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Global Fleet Station:
Station Ship Concept

By

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14. ABSTRACT

The Global Fleet Station concept is proposed to act as a persistent Sea Base of operations from which to coordinate and employ adaptive force packages within a region of interest. These can primarily be broken down into two types of missions; training and support and humanitarian aid. In support of the Military Effectiveness Group at NSWC-CD, the Center for Innovation in Ship Design developed the Global Fleet Station Station Ship concept design. The design is based on a general cargo ship built to merchant shipping standards and Classification Society rules. The general cargo ship design was modified to include a well deck, helicopter landing pad and hangar. The design is a 6,405mt ship, with a length of 140m, beam of 17.38m and a draft of 4.5m allowing close to shore operations. The ship has two large holds with removable hatches serviced by two cranes located on the ship's port side. The cargo load out is flexible; the holds can accommodate a wide range of dry cargo, containers, vehicles or a combination. The vessel has been designed to have a permanent complement of 95 personnel with space for an additional 82 personnel in austere reconfigurable accommodation. The propulsion system is fully electric with an installed power of 7.8MW generated by two diesel generators. The prime movers are four ABB compact azimuthing podded propulsors. The ship has limited command and control facilities to reduce cost and reflect the limited requirements of the GFS concept. This report concludes that the GFS Station Ship design is highly versatile and has demonstrated the effectiveness of a 6,405mt monohull in completing representative GFS missions.

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Abstract

The Global Fleet Station concept is proposed to act as a persistent Sea Base of operations from which to coordinate and employ adaptive force packages within a region of interest. These can primarily be broken down into two types of missions; training and support and humanitarian aid.

In support of the Military Effectiveness Group at NSWC-CD, the Center for Innovation in Ship Design developed the Global Fleet Station Station Ship concept design. The Station Ship design reported here is based on a general cargo ship built to merchant shipping standards and Classification Society rules. The general cargo ship design was modified to include a well deck, helicopter landing pad and hangar. The design is a 6,405mt ship, with a length of 140m, beam of 17.38m and a draft of 4.5m allowing close to shore operations. The ship has two large holds with removable hatches serviced by two cranes located on the vessel's port side. The cargo load out is flexible; the holds can accommodate a wide range of dry cargo, containers, vehicles or a combination.

The vessel has been designed to have a permanent complement of 95 personnel with space for an additional 82 personnel in austere reconfigurable accommodation. The propulsion system is fully electric with an installed power of 7.8MW generated by two diesel generators. The prime movers are four ABB compact azimuthing podded propulsors. The ship has limited command and control facilities to reduce cost and reflect the limited requirements of the GFS concept.

This report concludes that the GFS Station Ship design is highly versatile and has demonstrated the effectiveness of a 6,405 mt monohull in completing representative GFS missions.

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Table of Contents

Abstract i
Acknowledgements ii
Table of Contents iii
List of Tables iv
List of Figures iv
Acronyms v
Introduction 1
US Navy Ships used for GFS-Type Missions 2
Existing Foreign GFS-Type Ships 3
Requirements 5
Station Ship Design 6
Design Process 6
GFS Station Ship Final Design 6
Helicopter Deck 9
Weight and Space Estimates 10
Hull Structures 11
Machinery Weight 12
Electrical Plant, Command & Control, Auxiliary System, General Outfitting and Armament 15
Loads 17
Hydrostatics 18
Body Plan 18
Hydrostatics 19
Large Angle Intact Stability 19
Floodable Length 20
Seakeeping 21
Internal Multi-Purpose Space 22
Mission Loading 24
Humanitarian Aid Operations Loading 25
Training and Support Operations Loading 26
Theater Support Operations Loading 27
Design Risk 28
Summary 29
Recommendations 29
Appendix A – Hull Structure Estimate 31
Appendix B – SWBS Weight Summary 32
Appendix C - SWBS Space Breakdown 39
Appendix D – Additional Mission Loading Configurations 48
Appendix E – General Arrangement Drawings 50

References 60

List of Tables

Table 1 - Table of Final Requirements for Station Ship Mission 5
Table 2 - Principal Particulars for the GFS Station Ship 7
Table 3 - Table of Significant Equipment 8
Table 4 - Table of Cargo Hold Dimensions 8
Table 5 - SWBS Weight Summary 10
Table 6 – SSCS Area Summary 10
Table 7 - SWBS 100 Weight Summary 11
Table 8 - Propulsion Efficiencies 12
Table 9 - SWBS 200 Weights Summary 14
Table 10 - SWBS 300 Weight Summary 15
Table 11 - SWBS 400 Weight Summary 15
Table 12 - SWBS 500 Weight Summary 16
Table 13 - SWBS 600 Weight Summary 16
Table 14 - SWBS 700 Weight Summary 16
Table 15 - SWBS F00 Weight Summary 17
Table 16 - Table of Hydrostatic Particulars 19
Table 17 - Mission Payload – Humanitarian Aid 25
Table 18 - Mission Payload - Training and Support Operations 26
Table 19 - Mission Payload - Theater Support Operations 27

List of Figures

Figure 1 – JHSV-2 Swift 2
Figure 2 – FT. McHENRY 2
Figure 3 - USS EMORY S. LAND 2
Figure 4 - USNS MERCY 2
Figure 5 - HDMS ABSALON 3
Figure 6 - HMNZS CANTERBURY 4
Figure 7 - Design Evolution 6
Figure 8 – GFS Station Ship Concept 7
Figure 9 - Examples of Forward Helicopter Decks on FPSOs 9
Figure 10 - ABB Compact Pod 14
Figure 11 - SCHOTTEL Twin- Propeller 14
Figure 12 - GFS Station Ship Concept Pod Configuration 14
Figure 13 - GFS Station Ship Body Plan 18
Figure 14 - GZ Curve 19
Figure 15 - Floodable Length Curve 20
Figure 16 – Roll RAO for the GFS Station Ship in Beam Seas 21
Figure 17 - Helicopter Deck Accelerations in Head Seas at 0 Knots 22
Figure 18 - Internal Multipurpose Space 23
Figure 19 - Humanitarian Aid Ship Inboard Profile 25
Figure 20 – Foreign Partner Nation Training/Support Inboard Profile 26
Figure 21 - Theater Security Operations Inboard Profile 27

Acronyms

ABB	ABB, Ltd
ABS	American Bureau of Shipping
BSRA	British Ship Research Association
C_b	Block Coefficient
CISD	Center for Innovation in Ship Design
C_p	Prismatic Coefficient
C_w	Waterplane Coefficient
C&C	Command and Control
DESG	Defense Engineering and Science Group
ESM	Electronic Surveillance Measures
FPSO	Floating Production Storage & Offload
HMNZS	Her Majesty's New Zealand Ship
ICU	Intensive Care Unit
IEP	Integrated Electric Propulsion
ISO	International Standards Organization
JHSV	Joint High Speed Vessel
LCG	Longitudinal Center of Gravity
LPD	Landing Platform Deck
LSD(A)	Landing Ship Deck (Auxiliary)
MARPOL	Marine Pollution Convention 73/78
MEG	Marine Effectiveness Group
OR	Operating Room
QPC	Quasi-Propulsive Coefficient
ROSAM	Remote Operated Small Arms Mount
SOLAS	Safety of Life at Sea
SWBS	Ship Work Breakdown Structure
TCG	Transverse Center of Gravity
TEU	Twenty Foot Equivalent Unit
TSO	Theater Security Operations
RAO	Response Amplitude Operator
RMS	Root Mean Square
UAV	Unmanned Aerial Vehicle
UCL	University College London
US	United States
USN	United States Navy
USNS	United States Naval Ship
USCG	United States Coast Guard
VCG	Vertical Center of Gravity

Introduction

This report focuses on the concept ship design to fulfill the role of a Global Fleet Station (GFS) Station Ship. The aim of undertaking this design was to investigate the effectiveness of a modular cargo ship in completing the GFS mission and to evaluate the capability of a 5,000 to 10,000mt custom-made GFS design.

GFS has been defined as a highly visible, positively engaged, persistent sea base of operations from which to interact with partner nation military and civilian populations and the global maritime community. GFS offers a means to increase regional maritime security though cooperative efforts of joint, inter-agency, and multinational partners, as well as non-government organizations.

The major GFS missions are training and support and humanitarian aid. The aim of the training and support mission is to enhance a partner nation's maritime capabilities while building positive relationships. The mission objectives are to provide training in operations, maintenance and support to a foreign maritime force.

The humanitarian aid relief mission has two distinct mission profiles, intense effort or surge involved with disaster relief and the long-term assistance associated with sustained humanitarian aid efforts. The GFS mission is primarily sustained humanitarian support including provision of medical facilities, supply logistics, organizational headquarters facilities, transportation, and consequence management facilities.

There are two new types of vessel possibly required to complete GFS missions, a station ship and a patrol boat. This report will concentrate on the design of the larger station ship. The Military Effectiveness Group is currently investigating patrol boat concepts. For this design, a representative patrol boat footprint was used to allow the selection of the patrol boat later in the design process.

US Navy Ships used for GFS-Type Missions

GFS-type missions are not new. There have been many types of vessels used to complete the such missions, with varying degrees of cost effectiveness. The current US ships used in the GFS role are not custom-made designs and tend to have equipment and personnel surplus to mission requirements.

The following ships have been used in the GFS-type missions and have performed them satisfactorily, but with compromises. Their estimated effectiveness is briefly discussed.

The Joint High Speed Vessel (JHSV-2 Swift) shown in Figure 1 is a high-speed design. Swift has a top speed of 45+ knots, which is unnecessary in most GFS missions. Swift is also totally dissimilar to most host nation vessels and therefore the value of embedding a foreign crew is reduced.

Figure 1 – JHSV-2 Swift

Figure 2 – FT. McHENRY

The use of amphibious ships (Figure 2) has been popular in the last couple of years, but GFS is not the mission for which these ships were designed. Amphibious ships are currently in high demand for expeditionary strike groups. The amphibious ships also have a large amount of equipment not required for the GFS mission and they also tend to have large crews, both of which unnecessarily increase the operational cost of the mission.

The hospital ships USNS MERCY (Figure 4) and USNS COMFORT have been used on a number of GFS-type missions. Both ships are very capable casualty receiving ships, but they are very large and only two have been built. This means that they struggle to meet asset distribution goals. The draft of the vessels is approximately 10m which limits how close they can approach the coast, thereby making the logistics of patient transfer difficult. These ships still have an important role in the GFS mission for surge capability when dealing with disaster relief missions.

Figure 4 - USNS MERCY

Figure 3 - USS EMORY S. LAND

The USS EMORY S. LAND (Figure 3) is a submarine tender that was used on many GFS-type missions. This ship displaces 22,000mt and had a permanent Navy crew of 956. The current estimate of operating cost for this vessel completing the GFS mission is $100 million/yr. The ship's loaded draft is 8m leading to similar logistic problems in operating near the coast as USNS COMFORT and USNS MERCY.

Existing Foreign GFS-Type Ships

Many navies use small escorts and large auxiliaries to perform missions similar to the GFS concept. An example of an existing auxiliary ship is the Danish Navy flexible support ship, HDMS ABSALON shown in Figure 5. The HDMS ABSALON is 6,600mt command and control vessel with a draft of 6.3m. The ship contains a 900m^2 of reconfigurable space that can be configured to convert the ship into a casualty receiving ship. Other capabilities of this ship include a RO-RO vehicle deck, hangar and helicopter-landing pad. This ship is very capable in the GFS role, but has limited organic offload capability and has command and control facilities which are in excess of the GFS requirements.

Figure 5 - HDMS ABSALON

There are also many examples of small LPD ships being designed for or used for the GFS-type missions. A good example of ship designed for the GFS mission is the HMNZS CANTERBURY[1] (Figure 6), which is a new 9,000mt ship with a loaded draft of 5.4m and a cruise speed of 19 knots. HMNZS CANTERBURY is the primary sealift capability of the New Zealand Navy and can carry and organically offload 250 troops, via two landing craft. It also has a landing pad and hangar for one helicopter and optional storage for four. The ship is also capable of carrying a variety of vehicles and ISO containers with an area capacity of 1,450m^2. Points to note in the design are that the landing craft must be launched unloaded, with cargo loaded while they are afloat, due to the 55mt limit of the crane.

Figure 6 - HMNZS CANTERBURY

Requirements

For the GFS ship to complete the missions of training and support and humanitarian aid, a set of design requirements were developed with the Military Effectiveness Group at NSWCCD. These requirements, tabulated in Table 1, were taken as hard requirements and adhered to rigorously.

To address the high level of versatility required to fulfill the GFS mission, a modular cargo system was used in this design. This allows the ship to be loaded with the required adaptive force package in the form of a number of ISO TEU containers. This permits a basic ship to be loaded with mission specific packages the size of one or more TEU containers. The addition of these mission containers allows the basic ship to be transformed into a ship capable of completing a specialized mission role. The basic ISO TEU containers can be designed for any number of configurations and provide many different capabilities. For example there are commercially available, off the shelf, accommodation blocks and a variety of medical facilities based on multiple containers. The capabilities and effectiveness of these TEUs have been outlined in a CISD report into the uses of a commercial heavy lift ship for auxiliary naval operations[2]
.

Table 1 - Table of Final Requirements for Station Ship Mission

Particular	Requirements	Particular	Requirements
Core Requirements		Radar	Surface Search
Length (m)	120-150	ESM	Limited
Beam (m)	less than 32	**Crew**	
Loaded Draft (m)	< 4.5	Permanent Crew	60 persons
Cruising Speed (knots)	15	Mission Crew	35 persons
Max Speed (knots)	18	Segregation	Separate areas for mission and permanent crew
Range @ 15 knots (nm)	6,000	Accommodations Standard	US Navy
Displacement (mt)	5,000-10,000	VIP	1 VIP Suite
Supply Endurance (days)	30+	**Power & Water**	
Cargo (TEUs)	50	Water generation	43mt per day
Vehicles	Range of non-armored rolling stock	Water Storage (mt)	207
Crane Lift (mt)	26	Power Offload (MW)	3
Well Deck (Length x W) (m)	25 x 10	**Seakeeping**	
Aviation	1 x SH-60 + assorted UAVs	All Ship Operations	Up to Sea State 3
Re-Supply at Sea	1 x Kingpost	Air Operations at Zero Speed	Up to Sea State 6
Classification	ABS Steel Vessel Rules	Survivability	Up to Sea State 8
Command & Control		**Armament**	
Planning & Briefing	35 personnel	Guns	5 x .50 caliber Remotely Operated Small Arms Mounts
Control Rooms	Logistic Offload,Boat Ops + Helicopter Ops	Small Arms	35 weapons
Communications	Limited	Magazine	Support on board armament

Station Ship Design

Design Process

The ship was designed using an iterative weight and volume balancing method. This method assigns a weight and volume to each feature in the hull. This weight and space data is then used to generate a hull form to hold the required volume and displace the required weight. The process is repeated iteratively to refine capabilities and achieve a balanced design. Four iterations were completed during this study. The graphic evolution of the design through the iterations is shown in Figure 7.

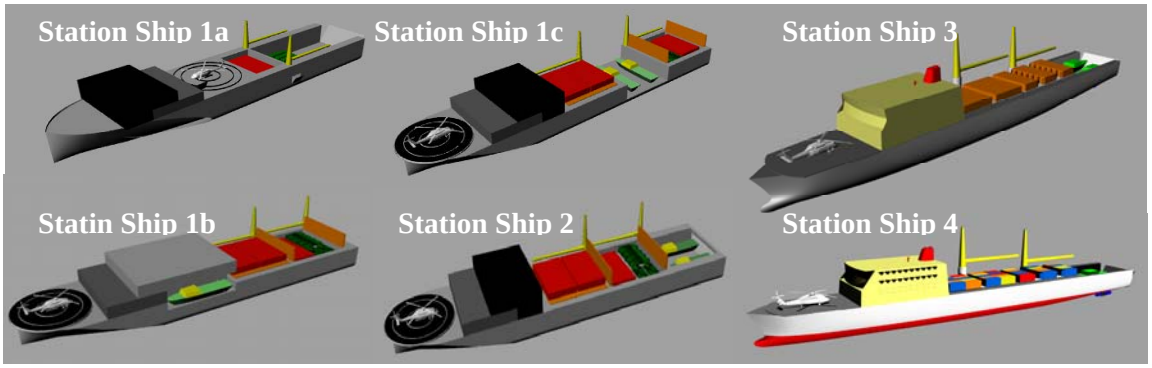


Figure 7 - Design Evolution

GFS Station Ship Final Design

Station Ship 4 was selected as the final GFS Station Ship design. That design (Figure 8 and Table 2) is based on a small general-purpose cargo ship built to merchant ship standards and Class Society rules. The vessel has a well deck, helicopter-landing pad and hangar. In addition it has two large flexible container / vehicle holds, with removable hatches. Two cranes located on the port side of the vessel service the holds. Additional containers or cargo can be carried on the removable hatches. The cargo capacity is flexible as it is capable of carrying a wide range of solid cargo limited only by overall size and weight.

