

REVISION 1

REPORT DOCUMENTATION PAGE			<i>Form Approved</i> OMB No. 074-0188	
Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing this collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503				
1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE 18 March 2004	3. REPORT TYPE AND DATES COVERED Symposium Paper 17-18 March 2004		
4. TITLE AND SUBTITLE LHA(R): Designing the Next Big Deck Amphibious Assault Ship		5. FUNDING NUMBERS N/A		
6. AUTHOR(S) Reynolds, Jason, A.				
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Naval Surface Warfare Center Carderock Division 9500 MacArthur Blvd West Bethesda MD 20817		8. PERFORMING ORGANIZATION REPORT NUMBER N/A		
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES) NAVSEA 05D & PMS 377 1333 Issac Hull Ave SE Washington DC 20376		10. SPONSORING / MONITORING AGENCY REPORT NUMBER N/A		
11. SUPPLEMENTARY NOTES Prepared for the Engineering the Total Ship (ETS) 2004 Symposium held in Gaithersburg, Md. at the National Institute of Standards & Technology and sponsored by the Naval Sea Systems Command & the American Society of Naval Engineers				
12a. DISTRIBUTION / AVAILABILITY STATEMENT Available for Public Release			12b. DISTRIBUTION CODE A	
13. ABSTRACT (Maximum 200 Words) The existing LHA Class Amphibious Assault Ships will reach the end of their expected service lives between 2011 and 2015. Previous analysis has determined that extending the service life of these ships is not operationally suitable or cost effective. The LHA Class ships are not fully compatible with the future Aviation Combat Element (ACE) envisioned to be embarked and do not meet current environmental, habitability and ship survivability standards. Over the last several years, multiple ship concept formulation studies were conducted by the Naval Sea Systems Command (NAVSEA) to determine the most cost effective solution to meet the Marine Corps' emerging warfighting requirements. Although many possible solutions were explored, the final decision was made to design a modified repeat ship of the LHD class. This paper provides the details of the ship design process, the design products being developed, and the Integrated Product Team (IPT) that makes it all possible.				
14. SUBJECT TERMS Systems Engineering, Amphibious Assault Ship			15. NUMBER OF PAGES 15	
			16. PRICE CODE	
17. SECURITY CLASSIFICATION OF REPORT Unclassified	18. SECURITY CLASSIFICATION OF THIS PAGE UNCLASSIFIED	19. SECURITY CLASSIFICATION OF ABSTRACT UNCLASSIFIED	20. LIMITATION OF ABSTRACT UL	

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. Z39-18
298-102

20040419 125

Engineering the Total Ship Symposium
LHA(R): Designing the Next Generation of Big Deck Amphibious Assault Ships
Jason Reynolds (NAVSEA 05D3)

Abstract

The existing LHA Class Amphibious Assault Ships will reach the end of their expected service lives between 2011 and 2015. Previous analysis has determined that extending the service life of these ships is not operationally suitable or cost effective. The future Aviation Combat Element (ACE) is growing in size and capability and is not fully compatible with the LHA Class ships. Design standards and policies for environmental, habitability, service life allowance and ship survivability have been modified and drive requirements for future ship designs.

Over the last several years, multiple ship concept formulation studies were conducted by the Naval Sea Systems Command (NAVSEA) to determine the most cost effective solution to meet the Marine Corps' emerging warfighting requirements. Although many possible solutions were explored, the final Department of Navy decision was made to design a modified repeat ship of the LHD 1 class, the LHA Replacement (LHA(R)).

Functional design and associated trade studies commenced in February 2003. This paper provides the details of the ship design process, the design products being developed, and the Integrated Product Team (IPT) that makes it all possible. The paper describes the functional design work accomplished to date and provides the author's vision for the first NAVSEA-led ship design in almost ten years.

Introduction: Selection of LHA(R) Concept

Before addressing the current status of the ship design, it is worthwhile to introduce the major studies and program decisions that have taken place over the past few years. The initial work concerning the future of big deck amphibious shipping was the LHA Development of Options Study (DOS), which completed in 1999. The study addressed three broad options: extending LHAs beyond 35 years through a major Service Life Extension Program (SLEP); replacing the LHAs with LHDs modified with gas turbine propulsion; or replacing the LHAs with a new ship design. The study concluded that a SLEP was technically feasible but had severe operational limitations. It would not resolve the key shortcomings in the LHA to support new Marine Corps equipment and operating concepts and would take ships out of service for several years. It also concluded that there was insufficient information to choose between a modified LHD and a new ship design and that an Analysis of Alternatives (AoA) should be conducted for ships scheduled to replace the LHAs beyond 2005.

The LHA(R) Mission Area Analysis (MAA), which completed in 2000, addressed requirements for aviation systems, amphibious lift and C4I support. The MAA concluded that although the LHD is a capable ship and would be a candidate to replace LHAs, there are important reasons to consider a new design that would better meet emerging requirements and provide more growth for the future. It was determined that a new ship was needed to accommodate the size and weight increase of future Marine Corps aircraft (i.e., F-35B and MV-22), as well as the associated increase in aircraft sustainment (weapons, fuel, etc.).

Other desired goals were to maintain Marine Corps vehicle lift capacity of the LHA class, increase service life allowance to comply with NAVSEA policy, and increase ship survivability features above those provided in the LHD Class. This provided the analytic rationale to develop a new program, known as the LHA Replacement, or LHA(R).

