XV. TSSE EXPEDITIONARY WARFARE SHIP DESIGN

A. INTRODUCTION

The purpose of the TSSE capstone design project was to examine the concepts associated with Sea Basing or Sea Based Logistics in support of ExWar in the context of OMFTS and STOM concepts of operation. The product from this examination was the creation of a ship design to enable effective Sea Basing operations.

The objectives for this project included maximizing the use of the material learned in previous TSSE courses. The project required the TSSE team to define the concept of employment needed to meet a broadly-defined need, as well as learning first-hand the ship-impact of requirements, cost and performance tradeoffs within technical and acquisition constraints. Through this process, the students became familiar with the process of evaluating a military need to determine how best to meet it, and obtain the experience in the process of translating broad military requirements to mission-based ship requirements and to specific design tasks resulting from those requirements. In addition, the project also stressed technical teamwork in an interdisciplinary design effort where the quality of the product is greatly affected by team dynamics. Lastly, the TSSE team practiced internalizing the systems approach to a naval ship as a single engineering system satisfying mission requirements, and exploring innovative ideas which may prove useful to those working on similar projects, both inside and outside NPS. Figure XV-1 illustrates the TSSE design roadmap.

1. Phase I

In phase I the team focused on requirements analysis. The goal was to review and understand the requirements from the Systems Engineering and Analysis (SEA) team for Sea Basing within expeditionary warfare. Further, the team had to analyze the nature of the requirements and anticipated solutions for the MPF(F), LHA(R), and Large Medium Speed Roll-on-roll-off (LMSR) ships. Through this analysis, the TSSE team determined if the ExWar Sea Basing requirements could be fully met by a single ship design (with variants permitted) that could be employed in lieu of the separate ship types. This would require us to consider such things as: combat systems capabilities; interfaces with transfer assets; survivability levels needed; nature of manning (civilian or Navy crews or some mix); etc. The team was expected to interface with the SEA team on a regular basis for clarification of their initial requirements document and for its updates, as appropriate, and to determine that the approach appeared to be on track to meeting the needs SEA had documented. The TSSE team would have to answer questions such as:

- Can a single design with variants meet the need?
- How will the variants vary?
- Which variant would be proposed and treated as the primary subject of further design?

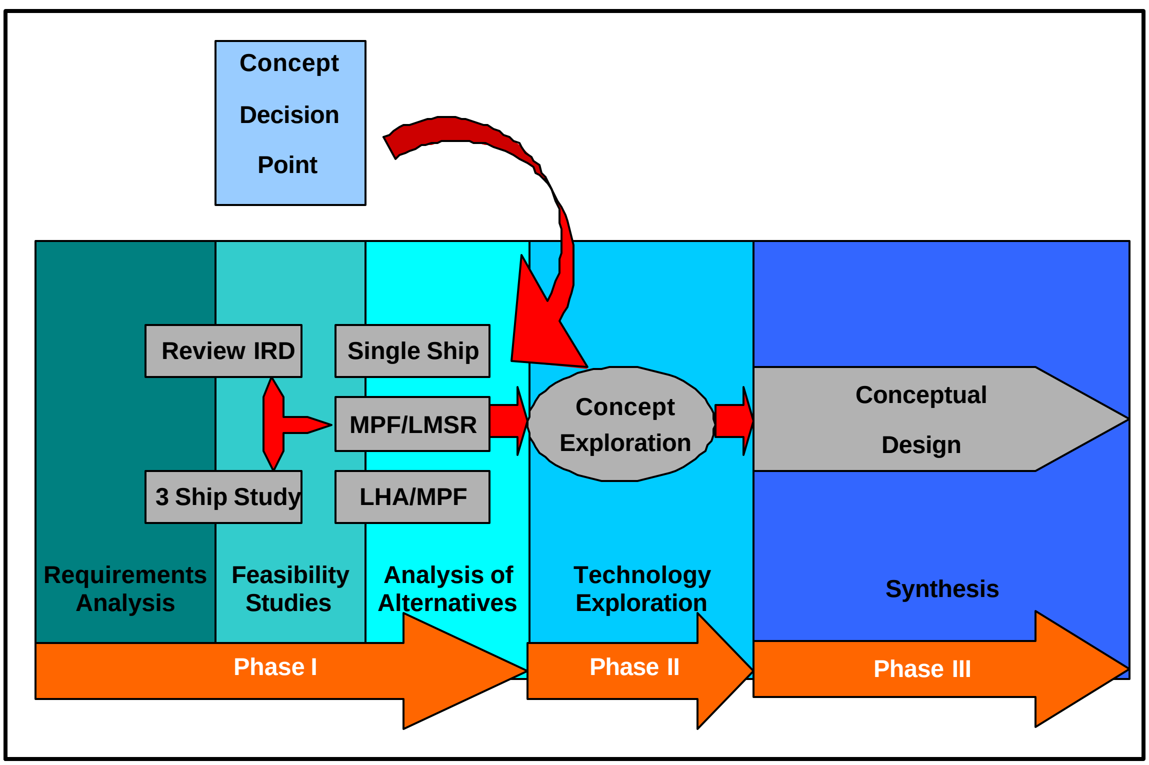


Figure XV-1: TSSE Design Roadmap

2. Phase II

In phase II the team explored concepts for meeting the basic design. By the end of the phase, the team reconciled in more detail the requirements for the basic ship and for its variants.

3. Phase III

During phase III the team performed a more complete design of the basic concept and variants resulting from Phase II.

B. REQUIREMENTS ANALISYS

Requirements analysis was one of the most important phases in the TSSE project design. Requirements analysis was important because it helped the team to understand the problem. By analyzing the requirements, the team defined and bounded the problem. In this particular case, the TSSE team needed to understand the mission of the system; by understanding the mission, the team becomes aware of the required capabilities needed to accomplish the mission. Knowing the required capabilities, the team could explore possible systems alternatives that would effectively perform the required capabilities. Requirements analysis also helped the team to understand the interfaces between systems, and how they affect each other. By understanding the interfaces, the team could make trade-off decisions among systems capabilities and resources. This trade-off allowed the team to arrived to a well-balanced and optimum design.

The TSSE requirements analysis approach was very similar to the strategy taken by the SEA team in the system of systems study of ExWar. The strategy derived the design requirements through both Top Down and Bottom Up analyses. Figure XV-2 illustrates the TSSE requirements generation process.

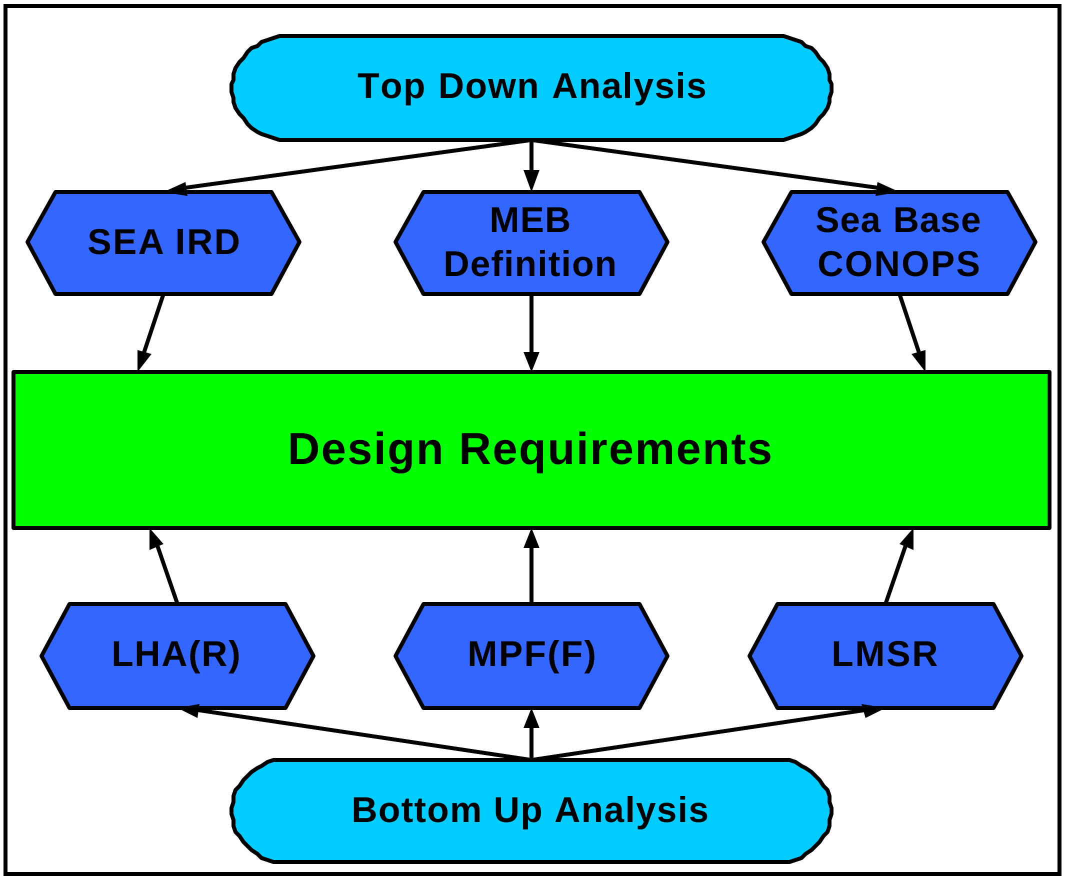


Figure XV-2: TSSE Requirements Generation Process

The Top Down analysis concentrated on understanding the SEA Initial Requirements Document (IRD), clarifying issues with the SEA team by an iterative process, and generating a requirements list. The second portion of the Top Down analysis studied the CONOPS for Sea Basing and what capabilities are required to do Sea Basing. The analysis also required us to understand the MEB, what composes it, and what are its requirements.

The Bottom Up portion of the requirements analysis focused on the LHA(R), MPF(F), and LMSR CONOPS, and current platforms in the Naval Expeditionary architecture. A list of requirements was generated and merged in the requirements from the Top Down analysis into master Required Operational Capabilities (ROC) document.

C. SEA INITIAL REQUIREMENTS DOCUMENT (IRD) ANALYSIS

The SEA IRD was the governing document in the analysis and development of the requirements for the TSSE concept design. The IRD identified Sea Base capability gaps through the Systems Engineering Top Down analysis. At this stage of the design process, it was crucial to the TSSE team to have a complete understanding of the IRD. Accordingly, the team commenced a detailed review of the requirements stated in the SEA IRD. Initially, two very important issues were quickly identified. The first issue was that the IRD did not define a MEB. The second issue dealt with the numerous documents that dealt with the Sea Base concept, each one of them having a different interpretation of the concept. The exploration of these two issues lead to the conception of a base line for the Notional MEB, and a Sea Base Concept of Operations, its required capabilities, and recommendations as to the type and number of ships required to meet these requirements.

1. The Marine Expeditionary Brigade (MEB)

a. Command Element (CE)

The MEB command element provides command and control for the elements of the MEB. When missions are assigned, the notional MEB command element is tailored with required support to accomplish the mission. Detachments are assigned as necessary to support subordinate elements. The MEB Command Element is fully capable of executing all of the staff functions of a Marine Air-ground Task Force (MAGTF) (administration and personnel, intelligence, operations and training, logistics, plans, communications and information systems, Comptroller, and COMSEC).

b. Ground Combat Element (GCE)

The ground combat element (GCE) is normally formed around a reinforced infantry regiment. The GCE can be composed of two to five battalion sized maneuver elements (infantry, tanks, LAR) with a regimental headquarters, plus artillery, Assault Amphibian Bn, reconnaissance, TOWs, and engineers.

c. Aviation Combat Element (ACE)

The aviation combat element (ACE) is a composite Marine Aircraft Group (MAG) task-organized for the assigned mission. It usually includes both helicopters and fixed wing aircraft, and elements from the Marine wing support group and the Marine air control group. The MAG has more varied aviation capabilities than those of the aviation element of a MEU. The most significant difference is the ability to command and control aviation with the Marine Air Command and Control System. The MAG is the smallest aviation unit designed for independent operations with no outside assistance except access to a source of supply. Each MAG is task-organized for the assigned mission and facilities from which it will operate. The ACE headquarters will be an organization built upon an augmented MAG headquarters or provided from other MAW assets.

d. Combat Service Support Element (CSSE)

The brigade service support group (BSSG) is task-organized to provide combat service support beyond the capability of the supported air and ground elements. It is structured from personnel and equipment of the force service support group. The Brigade Service Support Group provides the nucleus of the Landing Force Support Party and, with appropriate attachments from the GCE and ACE, has responsibility for the landing force support function when the landing force shore party group is activated.

e. Capabilities

- Inherently expeditionary combined arms force.
- Robust and scalable Command and Control capability.
- A full range operational capability from forcible entry to humanitarian assistance.
- Task organized for mission accomplishment.
- Capable of rapid deployment and employment via: amphibious shipping, strategic air/sealift, or any combination.
- Sustainable.
- Increased command and control and significantly expanded battle space, functions, and capabilities.

- Aviation element is capable of all aviation functions: Offensive Air Support, Anti-air Warfare, Assault Support, Air Reconnaissance Electronic Warfare, Control of Aircraft and Missiles, Exercise Command and Control of aircraft and airspace.
- Full spectrum of Expeditionary Combat Service Support: Supply, Maintenance, Transportation, General Engineering, Health Services, Services, and Messing.

2. Defining the MEB

The flexible nature of the Marine Corps made it difficult to establish a MEB baseline. In order to proceed with the design of the ship, the team had to establish the precise number of people, equipment, and supplies required to deploy a MEB. After careful considerations, the team proceeded to establish a notional baseline for a MEB based on the MPF MEB. Figure XV-3 illustrates the organizational diagram for the MEB. Tables XV-1, 2, 3 describe the major equipment, number of personnel, provisions, ordnance, and fuel required to sustain a MEB for 30 days.

