number of Decontamination Cases	10
Number of Staff	52
Number of Days	10
Generator power output (Continuous kilowatts)	1125
Generator fuel consumption (gph)	104
Daily power requirement (kW)	168

Ship Characteristics	
Water Storage Capability (Gal.)	71511.4

Food Storage Calculations

	Calculations Factor	*Total number of meals*	*Total Number of Pallets*	*Total Volume of Pallets (cu. Ft)*	*# of ISO Containers*
Patients (UGR-B type ration)	400 meals/pallet	1800	5	230.555556	1
Personnel (UGR-B type ration)	400 meals/pallet	1560	4	184.444444	1
Total		*3360*	*9*	*415*	*2*

Water Consumption Calculations (Method 1)

Personnel	*Calculation Factor*	*Gallons/Day*	*Volume(cu. Ft)/Day*	*Total Gal. for Operation*	*# of ISO Containers*
Total patients (beds) X 17.25 gallons	(# beds) x 17.25 gal.	1035	138.3593755	10350	2
Surgical cases X 19.0 gallons	(# cases) x 19.0 gal.	456	60.95833354	4560	1
Staff X 10.25 gallons (40%)	(# staff) x 10.25 gal.	533	71.25173635	5330	1
Bed patients X 22.0 gallons (ICU)	(# beds) x 22.0 gal.	264	35.29166678	2640	1
Minimal care patients X 10.0 gallons	(# MMC) x 10.0 gal.	280	37.43055568	2800	1
Staff X 9.4 gallons	(# staff) x 9.4 gal.	488.8	65.34305577	4888	1
Decontamination	*Calculation Factor*	*Gallons/Day*	*Volume(cu. Ft)/Day*	*Total Gal. for Operation*	*# of ISO Containers*
7 gallons per individual		7	0.935763892	70	1
380 gallons per major end item		380	50.79861128	3800	1

Vehicle maintenance	***Calculation Factor***	***Gallons/Day***	***Volume(cu. Ft)/Day***	***Total Gal. for Operation***	***# of ISO Containers***
1 gallon per vehicle (hot climate)		1	0.133680556	10	1
Loss/waste factor = 10 percent of total requirement		344.48	46.05027793	3444.8	1
Total Hospital Needs		*3789.28*	*506.5530572*	*37892.8*	*11*

Water Consumption Calculations (Method 2: Consumptive Factors)

Staff	***Gal/Man/Day***	***Gal/Day***	***Total Gal. for Operation***	***Total Volume (cu. Ft)***	***# of ISO Containers***
Drinking	1.5	78	780	104.270834	1
Hygiene	1.7	88.4	884	118.173612	1
Food prep	1.75	91	910	121.649306	1
Extra showers	5.3	275.6	2756	368.423612	1
Unit wastewater generation	7	364	3640	486.597224	1
Staff Total	*17.25*	*897*	*8970*	*1199.11459*	*5*
Patient	***Gal/Bed/Day***	***Gal/Day***	***Total Gal. for Operation***	***Total Volume (cu. Ft)***	***# of ISO Containers***
Cleanup	1	60	600	80.2083336	1
Heat treatment	0.2	12	120	16.0416667	1
Bed bath	5	300	3000	401.041668	1
Hygiene	1.7	102	1020	136.354167	1
Bed pan wash	1.5	90	900	120.3125	1
Laboratory	0.2	12	120	16.0416667	1
Sterilizer	0.2	12	120	16.0416667	1
X-ray	0.2	12	120	16.0416667	1
Handwashing	2	120	1200	160.416667	1
Cleanup	1	60	600	80.2083336	1
Unit wastewater generation	12	720	7200	962.500003	1
Patient Total	*25*	*1500*	*15000*	*2005.20834*	*11*
Surgical	***Gal/Case/Day***	***Gal/Day***	***Total Gal. for Operation***	***Total Volume (cu. Ft)***	***# of ISO Containers***
Scrub	10	240	2400	320.833334	1
Instrument wash	4	96	960	128.333334	1
OR cleanup	5	120	1200	160.416667	1
Unit wastewater generation	19	456	4560	609.583335	1
Surgical Total	*38*	*912*	*9120*	*1219.16667*	*4*