The Mission Need Statement (MNS) was approved by the Chief of Naval Operations (CNO) in January 2001 and reviewed and validated by the Joint Requirements Oversight Council (JROC) in March 2001. Milestone A approval was received in July 2001. The Milestone A Acquisition Decision Memorandum (ADM) approved entry into the Concept Exploration phase and initiation of an Analysis of Alternatives (AoA). The AoA was conducted from July 2001 through June 2002. During that analysis, three major categories of ship alternatives were examined: a repeat LHD 8 (with fact-of-life upgrades), a modified LHD 8, and new larger designs of varying capabilities. Based on the AoA, the Department of the Navy determined that the LHA(R) program would be comprised of four modified LHD 8 ships with enhanced survivability. The LHA(R) design incorporates two plugs and a beam expansion to the baseline LHD 8 design, as shown in Figure 1. Because of this change and the enhanced survivability features, this ship concept is commonly referred to as the "Plug Plus."

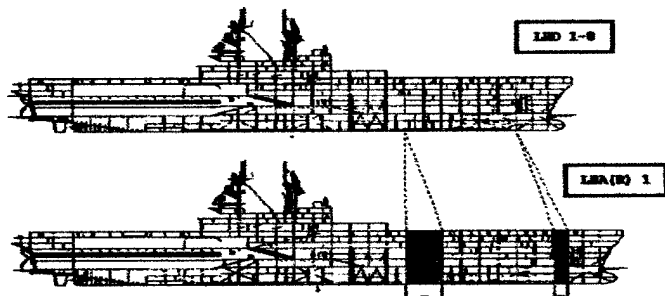


Figure 1: Comparison of LHD 8 and LHA(R) "Plug Plus"

Sea Power 21: LHA(R) Warfighting Requirements

Sea Power 21 is the vision to deliver enhanced warfighting capabilities through new concepts, technologies, and improved acquisition processes. The LHA(R) enables Sea Strike through the projection of precise and persistent offensive power as a key component of the future Expeditionary Strike Group. Through the execution of Ship to Objective Maneuver (STOM) the LHA(R) will enable the forcible entry, reconstitution, and redeployment of the USMC warfighting assets through air and surface delivery. LHA(R) will also apply the tenets of Sea Shield to project a layered defense for the strike group and own ship self-defense. LHA(R) will employ full dimensional protection with own-ship self defense assets, embarked aircraft, and strike group escorts as dictated by the strike group/force commander. LHA(R) will be the leading element of the Sea Base providing the over-the-horizon forward presence in a hostile environment. The LHA(R) will serve as the command and control platform to conduct the primary mission of the Expeditionary Strike Group, and will embark and operate with joint, inter-agency and combined command and control staffs. Execution of shipboard self-defense measures and command and control will rely on essential elements of information flow and situational awareness derived from FORCENet.

In November 2002 the warfare sponsor, OPNAV N75, identified the interim requirements for the LHA(R) and directed that capability trade studies in several areas be conducted. The program baseline requirements are the current WASP (LHD 1) Class Top Level Requirements (as amended for LHD 8)

and the following additional minimum capabilities:

- Aviation: 10 VTOL spots and a flight deck sized to operate a notional ACE mix of 12 MV-22, 6 (objective 8) F-35B, 4 CH-53E, 4 AH-1Z, 3 UH-1Y and 2 MH-60 aircraft
- Vehicle square not less than the TARAWA (LHD 1) Class equating to 25,400 net square feet
- Cargo capacity not less than the WASP Class, plus additional stowage allowance to support the future ACE, equating to 140,000 net cubic feet total cargo magazine capacity
- Floodable Well Deck sized for 3 LCACs or 2 LCU
- Troop capacity not less than WASP Class equating to 1687 personnel
- C4I (Navy/USMC) and ship self defense combat systems functionality equivalent to LHD 8
- Joint Spaces to include C4I, office, mission planning and berthing spaces to support Small Scale Contingency (SSC) Joint Task force (JTF) or a MEB/CPG staff, not to exceed 135 total staff billets
- Maximum affordable survivability enhancements to include reduced signatures (radar, IR, acoustic, and magnetic), magazine armor and advanced recoverability features
- A service life allowance of 7.5 percent displacement and 2.5 feet KG
- A sustained speed of 21.5 knots
- Manning not to exceed that of the LHD 1 class with a program goal to reduce crew manning 25% from the LHD 1 class

Table 1 is a summary of key mission requirements:

Table 1: Summary Mission Requirements

Troops	1,687
Aircraft	33
Vehicle (ft2)	25,400
Cargo (ft3)	140,000
Landing Craft	3 LCAC or 2 LCU

LHA(R) Functional Design: A Roadmap to the Contract

Functional Design and associated trade studies commenced in February 2003. The ultimate goal of the LHA(R) Design Team is to develop a Total Ship System that will safely and effectively perform the specified mission requirements within the cost constraints of the program. Functional Design is split into two phases, Preliminary Design and Contract Design. The two phases are not distinctly separate, as shown in Figure 2, and there will be no formal break or accompanying Milestone Decision between these Functional Design phases.

The Preliminary Design phase is allocating functions to major subsystems, selecting major subsystems and developing a top level engineering description of the total ship and its major subsystems in terms of system diagrams, preliminary arrangement drawings, and estimated performance characteristics. Trade-off studies are being conducted to refine system and subsystem definitions and to provide a technical basis for selection of major components. The LHA(R) Design Team is also identifying and considering all possible areas of cost reduction. Model testing is being initiated to confirm hull form performance predictions. Extensive design integration, at the total ship level, is being performed. The conclusion of preliminary design forms the technical basis for the Contract Design Technical Baseline

and a Class C procurement cost estimate.