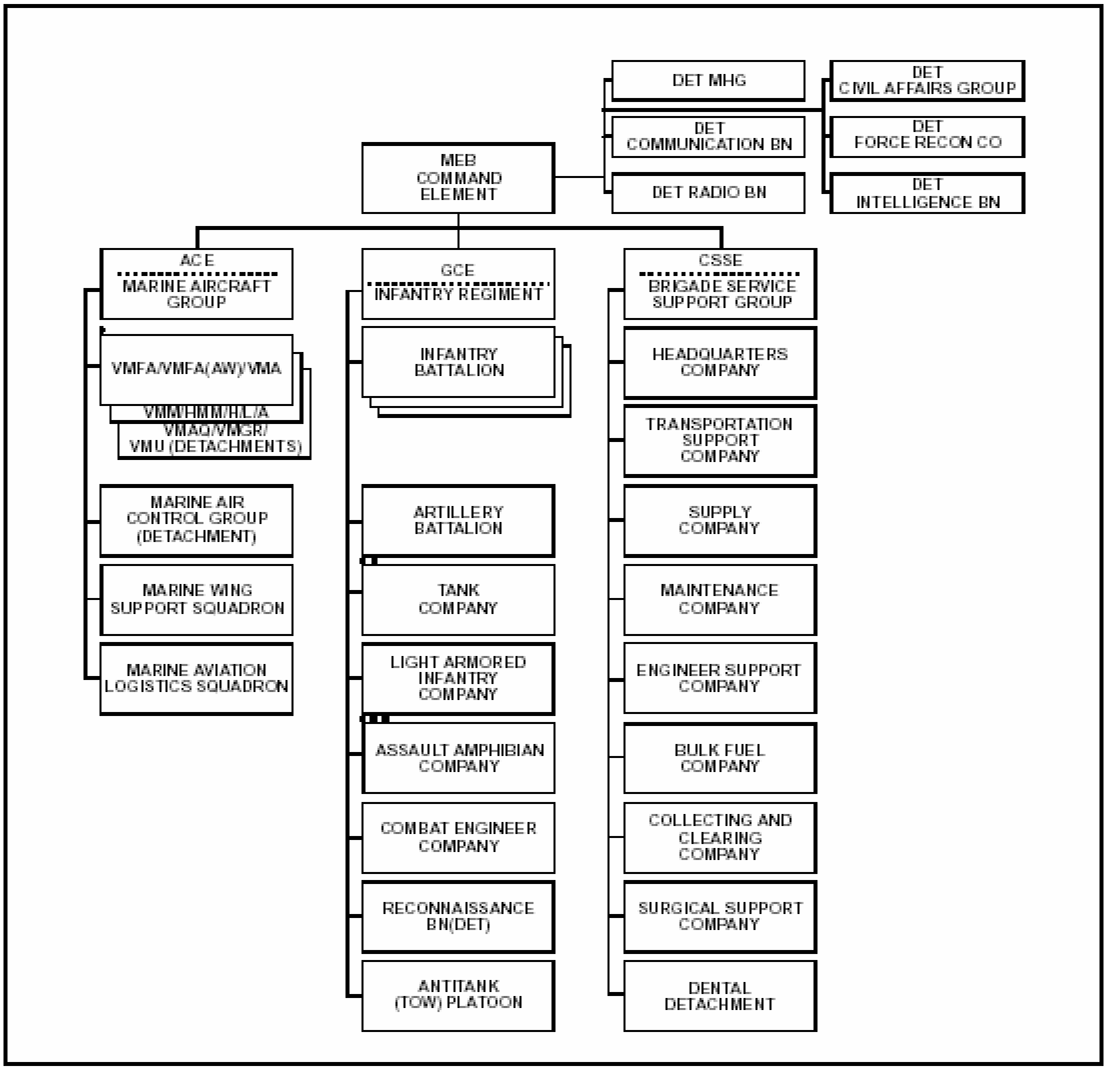


Figure XV-3: Marine Expeditionary Brigade

(Source: Marine Expeditionary Brigade, 2002)

Support Equipment		Major Weapons		Aviation Element		Total Personnel
Armed HMMWV	57	LAV AT	4	HLA	36	18,000
LVS Power Unit	109	LAV 25	14	AH-1Z	24	
LVS Wrecker	4	LAV LOG	3	UH-1Y	24	
LVS Trailer	53	LAV RECOV	3	MV-22	96	
5 Ton	282	AAVC7	9	JSF	36	
P-19 8	8	AAVR7	4			
HMMWV	473	AAVP7	96			
MRC-110	65	M1A1	58			
MRC-138	60	HMMWV (TOW)	72			
MRC-142	21	M198 Howitzers	30			
M970 Refueler	26					

Table XV-1: Equipment and Personnel for Conceptual MEB

3. Sustainment

Perhaps even more difficult than defining what constitutes a MEB was to define its sustainment requirements. In this instance, the team decided to use CDR Kennedy's (Kennedy 2002) thesis sustainment data to provide with guidance as to the amount of provisions, and ordnance, required by the Sea Base and the MEB ashore. Table XV-2, summarizes the amount of provisions and ordnance required by the Sea Base and MEB ashore. With respect to the amount of fuel required to sustain the MEB ashore, the team decided to utilize the data provided by the Center for Naval Analysis study titled Fuel Requirements and Alternative Distribution Approaches in an Expeditionary Environment (Center for Naval Analysis, 2001), Table XV-3, provides the amount of fuel in gallons required by the GCE, CSSE and the conceptual ACE. Table XV-4 presents the total weight and volume required including equipment, fuel, ordnance, and provision for 30 day at a surge rate.

Commodity	Days	Std. Rate(tons/day)	Weight	Volume (ft^3)	Surge Rate(tons/day)	Weight	Volume (ft^3)
Provisions	30	95	2850	304000	95	2850	304000
Ordnance	30	550	16500	880000	687.5	20625	1100000
Total			19350	1184000		23475	1404000

Table XV-2: Daily Sustainment Rates, Weight, and Volume for a MEB
(Source: Kennedy, 2002)

			Surge	Sustainment			Surge	Sustainment
	# per ship	Burn rate (lb/hr)	# Sorties per day	# Sorties per day	Range (nm)	Speed (knots)	Fuel (gallon)	Fuel (gallon)
QTR	5	4,000	4.0	2.5	500	200	29,412	18,382
AH-1Z	4	800	3.0	3.0	650	152	6,037	6,037
UH-1Y	4	800	3.0	3.0	650	120	7,647	7,647
MV-22	14	350	4.0	2.5	500	240	6,005	3,753
JSF	6	2,000	3.0	3.0	500	875	6,618	6,618
							55,719	**42,437**
		gal/mile						
LCAC	3	16	9.0	2.0	50	35	14,400	3,200
LCU-R	2	0.86	4.0	1.0	50	15	344	86
							14,744	**3,286**

Table XV-3: Fuel Requirements for 30 Days of Sustainment (ACE, LCAC, LCU)

	Weight (ST)	Volume ft^3
Total Standard Rate	68,555	13,023,771
Total Surge Rate	139,880	26,573,774

Table XV-4: Total Volume and Weight

Establishing the MEB baseline was an important step to understand the requirements stated in the SEA IRD. The baseline gave the team the necessary information and a working knowledge of how the MEB is organized, and how it conducts operations. This knowledge, along with the understanding of the Sea Base was the foundation to refine the requirements provided by the SEA IRD.

4. The Sea Base

a. Understanding the Sea Base Concept

Understanding the Sea Base concept was a challenging task for the team. First, because until now, there was not an established architecture for the Sea Base, how it should operate, or how it should be employed. Second, as mentioned earlier, there are a multitude of documents that try to define the Sea Base. These concepts range from creating a Sea Base with current systems, to the Mobile Offshore Base concept, which describes the Sea Base a series of massive interconnected platforms that could land heavy transport aircraft.

The team approached the Sea Base study as one that explored the different capabilities that a Sea Base should possess. With that philosophy in mind, the team proceeded to review as many documents as possible which dealt with the Sea Base concept, merged these capabilities with the requirements presented in the SEA IRD, and generated a common list of required capabilities for the Sea Base.

b. Operating Area/Environment

- On station – 25-250 NM from the beach.
- Threshold Sea State 3 (3.5-4 ft) for all missions.
- Transatlantic Capability – include supporting MEB en route.
- Escorts will be part of force structure in/en route to the Objective Area – SEA defined the numbers/type/distance requirements for the Expeditionary Strike Group (ESG) escorts.
- Must have ability to operate :
    - Independently in a low threat environment
    - As part of a larger Task Force (CVBG) with air cover from the Task Force in medium to high threat environment.

c. Logistics/Stowage

- System must provide C2 of logistics operations w/in the Sea Base and ashore.

- System must provide increased aviation ordnance stowage and handling facilities.
- TSSE must develop clear understanding of storage capacity required for fuel/ordnance/spares of both the ship and MEB.
- TSSE must develop storage plan for current and future aircraft and surface assault assets of afloat MEB as well as Long Range Heavy Lift Aero Design, Unmanned Underwater Vehicles (UUV), Unmanned Surface Vehicles (USV), and UAVs.
- Carry non-standard Special Forces ordnance.

d. Speed Requirements

- General - System must be capable of reaching theater at speeds no less than current platforms but preferably at cruise speed of 25 or above.
- Must meet requirements to allow for maneuver warfare from the sea in accordance with OMFTS.
- TSSE will have to specify desired operating speed for transatlantic mission with or without MEB embarked.

e. Sustainability

- Must have throughput ability for indefinite sustainability
- Must be able to sustained MEB for a min. 30 days
- Must be able to be replenished by legacy, future Commander Landing Force platforms, and commercial shipping.

f. Maintenance/Repair

- Must be able to conduct and facilitate Intermediate Level Maintenance to support GCE, ACE, CSSE equipment, and other units of the ESG.

g. Distribution & Interfaces

- Have multiple inherent capabilities to distribute logistics support to the maneuver units positioned up to 200 NM in shore. - not just rely on air platforms.
- Have "just/right time" distribution capability.
- Must be able to interface with legacy systems.

i. MEB Requirements

- Must be able to sustain a MEB ashore for a minimum of 30 days with throughput ability for indefinite sustainment.
- Throughput sustainability conducted via float-in and fly-in concept
- MEB size expected to be ~ 5,000 (GCE) Marines and support personnel/equipment

j. Medical

- Support natural disasters, noncombatant evacuation operations, Militaqry Operations other than War (MOOTW), and human suffering to include patient regulation, transport/evacuation, receipt, and stabilization.
- Treatment facilities for critical patients.
- Decompression facilities for Explosive Ordnance Disposal (EOD)

k. Habitability

- Ship's Crew - Mixed Gender
- MEB Personnel (GCE, CSSE, and ACE) approximately 15,000
- Support Special Forces Personnel
- Reduced Manning Employed
- Crew Comfort and Quality of Life must be incorporated
- Must support training areas for crew and embarked units

l. Survivability

- System must have Chemical, Biological, and Radiological protection.
- System must be able to defend itself against leakers (Anti-ship Cruise Missiles) from the escort forces.
- TSSE will determine stealth features.

m. Loading/Unloading Requirements

- Must be capable of performing loading/unloading in port and at sea.
- TSSE must determine rates for operations in order to fully support rapid optempo requirement for ExWar mission.
- Selective offload capability imperative.
- System must support reconstitution and redeployment of Ex War forces.
- Must be compatible with future fleet oilers and supply ships.
- Vertical Replenishment capabilities that fully support logistics needs of ExWar forces.
- Must be capable of receiving casualties from air/waterborne craft.

n. Warfare Capabilities

- Self-Defense Capability to include the following warfare areas:
    - Air Warfare (AW)– detect, ID, track, and defeat leakers.
    - Surface Warfare (SUW) - detect, ID, track and defeat multiple small high-speed surface craft.
    - Undersea Warfare (USW) – support antisubmarine Warfare (ASW) and Mine Countermeasures (MCM) ops to include helicopters, Unmanned Underwater Vehicles (UUVs), and Mine Warfare (MIW) assets.
    - Strike Warfare (STR) – coordinate, task and support strike missions.

- Offensive capability
    - Capability to coordinate, undertake and support of Strike Missions:
    - Provide initial operational fires to support the MEB (minimize footprint).
    - Support the Marine Corps Theater Air Missile Defense.

o. Replenishment

- System must act as an integrated OTH floating distribution center and workshop.
- Must be capable of repackaging and delivery of units to the Ex War force afloat or ashore.
- Spaces must allow for ease of reconfiguration (modularity) to support multi-mission functions of ExWar force.
- TSSE must determine how the interface with AC, small boats, and other cargo vehicles will flow.

p. Air Operations

- Support Tactical Recovery of Aircraft and Personnel missions.
- Accommodate MV-22, STOVL Joint Strike Force and all current MEB air assets.
- Ability to operate and launch UAVs/UCAVs.

q. C4ISR

- Defense in Depth with sufficient physical protection, firewalls, and redundancy for information and communication networks.
- Communications and computers must be, network centric, and compatible with other service, and coalition assets (interoperable).
- Theater to CONUS connection (Reach back) for ISR.

r. Modularity

- Incorporate modularity in design of selected compartment(s) to allow for reconfiguration depending on mission needs.
    - SOF operations, non Electronic Warfare operations, strike mission
    - Carrying less cargo but having more Vertical Launch System modules to support strike missions.