Laundry	***Gal/Bed/Day***	***Gal/Day***	***Total Gal. for Operation***	***Total Volume (cu. Ft)***	***# of ISO Containers***
Bed patients	22	1320	13200	1764.58334	2
Ambulatory patients	10	600	6000	802.083336	1
Staff smocks	9.4	564	5640	753.958336	1
Unit wastewater generation	41.4	2484	24840	3320.62501	3
Laundry Total	*82.8*	*4968*	*49680*	*6641.25002*	*7*
Decontamination	***Gal/Decon/day***	***Gal/Day***	***Total Gal. for Operation***	***Total Volume (cu. Ft)***	***# of ISO Containers***
Individual	7	70	700	93.5763892	1
Major end item	380	3800	38000	5079.86113	4
Vehicle 450	450	4500	45000	6015.62502	5
Wastewater generation To be determined		0	0	0	0
Decontamination Total	*837*	*8370*	*83700*	*11189.0625*	*10*
MISC	***Gal/Meal/100 Portions***	***Gal/Day***	***Total Gal. for Operation***	***Total Volume (cu. Ft)***	***# of ISO Containers***
Water usage table for food and beverage preparation staff menu (gallons per meal per 100 portions)	928	1447.68	14476.8	1935.26667	2
Water usage table for food and beverage preparation patient menu (gallons per meal per 100 portions).	928	2227.2	22272	2977.33334	3
Mission Total	***1856***	***36968.88***	***369688.8***	***49420.2043***	***42***

Alternate Water Storage Method

	Gal/Day	***# of 40 ft Treatment Containers***	***# of ISO Containers for Water Storage per Day***		***Total # of ISO Containers per Day***
	36968.88	***2***	***0***		***2***

Estimated Oxygen Requirements

Estimated Oxygen Requirements	***Liters/Day***	***Total Liters for Operation***	***Total # of E Storage Cylinders***	***Total # of Storage Units***	***# of ISO Containers***
OR Table Hours (HUB)	11678.89655	116788.9655	35	2	1
HUH	0	0	0	0	0
ICU Beds on Vent (HUB)	23124.25862	231242.5862	68	3	1
EMT and other Oxygen Requirements	84.36206897	843.6206897	1	1	1
Pneumatic Instruments	44272.34483	442723.4483	131	6	1
Total	*79159.86207*	*791598.6207*	*235*	*12*	*4*

Estimated Fuel Consumption

Fuel Consumption	***Gal/Day***	***Weight (lb)***	***Volume (cu. Ft)***	***Total Gal. for Operation***	***# of ISO Containers***
Diesel	997.28	7,010.87	133.635	9972.8	2

Solid Waste Factors

	Calculation Factor	***Gallons/Day***	***Volume(cu. Ft)/Day***	***Total Gal. for Operation***	***# of ISO Containers***
Total patients (beds) X 15 lbs = total patient solid waste	(# beds) x 15 lbs	900	120.3125004	9000	1
Staff X 12.5 lbs = total staff solid waste	(# staff) x 12.5 lbs	350	46.7881946	3500	1
Total		*1250*	*167.100695*	*12500*	*2*

Blood Storage Calculations

	Calculation Factor	***Total # of Units***	***Total # of Refrigerators***	***Total Refrigerator Surface Area (sq. ft)***	***# of ISO Containers***
Red Blood Cells	4 Units / Patient / Day	2400	3.333333333	48.6892361	1
Fresh Frozen Plasma	.08 Units / Patient / Day	48	0.066666667	0.97378472	0
Frozen Platelet Concentrate	.04 Units / Patient / Day	24	0.033333333	0.48689236	1
Total		*2472*	*3.433333333*	*50.1499132*	*2*

Power Requirements

	Gallons per hour	**Gallons per day**	**Gallons needed for mission duration**	**Cubic ft**	***# of ISO containers***
Fuel Consumption	104	2496	24960	3336.66668	3
	Generator power output (Continuous Watts)	**Daily requirement (kW)**	**#of generators needed**		***# of ISO containers***
Total	*1125*	*168*	*1*		*3*