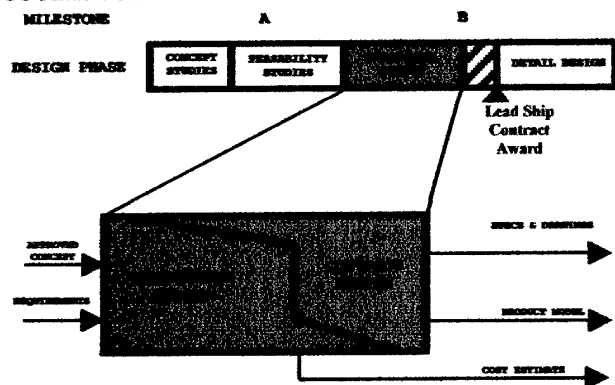


Figure 2: Functional Design

The Preliminary Design will consist of approximately seven major design iterations. The planned duration of each cycle varies from 8 to 12 weeks. As of December 2003, three design iterations have been completed and the fourth is nearing completion. The first iteration was used to increase the fidelity of the design and baseline the design changes from the AoA ship concept. During the following iterations, key trade-off studies have and will be performed, leading to the selection and location of major equipment and functions. Major trade studies were initiated and completed as early as possible, so that decisions to incorporate the proposed changes in the mainstream design can be accommodated before the design is "frozen" with respect to hull size, major weight additions or major cost additions. The final preferred variant was identified using a collaborative relative measure of effectiveness process and further validated by the Program Manager, the Resource Sponsor and the USMC shipbuilding advocate. Major trade study topics include:

- Survivability
- Sustained Speed
- Medical Capability
- Concurrent Flight Operations
- Hangar Modifications
- Bomb Farm

- Accommodation Standards
- Troop Training and Muster
- Selective Offload
- Cargo Volume
- Vehicle Area
- Boat Stowage

The Contract Design phase consists of the preparation and formalization of the ship specifications, drawings, the technical portion of the Contract Data Requirements List (CDRL), and other technical data required to establish a contractual base for the ship Detail Design and Construction contract. Because LHA(R) is a modified repeat design, the LHA(R) Design Team has begun development of a set of detail specifications using LHD 8 as the baseline. The team will diverge where necessary to use the most appropriate specifications language, whether it is derived from detail specifications, performance specifications, or the Naval Vessel Rules being developed by the American Bureau of Shipping (ABS). The LHA(R) Design Team's development of detail specifications at this stage of Functional Design will ensure better configuration control throughout Contract Design and Detail Design and Construction, and will facilitate accelerating Contract Design if the award date for the shipbuilding contract is accelerated.

The LHA(R) Design Team: NAVSEA Leadership is Essential

As the Program Executive Offices for the various ship programs continue to employ a wide spectrum of acquisition strategies, the LHA(R) Design Team is attempting to leverage the best aspects of all the acquisition options. NAVSEA Headquarters' ship design capabilities have been reshaped over the past several years and NAVSEA can no longer execute a traditional "in-house" design where

much of the "hands on" engineering was performed and/or directed by NAVSEA's technical codes. The technical codes are now executing policy and oversight to insure the appropriate standards are being applied and that the work is of acceptable quality to insure the safety and effectiveness of the design. The shipbuilders have assumed more responsibility in the early stages of designs on some of the more recent acquisition programs. All the while, there are two entities that have provided the stability to bridge the gap - the commercial design support contractors and the Navy laboratories. An integrated interdisciplinary team, with Government and industry participation, is developing the LHA(R) Functional Design. The LHA(R) functional design effort is being executed by a Navy-led Design Team comprised of Navy personnel from NAVSEA headquarters, the Warfare Centers, other Systems Commands, engineering support contractors, and the shipbuilder. The staffing of the team has been achieved via the "best athlete" approach with the most capable and available resource being employed. In the near future, the shipbuilder's unique expertise in areas such as producibility, engineering estimate development, material suitability and selection, and innovation from other ongoing shipbuilding programs will be coupled with the existing design team to produce a superior product during Functional Design.

Regardless of the degree of contractor, shipbuilder, or other Navy activity support, the Design Team members, in conjunction with appropriate Navy Technical Authorities, are ultimately responsible for all design products. Although the NAVSEA HQ engineering expertise has been reduced it has not been eliminated. LHA(R) is placing tremendous emphasis on lessons already learned

and the expertise that is maintained in corporate memory within the technical codes throughout NAVSEA. Design tasks are defined and documented based on established Standard Statements of Work (SOWs) which have been tailored to the specific requirements of the LHA(R) Program. These SOWs were negotiated among the design team leadership, the respective Central Technical Authorities (CTAs), and the program office. The CTAs, who are responsible for establishing and maintaining functional technical requirements, are being engaged to provide policy and oversight, and ultimately design approval.

In addition to the core team and CTAs, the Design Team is benefiting from continuous user feedback via a Requirements Working Group (RWG). The RWG is comprised of action officers from OPNAV N75, USMC HQ/PP&O, COMPHIBGRU 2, and other fleet representatives from the various user communities, as required. These end-user interface sessions are used to obtain the customer perspective in interpreting requirements and identifying ship and mission package design-related issues. The conduct of these sessions contributes to an early understanding and resolution of ship design issues and is designed to lead to an optimum LHA(R) design. The RWG facilitates discussions and builds consensus between Naval and Joint communities. Outputs of the RWG focus sessions are incorporated into the LHA(R) design as appropriate. This initiative fulfills the first tenet of Integrated Product and Process Development (IPPD): Focus on the Customer!

