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A Preliminary Investigation of

Ship Acquisition Options for Joint Forcible Entry Operations

Robert Button, Irv Blickstein
John Gordon, Peter Wilson
Jessie Riposo

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Preface

In the coming decades, the United States will face security challenges related to not only the continuing global war on terrorism but also to the growing power-projection capabilities of regional states armed with increasingly potent weapons. In the future global security environment, sea basing (a concept for assembling, equipping, launching, and supporting forces from the sea without reliance on land bases) will be critical to the Navy and Marine Corps' ability to project—and sustain—forces ashore. With sea basing, Marine combat power can build up more quickly in a littoral area, and the need to move large amounts of supplies ashore will be minimized. As such, sea basing clearly will be useful in the event of joint forcible entry operations (JFEOs). This monograph documents work done in support of the Navy and Marine Corps' review of JFEOs. It describes the global environment in which such operations might occur and the role of naval power in that environment; it also considers various options for substituting ships built to commercial standards ("black hulls") for those built to military specifications ("gray hulls"). This work should be of interest to individuals involved in defense policy or military procurement.

This work was sponsored by the United States Navy. It was carried out in the Acquisition and Technology Policy Center and the International Security and Defense Policy Center of the RAND National Defense Research Institute (NDRI). NDRI conducts research and analysis for the Office of the Secretary of Defense, the Joint Staff, the combatant commands, the defense agencies, the Department of

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For more information on the Acquisition and Technology Policy Center, contact the director, Philip Anton. He can be reached by e-mail at Philip_Anton@rand.org; by phone at 310-393-0411, extension 7798; or by mail at the RAND Corporation, 1776 Main Street, Santa Monica, CA 90407-2138. For more information on the International Security and Defense Policy Center, contact the director, James Dobbins. He can be reached by e-mail at James_Dobbins@rand.org; by phone at 703-413-1100, extension 5134; or by mail at the RAND Corporation, 1200 South Hayes Street, Arlington, VA 22202-5050. More information about the RAND Corporation is available at www.rand.org.

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Summary

Introduction

The current strategy for U.S. naval power is embodied in "Sea Power 21,"[1] which would integrate naval forces for global joint operations against regional and transnational threats. Three fundamental concepts underlie Sea Power 21: Sea Strike, which increases the ability to project precise and persistent offensive power from the sea; Sea Shield, which extends naval defensive firepower beyond the task force; and Sea Basing, which enhances operational independence and support for the joint force by placing at sea (to a greater extent than ever before) capabilities that are critical to joint and coalition operational success.

Sea Power 21 will be enabled by FORCEnet[2] and will be implemented by the Navy-Marine Corps Global Concept of Operations (Global CONOPS), which in turn will provide widely dispersed combat power by creating additional independent operational groups capable of responding simultaneously around the world. Naval capability packages will be readily assembled from forward-deployed forces. These forces will be tailored to meet the mission needs of the

[1] Sea Power 21 is a vision statement issued by the Chief of Naval Operations in 2002 for guidance. For more information, see Clark, Admiral Vern, "Sea Power 21 Series, Part I: Projecting Decisive Joint Capabilities," *Proceedings,* Annapolis, Md.: U.S. Naval Institute October 2002, (http://www.usni.org/Proceedings/Articles02/proCNO10.htm; last accessed November 2004).

[2] FORCEnet is an overarching effort to integrate warriors, sensors, command and control, platforms, and weapons. See Chapter One for more information.

Joint Force Commander, complementing other available joint assets, and will be sized to the magnitude of the task at hand. In meeting the capability packages required under the Global CONOPS, the Navy relies on its program of record, as defined by the 30-year Shipbuilding and Conversion, Navy (SCN) plan. The sea base will be composed of distributed forces of many types, including carrier strike groups (CSGs), expeditionary strike groups (ESGs), combat logistics force ships, Maritime Pre-Positioning Force (MPF) platforms, and, in the years ahead, high-speed support vessels. Under the Global CONOPS, no other force package will be expected to approach the CSG's combat survivability because ESGs "will prosecute Sea Strike missions in lesser-threat environments."[3] This raises questions about how well the Navy's shipbuilding program of record, as defined by the SCN, will meet the needs of Sea Power 21 and whether the program of record should be modified, in particular by directly substituting so-called black-hulled ships (or "black hulls," ships built to commercial standards) for so-called gray-hulled ships (or "gray hulls," ships built to military specifications).

In January 2003, Deputy Secretary of Defense Paul Wolfowitz asked for a thorough review of JFEOs. As part of his tasking, he asked the Joint Chiefs of Staff (JCS) to define and explore sea basing concepts and force capability packages. In particular, he asked the Department of the Navy (DoN) to outline the Joint Operations Concept for "operations from the sea" and the potential effect of those concepts on the Navy's out-year shipbuilding.

In response to this request, the DoN asked the RAND National Security Research Division to support the Navy by conducting an evaluation that would enable decisionmakers to examine the potential substitution of Maritime Pre-Positioning Force (Future) (MPF(F)) black-hulled ships for gray-hulled amphibious ships, particularly the LPD-17 and the LHA(R).

To meet this objective, RAND (1) assessed the future global security environment, (2) developed findings that argue for the imple-

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[3] Clark, 2002.

mentation of sea basing, (3) created a series of scenarios based on the review of the global security environment, and (4) developed two models and used them to examine alternatives to substituting black-hulled ships for gray-hulled ships.

The Importance of Sea Basing in the Future Global Security Environment

In the coming decades, the United States will face a bifurcated set of security challenges. Day to day, the operational driving force will continue to be related to the Global War on Terrorism (GWOT) and the issues arising from the focus on the GWOT. At the same time, the United States will be forced to confront growing challenges to its power-projection capabilities from regional states armed with increasingly potent weapons.

In this security environment, U.S. forces will be called upon to perform an extraordinarily wide range of missions, including conducting long-term training and advisory missions, developing intelligence on localized terrorist groups and global networks, protecting allies from ballistic-missile and cruise-missile attacks, and countering nation states that brandish nuclear weapons.

Within this environment, the emerging concept of sea basing[4] will be an important addition to the naval forces' ability to project—and sustain—forces ashore. With sea basing, Marine Corps combat power can build up more quickly in littoral areas, and the need to move considerable amounts of supplies ashore will be minimized. As such, the concept of sea basing clearly has important uses during joint forcible entry operations (JFEOs), which U.S. forces may confront in the future. But sea basing has value beyond its use in forcible-entry operations (which are likely to be the exception rather than the norm). In particular, the United States may have to conduct missions in the "zone of instability" extending from West Africa to Indonesia

[4] Loosely speaking, *sea basing* is the ability to assemble, equip, and support forces from sea platforms without relying on land bases.

or in Latin America, where a large U.S. military presence ashore is not politically acceptable. With such missions, considerable advantage can be gained by leaving as many functions as possible offshore at the sea base.

While the Navy and Marine Corps are currently thinking of sea basing in terms of enhancing their own capabilities, the concept of sea basing has further use beyond naval/marine forcible-entry operations or sustainment of Marine Corps operations ashore in areas where granting forces access is not politically acceptable. Sea basing might also prove to be a valuable part of joint operations involving the Army and Air Force.

Identifying Favorable Mixes of Gray Hulls and Black Hulls for JFEOS

Our analysis for this study focuses on identifying favorable mixes of gray-hulled and black-hulled ships for future JFEOs. In conducting this evaluation, we arrived at some analytic and programmatic conclusions.

Analytic Conclusions

We arrived at two main analytic conclusions from this study:

- Further concept development is needed for Maritime Pre-Positioning Ship Squadron (Future) (MPSRON(F)), MPF(F), and Landing Craft Air Cushion (LCAC) alternatives. Concepts of employment changed the course of our analysis. Specifically, the observation that one MPF(F) ship can be substituted operationally for more than one L-class ship redefined the substitution trade space, as did the finding that it may be possible to take up MPF(F) ships from MPSRONs temporarily with acceptable outcomes. *This new Concept of Employment functionally reduces MPF(F) ship cost by a factor of two or more*. Recognizing that LCACs will be decommissioned, even with a successful LCAC Service-Life Extension Program (SLEP), led us to further

examination of Concepts of Employment and the identification of additional means to improve force-closure performance—*with possible MPF(F) cost savings*.

- **Significant quantitative analysis is possible at this stage of operational concept development.** Our analysis identified various areas of uncertainty and managed them using filtering (to bypass unmanageable uncertainties); sensitivity analysis (to incorporate uncertainty); cost bounding (in place of equal cost analysis); and exploratory analysis (to understand problem sensitivities).

Programmatic Conclusions

Program of Record. Initial conclusions on the Navy's shipbuilding program of record are as follows:

- The program of record will not achieve the stated Marine Corps programming goal of 2.5 Marine Expeditionary Brigade Assault Echelons (MEB(AE)) lift capacity. Increasing demand for vertical take-off and landing (VTOL) and LCAC lift is outpacing the program of record in providing lift.
- MPF(F) ships may not be affordable. Eighteen MPF(F) ships—costing $1.75 billion each—would collectively cost $31.5 billion.[5] The goal of increasing the Navy force level from 292 ships in fiscal year (FY) 2004 to 375 ships under the Global CONOPS may heighten competition for funds and may make MPF(F) ships even less affordable.
- The 2025 program of record force, with MPF(F) ships, will be able to close a 2015 MEB in half the time required by a 2003 force. MPF(F) was the key difference between the 2003 force and the 2025 force under the program of record. In other words, *this transformational improvement in capability depends on acquiring some form of MPF(F) ships.*
- The time that is required for the same 2025 force to begin the assault phase of a sustained MEB-level amphibious operation is

[5] All dollar figures cited in this Summary are in fiscal year (FY) 2003 dollars.

expected to be halved relative to the time required for the 2003 force.
- The 2025 force will be more efficient than the 2003 force. Six ESGs would be required for a one-MEB(AE) lift capacity using the 2003 force. The 2025 force could achieve the same lift with five ESGs.
- A summary conclusion is that *MEB requirements have historically changed more quickly than has the amphibious force.* This points to a potential advantage of flexibility (ability to change without modification) and adaptability (ease of modification) in future ships.

Substituting Black Hulls for Gray Hulls. In considering the substitution of MPF(F) black-hulled ships for L-class gray-hulled amphibious ships under the Global CONOPS, we reached the following conclusions:

- MPF(F) ships could perform the mission assigned to LPD-17s. However, a better definition of the MPF(F) is required to address substitution of MPF(F) ships for LHA(R). Risk and cost are still issues. The level of risk to the MPF(F) in substituting MPF(F) ships for L-class ships depends on how the MPF(F) ships will be used (i.e., their concept of employment). Concept development is needed to perform risk evaluation. This study produced MPF(F) cost bounds to evaluate possible cost-saving substitutions. Final cost figures for MPF(F) ships will determine whether MPF(F) falls within those bounds. Cost savings are not expected with one-for-one substitutions of an LPD-17 or LHA(R). However, because operation-tempo restrictions applying to L-class ships do not apply to MPF(F) ships, which are crewed by civilians, a single MPF(F) ship can be substituted for two or more L-class ships. A one-for-two substitution of LPD-17s would allow the substituting MPF(F) ship to work up and deploy with ESGs, would maintain operational flexibility of

ESGs, and would lead to an amphibious lift capacity of 2.5 MEB(AE) with modest room for growth.
- A one-for-four substitution scheme would also be possible, but it would not allow the substituting MPF(F) to work up with ESGs, would not maintain operational flexibility, and would lead to an amphibious lift capacity of 2.5 MEB(AE) with only minimal room for growth. Then again, this substitution scheme would clearly offer more opportunities for cost reduction.
- Substitutions could involve additional, dedicated ships or MPF(F) ships taken up from a Maritime Pre-Positioning Ship Squadron Future (MPSRON(F)). Additional MPF(F) ships could be equipped with features to make them more capable or to reduce the risk to them, without the need to build such features into all 18 MPSRON(F) ships.
- There is little difference in choice, in terms of closure time or asset requirements, among the above substitution schemes.

Alternative Assault Landing Craft. Replacing LCAC in kind with Heavy Lift LCAC (HLCAC) would work within existing concepts of operation and employment. A replacement such as this offers improved maneuver performance, but conclusions on any such improvement are outside the scope of this analysis. Possible LCAC replacement alternatives other than HLCAC offer potential new operational concepts and, therefore, the possibility of further improvement in closure times.

- HLCAC alternatives may be able to deploy with ESGs and, thus, reduce the time required for force closure.[6]
- Alternatively, HLCAC alternatives may be forward deployed from bases such as Diego Garcia and Guam—again reducing time for force closure.

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[6] *Force closure* is the point in time when a supported joint force commander determines that sufficient personnel and equipment are in an operational area to carry out assigned tasks (Department of Defense, *Department of Defense Dictionary of Military and Associated Terms,* Joint Publication 1-02, 2003).

- Both concepts of employment (deploying with ESGs and forward deployment) would shift the driving "fingerprint" for force closure from LCAC spots to VTOL spots (see Chapter One). A positive result of this shift would be a reduced need for ample well decks on MPF(F) ships. In turn, reducing the size of expensive well decks could lead to MPF(F) cost reduction and increased capacity.
- VTOL closure time also needs to be addressed in the same way that troop closure time was addressed in this analysis.

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Of course, the authors alone are responsible for any errors.

Acronyms

AAC	Air-Assisted Catamaran
AAV	Assault Amphibious Vehicle
ACV	Air Cushion Vehicle
AoA	Analysis of Alternatives
ARG	Amphibious Ready Group
ATF	Amphibious Task Force
C4ISR	Communications, Computers, Intelligence, Surveillance, Reconnaissance
CBRNE	Chemical, Biological, Radiological, Nuclear and High-Yield Explosives
CEP	Circular Error Probable
CIWS	Close-in Weapon System
CNA	Center for Naval Analyses
CONOPS	Concept of Operations
CONUS	Continental United States
CSG	Carrier Strike Group
DoD	Department of Defense
DoN	Department of the Navy
ESG	Expeditionary Strike Group
ESS	Expeditionary Support Ship
FCS	Future Combat System
FDNF	Forward Deployed Naval Forces

FOB	Forward Operating Base
FOL	Forward Operating Location
FY	Fiscal Year
GWOT	Global War on Terrorism
HLCAC	Heavy-Lift Landing Craft Air Cushion
HSRS	High-Speed Response Ship
HSTSS	High-Speed Theater Support Ship
IAEA	International Atomic Energy Agency
IO	Information Operations
ISR	Intelligence, Surveillance, and Reconnaissance
JCS	Joint Chiefs of Staff
JFEO	Joint Forcible Entry Operations
JICM	Joint Integrated Contingency Model
JP	Joint Publication
kt	Knot
LAV	Light Armored Vehicle
LCAC	Landing Craft Air Cushion
LCTAC	Landing Craft, Tank, Air Cushion
LCU	Landing Craft Utility
LCU(R)	Landing Craft Utility Replacement
LDP	Liberal Democratic Party (Japan)
LHA(R)	LHA-Replacement
LHA/D	Amphibious Assault Ship
LHD(X)	LHD Replacement
LMSR	Large, Medium-Speed Roll-On/Roll-Off
LOTS	Logistics over the Shore
LPD	Amphibious Transport Dock
LSD	Dock Landing Ship
LSD(X)	LSD Replacement
MAGTF	Marine Air-Ground Task Force
MCCDC	Marine Corps Concept Development Center

MCRP	Marine Corp Reference Paper
MEB	Marine Expeditionary Brigade
MEB(AE)	MEB Assault Echelon
MEF	Marine Expeditionary Force
MEU	Marine Expeditionary Unit
mm	Millimeter
MPF	Maritime Pre-Positioning Force
MPF(F)	Maritime Pre-Positioning Force Future
MPS	Maritime Pre-Positioning Ship
MPS(F)	Maritime Pre-Positioning Ship Future
MPSRON	Maritime Pre-Positioning Ships Squadron
MPSRON(F)	Maritime Pre-Positioning Ship Squadron Future
NATO	North Atlantic Treaty Organization
NAVAIR	Naval Air Systems Command
OSD	Office of the Secretary of Defense
QDR	Quadrennial Defense Review
RO/RO	Roll On/Roll Off
SCN	Shipbuilding and Conversion, Navy
SLEP	Service Life Extension Program
SOA	Speed of Advance
SOC	Special Operations Capable
SOF	Special Operations Forces
STOM	Ship to Objective Maneuver
TSV	Tactical Support Vessel
TTO	Transnational Terrorist Organization
UN	United Nations
V/STOL	Vertical/Short Takeoff and Landing
VTOL	Vertical Takeoff and Landing

CHAPTER ONE

Introduction

Background

Strategies for U.S. naval power have evolved from a focus on blue-water, war-at-sea operations ("Maritime Strategy" in 1986), through an emphasis on operations in littoral regions (". . . From the Sea" in 1992, and "Forward . . . From the Sea" in 1994), to the broader current strategy embodied in "Sea Power 21," which would integrate naval forces for global joint operations against regional and transnational threats. Three fundamental concepts underlie Sea Power 21: Sea Strike, Sea Shield, and Sea Basing.

- **Sea Strike** is the ability to project precise and persistent offensive power from the sea. It will provide Joint Force Commanders with a mix of capability options, ranging from long-range precision strike to swift insertion of ground forces. Sea Strike operations will be fully integrated into joint campaigns, adding independence, responsiveness, and on-scene endurance in those operations.
- **Sea Shield** extends naval defensive firepower beyond the task force. Achieving battle-space superiority in forward theaters is central to the Sea Shield concept, especially as enemies become more capable at their area-denial efforts. In times of rising tension, pre-positioned naval units will sustain access for friendly forces and maritime trade. The result will be combat-ready forces able to achieve and sustain access before and during crises.

- **Sea Basing** enhances operational independence and support for the joint force by placing at sea—to a greater extent than ever before—capabilities that are critical to joint and coalition operational success: offensive and defensive firepower, maneuver forces, command and control, and logistics. Sea Basing will provide operational freedom for joint and coalition forces, compressed deployment timelines, and strengthened deterrence, and will project dominant and decisive combat power from the sea. The sea base will be composed of distributed forces of many types, including Carrier Strike Groups (CSGs), Expeditionary Strike Groups (ESGs), combat logistics force ships, Maritime Pre-Positioning Force (MPF) platforms, and, in the years ahead, high-speed support vessels. Working together, these forces amass effects (i.e., generate a level of decisive power) previously associated with massed forces, increase sensor coverage and force protection, and focus offensive and defensive firepower throughout a battlespace.

Sea Power 21 will be enabled by FORCEnet[1] and implemented by the Navy-Marine Corps Global Concept of Operations (Global CONOPS), which will provide widely dispersed combat power by creating additional independent operational groups capable of responding simultaneously around the world.

The Chief of Naval Operations describes naval capability packages required under the Global CONOPS as follows:

> Naval capability packages will be readily assembled from forward-deployed forces. These forces will be tailored to meet the mission needs of the Joint Force Commander, complementing other available joint assets. They will be sized to the magnitude of the task at hand. As a result, our Navy will be

[1] FORCEnet is an overarching effort to integrate warriors, sensors, command and control, platforms, and weapons. It will provide the architecture and physical connectivity to integrate all forces throughout a battlespace and to synchronize tasking, processing, exploitation, and dissemination of intelligence, surveillance, and reconnaissance, and it will increase the accuracy and speed of command at all levels. It is also the means by which network-centric warfare will be implemented.