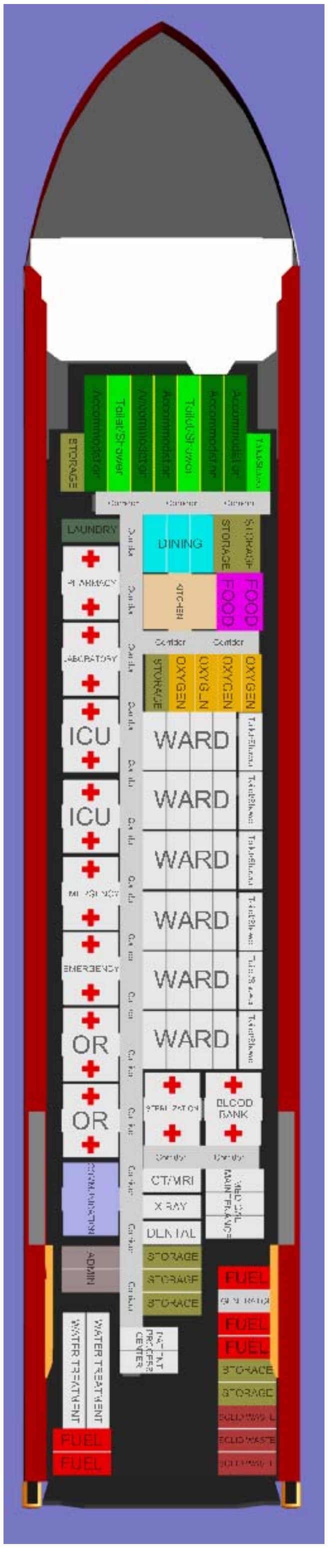
Laundry

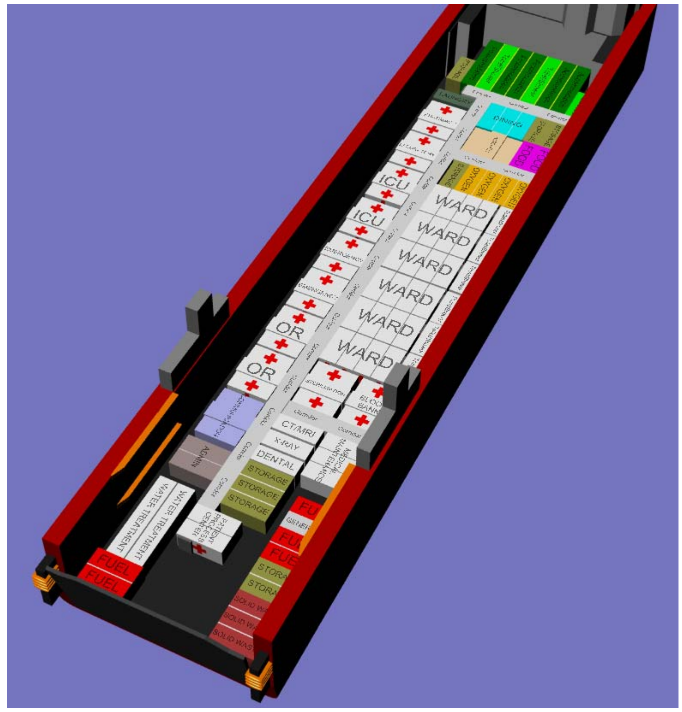
	Weight per person/day (lb)	**25kg to lb**	**Hourly wash 25kg/hr**	**Estimate 4 in 20 ft ISO (x2)**	**# of ISO containers**
Weight of clothing to be washed per day (4 lbs for personnel and 8 lbs for patients of clothing per person per day)	688	55.1155655	1322.773572	2645.54714	1