The Design Team also benefits from continuous feedback from a Senior Advisory Staff (SAS). The SAS is comprised of former Navy and industry ship design executives and

is chartered to provide the Design Team with "corporate" knowledge, experience, best practices and lessons learned from previous Navy ship designs and ensures that the LHA(R) design products meet the acceptance criteria and quality standards of the Navy's CTAs.

In order to provide a more effective environment for making timely design decisions and to facilitate team communications, the LHA(R) Ship Design Team is co-located to the greatest extent possible. The LHA(R) Design Team maintains a design site where the team managers, or their designated representatives, reside. The design site enables the concurrent development of multiple engineering products. Design integration, configuration control and design management activities are conducted at the Design Site. Both government and industry personnel are based at the site. Unassigned workstations are retained for the periodic use of those team members who are not on-site a majority of their time. Recognizing and accepting the reality of a distributed yet collaborative Design Team, an Integrated Data Environment (IDE) system has been incorporated to facilitate communications between geographically dispersed engineering managers and their associated team members. The Design Team employs the full range of Management Operating System tools to plan, task, report, and evaluate the individual steps that will enable the successful prosecution of the design work.

The LHA(R) Design Team is divided into eight major integrated product teams and one design integration team (see Figure 3). These teams have the core responsibility of developing the technical products and support other aspects of the program, such as cost, logistics and test & evaluation. Each team is led by a system engineering

manager (SEM) and an associated deputy. Each team is responsible for the composition of its workforce, the allocation of its budget, and the schedule of the deliverables within the guidelines established at the beginning of each fiscal year.

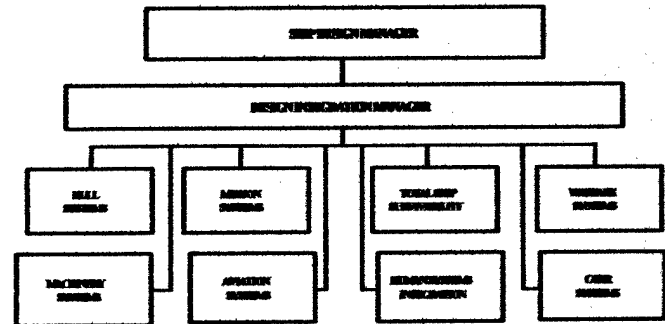


Figure 3: Design Team Organization

Integration and Decision Making: The Heart of Ship Design

The design integration team manages the configuration control of the mainstream design and coordinates major design trade-off studies, ensuring that trade-offs consider all applicable functional disciplines as well as the total-ship impacts. The goal is an integrated, well-documented design. Design Decision Memoranda (DDM) are used to document decisions and changes to formal deliverables, technical requirements, or the configuration baseline. Managing the design control process will ensure that each deliverable or decision is routed through the appropriate chain and approved at an appropriate level. The integration team also develops and maintains a Master Equipment List (MEL) of the major equipment and associated characteristics (including SWBS number, equipment identifier or level number, equipment nomenclature/description, quantity, weight and overall dimensions) that reflect the current state of the design.

Design integration oversees the application of all design tools and software. Modeling and Simulation (M&S) has become increasingly useful and important across all acquisition phases and applications. Within the LHA(R) design process there will be many opportunities to use M&S and to reap its four major benefits - total ownership cost savings, accelerated schedule, improved product quality, and acquisition cost avoidance.

An integrated product model is used extensively for the definition, analysis and documentation of the LHA(R) design. 3-D CAD is used in the preparation of key design products, including drawings, reports, lists, interface checks, walk-through and inputs to secondary analysis programs. Additional M&S tools, such as physics based and time/motion analysis are also being employed.

The design integration team is also principally responsible for the coordination and development of the integrated topside design. The LHA(R) is exploring several design options for the island: repeat or legacy LHD 8, modified LHD, and a "road map" island. The term "road map" refers to developmental warfare and C4I systems that will be deployed in the future but are not currently available today. All the island concepts are constrained to interface with the legacy deck penetrations for uptakes, elevators, ramp, and alignment with legacy structure. Both the modified island and the roadmap island have the primary goals of reducing RCS and footprint to improve the survivability of the ship and maximize the area allocation to the flight deck. Due to the availability of the sensors, the first ship is planned to receive the repeat or modified LHD island. However, ships 2-4 plan to be upgraded to incorporate the new planar arrays. As such, the

support services of the hull form are being designed into the first hull in anticipation of the follow ships having a more robust services load. Figure 4 shows the LHA(R) island design options.