> able to respond simultaneously to a broad continuum of contingencies and conflict, anywhere around the world. The Global Concept of Operations will employ a flexible force structure that includes:
>
> - Carrier Strike Groups that provide the full range of operational capabilities. Carrier Strike Groups will remain the core of our Navy's warfighting strength. No other force package will come close to matching their sustained power projection ability, extended situational awareness, and combat survivability.
> - Expeditionary Strike Groups consisting of amphibious ready groups augmented with strike-capable surface warships and submarines. These groups will prosecute Sea Strike missions in lesser-threat environments. As our operational concepts evolve, and new systems like Joint Strike Fighter are delivered to the fleet, it will be advantageous to maximize this increased aviation capability. New platforms being developed for Expeditionary Strike Groups should be designed to realize this warfighting potential.
> - Missile-defense Surface Action Groups will increase international stability by providing security to allies and joint forces ashore.
> - Specially modified Trident submarines will provide covert striking power from cruise missiles and the ability to insert Special Operations Forces.
> - A modern, enhanced-capability Combat Logistics Force will sustain the widely dispersed fleet.[2]

In meeting the capability packages required under the Global CONOPS, the Navy relies on its program of record, as defined by the 30-year Shipbuilding and Conversion, Navy (SCN) plan. However, under the Global CONOPS, no other force package will be expected to approach the CSG's combat survivability because ESGs "will prosecute Sea Strike missions in lesser-threat environments."[3]

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[2] Clark, Admiral Vern, "Sea Power 21 Series, Part I: Projecting Decisive Joint Capabilities," *Proceedings,* Annapolis, Md.: U.S. Naval Institute, October 2002 (http://www.usni.org/Proceedings/Articles02/proCNO10.htm; last accessed November 2004).

[3] Clark, 2002.

This situation raises questions about how well the program of record as defined by the SCN will meet the needs of the Global CONOPS and whether the program of record should be modified, in particular by directly substituting so-called black-hulled ships (or "black hulls," built to commercial standards) for so-called gray-hulled ships (or "gray hulls," built to military specifications).

Objectives

Widespread opposition to the U.S. war in Iraq could create further difficulties over access and basing in future such circumstances and has increased the importance of joint forcible entry operations (JFEOs). Such concerns led Deputy Secretary of Defense Paul Wolfowitz to ask for a thorough review of JFEOs and to ask the Joint Chiefs of Staff (JCS) to define and explore naval forces, sea-basing concepts, and force-capability packages as part of that review. In particular, Wolfowitz asked the JCS to look at potential future developments for ships capable of launching aircraft and potential future developments for high-speed vessels. He also asked the Department of the Navy (DoN) to outline the Joint Operations Concept for "operations from the sea" and the potential effect of that concept on the Navy's out-year shipbuilding.

In response to this request, the DoN asked the RAND National Security Research Division to support the Navy by conducting an evaluation that would enable decisionmakers to examine the potential substitution of Maritime Pre-Positioning Force (Future) (MPF(F)) black-hulled ships built to commercial standards for gray-hulled amphibious ships built to military standards, particularly the LPD-17 and the LHA(R).

Study Approach

To meet the objective of this study, RAND created a series of scenarios to be used in modeling ship-substitution alternatives and de-

veloped two models to examine those alternatives along the following dimensions:

- Ability to meet the fiscally constrained programming goal of lifting 2.5 Marine Expeditionary Brigade (Assault Echelons) (MEB(AE))
- Responsiveness
- Asset requirements/operational flexibility
- Cost
- Risks and advantages.

Lift is calculated by evaluating transport capacity, measured by the Navy and Marine Corps' five "fingerprints" of lift (1) number of troops, (2) vehicle square footage, (3) cargo cubic footage, (4) vertical takeoff and landing (VTOL) aircraft deck space, and (5) landing craft air cushion (LCAC) well-deck space. The fingerprint system was developed in the DoN Lift II study conducted over a decade ago and has been used by the Department of Defense (DoD) to describe the evolution of the MEB, amphibious ship capacities, and requirements for new amphibious ships. The fingerprint system provides a generally accepted set of metrics and is discussed in more detail in Chapter Three.

RAND's Static Lift model, developed for this study, measures force net lift capacity. It can be used to determine force alternatives sufficient for 2.5 MEB(AE) lift capacity by calculating the five categories of fingerprints.

RAND's Dynamic Lift model, also developed for this study, is used with the criterion of time to build up the fingerprints for a single MEB in selected theaters of choice, based on the scenarios created for this study. Using force alternatives from static lift and cost analyses, we used the model to flow forces from locations that are consistent with the Navy's Global CONOPS and to measure the arrival of the five fingerprints in selected theaters against the one MEB performance criteria. The model was also used to determine resource requirements for the most-rapid buildup and to characterize the force

resulting from the buildup. This determination, in turn, led to the consideration of risks and advantages of various force alternatives.

Organization of This Report

Chapter Two discusses the importance of the sea-basing concept in regard to future trends in the security and defense environment, providing the context for the development of the scenarios used in our evaluation. Chapter Three evaluates the mixes of gray hulls and black hulls in more detail and examines the results of that evaluation—specifically, possible changes to the Navy's shipbuilding program of record in terms of lift requirements, force closure performance, missions, cost, risks, and implications for operational concepts. Chapter Four offers our conclusions.

Appendix A provides additional information on the black hull and gray hull ships that are the subject of the evaluation in Chapter Three. Appendix B provides more details on the static and dynamic lift models used in the evaluation. Appendix C provides additional results of the force closure analysis, also discussed in Chapter Three.

CHAPTER TWO

The Importance of Sea Basing in the Future Global Security Environment

As the third component of Sea Power 21, sea basing is critical to ensuring the Navy's capabilities in future military operations. In this chapter, we examine trends in the future global security environment that argue for the importance of sea basing. We first discuss the security environment and then present reasons why sea basing is an important part of that environment.

What Will the Global Security Environment Look Like in the Future?

In the coming decades, the United States will face a bifurcated set of security challenges. Day-to-day, the driving force behind will continue to be related to the Global War on Terrorism (GWOT) and the issues such a focus will have. At the same time, the United States will be forced to confront growing challenges to its power-projection capabilities from regional states armed with increasingly potent weapons.

Pursuing the Global War on Terrorism

A decade after the collapse of the Soviet empire in 1991, the terrorist attacks on the United States homeland on September 11, 2001, accelerated a period of historical discontinuity. In response to the emergence of al Qaeda as a globally lethal transnational terrorist organization (TTO), the United States embarked upon the GWOT. Further,

the Bush administration has linked the threat of al Qaeda and its allies with the prospect that a variety of "rogue" states, most specifically Iraq, may provide these TTOs with chemical, biological, radiological, and possibly nuclear weapons. To preempt that possibility, the United States (along with its coalition of allies) launched a war on March 19, 2003, to overthrow the regime of Saddam Hussein, a major event in this period of historical discontinuity.

The Importance of the Zone of Instability. As a result of the focus on the GWOT, it is likely that the so-called zone of instability that extends from West Africa to Indonesia will continue as a focal point of American military operations for the rest of this decade and possibly much longer. Much of the region is Islamic, much of it is ruled by corrupt or ineffective governments, and much of it is already seething with various local conflicts and insurgencies. Given that the GWOT is currently focused on radical Islamic movements and nations that support or condone the activities of radical Islamic terrorist groups, it is virtually certain that the U.S. military will have to deal with threats originating from this region for years to come. This is even the more certain given the global economy's dependence on the free flow of oil from the Persian Gulf region; the imperative of bringing a measure of stability to Iraq; the ongoing Israeli-Palestinian conflict; and the ongoing conflict with Al Qaeda and its allies.

While Pakistan is currently a U.S. ally within the zone of instability, continued cooperation from the Pakistan government in the campaign to destroy al Qaeda may depend on the rule of President Parvez Musharraf. The overthrow, by coup or violent civil unrest, of the Musharraf regime could present a nightmarish scenario for the United States. Assassination attempts in December 2003 against the Pakistani president are examples of the threat he faces. A distinctly possible outcome would be the emergence of a more pro-militant Islamist regime, which might be more willing to harbor elements of al Qaeda and their Taliban supporters. As "book ends" of the zone of instability, both Indonesia and Nigeria may be teetering on the verge of major internal strife. In the former case, the dominant Javanese population and elite are increasingly challenged by Islamic and non-Islamic regional/nationalist movements. Furthermore, tension be-

tween Christian and Muslim communities has dramatically increased with the emergence of ever-more-militant Islamic groups, such as Jemaal Islamiyah. The Ivory Coast also represents a worrisome model, because Islamic-based insurgents there have gained considerable outside assistance from countries such as Libya.[1]

Changes in Strategic Alliances. Many U.S. and European national security specialists expected that with the end of the Cold War the decades-long shared perspective on security of the United States and many of its key allies, especially in Europe, would erode. Contrary to these expectations, the protracted Yugoslavian civil wars eventually compelled joint action within the North Atlantic Treaty Organization (NATO). Immediately after the September 11 attacks, the United States received support and sympathy from NATO, including the first Article V declaration in the alliance's history. Many European nations supported the United States in the GWOT, and true to World War II tradition, the United Kingdom has provided the most vigorous diplomatic and military support.

However, significant differences in perspectives have emerged with and between many traditional European allies, especially regarding the current U.S. war with Iraq and its geostrategic/geoeconomic aftereffects. Specifically, an important "fault line" has developed between the United States and some European nations over the war to overthrow the regime of Saddam Hussein. There is some danger that this split over the United States' conduct of the Iraqi war and its ongoing occupation of Iraq could lead to major medium-term changes in the relationship between he United States and NATO Europe, although Washington, Berlin, and Paris all appear to be working to overcome these differences.

In Northeast Asia, the traditional political-military relationship with Japan and South Korea remained relatively unchanged during the 1990s. North Korea remained the principal rationale for a U.S. presence in Japan and South Korea. Until fall 2002, it appeared that a gradual process of reintegration of North and South Korea was

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[1] Larrabee, F. Stephen, John Gordon IV, and Peter A. Wilson, "The Right Stuff, Defense Planning Challenges for a New Century," *National Interest,* Fall 2004.

under way, with the threat of a North Korean nuclear breakout through the plutonium production process contained by the 1994 Agreed Framework. In the wake of the confirmation of a secret parallel uranium-enrichment program in North Korea, the Japanese government and, more forcefully, the South Korean government have taken a diplomatic approach that at times differs from that of the United States on how to deal with the threat posed by Pyongyang's attempt to acquire a nuclear arsenal. How the North Korean nuclear crisis is resolved will have major implications for the United States' political-military relations with both South Korea and Japan.

Meanwhile, in the Middle East, nations have proved unwilling to support the U.S.-led military campaign against Iraq, especially without United Nations (UN) sanctions.

While the United States is clearly the only global superpower, its ability to lead other nations into potentially dangerous regional military operations is limited. Unpredictable demands from the new global security environment may make it difficult to predict which nations the American military may be required to work alongside in the future.

Changes in the Ability to Gain Access Ashore. When the United States mounted operations against the Taliban and Al Qaeda in Afghanistan—a region in which the United States had no military facilities, few traditional allies, and no plan to fight a war—it had to scramble to gain rights to use the airspace and bases of nations near Afghanistan.

The recent war with Iraq highlights the difficulty that the United States faces in access ashore in key regions. Despite months of negotiations, the United States could not obtain permission to use Saudi or Turkish bases for the invasion of Iraq. Political pressures inside those nations made the granting of basing rights to U.S. forces too difficult, despite the long-standing ties between those nations and the United States (and despite the fact that Turkey is a NATO member). Widespread opposition to the U.S. invasion of Iraq could create further difficulties with access ashore in future situations.

Changing Nature of Strategic Surprise and Initiative. In the past, the most important factors in crisis preparation have been "sur-

prise" initiatives. A major worry and an important reason for the requirement for rapid transoceanic deployment is the threat of short-warning acts of regional aggression. The North Korean invasion of South Korea is the paradigm of this type of act. Much of the analysis of joint forces requirements after the 1991 Persian Gulf War focused on the possibility that either Iraq or North Korea could and would launch a massive offensive operation against their respective neighbors with little operational or tactical warning. The threat of these acts occurring generated a wide range of studies evaluating the capacity of the United States to halt and defeat a regional aggressor.

However, the prospect of strategic and operational surprise by a regional predator may well have been diminished by the fall of Saddam Hussein's regime. The U.S. and UK military operation to overthrow the Iraqi regime was a very large forcible-entry operation on the scale of a major contingency in which Washington and London had the strategic and operational initiative. Now, in the context of supporting the ongoing GWOT in the zone of instability, the United States may normally have the strategic and operational initiative, which will allow it to "lean forward" (make early preparations) to take advantage of capabilities provided by its operational hubs. This is not to suggest that the United States will not need globally responsive military capabilities, including brigade-size units that can be deployed via transoceanic airlift or via pre-positioned units that are on board either black-hull or gray-hull amphibious ships. Given the size of the airlift fleet and the limited number of forward-deployed equipment sets, it is unlikely that the Army or the Marine Corps will be able to deploy more than one or two brigade-sized elements in the first two weeks of a crisis. For practical reasons involving cost and the limits of airlift technology, deployment of several brigades, much less division equivalents, of the ground component of an expeditionary force will continue to rely on sealift.

Threats to Power Projection Operations

While the concerns discussed above that are driven by the U.S. pursuit of the GWOT now dominate security planning and will continue do so in the future, the United States will face other global

security concerns—in particular, other terrorist threats outside the zone of instability; the emergence of China as a great power; the need to identify and diminish the threat from chemical, biological, radiological, nuclear, and high-yield explosives (CBRNE) weapons; the diffusion of dual-purpose technology; and challenges to Command, Control, Communications, Computers, Intelligence, Surveillance, Reconnaissance (C4ISR).

Other Terrorist Threats Outside the Zone of Instability. Outside the zone of instability with its strong Islamic features, severe insurgency/terrorism in the Western Hemisphere could intensify in Colombia, where the United States has upped the ante by providing the Colombian government expanded military assistance. Insurgent groups, most specifically the Revolutionary Armed Forces of Colombia and the National Liberation Army, have stepped up their attacks in the region. What is very worrisome is the possibility that Venezuela, under the increasingly authoritarian and regionally ambitious regime of Hugo Chavez, may provide greater material assistance and possible sanctuary to one or more radical insurgent groups.[2]

China As an Emerging Great Power. Considerable uncertainty surrounds the balance of cooperation and confrontation between the United States and the People's Republic of China. The Chinese leadership appears to want to delay resolution of the Taiwan issue and focus on the massive challenges of stimulating and modernizing the Chinese economy without setting off a political and social explosion. Consistent with this priority, the rhetoric over Taiwan has cooled. Additionally, the Chinese appear to have some shared interests with the United States on the Korean Peninsula, opposing a nuclear North Korea and wanting a diplomatic rather than a violent resolution of the North Korean nuclear challenge.

Because China shows no signs of exploiting Islamic terrorism (indeed, the Chinese are inclined to suppress groups that can cause instability in their western regions), there is no other near-term source of conflict between the United States and China, other than Taiwan

[2] Larrabee, Gordon, and Wilson, 2004.

and North Korea. Thus, unless a crisis occurs as a result of Taiwanese efforts to achieve international recognition as a separate and independent nation, China will not likely directly threaten the U.S. interests in Asia during the current decade.

However, things are far less clear beyond the near-term. How Taiwan and North Korea, plus various economic issues, are handled during this decade may decide whether the United States–Chinese relationship moves toward entente or toward an intensified great-power rivalry. How much effort the United States military should devote to countering possible challenges from China is uncertain. This is an important point, because China is the only potentially hostile nation that will have the economic and technological resources to pose a major military challenge to the United States during the second decade of this century. A major uncertainty in strategic planning is the effectiveness of the Chinese military and China's technological modernization programs.

A point worth noting is the Chinese leadership's commitment to a robust space program, as seen in its success of the first Chinese human spaceflight on October 15, 2003. The Chinese elite clearly appears committed to modernizing its military establishment, but this effort will continue to be constrained because of daunting domestic economic, financial, and political challenges of rapid national growth.

How Japan reacts to the emergence of China as a great power and the prospect that North Korea has or may soon have an operational nuclear arsenal is a major geostrategic uncertainty in Northeast Asia. The Japanese political class, dominated by the Liberal Democratic Party (LDP), faces multiple economic, financial, and national-security challenges. Japan may be on verge of big and rapid change. A central question for the Japanese elite is whether Japan will acquiesce to the emergence of China and at least one nuclear-armed Korea, or whether a form of Japanese neonationalism will emerge that would include the decision to acquire an independent nuclear arsenal.

Strains Related to the Nuclear Non-Proliferation Treaty. One concern for Pakistan is a much more aggressive nuclear-weapon technology policy and a resumption in its transfer of nuclear weapons and nuclear-weapon-delivery technologies, or even the weapons them-

selves. Most disturbing have been the recent revelations that a clandestine nuclear-weapon supply network has emerged from the Pakistani nuclear weapons establishment. This clandestine operation, apparently conducted without official sanction, has seriously damaged the viability of the Nuclear Non-Proliferation Treaty. There is the distinct chance that India might consider various preventive war options to destroy a clearly more militant Islamic regime armed with nuclear weapons. Kashmir is the likely flashpoint.

As for Northeast Asia, North Korea appears to be conducting a nuclear weapon breakout strategy. Apparently, Kim Jong Il has decided to attempt a strategic version of "having your cake and eating it too" with the acquisition of a nuclear arsenal coupled with continued and possibly improved political and economic relations with South Korea and Japan. If not blocked, the emergence of a nuclear arsenal in North Korea might prompt the South Korean and Japanese publics and elites to seriously reconsider their current "no nuclear" weapon status.

Iran has also been pressing ahead with a nuclear program. Recent inspection trips by the International Atomic Energy Agency (IAEA) reveal that Iran has made major progress in the development of uranium enrichment.[3] Iran's recent agreement to allow inspections of its facilities may prove to be an inadequate deterrent to a continued nuclear weapons program.

Intensification of CBRNE Threat. A dismal reality of the early 21st century is that the United States will face more potential opponents armed with CBRNE weapons. During this first decade of the century, a number of potential opponents either have or will acquire substantial short- and medium-range missile capabilities armed with a large stockpile of chemical and possibly biological weapons. Less certain is the number of states that will acquire an operational nuclear arsenal. A new emerging factor is that these weapons may no longer be limited to nation states; nonstate terrorist groups could acquire at

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[3] Kerr, Paul, "IAEA Presses Iran to Comply with Nuclear Safeguards," *Arms Control Today,* July/August 2003 (www.armscontrol.org/act/2003_07-08/iran_julaug03.asp; last accessed November 2004).

least some types of these weapons. There is also the real concern that one or more terrorist organizations will exploit radiological material to create a weapon of mass disruption that could cause serious psychological and economic damage. There is the far more grave threat that a nonstate terrorist organization may acquire one or more nuclear weapons to threaten U.S. or allied cities with the true threat of mass destruction.