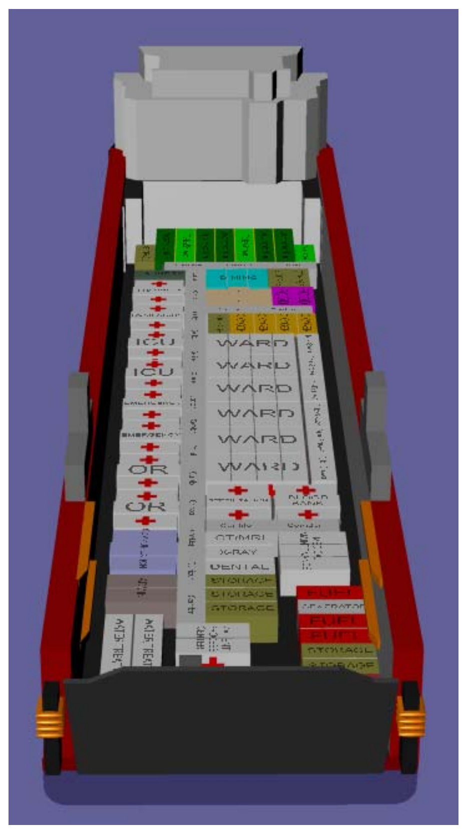
Accommodations

	Number of Accommodations for personnel 40ft containers
Total	*3*

Appendix G: Explorer Views







Appendix H: FH calculations for the Explorer

FH Requirements	*Input*
Number of Patients (Total)	96
Number of Surgical Cases	24
Number of Bed Patients (ICU)	12
Number of Minimal Care Patients	45
Number of Decontamination Cases	10
Number of Staff	83
Number of Days	10
Generator power output (Continuous kilowatts)	1125
Generator fuel consumption (gph)	104
Daily power requirement (kW)	268

Ship Characteristics	
Water Storage Capability (Gal.)	71511.4

Food Storage Calculations

	Calculations Factor	*Total number of meals*	*Total Number of Pallets*	*Total Volume of Pallets (cu. Ft)*	*# of ISO Containers*
Patients (UGR-B type ration)	400 meals/pallet	2880	8	368.888889	1
Personnel (UGR-B type ration)	400 meals/pallet	2490	7	322.777778	1
Total		*5370*	*15*	*691.666667*	*2*

Water Consumption Calculations (Method 1)

Personnel	*Calculation Factor*	*Gallons/Day*	*Volume(cu. Ft)/Day*	*Total Gal. for Operation*	*# of ISO Containers*
Total patients (beds) X 17.25 gallons	(# beds) x 17.25 gal.	1656	221.3750007	16560	2
Surgical cases X 19.0 gallons	(# cases) x 19.0 gal.	456	60.95833354	4560	1
Staff X 10.25 gallons (40%)	(# staff) x 10.25 gal.	850.75	113.728733	8507.5	1
Bed patients X 22.0 gallons (ICU)	(# beds) x 22.0 gal.	264	35.29166678	2640	1
Minimal care patients X 10.0 gallons	(# MMC) x 10.0 gal.	450	60.1562502	4500	1
Staff X 9.4 gallons	(# staff) x 9.4 gal.	780.2	104.2975698	7802	1
Decontamination	*Calculation Factor*	*Gallons/Day*	*Volume(cu. Ft)/Day*	*Total Gal. for Operation*	*# of ISO Containers*
7 gallons per individual		7	0.935763892	70	1
380 gallons per major end item		380	50.79861128	3800	1

Vehicle maintenance	*Calculation Factor*	*Gallons/Day*	*Volume(cu. Ft)/Day*	*Total Gal. for Operation*	*# of ISO Containers*
1 gallon per vehicle (hot climate)		1	0.133680556	10	1
Loss/waste factor = 10 percent of total requirement		484.495	64.76756098	4844.95	1
Total Hospital Needs		*5329.445*	*712.4431708*	*53294.45*	*11*

Water Consumption Calculations (Method 2: Consumptive Factors)

Staff	*Gal/Man/Day*	*Gal/Day*	*Total Gal. for Operation*	*Total Volume (cu. Ft)*	*# of ISO Containers*
Drinking	1.5	124.5	1245	166.432292	1
Hygiene	1.7	141.1	1411	188.623265	1
Food prep	1.75	145.25	1452.5	194.171008	1
Extra showers	5.3	439.9	4399	588.060766	1
Unit wastewater generation	7	581	5810	776.68403	1
Staff Total	*17.25*	*1431.75*	*14317.5*	*1913.97136*	*5*
Patient	*Gal/Bed/Day*	*Gal/Day*	*Total Gal. for Operation*	*Total Volume (cu. Ft)*	*# of ISO Containers*
Cleanup	1	96	960	128.333334	1
Heat treatment	0.2	19.2	192	25.6666668	1
Bed bath	5	480	4800	641.666669	1
Hygiene	1.7	163.2	1632	218.166667	1
Bed pan wash	1.5	144	1440	192.500001	1
Laboratory	0.2	19.2	192	25.6666668	1
Sterilizer	0.2	19.2	192	25.6666668	1
X-ray	0.2	19.2	192	25.6666668	1
Handwashing	2	192	1920	256.666668	1
Cleanup	1	96	960	128.333334	1
Unit wastewater generation	12	1152	11520	1540.00001	2
Patient Total	*25*	*2400*	*24000*	*3208.33334*	*12*
Surgical	*Gal/Case/Day*	*Gal/Day*	*Total Gal. for Operation*	*Total Volume (cu. Ft)*	*# of ISO Containers*
Scrub	10	240	2400	320.833334	1
Instrument wash	4	96	960	128.333334	1
OR cleanup	5	120	1200	160.416667	1
Unit wastewater generation	19	456	4560	609.583335	1
Surgical Total	*38*	*912*	*9120*	*1219.16667*	*4*