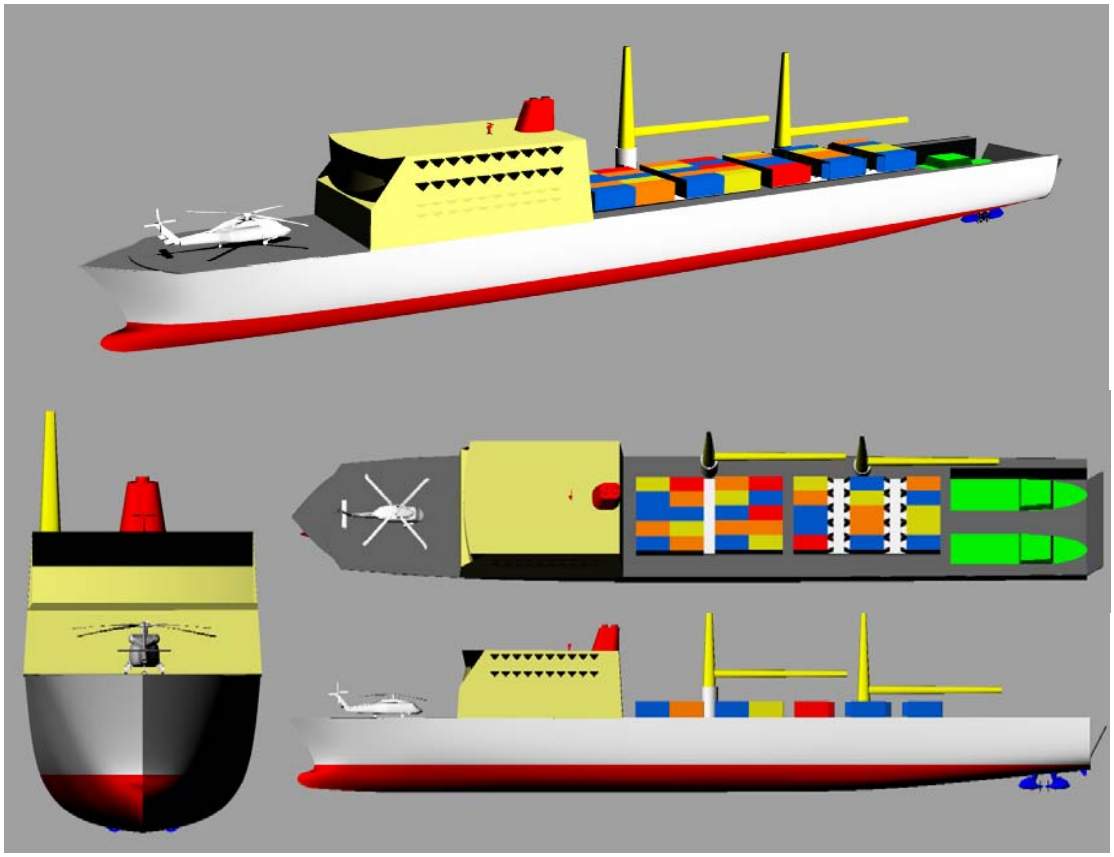


Figure 8 – GFS Station Ship Concept

The design is intended to use commercial rather than military construction approaches and therefore is to be designed to meet regulatory body rules and SOLAS. The vessel will not be required to operate in high threat environments and hence does not require shock or signature reduction policies. Armament is limited to five .50 caliber Remote Operated Small Arms Mounts (ROSAM) and any embarked capabilities.

Table 2 - Principal Particulars for the GFS Station Ship

Particular	Value
Length Between Perpendiculars (m)	140
Beam (m)	17.38
Draft (Loaded) (m)	4.5
Hull Depth (m)	11.9
Loaded Displacement (mt)	6,405
Lightship Displacement (mt)	4,797
Design Speed (knots)	15
Max Speed (knots)	19.00
Range @ 15 knots (nm)	6,000
Ship Crew	60
Permanent Mission Force	35
Transient Force	83

Table 3 - Table of Significant Equipment

Particular	Value
Engine Type (Diesels)	2x12V26 Wartsila
Generator Set Power (KW)	2 x 3,900
Azimuth Pods	4 x ABB Compact pods, size 3
Ships Fuel Load (Diesel) (mt)	292
Aircraft Fuel Load (mt)	25
Aircraft	1 x H-60 Helicopter + 2 x Sea Scout UAVs
Well Deck Dimensions (m)	14.7 X 25
Armament	5 x .50 caliber ROSAM
Cranes	2 x MacGregor GL-2 25 ton

Data in Table 2 is indicative of similar ships chosen for design purposes

Table 4 - Table of Cargo Hold Dimensions

Particular	Value
Number of Container Holds	2
Internal capacity of Hold 1	40 ISO TEU Containers (26.8m x 13.45m x 5.2m)
Internal capacity of Hold 2	40 ISO TEU Containers or 5 x 24.3m vehicle lanes (26.8m x 13.45m x 5.2m)
Above Hold 1 Deck Capacity (Hatches 1, 2)	40 ISO TEU Containers or 5 x 24.3 vehicle lanes (26.8m x 13.45m x 5.2m)
Above Hold 2 Deck Capacity (Hatches 3,4)	20 ISO TEU Containers or 5 x 24.3m vehicle lanes (26.8m x 13.45m x 5.2m)
Maximum total mass of all cargo located in the holds and on deck (mt)	728

Helicopter Deck

The GFS Station Ship design shows a deck arrangement with a forward helicopter deck. This arrangement was selected to avoid space conflicts with the open well deck, hatches and container stowage cranes at the stern. The requirements for helicopter operations are Sea State 6 and below with the vessel stationary. During the majority of the GFS missions, the helicopter deck will only be used when the ship is on-station off a coastline or moored in port. The forward helicopter deck will be operational at zero or slow forward speeds when completing helicopter operations.

The forward helicopter deck is not a new concept and has been used in the offshore oil industry (Figure 9) extensively for many years. This arrangement is not the only option for this design. Other options considered include landing on the top of the deckhouse or on an aft helicopter pad, but these configurations added approximately 20m of length to the vessel. Therefore the forward helicopter pad arrangement was selected as it led to the most operationally effective and ergonomic arrangement for the envisaged missions.

Figure 9 - Examples of Forward Helicopter Decks on FPSOs

Weight and Space Estimates

Weight and space estimates for this design were developed using the US Navy's Ship Work Breakdown Structure (SWBS) system and Ship Space Classification System (SSCS). The major weight and space groups were calculated from first principles or calculated using algorithms derived from previous ship data, but data was unavailable for the subsystems and some of the detailed lines. As weight and space reports were available for LPD 17, it was used as a basis for scaling the subsystems. A three digit SWBS weight breakdown for the GFS Station Ship is shown in Appendix B and the area summary is shown in Appendix C. The one digit weight and area summaries for the GFS Station Ship are shown in Table 5 and Table 6.

Table 5 - SWBS Weight Summary

Group	Weight (mt)
SWBS 100 - Hull Structures	3,047
SWBS 200 - Propulsion Plant	456
SWBS 300 - Electric Plant	105
SWBS 400 - Command + Surveillance	87
SWBS 500 - Auxiliary Systems	676
SWBS 600 – Outfit & Furnishings	504
SWBS 700 - Armament	1
Lightship	4,880
SWBS F00 - Loads	1,525
Loaded Displacement	6,405

Table 6 – SSCS Area Summary

Group	Area (m^2)
Mission Support	548
Human Support	1,057
Ship Support	3,392
Ship Machinery System	554

Hull Structures

The GFS Station Ship hull was designed as a commercial steel vessel with no shock mounting, hardening or other survivability characteristics incorporated. The structural weight was estimated using an algorithm based on data from existing merchant ships[3]. Different ship types are modeled in the algorithm though the selection of appropriate non-dimensional factors. Unfortunately the GFS Station Ship does not fit neatly into a merchant ship group because of features such as a well deck, cargo hold and the size of the crew. The main features resembled a cross between a container ship and a ferry. As a result, an appropriate non-dimensional factor was selected. Using the merchant ship structural estimates detailed in Appendix A resulted in a hull structure weight estimate of 2,770mt. A 10% margin was also applied to this group to give a total of 3,047mt.

An estimate of the 3-digit hull weight group was determined by creating a similar ship in ASSET and using the weight breakdown percentages obtained. The results are shown in Table 7.

Table 7 - SWBS 100 Weight Summary

Group	Description	Weight (mt)
110	SHELL + SUPPORTS	1,168
120	HULL STRUCTURAL BULKHDS	197
130	HULL DECKS	597
140	HULL PLATFORMS/FLATS	230
150	DECK HOUSE STRUCTURE	274
160	SPECIAL STRUCTURES	118
170	MASTS + KINGPOST	4
180	FOUNDATIONS	110
190	SPECIAL PURPOSE SYSTEMS	71
100	HULL STRUCTURES	2,770
*100	HULL STRUCTURES INC. 10% MARGIN	3,047

Machinery Weight

A full electric ship was selected because it had significant advantages, one of which was the required ability to offload power to the shore. A fully electric ship also allows flexibility in placement of main propulsion machinery. This allowed the placement of the engines forward in the ship without a large shaft weight penalty. Also, possible conflicts between the shafting and the well deck were avoided. The podded propulsors allow for greater maneuverability in port and negate the need for rudders. In addition, with a podded system the propeller is exposed to a more favorable wake field than a traditional twin propeller design increasing efficiency, all at a relatively shallow draft.

The resistance of the ship was calculated using BSRA merchant ship methodical series data[4] combined with standard hull efficiencies to estimate the required installed power. The BSRA series provided the bare hull resistance, a total margin of 15% was applied, 2% to account for air resistance and a conservative margin of 13% to account for the appendage resistance of the pods and bilge keels. The efficiencies used are shown in the Table 8.

Table 8 - Propulsion Efficiencies

Particular	Value
Relative Rotative Efficiency	0.98
Open Water Efficiency	0.63
Hull Efficiency	1.00
QPC	0.62
Efficiency of PM Motor	0.96
Efficiency of Converter	0.95
Efficiency of Generator	0.98

GFS Station Ship is not required to operate with other Navy assets such as the Amphibious fleet. Consequently, there is no requirement for the higher sustained speeds of those assets. While these higher speeds could be achieved, the higher installed power and added fuel load would greatly increase cost. Guidance provided by the Military Effectiveness Group indicated that unnecessary costs were to be avoided. Consequently, the machinery plant was designed to provide speeds lower than those of Navy Amphibs.

Two 12V26 Wartsila diesel generators with a combined power of 7.8MW were selected as the prime movers for the GFS Station Ship concept. The ship service power was estimated at 1.5MW, which led to an available power for propulsion of 6.3MW.

The power required to propel the ship at the endurance speed of 15 knots with a 10% margin for weather is 2.5MW. The sustained speed of 18 knots was achieved at 80% power and the maximum trial speed is predicted to be 19 knots.

The selection of podded propulsors was driven primarily by the draft constraint defined in the requirements and the power needed to drive the vessel. The pod height from blade tip to hull was constrained to be less than 4m. The delivered power required is between

4.6MW and 6.1MW to obtain the cruise and maximum speeds. To meet these two requirements, four size 3 ABB compact pods illustrated in Figure 10 were selected.

Figure 10 - ABB Compact Pod

Other propulsion options were investigated during the design including rim drive thrusters and mechanical pods with two counter-rotating propellers. The rim drive thrusters offered the benefit of a ducted propeller for high thrust, but without the large hub and propeller tip vortices efficiency losses[5]. The rim drive was not selected as there was no requirement for high thrust loading and rim drives of the required power are not commercially available. The Schottel Group's twin counter-rotating mechanical pod[6], shown in Figure 11, offered high QPC and low pod drag, but was not selected due to space constraints in the hull at the pod location.

Figure 11 - SCHOTTEL Twin- Propeller

The size 3 ABB compact pods[7] have a height from propeller tip to hull of 3.5m satisfying the draft requirement. Each pod has a delivered power of up to 2MW. This means that a total of four pods were required.

After qualitatively evaluating the various configurations of four azipods, the configuration shown in Figure 12 was selected. The reasoning behind this configuration is that the pod sets can have counter-rotating propellers to improve the QPC and therefore the fuel efficiency.

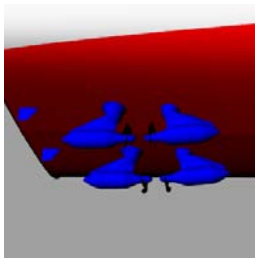


Figure 12 - GFS Station Ship Concept Pod Configuration

It is also proposed that the aft pods are azimuthing to give good maneuverability in port. Small trim tabs were placed aft of the propeller to provide the ability to make small alterations to the heading while underway without moving the pods. Weight for the propulsive units was obtained from ABB published data. The machinery sub-systems were unknown so they were scaled from a similar hull form and propulsion system generated in ASSET. The SWBS 200 breakdown is shown below:

Table 9 - SWBS 200 Weights Summary

Group	Description	Weight (mt)
210	ENERGY GEN SYS (NUCLEAR)	0
220	ENERGY GENERATING SYSTEM	(see SWBS 310)
230	PROPULSION UNITS	226.6
240	TRANSMISSION+PROPULSOR SYSTEMS	0.0
250	SUPPORT SYSTEMS	77.9
260	PROPUL SUP SYS- FUEL, LUBE OIL	41.8
290	SPECIAL PURPOSE SYSTEMS	68.5
200	PROPULSION PLANT	414.8
*200	PROPULSION PLANT INC. 10% MARGIN	456.28

Electrical Plant, Command & Control, Auxiliary System, General Outfitting and Armament

The SWBS 300-600 groups incorporate the Electrical Plant, Command and Surveillance, Auxiliary Systems and General Outfitting and Furnishing. The majority of these groups are subsystems, furnishings and outfittings and it was not possible to calculate their weight and space data from first principles. Therefore the LPD 17 weight and space data was manipulated to make it relevant to the GFS Station Ship design. For example a large amount of the command and control systems were not scaled from LPD 17 as the GFS Station Ship does not require these facilities. The SWBS 300-600 groups are shown in the Tables 10 to 13.

Table 10 - SWBS 300 Weight Summary

Group	Description	Weight (mt)
310	ELECTRIC POWER GENERATION	45
320	POWER DISTRIBUTION SYS	24
330	LIGHTING SYSTEM	3
340	POWER GENERATION SUPPORT SYS	21
390	SPECIAL PURPOSE SYS	7
300	ELECTRIC PLANT, GENERAL	100
*300	ELECTRIC PLANT, GENERAL INC. 5% MARGIN	105

Table 11 - SWBS 400 Weight Summary

Group	Description	Weight (mt)
410	COMMAND+CONTROL SYS	28
420	NAVIGATION SYS	8
430	INTERIOR COMMUNICATIONS	43
440	EXTERIOR COMMUNICATIONS	3
450	SURF SURV SYS (RADAR)	2
460	UNDERWATER SURVEILLANCE SYSTEMS	0
470	COUNTERMEASURES	0
480	FIRE CONTROL SYS	0
490	SPECIAL PURPOSE SYS	15
400	COMMAND+SURVEILLANCE	83
*400	COMMAND+SURVEILLANCE INC. 5% MARGIN	87

Table 12 - SWBS 500 Weight Summary

Group	Description	Weight (mt)
510	CLIMATE CONTROL	32
520	SEA WATER SYSTEMS	135
530	FRESH WATER SYSTEMS	30
540	FUELS/LUBRICANTS,HANDLING+STORAGE	37
550	AIR,GAS+MISC FLUID SYSTEM	85
560	SHIP CNTL SYS	0.0
570	UNDERWAY REPLENISHMENT SYSTEMS	105
580	MECHANICAL HANDLING SYSTEMS	142
590	SPECIAL PURPOSE SYSTEMS	78
500	AUXILIARY SYSTEMS	644
*500	AUXILIARY SYSTEMS INC. 5% MARGIN	676

Table 13 - SWBS 600 Weight Summary

Group	Description	Weight (mt)
610	SHIP FITTINGS	45
620	HULL COMPARTMENTATION	147
630	PRESERVATIVES+COVERINGS	208
640	LIVING SPACES	19
650	SERVICE SPACES	11
660	WORKING SPACES	25
670	STOWAGE SPACES	21
690	SPECIAL PURPOSE SYSTEMS	8
600	OUTFIT & FURNISHING	484
*600	OUTFIT & FURNISHING INC. 5% MARGIN	507

Table 14 - SWBS 700 Weight Summary

Group	Description	Weight (mt)
710	GUNS+AMMUNITION	1
720	MISSLES+ROCKETS	0
730	MINES	0
740	DEPTH CHARGES	0
750	TORPEDOES	0
760	SMALL ARMS+PYROTECHNICS	0
770	CARGO MUNITIONS	0
780	AIRCRAFT RELATED WEAPONS	0
790	SPECIAL PURPOSE SYSTEMS	0
700	ARMAMENT	1
*700	ARMAMENT INC. 5% MARGIN	1

Loads

Cargo loads carried by the GFS Station Ship vary significantly depending on the mission choices. A representative cargo loading for the ship is 43 ISO containers, two 100mt patrol boats and five trucks weighing a total of 50mt. The maximum weight of an ISO TEU container is 24mt. As it is unlikely that all containers will be maximum loaded, an average weight of 13.6mt per ISO container was used. The fuel loads include 288mt of ships diesel fuel to achieve the required range of 6,000 nm and 24mt of aviation fuel. The GFS Station Ship loads are summarized in Table 15.