As nuclear weapons and associated delivery systems proliferate, the options the United States has for dealing with a nuclear-armed opponent change and become more limited. Once a potentially hostile nation acquires nuclear weapons and the associated means of long-range delivery, it becomes much more of a threat to others in the region who may then become far less willing to employ force or allow the United States to use force against their now more powerful neighbor. Put simply, the United States will find it much more difficult to create a "coalition of the willing" in the face of a nuclear-armed regional predator than it would to create a coalition to confront a regional predator armed with only conventional weapons. Pakistan, a nuclear-armed state that is a critical, albeit uncertain, security partner of the United States, might be subject to dramatic domestic shifts in its government and rapidly emerge as a strategic threat.

Although many in the U.S. military establishment believe that the very large and secure American nuclear deterrent is sufficient to stay the hand of any nuclear-armed opponent, there is always the prospect that this calculation may prove to be wrong. A worrisome scenario is the limited use of nuclear weapons at high altitude by a nuclear-armed opponent designed to create wide-area electromagnetic effects or lower-radiation-belt pumping that severely damages U.S. C4ISR systems and unprotected combat vehicles.

Continued Diffusion of Advanced Dual-Purpose and Military Systems and Technologies. Even if CBRNE weapons are not used by a future military opponent, the U.S. services may face missile attacks with high-explosive or exotic-explosive warheads. The next generation of ballistic and cruise missiles will have sufficient range and accuracy to menace many key facilities, such as ports and air fields, that

the United States plans to use during the deployment and conduct of a theater war.

By 2010, a larger number of countries may have 2000-to-3000-kilometer range, solid-propellant ballistic missiles. Cruise missiles with terminal guidance may have circular error probables (CEPs) as small as five meters. Launched from mobile transporter erector launchers that operate from hidden and hardened main operating bases, these missiles may be very difficult to find and destroy by aerial counterforce attacks. These threats point to the need for ever more effective theaterwide aerospace defenses operated by all four services and a ground force capacity to operate, if only initially, under long-range artillery fire.

Aside from acquiring ballistic and cruise missiles, a future opponent may be able to acquire through the international arms market a variety of contemporary fighter-bombers armed with high-performance guided weapons. At present, only the United States, the Russian Federation, and several European Union aerospace consortiums can supply high-performance combat aircraft. However, by the end of the decade, China and India may master a similar aerospace production capability. Coupled with even a limited theaterwide reconnaissance capability, these forces may present a serious anti-access capability.[4]

Other likely niche guided-weapon threats include the widespread acquisition of the full range of direct- and indirect-fire guided weapons from the global marketplace. Specifically, the U.S. Army and its sister services will face increasing challenges in operating low-flying aircraft and motorized ground forces against insurgents and other irregular forces equipped with contemporary man-portable or light-vehicle-transportable surface-to-air and antitank missiles. There is a clear need to develop and deploy high-performance countermeasures such as directional infrared countermeasures to protect low-flying fixed-wing and rotary-wing combat aircraft against the in-

[4] For a description of China's reliance on the Russian aerospace industry as part of its military modernization plans, see Coniglio, Sergo, "China's Aviation—A Military and Industrial Perspective," *Military Technology,* November 2004, pp. 14–21.

creasingly sophisticated array of electro-optical, guided antiaircraft artillery and surface-to-air missiles. A new generation of counters to the anti-tank guided missile is needed as well.

Furthermore, future opponents are likely to exploit the expanding civilian architecture of advanced space-based telecommunications, navigation, and surveillance systems. In many future conflicts, U.S. opponents may be able to rely on these global utilities in the expectation that the United States is unwilling to disrupt their own access to them.

Finally, a major information operations (IO) threat may emerge to challenge the capacity of the U.S. expeditionary force to operate rapidly and efficiently. The U.S. military's move from a "just-in-case" to a "just-in-time" logistics system leads to a much more information-intensive and information-dependent system, driven in part by the requirement to save peacetime dollars through a "revolution in business affairs."

There are powerful wartime motives as well. First, there is the need to create military services that are much more strategically and operationally agile. Second is the need for air-ground forces that can operate with a much smaller logistics "footprint" to reduce the number of concentrated high-value targets vulnerable to long-range missile attacks. Third is a requirement to reduce the number of aircraft and ships needed to move a logistics "mountain" into a hostile area.

These information-intensive military and supporting civilian infrastructures may become vulnerable to an array of information warfare attacks, including the use of physical, electromagnetic, and computer network attack tools and techniques. The Department of Defense will have to invest in its command, control, and communications systems to reduce the vulnerability of that architecture to IO. Given the U.S. military's reliance on the civilian strategic infrastructure, the Office of the Secretary of Defense will work closely with other elements of the federal government to stimulate the private sector—the owners and operators of these infrastructures—to take meaningful defensive and recovery measures.

Challenges to C4ISR. U.S. forces may have to quickly enter a region where a crisis is rapidly escalating and do so in rather limited

numbers. This possibility means that a premium will be placed on a global reconnaissance and surveillance capability that can rapidly be focused on wherever operations are taking place. In addition to the reconnaissance requirements of rapidly deployed forces, the fleeting nature and small targets associated with the GWOT (such as small terrorist groups) mean that a wide-area, real-time surveillance capability would be needed. Some of these assets will be manned, and others will be unmanned. In fact, much of the targeting against members of a TTO will come primarily from law enforcement and intelligence services, often using traditional tradecraft.

Key elements of the contemporary "revolution in military affairs" include the exploitation of the rapid advance in sensor, computer, and information technologies. Development of increasingly effective and responsive reconnaissance-strike capabilities is needed to find and destroy in a timely fashion the full spectrum of military targets that may present themselves during future conflict. Currently, major progress has been made in the development and deployment of Intelligence, Surveillance, and Reconnaissance (ISR) systems that can detect maneuvering armored forces and their associated logistic trains, warships operating on the surface of the ocean, and aerodynamic vehicles in flight. Major challenges remain, including developing ISR capabilities that can reliably detect and identify military forces operating in complex terrain such as cities and heavy forests, ground mobile missile (ballistic/cruise) launchers and long-range artillery systems operating from concealed and/or hardened locations, mobile EO guided low-altitude air defenses, submarines, and sea and land mines. The U.S. military has successfully invested in ISR capabilities that can find and identify traditionally configured military opponents equipped with contemporary fighting vehicles.

The challenge is to find and defeat opponents who either operate in the spectrum of irregular warfare or who may menace the United States with long-range mobile missile systems armed with chemical, biological, and nuclear warheads. Related challenges are the design and deployment of ISR systems than can provide effective targeting information against opponents who build extensive and deep underground facilities that both conceal and protect. Even with ma-

jor advances in various robotized sensor platforms, many forms of peace enforcement and combat in complex terrain will continue to require high-density ground-combat troops to seize and hold key terrain.

Why Will Sea Basing Be Important in This Environment for All the Services?

As discussed above, the United States may have difficulty securing access to facilities in coming years; unfortunately, it will still need to maintain an adequate U.S. presence in areas of vital interest. Even with possible negative political and diplomatic fallout from the Iraq war, the United States may find it possible to reconfigure its peacetime presence in both Europe and Northeast Asia in useful ways. In NATO Europe, there is the prospect of downsizing and reconfiguring the U.S. services' presence in Europe to facilitate future power-projection operations in the Greater Middle East and Africa. This would allow units to be redeployed to either CONUS or among forward operating bases, and to forward operating locations that may be created during the next few years.

However, in pursuing the GWOT, areas of vital interest for the United States are going to be within the zone of instability—a wide swath of territory that is distant from traditional American operating areas, allies, and facilities. The two services most affected by such situations are the Army and Air Force. The Navy and Marine Corps, because of their ability to operate indefinitely in international waters, will be able to compensate at least partly for a reduction of Army and Air Force elements from key regions through their sea-basing capabilities. In addition to providing normal peacetime presence in such areas, naval forces can be selectively increased in the event of an emerging crisis.

The emerging concept of sea basing will be an important factor in the naval forces' ability to project—and sustain—forces ashore. With sea basing, Marine combat power can build up more quickly in a littoral area, and the need to move considerable amounts of supplies

ashore will be minimized. As such, the sea-basing concept clearly has important uses during forcible-entry operations, which U.S. forces may confront in the future. But sea basing has value beyond forcible-entry operations, which are likely to be the exception rather than the norm. As mentioned above, the United States may have to conduct missions in the zone of instability or in Latin America, where a large U.S. military presence ashore is not politically acceptable. Therefore, considerable advantage can be gained by leaving as many functions offshore at the sea base as possible.

While the Navy and Marine Corps are currently thinking of sea basing in terms of enhancing their own capabilities, the concept of sea basing has use beyond just naval/marine forcible-entry operations or the sustainment of Marine Corps operations ashore in areas where granting access is not politically acceptable. The concept is also valuable as a part of joint operations involving the Army and Air Force.

Despite an effort to reduce its reliance on heavy armored forces, the Army is realizing that air deployment is feasible only for a small fraction of its forces. The tonnage required to deploy and sustain a sizable Army force is simply beyond the capabilities of airlift. Additionally, while airlift may allow a small number of forces to arrive in a crisis location quickly, within no more than two weeks, ships will arrive (assuming the crisis is accessible from the sea) carrying tonnage that totally dwarfs what can be deployed by air. If the Army's equipment is pre-positioned aboard ships, the time required to reach a crisis location can be considerably reduced. Therein lies the value of the Army becoming part of the sea-basing concept.

Today, the Army has maritime pre-positioned equipment at Diego Garcia. At some point, those ships will have to be replaced. If the Army could be encouraged to buy ships similar to those that the Marines will need for the Maritime Pre-Positioning Force Future (MPF(F)) squadrons, the Army's ability to deploy its forces rapidly would improve, as would its ability to sustain its operations from the sea. When an MPF(F) squadron sails from the Mediterranean Sea, Guam, or Diego Garcia to respond to a future crisis, Army (and Air Force) ships of similar type could be part of the force—all simultaneously protected by Sea Shield capabilities.

In the case of the Air Force, it currently has ammunition ships positioned in the U.S. Central Command region. If there is a crisis in a location where no Air Force munitions, fuel, and maintenance equipment are already waiting, Air Force operations would be initially constrained until the required supplies and equipment reach the area— a time-consuming process if the supplies (especially fuel and ammunition) have to be flown long distances to the austere bases where fighters await. By loading several ships with fuel, ammunition, and spare parts for, say, one Air Expeditionary Force of aircraft, the Air Force could considerably reduce the time required to commence operations from what would otherwise be poorly provisioned bases. Again, if such ships were integral to an MPF(F) squadron, they would move out together with Marine Corps and Army equipment, all protected by the Navy's Sea Shield.

Even with current and projected airlift and sealift capability, the U.S. services will face a major challenge to move significant combat power, say an MEB or Stryker Brigade Combat Team, transoceanic distances within a week. To deal with the reality of time and distance, it is likely that all the services will exploit an array of "hubs" located around the periphery of Eurasia. Currently, these hubs include Okinawa, Guam, Diego Garcia, Germany, the United Kingdom, Italy, Kuwait, and the Gulf Coordination Council states. In the future, these theater rear-echelon bases may include Darwin, Ascension Island, and other locations in Southeast Europe. Hubs are located within 2,000 nautical miles of most potential theaters of operation, which will allow for the exploitation of a major airfield and harbor where pre-positioned equipment and supplies can be kept on site on board black-hull ships. Airfields can be used to receive ground-combat personnel to marry up with sea-based equipment sets or to stage long-range bombers and their associated tankers. In the near future, several of these hubs may be equipped with high-speed (30-knot-plus) sealift ships to support a variety of Marine Corps and Army rapid-deployment postures. An attractive feature of most of the proposed hubs is that they are some distance away from potential missile threats, thereby allowing for the deployment of high-performance advanced air and missile defenses.

The hub concept coupled with an array of forward operating bases (FOBs) and forward operating locations (FOLs) can support a variety of power-projection concepts that range from rapid reaction to a surprise attack by a regional aggressor to taking a strategic and operational initiative in support of the GWOT. An FOB may have many of the functions of a hub, the key difference being that the FOB does not have as extensive a military infrastructure. Then again, several of the FOBs, such as those located in the Gulf Cooperation Council (GCC), may be much closer to air and missile threats and, thus, require a very robust local defense capability.

An FOL, as the name implies, will be temporary location, such as the current Task Force Djibouti. The role of traditional U.S. forces at an FOL will range from providing specialized special operations forces (SOF) that operate in the region, to providing more traditional combat, combat support, and combat service support units. The latter could be used to protect or back up SOF operations in a hostile region.

The organizational and conceptual changes within the U.S. military that started in the 1990s, including greater emphasis on joint operations and a focus on supporting operations ashore in littoral regions, have made the Navy and Marine Corps better prepared for the current and emerging strategic global security environment. However, the Navy and Marine Corps may require additional ships and personnel to meet a greater forward presence requirement and/or a newer and more creative rotation policy for their existing ships. One such policy being explored by the Navy is Sea Swap, a crew-change initiative now underway with *USS Fletcher*.

But significant increases in fleet size do not come about overnight. Short-term solutions might be required to compensate for reduced presence ashore, at least until the size of the fleet and Marine Corps can be adjusted appropriately. Short-term measures could include increasing the capability and quantity of precision munitions in carrier strike groups, thus increasing the effectiveness of their air wings; making provisions for rapidly increasing the number of aircraft aboard carriers after a crisis appears imminent; and providing the ability to surge amphibious deployments to increase the number of

Marines offshore if a crisis appears imminent. The Navy's new Global Concept of Operations that distributes combat striking power in a dispersed networked fleet is a move in the right direction.

However, in the longer term, the Sea Services will likely need more Navy ships and Marines if it became clear that the United States would have to increasingly rely on naval forces to maintain a credible presence in certain regions. The specific mix of gray-hulled and black-hulled ships for JFEOs is addressed in the next chapter.

CHAPTER THREE

Identifying Favorable Mixes of Gray Hulls and Black Hulls for Joint Forcible Entry Operations

As discussed previously in this report, JFEOs are one type of mission that likely will be part of sea basing in the future. A JFEO is defined by Joint Publication 3-18 (JP 3-18) as follows:

> Forcible entry is seizing and holding a military lodgment in the face of armed opposition. A lodgment is a designated area in a hostile or potentially hostile territory that, when seized and held, makes the continuous landing of troops and materiel possible and provides maneuver space for subsequent operations (a lodgment may be an airhead, a beachhead, or a combination thereof). A lodgment may have established facilities and infrastructure (such as those found at international air and sea ports) or may simply have an undeveloped landing strip, an austere drop zone, or an obscure assault beach.[1]

One of the key questions surrounding such operations in the future is, what are the favorable mixes of gray-hulled and black-hulled ships for JFEOs? As mentioned in Chapter One, we refer colloquially to amphibious ships built to military standards as "gray hulls" and to Maritime Pre-Positioning Ships (MPSs) built to commercial standards and operated by the Military Sea Lift Command as "black hulls." At present, JFEOs must rely on the military's gray hulls, because the current generation of MPF ships cannot offload selectively and do not support force reconstitution. However, the current generation of MPF ships will be replaced under the Navy's shipbuilding

[1] Joint Publication 3-18, "Joint Doctrine for Forcible Entry Operations," July 16, 2001.

program of record by MPF(F) ships, which will have those capabilities. Thus, looking to the future, we can examine possible changes to the shipbuilding program of record through the substitution of black hulls for gray hulls in terms of the Navy's capability to conduct JFEOs.

In terms of gray hulls, the United States currently has 37 amphibious warships, also called expeditionary assault ships, which are divided into 12 (three-ship) Amphibious Ready Groups (ARGs) and a command ship in support of presence requirements.[2] The centerpiece of each ARG is a *Wasp*-class or *Tarawa*-class amphibious assault ship. The five *Tarawa*-class general-purpose amphibious assault ships (LHA) will reach the end of their expected service lives in 2007–2021.[3] LHD-8 will replace one of these LHAs, while the LHA-Replacement (LHA(R)) program will replace the other four *Tarawa*-class LHAs, at a cost of approximately $3.2 billion each.[4] Each three-ship ARG is composed of an LHA or LHD, a dock landing ship (LSD), and an amphibious transport dock (LPD). The characteristics and functions of these ships, and of amphibious assault landing craft, are described in Appendix A.

These expeditionary assault ships provide forward-presence and crisis-response capabilities. They are designed to deliver the lead combat elements of a Marine Air-Ground Task Force (MAGTF)—which include combat troops, equipment, vehicles, and cargo—to an

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[2] Prior to World War II, the Marine Corps had no amphibious ships; much oversea Marine Corps troop movement used passenger liners. U.S. industry rose to the challenge of Pearl Harbor, and by 1944 the nation had a force of more than 2,000 amphibious ships. After the war, the level of amphibious forces fell as quickly, dropping to 60 ships in 1949. The number of amphibious ships was restored somewhat during the Korean and Vietnam wars, but the long-term trend has been a decline to a level of about three dozen amphibious ships.

[3] The first five amphibious assault ships, designated general purpose (LHA), were commissioned between 1976 and 1980. They were followed by seven more amphibious assault ships, designated multipurpose (LHD). LHAs were designed for a 35-year service life but are aging more quickly than expected; they are being replaced under the LHA Replacement (LHA(R)) program. LHDs will eventually be replaced; their successors are currently designated LHD(X).

[4] All cost figures cited in this chapter are in fiscal year (FY) 2003 dollars. The cost data were provided by the U.S. Navy.

objective area. Because they are expeditionary ships, they are capable of mounting sustained offensive and defensive combat. An amphibious force consists of a group of ships—the amphibious task force (ATF) and a landing force. The ATF is a mix of amphibious warships and support ships, sometimes augmented by black hulls, or MPS ships. During crisis or combat situations, most ATFs will operate with an aircraft carrier battle group, which provides cover for the ATF and supports operations ashore.

MPS ships are part of the Military Sealift Command's Pre-Positioning Program and pre-position Marine Corps vehicles (including tanks), fuel, equipment, ammunition, food, and water. Sixteen[5] MPS ships compose the MPF. The MPS ships are organized into three Maritime Pre-Positioning Ship Squadrons (MPSRONs), each commanded by a Navy captain. MPS Squadron One, usually located in the Atlantic Ocean or Mediterranean Sea, has five ships; MPS Squadron Two, usually located at Diego Garcia, has six ships; and MPS Squadron Three, normally in the Guam/Saipan area, has five ships. Each MPSRON is able to support approximately 17,000 Marines (roughly the equivalent of one MEB) in initial military operations for 30 days. Each ship can discharge cargo either pierside or while anchored offshore using lighterage carried aboard.