Laundry	***Gal/Bed/Day***	***Gal/Day***	***Total Gal. for Operation***	***Total Volume (cu. Ft)***	***# of ISO Containers***
Bed patients	22	2112	21120	2823.33334	3
Ambulatory patients	10	960	9600	1283.33334	2
Staff smocks	9.4	902.4	9024	1206.33334	1
Unit wastewater generation	41.4	3974.4	39744	5313.00002	5
Laundry Total	*82.8*	*7948.8*	*79488*	*10626*	*11*
Decontamination	***Gal/Decon/day***	***Gal/Day***	***Total Gal. for Operation***	***Total Volume (cu. Ft)***	***# of ISO Containers***
Individual	7	70	700	93.5763892	1
Major end item	380	3800	38000	5079.86113	4
Vehicle 450	450	4500	45000	6015.62502	5
Wastewater generation To be determined		0	0	0	0
Decontamination Total	*837*	*8370*	*83700*	*11189.0625*	*10*
MISC	***Gal/Meal/100 Portions***	***Gal/Day***	***Total Gal. for Operation***	***Total Volume (cu. Ft)***	***# of ISO Containers***
Water usage table for food and beverage preparation staff menu (gallons per meal per 100 portions)	928	2310.72	23107.2	3088.98334	3
Water usage table for food and beverage preparation patient menu (gallons per meal per 100 portions).	928	3563.52	35635.2	4763.73335	4
Mission Total	***1856***	***47999.34***	***479993.4***	***64165.7846***	***49***

Alternate Water Storage Method

	Gal/Day	***# of 40 ft Treatment Containers***	***# of ISO Containers for Water Storage per Day***		***Total # of ISO Containers per Day***
	47999.34	***2***	***0***		***2***

Estimated Oxygen Requirements

Estimated Oxygen Requirements	***Liters/Day***	***Total Liters for Operation***	***Total # of E Storage Cylinders***	***Total # of Storage Units***	***# of ISO Containers***
OR Table Hours (HUB)	18665.37931	186653.7931	55	3	1
HUH	0	0	0	0	0
ICU Beds on Vent (HUB)	36957.52047	369575.2047	109	5	1
EMT and other Oxygen Requirements	134.8286638	1348.286638	1	1	1
Pneumatic Instruments	70756.69397	707566.9397	208	9	1
Total	*126514.4224*	*1265144.224*	*373*	*18*	*4*

Estimated Fuel Consumption

Fuel Consumption	*Gal/Day*	*Weight (lb)*	*Volume (cu. Ft)*	*Total Gal. for Operation*	*# of ISO Containers*
Diesel	997.28	7,010.87	133.635	9972.8	2

Solid Waste Factors

	Calculation Factor	*Gallons/Day*	*Volume(cu. Ft)/Day*	*Total Gal. for Operation*	*# of ISO Containers*
Total patients (beds) X 15 lbs = total patient solid waste	(# beds) x 15 lbs	1440	192.5000006	14400	2
Staff X 12.5 lbs = total staff solid waste	(# staff) x 12.5 lbs	562.5	75.19531275	5625	1
Total		*2002.5*	*267.6953134*	*20025*	*3*

Blood Storage Calculations

	Calculation Factor	*Total # of Units*	*Total # of Refrigerators*	*Total Refrigerator Surface Area (sq. ft)*	*# of ISO Containers*
Red Blood Cells	4 Units / Patient / Day	3840	5.333333333	77.9027778	1
Fresh Frozen Plasma	.08 Units / Patient / Day	76.8	0.106666667	1.55805556	0
Frozen Platelet Concentrate	.04 Units / Patient / Day	38.4	0.053333333	0.77902778	0
Total		*3955.2*	*5.493333333*	*80.2398611*	*1*

Power Requirements

	Gallons per hour	**Gallons per day**	**Gallons needed for mission duration**	**Cubic ft**	***# of ISO containers***
Fuel Consumption	104	2496	24960	3336.66668	3
	Generator power output (Continuous Watts)	**Daily requirement (kW)**	**#of generators needed**		***# of ISO containers***
Total	*1125*	*268*	*1*		*3*