Table 15 - SWBS F00 Weight Summary

Group	Description	Weight (mt)
F10	SHIPS FORCE	13
F20	MISSION SYSTEMS	234
F30	STORES	19
F40	LIQUIDS, PETROLEUM	317
F50	LIQUIDS, NON-PETROLEUM	212
F60	CARGO	730
F00	LOADS	1,525
	FULL LOAD INCLUDING MARGIN	**6,405**

The calculation of the weight and space data led to a detailed estimate of the displacement and the internal volume for the GFS Station Ship. This data was used to generate the hull form discussed in the next section and led to the generation of the general arrangement shown in Appendix E.

Hydrostatics

The hull form was generated from the principal dimensions and the hull geometry coefficients C_b, C_w and C_p. Two major features also had to be present in the design: a bulbous bow and a stern configuration to allow podded propulsors to be fitted without increasing the draft of the vessel. Other considerations included maximizing deck area and increasing forward flare to give greater deck area for the helicopter decks.

The intact hydrostatics have been completed for this vessel and are displayed in Table 16. A detailed damage stability analysis will be required for the next stage of the design to ensure the GFS Station Ship conforms to ABS rules, but no issues are expected.

Body Plan

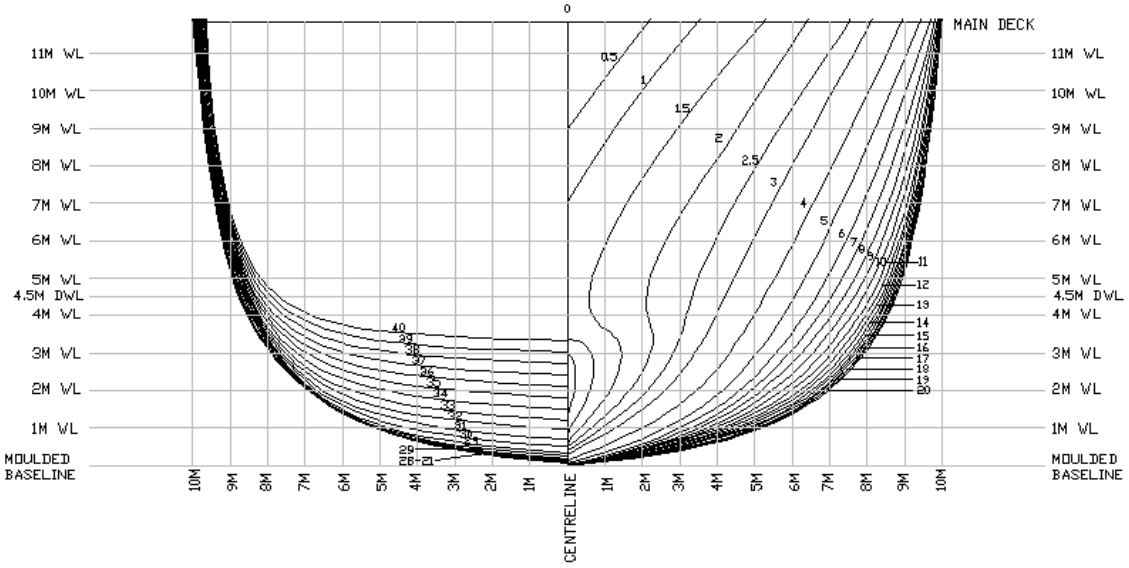


Figure 13 - GFS Station Ship Body Plan

Hydrostatics

Table 16 shows the intact hydrostatic properties of the GFS Station Ship hull at full load displacement.

Table 16 - Table of Hydrostatic Particulars

Particular	Value	Unit	Particular	Value	Unit
Draft Amidship	4.458	m	LCB from midships (+ fwd)	-0.12	m
Displacement	6,406	mt	LCF from midships (+ fwd)	-4.49	m
Heel to Starboard	0	degree	KB	2.8	m
Draft at FP	4.15	m	VCG	8.14	m
Draft at AP	4.76	m	BMt	7.89	m
Draft at LCF	4.47	m	BML	506	m
Trim (+ by stern)	0.6	m	GMt	2.55	m
Waterline Length	140.6	m	GML	501	m
Watrline Beam	17.48	m	KMt	10.6	m
Wetted Area	2,635	m2	KML	510	m
Waterplane Area	2,205	m2	Immersion (TPc)	22.6	mt/cm
Prismatic Coefficient	0.77		Moment to Change Trim 1 cm	229	mt-m
Block Coefficient	0.60		Max deck inclination	0.2	degree
Midship Area Coefficient	0.75		Trim angle (+ by stern)	0.2	degree
Waterplane Area Coefficient	0.9				

Large Angle Intact Stability

Figure 14 shows the GZ curve for the GFS Station Ship at full load displacement. The GZ curve has been evaluated and met the general ship stability criteria defined in the Code of Federal Regulations[8] for vessels of usual proportion and form.

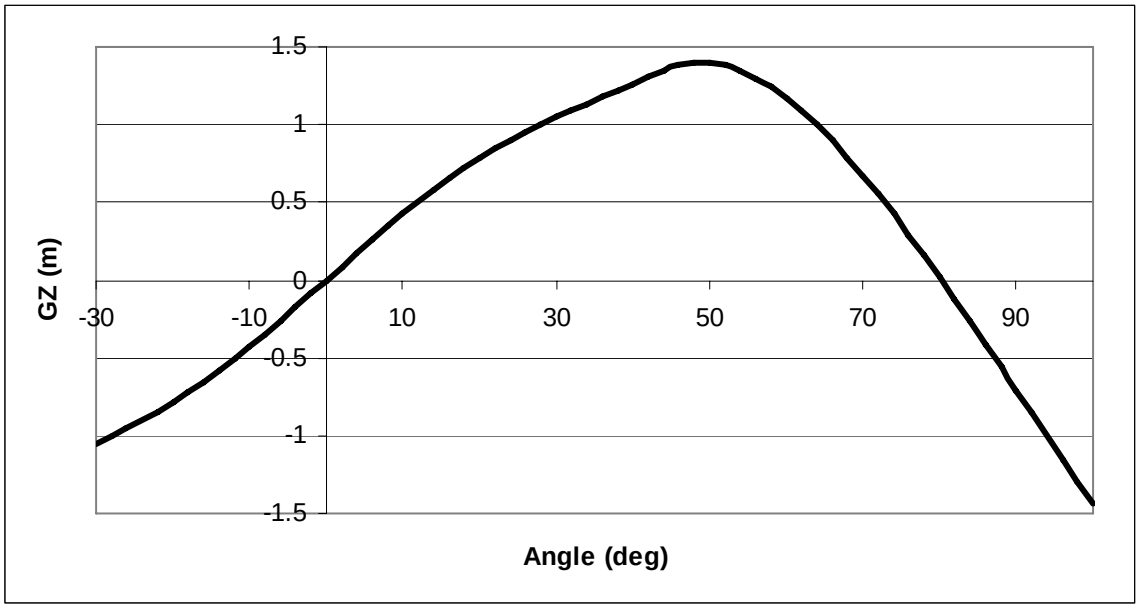


Figure 14 - GZ Curve

Floodable Length

The floodable length of this vessel was generated with a margin line 76mm below the main deck which in this design is the upper bulkhead deck. The bulkheads were placed as uniformly as possible and have been arranged to meet two-compartment damage stability criteria. In further iterations, the bulkheads may have to be moved to meet the applicable damaged stability criteria. The floodable length curve is shown in Figure 15. The small and large triangles reflect the one and two compartment standard, respectively. If the peak of the triangle breaks the floodable length curves the ship would sink below the margin line with those compartments flooded. The results indicate that fewer, more widely space bulkheads could be used without submerging the margin line. The GFS Station Ship will be required to satisfy more comprehensive intact and damaged stability cases that will drive the bulkhead spacing. Therefore at this stage in the design this conservative bulkhead spacing was used.

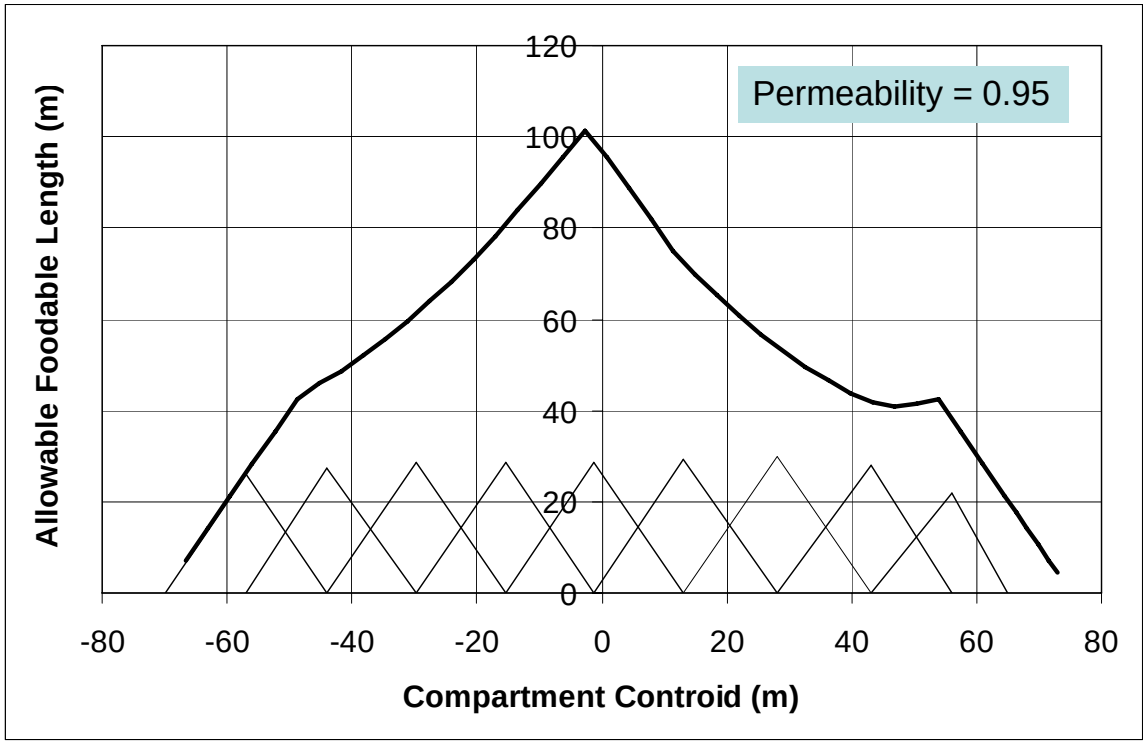


Figure 15 - Floodable Length Curve

Seakeeping

A seakeeping analysis was completed using the Maxsurf Seakeeper ® package which is a frequency domain seakeeping program. The hull was analyzed to discover the roll natural frequency and calculate the accelerations on the flight deck at various speeds, headings and sea states. The sea states[9] used in this analysis were 3, 4, 6 and 8 and the speeds used were 0, 15 and 18 knots. As the non-dimensional roll damping coefficient was not known for this ship at this stage in the design, a representative value of 0.075 was used. This means the magnitude of the peak of the RAO graph is not accurate, but the peak does show the natural frequency of the ship roll motions in beam seas. It can be seen from Figure 16 that the peak roll RAO occurs at 0.7 rad./s or an 8.5 second wave period. Northern North Atlantic wave data[9] shows that the percentage occurrence of 8.5 second period is 22% in sea states between 2 and 3. Due to the high probability of this wave period occurring it will be necessary to fit the GFS Station Ship with bilge keels, and possibly active stabilizers, to dampen the motion of the vessel.

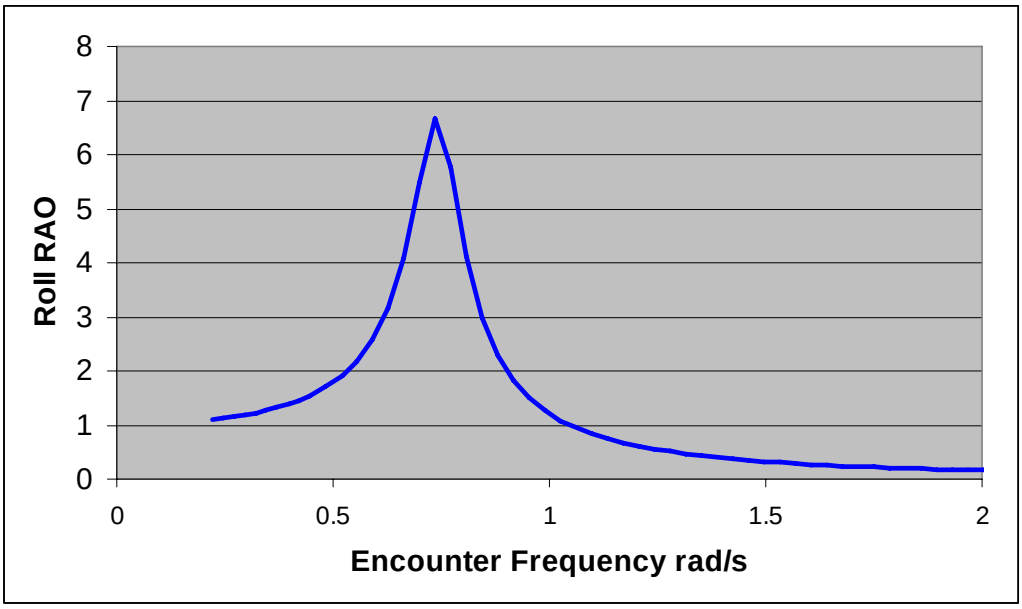


Figure 16 – Roll RAO for the GFS Station Ship in Beam Seas

The motions of the helicopter deck were also calculated to ensure operability up to sea state 6. The motions criteria used for helicopter operations was 2 ms^{-2} RMS acceleration at the helicopter deck[10]. Figure 17 shows that the RMS acceleration on the flight deck is less than 0.5 ms^{-2} for all the sea states investigated.

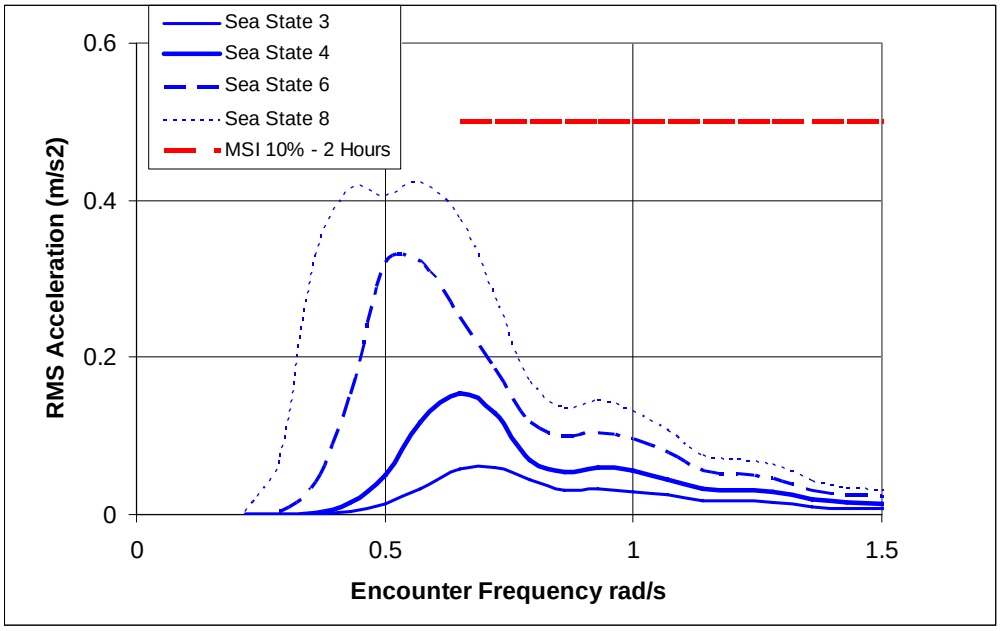


Figure 17 - Helicopter Deck Accelerations in Head Seas at 0 Knots

Internal Multi-Purpose Space

The GFS Station Ship is intended to perform a number of different missions requiring various mixes of cargo, mission personnel and mission equipment. The internal multi-purpose space was included in the design to support a variety of missions. The space includes a 35-person lecture theater, an 18-person computer suite, lockers, a storeroom, sanitary facilities and a range of smaller multi-configurable compartments. The multi-configurable space can be outfitted with a variety of equipment, transforming it into what is required for the current mission.