D. REQUIREMENTS GENERATION FROM LHA (R), MPF(F), AND LMSR OPERATIONAL CONCEPTS

The next step for the TSSE design team was to analyze the LHA (R), MPF (F), and LMSR CONOPS, and current LHA/D capabilities. This analysis took ensured that no capabilities were left without being analyzed. In addition, as new systems are designed to replace old ones, their CONOPS will incorporate new capabilities which are necessary to support future CONOPS such as Sea Basing and STOM. The analysis of these CONOPS allowed us to revisit the Sea Basing concept, compare its required capabilities with the capabilities already compiled from the SEA IRD analysis, and consolidate them into a master requirements document. Capabilities for both conceptual and current platforms were consolidated into mission areas.

a. Air Warfare

The ship must be able to defend against advance Anti-Ship Cruise Missiles. It must be able to support and leverage joint integrated air defense systems to provide support throughout the Objective Area, but especially support of the Marine Corps Theater Air Missile Defense. The ship should have decoy systems, which at a minimum have the capabilities and characteristics of systems installed in current platforms. The Electronic Warfare suite should be able to facilitate "soft kill" of air threats. The ship will not be expected to be a long-range air defense platform.

b. Amphibious Warfare

The ship must be able to transport 1700 troops. Current platforms have a 300 ft well deck that supports 3 Landing Craft Air Cushion (LCAC), or 2 Landing Craft Utility (LCU), AAV, AAAV, and future LCU and LCAC replacements. Amphibious operations will be conducted OTH at least 25 NM from shore. Once the initial assault takes place, ships can move further out to sea to commence the sustainment phase. Current Marine Corps sustainment policy requires the ships to support a MEU for 15 days, a MEB for 30 days, or a MEF for 60 days. The ship must be able to transport and support the landing force with maintenance, supply, medical and fire support coordination as part of a Sea Base. As part of the Command and Control architecture, the ship must provide airspace and surface management throughout the objective area with high-density airspace control zone. The ship must be able to support and operate with the MV-22, AAAV, STOVL Joint Strike Force, SH-60R, and UAV with at least 42 multiple points for aircraft spotting. The ship must be able to conduct both rotary and fixed wing flight operations simultaneously. In order to support the Marine Corps Advanced Fire Concept, the ship will conduct or coordinate the Sea Base assets to conduct fire support missions, around the clock

The ship must be able to employ torpedo decoy systems, and be able to support sustained littoral campaigns in a coastal water submarine environment.

c. Command Control Communications

The ship will be able to support the Expeditionary Sensor Grid (ESG). It must also be able to receive information from various UAV platforms, with full tactical control systems. The ship will provide tactical, secure voice or data communications, plan, coordinate, and control implementation of Operations Security measures. The ship must be able to communicate with the embassies, theatre or JTF commander, and Special Operation Forces working in conjunction with expeditionary forces. In addition, the ship must be able to support communications for embarked staff. Communications systems must be compatible with tactical command and the control architecture of the Amphibious Task Force. The C2 architecture must be network centric warfare based to allow Joint C4I interoperability.

d. Command Control Warfare

The ship's Electronic Warfare (EW) suite must be able to facilitate "soft kill" of air threats, and complicate the enemy's targeting process.

e. Fleet Support Operations

The ship must have at a minimum a 578-bed hospital/morgue, 6 operating rooms, provide medical, and dental facilities to support Sea Base personnel. The ship will perform intermediate level aircraft maintenance, and provide support for organizational level preventive and corrective maintenance. The ship will support forces ashore for supply maintenance, distribution, and salvage engineering.

f. Intelligence

The ship must be able to receive information from various UAV platforms, with full tactical control systems. The ship must be able to monitor electronic emissions from shore and from other ships.

g. Logistics

In order to transport the large number of vehicles and stores, the ship must have at least 25,400 square feet of vehicle storage volume, and 125,000 cubic feet of cargo storage volume (3087 cubic meters of dry cargo space). The ship will carry at least 1232 tons of aviation fuel. The ship must provide indefinite sustainment for logistic support, and be able to integrate operations with Joint in theater logistic agencies and transition from Sea Based logistics support system to a shore based system. The ship must be able to receive and process 20 ft standard containers and other packaging configurations from intra or inter theater distribution sources, segregate contents, and assemble components into unit level loads for distribution. The ship will be able of operating independently to provide strategic sealift capacity in support of rapid deployment of heavy mechanized Army and Marine Corps combat units on a worldwide basis. In additions, the ship must provide ship configuration suitable for container loading and discharging by a shore facility (non-self sustaining container ship), and load, stow, transport, and discharge outsized and oversized military equipment. The ship will fulfill the Strategic Sealift mission by transporting common-user cargo and military vehicles, including tanks and helicopters, pre-positioned overseas or surged from the United States to support exercises and real–world contingencies. The Ship will be equipped with self-sufficient Roll-on/Roll-off and/or Lift–on/Lift–off facilities for rapid loading, deployment, and offloading. The ship will have systems compatible with the Standard Tensioned Replenishment Alongside Method for the transfer of ammunition, cargo, missiles, and personnel. The ship will provide small boat services for transfer of personnel, cargo, weapons, provisions and supplies. In addition, the ship must provide a safe and secure small arms storage area, and provide for proper storage, handling, use, and transfer of hazardous materials.

h. Mine Interdiction Warfare

In order to support MIW operations, the ship must have facilities and capabilities fully compatible with operating and supporting mine sweeping assets to include the "flyaway" version of the Remote Mine-hunting System, SH-60R with Airborne Mine Countermeasures kits (hunt and kill), and the ability to embark Mine Countermeasures staff. The ship must possess self-protective measures to manipulate its signature, harden the platform for detonation effects, and detect, avoid and neutralize mines.

i. Mobility

The ship's speed must be comparable to other Navy surface ships in the timeframe of 2015 and beyond (25-27 knots or more). The design will not be restricted in size by the Panama Canal. It should be able to operate in at least sea-state 3, with a range of 10,000 NM. The ship must facilitate theater reconstitution and redeployment of forces without a requirement for extensive material, maintenance, or replenishment support at a strategic sustainment base.

The ship must counter and control Chemical, Biological, and Radiological contaminants/agents, and provide damage control security and surveillance. The ship must be able to get underway, moor, anchor, and sortie with duty section in a safe manner, provide life boat/raft capacity in accordance with unit's allowance, and moor alongside oceangoing fleet tug shipping or docks.

j. Non Combatant Operations

The ship must be able to operate with other military services, government agencies and multinational forces, operating with aircraft, displacement and non-displacement craft, and command/control systems to coordinate these operations. The ship will require a robust multi-media capability that will be able to produce leaflets, posters, and schedules. The ship will require areas for medical and dental care, feeding, and berthing of evacuees. The ship will support or conduct helicopter/boat evacuation of noncombatant personnel as directed by higher authority, and provide for embarkation, identification, processing of evacuees.

k. Naval Special Warfare (SPECOPS)

The ship must be able to support Special Warfare personnel, equipment, and special ordnance.

l. General

The ship must support varying ratios of male and female crew, troops, and staff. It must be designed to permit rapid reconfiguration to respond to changing threats and missions. The ship must allow embarked personnel to conduct and prepare unrelated missions and be able to successfully complete them.

The ship must be able to provide facilities and personnel for material, mail, and passenger handling. It must provide stowage and berthing spaces for equipment and personnel during transit. The ship must monitor the health and well being of the crew to ensure that habitability is consistent with approved procedures and standards. The ship must be able to safely operate and execute all assign missions in a manner that is consistent with naval directives pertaining to the prevention of environment pollution.

3. Merging SEA IRD, LHA(R), MPF(F), and LMSR requirements

Up to this point in the design process, the TSSE team had analyzed the SEA IRD, studied current MEB architecture, analyzed Sea Basing, and produced a list of required capabilities. The team had also studied concepts of operation for LHA(R), MPF(F), and LMSR and generated their requirements. All these requirements were fused into a master Required Operational Capabilities (ROC) document. This document eliminated redundancies, consolidated all of the previous requirements, and became the baseline for the TSSE design. The master ROC is listed in appendix 16-1 of this chapter.

E. FEASIBILITY STUDIES

After establishing the requirements baseline, it was necessary to identify possible systems solutions which could meet those requirements; and then evaluate the most likely concepts in terms of performance, effectiveness, maintenance, logistical support, concept of operations, and potential cost. Recommendations were made from all the feasible alternatives, and advantages and disadvantages were identified for the selected courses of action.

The starting point for the feasibility study was to make a determination on the number and types of ships needed to fulfill the requirements. After determining these two issues, the study focused specifically on refining the selected alternatives. Characteristics such as ship type, displacement, length and beams were estimated for each of the alternatives. The final three alternatives were as follow:

a. LHA/MPF With LMSR Variant
b. MPF/LMSR With LHA Variant
c. Single Ship

1. Number of Ships

Once a MEB baseline and an estimate of the weight and volume requirement were established, it was necessary to approximate the number of ships and their displacements. Tables XV-5 and XV-6 present the 3 and 6 ships options respectively. Taking table XV-5 as an example, the total payload requirement is 140,000 short tons (ST). That figure divided by 3 ships resulted in a payload per ship of approximately 46,667 ST. The next five columns represent the payload to displacement ratio. In a warship such as a frigate or destroyer, the payload is approximately 25% of the ship's displacement. On the other side of the spectrum in a container ship, where the payload is 80% of the ship's displacement. The same is applicable for table XV-6, except that in this case, the total payload was divided among 6 ships. Based on these two tables, the team decided that the 6-ship option was the best because the displacement per ship was more feasible. Furthermore, the team also estimated that the displacement would likely fall between 35% and 60% of the ship's payload. These conclusions were consistent with current LHA/D class of amphibious assault ships characteristics.

3 SHIPS					Displacement & Volume per Ship		
			Warship Ratio	Somewhere in between			Container Ship Ratio
Payload	Total Payload	Payload per Ship	25%	35%	50%	60%	80%
Weight (ST)	140,000	46,667	186,667	133,333	93,333	77,778	58,333
Volume (ft^3)	26,600,000	8,866,667	35,466,667	25,333,333	17,733,333	14,777,778	11,083,333

Table XV-5: Feasibility of a 3 Ship Family Taking in Consideration Payment to Displacement Ratio.

6 SHIPS					Displacement & Volume per Ship		
			Warship Ratio	Somewhere in between			Container Ship Ratio
Payload	Total Payload	Payload per Ship	25%	35%	50%	60%	80%
Weight (ST)	140,000	23,333	93,333	66,667	46,667	38,889	29,167
Volume (ft^3)	26,600,000	4,433,333	17,733,333	12,666,667	8,866,667	7,388,889	5,541,667

Table XV-6: Feasibility of a 6 Ship Family Taking in Consideration Payment to Displacement Ratio.

2. Types of Ships

Other options explored by the team were the common platform design and the variants design. In the common platform design, all the ships would have exactly the same capabilities. In the variants design plan, related capabilities would be designed into a single ship type. For example, a ship of the Sea Base would have more logistic capabilities than combat capabilities. The following paragraphs describe both design philosophies advantages and disadvantages.

a. Common Platform Design

Advantages

- Able to operate independently.
- Flexible redeployment.
- Redundancy.
- Independent self-protection capabilities.

Disadvantages

- Larger ship.
- Might cost more in monetary terms.

b. Variants Design

Advantages

- Focused responsibility
- Might cost less in monetary terms

Disadvantages

- Functions only as a package with all its variants
- Some variants have no self-protection capabilites.
- Limited Redundancy
- More communications required

3. LHA/MPF With LMSR Variant

The LHA/MPF with LMSR alternative was based on the same hull. As stated in the requirements, the system of ships would require to sustain a MEB force for 30 days, but with the option for indefinite sustainment of the force. Since most of the expeditionary operations undertaken by the Marines are executed by MEU size forces, scalability of the Sea Base ships was an important consideration. Another important consideration was the ability to selectively offload equipment and supplies. This ability would allow the forces ashore to receive only what they considered necessary to accomplish the mission. This alternative concept assigned the LHA/MPF variant as the combat ship, and the LMSR as the supply and support ship. If required by the size of the operation, three LHA/MPF and three LMSR would have enough capabilities and support for a MEB size contingency.

a. LHA/MPF Variant

This ship concept would combine the fleet combatant capabilities inherent to the LHA and combined it with the MEB cargo carrier capacity provided by the MPF to enhance the overall capability in a Sea Based operation. This type of ship would be flexible enough to replace the LHAs and LHDs in an ARG capacity as they are phased out of service. The following summary describes the primary and secondary missions for this ship type.

- Primary
  - Carry and support combat systems and ACE
  - Perform C4ISR duties as command platform
- Secondary
  - Maximize logistic services through selective offloading
  - Serve as a troop/cargo carrier

b. *LMSR Variant*

The LMSR variant would retain all of its current capabilities such as bulk storage, equipment storage, and heavy cranes to handle container size cargo. New capabilities design to this type of ship would include C4ISR, medical facilities, vehicle and aircraft intermediate maintenance facilities, and increased habitability spaces for extra troops and crew. The following summary describes the primary and secondary missions for this ship type.

- Primary
    - o Provide conduit between Commander Landing Force/Merchant and Sea Basing ships
    - o Provide logistics support through selective offloading and container handling capability
    - o Provide maintenance and repair facilities
    - o Serve as a troop/cargo carrier
    - o Provided medical and dental services
- Secondary
    - o Support logistic support through maximizing flight deck and air assets

c. Development Process

The design methodology for this concept followed a Top Down, Bottom Up approach. On the Top Down approach, the design was driven by MEB requirements such as equipment storage, number of personnel, and combat systems capabilities. The following paragraph describes the parameters used for the concept design.