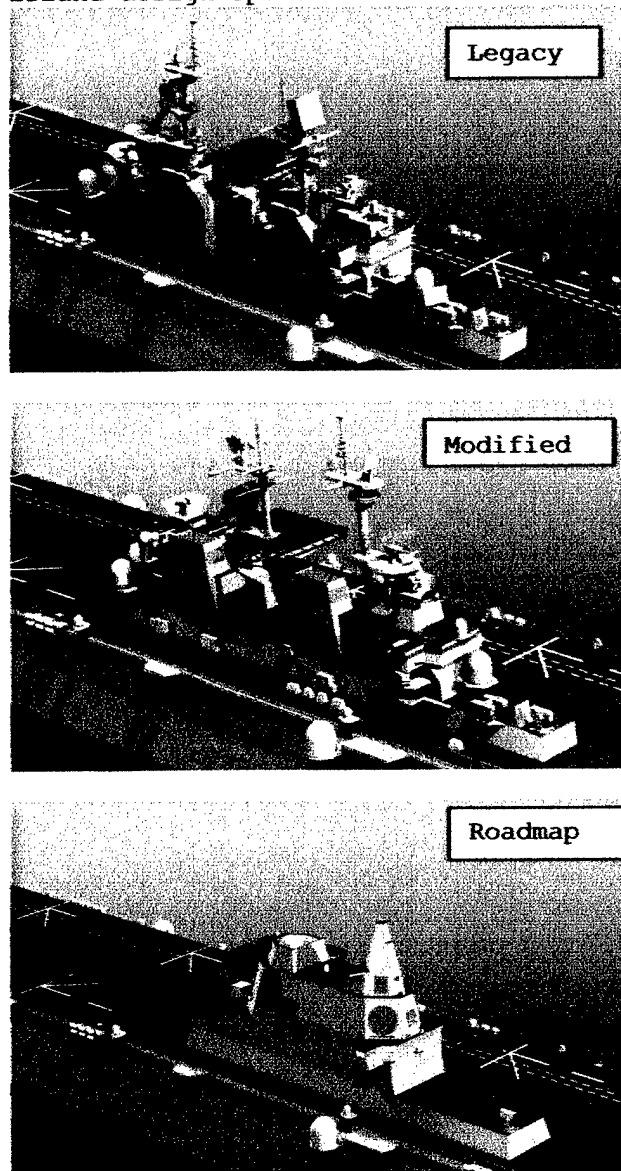


Figure 4: LHA(R) Island Options

Hull Systems: A New Hull for the 21st Century

The LHA(R) is being designed with a new, improved hullform (see Figure 1). The elimination of the requirement to transit the Panama Canal allowed the beam to be unconstrained and therefore increased 10 feet to improve the KG

and displacement. The length of the hull also increased 77 feet to provide the additional volume and displacement needed to meet the new requirements. The new hullform enabled the realization of hydrodynamic efficiencies, enabling the LHA(R) to have similar powering results as the LHD Class. The principal hull characteristics are listed in Table 2.

Table 2: Summary Principal Dimensions

Full Load Displacement (long tons)	50,125
Length, Overall (ft)	921
Length Between Perpendiculars (ft)	855
Beam, DWL (ft)	116
Beam, Flight Deck (ft)	128
Design Draft (ft)	26.4

The LHA(R) class is designed to meet the full Service Life Allowance (SLA) requirement of 2.5 feet of KG and 7.5 percent full load displacement. This is a dramatic improvement over the LHD class that is designed with a 0.5-foot KG and 1,000-long ton (LT) displacement margin (vice a full 1.0-foot KG and 5 percent displacement that is normal for a combatant). The reason for the substantial improvement is because historically the LHA/LHD ships have rapidly used up their weight and stability SLA to support the evolution of new systems. Once the SLA is expended the costs of subsequent ship alterations is significantly increased. The LHA(R) SLA requirements resulted in additional sea keeping considerations associated with the new hull form in the beginning of service life. This issue was investigated by the SAS and is being examined closely with NAVAIR to ensure acceptable ship motions for aviation operations.

A five-foot half breadth increase was added outboard of each 40' longitudinal bulkhead. This

additional space enabled the LHA(R) to have a clean compensating fuel tank system similar to the LPD 17. This design feature allows the wingwall tanks to have adjacent tanks that fill with seawater as the ship's fuel is drawn from the fuel tanks. This is similar to a compensating fuel system, however, there is no fuel/water interface due to the tank separation (see Figure 5). This architecture prevents oily seawater from being discharged as the tanks are refilled with fuel.

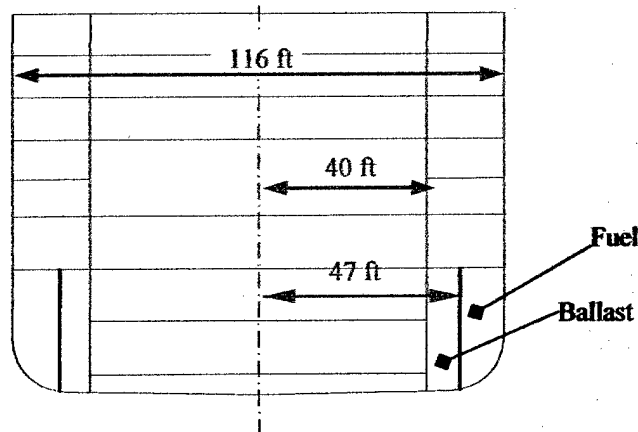


Figure 5: Compensated Fuel System

The LHA(R), like the LHD Class ships, is designed with a wet well capable of transporting three LCACs or two LCUs. The well deck is 6 inches higher than the LHD class ships. This modification allows a more than 1,200-Lton increase to the displacement limit of the ship. Additionally, overhead structure was reduced 6 inches to enable a constant distance between the decking and overhead systems.

Accommodations were added for dedicated berthing of the detachments and staff that typically accompany the ship as shown in Table 3. Additional surge berthing was added to accommodate the increase capability to operate a small-scale contingency Joint Task Force (JTF) or PHIBGRU/MEB level command elements. All of the accommodations are designed to be

fully compliant with OPNAVINST 9640.1A.