It is envisaged that the 35-person lecture theater would be used for teaching in training and humanitarian aid missions or as a briefing room for mission planning. The 18-person computer suite can be used for tutorials in the training mission or operational planning. The additional re-configurable space becomes austere accommodation for troops, trainee accommodation in the training mission and hospital staff accommodation in the humanitarian aid mission. The berthing, sanitary and storage facilities are co-located for convenience. The configuration is illustrated in Figure 18.

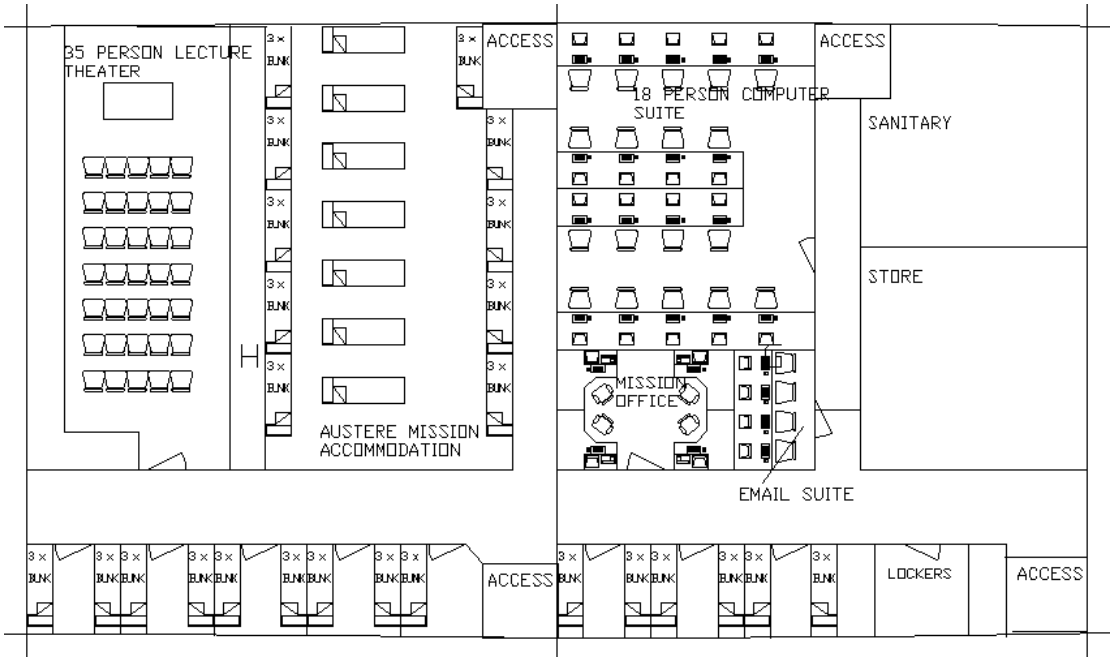


Figure 18 - Internal Multipurpose Space

Mission Loading

The representative mission loadings discussed in this section describe the configuration of each load-out and allow the ship capabilities to be evaluated. Although the constituent material and personnel required for the individual GFS mission loading configurations have not been defined, notional sets of existing boats, aircraft, and containerized systems, as well as their supporting personnel, have been used to illustrate these capabilities. The hypothetical mission loading configurations for the two principle GFS missions, foreign partner nation training and support and humanitarian aid, are shown below.

An additional two loading configurations, multi-role and UAV/USV, have been completed in this study and are shown in Appendix D. The multi-role configuration is a non-mission specific standby condition which would allow the GFS Station Ship to effectively act in several of the three primary missions, but with less total capability in any one mission. The UAV/USV is a capability demonstrating mission configuration showing the number of UAV/USV that could be carried by the GFS Station Ship.

The GFS Station Ship design has been designed to be flexible to complete the many and varied types of missions which would be required of a GFS station ship. The flexible loading arrangement is based primarily on ISO TEU containers, but the ship can carry any cargo within its weight and space limitations. The cargo area and maximum cargo weight restrictions are shown in Table 2**.** The cargo holds have a combined area of 766m^2 and the cargo hatches have a combined area of 674m^2. The cargo hold and hatches can be loaded with any combination of vehicles, containers or solid stores, but only the aft cargo hold can organically offload vehicles at sea. In these missions loading configurations, there are two types of containerized equipment, accessible and inaccessible. The accessible containers contain equipment which can be fully accessed and used at sea, while the inaccessible containers contain cargo which is purely for transportation to a port, or for offload at sea.

Humanitarian Aid Operations Loading

A casualty receiving ship was selected as a representative humanitarian aid mission. The loading arrangement was scaled from the hospital ship arrangement of ref[2]. The GFS Station Ship has 60 accessible container slots and these were divided up in the correct ratios to function as a casualty receiving ship capable of dealing with 108 patients per day. The emergency care and the ICUs were placed on the deck as short a distance from the helicopter deck as possible. Wards were placed in the holds to give greater weather protection. The current shortcoming of the design is that it is a multiple level hospital requiring lift transportation for staff and patients. It has been suggested that for the next iteration a lift be included in the design for the movement of patients. The detailed layout is shown in humanitarian aid ship general arrangement in Appendix E. The principle loading characteristics are shown in the table below and Figure 19 shows the ship's profile in this loading configuration.

Table 17 - Mission Payload – Humanitarian Aid

	Humanitarian Aid Mission
Vehicles	N/A
Accessible TEUs	60
Inaccessible TEUs	0
Helicopters	1 SH - 60 2 ire Scout UAV
Boats	2 LCM 6
Other Aircraft	N/A
Mission Personnel	60 Ship's Crew 108 Patients 93 Medical Staff

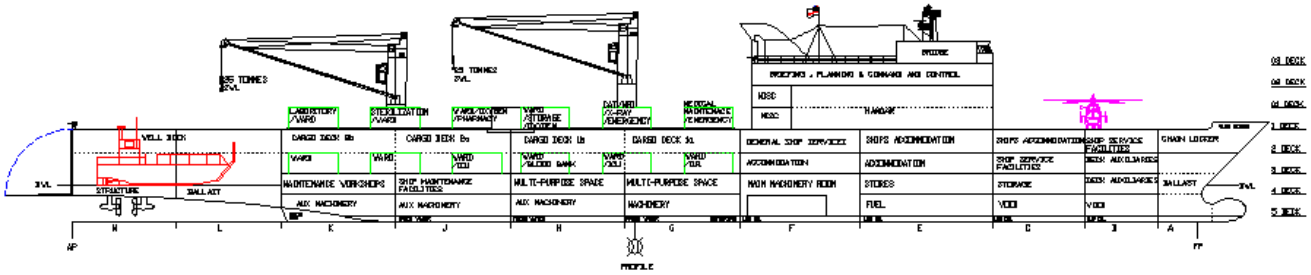


Figure 19 - Humanitarian Aid Ship Inboard Profile

Training and Support Operations Loading

In the foreign partner nation training and support mission, it was envisaged that the mission would require an increased number of indicative patrol boats. In addition to the two patrol boats berthed in the well deck, two additional patrol boats are placed on the main deck at the maximum loading position of the cranes. This loading condition limits the mass of the patrol boats to the maximum lifting capacity of the cranes which at half span is 50mt. The principle loading characteristics are shown in the table below and Figure 20 shows the ships profile in this loading condition.

Table 18 - Mission Payload - Training and Support Operations

	Allied Coastguard Training and Support Mission
Vehicles	N/A
Accessible TEUs	36
Inaccessible TEUs	8
Helicopters	1 SH - 60 2 Fire Scout UAV
Boats	4 Spec Ops Mk 5
Other Aircraft	N/A
Mission Personnel	60 Ships Crew 35 Training Staff 83 Trainees

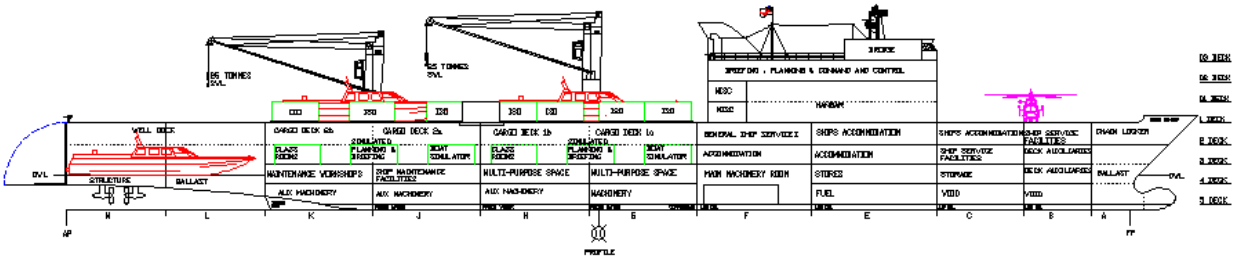


Figure 20 – Foreign Partner Nation Training/Support Inboard Profile

Theater Support Operations Loading

A light company deployment was selected as the representative load for the Theater Support Operations mission. A company was assumed to consist of three platoons and a headquarters unit. A platoon consists of approximately 44 men and a full company including officers is estimated at 150 men. To berth a company, 32 troops would need to be accommodated in ISO containers in addition to the 83 troops in the internal austere accommodation. The vehicle requirement for a company can vary from zero, if supported by aviation, to approximately 10-7 ton trucks and 15 HMMWVs for a light company[11]. The ship was also loaded with a Lake seaplane to increase the reconnaissance capability of the ship. Loaded with this payload, the remaining TEU slots have been designated for equipment storage. The principal loading characteristics are shown in the table below and Figure 21 shows the ships profile in this loading condition.

Table 19 - Mission Payload - Theater Support Operations

	Theater Security Operations Mission
Vehicles	10 Truck 15 HMMWV
Accessible TEUs	5
Inaccessible TEUs	40
Helicopters	1 SH - 60 2 Fire Scout UAV
Boats	1 Spec Ops Mk 5 1 LCM 6
Other Aircraft	1 Lake Seaplane
Mission Personnel	60 Ships Crew 35 Full 83 Austere 32 TEU Accommodation

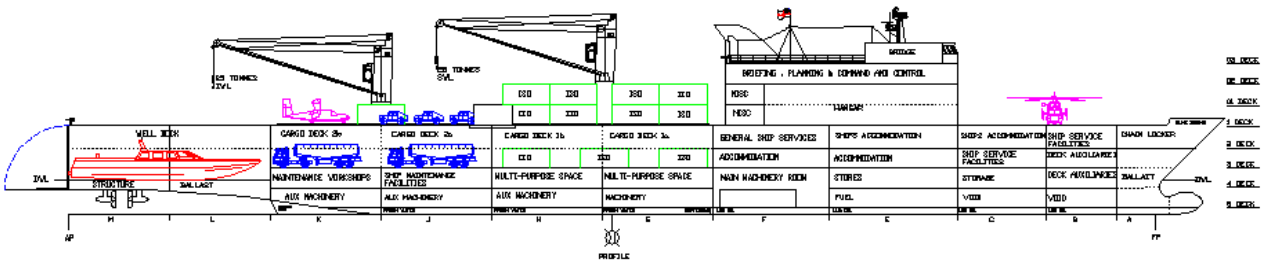


Figure 21 - Theater Security Operations Inboard Profile

Design Risk

The risk inherent in this design is low as all equipment is commercially available. The hull is a conventional steel monohull designed in accordance with ABS Steel Vessel rules. Fully integrated electric propulsion systems are currently used extensively, and a similar system has been used in a number of USN auxiliaries. Therefore, the system presents a low risk to the design. Podded propulsion systems are used extensively within the cruise ship industry: however, the US Navy currently has little operational experience with this technology. The forward helicopter landing pad would be a new operating procedure for the US Navy, but is currently used extensively in the oil industry and presents a low risk to air operations when forward speed vessel is very low.

Summary

The purpose of this project was to establish that a ship in the range of principal dimensions set out by the requirements could be designed to fulfill the GFS ship mission. The GFS Station Ship concept has demonstrated that GFS mission capabilities can be provided by a 6,400 mt monohull for the various representative mission loadings. The ship concept has been taken to the detailed concept stage; a complete SWBS breakdown and detailed general arrangement have been completed.

The ISO TEU container based loading plan has demonstrated significant flexibility. It allows for transporting large amounts of equipment in containers. This flexible loading arrangement allows the GFS Station Ship concept's loading to be tailored to the mission requirements.

The GFS Station Ship concept has several advantages including shallow draft, a non-military appearance and a flexible loading plan allowing the ship to be tailored to any mission. While a cost analysis has not been completed, the exclusive use of commercial off the shelf equipment in a steel monohull design with very limited military features is expected to minimize cost.

Recommendations

This project was intended to generate a detailed concept design. Therefore, the next stage of the process is the detailed design which can build on the current work. In addition to the detailed design, a number of areas have been identified as requiring further attention:

- refinement of mission requirements and design standards;
- refinement of the number and location of watertight bulkheads via a comprehensive hydrostatic analysis;
- improvement of the structural weight estimate by developing a structural design conforming to ABS Steel Vessel Rules ; and
- optimization of the hull form, arrangement and machinery.

Appendix A – Hull Structure Estimate

Watson & Gillfillan in 'Some Ship Design Methods' RINA 1976 suggest the following procedure for structural weight estimation:

$$Ws = Ws7\left[1 + 0.5(Cb - 0.70)\right], \text{ where} \quad (1)$$

$$W_{S7} = KE^{1.36} \quad (2)$$

Where E is related to dimensions by the following formula:

$$E = L(B+T) + 0.85L(D-T) + 0.85\sum l_1 h_1 + 0.75\sum l_2 h_2 \quad (3)$$

Where l_1h_1 refers to the length and height of the full width superstructure
l_2h_2 refers to the length and height of the partial width superstructure

The following table shows the K values which are defined separately for different types of Merchant ships.

Table A1 - K values for Merchant Ships

Ship Type	K
Tanker	0.029 – 0.035
Chemical Tanker	0.036 – 0.037
Bulk Carrier	0.029 – 0.032
Container	0.033 – 0.040
Ferries	0.024 – 0.037

The K value used in the GFS Station Ship hull structural mass estimate was K = 0.033

Where:
C_b - Block coefficient
L - Length (m)
B - Beam (m)
T - Draft (m)
l_1 - Length of full width superstructure
h_1 - Height of the full width superstructure
l_2 - Length of partial width superstructure
h_2 - Height of the partial width superstructure

Appendix A – Hull Structure Estimate

Appendix B – SWBS Weight Summary

SWBS 100 – Hull Structures

Group	Description	Weight (mt)
110	SHELL + SUPPORTS	1,167.7
120	HULL STRUCTURAL BULKHDS	197.1
130	HULL DECKS	596.5
140	HULL PLATFORMS/FLATS	230.4
150	DECK HOUSE STRUCTURE	274.4
160	SPECIAL STRUCTURES	118.5
170	MASTS + KINGPOST	3.5
180	FOUNDATIONS	110.2
190	SPECIAL PURPOSE SYSTEMS	70.5
100	HULL STRUCTURES	2,770.4
*100	HULL STRUCTURES INC. 10% MARGIN	3,047.4

SWBS 200 – Propulsion Plant

Group	Description	Weight (mt)
233	DIESEL ENGINES	118.6
235	ELECTRIC PROPULSION POD	108.0
230	PROPULSION UNITS	226.6
241	REDUCTION GEARS	0.0
242	CLUTCHES + COUPLINGS	0.0
243	SHAFTING	0.0
244	SHAFT BEARINGS	0.0
245	PROPULSORS	0.0
240	TRANSMISSION+PROPULSOR SYSTEMS	0.0
251	COMBUSTION AIR SYSTEM	20.6
252	PROPULSION CONTROL SYSTEM	5.7
256	CIRC + COOL SEA WATER SYSTEM	2.2
259	UPTAKES (INNER CASING)	49.4
250	SUPPORT SYSTEMS	77.9
261	FUEL SERVICE SYSTEM	3.8
262	MAIN PROPULSION LUBE OIL SYSTEM	31.3
264	LUBE OIL HANDLING	6.7
260	PROPUL SUP SYS- FUEL, LUBE OIL	41.8
298	OPERATING FLUIDS	39.4
299	REPAIR PARTS + TOOLS	29.1
290	SPECIAL PURPOSE SYSTEMS	68.5
200	PROPULSION PLANT	414.8
*200	PROPULSION PLANT INC. 10% MARGIN	456.3