In the analysis that follows, we examine ship substitution options and issues within the framework of lift requirements, force closure performance, gray-hull missions, cost, risks, advantages, and implications for operational concepts. As part of this analysis, we also examine follow-on options[6] to LCAC amphibious landing craft in anticipation of the end of their service lives, which will occur early in the lives of the next generation of MPS—the Maritime Pre-Positioning Ship Force Future (MPF(F)). The topics of LCAC follow-on choices and the future amphibious force are inseparable; some follow-on options for LCAC could significantly improve force closure

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[5] Until recently, when three ships were added, the MFP had 13 MPS ships. For more information regarding MPS, see www.globalsecurity.org/military/systems/ship/sealift-mps.htm.

[6] A follow-on could consist of existing LCACs with a service life extension, a new (and probably larger) design, or a radical new design.

performance, reduce the cost of black hulls (by reducing requirements for expensive well decks), reduce risk to black hulls (by increasing workable standoff distances from objective areas), and have possible implications for future operational concepts.

In the remainder of this chapter, we provide the context for our analysis and then the analysis findings.

Context of Analysis

In providing the context for this analysis, we start with a quick look at the operational and analytical issues associated with JFEOs. Then, we describe the methodology we used to conduct the analysis.

Operational and Analytical Issues

The undeveloped state of JFEO concepts creates broad issues, both operational and analytic, to be addressed in this study. For purposes of this discussion, operational issues are those relating to concepts of employment and operational requirements. Analytical issues are those relating to what should be analyzed and how it should be analyzed.

Operational Issues. One set of operational issues centers on the potential for substituting black hulls for gray hulls. In addressing those issues, we focus on a series of questions:

- To what extent can MPF(F) ships be used directly in a JFEO? Can they be used directly to launch assaults?
- What survivability standards are appropriate for MPF(F) ships, and how would they be operated to reduce their vulnerability?
- What level of protection will be provided to MPF(F) under the Sea Shield concept?
- Can the same MPF(F) ship move between ESGs and MPSRONs?

These broad operational issues, all related to this analysis, are under discussion within the Navy and the Marine Corps. This analysis may shed some light on these issues by answering questions such

as what the consequence would be of taking up MPF(F) from future MPSRONs.

Another operational issue centers on the ability to operate with amphibious assault craft. At present, transfer of cargo is limited to sea states of two or less.[7] In some regions, transfer of cargo with current technology is possible less than half the time. For now, we posit that transfers at sea states higher than two will become possible.

Questions related to specific operational issues include the following:

- How far from shore should MPF(F) ships operate? *(*sea base distance from shore is an ongoing operational issue.) It has been argued that MPF(F) ships should be kept as far from shore as possible to reduce the threat of damage. It has also been argued they should be kept as close to shore as possible to achieve the same objective.[8]
- What are the aviation requirements? Fully sea-based operations may require additional (surge) aircraft. Where will aircraft be sea based so that they are available when needed?

Analytical Issues. Other than uncertainty about the characteristics of MPF(F) ships, questions related to the major analytical issues include the following:

- What are the key elements (people and things) that are required for JFEO?
- More specifically, to what extent is the set of measures defined by the system of five "fingerprints" listed in Chapter One—(1) number of troops, (2) vehicle square footage, (3) cargo cubic

[7] A *sea state* of two means that wave heights must be less than two feet for cargo transfer.

[8] The coastal cruise missile, one of the greatest threats to MPF(F), has a minimum effective engagement range (i.e., a minimum target range) at which the missile can detect, acquire, and home in on its target. It has been argued that if MPF(F) can be positioned inside the minimum effective range of coastal cruise missile launchers, they will be safe from those missile launchers. As an analogy, a small boat could pull up so close to a battleship that the battleship's guns could not be aimed at it.

footage, (4) VTOL aircraft deck spots, and (5) LCAC spots—adequate for balancing the mix of gray hulls and black hulls?
- What other items should be considered?
- What are the essential steps in the force buildup process and what do they require?
- Which of the essential steps are both time consuming and lie on the critical path to force buildup?

We examined the missions assigned to L-class ships and the extent to which the performance of those missions is reflected in the five fingerprints. The *Amphibious Ships and Landing Craft Data Book* describes the assigned missions for LPD and LHD ships as follows:

- The assigned mission of the LPD is to transport and land troops and their essential equipment and supplies in an amphibious assault by means of embarked landing craft or amphibious vehicles augmented by helicopter lift.
- The assigned mission of the amphibious assault ship (multipurpose) (LHD) is to embark, deploy, and land elements of a Marine landing force in an amphibious assault by helicopters, landing craft, amphibious vehicles, and by combinations of these methods. The LHD is assigned a secondary mission of sea control and power projection in which additional fixed-wing vertical/short takeoff and landing (V/STOL) aircraft and helicopters are deployed.[9]

The current warfighting lift requirement is stated in terms of MEB (AEs). Lift is calculated by evaluating transport capacity, or fingerprints, of the five basic categories listed above: (1) number of troops, (2) vehicle square footage, (3) cargo cubic footage, (4) VTOL aircraft deck spots, and (5) LCAC spots. As mentioned in Chapter One, the fingerprint system was developed in the DoN Lift II study

[9] U.S. Marine Corps, Department of the Navy, *Amphibious Ships and Landing Craft Data Book,* MCRP 3-31B, Washington, D.C.: Headquarters United States Marine Corps, October 1, 2000, p. 6.

conducted more than a decade ago and has been used ever since to describe the evolution of the MEB, amphibious ship capacities, and requirements for new amphibious ships.

As often happens when simple measures are developed to describe complex systems, the five-fingerprint system has idiosyncrasies:

- The **number of troops** that can be lifted depends on standards of habitability (the amount of space per person and the arrangement of the shipboard accommodations).
- **Vehicle square footage** (sometimes called "vehicle square") can be altered on pre-positioning ships by changing the density of stored vehicles. Selective offload requires a relatively low vehicle storage density. Some ships currently being conceived have increased vehicle square to accommodate the need to move vehicles into specific combat-loaded configurations. Vehicle square is currently the lift fingerprint in shortest supply.
- **Cargo storage** is measured by the net cubic feet of cargo that can be stored. Selective offload also requires a relatively low cargo-storage density.
- **VTOL deck spots** is measured using "CH-46 equivalent spots." The Naval Air Systems Command (NAVAIR) provides the number of CH-46 equivalent spots by ship class for flight-certified ships. VTOL aircraft are assigned a "spot factor" according to aircraft type and model, which represents the aircraft's storage requirement as compared with that of the CH-46 helicopter. It enables planners to determine viable mixes of VTOL aircraft for a given ship. A wrinkle in this process is that spot factors are determined separately and vary slightly by ship class. By definition, the CH-46 helicopter has a spot factor of 1.0. The larger CH-53D helicopter has a spot factor of about 1.6, depending on ship class.
- **LCAC spots** is a count of the number of LCACs a ship can carry and operate. A ship may use its LCAC spots for landing craft other than LCACs. Also, pre-positioning ships with LCAC spots may not carry any landing craft. LCACs, in particular, are in

limited supply, expensive, and maintenance intensive; thus, they may be unsuited to being carried routinely by pre-positioning ships. While this study was in progress, the Marine Corps Concept Development Center (MCCDC) updated the MEB(AE) standard to be used in studies done within a few years of 2015 by increasing the number of required LCAC spots from 24 to 31, which is consistent with a recent Center for Naval Analyses (CNA) study that suggests a number ranging around 30 per MEB.[10]

The five fingerprints largely capture the mission assigned to the LPD-17. However, they do not, of course, capture risk or cost. The LPD mission statement, repeated elsewhere in Marine Corps documents beside MCRP 3-31B, suggests that the five fingerprints, plus risk and cost, are adequate for the purpose of LPD-17 analysis for this study. However, additional filters are required to analyze alternatives to LHA(R). For both the LPD-17 and the LHA(R), the fingerprints can be used to determine the range of substitutions possible and to reject some MPF(F) options as being unsuitable substitutions. For example, and to get ahead of the current discussion for a moment, an MPF(F) ship without a well deck cannot be substituted for LPD-17.

Another analytical issue raised during this study is the need to examine ship-to-shore maneuver. The reason for analyzing differences between amphibious and MPF forces in maneuver capability is that the crux of forcible entry is the transition from deployment to employment. Therefore, difference in maneuver capability would be a useful force discriminator. While we recognize that maneuver capability is at the heart of amphibious operations, it is not clear that a maneuver analysis would be productive at this time. Sea base distance from shore and the operational characteristics of a yet-to-be-invented transfer system (capable of operating in sea states above two) would be major unknowns. Moreover, any maneuver analysis addressing an appropriate concept of employment for the sea base would be ham-

[10] Center for Naval Analyses, *The LHA(R) Analysis of Alternatives Summary Report,* Alexandria, Va.: CNA, CRM D0006422.A, September 2002, p. 38.

pered by a dearth of design data, the absence of good maneuver models, the lack of operational experience with comparable ship designs, and a lack of consensus. Thus, within the context of this study, it was not possible to achieve meaningful, reasonably assured, and widely acceptable results for maneuver capability.

Combat outcome was also considered as another means of differentiating between forces. However, a combat outcome analysis was found to be infeasible given the variety of force alternatives under consideration in this study.

As a result, we selected the following primary measures, among others:

- **Ability to Meet Emerging Amphibious Lift Requirements**. As we discuss later in this chapter, we find a situation in which the shipbuilding program of record no longer meets programming goals. We examine this problem and the means to remedy it.
- **Time to Achieve Force Closure**[11] **(Particularly Within the Zone of Instability).** Because closure time has been used in previous studies, good models and data for measuring closure time are available. Also, a preliminary analysis suggested that closure time would be a useful force discriminator. We built a new closure model capable of representing simple planning decisions and used existing spreadsheet models to verify it.
- **Resources Required for Earliest Force Closure**. Resource requirements go directly to operational flexibility under the Global CONOPS (described in Chapter One).

Analysis Methodology

In identifying favorable mixes of gray and black hulls for JFEO, the key questions to be answered are (1) how the program of record might be modified advantageously through the substitution of black

[11] *Force closure* is the point in time when a supported joint force commander determines that sufficient personnel and equipment are in an operational area to carry out assigned tasks (Department of Defense, *Department of Defense Dictionary of Military and Associated Terms,* Joint Publication (JP) 1-02, April 12, 2001).

hulls for gray hulls, (2) what the alternatives are and which alternatives appear to be the most advantageous, (3) which choices cost more or save money, and (4) what the risks involved with each choice are.

The key transformational abilities provided by the JFEO concept include increased U.S. joint force responsiveness; the ability to rapidly defeat anti-access strategies; and leaner, more agile forces. Speed is increased by compressing each operational phase and by conducting phases in parallel. Naval forcible entry operations have five phases: Preparation and Deployment (Phase I), Assault (Phase II), Stabilization of the Lodgment (Phase III), Introduction of Follow-On Forces (Phase IV), and Termination or Transition Operations (Phase V).[12] Of the five phases, Phases I and II are most closely linked to the issue of balancing gray and black hulls; however, the data that were available to RAND did not support a quantitative analysis of the assault phase. Therefore, the analysis methodology developed for this study focused on Phase I—Preparation and Deployment—with an emphasis on the ability to support Phase I and the speed at which Phase I can be accomplished.

Filtering. The methodology developed for this study dealt with large uncertainties about key characteristics and costs of MPF(F) ships. At the core of the methodology is a process called *filtering*. The filtering process, sometimes called *screening,* is a traditional RAND methodology. It is used primarily when the number of cases that might be studied exceeds a study's capability for detailed examination. Filtering uses rejection criteria to eliminate the least-promising alternatives while attempting to retain the most-promising ones for more detailed scrutiny. Rejection criteria are developed, and alternatives are passed through filters sequentially, with candidates screened out at each stage of the process. Rejection criteria generally do not consider all aspects of a problem. For example, a force mix that clearly fails to meet static lift requirements can be rejected, regardless of all other considerations. This approach can be used to avoid or bypass uncertainties in an analysis.

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[12] Joint Publication 3-18, "Joint Doctrine for Forcible Entry Operations," July 16, 2001, pp. III-1–III-5.

When uncertainties must be addressed, they are identified explicitly and incorporated into the analysis—a key element of Capability Based Planning. Rather than using point scenarios (those without a range of conditions) to eliminate uncertainty, we evaluated each force alternative in the context of scenarios set in ten regions selected for force closure—Colombia, Nigeria, Lebanon, Somalia, the Gulf of Oman, Bangladesh, the Strait of Malacca, Taiwan, the Philippines, and the Korean Peninsula.

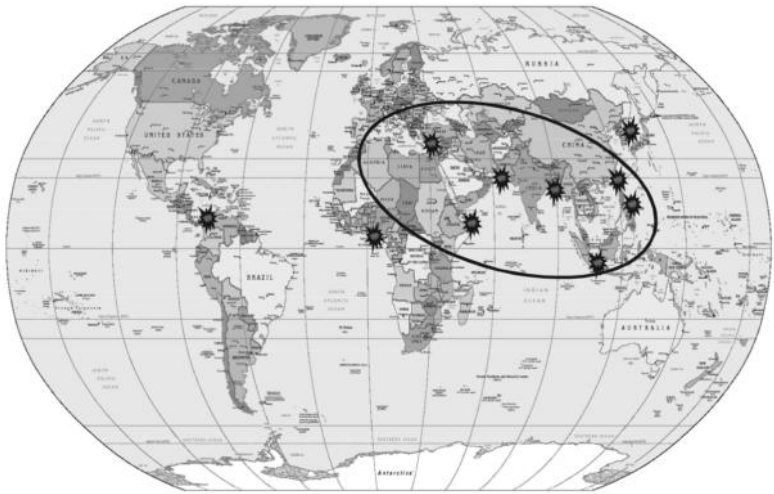
As shown in Figure 3.1, the ten regions are clustered in the zone of instability. We examined each region using two representative initial-force dispositions at the time force movement begins, consistent with the Global CONOPS: (1) the six-ESG case: two deployed ESGs (Mediterranean Sea and Gulf of Oman) and four surge ESGs (Japan Forward Deployed Naval Forces (FDNF), two in Norfolk, and San Diego); and (2) the five-ESG case: two deployed ESGs (Gulf of Oman and Japan FDNF in the Philippines) and three surge ESGs (two in Norfolk and San Diego). (See Appendix C for more details on the force dispositions.)

Beyond the ESGs enumerated in these two cases, additional "backfill" ESGs are required to maintain presence as forward deployed ESGs are moved to a crisis region. The so-called six-ESG case, therefore, requires one or two additional ESGs for backfill. With up to eight of 12 ESGs either deployed or ready to surge, the six-ESG case requires two-thirds (8/12) of the amphibious force to be deployed or ready to surge. In terms of readiness and availability, it is the best case.

The ability to respond to crises in selected regions depends on the deployment posture at the start of a crisis, which is an uncertainty. In this analysis, we used two representative deployment postures for each region, which gave us at least 20 scenario cases for evaluating each alternative.

Filtering uses analytic resources efficiently. Later in this section, we analyze force-mix alternatives that might not otherwise have been considered without filtering, and we found some of them to be

Figure 3.1
Regions Selected for Force Closure



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attractive. As a final note on filtering, emerging information may create more filters at a later date; alternatives that seem to be attractive at this stage of analysis might yet be rejected with further analysis.

The filtering methodology we used in this analysis describes the program of record, marshals what is known of black-hull alternatives, and considers alternative mixes of gray and black hulls for JFEO under the concept of Sea Power 21. We selected three filters:

- **Lift Capacity Requirements**. Static lift requirements are expressed in terms of the MEB (AE) requirements for the five fingerprints: troops, vehicle storage area, cargo volume, aircraft spots, and well deck spots. For this study, we used the fiscally constrained DoN/Quadrennial Defense Review (QDR) programming goal of lifting 2.5 MEB(AE) as the requirement. Any force alternative that worsens the lift shortfall for the 2015 MEB is rejected.
- **Dynamic Lift Performance**. The time to achieve force closure (i.e., build up an operational force) is paramount to considering

alternatives to the program of record. We will show later that the program of record is capable of reducing force closure time on a global basis under the Global CONOPS. Any alternative that slows force closure relative to the program of record is rejected.

- **Cost**. The initial intent of this study was to make equal cost or equal performance comparisons of the alternatives. However, the latest available cost inputs for MPF(F) variants have been invalidated. As a result, cost has been reduced from a potential filter for making comparisons to a guidelines for future decisionmaking.[13]

We also considered risks associated with the alternatives. Risk comes in several forms, including cost risk. Because risk acceptability is subjective, risk cannot be used as a filter. However, we have noted the observed risks as potential inputs for future decisionmaking.

Force-Mix Alternatives. As indicated in the Global CONOPS (see Chapter One), the Navy should consider direct substitution of black hulls for gray hulls.

Three groups of force-mix alternatives were selected for this analysis:

1. The program of record as defined by the 30-year Shipbuilding and Conversion, Navy (SCN) plan.
2. The program of record modified by *procuring additional black hulls* to be substituted for amphibious ships while reducing the number of amphibious ships.

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[13] Cost estimates for MPF(F) more than doubled over the course of this analysis. With MPF(F) designs still in flux, cost estimates must be considered as being highly uncertain. Given such uncertain cost estimates, we elected to provide cost rules to be used when costs become firm, rather than cost-savings estimates. In seeking a favorable mix of gray and black hulls, we considered the possibility of using some form of mathematical programming, such as integer programming. The problem we faced was how to simultaneously minimize the duration of the emerging lift shortfall (measured in years) while minimizing time to achieve force closure (measured in days) and the number of ESGs and MPF(F) squadrons required for earliest possible force closure. The complexity of this problem is compounded by nonlinear problem constraints.

3. The program of record modified by *taking up black hulls from future MPSRONs* to be substituted for amphibious ships while reducing the number of amphibious ships.

We use the term Expeditionary Support Ship (ESS) for an additional black hull to be substituted for gray hulls to avoid confusion with MPSRON ships.[14] The summary report on the LHA(R) analysis of alternatives defines the ESS as follows:

> The essential characteristics of an ESS include: (1) the ability to assemble in the open ocean and offload to amphibious ships and to the shore, (2) multiple MV-22/CH-53 operating spots and LCAC interface (a well deck, or some type of side discharge facility, or other arrangement that is workable up to sea state 3, (3) the capacity to store a substantial amount of vehicles and cargo and to conduct selective offload, and (4) enhanced survivability compared to a commercial ship or LMSR (but less than a combatant)—and all at a cost that is affordable.[15]

The *essential* characteristics of an ESS stated above are entirely consistent with the findings of this study.

Analysis Tools. RAND elected to develop two main tools—a Static Lift model and a Dynamic Lift model—to support decisions based on the five fingerprints while also providing additional information to aid decisionmakers. By design, the tools can be used to examine a wide range of lift issues beyond those related to the five fingerprints. Both models have an open-ended architecture (i.e., have no practical limit to the number of closure factors that can be tracked). The two models are described briefly next and in more detail in Appendix B.

The Static Lift model is a simple tool for calculating total amphibious lift by year expressed in terms of the five fingerprints. Re-

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[14] For convenience, we use the term Maritime Prepositioning Ship Squadron Future (MPSRON(F)) to designate a future MPSRON made up of MPF(F) ships.