Laundry

	Weight per person/day (lb)	**25kg to lb**	**Hourly wash 25kg/hr**	**Estimate 4 in 20 ft ISO (x2)**	**# of ISO containers**
Weight of clothing to be washed per day (4 lbs for personnel and 8 lbs for patients of clothing per person per day)	1100	55.1155655	1322.773572	2645.54714	1

Accommodations

	Number of Accommodations for personnel 40ft containers
Total	5

Appendix I: Space and Weight Analysis

Space Analysis for M.V. Black Marlin			
	Single Area (m^2)	*Number of units*	*Total (m^2)*
Accommodation	30	10	300
Toilet/Shower (20ft)	15	2	30
Toilet/Shower (40ft)	30	4	120
Laundry	15	2	30
Storage	15	2	30
Food Storage	15	2	30
Kitchen	47	1	47
Dining	15	5	75
Administration	15	2	30
Blood Bank	47	1	47
Communication	47	1	47
CT/MRI Scanner	15	1	15
Dental	15	1	15
Emergency triage	47	4	188
ICU	47	4	188
Laboratory	47	1	47
Medical Maintenance	15	3	45
WARD	15	56	840
Patient Process Center	15	2	30
Pharmacy	47	1	47
Sterilization	47	1	47
OR	47	2	94
Oxygen Storage	15	4	60
Storage	15	1	15
Toilet/Shower	15	7	105
X-Ray	15	1	15
Fuel Storage	15	6	90
Helicopter pad	1211	1	1211
Generator	15	1	15
Maintenance	15	3	45
Solid Waste Storage	15	7	105
Storage (Miscellaneous)	15	14	210
Water Storage	15	9	135
Water Treatment	30	3	90
Corridor	15	24	360
Total Utilized			**4798**
Total Deck Area			**7484.4**
Percent Utilized			**65**
Total Number of Units			**189**

Weight Analysis for M.V. Black Marlin	
Total Weight (MT)	**3024**
Weight Capacity of ship (MT)	**205821**
Percentage Utilized	**2**