SWBS 300 – Electric Plant

Group	Description	Weight (mt)
311	SHIP SERVICE POWER GENERATION	0.0
312	EMERGENCY GENERATORS	4.2
313	BATTERIES+SERVICE FACILITIES	0.5
314	POWER CONVERSION EQUIPMENT	40.0
310	ELECTRIC POWER GENERATION	44.7
324	SWITCHGEAR+PANELS	24.1
320	POWER DISTRIBUTION SYS	24.1
331	LIGHTING DISTRIBUTION	1.6
332	LIGHTING FIXTURES	1.1
330	LIGHTING SYSTEM	2.7
342	DIESEL SUPPORT SYS	20.8
340	POWER GENERATION SUPPORT SYS	20.8
398	ELECTRIC PLANT OP FLUIDS	4.3
399	REPAIR PARTS+SPECIAL TOOLS	2.9
390	SPECIAL PURPOSE SYS	7.2
300	ELECTRIC PLANT, GENERAL	99.6
*300	ELECTRIC PLANT, GENERAL INC. 5% MARGIN	104.6

SWBS 400 – Command and Surveillance

Group	Description	Weight (mt)
411	DATA DISPLAY GROUP	6.5
412	DATA PROCESSING GROUP	9.8
413	DIGITAL DATA SWITCHBOARDS	1.2
414	INTERFACE EQUIPMENT	0.0
415	DIGITAL DATA COMMUNICATIONS	10.0
417	COMMAND+CONTROL ANALOG SWBD	0.0
410	COMMAND+CONTROL SYS	27.5
421	NON-ELECT NAVIGATION AIDS	0.3
422	ELECTRICAL NAVIGATION AIDS	0.2
423	ELECTRONIC NAVIG AIDS, RADIO	2.9
424	ELECTRONIC NAVIG AIDS, ACOUSTIC	0.5
426	ELECTRICAL NAVIGATION SYS	4.1
427	INERTIAL NAVIGATION SYS	0.0
428	NAVIGATION CONTROL MONITORING	0.0
420	NAVIGATION SYS	8.0
431	SWITCHBOARDS FOR I.C. SYSTEMS	0.0
432	TELEPHONE SYSTEMS	10.0
433	ANNOUNCING SYSTEMS	3.4
434	ENTERTAINMENT + TRAINING SYS	3.7
436	ALARM, SAFETY, WARNING SYSTEMS	2.4
437	INDICATING, ORDER, METERING SYS	2.1
438	INTEGRATED CONTROL SYSTEMS	21.0
439	RECORDING + TELEVISION SYSTEMS	0.0
430	INTERIOR COMMUNICATIONS	42.6
441	RADIO SYSTEMS	2.0
442	UNDERWATER SYSTEMS	0.0
443	VISUAL + AUDIBLE SYSTEMS	0.5
444	TELEMETRY SYSTEMS	0.0
445	TTY + FACSIMILE SYSTEMS	0.0
446	SECURITY EQUIPMENT SYSTEMS	0.0
440	EXTERIOR COMMUNICATIONS	2.5
451	SURFACE SEARCH RADAR	0.1
455	IDENTIFICATION SYSTEMS (IFF)	2.0
450	SURF SURV SYS (RADAR)	2.1
493	NON-COMBAT DATA PROCESSING SYS	10.8
499	REPAIR PARTS+SPECIAL TOOLS	4.3
490	SPECIAL PURPOSE SYS	15.0
400	COMMAND+SURVEILLANCE	82.8
*400	COMMAND+SURVEILLANCE INC. 5% MARGIN	87.0

SWBS 500 – Auxiliary Systems

Group	Description	Weight (mt)
511	COMPARTMENT HEATING SYSTEM	0.1
512	VENTILATION SYSTEM	7.9
513	MACHINERY SPACE VENT SYSTEM	15.5
514	AIR CONDITIONING SYSTEM	7.7
516	REFRIGERATION SYSTEM	1.0
510	CLIMATE CONTROL	32.2
521	FIREMAIN+SEA WATER FLUSHING SYS	33.2
522	SPRINKLING SYSTEM	4.7
523	WASHDOWN SYSTEM	8.6
524	AUXILIARY SEAWATER SYSTEM	13.6
526	SCUPPERS+DECK DRAINS	15.0
528	PLUMBING DRAINAGE	4.0
529	DRAINAGE+BALLASTING SYSTEM	56.3
520	SEA WATER SYSTEMS	135.4
531	DISTILLING PLANT	10.0
532	COOLING WATER	1.3
533	POTABLE WATER	5.0
536	AUXILIARY FRESH WATER COOLING	13.9
530	FRESH WATER SYSTEMS	30.1
541	SHIP FUEL+COMPENSATING SYSTEM	26.0
542	AVIATION+GENERAL PURPOSE FUELS	5.0
543	AVIATION+GENERAL PURPOSE LUBO	1.0
544	LIQUID CARGO	0.0
549	SPEC FUEL+LUBRICANTS HANDL+STOW	5.0
540	FUELS/LUBRICANTS,HANDLING+STORAGE	37.0
551	COMPRESSED AIR SYSTEMS	21.8
553	O2 N2 SYSTEM	0.5
555	FIRE EXTINGUISHING SYSTEMS	62.5
550	AIR,GAS+MISC FLUID SYSTEM	84.7
561	STEERING+DIVING CNTL SYS	0.0
562	RUDDER	0.0
565	TRIM+HEEL SYSTEMS	0.0
568	MANEUVERING SYSTEMS	0.0
560	SHIP CNTL SYS	0.0
571	REPLENISHMENT-AT-SEA SYSTEMS	6.1
572	SHIP STORES+EQUIP HANDLING SYS	3.2
573	CARGO HANDLING SYSTEMS	83.5
575	VEHICLE HANDLING+STOWAGE SYSTEMS	12.0
570	UNDERWAY REPLENISHMENT SYSTEMS	104.8
581	ANCHOR HANDLING+STOWAGE SYSTEMS	60.8
582	MOORING+TOWING SYSTEMS	18.4
583	BOATS,HANDLING+STOWAGE SYSTEMS	6.9
584	MECH OPER DOOR,GATE,RAMP,TTBL SYS	23.5
587	AIRCRAFT LAUNCH SUPPORT SYSTEM	0.2
588	AIRCRAFT HANDLING,SERVICE,STOWAGE	32.4
580	MECHANICAL HANDLING SYSTEMS	142.2

Group	Description	Weight (mt)
593	ENVIRONMENTAL POLLUTION CNTL SYS	1.2
598	AUX SYSTEMS OPERATING FLUIDS	66.8
599	AUX SYSTEMS REPAIR PARTS+TOOLS	9.6
590	SPECIAL PURPOSE SYSTEMS	77.6
500	AUXILIARY SYSTEMS, GENERAL	644.0
*500	AUXILIARY SYSTEMS, GENERAL INC. 5% MARGIN	676.2

SWBS 600 – Outfit and Furnishings

Group	Description	Weight (mt)
611	HULL FITTINGS	24.2
612	RAILS,STANCHIONS+LIFELINES	20.2
613	RIGGING+CANVAS	1.1
610	SHIP FITTINGS	45.4
621	NON-STRUCTURAL BULKHEADS	18.4
622	FLOOR PLATES+GRATING	90.2
623	LADDERS	23.6
624	NON-STRUCTURAL CLOSURES	11.1
625	AIRPORTS,FIXED PORTLTS, WINDOWS	3.2
620	HULL COMPARTMENTATION	146.5
631	PAINTING	48.3
632	ZINC COATING	0.0
633	CATHODIC PROTECTION	22.5
634	DECK COVERINGS	86.8
635	HULL INSULATION	36.3
637	SHEATHING	11.7
638	REFRIGERATION SPACES	1.9
630	PRESERVATIVES+COVERINGS	207.6
641	OFFICER BERTHING+MESSING	3.4
642	NON-COMM OFFICER B+M	3.9
643	ENLISTED PERSONNEL B+M	8.6
644	SANITARY SPACES+FIXTURES	2.0
645	LEISURE+COMMUNITY SPACES	0.8
640	LIVING SPACES	18.8
651	COMMISSARY SPACES	4.2
652	MEDICAL SPACES	1.9
653	DENTAL SPACES	0.2
654	UTILITY SPACES	3.6
655	LAUNDRY SPACES	1.2
650	SERVICE SPACES	11.0
661	OFFICES	0.7
662	MACH CNTL CENTER FURNISHING	0.1
663	ELECT CNTL CENTER FURNISHING	0.5
664	DAMAGE CNTL STATIONS	6.3
665	WORKSHOPS,LABS,TEST AREAS	17.0
660	WORKING SPACES	24.6
671	LOCKERS+SPECIAL STOWAGE	0.9
672	STOREROOMS+ISSUE ROOMS	20.1
670	STOWAGE SPACES	21.0
698	OPERATING FLUIDS	0.3
699	REPAIR PARTS+SPECIAL TOOLS	4.6
690	SPECIAL PURPOSE SYSTEMS	8.0
600	OUTFIT+FURNISHING,GENERAL	482.9
*600	OUTFIT+FURNISHING,GENERAL INC. 5% MARGIN	507.0

SWBS 700 – Armament

Group	Description	Weight (mt)
710	GUNS+AMMUNITION	1.0
720	MISSLES+ROCKETS	0.0
730	MINES	0.0
740	DEPTH CHARGES	0.0
750	TORPEDOES	0.0
760	SMALL ARMS+PYROTECHNICS	0.0
770	CARGO MUNITIONS	0.0
780	AIRCRAFT RELATED WEAPONS	0.0
790	SPECIAL PURPOSE SYSTEMS	0.0
700	ARMAMENT	1.0
*700	ARMAMENT INC. 5% MARGIN	1.1
	LIGHTSHIP INC. MARGINS	**4,879.6**

SWBS F00 – Loads

Group	Description	Weight (mt)
F10	SHIPS FORCE	12.1
F20	MISSION SYSTEMS	
	- AIRCRAFT	20
	- AIRCRAFT SUPPORT	5
	- BOATS	204
	- BOAT SUPPORT	5
F30	STORES	
	- PROVISIONS	10
	- GENERAL STORES	9
F40	LIQUIDS, PETROLEUM	
	- DIESEL FUEL	288
	- JP 5	24
	- LUBE OIL	5
F50	LIQUIDS, NON-PETROLEUM	
	- SEAWATER	2
	- FRESH WATER	207
	- HYDRAULIC FLUID	1
	- SANITARY TANK FLUID	2
F60	CARGO	
	- LAND VEHICLES	50
	- CONTAINERS	697.1
F00	LOADS	1,525.5
	FULL LOAD INC. MARGIN	**6,405.1**

Appendix C - SSCS Space Summary

Group 1 – Mission Support				
Group	**Description**	**Area (m^2)**		
1	MISSION SUPPORT	548.2		
1.1	COMMAND,COMMUNICATION+SURV	82.3		
1.11	EXTERIOR COMMUNICATIONS	0.0		
1.111	RADIO		0.0	
1.112	UNDERWATER SYSTEMS		0.0	
1.113	VISUAL COM		0.0	
1.12	SURVEILLANCE SYS	0.0		
1.121	SURFACE SURV (RADAR)		0.0	
1.122	UNDERWATER SURV (SONAR)		0.0	
1.13	COMMAND+CONTROL	67.3		
1.131	COMBAT INFO CENTER			
1.132	CONNING STATIONS		67.3	
1.13201	PILOT HOUSE			62.2
1.13202	CHART ROOM			5.0
1.14	COUNTERMEASURES			0.0
1.15	INTERIOR COMMUNICATIONS	15.1		15.1
1.3	AVIATION	182.3		
1.32	AVIATION CONTROL	17.1		
1.321	FLIGHT CONTROL			17.1
1.34	AIRCRAFT STOWAGE			0.0
1.35	AVIATION ADMINISTRATION	25.6		25.6
1.36	AVIATION MAINTENANCE	17.3		17.3
1.38	AVIATION FUEL SYS	95.0		95.0
1.39	AVIATION STORES	27.3		27.3
1.4	AMPHIBIOUS	104.4		
1.42	AMPHIB CONTROL	22.5		22.5
1.43	AMPHIB HANDLING	76.7		
1.43007	STERN GATE OP GR RM			55.8
1.43008	INHAUL MACH RM			20.9
1.44	AMPHIB STOWAGE			0.0
1.44001	VEHICLE STOWAGE			0.0
1.44002	WELL DECK			0.0
1.45	AMPHIB ADMIN	5.2		
1.451	LANDING FORCE CMDR ADMIN			0.0
1.453	TROOP ADMIN			5.2
1.45401	COMBAT CARGO OFFICE			0.0
1.46	AMPHIB MAINTANENCE			0.0
1.46001	CANVAS & RUBBER SKRT SHP			0.0
0	Cargo Accounted for in PL			0.0
1.6	INTERMEDIATE MAINT FAC	127.3		
1.7	FLAG FACILITIES	11.7		

Group	Description	Area (m^2)		
1.71	OPERATIONS			0.0
1.72	CONTROL			11.7
1.73	HANDLING			0.0
1.74	STOWAGE			0.0
1.75	ADMIN			0.0
1.8	SPECIAL MISSIONS	28.3		
1.9	SM ARMS,PYRO+SALU BAT	11.9		
1.91	SM ARMS (LOCKER)			1.0
1.92	PYROTECHNICS (MAGAZINE)			0.4
1.93	SALUTING BAT			0.0
1.94	ARMORY			7.9
1.95	SECURITY FORCE EQUIP			2.6

Group 2 – Human Support				
Group	**Description**	**(Area m^2)**		
2	HUMAN SUPPORT	1057.4		
2.1	LIVING	497.9		
2.111	BERTHING	177.6		
2.1111	SHIP OFFICER		107.4	
2.1111101	COMMANDING OFFICER CABIN			32.9
2.1111104	COMMANDING OFFICER STATEROOM			18.6
2.1111206	EXECUTIVE OFFICER STATEROOM			3.1
2.111123	DEPARTMENT HEAD STATEROOM			13.1
2.1111302	OFFICER STATEROOM (DBL)			39.7
2.1113	TROOP OFFICER		70.2	
2.1113103	TROOP COMMANDER CABIN			32.9
2.1113104	TROOP COMMANDER STATEROOM			18.6
2.1113301	TROOP OFFICER STATEROOM			7.0
2.1113302	TROOP OFFICER STATEROOM (DBL)			11.7
2.1114	AVIATION OFFICER			0.0
2.1115	FLAG OFFICER			0.0
2.112	SANITARY	24.6		
2.1121	SHIP OFFICER		15.6	
2.1121101	COMMANDING OFFICER BATH			4.6
2.1121201	EXECUTIVE OFFICER BATH			2.8
2.1121203	OFFICER BATH			2.1
2.1121303	OFFICER WR, WC & SH			6.1
2.1123	TROOP OFFICER			0.0
2.1123101	TROOP COMMANDER BATH			4.6
2.1123302	TROOP OFFICER WR, WC & SH			4.4
2.1124	AVIATION OFFICER			0.0
2.1125	FLAG OFFICER			0.0
2.12	CPO LIVING	77.6		
2.121	BERTHING		61.5	
2.1211	SHIP CPO			34.0
2.1213	SENIOR TROOP NCO			27.5
2.122	SANITARY		16.1	
2.1221	SHIP CPO			8.6
2.1223	SENIOR TROOP NCO			7.5
2.13	CREW LIVING	159.9		
2.131	BERTHING		116.9	
2.131101	LIVING SPACE CREW			83.5
2.1313	TROOP			33.4
2.132	SANITARY		27.8	
2.1321	SHIP CREW			15.6
2.1323	TROOP			12.3
2.133	RECREATION		15.1	
2.13301	RECREATION ROOM			3.9

Group	Description	(Area m^2)		
2.13302	LIBRARY			3.9
2.13304	HOBBY SHOP			3.8
2.13305	PHOTOGRAPHIC DARK ROOM			3.4
2.13306	CREW LOUNGE			0.0
2.14	GENERAL SANITARY FACILITIES	18.0		
2.14001	LADIES RETIRING ROOM			11.1
2.14002	BRIDGE WASHRM & WC			2.3
2.14003	DECK WASHRM & WC			2.3
2.14004	ENGINEERING WR & WC			2.3
2.15	SHIP RECREATION FAC	36.9		
2.151	MUSIC		4.3	
2.15101	ENTERTAINMENT EQUIP STRM			4.3
2.15103	BAND EQUIPMENT STOREROOM			
2.152	MOTION PIC FILM+EQUIP		1.9	
2.15201	PROJECTION EQUIP RM			1.9
2.153	PHYSICAL FITNESS		21.9	
2.15301	PHYSICAL FITNESS RM			9.3
2.15302	ATHLETIC GEAR STRM			5.5
2.15303	TROOP ATHLETIC GR STRM			7.1
2.154	TV ROOM		8.8	
0	TV ROOM			8.8
2.16	TRAINING	3.3		
2.16002	RECOGNITION TRAINING LKR			3.3
2.2	COMMISSARY	175.9		
2.21	FOOD SERVICE	79.0		
2.211	OFFICER		26.9	
2.21102	WARDROOM MESSR00M			18.5
2.21103	WARDROOM LOUNGE			8.4
2.212	CPO		27.5	
2.21201	CPO MESSROOM AND LOUNGE			27.5
2.213	CREW		21.0	
2.21301	1ST CLASS MESSROOM			3.1
2.21303	CREW MESSROOM			17.9
2.214	MESS MANAGEMENT SPLST		3.5	
2.21401	MESS MNGMNT SPLST MESSRM			3.5
2.215	FLAG OFFICER			0.0
2.22	COMMISSARY SERVICE SPACES	49.2		
2.221	FOOD PREPARATION SPACES		15.1	
2.22101	MEAT PREPARATION ROOM			3.9
2.22105	VEGETABLE PREPARATION ROOM			3.9
2.22107	THAW ROOM			7.3
2.222	GALLEY		24.4	
2.22201	COMMANDING OFFICER GALLEY			10.7
2.22202	WARD ROOM GALLEY			2.3
2.22203	CPO GALLEY			3.9