Table 3: LHA(R) Accommodations

	Flag	Off	CPO/SNCO	OEP	Total
Ship	2	65	81	977	1123
Margin		7	8	98	113
Dets		33	13	61	107
Troop		174	64	1449	1687
JTF		5			5
Total	2	284	166	2585	3035
JTF Surge		40	30	60	130
Troop Surge		19	6	159	184

Machinery Systems: Improving a Solid Baseline

LHA(R) will incorporate a modified LHD 8 propulsion plant based on a LM2500+ geared mechanical drive with electric auxiliary propulsion motors. The modified plant will incorporate a new main reduction gear and parallel shaft alignment (see Figure 6).

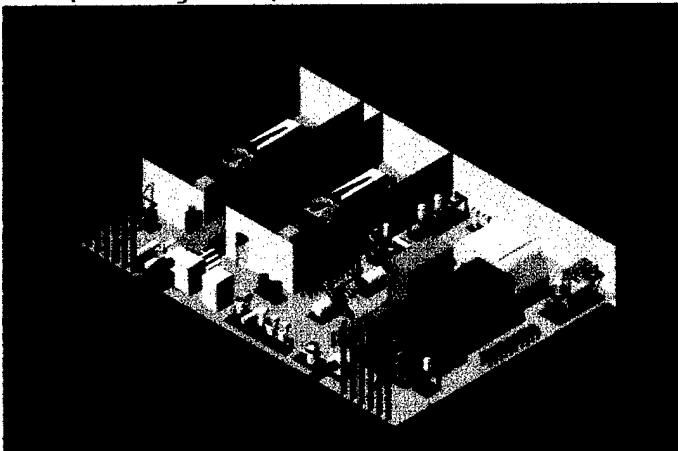


Figure 6: LHA(R) Machinery

The system will be more efficient and enable producibility and survivability improvements. The LHA(R) will also leverage the all-electric auxiliary systems architecture developed for the LHD 8. Although many of the machinery components will be identical to

those found on ships of the LHD class, many would be replaced to account for the increased capacity required for the larger ship. Specific examples include increasing the power generating capacity and size of the ship service diesel generators (SSDG) and the development of a new 500-ton AC plant. Table 4 lists the primary machinery systems and associated components.

Table 4: Major Machinery System

LM2500+ Gas Turbines	2 @ 35,000 HP
Controllable Pitch Propellers	2 x 16.5 ft. Diameter
Variable Speed Electric Motors	2 @ 5,000 HP
A/C Plants	6 x 500 tons
RO Plants	4 x 50,000 GPD 1 x 3,000 GPD
Fire Pumps	17 x 1,000 GPM
Deballast Compressors	6 x 2,160 SCFM
Cargo Elevators	8 x 12,000 lb.
Diesel Generators	6 @ 5,400 kW
All-Electric Auxiliaries	

Total Ship Survivability (TSS): Ensuring Mission Delivery

The LHA(R) is a capital ship of the US Navy, designed to go in harm's way and withstand damage if attacked. Significant improvements have been designed into the ship to avoid detection, improve combat systems effectiveness, withstand damage, and recover from an attack. LHA(R) will embark on a robust Live Fire Test and Evaluation program over the next few years to quantify the improvements established using analytical and empirical methods. The key focus of the TSS team is to take a balanced total ship approach to achieving reasonable levels of improvement across the entire survivability spectrum within cost, weight, stability, and space constraints. The team is accomplishing this goal by providing a solution that: significantly reduces the radar, magnetic, acoustic, and IR

signatures; integrates the results of a warfare systems effectiveness analysis; incorporates substantial damage tolerance improvements against a wide variety of current and near-term threats; and incorporates substantial improvements in advanced damage control and recoverability features.

Warfare Systems: Sensors with an Eye for the Future

Extensive analysis has been done to assess the performance of the baseline warfare system for LHA(R)1 and the potential improvements of various system substitutions. Specific examples include the possible removal of the SPS-49, the SPN-67, and the CIWS and the possible addition of the MK46 gun system. LHA(R) 2-4 are planned to incorporate new self-defense warfare systems, including the Multifunction Radar (MFR), and the Volume Search Radar (VSR) that are being developed for other US Navy shipbuilding programs. Due to the developmental nature of those systems, the "road map" warfare systems are less defined at this time and require constant monitoring. Table 5 is a list of the current baseline self defense suite.

Table 5: Major Self-Defense Systems

SLQ-25A/32A
MK 36 Mod 18 DLS
SSDS Mk 2
SPS-48E
SPS-49A
CIWS
RAM
NSSMS
.50 Cal
MK 38 25 mm GWS

C4I Systems: Collaboration is the Key

LHA(R)1 will have minor changes in the topside configuration of the sensors. However the C2 complex

located on the 02 level will undergo a complete redesign. The spaces will be realigned to facilitate multi-purpose/reconfigurable spaces. The new spaces will also have dedicated workspace for the increased command element afloat. LHA(R) 2-4 are planned to incorporate new planar antenna arrays that replace many of the legacy dish and rod type antennas. Table 6 is a list of the major components of the baseline C2 suite.