The MEB load included landing craft, replenishment requirements, major communications equipment, and engineering equipment. The volume calculated was twice the original value for equipment and supplies to account for space between equipment and required accessibility. Propulsion and auxiliaries were estimated using the LM2500+ propulsion data to provide 27 knot sustained speed. Combat systems were based on 2000/2001 TSSE concept designs. Galley, wardroom, messing and recreation facilities, and berthing were calculated for approximately 20,000 USN/USMC personnel in the MEB. Well decks were based on the MPF 2010 concept design; two well decks for the LMSR to accommodate additional MEB equipment to go to shore via LCAC, and one well deck for the LHA/MPF variant. The hangar deck was based on each aircraft folded spot factor and the requirement to fit all aircraft in the hangar bay. The distribution of aircraft was 80% on the LHA/MPF and 20% on the LMSR. Figure XV-7 present volumetric analysis and distribution compartment volumes between the LHA/MPF and LMSR variants.

HABITABILITY		LMSR			MPF-LHA		
Berthing Volume		% vol in variant			% vol in varinat		
Ship's Company Berthing		0.25	128315.5	3635.0	0.4	205304.8	5816.0
Marine Berthing		0.6	2054190.0	58192.4	0.4	1369460.0	38794.9
Galley		0.6	50832.0	1440.0	0.4	33888.0	960.0
Recreation Rooms		0.6	32532.5	921.6	0.4	21688.3	614.4
Wardroom		0.6	99715.4	2824.8	0.4	66477.0	1883.2
CPO Mess		0.6	159358.3	4514.4	0.4	106238.9	3009.6
Crew's Mess		0.6	1428379.2	40464.0	0.4	952252.8	26976.0
MISC COMPARTMENTS							
Aircraft Maintenance Shops		0.2	10844.2	307.2	0.8	43376.6	1228.8
Offices		0.5	18638.4	528.0	0.5	18638.4	528.0
Ship's Work Shops		0.5	15885.0	450.0	0.5	15885.0	450.0
Training Rooms		0.6	48798.7	1382.4	0.4	32532.5	921.6
Departmental Storerooms		0.5	18638.4	528.0	0.5	18638.4	528.0
MEDICAL							
Hospital Rooms (ICE, beds, op room)		0.8	168247.6	4766.2	0.2	42061.9	1191.6
FUEL							
Airwing		0.2	53472.0	1514.8	0.8	213888.0	6059.2

Table XV-7: Distribution of Compartment Volumes Between LHA/MPF and LMSR Variants

On the Bottom Up approach, the design was based on a block estimate given by current notional space requirements. In other words, an initial size of the ship was determined through a graphical comparison of current platforms. Based on current and planned platforms, Figure XV-4 shows the displacement to length ratio for the concept design. With the displacement to length ratio equal to 91, the length of the ship can easily be calculated based on the payload required for the ship. In this case the displacement of the LHA/MPF variant was calculated approximately 51,000 tons.

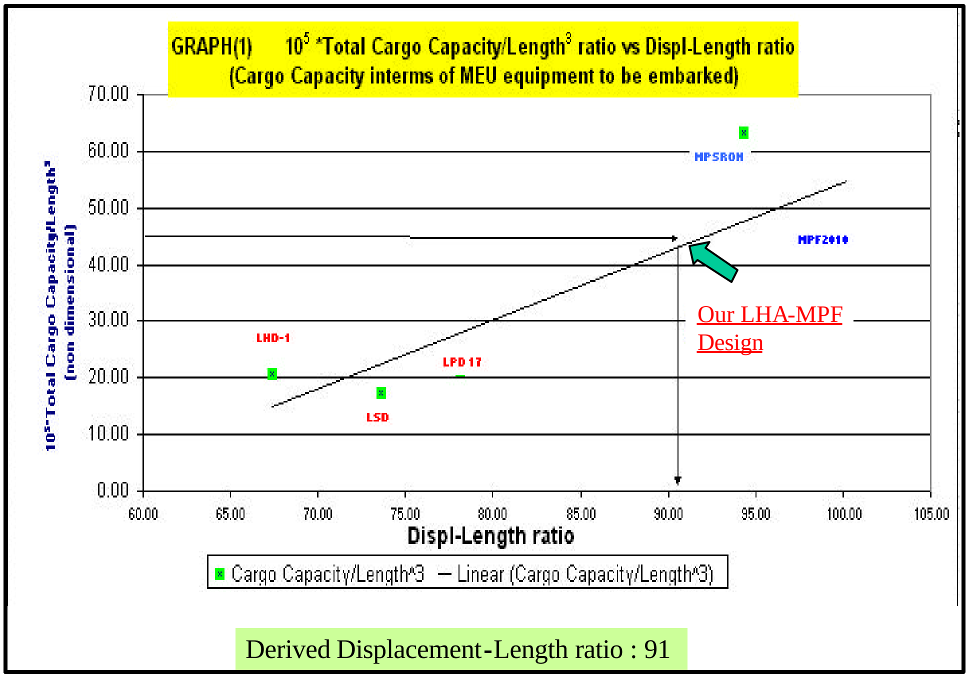


Figure XV-4: Feasibility of LHA-MPF Variant Compared to Other Platforms.

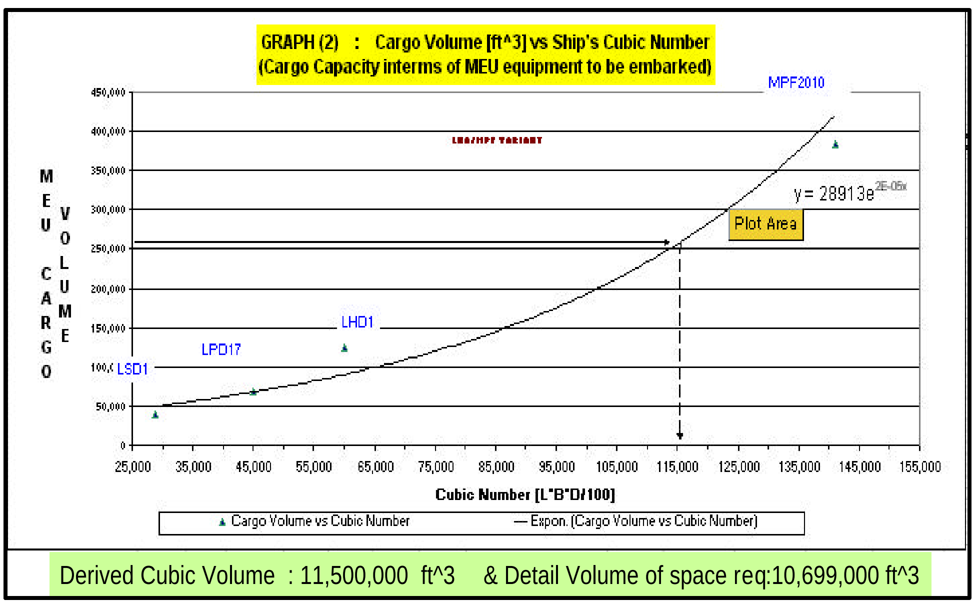


Figure XV-5: Feasibility of LMSR Variant Compared to Other Platforms

Table XV- 8 Summarizes the Top Down and Bottom Up sizing estimate for both LHA/MPF and LMSR concepts.

INITIAL SHIP SIZING ESTIMATES		TSSE Design 2002	
		LMSR[K]	LHA/MPF[LM]
		SAME HULL FORM	
Length (ft)		850	850
Beam (ft)		140	140
Design Draft (ft)		TBD	TBD
Depth(ft)		96.64	96.64
Length/Beam ratio		6.07	6.07
Length/Draft ratio		TBD	TBD
FL Disp (LT)		55,885	55,885
Volumetric Displacement		1,955,988	1,955,988
Displ-Length ratio		91	91
Ship's Cubic Number		115000	115000
Speed - sustained		27	27
Speed -Length ratio		0.93	0.93
Installed SHP		128,200	128,200
Features			
Flight Deck Spots (include 6 x Landing spots CH-53)		28.17	64.98
Well Deck (#LCAC)		2	1
Vehicle Deck Area [ft^2]		135,000	50,000
Volume MEU EquipmCarried(not incl troops)		969,010	899,627
Cubic Volume of Ship Hull[ft^3]		11,500,000	11,500,000
Detail Volume req [ft^3]		7,158,242	7,562,795
Discrepancies		4,341,758	3,937,205

Table XV-8: Summary of Characteristics for LHA/MPF and LMSR Variants.

The advantages and disadvantages for the LHA/MPF with LMSR alternative are listed below.

Advantages:

- MEU remains a scalable fighting capability- keep smallest MAGTF unit intact
- LMSR can be designed to Military Specifications to conform with survivability issues

  More survivable as a combat ship – Defensive Capability, Structural Integrity, etc.
- High Learning Curve for shipyard production
- Shipyard compatible (similar size to LHA/LHD)

Disadvantages:

- Aircraft are loaded onto LHA/MPF, but over half of MEB equipment is on LSMR

  Would require LSMR to have the capability to get necessary equipment onto flight deck for subsequent loading

- Over design of LMSR?
- Loss of one ship of a set --
  Could mean loss of 1/3 capability of MEU+
- Some ship-to-ship transfer would have to occur at sea for indefinite sustainment as not everything can come via airlift.
- Personnel on LMSR – MSC or Mil?

4. MPF/LMSR With LHA Variant

The approach for this design concept was very similar to the previous one. The MEB was divided into three parts, each part consisting of one LHA and one MPF/LMSR variant. The LHA and MPF would carry the equivalent load for 1/3 of a MEB. Each ship set would carry approximately 6,600 personnel. LHA would carry 2,000 troops, plus 1,200 for ship's company. MPF/LMSR would carry approximately 3,000 troops in addition to the 400 for ship's company.

a. LHA Variant

The LHA variant for this design concept would be the primary combat ship. This ship would carry combat troops and transport aircraft. It would also have one well deck to accommodate 2 LCACs. Its air defense systems would consist of Free Electron Laser and on board chaff dispensers. The ship would be able to carry approximately 6 Joint Strike Forces, 8 CH-53's, 8 MV-22's, 3 AH-1Z, 3 UH-1Y's. Its flight deck would accommodate all aircraft in spread configuration, and the hangar deck would accommodate all aircraft in folded configuration. The ship would possess basic self-defense and avoidance capabilities for mine warfare. The ship would be able to sustain a speed of 25 knots on transoceanic sorties. Some basic ship characteristics are listed below.

Displacement:	55,000 LT
Length:	900'
Beam:	130'
Draft:	35'

Internal Volume: 7.5 ft^3

b. MPF/LMSR Variant

The primary mission for this ship would be to provide the Sea Base with supplies and fleet support. The ship would have one well deck and could carry up to four LCACs. Its air defense systems would consist of Free Electron Laser and on board chaff dispensers. The ship would be able to carry approximately 3 CH-53's, 4 MV-22's, 1 AH-1Z, and 1 UH-1Y's. Its flight deck would accommodate all aircraft in spread configuration. The ship would possess basic self-defense and avoidance capabilities for mine warfare. This ship would contain nearly all the MEB's medical and dental capabilities. This ship would also possess the transfer at sea capabilities to interface with commercial and other sustainment platforms via cranes and LCACs. The ship would be able to sustain a speed of 25 knots on transoceanic sorties.

c. Development Process

The development process started with requirements such as total payload, cargo volume, and vehicle deck area. Each of this figures were plotted against and checked with previously established design parameters. In this case, data from LPD-17, LHD, LSD, MPFS and LMSR were used to compare the design requirements. In figure XV-6 the volume required for provision is approximately 50,000 lbs. This figure was then compared against the displacement to length ratio plotted from established platforms. The displacement to length ratio for the LMSR variant was estimated at approximately 100 tons/ft. On figure XV-7, the required vehicle deck area is approximately 130,000 ft^2 for the LMSR variant and approximately 50,000 for the LHA/MPF variant. The LMSR variant requirement is plotted against data from the existing LMSR and MPFS data. The displacement to length ratio for this variant is estimated at approximately 92 tons/ft. The requirement for the LHA/MPF is plotted against data from current LPD, LSD, and LHD data and estimated at approximately 92 tons/ft. Using the same method, the cargo volume is plotted against the ship's cubic number and estimated at approximately 115,000 ft^3. This relationship is illustrated in figure XV-8.