Group	Description	Area (m^2)		
2.22204	CREW GALLEY			7.5
2.223	PANTRIES		7.6	
2.22303	CPO PANTRY			7.6
2.224	SCULLERY		2.1	
2.22403	CREW SCULLERY			2.1
2.225	GARBAGE DISPOSAL			0.0
2.22501	GARBAGE DISPOSAL ROOM			0.0
2.226	PREPARED FOOD HANDLING			0.0
2.23	FOOD STORAGE+ISSUE	47.7		
2.231	CHILL PROVISIONS			6.0
2.232	FROZEN PROVISIONS			5.9
2.233	DRY PROVISIONS			16.8
2.23401	PROVISION ISSUE ROOM			19.1
2.3	MEDICAL+DENTAL (MEDICAL)	101.9		
2.31	MEDICAL FACILITIES	94.6		
2.31001	MEDICAL APPARATUS ROOM			2.2
2.31005	BACTERIOLOGICAL LAB & PHRMCY			15.6
2.31007	DIET PANTRY			7.0
2.3101	INTENSIVE CARE QUIET RM			0.0
2.31011	MEDICAL LINEN ISSUE RM			0.0
2.31012	MEDICAL TREATMENT ROOM			6.1
2.31013	MEDICAL X-RAY DARK ROOM			3.0
2.31014	MEDICAL X-RAY EXPOSURE RM			9.7
2.31015	OPERATING ROOM			2.3
2.31018	QUIET ROOM			3.5
2.31019	QUIET ROOM BATH			5.6
2.3102	SCRUB ROOM			5.9
2.31021	SURGICAL DRESSING ROOM			2.3
2.31022	STERILIZING ROOM			7.4
2.31023	MEDICAL UTILITY RM			5.2
2.31024	WARD			4.6
2.31025	WARD BATH			14.1
2.31026	WARD NURSING CENTER			0.0
2.31027	MORGUE			0.0
2.33	BATTLE DRESSING	23.3		
2.331	AUX BATTLE DRESSING		2.3	
2.33101	FWD AUX BATTLE DRESS ST			2.3
2.33102	AFT AUX BATTLE DRESS ST			0.0
2.332	MAIN BATTLE DRESSING		21.0	
2.33201	FWD BATTLE DRESSING STA			7.0
2.33202	MID BATTLE DRESSING STA			7.0
2.33203	AFT BATTLE DRESSING STA			7.0
2.34	MEDICAL & DENTAL STOWAGE	7.3		
2.341	MEDICAL		7.3	
2.34101	MEDICAL STOREROOM			3.9

Group	Description	(Area m^2)		
2.34102	PHARMACY STOREROOM			0.0
2.34104	BATTLE DRESSING STRM			3.5
2.342	DENTAL			0.0
2.35	MEDICAL & DENTAL ADMIN			0.0
2.352	DENTAL ADMIN			0.0
2.4	GENERAL SERVICES	163.2		
2.41	SHIP STORE FACILITIES	14.7		
2.41001	SHIP STORE			14.7
2.41002	CLOTHING & SMALL STRS ISSUE RM			0.0
2.41003	SNACK BAR			0.0
2.41005	VENDING MACHINE AREA			0.0
2.42	LAUNDRY FACILITIES	44.0		
2.42001	LAUNDRY			11.8
2.42002	LAUNDRY ISSUE ROOM			3.4
2.42003	LAUNDRY RECEIVING ROOM			14.7
2.43	DRY CLEANING			14.1
2.44	BARBER SERVICE	34.8		
2.44001	OFFICER BARBER SHOP			7.0
2.44002	BARBER SHOP			13.9
2.44003	TROOP BARBER SHOP			13.9
2.46	POSTAL SERVICE	2.1		
2.46001	POST OFFICE			2.1
2.47	BRIG	30.2		
2.47001	BRIG - CELL LOBBY			7.4
2.47002	DETENTION CELL			7.4
2.47003	BRIG - SENTRY VESTIBULE			8.9
2.47004	BRIG - SOLITARY CELL			6.5
2.48	RELIGIOUS	37.4		
2.48001	CHAPLAIN OFFICE			13.0
2.48002	CHAPLAIN OFFICE LOBBY			9.3
2.48003	CHAPLAIN LOCKER			1.2
2.48004	CHAPEL			13.9
2.5	PERSONNEL STORES	36.4		
2.51	BAGGAGE STOREROOMS	13.3		
2.51001	OFFICER BAGGAGE STRM			4.0
2.51002	CPO BAGGAGE STRM			2.2
2.51003	CREW BAGGAGE STRM			4.4
2.51005	TROOP OFF BAGGAGE STRM			2.7
2.52	MESSROOM STORES	10.8		
2.52001	WARDROOM STOREROOM			4.5
2.52002	CPO STOREROOM			4.5
2.52003	COMMANDING OFFICER STRM			1.9
2.55	FOUL WEATHER GEAR	12.2		
2.55001	FOUL WEATHER GEAR LOCKER			3.2
2.55002	DRYING ROOM			3.1
2.56	LINEN STOWAGE			2.8

Group	Description	(Area m^2)		
2.57	FOLDING CHAIR STOREROOM			3.1
2.6	CBR PROTECTION		80.2	
2.61	CBR DECON STATIONS	6.9		
0	CBR DECON STATIONS			6.9
2.62	CBR DEFENSE EQUIPMENT	9.1		
2.62001	CBR DEFENSE EQP STRMS			9.1
0	CPS AIRLOCKS	64.2		
2.63	CPS AIRLOCKS			64.2
2.7	LIFESAVING EQUIPMENT		1.9	
2.71	LIFEJACKET LOCKER			1.9

Group 3 – Ship Support				
Group	**Description**	**(Area m^2)**		
3	SHIP SUPPORT		3392.1	
3.1	SHIP CNTL SYS(STEERING&DIVING)		80.6	
3.11	STEERING GEAR		75.5	
3.12	ROLL STABILIZATION		0.0	
3.15	STEERING CONTROL		5.1	
3.2	DAMAGE CONTROL		99.4	
3.21	DAMAGE CNTRL CENTRAL		0.0	
3.22	REPAIR STATIONS		49.2	
3.25	FIRE FIGHTING		50.2	
3.3	SHIP ADMINISTRATION		52.4	
3.301	GENERAL SHIP		2.2	
3.302	EXECUTIVE DEPT		5.1	
3.303	ENGINEERING DEPT		25.2	
3.304	SUPPLY DEPT		5.7	
3.305	DECK DEPT		10.9	
3.306	OPERATIONS DEPT		3.3	
3.307	WEAPONS DEPT		0.0	
3.308	REACTOR DEPT		0.0	
3.309	MARINES DEPT		0.0	
3.31	SHIP PHOTO/PRINT SVCS		0.0	
3.5	DECK AUXILIARIES		376.9	
3.51	ANCHOR HANDLING		88.9	
3.52	LINE HANDLING		160.4	

Group	Description	Area (m^2)		
3.53	TRANSFER-AT-SEA		19.3	
3.54	SHIP BOATS STOWAGE		108.3	
3.6	SHIP MAINTENANCE		99.4	
3.61	ENGINEERING DEPT	94.0		
3.611	AUX (FILTER CLEANING)		19.9	
3.612	ELECTRICAL		5.8	
3.613	MECH (GENERAL WK SHOP)		65.8	
3.614	PROPULSION MAINTENANCE		2.5	
3.62	OPERATIONS DEPT (ELECT SHOP)		0.0	
3.63	WEAPONS DEPT (ORDINANCE SHOP)		0.0	
3.64	DECK DEPT (CARPENTER SHOP)	5.4		
3.7	STOWAGE DEPT		458.0	
3.71	SUPPLY DEPT	443.7		
3.711	HAZARDOUS MATL (FLAM LIQ)		97.7	
3.712	SPECIAL CLOTHING		3.3	
3.713	GEN USE CONSUM+REPAIR PART		342.7	
3.714	SHIP STORE STORES		0.0	
3.715	STORES HANDLING		0.0	
3.72	ENGINEERING DEPT	3.1		
3.73	OPERATIONS DEPT	4.3		
3.74	DECK DEPT (BOATSWAIN STORES)	4.8		
3.75	WEAPONS DEPT	0.0		
3.76	EXEC DEPT (MASTER-AT-ARMS STOR)	0.0		
3.78	CLEANING GEAR STOWAGE	2.1		
3.8	ACCESS		1528.2	
3.82	INTERIOR	1528.2		
3.821	NORMAL ACCESS		1505.0	
3.822	ESCAPE ACCESS		23.2	
3.9	TANKS		697.3	
3.91	SHIP PROP SYS TNKG		0.0	
3.911	SHIP ENDUR FUEL TNKG		0.0	
3.92	BALLAST TNKG		0.0	
3.93	FRESH WATER TNKG		0.0	
3.94	POLLUTION CNTRL TNKG		0.0	
3.941	SEWAGE TANKS		0.0	
3.942	OILY WASTE TANKS		0.0	
3.95	VOIDS	697.3		
3.96	COFFERDAMS		0.0	
3.97	CROSS FLOODING DUCTS		0.0	

Group	Description	Area (m^2)		
Group 4				
4	SHIP MACHINERY SYSTEM	554.0		
4.1	PROPULSION SYSTEM	123.2		
4.13	INTERNAL COMBUSTION	123.2		
4.131	ENERGY GENERATION AIR		50.0	
4.132	COMBUSTION		19.2	
4.133	EXHAUST		41.3	
4.134	CONTROL		12.6	
4.2	PROPULSOR & TRANSMISSION SYST	0.0		
4.21	SCREW PROPELLER		0.0	
4.21001	PROP SHAFT ALLEY		0.0	
4.22	CYCLOIDAL PROPELLER ROOMS		0.0	
4.23	WATERJET ROOMS		0.0	
4.24	AIR FAN ROOMS		0.0	
4.3	AUX MACHINERY	430.8		
4.32	A/C & REFRIGERATION	9.1		
4.321	A/C (INCL VENT)		7.4	
4.322	REFRIGERATION		1.7	
4.33	ELECTRICAL	154.0		
4.331	POWER GENERATION		0.0	
4.332	PWR DIST & CNTRL		77.0	
4.334	DEGAUSSING		77.0	
4.34	POLLUTION CONTROL SYSTEMS	8.2		
4.341	SEWAGE		5.4	
4.342	TRASH		2.9	
4.35	MECHANICAL SYSTEMS	206.7		
4.36	VENTILATION SYSTEMS	52.8		

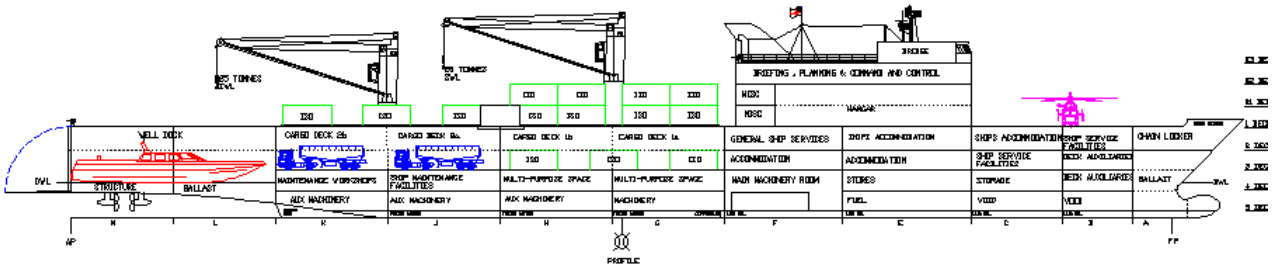
Appendix D – Additional Mission Loading Configurations

Multi-Role Loading

The multi-role representative loading is the loading on the ship when it is deployed with no specific mission. The ship has been loaded so that it can assist in a wide variety of missions with a large number of inaccessible TEU containers to carry different types of mission equipment. The tabulated layout and the loaded profile are shown below.

Mission Payload - Multi-role

	Multi-role Mission
Vehicles	7 Truck 8 HMMWV
Accessible TEUs	23
Inaccessible TEUs	40
Helicopters	1 SH - 60 2 Fire Scout UAV
Boats	1 Spec Ops Mk 5 1 LCM 6
Other Aircraft	1 Lake Seaplane
Mission Personnel	60 Ships Crew 35 Full 83 Austere



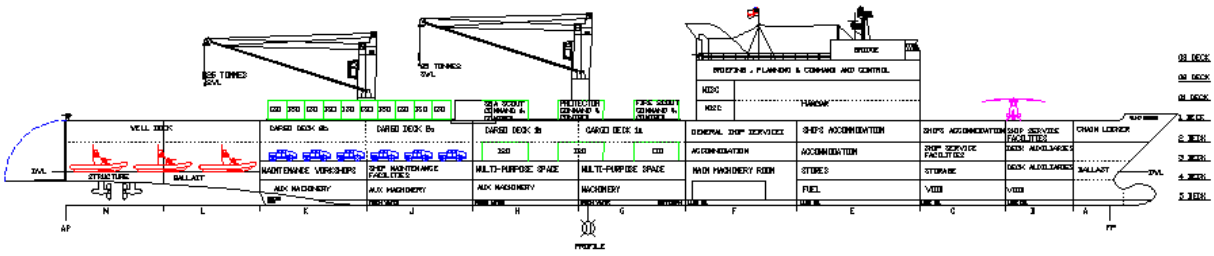
Arrangement Multi-Role Layout

UAV/USV Mission Loading

The UAV/USV mission is not a requirement for the GFS mission, but GFS may be required to carry more than one type of UAV/USV. This mission loading is extreme and may not be realistic, but it demonstrates an extreme end of the operational envelope. GFS Station Ship has been loaded with three types of UAV/USV: the Fire Scout[12], the Sea Scout[13] and the Protector[14]. The principle loading characteristics are shown in the table and figure below

Mission Payload - UAV/USV

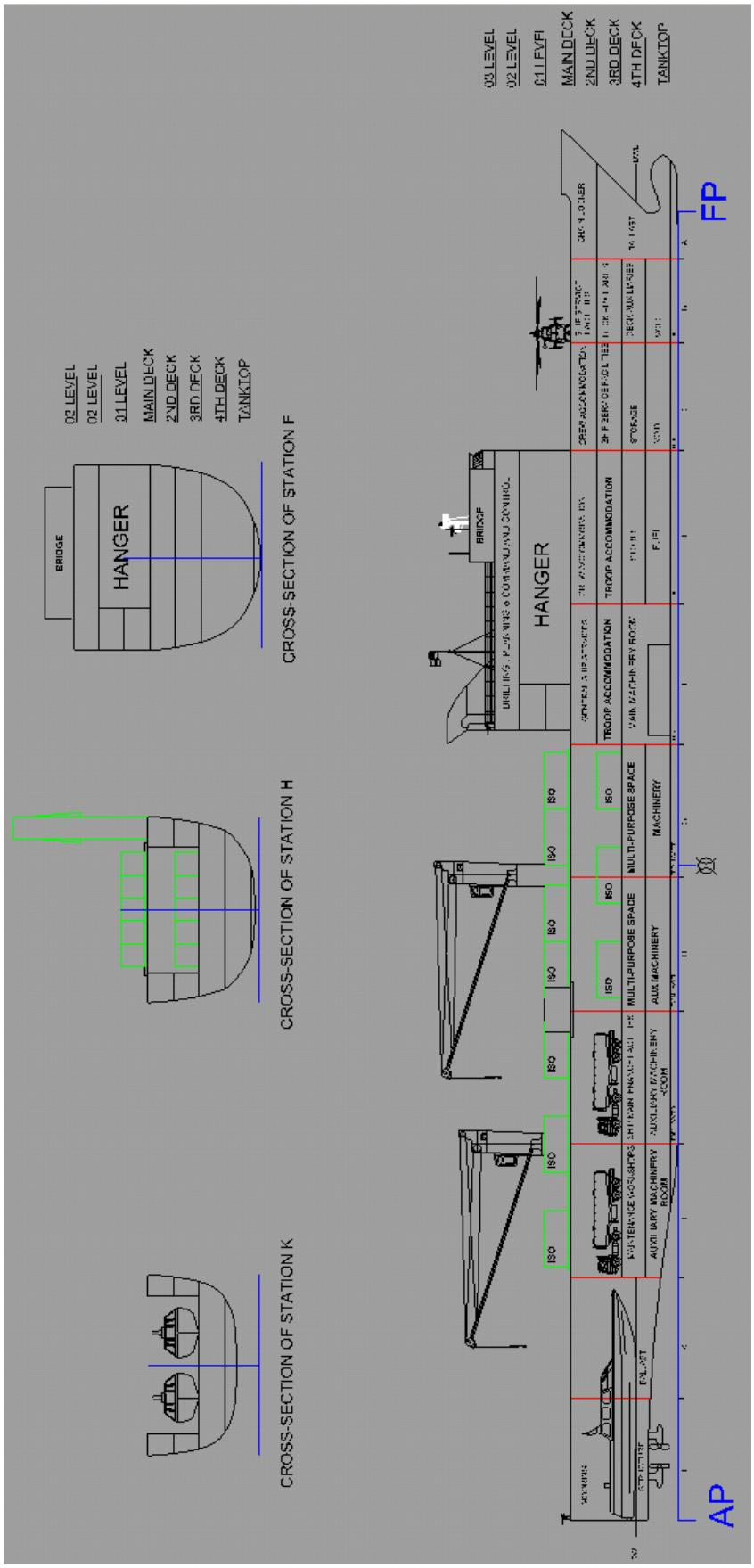
	USV/UAV Mission
Vehicles	36 HMMWV
Accessible TEUs	40
Inaccessible TEUs	0
Helicopters	5 Fire Scout UAV
Boats	6 Protector USV 1 LCM 6
Other Aircraft	5 Sea Scout UAV
Mission Personnel	60 Ships Crew 35 Full 83 Austere