Table 6: C2 Suite

GCCS-M
Links 4A, 11, 16, 22
AFATDS/NFN/JFN
SPQ-14
SGS/AC
ERP
CENTRIXS
TBMCS
CDL

Mission Systems: Enabling the Assault:

The Design Team is also investigating improved cargo/ammo handling capabilities to improve assault resources flow and selective offload on the LHA(R). The capacities of the vehicle decks and cargo/ammo magazines have been increased to enable the new requirements of the carried systems used to support the Marines. Figure 7 shows the total area assigned to vehicle storage in the upper vehicle deck. Extensive use of modeling and simulation is being employed to quantitatively assess the performance of the ship to meet desired offload rates of cargo, vehicles and troops. The current Troop Training and Marshalling space on all the LHD class ships is converted into a crew/troop physical fitness facility. The LHA(R) intends to redesignate that space as such and provide an additional dedicated troop training and marshaling space aft of troop living on the 01 level with ready access to the vehicle ramp that

travels from the hangar to the flight deck. The medical capability will remain the same as the LHD class. However, the primary ward will be designated as dual use space for surge berthing space when the ship is not in a casualty receiving and treatment posture.

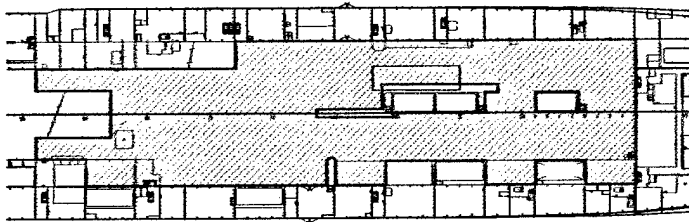


Figure 7: LHA(R) Vehicle Stowage

Aviation Systems: The Distinguishing Capability

LHA(R) will have an improved and enlarged flight deck to accommodate the larger, more capable aircraft.

Five out of six of the aircraft type/model/series will be new for the LHA(R). These new aircraft offer significant capability improvements that are central to the Marine concept of ship-to-objective maneuver (STOM), but they also are significantly larger and heavier than the aircraft that they will replace. Table 7 is a list of the current and future aircraft and their associated spot factors. The LHA(R) flight deck provides an additional operating spot, which facilitates more efficient helicopter operations and supports limited concurrent flight operations.

Table 7: Aircraft and Spotfactors

Current Airwing	Spot Factor	Number of Aircraft	Total Spot Factor	Future Airwing	Spot Factor	Number of Aircraft	Total Spot Factor
CH-46 (SAR)	1	2	2	MH-60S (SAR)	0.87	2	1.74
CH-46E	1	12	12	MV-22	2.22	12	26.64
AH-1W	0.83	4	3.32	AH-1Z	0.92	4	3.68
UH-1N	0.93	3	2.79	UN-1Y	0.94	3	2.82
CH-53E	2.68	4	10.72	CH-53E	2.68	4	10.72
AV-8B	1.53	6	9.18	F-35B	2	8	16
Total Spot Factor 40.01				Total Spot Factor 61.6			

Significant collaboration with NAVAIR engineering was accomplished to insure the new hullform and associated ship motions are suitable for the aviation operations. Figure 8 is a plan view of the flight deck.

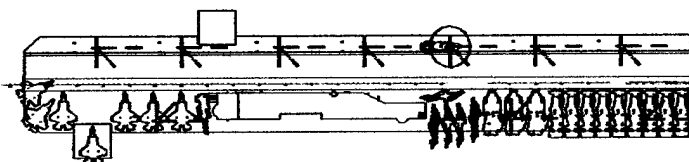


Figure 8: Plan view of LHA(R) Flight Deck

The hangar will undergo a major redesign: increasing the usable deck area, expanding the current high bay by 2 frames (each frame is 7 feet), and adding a second high bay. Figure 9 is a plan view of the new hangar bay arrangement. Additional volume has also been allocated for the proper storage of the aviation supplies typically stored in the hangar.

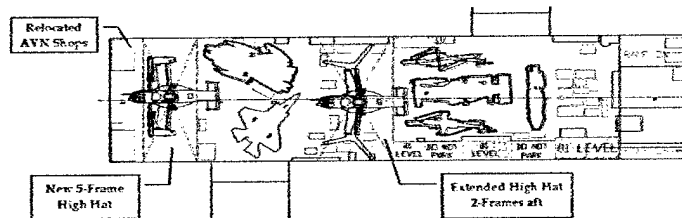


Figure 9: Hangar Bay Arrangement

Human Systems Integration (HSI): Designed for the Warfighter

Primary emphasis and consideration will be given to manpower requirements, training concepts, system safety and personnel survivability, human factors engineering, quality of life and habitability concerns as part of the overall design process. The objectives of the LHA(R) HSI Program will concentrate on achieving early integration of HSI criteria into the design process to ensure that the inherent capabilities and limitations of warfighters are incorporated into the equipment and subsystem design. The achievement of these objectives will enable a ship capable of maintaining the highest level of operational effectiveness while conserving valuable human and material resources. The LHA(R) goal of achieving a 25% manning reduction of from LHD 1-class levels is being assessed through the execution of a manpower functional high-driver analysis (see Figure 10). This analysis identifies ship functions that are manpower intensive, which could be addressed via technology, process, and/or policy changes. From the beginning of Preliminary Design, all design efforts must identify and consider all possible areas of shipboard workload reduction and the impact on ship manning requirements. The ultimate objective of designing for optimal manning is to reduce ship lifecycle costs through reduction in workload, and in turn, the manpower requirements to operate and maintain the ship across its range of missions.