[15] Center for Naval Analyses, *The LHA(R) Analysis of Alternatives Summary Report,* Alexandria, Va.: CRM, D0006422.A, September 2002, p. 40.

sults are expressed in terms of MEB lift. The model was used for this study to calculate lift over the period 2008–2025 using the 30-year shipbuilding program. Results are expressed in terms of the 2015 MEB.[16]

The Dynamic Lift model determines how quickly force closure (Phase I) can be accomplished, how early the assault phase (Phase II) can begin, what resources are required to establish a sea base as quickly as possible, and what the most salient features of the assembled force are. The Dynamic Lift model addresses these questions according to the force requirement, the initial disposition of amphibious forces, MPF(F) characteristics, and the force closure location. The model moves all useful and available assets as soon as possible[17] toward a designated crisis region while monitoring force closure using the five fingerprints. When the last fingerprint is satisfied, the model notes the time to achieve force closure, the resulting fingerprint levels, the assets used, and the selected force characteristics. This model was developed with extensive cooperation of OPNAV N7 (Warfare Requirements and Programs) personnel. Essential steps in the buildup process were developed through discussions with OPNAV N7 personnel and evolved over the course of the study. Some examples of essential steps that are time consuming and that could be on the critical path to force buildup are ship loading and troop movement. These steps were included in the analysis using OPNAV N7 inputs, and the model was tested against material furnished by OPNAV N7.

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[16] The Static Lift model can also calculate lift in terms of the 1991 MEB, or in terms of hypothetical MEBs.

[17] Some amphibious assets cannot move immediately upon warning. Surge ESGs must load troops before they can move. Some ESGs must queue up behind other ESGs in the loading process. MPSRONs may be required to transport troops and, therefore, may be held in port until troops reach them.

Analysis Findings

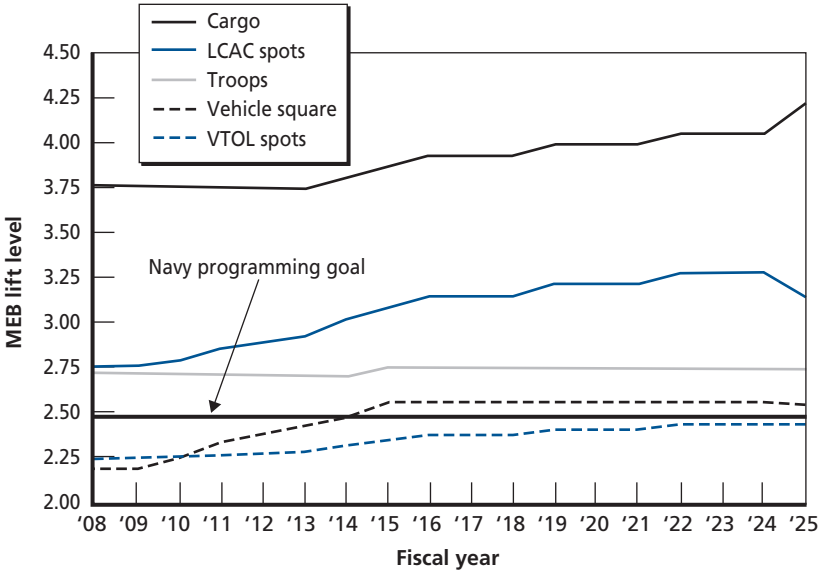
This section presents the results of our analysis for the three alternatives discussed is the previous section: (1) shipbuilding program of record; (2) program of record modified by procuring additional black hulls to be substituted for amphibious ships while reducing the number of amphibious ships; and (3) program of record modified by taking up black hulls from future MPSRONs to be substituted for amphibious ships while reducing the number of amphibious ships. In each case, we examine the results from applying the static lift and dynamic lift models. Finally, we also analyze alternative assault landing craft.

Alternative 1: The Shipbuilding Program of Record

Static Lift Findings. Figure 3.2 shows lift levels by fingerprint for the program of record. As seen in the figure, cargo lift exceeds the level of 4 MEB lift in the outer years. LCAC spots peak at more than 3.25 MEB. Troop capacity stays relatively constant around 2.75 MEB. Vehicle square, the current limiter, begins to increase in 2009 and exceeds 2.5 MEB(AE) lift in 2015. VTOL spots are the limiting fingerprint beyond 2015. This figure may suggest that LCAC spots, which have the second-highest lift level, are not a problem from the perspective of static lift requirements. They become a problem, as shown in the next section, in force closure using a mix of gray hulls and black hulls.

As can be seen from the figure, the program of record will not provide 2.5 MEB(AE) amphibious lift by 2025. The explanation for this anomaly lies in the fact that the definition of the MEB—the ruler against which amphibious lift is measured—has been stretched. Had it not been changed, the lift requirement would have been met. This complex situation is illuminated in Figure 3.3, which compares changes in requirements (between the 1991 MEB and the 2015 MEB) with the corresponding change in lift capacity (from the current amphibious force to its 2025 counterpart). The figure supports the following observations:

Figure 3.2
Lift Levels by Fingerprint for the Program of Record



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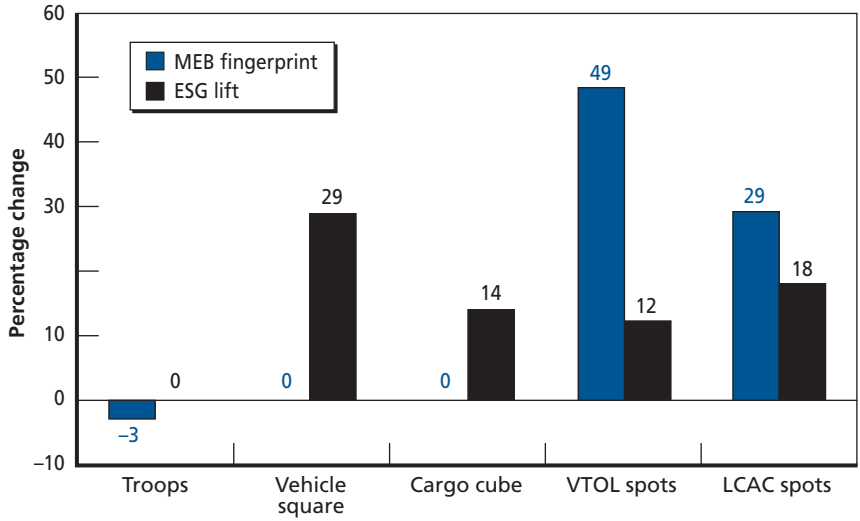
- The 2015 MEB will have fewer troops than the 1991 MEB, while amphibious troop lift essentially will be fixed.
- The vehicle lift requirement is unchanged, while lift capacity will increase, suggesting that the current shortfall in vehicle lift will be reduced.
- The cargo lift requirement is also unchanged, while cargo lift capacity will also increase.
- The VTOL spot requirement will increase by nearly 50 percent, outstripping a modest increase in VTOL lift capacity. This suggests a possible lift shortfall in VTOL spots.
- Similarly, the LCAC spot requirement will increase by nearly 30 percent, outpacing an increase in LCAC lift capacity.

Figure 3.3
Changing Lift Requirements and Capacities



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Overall, Figure 3.3 indicates a shift in lift requirements, with VTOL and LCAC spots rather than vehicles as driving lift operations. The following discussion explores this finding quantitatively to provide a better understanding of the situation and to illustrate the operation of the Static Lift model.

Because the MEB is the yardstick for lift, the model begins with MEB data. Table 3.1 compares the 1991 MEB with the 2015 MEB in terms of the fingerprint lift requirements of both. Where fingerprints have changed, the percentage change is shown. These percentage differences are mirrored in Figure 3.2 above.

Next, net amphibious lift is determined, by fingerprint, by finding the lift for each amphibious ship class (such as LSD-41), multiplying that figure by the number of ships in the class, and summing across classes. Table 3.2 compares the total amphibious lift for the current force and the 2025 force under the program of record.

Table 3.1
1991 and 2015 MEBs, by Lift Fingerprint

Fingerprint	1991 MEB	2015 MEB
Troops	13,100	12,700 (–3%)
Vehicles (x 1,000 square feet)	300	300
Cargo (x 1,000 cubic feet)	560	560
VTOL spots	175	260 (+49%)
LCAC spots	24	31 (+29%)

Next, we divide the entries in Table 3.2 by their corresponding entries in Table 3.1, which gives the desired result by fingerprint. For example, with a net lift capacity of 35,087 troops in 2003 (see Table 3.2) and a 1991 MEB troop level of 13,100 (see Table 3.1), 2.68 MEBs worth of troops can be lifted. With a net lift capacity of 35,096 troops in 2025 and a 2015 MEB troop level of 12,700, there will be a capability to lift 2.76 MEBs worth of troops. The results for the two cases are shown in Table 3.3.

The last step involves using the lowest value from Table 3.3. For the 2003 force, the lowest value—1.99—is for vehicles, while for the 2025 force, the lowest value—2.45—is for VTOL spots. Taken together, this results in the current amphibious force having a net lift capacity—limited by vehicle capacity—of 1.99 MEB(AE) for the 2015 MEB. Under the program of record, net lift capacity will increase to 2.45 MEB(AE)—limited by VTOL capacity. Thus, the program of record does not quite reach 2.5 MEB(AE) lift through 2025.

The Static Lift model automates the previous calculations and was used with the program of record (the results shown in Figure 3.2) to produce the results shown in Figure 3.4. As the figure shows, a total lift level of 2.5 MEB(AE) is approached in the outer years but is not achieved within the time period of interest.

The number of ESGs required to lift a MEB is another indicator of static lift capacity. A question to ask at this point is, on average, how many ESGs are needed for one MEB(AE) lift? The capacity of the average ESG can be found by dividing the total lift capacity (see

Table 3.2
2003 and 2025 Amphibious Force Lift, by Lift Fingerprint

Fingerprint	2003 Amphibious Force	2025 Amphibious Force
Troops	35,087	35,096 (+0.02%)
Vehicles (x 1,000 square feet)	596	768 (+29%)
Cargo (x 1,000 cubic feet)	2,072	2,363 (+14%)
VTOL spots	569	638 (+12%)
LCAC spots	83	98 (+28%)

Table 3.3
2003 and 2025 Lift Capacity in Terms of 2015 MEB

Fingerprint	2003 Lift Capacity	2025 Lift Capacity
Troops	2.68	2.76
Vehicles (x 1,000 square feet)	1.99	2.56
Cargo (x 1,000 cubic feet)	3.7	4.22
VTOL spots	3.25	2.45
LCAC spots	3.46	3.16

Table 3.2) by the number of ESGs, which is expected to be 12, as discussed earlier. The resulting average ESG lift capacities are shown in Table 3.4, while the average number of ESGs required for each fingerprint is shown in Table 3.5 (which is calculated by dividing MEB fingerprint levels by average ESG capacity in terms of fingerprint). Dividing the totals in Table 3.2 by the corresponding entries in Table 3.3 gives the mean number of ESGs required to achieve one MEB(AE) lift by fingerprint (see Table 3.5).[18]

These results support the following observations:

- The 2025 force will be more efficient than the 2003 force. At least six ESGs would be required for a 1.0 MEB(AE) lift using the current force. The 2025 force could achieve the same lift with five ESGs. Thus, the program of record in 2025 will pro-

[18] These numbers could be arrived at more simply. However, the technique used here has the additional benefit of providing descriptions of the ESGs.

vide greater operational flexibility than a replacement-in-kind force.

- The 2025 force will be able to support larger operations. Looking at the Global CONOPS, no more than six ESGs would be available on a day-to-day basis. With six ESGs, the current force could support a sustained MEB-level forcible entry operation. The 2025 force, with six ESGs, could support the same operation plus one at the Marine Expeditionary Unit (MEU) Special Operations Capable (SOC) level, which requires a single ESG.

Dynamic Lift Findings. The speed with which force closure can be accomplished and the level of effort required for force closure are closely related. This section addresses both topics, comparing the program of record against the lift yardstick of the current force. Specifically, these comparisons use *today's amphibious force and MPSRONs against the amphibious force of 2025 and MPSRON(F)*.

Figure 3.4
Program-of-Record Lift Level, Relative to 2015 MEB

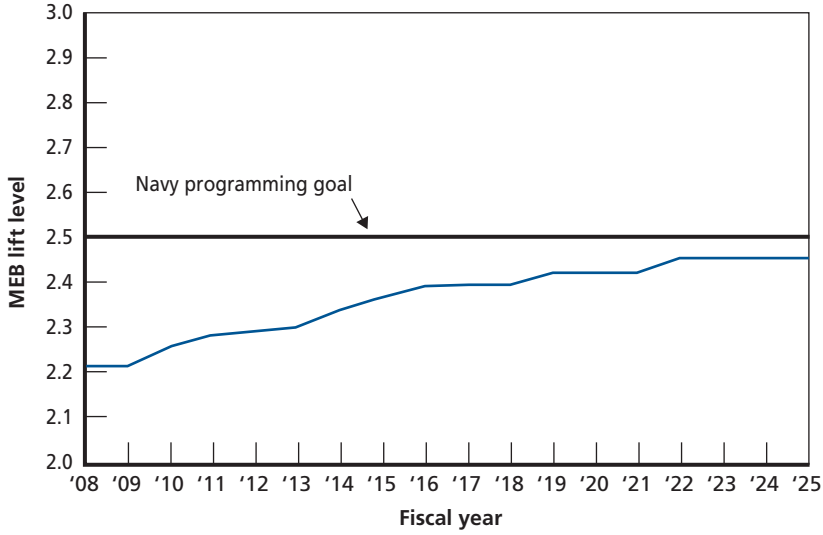

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Table 3.4
Mean 2003 and 2025 ESG Lift Capacities, by Fingerprint

Fingerprint	2003 ESG	2025 ESG
Troops	2,924	2,925
Vehicle (x 1,000 square feet)	49.6	64
Cargo (x 1,000 cubic feet)	172.7	197
VTOL spots	47.4	53
LCAC spots	6.9	8.2

Table 3.5
Mean Number of 2003 and 2025 ESGs Required for One 2015 MEB Lift, by Fingerprint

Fingerprint	2003 ESGs	2025 ESGs
Troops	4.35	4.34
Vehicle	6.06	4.69
Cargo	3.25	2.84
VTOL spots	5.50	*4.91*
LCAC spots	4.48	3.78

The analysis considers the time and resources required to establish a sea base as quickly as possible and the salient features of the assembled force. It is also intended to provide insights into the time required to begin an assault phase.

We begin with a look at the six-ESG initial force disposition case[19] for force closure in the Gulf of Oman. From Table 3.4, we can see that six current ESGs are required to satisfy all lift fingerprint requirements. Therefore, all six available ESGs must be used. The last ESG to arrive in the Gulf of Oman comes from San Diego—it requires 32 days to prepare and transit. Thus, the current force (or a future force with replacement in kind) completes force closure in 32 days, as shown in Figure 3.5.

[19] The six ESGs include two deployed ESGs (Mediterranean Sea and Gulf of Oman) and four surge ESGs (Japan Forward Deployed Naval Force, two surge ESGs in Norfolk, and one surge ESG in San Diego). Two additional "backfill" ESGs are required to maintain presence requirements.

However, by combining three 2025 ESGs and one MPSRON(F), 100 percent of 2015 MEB lift requirements can be met. Force closure can be achieved by the three deployed ESGs and a single MPSRON(F), which means that no ESG movement from the continental United States to the Gulf of Oman is needed. Under the program of record, and as shown in Figure 3.5, the 2025 amphibious force completes closure in 16 days—*a 50 percent reduction in closure time*. The result for the Gulf of Oman is representative of results for all the scenarios examined for this study.[20]

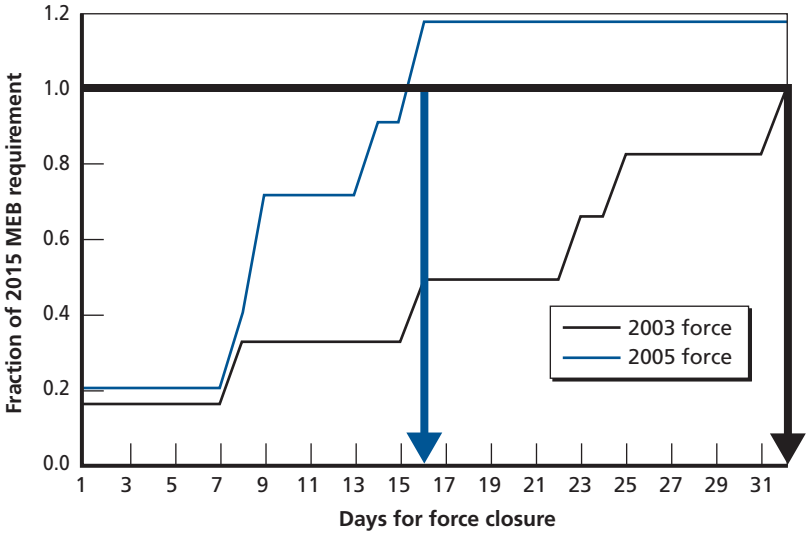
The point at which assault operations can begin using a rolling buildup obviously depends on the specifics of the scenario and on military judgment. That said, today's amphibious force would take about twice as long as the 2025 program of record force to achieve high buildup levels. Similarly, the current force would take twice as long as the 2025 program of record force to achieve a 100-percent buildup. The current force would take 27 days to achieve an 80-percent buildup, whereas the 2025 program of record force would take 13 days. This suggests that the 2025 program of record can begin an assault phase in half the time required by the current force, a finding that is clearly transformational.

We find that under the program of record, the amphibious force of 2025, with MPF(F), can achieve force closure in about half the time required for today's amphibious force and MPRSONs. By inference, the amphibious force of 2025, with MPF(F), can also begin an assault phase in about half the time.

The deciding factor in these time reductions was MPF(F), given their large ship capacities and selective offload. More specifically, when current and future amphibious forces and MPF(F) squadrons were mixed, the current amphibious force with MPF(F) ships did almost as well as the 2025 force. This outcome specifically reflects the

[20] Force closure time was reduced by at least 50 percent in five of the ten locations. Within the zone of instability, it was reduced by 40 to 55 percent. More details are provided in Appendix C.

Figure 3.5
2003 and 2025 Program-of-Record Force Closure Times for Gulf of Oman Scenario



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addition of selective offload and VTOL spots to the New Design Rotary Wing Only MPF(F) ship (see Appendix C for more information on this MPF(F) option).

Under the program of record in 2025 for MPF, the fingerprint in shortest supply is VTOL spots; for MPF(F) ships, the fingerprint in shortest supply is LCAC spots. The 2015 MEB requires nearly 50 percent more VTOL spots and nearly 30 percent more LCAC spots than the 1991 MEB. These two fingerprints then emerge as problem drivers by 2025. The New Design Rotary Wing Only MPF(F) ship has nearly as many VTOL spots as an LHA/D. Replacing MPF ships with MPF(F) ships more than meets the increased demand for VTOL spots.[21] With the additional demand for VTOL spots met by

[21] Per Table 3.5, five ESGs are required to provide the VTOL spots for a MEB; the average ESG will have 20 percent of the VTOL spots for an MEB. For the New Design Rotary Wing Only MPF(F), each MPSRON will have 90 percent of the VTOL spots needed for a MEB. The VTOL fingerprint requirement is met when one ESG and one MPSRON meet

MPF(F), LCAC spots become the driving fingerprint.[22] Clearly, for an MPF(F) ship without VTOL spots, VTOL spots would reemerge as the driving fingerprint, followed by LCAC spots.