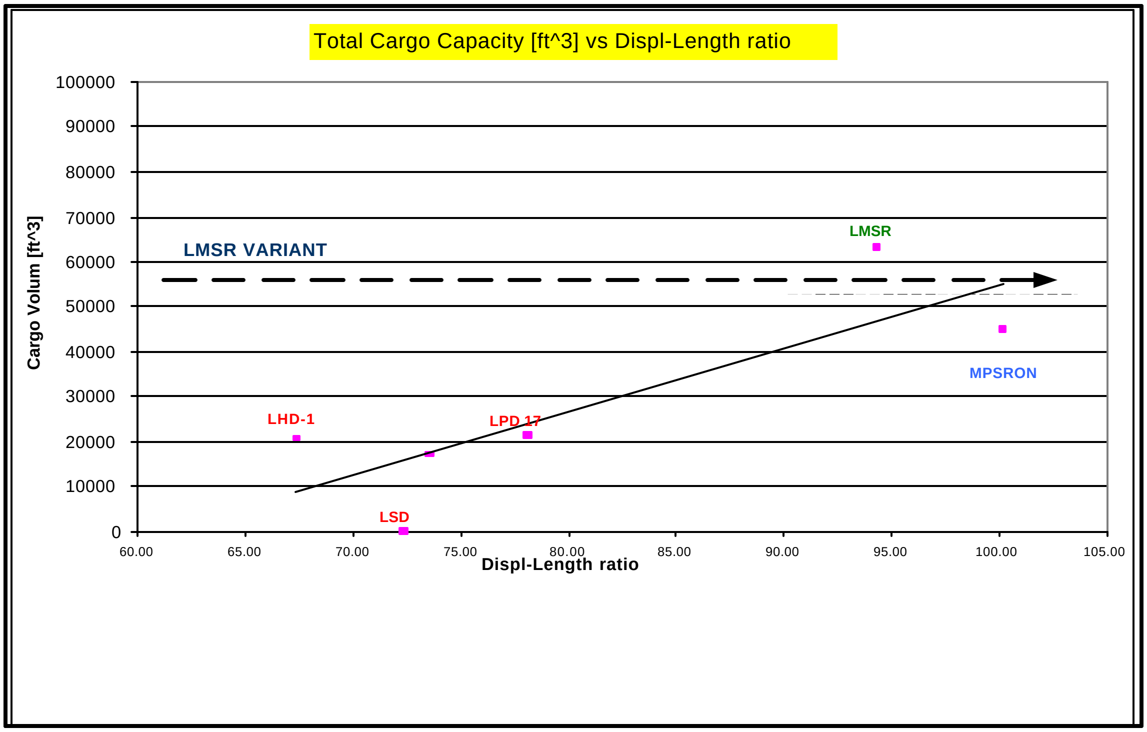


Figure XV-6: Feasibility of LMSR Variant Compared to Other Platforms Cargo Capacity

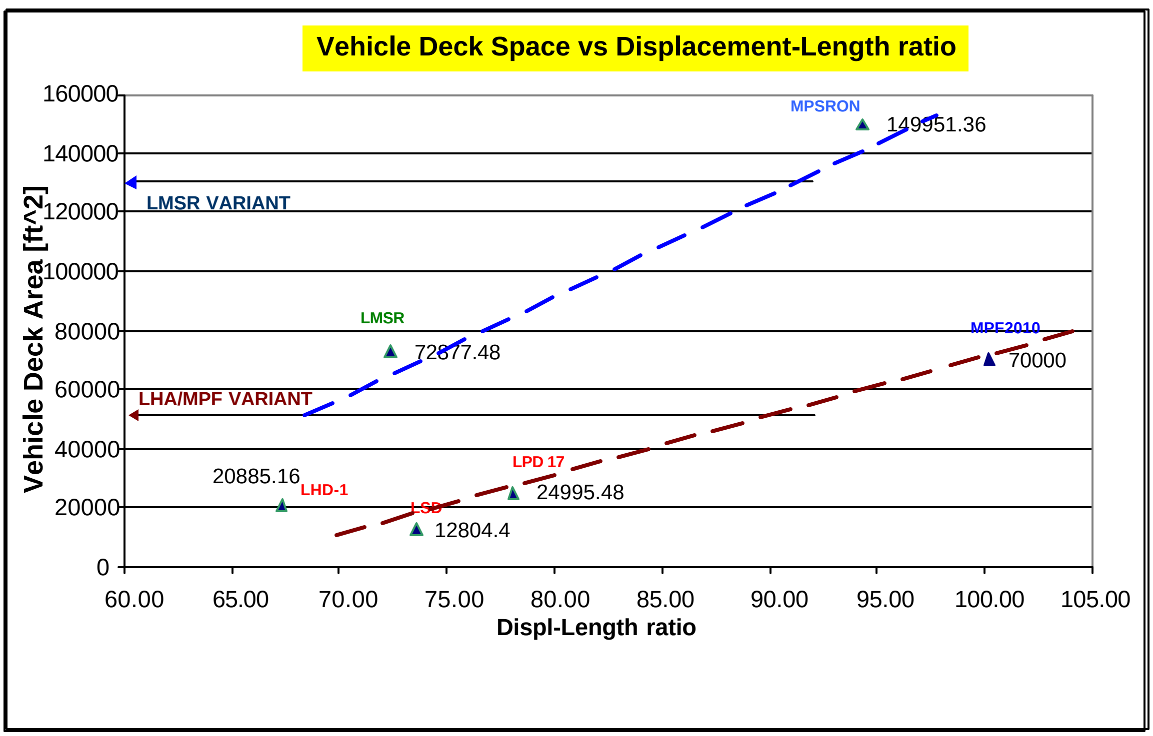


Figure XV-7: Feasibility of LMSR and LHA/MPF Variant Compared to Other Platforms Vehicle Deck Area.

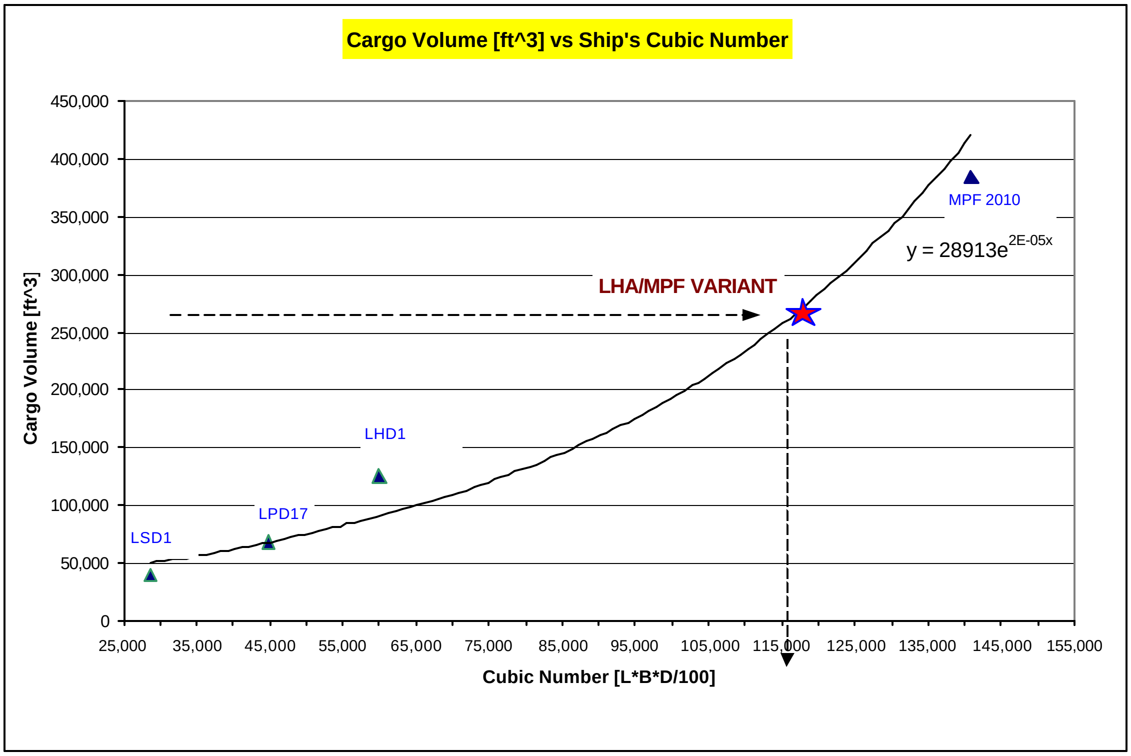


Figure XV-8: Feasibility of LHA/MPF Variant Compared to Other Platforms Cargo Volume.

Advantages:

- Division of equipment/troops is straight-forward in basic design layout.
- Forces are scalable (Each pair of ships=1/3 MEB). This allows easy replacement of ships every thirty days or as required.
- Two ships are roughly the same size equating to one hull form with two variants.

Disadvantages

- If operating as a MEU (one pair of ships), and one is disabled either the entire combat or support element of the MEU is lost.
- At-sea transfer needs to be more closely analyzed. Our alternative places two cranes and at least one ramp onboard MPF to facilitate transfer with commercial ships. Transfer between MPF and LHA can then be accomplished via LCAC's, underway replenishment.

5. X Ship Variant

The final design concept was the single ship or the "X" ship. This concept was very similar to the TSSE MPF 2010 design project of 1998. There would be approximately 6 ships per MEB, but since every ship has the same capabilities it could also operate in pairs for a MEU size contingency, or even as a single ship with a capability of ½ MEU. The ship would carry troops, their equipment, and sustainment provisions for 30 days. It would also have at sea transfer capabilities to interface with commercial and other supply ship to provide the Sea Base with indefinite sustainment. Every ship would have the same number of aircraft, bigger flight deck, and therefore have more airlift and transport capabilities than the previous alternatives. The ship would also have a well deck to accommodate LCACs and LCUs. Modularity would allow this ship to be stripped of its combat system, berthing, and other modules to effectively converted into a re-supply ship. Some of the ship's basic characteristics are listed below.

a. Development Process

The development process for this concept was a Top Down requirements analysis. From the requirements, total weight and volume were calculated for each ship. Table XV-9 illustrates the basic ship's characteristics, and Table XV-10 presents the estimated volume for each ship section and its correspondent percentage.

Category	Approximate Value
Total Volume	8,056,952
Displacement	70000
Length	1000
Beam	150
Draft	40
Number of well-decks	2
Number of LCACS (per ship)	4

Table XV-9: Ship's Basic Characteristics

	Volume ft^3	Percent
Propulsion	500000	0.062058209
Auxiliary	0	0
Fuel	334200	0.041479707

Habitability	607500	0.075400723
Combat Systems	15000	0.001861746
C4I	15000	0.001861746
Hospital	240000	0.02978794
Medical Facilities	0	0
Hangar	800000	0.099293134
Aircraft Maintenance	247500	0.030718813
Aircraft Equipment stowage	108000	0.013404573
Well Deck	300000	0.037234925
Miscellaneous	3000000	0.372349251
SHIP VOLUME	**8056951.879**	

Table XV-10: Ship's Volume

Advantages

- Redundancy is enhanced (all ships do the same thing, loss of one ship equals 1/6 loss in capability).
- Increased flight deck/aircraft capacity helps the Marine Corps to achieve STOM.
- All capabilities are on one ship, enhancing coordination of forces.
- All military equipment is stored on military ships, enhancing survivability.

Disadvantages

- Because everything has to fit on one ship, capabilities might have to be compromised.
- These ships will be significantly larger.
- Must be re-supplied by other vessels.

  Can be made easier by using non-militarized version as a sustainment ship and transferring with vertical replenishment and LCAC's

F. ANALYSIS OF ALTERNATIVES

In the analysis of alternatives phase, the objective was to evaluate each feasible alternative, in terms of problem definition. In the case of the TSSE design, this problem definition was directly linked with the capabilities required to perform Sea Basing, OMFT, and STOM.

The most important evaluation criteria was the ability of the concepts to maximize the effectiveness of air, sea, and land assets in deployment, support, and reconstitution of MEB size forces in a STOM environment. Other related capabilities were also considered:

- Ships must be able to scale operations to the MEU level in support of STOM.
- Ships must be able to support three coordinated and simultaneous attacks of a MEU size force up to 200 NM inland.
- Ships must be able to allocate assets to maximize the support of marine units ashore.
- Ships must have the ability to prepare for a different type of mission while supporting a current mission.
- Ships must have the ability to withdraw and re-deploy troops in an efficient manner.
- Ships must possess long-term sustainment capability.
- Ships must have the ability to interface with commercial shipping.
- Ships must maximize the options for on-load and off-load of troops, stores, fuel, and combat supplies.
- Ships must provide support to other ships in the Sea Base.
- Ships must maximize the allocation of assets to minimize the degradation in system performance in the event a unit is lost.
- Ships must maximize support and operations of aviation assets.

Area	Mission Area	% Weight
AMW	Amphibious Warfare	40
LOG	Logistics	28
FSO	Fleet Support	11
C4ISR	Command, Control, Computers	10

MIW	Mine Warfare	5
ASW	Anti-submarine Warfare	2
MOB	Mobility	2
USW	Under Sea Warfare	1
AAW	Anti-air Warfare	1

Table XV-11: Mission Area Weights

In order to prioritize the importance of each mission area, the team decided to apply a mission area weight. The final weight factor results are listed in Table XV-11. This weight would then be applied in the final concept evaluation.

The final evaluation assessed all the mission areas, and the operational concept of each alternative. The technical score consisted of a score of 1 to 5 assigned to each mission area. The operational score was a score from 1 to 5 assigned to each of the alternative's concepts of operation. The technical score had a weight of 75% of the total score, and the operational score had a weight of 25% of the total score. Appendix 16-2 lists the evaluation for each of the alternatives.

Figure XV-9 shows the results for the four most important mission areas and the operational concept score for each of the alternatives. Figure XV-10 show the overall technical score and operational score for the three alternatives. Based on this evaluation procedure, the selected alternative was the single ship concept or X-Ship.