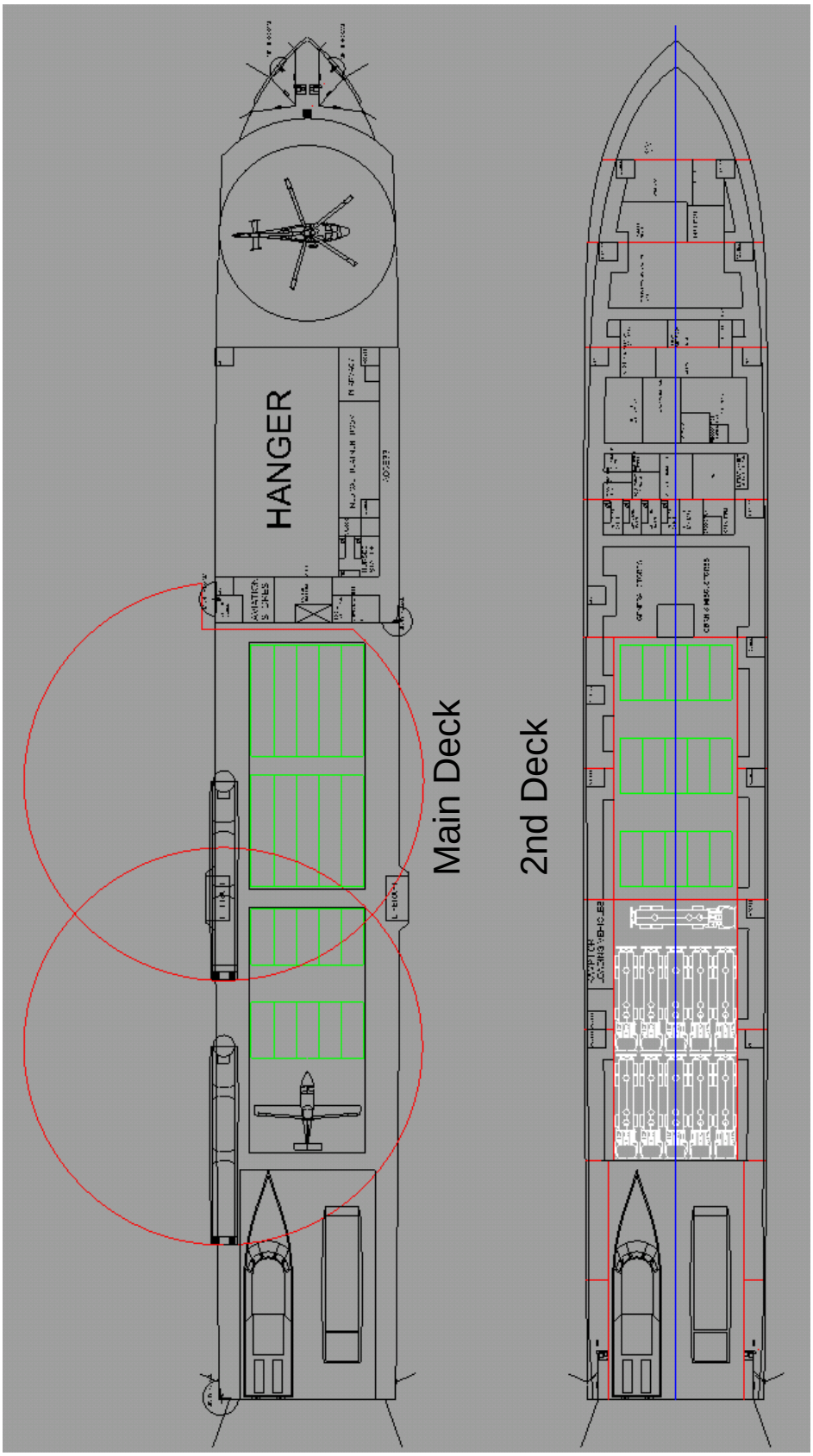
Arrangement USV/UAV Layout

Appendix E – General Arrangement Drawings

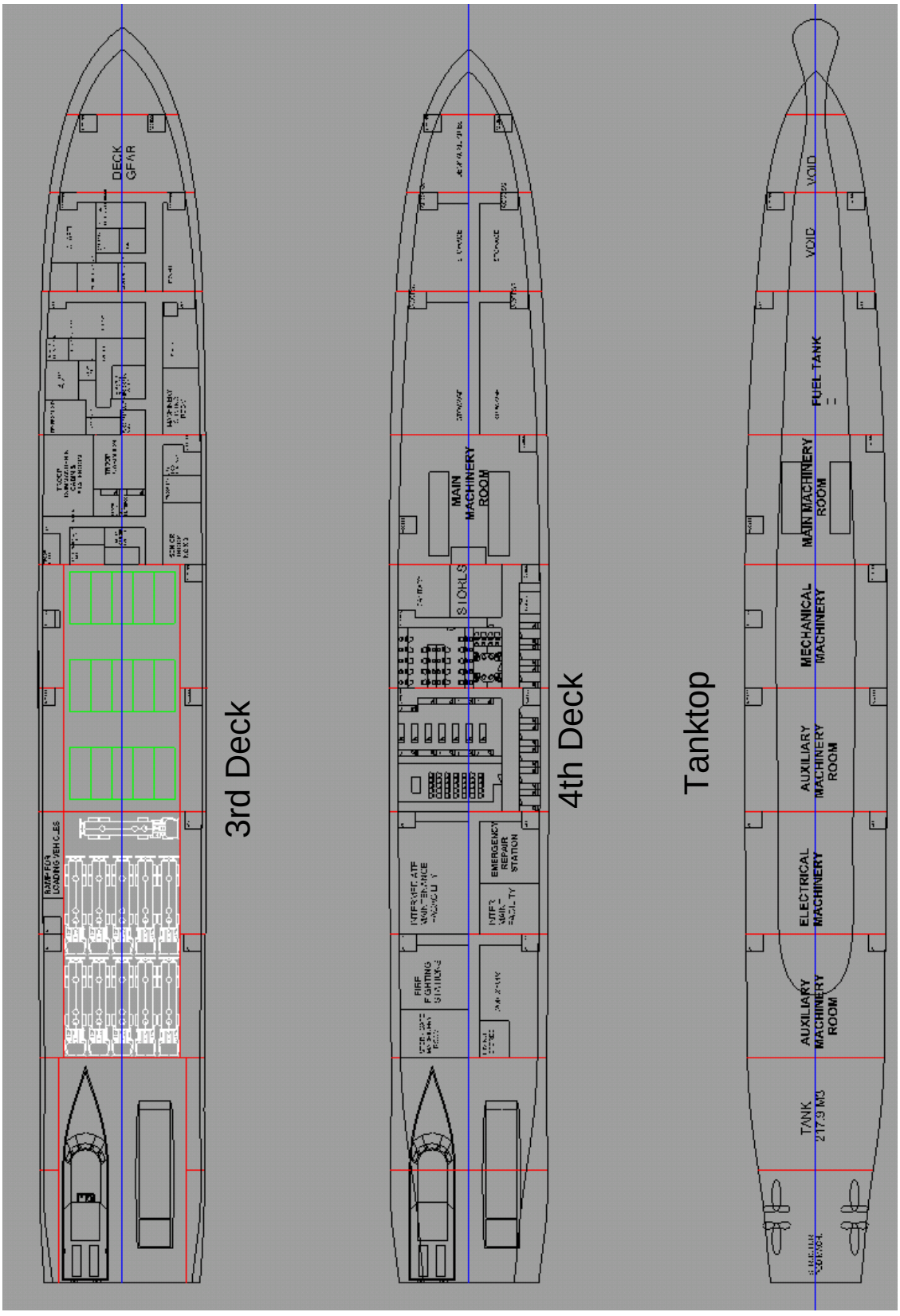
Multi-Role Inboard Profile & Sections



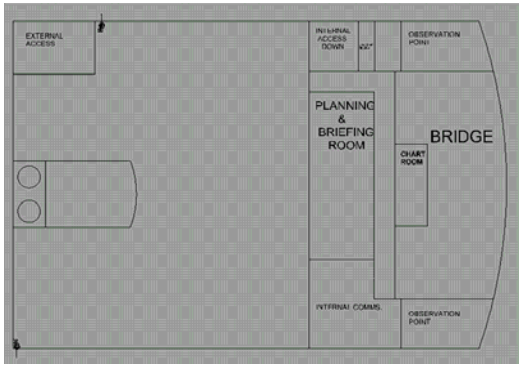
Multi-Role Hull Arrangements



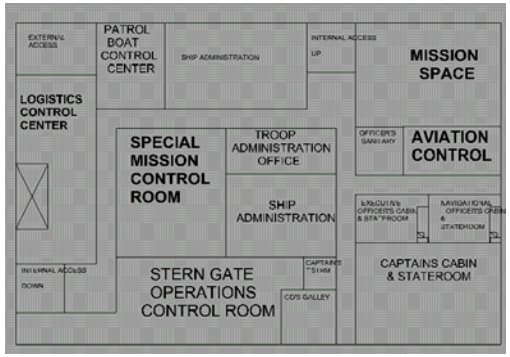
Multi-Role Hull Arrangements (cont.)