Under the program of record, typically two or three ESGs and one or two MPSRON(F)s can be used to assemble the sea base most quickly. In a typical case, such as the Gulf of Oman scenario, model results show that planners could either use a single MPSRON(F) (for global operational flexibility) or two MPSRON(F)s (for added capability) without affecting closure time.

We found that the time to achieve force closure with the 2025 force was similar in the six-ESG and five-ESG case. The Dynamic Lift model was often able to offset the loss of an available ESG by using an additional MPSRON(F). In contrast, force closure for one 2015 MEB is unachievable with five 2003 ESGs.

Risks and Advantages. The program of record minimizes warfighting risks at the risk of unaffordability. The total cost of the remaining six programmed LPD-17s—at $1.14 billion each—will be approximately $6.8 billion. An additional 18 MPF(F) ships—with a rough order-of-magnitude cost of $1.75 billion each—is expected to be $31.5 billion. A total outlay of about $38 billion would then be

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up. *With this in mind, closure rate and the driving fingerprint do not depend on the exact characteristics of the MPF(F) design*. Using the Gulf of Oman case as an illustration, three ESGs and one MPF(F) MPSRON were used for force closure. The three ESGs provided 60 percent of the required VTOL spots. Decreasing the number of VTOL spots on the MPF(F) by 50 percent, for example, so that the MPSRON provides 45 percent of the needed VTOL spots, does not change the time for force closure. Similar logic applies to the LCAC-spot fingerprint.

[22] The LHA(R) Analysis of Alternatives (AoA) projects *excess* LCAC spots. There are two reasons for this apparent contradiction. First, CNA's study used a 2015 MEB having an LCAC fingerprint of 24 LCAC spots instead of the updated requirement of 31 LCAC spots. The second reason is less obvious. *Looking only at ESGs*, the average ESG for 2025 has at least one more LCAC spot than the current average (see Table 3.6). Using ESGs only, the five 2025 ESGs required to close a one-MEB force provide 41 LCAC spots—ten more than the 31-LCAC-spot requirement. MPF(F) changes this equation. The same force closure can be accomplished with three ESGs and one MPSRON. Inserting one MPSRON (with a total of six LCAC spots) and removing two ESGs (with a total of 16 LCAC spots) reduces the total number of LCAC spots to 31. Rather than exceeding the requirement, it is met with *no spare LCAC spots*. Simply put, MPF(F) vehicle and cargo capacities that are large relative to the ship's LCAC capacity shift the fingerprint balance.

expected if it is calculated out to 2025, amounting to about $1.5 billion annually. However, the DoN FY 2004/2005 procurement program indicates an average budget of about a billion dollars a year for FY 2002–2005. The risk of unaffordability is further amplified by the large (18-ship) MPF(F) buy. To illustrate, if the cost of MPF(F) ships were to reach $2.5 billion each, MPF(F) cost would be FY03 $45 billion, and total cost under the program of record would reach about FY03 $52 billion. LHA(R) costs, unknown at this time, will increase the total outlay. Furthermore, the goal of increasing the Navy force level from 292 ships in FY 2004 to 375 ships under the Global CONOPS may heighten competition for Shipbuilding and Conversion, Navy (SCN) funds and worsen the problem of unaffordability.

Another risk associated with the program of record, gleaned from our discussions with N7 personnel, is the risk of a lack of flexibility due to the program's tendency toward "heavy forces" that are best suited for high-end scenarios. A mix of gray and black hulls could provide new dimensions of response for less-threatening scenarios. More generally, MPF(F) ships offer the advantages of adaptability and flexibility that are absent in gray hull designs. For example, the LPD-17, optimized for vehicle storage, cannot be adapted in response to increasing demand for VTOL spots that are needed to conduct sea-based operations.

Shipyard requirements (in terms of schedule and capacity) present risks related to manufacturing capabilities. The requirements for building the LPD-17 class are known, so there is no question of the feasibility of building LPD-17s. However, the same cannot be said for building additional MPF(F) ships. The program of record also offers a stable and mature LPD-17 as opposed to the unknowns of the MPF(F).

Alternative 2: Program of Record Modified by Procuring Additional Black Hulls to Substitute for Amphibious Ships, While Reducing Number of Amphibious Ships

The second alternative we analyzed calls for additional MPF(F)—ESS—to be substituted for L-class ships, while meeting static lift requirements and not degrading force closure performance. More spe-

cifically, we sought to determine whether cost savings are possible with this alternative and which substitution alternatives are the most attractive.

We begin by looking at the planned procurements for the amphibious force and MPF(F) program of record, listed in Table 3.6. (The LPD-17, LHA(R), and MPF(F) ships are discussed in detail in Appendix A.) As the shading in the table shows, LPD-17 and MPF(F) procurements overlap in time; the last four LPD-17s will be procured during the same period that the first six MPF(F) ships are procured. This makes the LPD-17 a candidate for substitution by additional MPF(F) ships. Similarly, additional MPF(F) ships could be used in place of LHA(R) ships as a replacement for retiring LHAs. The LSD(X) is a placeholder replacement for the LSD-41 class; the

Table 3.6
Planned MPF(F) and L-Class Procurements

Fiscal Year	LPD-17	LHA(R)	18-Ship MPF(F)	LSD(X)	LHD(X)
2006	2				
2007	1	1			
2008	1		1		
2009	1		2		
2010	1	1	2		
2011	1		1		
2012			2		
2013		1	2		
2014			1		
2015			2		
2016		1	1		
2017			1		
2018			1		
2019			2		
2020				1	
2021				1	
2022				1	1
2023				1	
2024				1	
2025				1	1

LSD(X) has defined performance and cost characteristics only if alternatives are analyzed. Thus, it cannot be considered as a substitution candidate. Similarly, LHD(X) cannot be considered as a substitution candidate. LPD-17 and LHA(R) are the only two candidates for substitution. (The missions assigned to the LPD-17 and LHA(R) are described in Appendix A.)

Cost Bounds. It appears unlikely that additional MPF(F) ships will cost less than LPD-17 ships on a ship-for-ship basis.[23] Thus, it might seem pointless to discuss the operational questions of an additional MPF(F) ship substituting for LPD-17s. However, in considering concepts for employing gray hulls, we find that additional individual MPF(F) ships could be substituted for more than one gray hull. We explore this idea here and derive cost bounds for additional MPF(F) ships, with cost savings.

Two or three ESGs would normally be deployed under the Global CONOPS; LPD-17s would normally be deployed a quarter of the time or less, which reflects operational tempo limits the Navy places on all gray hulls. However, operational tempo limits do not apply to black hulls; ships of the Mediterranean Sea MPSRON, for example, are typically at sea most of the time.

The most aggressive substitution scheme of an additional MPF(F) ship for LPD-17s would have the additional MPF(F) ship deployed more or less continuously. For example, suppose a policy was established for full-time presence in a region such as the Gulf of Oman or the Mediterranean Sea. An additional MPF(F) ship assigned to the region could operate as part of ESGs already operating in the region. The result would be the wholesale *substitution of one additional MPF(F) for four LPD-17s*.

There are several drawbacks associated with the concept of using a regional ESS to substitute for four LPD-17s. One drawback is that the additional MPF(F) ship would not be able to prepare for deployment with each ESG prior to deployment. One drawback associated

[23] Based on Navy data supplied to the authors, LPD-17 ship cost is $1.14 billion. A rough order-of-magnitude cost per MPF(F) ship is $1.75 billion, about $600 million more per ship.

with this substitution scheme stems from its basis of rotational deployments for military presence in given regions. It goes against the operational concept of a surge ESG being operationally ready to deploy when and where it is needed. There is the chance that the collection of ships that would meet with the regional ESS to form an ESG[24] would not be as capable as an ESG. To illustrate, suppose that for full-time presence required for the Gulf of Oman, an additional MPF(F) ship is assigned to that region continuously. Then, ships in the next ESG scheduled to deploy to the region cannot be used as a fully capable ESG in some other region because the assigned MPF(F) ship is not free to deploy to that region.

A less aggressive substitution scheme is best described from the perspective of the additional MPF(F) ship. The ship would go through an alternating cycle of work-ups and deployments, for example, working up as an element of an ESG, deploying with it, and returning to port with it. It would then go into work-up as part of another ESG, and so on. Maintenance also would be performed in this period. Each additional MPF(F) ship would be deployed half the time, meaning that it would substitute for two LPD-17s. This substitution scheme avoids the two drawbacks associated with the more aggressive substitution scheme described above.

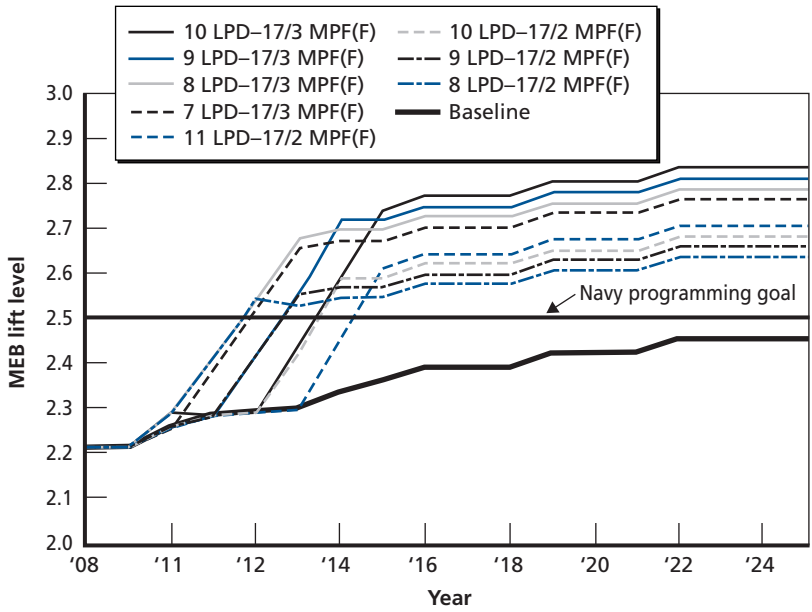
Under the less aggressive substitution scheme, a single additional MPF(F) ship could substitute for two LPD-17s (with a net cost for those two hulls of $2.28 billion). With the more aggressive substitution scheme, a single additional MPF(F) could substitute for up to four LPD-17s (with a net cost of $4.56 billion). These are the cost bounds for substituting an additional MPF(F) ship for LPD-17s, depending on the level of additional risk judged to be acceptable. Similarly, a single additional MPF(F) could be substituted for two LHA(R)s (with a net cost of $6.4 billion) and for four LHA(R)s (with a net cost of $12.8 billion). Again, these are the cost bounds for substituting an additional MPF(F) for LHA(R)s, depending on the level of additional risk judged to be acceptable. A Full Air Operations

[24] The ESG would consist of an LHA/D and an LSD, and their combatant escorts.

MPF(F) ship substituting for LHA(R)s would be more affordable with the latter cost bounds (for two or four LHA(R)s).

Static Lift Findings. The static lift analysis began with an examination of the program of record to determine feasible ship substitutions. We ruled out ship substitutions that would interrupt LPD-17 production, or that would put an excessive construction load on shipyards, or that would impose excessive single-year costs through simultaneous procurements. We used the substitution schemes introduced in the previous paragraphs to determine alternatives leading to 2.5 MEB(AE) of lift capability, with the New Design Rotary Wing Only MPF(F) ship as a starting point. The results of this analysis, shown in Figure 3.6, are discussed next.

Figure 3.6
Possible MPF(F)-for-LPD-17 Substitutions



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The shipbuilding program of record calls for a total of 13 LPD-17 ships. If the last three LPD-17s are not procured, the LPD-17 end force would have ten ships. A one-for-one substitution of an additional MPF(F) for the three LPD-17s not procured (shown by the top line, labeled "10 LPD 17/3 MPF(F)") yields the highest total amphibious task force lift, eventually exceeding 2.8 MEB. However, this substitution achieves the 2.5 MEB(AE) lift level relatively late—in 2015—because the procurement of the three additional MPF(F) ships must be deferred until after completion of the LPD-17 buy to avoid excessive single-year procurement costs. Eliminating an additional LPD-17 moves forward the first procurement of the first additional MPF(F), and as such achieves the 2.5 MEB(AE) lift level earlier. This result is shown in the second-from-the-top line (labeled "9 LPD 17/3 MPF(F)"). The top four lines in the figure reflect the results of substituting three additional MPF(F) ships for three, four, five, and six LPD-17s, respectively. The four broken lines show substitutions using two additional MPF(F) ships for two, three, four, and five LPD-17s, respectively.

VTOL spots drive these results.[25] For the substitution scheme of two MPF(F) ships for four LPD-17s (the curve labeled "9 LPD 17/2 MPF(F)"), the margin for growth for the 2015 MEB is 29 CH-46 equivalent VTOL spots. This difference corresponds to adding more than a dozen CH-53Es or V-22s per MEB.

The result of substituting a single additional MPF(F) ship for four LPD-17s is not shown. Doing so would result in a 2.55 MEB(AE) lift capacity, leaving little room for growth beyond the 2015 MEB. MEB growth potential for this substitution would be nine additional VTOL spots, which corresponds to adding four CH-53Es or V-22s per MEB.

Based on the Static Lift model, we conclude the following:

- Substitutions that result in the greatest amphibious task force lift achieve the required 2.5 MEB(AE) lift capacity relatively late.

[25] The MPF(F) design was assumed to have at least one LCAC spot, making VTOL spots the clear results driver.

One-for-one substitutions of an additional MPF(F) for an LPD-17 are the last to achieve the 2.5 MEB(AE) lift.
- Aggressive substitution of a single additional MPF(F) for four LPD-17s would achieve the required 2.5 MEB(AE) lift requirement with little room for growth beyond the 2015 MEB.

These results are, of course, specific to the New Design Rotary Wing Only MPF(F). Design goals for this ship include MPSRON(F) lift for the rotary-wing air combat element of one MEB. With 260 CH-46-equivalent VTOL spots required and six ships per MPSRON(F), each MPF(F) ship needs a minimum of 43.3 VTOL spots. As long as the MPF(F) is sized so that six ships can carry the rotary-wing air combat element for one 2015 MEB, the above results are valid.

Because VTOL spots are the limiting static-lift fingerprint, and the New Design Rotary Wing Only MPF(F) has fewer VTOL spots than the LHA(R) ships, substituting the MPF(F) design for the LHA(R) would worsen the 2015 MEB lift shortfall. Substituting a Full Air Operations Ship MPF(F) (refer to Figure A.12 in Appendix A) for LHA(R) ships would clearly produce a more favorable static-lift result.

Dynamic Lift Findings. The overarching operational finding is that in terms of closure rates or asset requirements, *substitution of additional MPF(F) ships for LPD-17s made no significant difference in establishing a sea base*. Specifically:

- Closure times were essentially unchanged by substituting additional MPF(F) ships for gray hulls. The Dynamic Lift Model indicated that in some cases an additional day (within the model's level of accuracy) would be required to achieve force closure. We conclude that closure times would essentially be unchanged.
- The number of ESGs required for earliest force closure was unchanged.
- The number of MPSRON(F)s required for earliest force closure was decreased slightly. By increasing ESG troop, vehicle, and

cargo lift, the additional MPF(F) substitution marginally reduced the demand for MPSRON(F).

Risks and Advantages. MPF(F) ships will not be built to the survivability standards of gray hulls and will lack the gray hulls' defensive systems, which clearly imposes a risk. In addition, the greater vulnerability of MPF(F) ships relative to LPD-17s has an associated risk of greater requirements being placed on Sea Shield defenses. Both of these risks might be mitigated with the use of faster assault landing craft, enabling maneuver operations farther from the coast. Faster landing craft are more difficult to target and more difficult to hit with weapons such as coastal cruise missiles. LPD-17 systems (such as surface-search radars) that are not specific to the LPD-17s' primary mission would be lost in substituting MPF(F) ships for LPD-17s, with possible associated risks from the loss of their capabilities. Finally, any substitution of MPF(F) ships for LPD-17s would replace the known LPD-17 ship-to-shore capabilities with unknown MPF(F) ship-to-shore capabilities.

The New Design Rotary Wing Only MPF(F) is a more capable VTOL platform than the LPD-17. Any substitution of a similar ship for the LPD-17 would increase the flexibility of ESG flight operations, which is a clear improvement. Any substitution of ESS for LPD-17s would also increase ESG lift capacity and sea base potential and would improve ESG sustainment.

A specific advantage of the ESS concept over the concept of taking up MPF(F) ship from MPSRON(F) is that additional MPF(F) ships could be given enhanced features (such as improved survivability or medical facilities) without incurring the cost of building those features into every MPSRON(F) ship.

Alternative 3: Program of Record Modified by Taking Up Black Hulls from Future MPSRONs to Substitute for Amphibious Ships, While Reducing Number of Amphibious Ships

This alternative relates to the less aggressive substitution scheme discussed earlier—using two MPF(F) ships taken up from MPSRONs to substitute for four LPD-17s. One MPF(F) ship was taken from the

Mediterranean Sea MPSRON(F), and one was taken from the Guam MPSRON(F). The Diego Garcia MPSRON(F) was unchanged.

Cost Considerations. Eliminating the last four LPD-17s (see Table 3.6) would yield an immediate cost reduction of $4.68 billion, which might be offset by any additional MPF(F) costs required for such a substitution.

Static Lift Findings. As mentioned previously, net lift capacity under the program of record will increase by 2025 to 2.45 MEB(AE), limited by VTOL capacity. Amphibious lift would be reduced through the elimination of four LPD-17s. In terms of VTOL capacity, a total of 24 CH-46-equivalent spots would be lost, and net lift capacity would increase instead to 2.36 MEB(AE).

Dynamic Lift Findings. Relative to the case of additional MPF(F) ships for LPD-17s, closure rates and resource requirements were unchanged.

Risks and Advantages. The risks and advantages of *any* substitution of MPF(F) ships for LPD-17s were introduced earlier under "Alternative 1: The Shipbuilding Program of Record." As for the risks and advantages associated with using MPF(F) ships taken from MPSRON(F), there is the risk that this substitution scheme would lead to adding capabilities to the baseline MPF(F) and thereby drive up its cost. Alternatively, this substitution scheme could require designated MPF(F) variants with "lead ship" costs (costs associated with the first ship in a class). A possible advantage of this substitution scheme is that it would make MPF(F) ships more operationally capable.

Issues. This alternative raises a number of questions:

- What would be the new Concept of Employment (i.e., generic plan for using systems or platforms) for MPSRON(F)?
- What are the joint services issues for MPSRON(F)?
- What capabilities that are planned for additional MPF(F) ships should be added to some or all of those ships??
- How would the cost of those capabilities compare with the cost of two additional MPF(F) ships or four LPD-17s?
- What are the implications for operation and maintenance costs?