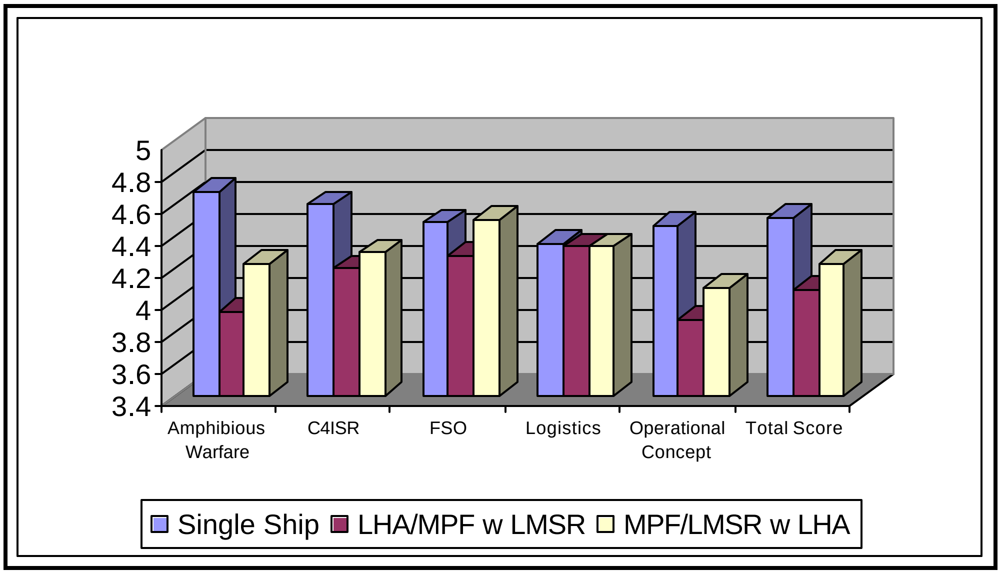


Figure XV-9: Single Ship Concept Dominated All Areas Except FSO

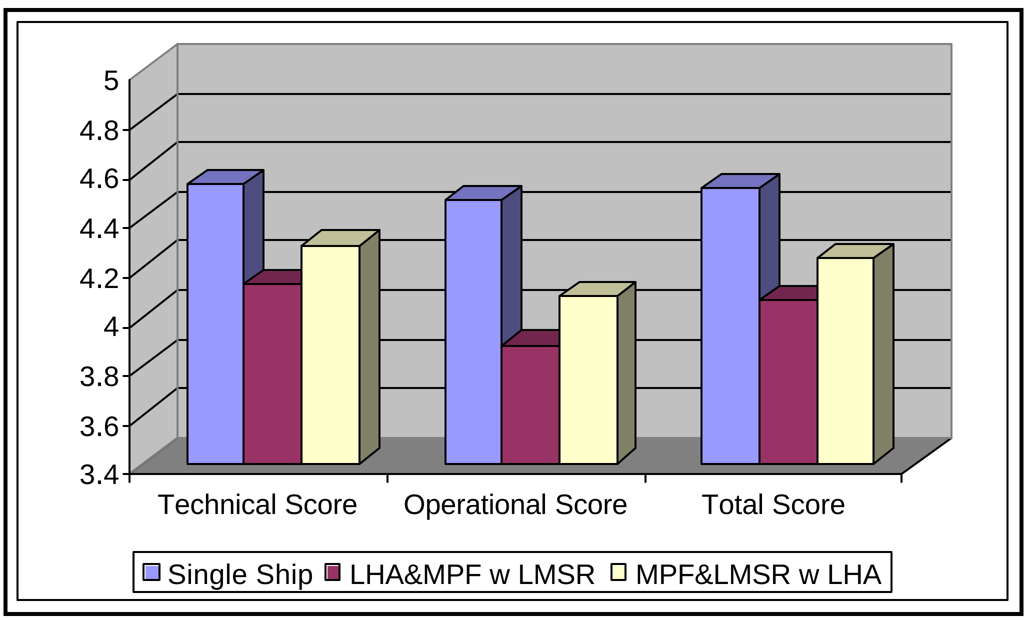


Figure XV-10: Technical and Operational Scores

G. CONCEPT EXPLORATION

Once a concept design was selected, the team proceeded to enter the concept exploration phase. Traditionally, in an acquisition program the concept exploration phase follows the identification of the mission need. In the case of the TSSE design project, the concept exploration phase was more of a technology exploration phase. Technology exploration was needed because many of the mission areas and capabilities required for the final design could be implemented with current technology. For example, the team realized that STOM operations relied heavily on aircraft, therefore the need for a large flight deck. In the concept exploration phase, the hull team realized that flight deck area could be maximized by the designing the ship based on a trimaran hull. Unfortunately, resistance and performance data for this type of hull, especially for large hull is nonexistent. Therefore, the team had to rely on data collected from analysis made from smaller trimaran hulls.

For this phase, the TSSE team subdivided into smaller groups. Each group consisted of two members, and was tasked to research technology in their specific mission area. Figure XV-11 illustrates the different groups and mission responsibilities.

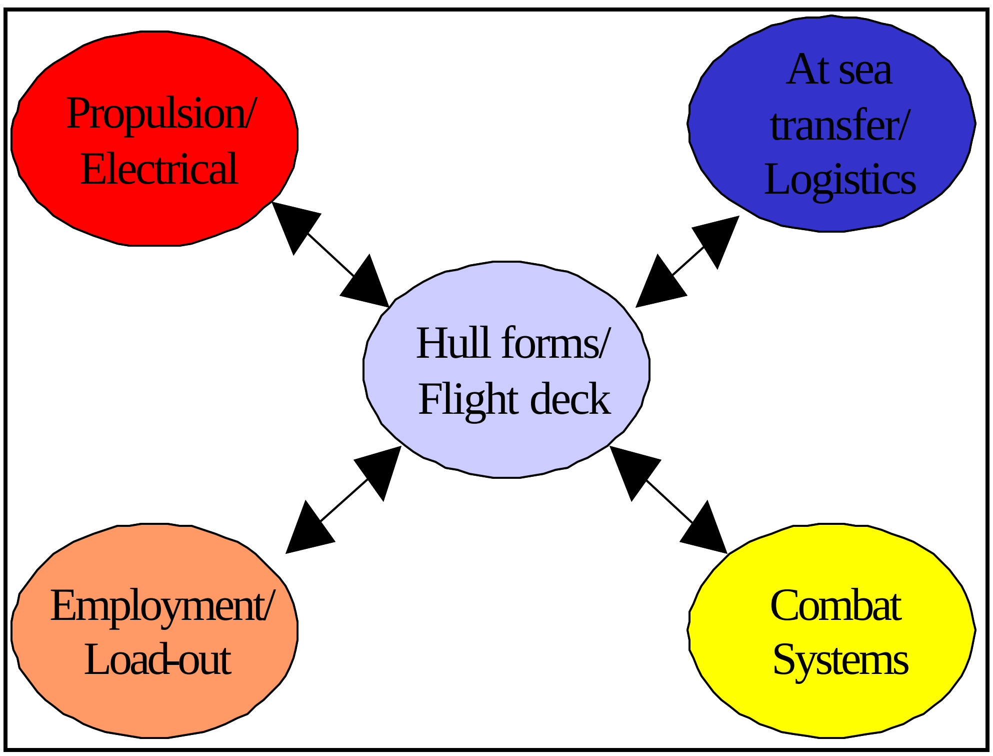


Figure XV-11: Mission Area Assignments

1. Hull forms and Flight Deck

This group was mainly concerned with the exploration of new hull designs to maximize the flight deck area and cargo capacity. Originally, a single hull was considered for the final design, but the requirement for a large flight deck eliminated this alternative. The second alternative was to base the design in a catamaran. The catamaran hull allowed for the arrangement of a larger flight deck with a negative trade off on internal volume due to the smaller side hulls. The third alternative was the trimaran. This hull type gave the design the large flight deck requirement without compromising internal cargo volume. In addition, the trimaran proved to be a stable hull. Eventually, the trimaran hull became the hull of choice for the final design.

2. Propulsion and Electrical Systems

The propulsion group explored innovations in propulsion and power distribution systems. Consideration for propulsion systems were given to nuclear steam, fuel cell, gas turbine, diesel engines, and electric drive technologies. Many Gas Turbines were studied and the LM600 and LM2500+ seemed to be the best regarding power, Specific Fuel Consumption, and total fuel consumption considerations for the design. Three alternatives were considered for the prime movers: combination of either 4 LM6000, or 5 LM2500 or 3 LM6000 and 1 LM2500+. The third alternative seemed to reach the power required with the minimum fuel consumption. Electrical pods and conventional propellers were compared, and pods proved to have the highest efficiency and maneuverability. Conventional electrical distribution, Integrated Power Systems, Radial electrical distribution, DC zonal distribution, AC zonal distribution, and AC/DC zonal distribution were studied considering the efficiency and high power requirements for the combat system.

3. At Sea Transfer and Logistics Systems

Transfer at sea and logistics systems required efficient transfer, storage, and distribution systems in order to supply the troops ashore. Some of the most important findings in this area were technology innovation in motion compensated cranes, logistics automation and at sea transfer technologies, hybrid linear actuators, omni directional vehicles, automated magazines and stowage and retrieval system.

4. Employment and Load-out

The task for the employment and load-out group was to make the use of the ship's internal volume. The team considered the location of the vehicle decks, magazines, propulsion spaces, maintenance facilities, among others. A manning studied was performed in order to estimate the approximate number of personal required to operate the ship.

5. Combat Systems

The combat systems group investigated weapons technologies and innovations. The required combat systems capabilities for the design were basic self-defense in some warfare areas. Some others, such as the Naval Gun Fire Support, had to be research since current platforms do not have the required capabilities to support the forces ashore in a STOM environment. Some of the explored concepts were the Electromagnetic Rail Gun, Free Electron Laser, UUVs, and UAVs, among others. Consideration was given to stealth technology and ways to reduce the radar cross section of the ship. Sensor technology exploration included the Digital Phase Array Radar. Finally, a very important shortfall of the new weapons systems is that they are high power intensive. Power estimates were performed in order to study the impact of these weapons systems upon the ship's power generation and distribution systems.

H. SHIP CONCEPT DESIGN

In the ship concept design of the project, the integration of all the ship's subsystems took place. The design process involved the translation of requirements and environmental problems into engineered system solutions. The design was a highly disciplined and iterative process in which trade off decisions and compromises among conflicting needs took place almost every day. Innovative and revolutionary technologies were involved as much as possible. Figure XV-12 illustrates the iterative nature of the ship design process. Each spiral indicates modifications and trade offs made to ship's systems until the process arrived to the center of the spiral where the established requirements were meet with the best compromises among ship's systems.

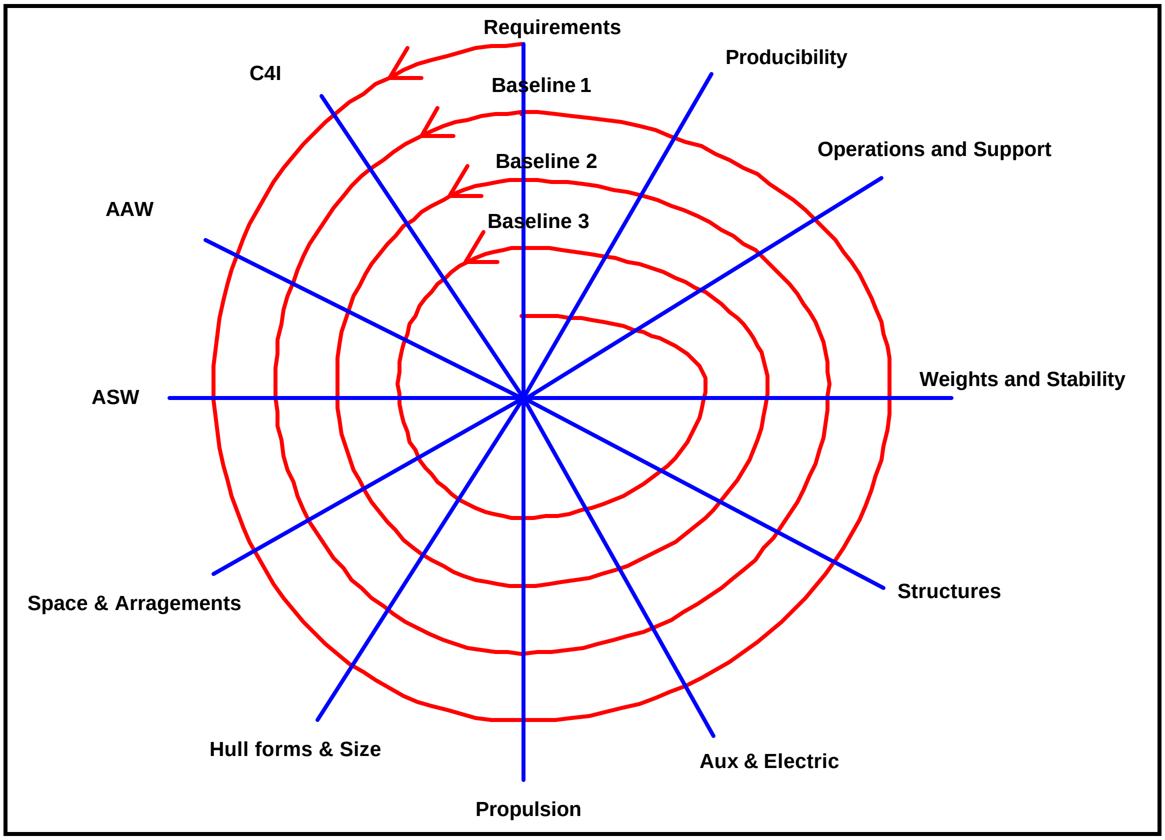


Figure XV-12: The Iterative Process of Ship Design
(Source: TS 3002 Course Notes)

Another important step in the ship design process was the establishment of a ship design philosophy. The ship design philosophy is a top-level statement of guidance for the design team to assist them in carrying out the design trade-offs in a consistent manner. In the TSSE design, the ship design philosophy focused in maximizing the air operations of the ship followed by enhanced at sea transfer capabilities. The following list presents the entire ship design philosophy for the TSSE design.

- Maximize Air lift/Air Ops capability.
- Enhanced At-sea transfer capability.
- Maximized modularity.
- Selective off-load.
- Survivability in a littoral environment.
- Maximize flexible employment on less than the MEU level.

- Habitability/Support of MEU troops.
- Manning reduction.
- Port accessibility.
- Shipyard production capability.
- Combat systems offensive capability.
- Future growth potential.
- Use of commercial off the shelf technology.