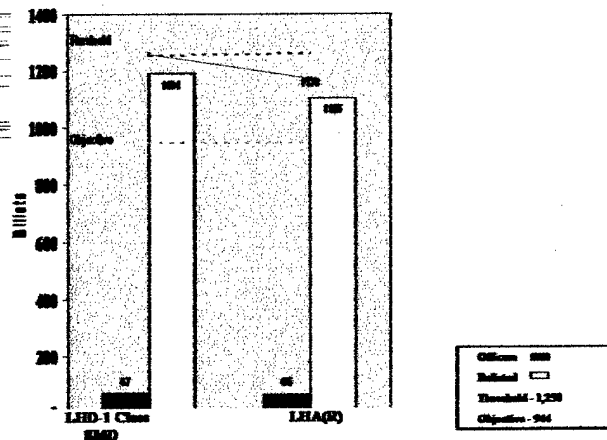


Figure 10: LHA(R) Manpower

Way Ahead

Over the past year the LHA(R) program executed the initial phases of functional design with the first Navy-led design team in over a decade. The team completed four design iterations while concurrently performing over 40 requirements development trade studies, implementing a Measures of Effectiveness process to identify the optimum design emanating from the results of those trade studies. It presented that design to USN/USMC leadership and received their concurrence on an integrated trade study solution. The Design Team has labored to ensure that sufficient engineering rigor and total ship integration have been applied to provide confidence in the safety and survivability of the ship and its personnel. Sound engineering practices have been established through the use of qualified personnel and established design criteria. The Design Team has maintained a concerted effort to ensure all stakeholders were regularly informed and consulted through the use of information exchange events, document and design decision approval process discipline, and regular posting of information to NAVSEA's data management system. The Design Team has worked to strengthen the

organizational ties to the technical authorities thereby insuring that appropriate levels of independent policy and oversight are achieved. The LHA(R) Design Team will continue to refine these practices with two overarching goals in mind: (1) the ship delivered to the fleet will meet or exceed all key performance measures and (2) future ship programs benefit from our example.

References

Bebar, M. and R. Finney,
"Reinventing Naval Ship Design,"
Naval Engineers Journal, May 1999.

Keane, Robert G., Jr. and Barry F. Tibbitts, "A Revolution in Warship Design: Navy-Industry Integrated Product Teams," SNAME Journal of Ship Production, November 1996.

Perin, David A. Peter B. Strickland, Denise B. Anderson and Jason E. Thomas. LHA(R) Analysis of Alternatives (AOA) Summary Report, Jul 2002

Strickland, Peter B. and Michael M. McCrea. Replacement of the LHA Class: The Development Of Options Study, Dec 1999

Tibbitts, Barry, CAPT, USN (Ret.) and Robert G. Keane Jr., "Making Design Everybody's Job," Naval Engineers Journal, May 1995.

Tibbitts, Barry, Edward Comstock, Philip M. Covich, and Robert G. Keane Jr. "Naval Ship Design in the 21st Century," SNAME Transactions, 1993.

N75, LHA-Replacement Mission Need Statement, approved Jul 2001

USD(AT&L) memorandum dated 20 July 2001, LHA(R) Milestone A Acquisition Decision Memorandum

Top Level Requirements (TLR) for the Amphibious Assault Ship (Multi-Purpose) (LHD 1 Class) as amended for LHD 8

Director, Expeditionary Warfare Division (N75) letter, "Amphibious Assault Ship Replacement (LHA(R)) Required Capabilities, date 19 Nov 02

Director, Expeditionary Warfare Division (N75), Director, Operations Division (PO) Plans, Policies, and Operations letter,

"(LHA(R)) Capabilities", dated 14 Nov 03

OPNAVINST 9640.1A, "Shipboard Habitability Program," 3 Sep 96

OPNAVINST 9070.1, "Survivability Policy for Surface Ships of the U.S. Navy," 23 Sep 88

OPNAVINST 9096.1, "Weight and Stability Limits for Naval Surface Ships," 12 Nov 85

Acknowledgements

It has been an honor to summarize the outstanding effort of over 400 scientists, engineers and technicians. Their professionalism and dedication is a tribute to the Navy and their individual professions. Specific thanks must be given to PMS 377 and SEA 05D for providing me the opportunity to write this paper and to the technical codes and system engineering managers who ensure the safety and effectiveness of the total ship system design. Additionally, I would like to personally thank Mr. Robert Keane for his support and guidance and Mr. Matthew McCarton who provided the technical editing critical to the development of this paper.

Biography

Mr. Jason Reynolds is currently the Ship Design Manager for the Amphibious Assault Ship, Replacement (LHA(R)). Responsible for total ship systems engineering and management, including design integration of hull systems, mechanical systems, warfare systems, C4I systems, mission systems, aviation systems, survivability, and human systems integration.

Mr. Jason Reynolds principal assignments have included: Senior Concept Engineer for in support of CNO Strategic Studies Group, USCG

Deepwater Program, and LCU(R);
Systems Engineering Manager for the
CVNX environmental and auxiliary
systems; Life Cycle Manager for
Aviation and MOGAS fuel systems;
Auxiliary Systems Engineer for LPD-
17; and Waterfront Engineer for CVN
68 class.

Mr. Jason Reynolds received his
baccalaureate degree from Virginia
Tech, where he majored in
mechanical engineering (1993). He
received his masters degree from
University of Virginia, where he
majored in mechanical and aerospace
engineering (1999). He is a member
of the Department of the Navy
Acquisition Professional Community
(SPRDE, Level
III).