Additional Analysis: Alternative Assault Landing Craft

As noted previously, LCACs are now reaching the end of their service lives due to corrosion and other factors. (Further information on LCACs is provided in Appendix A.) Given a successful LCAC SLEP, LCACs are programmed to remain in service until 2024, roughly a decade after the introduction of MPF(F). An LCAC follow-on would then be used for most of the MPF(F) ships' service life. It is reasonable to ask how the three force-mix alternatives discussed above—the shipbuilding program of record and the two substitute alternatives—would fare under emerging landing craft concepts. Assault landing craft alternatives that are capable of operating with an ESG would be the best operational substitutes for LCACs in terms of achieving rapid closure. Considerations such as maintenance requirements or the need for additional stores could rule out the idea of LCAC follow-ons regularly deploying with ESGs. Therefore, this subsection examines the requirements for LCAC alternatives that could not deploy with ESGs. It also identifies gains in closure time performance that could be achieved by deploying LCAC alternatives with ESGs.

Self-Deploying Alternatives. For self-deploying LCAC alternatives, such as Landing Craft, Tank, Air Cushion (LCTAC), the key performance parameters are endurance and speed of advance (SOA). Capacity is less important because capacity shortfalls can be made up with additional landing craft. For transport options, such as a heavy lift carrier, load/offload time, and SOA are the key performance parameters.

Questions that need to be answered about these alternatives are as follows:

- Where could they be based? (The choice of basing location will clearly affect their performance.)
- What are the key performance-parameter requirements to maintain the performance gains experienced under the program of record?
- Which global regions might be explored for further performance gains?

Self-Deploying Alternative Findings. Answering the questions above requires repeating our original analysis and also analyzing basing issues, which our original analysis did not touch on. Also, greater uncertainty is associated with self-deploying alternatives, which are for the most part immature and untested systems. To limit the scope of the analysis, we address only key performance parameter requirements and which landing craft options meet those requirements. The analysis begins with self-deploying systems, such as LCTAC, and where they should be based.

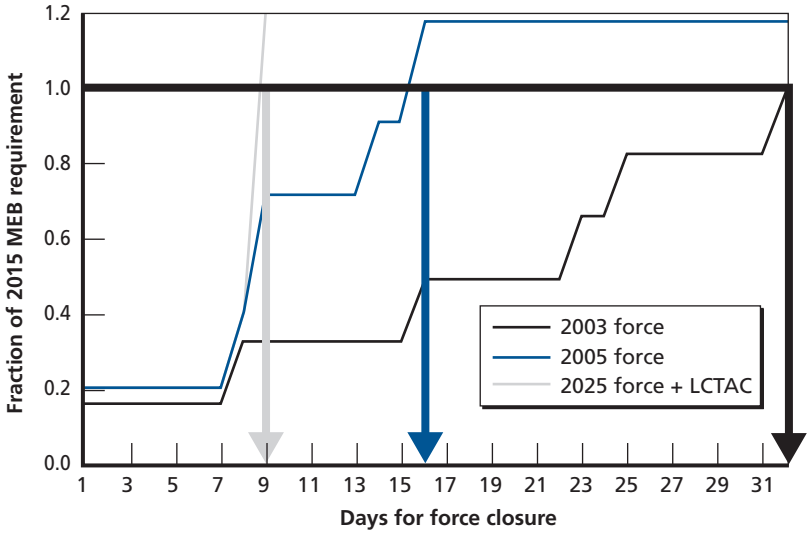
Logical basing options for LCTAC-like vessels include Norfolk, Diego Garcia, and Guam. We first determine the SOA requirements for these three bases to preserve performance gains achieved under the program of record.

A self-deploying alternative to LCAC based in Norfolk would need an SOA of more than 35 knots to maintain the performance gains achieved through the program of record. Maintaining an SOA this high over distances exceeding 10,000 nautical miles is daunting. Of the ten global regions examined in this study, the most challenging in terms of SOA would be the regions surrounding Bangladesh, the Philippines, Indonesia, and Taiwan.

For LCAC-alternative basing in Guam or Diego Garcia, the SOA requirement drops to somewhat under 30 knots to avoid slowing closure. Transit distances into the zone of instability, which extends from West Africa to Indonesia, are reduced substantially relative to basing in Norfolk.

LCAC alternatives that could deploy with ESGs or self-deploy without slowing force closure (that is, shift the driving fingerprint from LCAC spots to VTOL spots) offer the option of further reducing time to force closure beyond what could be achieved using MPSRON(F) ships to provide LCAC spots. Results of an analysis for a sea base in the Gulf of Oman (see Figure 3.7) indicate force closure in nine days. In the figure, the line labeled "2025 Force + LCTAC" represents the 2025 force with any self-deploying alternative capable of a 30-knot SOA, including LCTAC, or capable of deploying with

Figure 3.7
Closure Rate with Self-Deploying LCAC Alternatives, Gulf of Oman



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ESGs. Put another way, the 2025 Force + LCTAC line reflects the result of eliminating delay in building up LCAC spots. (The figure label, which was abbreviated for space reasons, does not indicate any preference for LCTAC over the SeaCoaster LCU(R) concept [see Appendix A], or any other similar amphibious landing craft concept.)

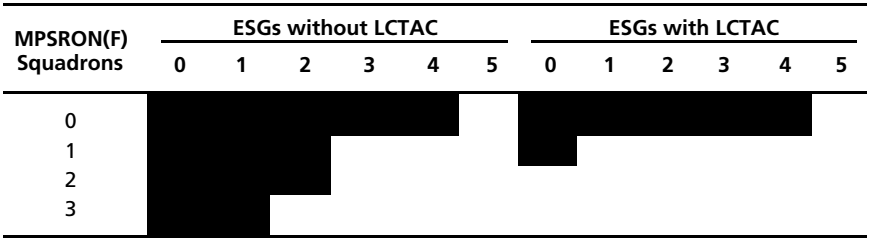
The advantage in closure times for a self-deploying LCAC alternative based in Guam is not typical. Indeed, the greatest advantages to a self-deploying LCAC are seen in the zone of instability. In contrast to the results for this region, force closure time in Colombia is unimproved by basing LCTAC in Diego Garcia or Guam. Detailed results are provided in Appendix C. More detailed results from our analysis regarding the assets required for earliest force closure are provided in Appendix C.

We now return to an examination of assets required to achieve MEB-level force closure, discussed earlier in this chapter. We sought to answer the following question: Which combinations of 2025 ESGs and MPF(F) squadrons would provide the lift fingerprints required

by a MEB, with and without a self-deploying alternative to LCAC(SLEP)? The answer is shown in Table 3.7. As before, the results apply to any self-deploying LCAC alternative capable of a 30-knot SOA, including LCTAC, or to any self-deploying LCAC capable of deploying with ESGs. (Again, the column headlines were abbreviated for space reasons and do not indicate any preference.)

Table 3.7 indicates, for example, that with a single available MPSRON(F), it would take three ESGs without LCTAC or one ESG with LCTAC to satisfy the lift requirements. As another example, with two ESGs available, it would take three MPF(F) squadrons without LCTAC or one MPF(F) squadron with LCTAC to satisfy the lift requirements.[26] The potential to reduce assets required for force closure—both ESGs and MPF(F) squadrons—through the use of self-deploying alternatives to LCAC(SLEP) is clear. As observed previously, a self-deploying LCAC alternative capable of a 30-knot SOA or capable of deploying with ESGs would increase operational flexibility by adding viable deployment options.

Table 3.7
Combinations of 2025 ESGs and MPSRON(F) Squadrons Satisfying MEB Fingerprint Lift Requirements



NOTE: Combinations within shaded cells do not provide needed lift capacity.

[26] On average, the combination of three 2025 ESGs with one MPSRON(F) squadron provides 30.6 LCAC spots. With 31 LCAC spots required, the LCAC spot requirement is not strictly met. This combination meets all other lift fingerprint requirements. In light of a 1 percent shortfall for a single requirement, it has been scored as meeting MEB lift requirements. The crediting of 99 percent as complete success was done consistently throughout this analysis.

Landing Craft Transport Alternatives. Turning to the concept of landing craft transports as an alternative to self-deploying landing craft, we looked first at candidate ships as a basis for analysis. Heavy lift deckships, semisubmersible heavy transport vessels, were the best alternatives. These ships are best known for transporting the *USS Samuel B. Roberts* (damaged by an Iranian mine in 1988) and the *USS Cole* (attacked by terrorists in 2000). A single ship of this type could carry a dozen or more LCACs. The ship would be flooded down, LCACs would position themselves over the submerged deck, and the ship would then deballast to place LCACs on its deck without the need to lift them (which would risk damaging their rubberized skirts). The problem with such ships is that they are slow and would create delays for loading/offloading landing craft. The M/V Blue Marlin, which transported the *USS Cole*, cruises at 15 knots—slower than the MPSRON(F) SOA.

Absent a candidate ship or design for analysis, we conducted a parametric analysis of SOA and load/offload time to establish transport ship requirements. The parametric analysis addressed two questions:

- What combinations of load/offload times and SOAs would be required to match the closure times for self-deploying landing craft (as shown in Figure 3.7)?
- What combinations of load/offload times and SOAs would be required to provide additional landing craft to match the force closure times seen for the program of record?

Landing Craft Transport Findings. To answer the above questions, required time of arrival (that seen for the program of record) is known, and transit distance is known for a given transport base—once again, Guam. It is then a simple matter to subtract load/offload time from the time available and to convert the remaining time to an SOA requirement. Results of the parametric analysis to answer the previous two questions are shown in Figures 3.8 and 3.9.

Figure 3.8
Landing Craft Transport Requirements Needed to Match Self-Deploying Landing Craft Closure Times

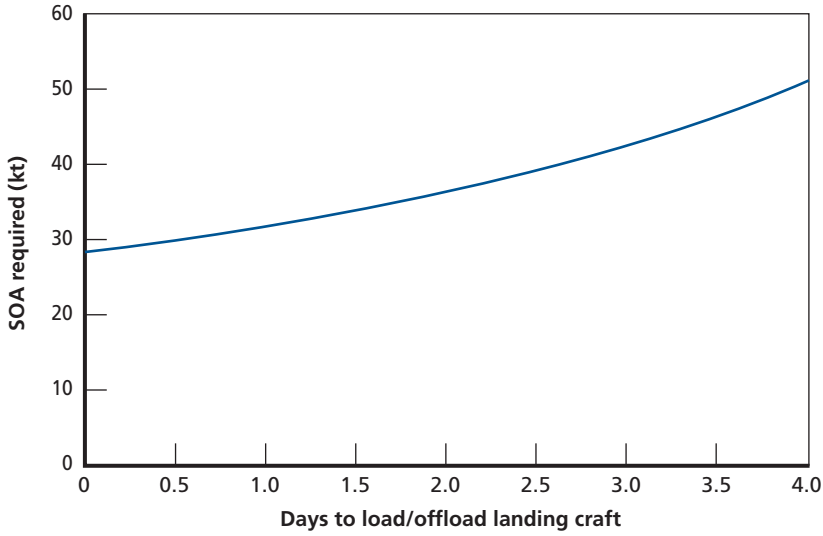


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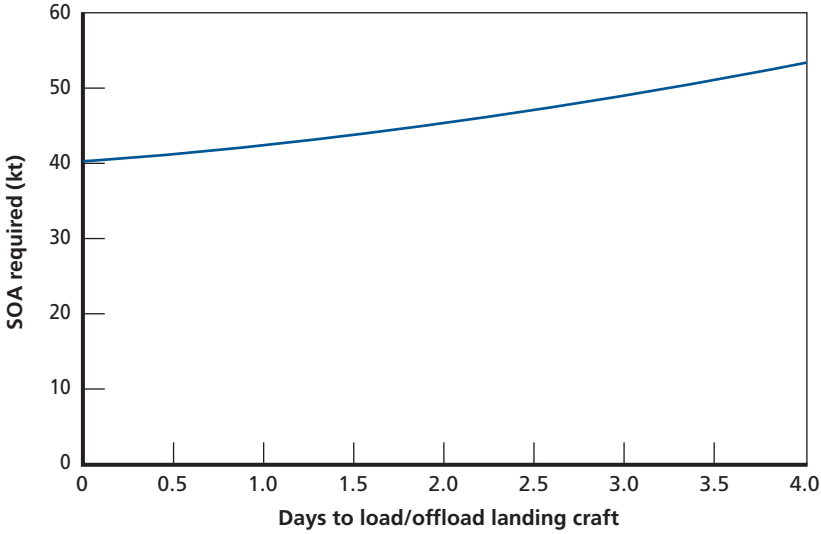
Figure 3.8 indicates that if the objective is to minimize force closure time, there is a substantial penalty for load/offload time; if the load/offload time were as long as four days, SOAs in excess of 50 knots would be required. Figure 3.9 indicates that if the objective is to provide landing craft in support of closure times that are achieved through the program of record, SOA requirements are substantially reduced. The methodology for deriving these results is described in Appendix C.

Marrying Up VTOL Aircraft. Our analysis considered the time required to marry up troops and landing craft but not the time to marry up VTOL aircraft. VTOL aircraft can presently deploy into theater on L-class ships, or can be airlifted or self-deploy into theater. A new concept, the High Speed Response Ship (HSRS), could be used as future VTOL aircraft transport. In the context of force closure within about a month with a heavy reliance on L-class ships, marrying up VTOL aircraft is not an issue. Closure times of about

two weeks are also achievable. Closure times of less than ten days may not be possible in some regions without early aircraft movement. This matter warrants further consideration, especially in the context of HSRS.

Figure 3.9
Landing Craft Transport Requirements Needed to Match Program of Record Closure Times



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CHAPTER FOUR

Conclusions

In this concluding chapter, we summarize various points regarding the importance of sea basing to future global security and our overall findings on the mix of gray hulls and black hulls for future JFEOs.

The Importance of Sea Basing in the Future Global Security Environment

What Will the Future Global Security Environment Look Like?

In the coming decades, the United States will face a bifurcated set of security challenges. Day to day, the driving force behind security challenges will continue to be related to the global war on terrorism and the issues raised by a focus on the GWOT. At the same time, the United States will be forced to confront growing challenges to its power-projection capabilities from regional states armed with increasingly potent weapons. In light of this situation, four key issues emerge:

- **The Importance of the Zone of Instability.** Given the focus on the GWOT, it is likely that the so-called zone of instability that extends from West Africa to Indonesia will continue to be the focal point of U.S. military operations until the end of this decade and possibly much longer. In addition, as the "book ends" of the zone of instability, Indonesia and Nigeria may be teetering on the verge of major internal strife.

- **Changes in Strategic Alliances.** A significant "fault line" has developed between the United States and some European states over the war to overturn the regime of Saddam Hussein. There is some danger that this split over the United States' conduct of the Iraqi war and its ongoing occupation of Iraq could lead to major medium-term changes in the relationship between the United States and NATO Europe, although Washington, Berlin, and Paris all appear to be working to overcome these differences.
- **Changes in the Ability to Gain Access Ashore.** Recent U.S. operations in Afghanistan and Iraq highlight the difficulties the United States faces in gaining access ashore in key regions. Widespread opposition to the U.S. invasion of Iraq could create further difficulties with access ashore in future operations.
- **Changing Nature of Strategic Surprise and Initiative.** In the context of supporting the ongoing GWOT in the zone of instability, the United States may have the strategic and operational initiative, which will allow it to "lean forward" to take advantage of its operational hubs. Nevertheless, the United States will still need globally responsive military capabilities, including brigade-size units that can be deployed via transoceanic airlift or via prepositioned units that are either onboard black-hulled or gray-hulled amphibious ships. Given the size of the airlift fleet and the limited number of forward-deployed equipment sets, it is unlikely that the Army or the Marine Corps will be able to deploy more than one or two brigade-sized elements in the first two weeks of a crisis. For practical reasons related to the cost and limits of airlift technology, deploying several brigades, much less deploying division equivalents, of an expeditionary force ground component will continue to rely on sealift.

While the United States is engaged in a vigorous effort to counter terrorist groups with global reach, it must also cope with growing challenges to its large-scale power projection. Preeminent among those challenges are the emergence of China as a great power; the requirement to locate and neutralize threats posed by the prolif-

eration of CBRNE weapons and their means of delivery, primarily ballistic missiles; the diffusion of dual-purpose technology; and challenges to its C4ISR systems.

Why Will Sea Basing Be Important in the Future Global Security Environment?

Regions that will be vitally important to future U.S. security are within the zone of instability—a wide global swath of territory that is geographically distant from traditional U.S. operating areas, allies, and facilities. The two services most affected by this situation are the Army and Air Force. The Navy and Marine Corps—because of their ability to operate indefinitely in international waters—will be able to at least partly compensate for a reduction of Army and Air Force presence in key regions through their sea-basing capabilities. In addition to providing normal peacetime presence in such areas, naval forces can be selectively increased in the event of an emerging crisis.

The emerging concept of sea basing will be an important factor in the naval forces' ability to project—and sustain—forces ashore. With sea basing, Marine combat power can build up more quickly in littoral areas, and the need to move considerable amounts of supplies ashore will be minimized. As such, the sea-basing concept clearly has important uses during forcible-entry operations, which U.S. forces may confront in the future. But sea basing has value beyond forcible-entry operations, which are likely to be the exception rather than the norm. As mentioned earlier in this report, the United States may have to conduct missions in the zone of instability or in Latin America, where a large U.S. military presence ashore may not be politically acceptable. Therefore, considerable advantage can be gained by leaving as many functions offshore at the sea base as possible.

While the Navy and Marine Corps are currently thinking of sea basing in terms of enhancing their own capabilities, the concept of sea basing has uses beyond just naval/marine forcible-entry operations or the sustainment of Marine Corps operations ashore in areas where granting access to U.S. forces is not politically acceptable. The concept also has value as part of joint operations involving the Army and Air Force. For the Army, the value of the sea-basing concept lies in

the Army's being able to considerably reduce the time required to reach a crisis location by pre-positioning its equipment aboard ships. In the case of the Air Force, the value of sea basing lies in the Air Force's being able to load several ships with fuel, ammunition, and spare parts, thus considerably reducing the time required to commence operations from what would otherwise be poorly provisioned bases.

Even with current and projected airlift and sealift capability, the U.S. services will face a major challenge in moving significant combat power, say an MEB or Stryker Brigade Combat Team, transoceanic distances within a week. To deal with the realities of time and distance, it is likely that all the services will exploit an array of "hubs" located around the periphery of Eurasia, which will allow for the exploitation of a major airfield and harbor where pre-positioned equipment and supplies can be kept on-site, onboard black-hulled ships. Airfields can be used to receive ground combat personnel to link up with sea-based equipment sets, or to stage long-range bombers, reconnaissance assets, and their associated tankers. In the near future, several of these hubs may be equipped with high-speed (30-plus-kt) sealift ships to support a variety of Marine Corps and Army rapid-deployment postures. An attractive feature of most of the hubs proposed is that they are some distance away from potential missile threats, thereby allowing for the deployment of high-performance advanced air and missile defenses.