1. Hull and Flight Deck

Electing the most suitable hull would be critical for the ship's mission. The team was mainly concerned with the exploration of new hull designs to maximize the flight deck area and cargo capacity. Originally, a single hull was considered for the final design, but the requirement for a large flight deck eliminated this alternative. The second alternative was to base the design in a catamaran. The catamaran hull allowed for a larger flight deck but with a negative trade off on internal volume due to the smaller side hulls. The third alternative was the trimaran. This hull type gave the design the large flight deck requirement without compromising internal cargo volume. The trimaran hull became the hull of choice for the final design.

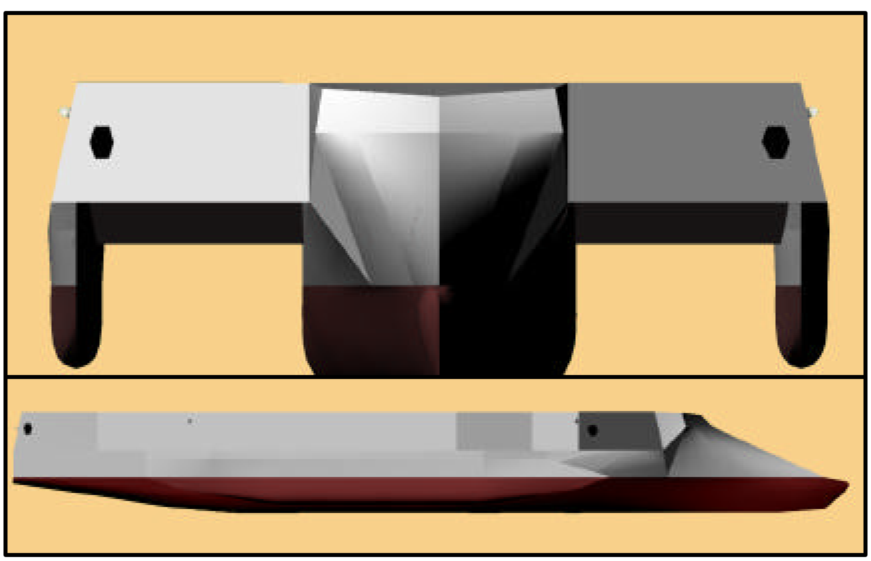


Figure XV-13: Trimaran Hull

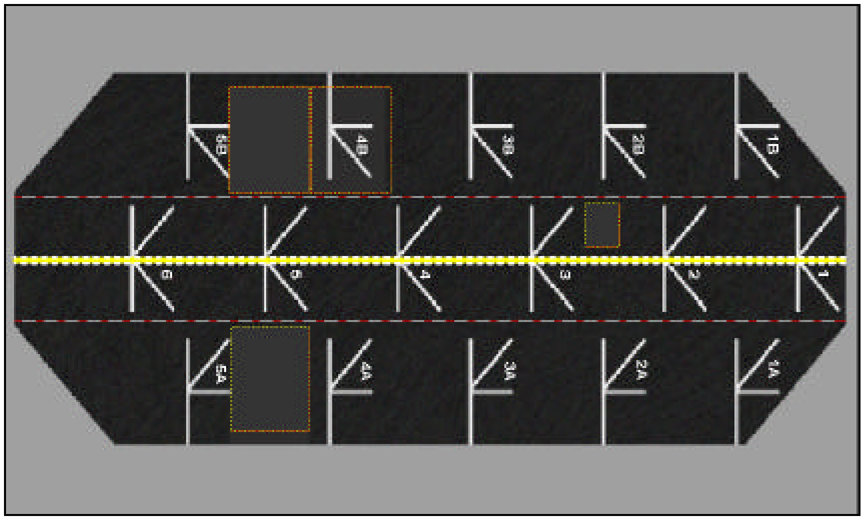


Figure XV-14: Triple Tram Flight Deck

The center hull was based on the TAKR hull design. This hull form was stretched until it was 990 feet long, 106 feet wide and 42 feet deep. This gave a displacement of roughly 75,500 LT, which was close to the predicted weight of the ship as found in the Amphibious Operations Area phase. The resulting hull had a length to width ratio of 9.3, very descent ratio for the type of ship and mission requirements. Several modifications were done to the hull. First, the transom was flattened to facilitate the inclusion of a well deck. Next, the bottom was flattened and raised at the stern, giving it the same shape as an LHD stern. This was done to provide space for the propulsion system. Finally, the bow was designed both bulbous and wave piercing. The bulbous bow would reduce the bow wave at higher speeds, increasing the efficiency of the hull, while the wave piercing bow would minimizes the buoyancy above the waterline forward, reducing the vertical motion of the bow due to ocean waves.

Side hulls were designed next, and given the dimensions of 550 feet long, 32 ft deep and 20 feet wide. These dimensions gave the side hulls a displacement of roughly 6,000 LT each. The outriggers were design as thin as possible to reduce their wave making resistance. The side hulls would be mostly tankage, and non-vital machinery that would provide buoyancy for stability, and minimize damage if hits were taken.

Putting the hulls together with a superstructure produced the final ship design. Because of hangar height requirements, the superstructure was made to be 43 feet tall. Longitudinally, the outriggers were placed near the center of the main hull. The two side hulls were placed 140 feet out from the longitudinal axis, giving 77 feet of water between hulls. This space was made to reduce wave interaction between the hulls, and to give enough space for an LCU to drive between hulls. The vertical clearance under the superstructure is 30 feet. The LCUs would be stored in the superstructure. When needed, they would drop down, and when not in use, they would be winched back up into the superstructure. The superstructure ended up being octagonal in shape, with sides angled at 12 degrees to reduce radar cross section area. Floodable length calculations for this trimaran hull were done, and the minimum floodable length found was 175 ft. The watertight bulkheads were placed so that no space would exceed 15% of floodable length below the waterline. After the weight estimation was completed, the maximum bending stress of the ship was calculated. The highest static bending stress was found to be 10,051 psi. Figures XV-15 and XV-16 illustrate longitudinal strength and floodable length calculations.

The flight deck has dimensions of 770 by 300 ft for a total area of 230,000 square ft. The triple tram design and the absence of a superstructure, enables the ship to conduct simultaneous fixed and rotary wing operations with sufficient throughput to deploy, and sustain a MEB-sized force ashore. The center runway will conduct STOVL aircraft operations. The 16 aircraft spots were calculated using the standard 15 ft separation between rotating blades requirement in the LHA/D manual for flight deck operations. The aircraft spots are capable of operating with current and planned aircraft. The AERO heavy lift aircraft will operate using two aircraft spots due to its larger size. The flight deck also has three aircraft elevators with a lift capacity of 70,000 lbs each. Elevators 2 and 3 on the port side can operate independently or simultaneously to accommodate the larger AERO design heavy lift aircraft.

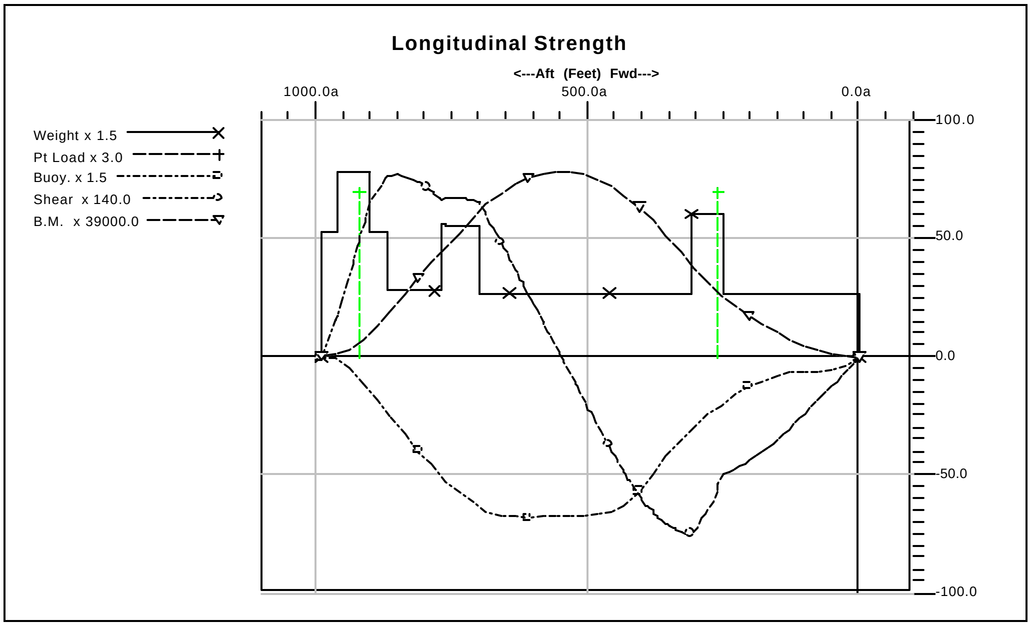


Figure XV-15: Longitudinal Strength

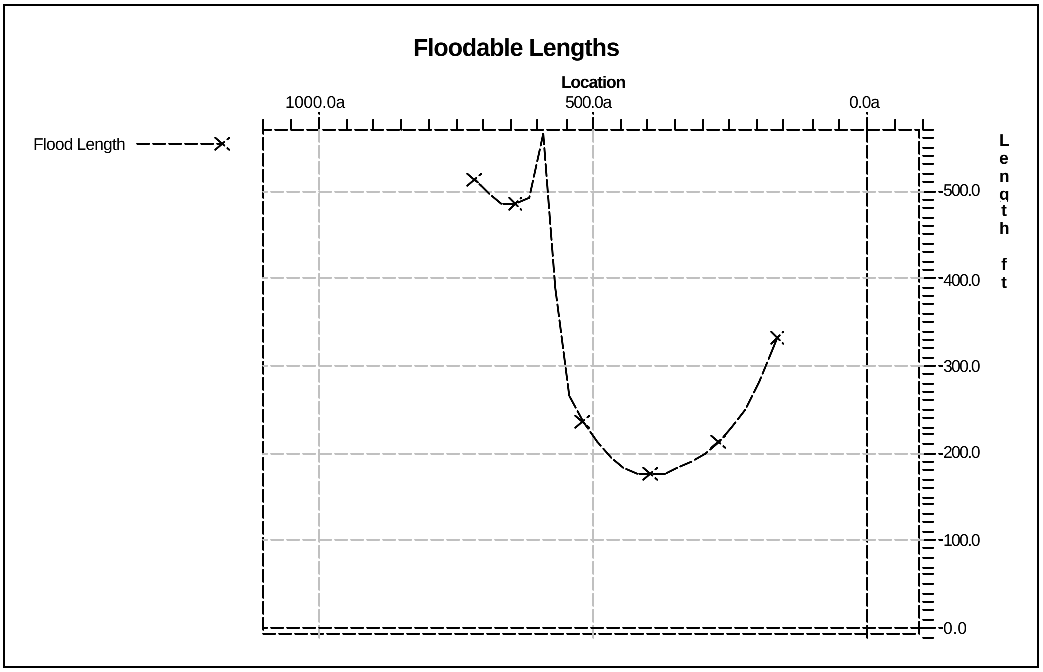


Figure XV-16: Floodable Length

2. Propulsion and Electrical Systems

The propulsion group explored innovation in propulsion and power distribution systems. Consideration for propulsion systems were given to nuclear steam, fuel cell, gas turbine, diesel engines, and electric drive technology. Analysis of prime movers focused mainly on Gas Turbines. The LM600 and LM2500+ seemed to be the best suited for power, Specific Fuel Consumption, and total fuel consumption requirements. Three different configurations were considered. The first consisted of four LM6000. The second option required five LM2500, and the third configuration consisted of three LM6000 and one LM2500+. From the three configurations, the third alternative was selected because of its optimum power generation and smaller fuel consumption. Waterjets, hydro drives, conventional propellers, and propulsion pods were considered for propulsion. Due to weight, volume, and maneuverability at low speeds, propulsion pods were selected. Propulsion motor selection was made among conventional motors, High Temperature Superconducting AC synchronous motors, and DC super conducting motors. The most feasible motor was the High Temperature Superconducting AC Synchronous motors by American superconducting company for the design figure XV-17 illustrates speed vs. power requirements.

For power distribution, Integrated Power Systems distribution was selected due to its flexibility, modularized open architecture. The total installed electrical power is 159 MW. Most of the electrical power generation is devoted for the weapon systems with a requirement of 120 MW. This energy will be stored in capacitor banks and fly-wheels, and made available to the Electromagnetic Railgun and the Free Electron Laser. The Integrated Power Systems architecture consists of 15 electrical zones in a combined AC and DC electrical distribution. To maximize redundancy, four buses will run along the port and starboard sides of the ship, and above and bellow the waterline. Two buses will carry 4160 volts AC, and the other 2 will carry 1100 volts DC.

AC buses will be connected to the zones through a step down transformer, and DC buses will be connected through a Ships Service Converter Module and diode auctioneering giving as output 900 volts DC for the port side and 850 volts DC on the starboard side. Through diode auctioneering, if primary 900 volts DC power source is lost the secondary 850 volts DC power source will be ready for back up to provide power for the vital loads. All sensitive AC and DC equipment requiring a smooth waveform will be connected to the DC and AC buses through Ships Service Converter Module and a Ships Service Inverter Module. The sensitive vital loads such as combat system computers or lighting are tied to both buses. Non-sensitive equipments that do not require a smooth waveform are connected to the AC buses through a step down transformers and SSCM figure XV-18 illustrates the IPS used in the TSSE concept design.