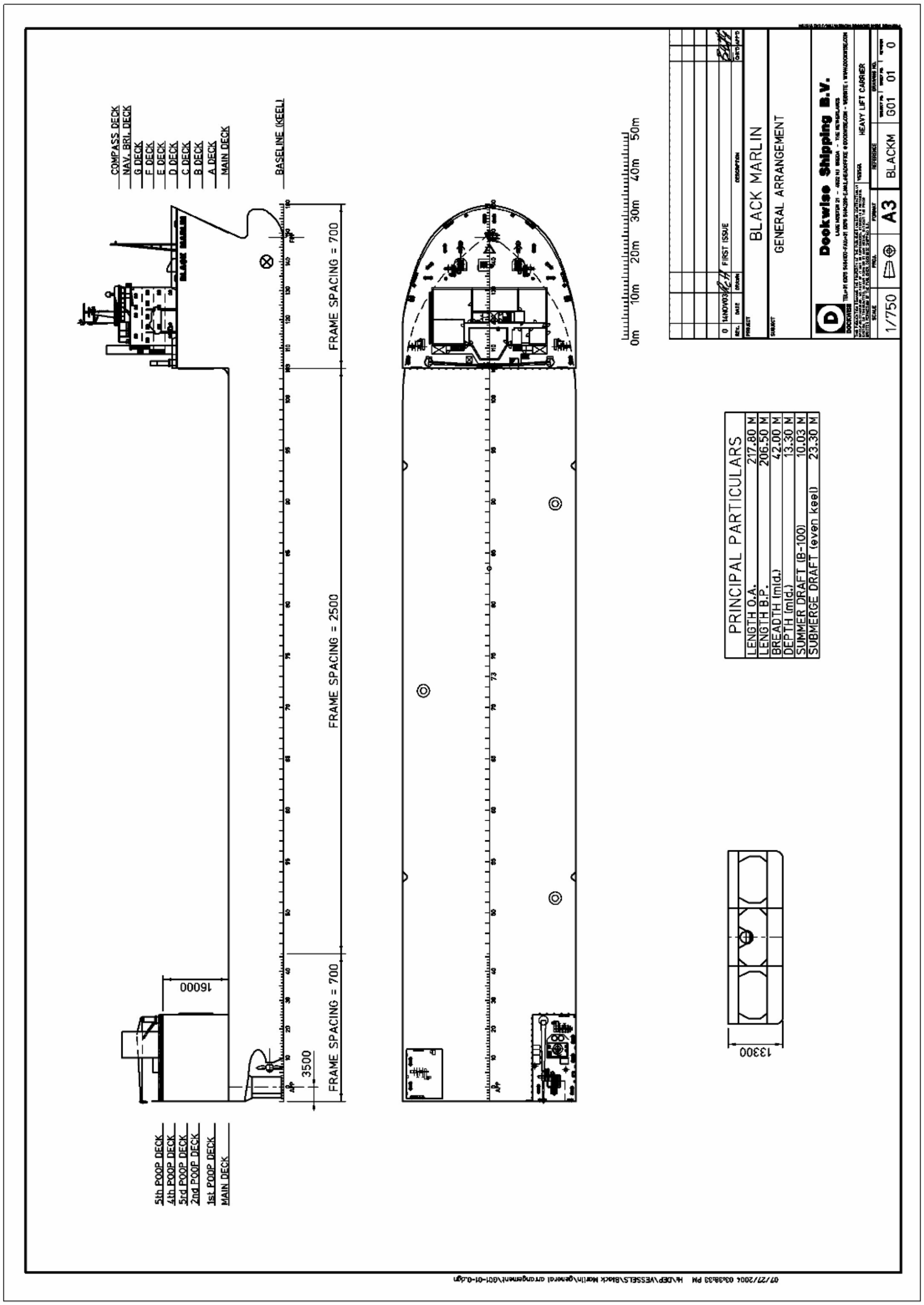
Space Analysis for CombiDock			
	Single Area (m^2)	*Number of units*	*Total (m^2)*
Accommodation	30	3	90
Toilet/Shower (20ft)	15	1	15
Toilet/Shower (40ft)	30	1	30
Laundry	15	1	15
Storage	15	1	15
Food Storage	15	2	30
Kitchen	47	1	47
Dining	15	3	45
Administration	15	2	30
Blood Bank	47	1	47
Communication	47	1	47
CT/MRI Scanner	15	1	15
Dental	15	1	15
Emergency triage	47	2	94
ICU	47	2	94
Laboratory	47	1	47
Medical Maintenance	15	3	45
WARD	15	12	180
Patient Process Center	15	2	30
Pharmacy	47	1	47
Sterilization	47	1	47
OR	47	1	47
Oxygen Storage	15	4	60
Storage	15	0	0
Toilet/Shower	15	3	45
X-Ray	15	1	15
Fuel Storage	15	6	90
Helicopter pad	1211	0	0
Generator	15	1	15
Maintenance	15	0	0
Solid Waste Storage	15	2	30
Storage (Miscellaneous)	15	0	0
Water Storage	15	0	0
Water Treatment	30	2	60
Corridor	15	24	360

Total Utilized	**1747**
Total Deck Area	**2506.1**
Percent Utilized	**70**
Total Number of Units	**87**
Weight Analysis for CombiDock	
Total Weight (MT)	**1392**
Weight Capacity of ship (MT)	**53888**
Percentage Utilized	**3**