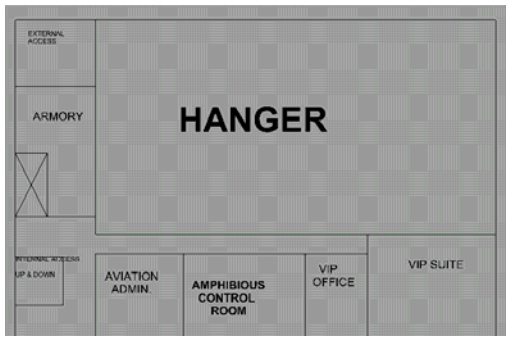
Multi-Role Deckhouse Arrangement



03 Level

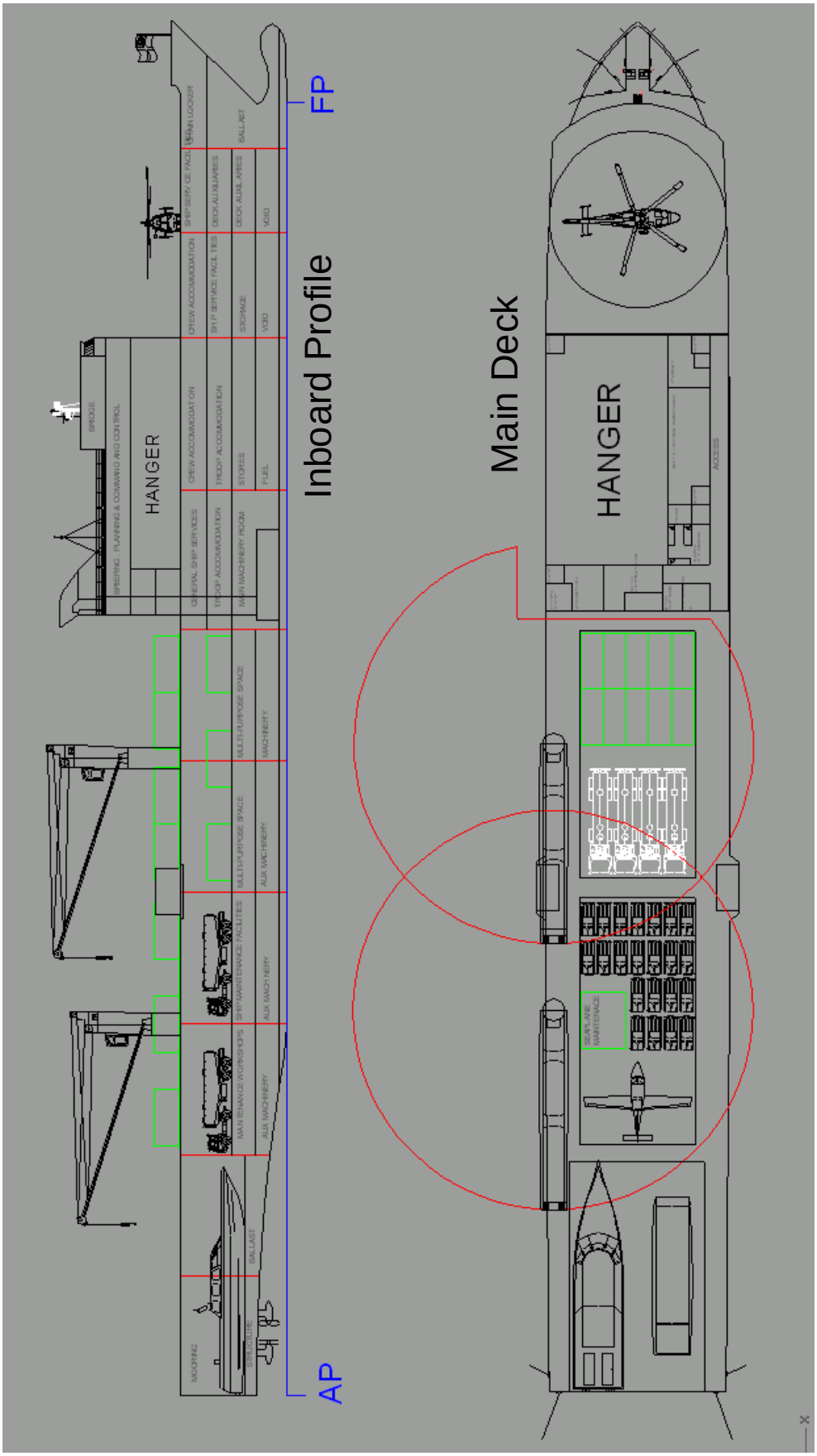


02 Level

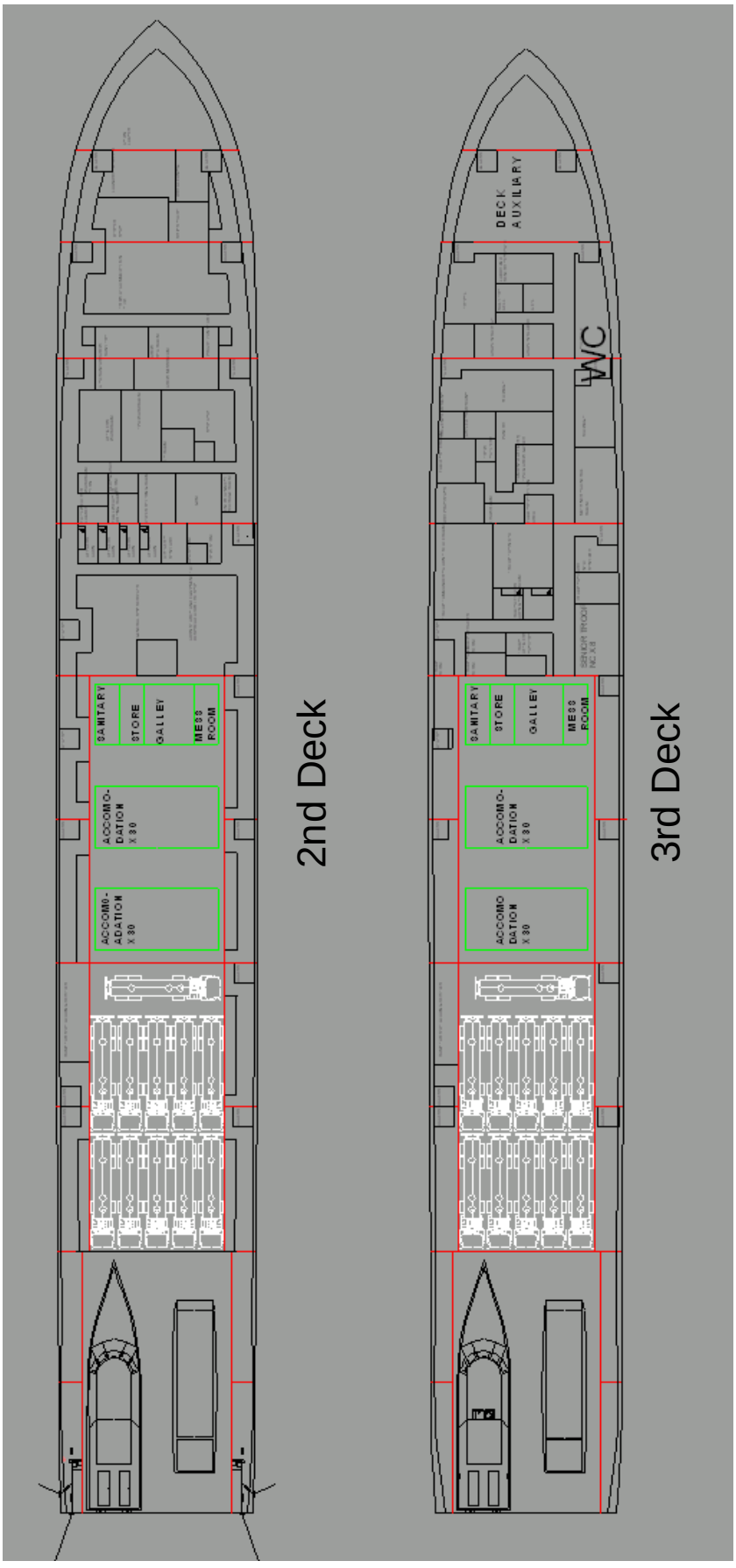


01 Level

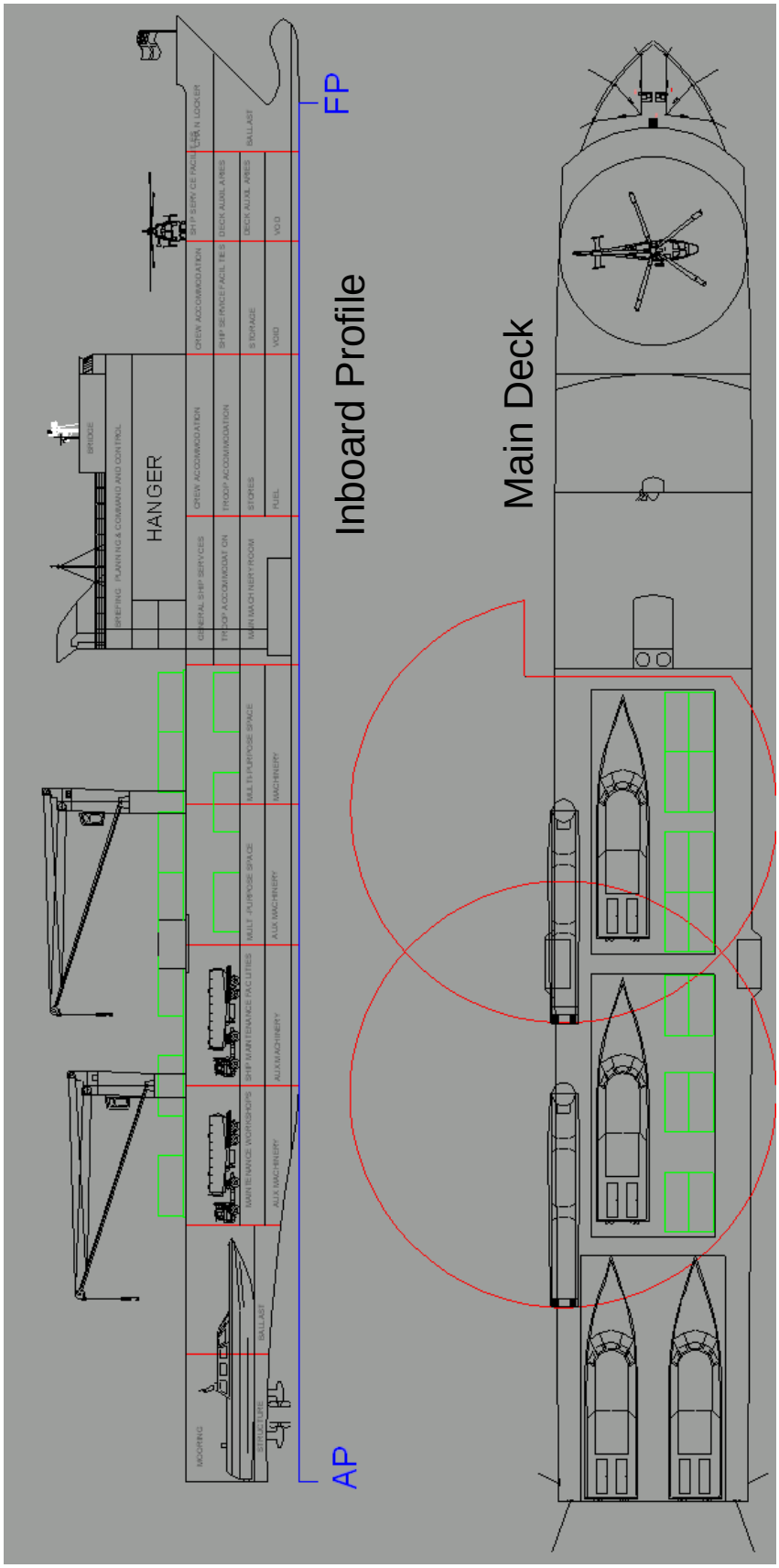
TSO Ship Arrangements



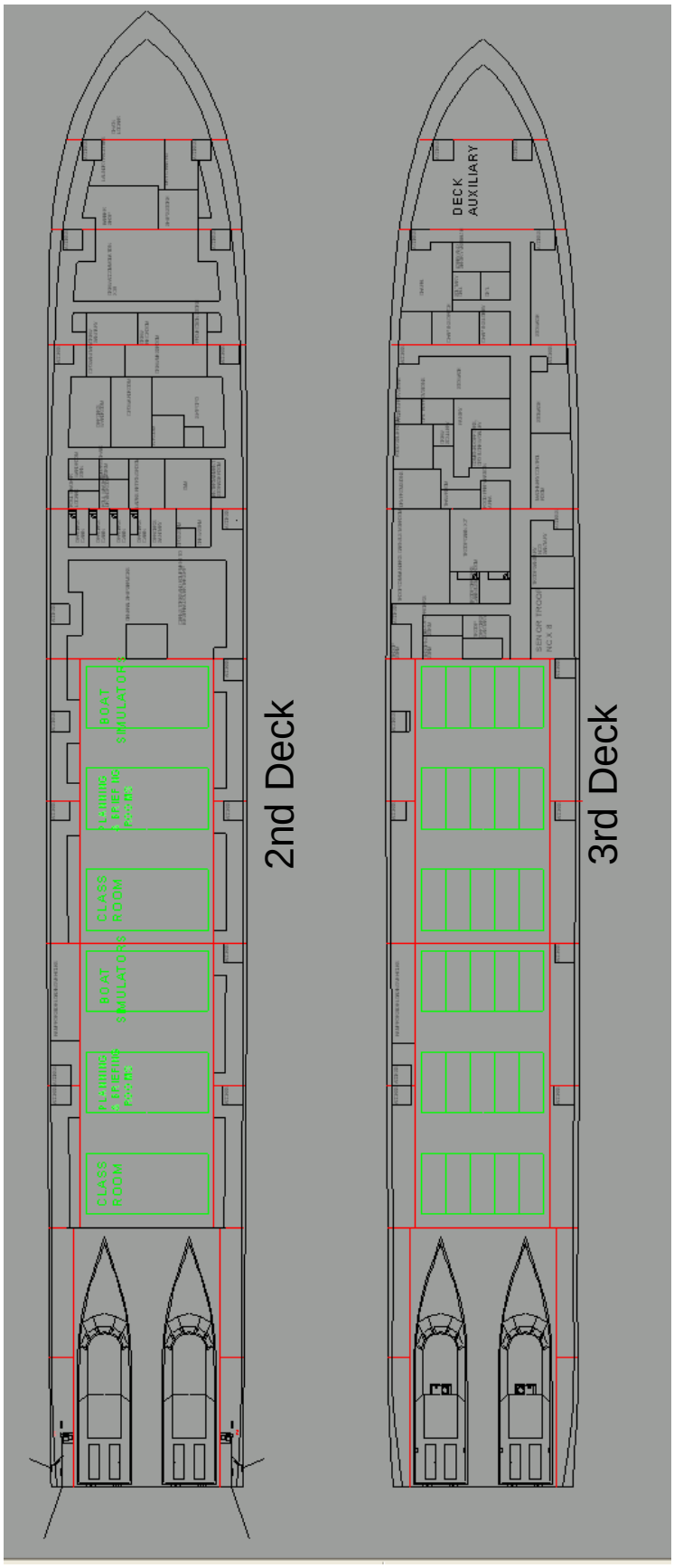
TSO Ship Arrangements (con't)



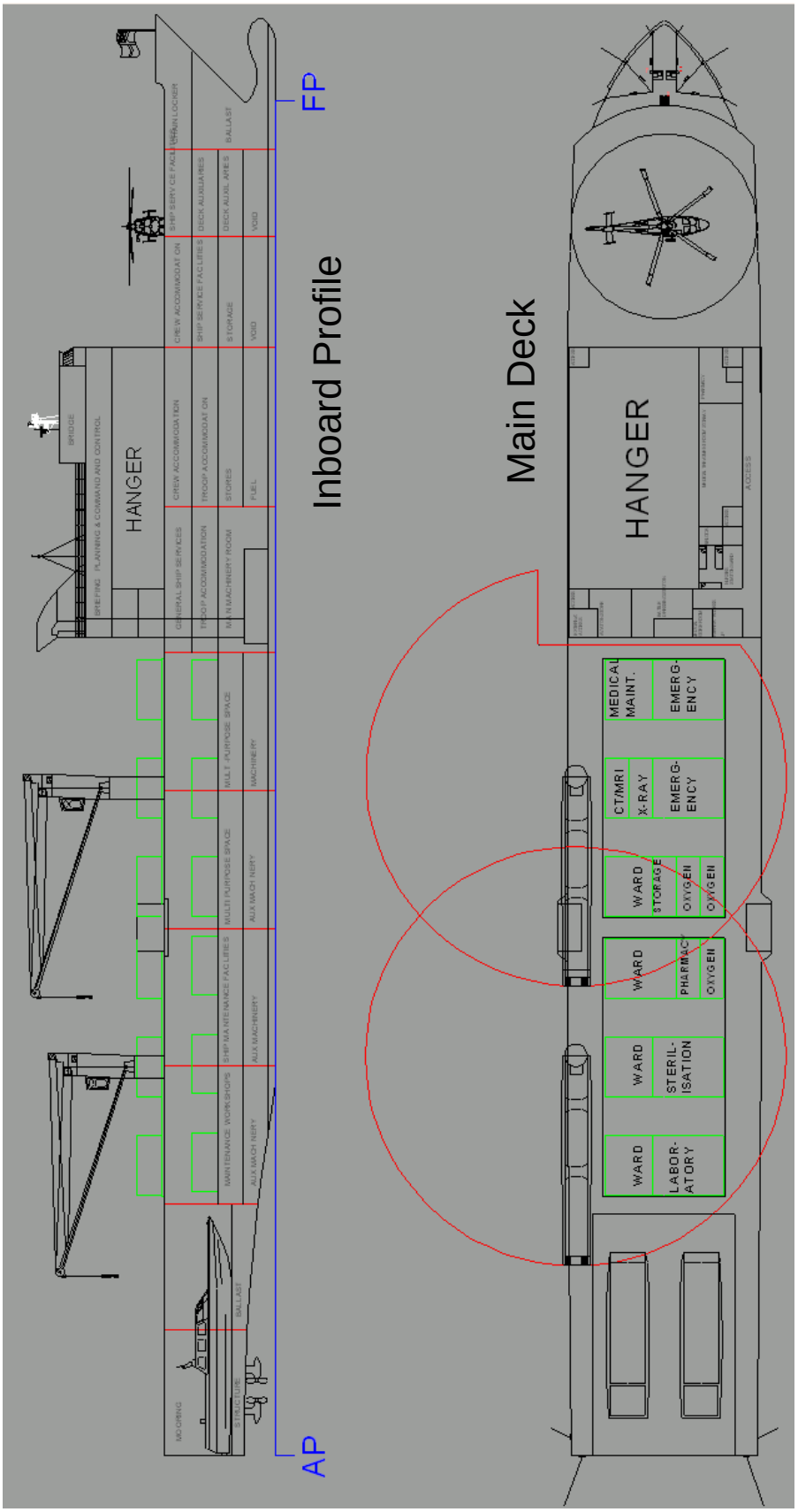
Foreign Nation Partner Training & Support Ship Arrangements



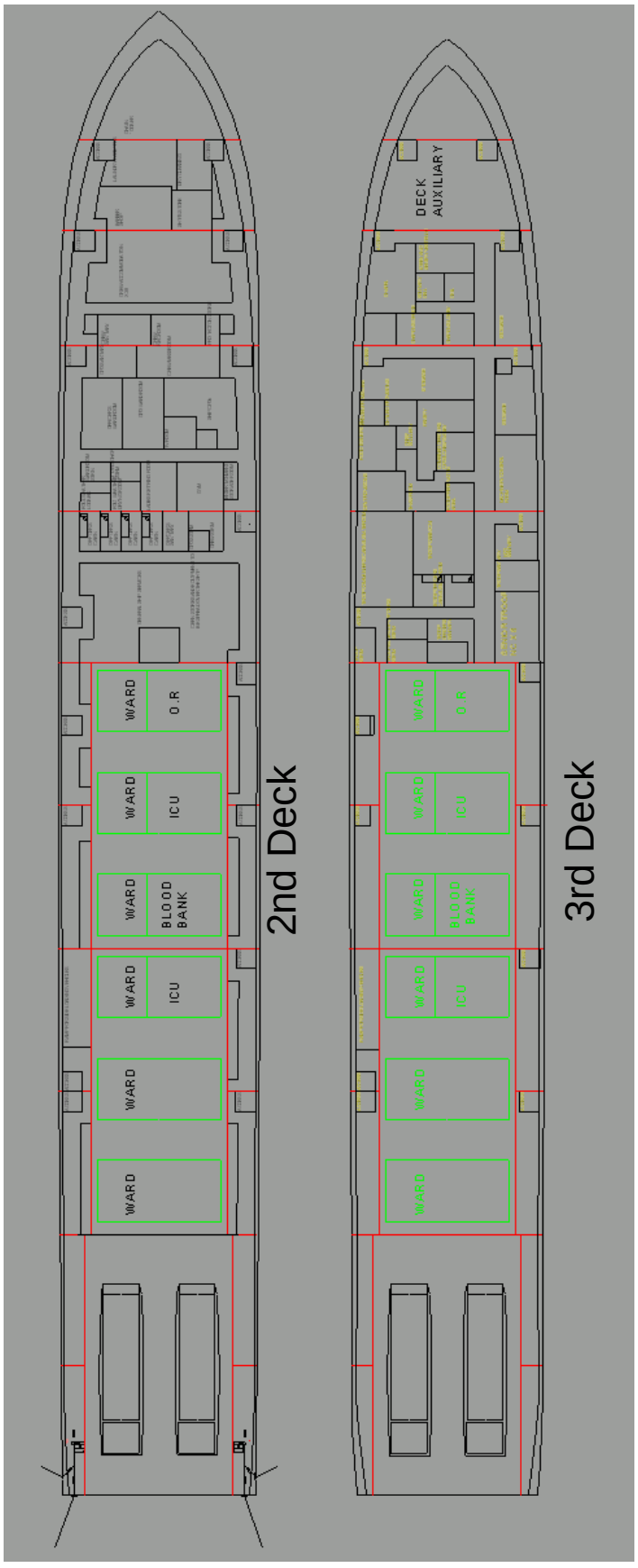
Foreign Nation Partner Training & Support Ship Arrangements



Hospital Ship Arrangements



Hospital Ship Arrangements (con't)



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