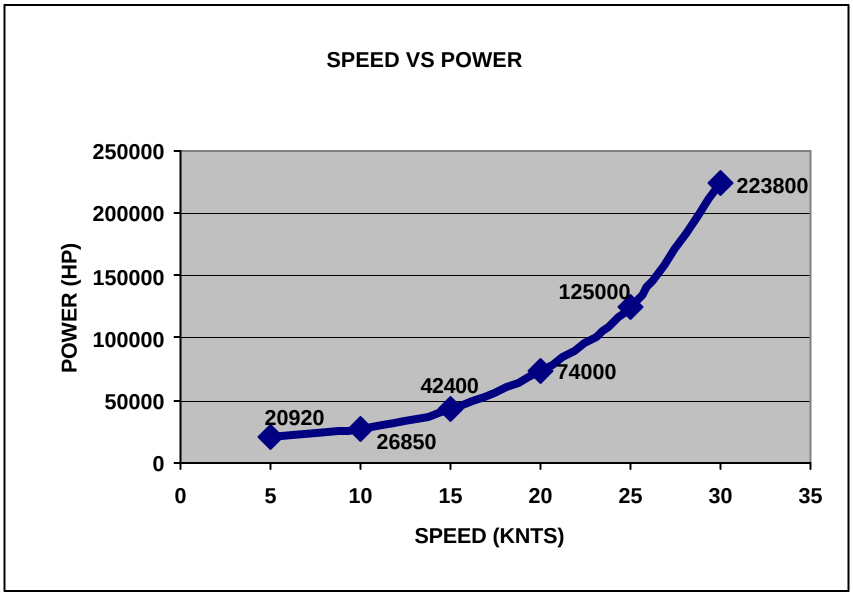


Figure XV-17: Speed vs. Power Requirements

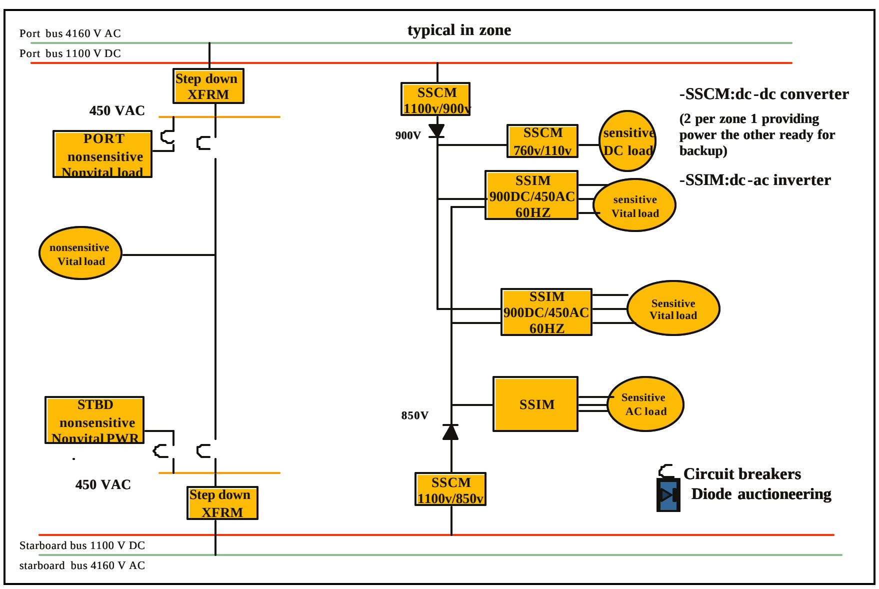


Figure XV-18: Integrated Power System

3. Logistic Systems

Transfer at sea and logistics systems require efficient transfer, storage, and distribution in order to effectively re-supply the troops ashore. Some of the most important incorporations to the design in this area were technology innovation in motion compensated cranes, automation, at sea transfer technologies, hybrid linear actuators, omni directional vehicles, automated magazines, stowage and retrieval system. A standard 20 foot (twenty-foot equivalent unit – TEU) container weighs approximately 12 tons. And each ship will carry an equivalent cargo payload of 188 TEUs or 3500 long ton (LT). The required amount of fuel for the ACE, LCACs, and LCUs to be carried by the Sea Base ships was calculated using the required sorties and burn rate for each type of craft, and assuming an operational range of 250 NM for aircraft, and 50 NM seaborne craft. A total 2.4 million gallons or 9195 LT of fuel is required. The amount of fuel required by the Ground Combat Element was taken from the Center for Naval Analysis study Fuel Requirements and Alternative Distribution Approaches in an Expeditionary Environment. The transfer requirements for subsequent sustainment beyond the first 30 days were calculated to be 15 TEUs per day per ship. In order to maximize the throughput and facilitate indefinite sustainment, the primary modes for logistics transfer will be vertical and surface replenishment. The ship's trimaran hull form with its triple tram line would maximize flight deck operations for logistics distribution. Although the need for ship to ship transfers was minimized, the ship will still retain the capability to conduct transfers by Connected Replenishment using high lines or via the motion compensated crane which is integrated into the automated warehouse. Handling of liquid cargo will be via dedicated refueling positions on both port and starboard sides of the ship. For Vertical Replenishment, there are 16 aircraft spots for airborne assets such as MV-22, and heavy lift AERO design to handle up to pallet size loads. The well deck spots and LCU ramp access between the hulls would support Surface Replenishment for larger TEUs size loads using LCACs & LCUs. Once the cargo is onboard the ship, through either modes of transfer, the ship layout was arranged to allow for multiple unfettered access from the entry point to its intended storage locations in the hangar, ammunition stronghold, warehouse staging area or the well deck.

A prototype of a motion compensated crane for the Mobile Offshore Base has been developed by Scandia National Laboratory and Carderock. A smaller version crane system integrated into the warehouse will provide Lift On/Lift Off capability to transfer of cargo either from or to Combat Logistic, MPF, or commercial shipping. In its normal mode of operations, the motion compensated crane would extend transversely from the warehouse lifting container loads at sea state 4 with an estimated throughput of 29 TEUs per hour. The crane would operate flushed to the flight deck to minimize interference with flight deck operations. When not in use, the crane would be recessed into the warehouse.

Two identical ordnance magazines are located on 3th and the 4th decks well below the waterline in the center main hull. Their locations are transversely shielded by the side hulls. The spaces are segregated by watertight bulkheads which are located 95 ft forward of magazines 2 and 4. Ordnance is stored in rack three pallets high. Magazines 2 and 4 have an area of 7,600 ft^2 with a capacity to store 550 pallets each. Magazines 1 and 3 have an area of 6,500 ft^2 with a capacity to store 478 pallets each. The four magazines have a total capacity of 2,056 pallets. Two ordnance elevators provide dual and redundant access to critical decks on the vehicle, warehousing and flight deck levels.

The automated warehouse is segregated into three different sections. The first section of the warehouse holds 72 TEUs. The second section contains 576 quadruple containers. The third and largest sections contains 1344 pallets arrange in two sets of racks side by side, 8 pallets long, and stacked 6 pallets high. A pigeon-hole design for storage allows for each pallet rack to have a capacity for 96 pallets. Cargo movement will be conducted via the Linear Inductor Motor conveyor currently under research. The conveyor will have a capacity to handle up to 12,000 lbs, and will provide a significant improvement in cargo movement. It is mounted along the port side of the main hull to provide rapid access through the hangar bay, to the LCU ports, and to the aircraft elevators.

For the warehouse, the use of automation enhances the efficiency logistical support and will allow selective offloading. An electronic gantry located across the staging area, will electronically scan all cargo prior to entry into the warehouse. Once inside the warehouse, the 2 overhead cranes will have access to any point in the warehouse. The center transit lane is 10 ft wide and will allow access by omni directional vehicles and automated forklifts which will move the cargo from the staging/processing area to storage or the Linear Inductor Motor conveyor.

Figure XV-19: Automated Magazine
(Source: Office of Naval Research)

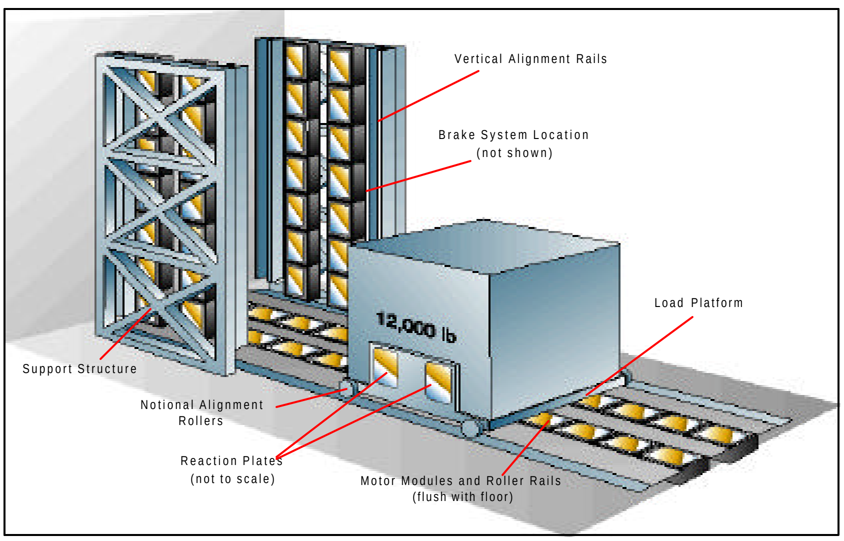
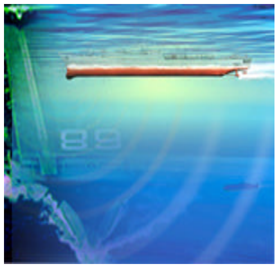


Figure XV-20: Linear Inductor Motor (LIM) Conveyor Belt.
(Source: Office of Naval Research)

4. Combat Systems

The required combat systems capabilities for the design were basic self-defense, but an extremely important mission for the ship was the Naval Gun Fire Support to provide the forces ashore with effective fires in a STOM environment. Some of the selected weapon systems were the Electromagnetic Rail Gun, Free Electron Laser, Unmanned Underwater and Aerial Vehicles among others. Consideration was given to stealth technology and ways to reduce the radar cross section of the ship. Sensor technology exploration included the Digital Phase Array Radar.

Figures XV-21 and 23 illustrate the major weapon systems incorporated to the TSSE design and their area coverage.



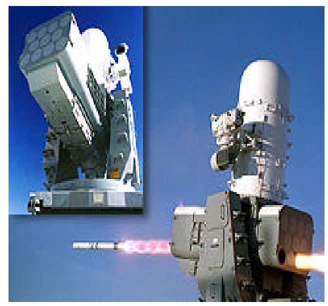
Unmanned Underwater

3-D Phase Array Radar

Free Electron Laser (FEL)

Electromagnetic Railgun/

Forward Looking Infrared (FLIR)



Sea Rolling Airframe Missile

Figure XV-21: Weapon and Sensor Systems

Figure XV-22: Area Coverage for Major Weapon Systems

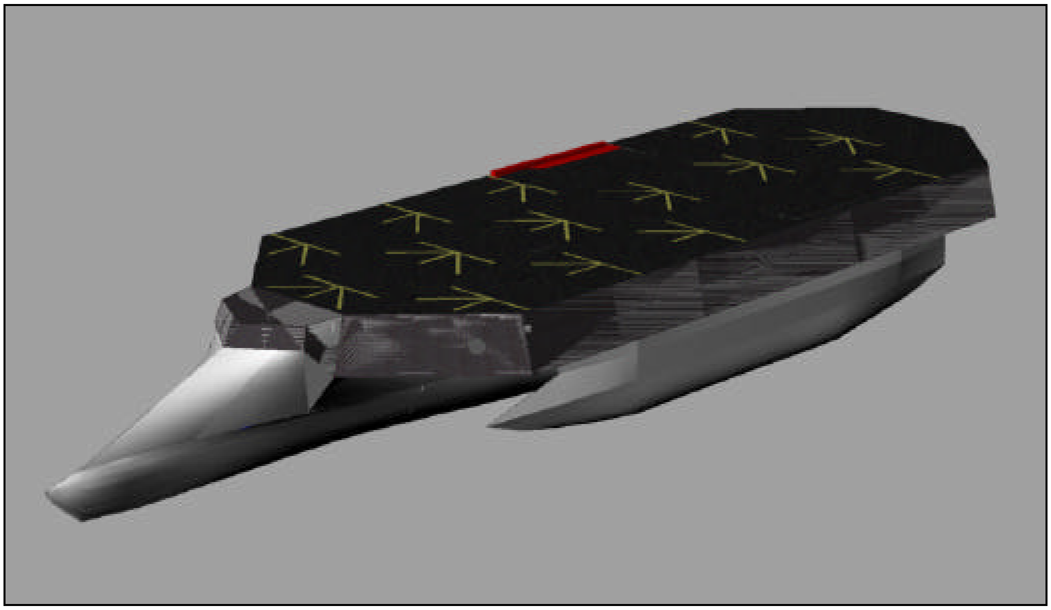


Figure XV-23: TSSE Conceptual Design

I. SUMMARY AND CONCLUSIONS

OMFTS and STOM require flexible and agile forces at sea and ashore. These two concepts of operation present challenges to the current Navy and Marine Corps infrastructure. Some of the most important concerns involved rapid and accurate delivery of supplies, the ability of sea platforms to selectively off load materiel, the shifting of maintenance and medical support from land to sea, the ability to indefinite sustainment the forces, and the rapid reconstitution and redeployment of forces. The SEI team at the NPS was tasked to analyzed and identified capability gaps required for future expeditionary forces. From this analysis, the SEI team produced a requirements document which would be the basis for a ship design. The requirements identified by the SEI team drove the ship design. For example, the large flight deck and cargo capacity requirements to supply the troops in a STOM environment were decisive design factors. The trimaran hull provided the means for a large flight deck without compromising the carrying capability and volume requirements. Logistics systems were derived from sustainment requirements. The use of technology in many areas of the design were aimed to minimize manning, and maintenance while maximizing the throughput of the supplies to the forces ashore. The TSSE team analyzed, defined, and transform those requirements into a ship design that would enable effective Sea Base operations, and if built would become the new face of ExWar.