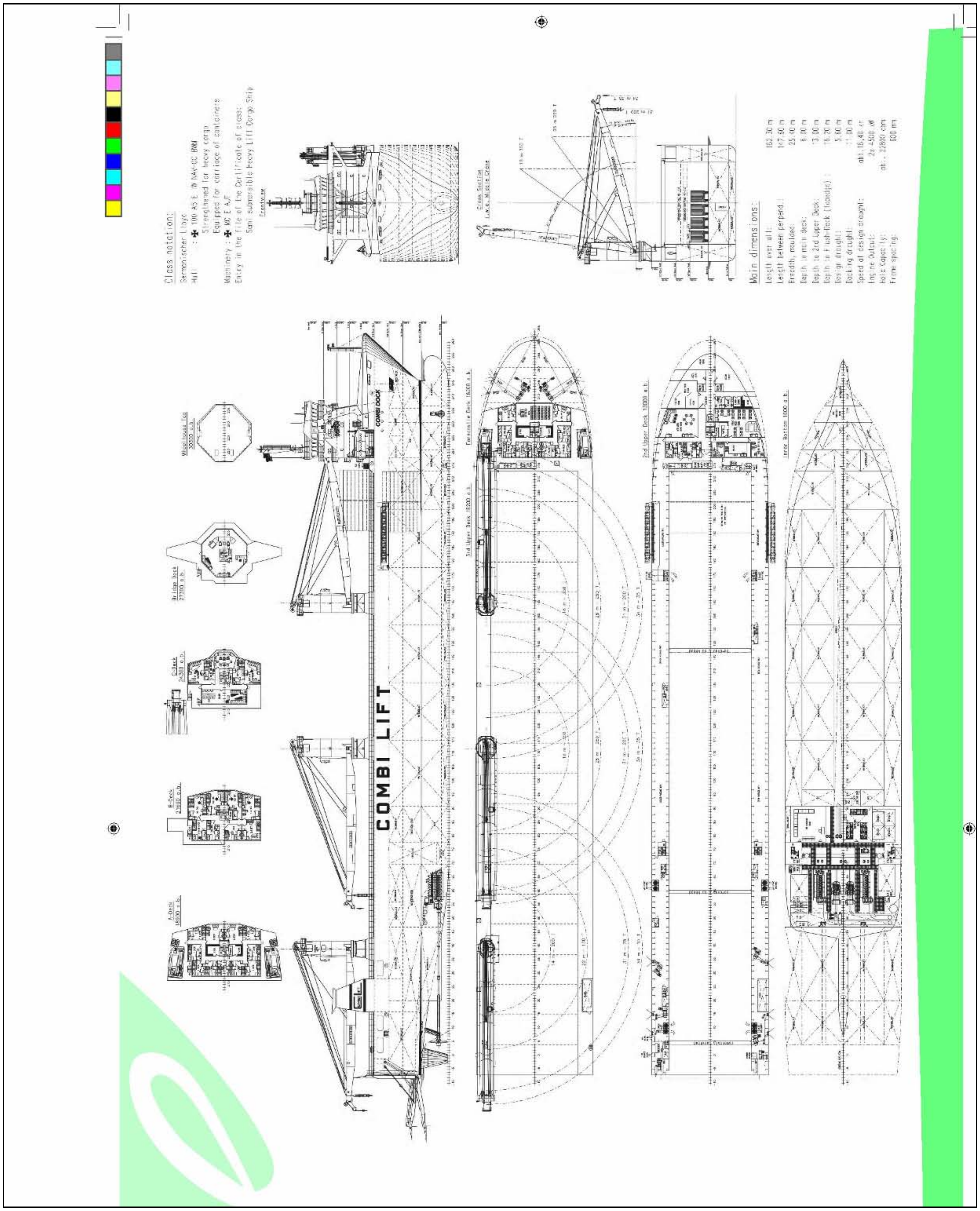
Space Analysis for Explorer			
	Single Area (m^2)	*Number of units*	*Total (m^2)*
Accommodation	30	5	150
Toilet/Shower (20ft)	15	1	15
Toilet/Shower (40ft)	30	2	60
Laundry	15	1	15
Storage	15	3	45
Food Storage	15	2	30
Kitchen	47	1	47
Dining	15	3	45
Administration	15	1	15
Blood Bank	47	1	47
Communication	47	1	47
CT/MRI Scanner	15	1	15
Dental	15	1	15
Emergency triage	47	2	94
ICU	47	2	94
Laboratory	47	1	47
Medical Maintenance	15	1	15
WARD	15	6	90
Patient Process Center	15	1	15
Pharmacy	47	1	47
Sterilization	47	1	47
OR	47	2	94
Oxygen Storage	15	4	60
Storage	15	4	60
Toilet/Shower	15	6	90
X-Ray	15	1	15
Fuel Storage	15	5	75
Helicopter pad	1211	0	0
Generator	15	1	15
Maintenance	15	0	0
Solid Waste Storage	15	3	45
Storage (Miscellaneous)	15	2	30
Water Storage	15	0	0
Water Treatment	30	2	60

Corridor	15	21	315
Total Utilized			**1854**
Total Deck Area			**2822.8**
Percent Utilized			**66**
Total Number of Units			**89**
Weight Analysis for Explorer			
Total Weight (MT)			**1424**
Weight Capacity of ship (MT)			**42342**
Percentage Utilized			**4**

Appendix J: M. V. Black Marlin



Appendix K: CombiDock



Appendix L: Explorer