Identifying Favorable Mixes of Gray Hulls and Black Hulls for JFEOS

In identifying favorable mixes of gray and black hulls for future JFEOs, we arrived at several analytic and programmatic conclusions.

Analytic Conclusions

We arrived at the following two main analytic conclusions concerning concepts of employment and operation and managing analytic uncertainty.

Concepts of Employment/Operation. Further concept development is needed on MPSRON(F), MPF(F), and LCAC alternatives before the following questions can be answered:

- Is the Department of the Navy willing to break down the administrative barrier dividing gray hulls from black hulls? How would additional MPF(F) ships be used?
- What operations should be conducted from additional MPF(F) ships?
- Should SLEP LCACs be replaced in kind (with HLCACs), or should concepts such as self-deploying LCAC replacements be used instead?

Concepts of employment changed the course of this analysis. Specifically, the recognition that one MPF(F) can be substituted operationally for more than one L-class ship redefined the substitution trade space, as did the recognition that it might be possible to take up MPF(F) ships from MPSRONs with acceptable consequences. *Taking up MPF(F) ships from MPSRONs functionally reduced the MPF(F)-ship cost by a factor of two or more*. The recognition that LCACs will be decommissioned, even with a successful LCAC SLEP, led to a further examination of concepts of employment and the identification of additional means to improve force closure performance *with possible MPF(F) cost savings*.

Treating Uncertainty. Significant quantitative analysis is possible at this stage of concept development. The analysis in this report identified areas of uncertainty (such as the costs and capabilities of various ships under consideration) and managed them using filtering (to bypass unmanageable uncertainties), sensitivity analysis (to manage uncertainty), cost bounding (in place of equal-cost analysis—i.e., comparing the performance of alternatives having approximately equal cost), and exploratory analysis (to better understand problem sensitivities). Exploratory analysis was accomplished by using agile tools—the Static Lift model and Dynamic Lift model—that enabled us to systematically explore hundreds of force-lift scenarios. To limit the need for exploratory analysis, these tools used no more assump-

tions or inputs than were necessary. In combination, these techniques enabled us to develop insights on and solutions to problems.

The tools developed for this analysis have an open-ended architecture (i.e., are practically unlimited in the number of force-closure factors they can track) and can be used for further exploration of other alternatives (such as the HSRS) under possible concepts of operation/employment.

Programmatic Conclusions

We also arrived at three sets of conclusions regarding the Navy's program of record and proposed alternatives to that program.

Program of Record. Preliminary conclusions in advance of examining the various options include the following:

- The program of record will not achieve the goal of 2.5-MEB lift capacity. Increasing demand for VTOL and LCAC lift is outpacing the program of record's ability to provide lift capacity. Specifically, the L-class ships about to enter service, LPD-17s, are designed to address a vehicle lift problem, not the emerging VTOL and LCAC problems.
- MPF(F) may not be affordable. Eighteen MPF(F) ships—costing $1.75 billion each[1]—would collectively cost $31.5 billion. To put these figures in perspective, the DoN's recent annual SCN budgets have been about $9 billion.[2] MPF(F) procurements are planned for FY 2008–2019. A cost figure of $1.5 billion per ship is viewed as being optimistic. The risk of unaffordability is amplified by the large (18-ship) MPF(F) buy. If the cost of each MPF(F) ship were to reach $2.5 billion, for example, the total cost would be $45 billion. The goal of increasing Navy force level from 292 ships in FY 2004 to 375 ships

[1] The cost figures cited in this chapter are in FY 2003 dollars.

[2] Assistant Secretary of the Navy (Financial Management and Comptroller), Office of Budget, Department of the Navy, "Highlights of the Department of the Navy FY 2004 President's Budget," February 2003, Table 19 (http://navweb.secnav.navy.mil/pubbud/04pres/highbook/04Highlights.htm, last accessed November 2004).

under the Global CONOPS may heighten competition for funds and worsen the problem of being able to afford MPF(F).

- The 2025 program-of-record force, with MPF(F) ships, will be able to close a 2015 MEB in half the time the 2003 force requires. MPF(F) ships were the key difference between the 2003 force and the 2025 force under the program of record. In other words, *this transformational improvement in capability depends on acquiring some form of MPF(F).*
- The time required for the same 2025 force to begin the assault phase of a sustained MEB-level amphibious operation is expected to be halved relative to the 2003 force. This finding and the previous finding are expected to be applicable to global regions of interest, including the zone of instability.
- The 2025 force will be more efficient than the 2003 force. Six ESGs would be required for a one-MEB(AE) lift using the 2003 force. The 2025 force could achieve the same lift with five ESGs. Hence, the program of record in 2025 will provide greater operational flexibility than will a replacement-in-kind force.
- A summary conclusion is that *MEB requirements have historically changed more quickly than has the amphibious force.* This points to a potential advantage of flexibility (ability to change without modification) and adaptability (ease of modification) in future ships.

Substituting Black Hulls for Gray Hulls. In considering the substitution of MPF(F) ships for L-class ships under the Global CONOPS, we reached the following conclusions:

- MPF(F) ships could perform the mission assigned to LPD-17s.[3] However, better definition of MPF(F) is required to address

[3] As stated in the *Amphibious Ships and Landing Craft Data Book,* "The assigned mission of the LPD is to transport and land troops and their essential equipment and supplies in an amphibious assault by means of embarked landing craft or amphibious vehicles augmented by helicopter lift" (U.S. Marine Corps, Department of the Navy, *Amphibious Ships and*

substitution of an MPF(F) ship for an LHA(R) because the LHA(R) has primary and secondary missions. While the LHA(R)'s primary mission is identical to that of the LPD and, thus, could be performed by an MPF(F) ship, its secondary mission, sea control and power projection, is too complex to be addressed with the data that are available.

- Risk and cost are still issues. The level of risk to MPF(F) ship substituting for L-class ships depends upon how it will be used—its concept of employment. Concept development is needed to perform risk evaluation.[4] This analysis produced MPF(F) cost bounds for cost-saving substitutions. Final cost figures will determine whether MPF(F) falls within these bounds.
- Cost savings are not expected with one-for-one substitutions of an MPF(F) ship for an LPD-17 or an LHA(R). However, a single MPF(F) ship can be substituted for two or more L-class ships. Operation tempo restrictions applying to L-class ships do not apply to MPF(F) ships because they are crewed by civilians. The resulting high operating tempo that is possible for an MPF(F) ship would enable it to substitute for two or more L-class ships.
- In substituting MPF(F) ships for LPD-17s, a one-for-two substitution would allow the substituting MPF(F) to work up and deploy with ESGs, would maintain operational flexibility of ESGs, and would lead to an amphibious lift capacity of 2.5 MEB with modest room for growth.
- A one-for-four substitution scheme would also be possible. However, it would not allow the substituting MPF(F) to work up with ESGs, would not maintain operational flexibility, and

Landing Craft Data Book, Marine Corps Reference Publication (MCRP) 3-31B, Washington, D.C.: Headquarters United States Marine Corps, October 1, 2000).

[4] The greatest risks to MPF(F) ships are considered to be related to their distance from a hostile coast. If an MPF(F) ship is part of a sea base 25 nautical miles from a coast, an acceptable level of protection for the ship may not be possible. If it were located twice as far from the coast (and used assault landing craft with twice the speed and endurance of LCACs), the story would be different.

would lead to an amphibious lift capacity of 2.5 MEB with minimal room for growth. Then again, this substitution scheme would clearly offer greater cost reduction.

- Substitutions could use additional, dedicated ships—ESS—or MPF(F) taken up from MPSRON(F). Additional MPF(F) ships could be given additional features to make them more capable or to reduce risk to them, without having to build such features into all 18 MPSRON(F) ships. Under the ESS concept, 2.5-MEB lift capacity would be achieved before 2015. However, this improvement in lift capacity would incur a cost for additional ships. Use of MPF(F) ships taken up from MPSRON(F) would mean that no additional hulls would be needed to eliminate four LPD-17s (with a total cost of approximately $4.6 billio). An intermediate concept, between using dedicated ESS ships and taking up MPF(F) ships from MPSRON(F), would be to embed ESS-like ships in MPSRON(F).
- There is little preference in terms of closure time or asset requirements between these two substitution schemes. Modeled differences were small and did not uniformly favor one substitution scheme over the other.

Alternative Assault Landing Craft. Replacing LCAC in kind with HLCAC would work within existing concepts of operation or employment. This type of replacement offers improved maneuver performance, but conclusions on any such improvement is outside the scope of this analysis. Other possible alternatives may suggest new operational concepts and therefore the possibility of further improvement in closure times.

- LCAC alternatives, such as LCTAC or the SeaCoaster AAC, may be able to deploy with ESGs and, thus, reduce the time required for force closure. Alternatively, they might be forward deployed in areas such as Diego Garcia and Guam—again reducing the time for force closure. However, the operational concept of deploying with ESGs would stress the endurance capabilities of these vessels. The operational concept of forward-

deploying these vessels would resemble plans to marry up V-22 aircraft with the MEB(AE) using self-deployment.

- Both concepts of employment (deploying with ESGs and forward deployment) would shift the driving fingerprint for force closure from LCAC spots to VTOL spots. A positive result of this shift would be a reduced need for well decks on MPF(F) ships. Reducing the need for expensive well decks in turn could lead to MPF(F) cost reduction and increased capacity.
- VTOL closure time also needs to be addressed in a future study in the same way that troop closure time was addressed in this analysis.

APPENDIX A

Specifics on Gray Hulls and Black Hulls

At the heart of this study is the identification of an appropriate balance between gray-hulled and black-hulled ships for joint forcible entry operations. In this appendix, we discuss some specifics of gray hulls and black hulls.[1]

Gray Hulls

Amphibious Assault Ships (LHA/D)

Amphibious assault ships (LHA/D) are more than 800 feet long and resemble aircraft carriers (see Figure A.1).[2] The assigned mission of an amphibious assault ship is to embark, deploy, and land elements of a Marine Corps landing force in an amphibious assault by helicopters, landing craft, and amphibious vehicles and by combinations of these items.[3] The LHD is assigned a secondary mission of sea control and power projection, in which additional fixed-wing V/STOL aircraft and helicopters are deployed.[4]

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[1] All data in this appendix are current as of November 2003.

[2] The photos in this appendix are used courtesy of the U.S. Marine Corps.

[3] *Amphibious Ships and Landing Craft Data Book,* Marine Corps Reference Publication (MCRP) 3-31B, August 29, 2003, p. 3.

[4] *Amphibious Ships and Landing Craft Data Book,* 2003, p. 5.

Figure A.1
LHD-1 (*USS Wasp*)

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LHA and LHD have full-length flight decks, landing-craft docking wells (well decks), storage areas for vehicles and cargo, and troop berthing for a reinforced battalion. Flag spaces are designed to support the staff of the embarked Navy organization (an amphibious squadron or amphibious group staff) and the Marine landing force staff (Marine expeditionary unit [MEU], MEB, or Marine expeditionary force [MEF]). LHA/D designs provide an operational environment for ship's company, embarked staff, troops, and support personnel prior to, during, and after an amphibious operation.

The five ships of the Tarawa class were commissioned between 1976 and 1980. They carry the following aircraft (depending on the mission): 12 CH-46 Sea Knight helicopters, four CH-53E Sea Stallion helicopters, six AV-8B Harrier attack aircraft, three UH-1N *Huey* helicopters, and our AH-1W *Super Cobra* helicopters. Their

well decks can accommodate a single LCAC vehicle.[5] Armament consists of two Rolling Airframe Missile launchers, two *Phalanx* 20-millimeter (mm) Close-in Weapon System (CIWS) mount, three .50-caliber machine guns, and four 25-mm MK 38 machine guns.

The first LHD (*USS Wasp*) was deployed in 1989, and there are now seven LHDs. Ships of the *Wasp* class have space for three additional CH-46s or their equivalents. Significantly, LHD well decks can accommodate three LCACs—two more than the LHA capacity. Relative to LHA, LHD armament adds two NATO Sea Sparrow missile launchers and an additional Phalanx 20-mm CIWS mount.

The LHA-Replacement program was established in 2001 to replace the *Tarawa*-class ships. The first LHA will be replaced by the LHD-8, which is to differ from the earlier LHDs in terms of its propulsion plant and in other respects. The Navy currently plans to procure a ship called the LHA-Replacement ship, or LHA(R), to replace later LHAs. The intended design of the LHA(R) has changed over time; this study uses the intended LHA(R) design as of November 2003.

Dock Landing Ship (LSD)

The Whidbey Island (LSD-41) and Harpers Ferry (LSD-49) classes make up the current LSD force. (Figure A.2 shows an LSD-45.) The LSD-41 was designed specifically to operate LCAC vessels and has the largest LCAC capacity (four) of any U.S. Navy amphibious platform. It also provides docking and repair services for LCACs and for conventional landing craft. The LSD-49 operates two fewer LCACs than does the LSD-41, but it has ten times the cargo volume.

The LSD-41 and LSD-49 carry no aircraft. Their armament consists of two 25-mm MK 38 machine guns, two 20-mm Phalanx CIWS mounts, and six .50-caliber machine guns.

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[5] These amphibious assault landing craft are described later in this section.

Figure A.2
LSD-45 (*USS Comstock*)

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Amphibious Transport Dock

Amphibious transport docks, or LPDs, transport and land Marines and their equipment and supplies by embarked air-cushion, conventional landing craft, or amphibious vehicles, augmented by helicopters or VTOL aircraft. These ships incorporate both a flight deck and a wet well deck that can support landing craft or amphibious vehicles.

The current Austin (LPD-4) class can embark 788 troops, and has 11,800 square feet for vehicles and 38,300 cubic feet for cargo and ammunition. It has two helicopter spots with the capacity to carry four helicopters (CH-46 equivalents) and the capability to carry one LCAC. Some ships of the class are configured with Navy and Marine Corps command and control facilities.

All LPD-4s are to be decommissioned by 2014. The San Antonio is scheduled for commissioning in FY 2005. The LPD-4 decommissioning plan is predicated on the expected delivery of LPD-17 on a one-for-one basis. The unit cost of LPD-17 is approximately $1.17 billion.

The San Antonio (LPD-17) class ship (as shown in Figure A.3) was designed to provide the amphibious lift needed for a 2.5 MEB

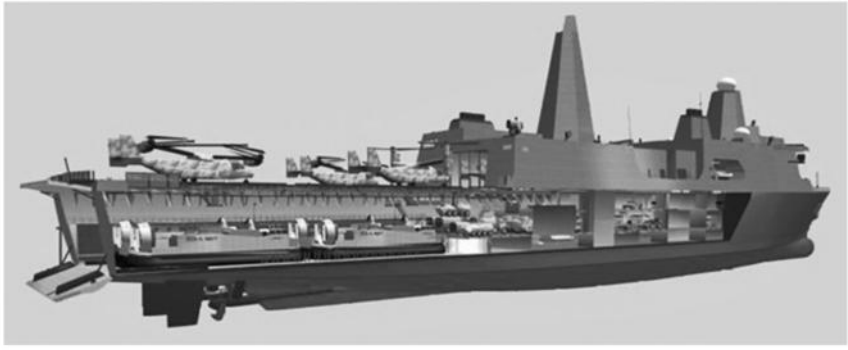
lift capability through additional vehicle square footage. LPD-17 will embark 720 troops with 25,000 square feet for vehicle storage and have 36,000 cubic feet for cargo and ammunition. LPD-17 aviation facilities are designed with two primary landing spots and a permanent hangar sized to provide organizational-level support for either a CH-53E, an MV-22, two CH-46s, or four UH-1s. The flight deck will support four MV-22s (two folded and two spread) or four CH-46s. The well deck will support two LCACs. LPD-17 will also be equipped to function as a casualty receiving and treatment ship with 24 ward beds and one operating room.

The LPD-17 has an array of self-defense systems, including air-search and surface-search radar systems, the Rolling Airframe Missile system, and the Mk 53 Decoy Launching System. The ship will also carry two Mk 46 Mod 1 automated 30-mm gun system mounts capable of engaging small, high-speed, surface targets. The LPD-17 has a reduced radar cross-section to reduce its vulnerability.

Amphibious Assault Landing Craft

The assigned mission of amphibious assault landing craft is to land heavy vehicles, equipment, personnel, and cargo in amphibious assaults. There are now two broad types of amphibious assault landing craft—air cushion vehicles (ACVs) and displacement vehicles.

Figure A.3
LPD-17 (*USS San Antonio*)



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Relatively new air-cushion technology adds high speed and, hence, the ability to operate from greater distances (for operations over a limited time period, such as in cover of darkness). ACVs also offer the ability to operate independent of tides and hydrographic constraints (such as shallow water). However, ACVs lack the lift capacity, range, and ruggedness offered by displacement vehicles.

New technologies for amphibious assault landing craft are emerging, and ACVs may be replaced by landing craft offering a different capability mix. This suggests a need to maintain options for new types of landing craft and to exploit new capabilities (such as the combination of heavy lift with speed or the ability to self-deploy) those new landing craft might offer.

Landing Craft Air Cushion. The LCAC is an ACV approximately 88 feet long[6] and capable of operating at speeds in excess of 40 knots with a design load of 60 tons. It is capable of traveling over land and water. An LCAC operation with a mixed load of vehicles is illustrated in Figure A.4.

LCAC offers the military planner another method (in addition to LCUs, discussed next) for attaining surprise when conducting amphibious operations from over the horizon. Approximately 80 percent of the world's beaches are accessible to LCACs, in contrast to 20-percent accessibility for displacement assault landing craft. Weather can affect LCAC operations, but it is less of a factor than for other means of ship-to-shore delivery.

LCACs are nearing the end of their planned 20-year service lives. The LCAC Service Life Extension Program (SLEP) is a Navy and Marine Corps program to extend hull life from 20 to 40 years. Given a successful LCAC SLEP, LCACs are programmed to remain in service until 2024—less than a decade beyond the introduction of the next generation of Maritime Pre-Positioning Ships. Therefore, LCAC follow-ons will be used for most of the next-generation ships' service life. New concepts of employment would be used for some

[6] LCAC length increases by seven feet when the rubberized fabric skirt is inflated.

Figure A.4
An LCAC Operation in Operation Enduring Freedom

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LCAC follow-on candidates, creating opportunity for performance gains.

Landing Craft Utility. Like LCACs, LCUs are carried aboard amphibious assault ships to the objective area. LCUs are capable of transporting tracked or wheeled vehicles and troops from amphibious assault ships to beachheads or piers (see Figure A.5). Whereas the LCAC is capable of high speed with a limited load, LCUs carry large loads with limited speed.

As noted previously, about 20 percent of the world's beaches are accessible to LCUs, as compared with 80 percent being accessible to LCACs. An obvious problem with LCUs arises if the sea base is kept far from the shore. LCUs are relatively slow, so round trips from ship to shore take longer. For example, with a ship-to-shore distance of 25 miles, the LCU requires two hours or more to reach the shore or four hours for a round trip.

Figure A.5
Four LCUs on the Beach in Operation Enduring Freedom

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Heavy Lift LCAC. The Heavy Lift LCAC (HLCAC) is intended to replace the SLEP LCAC at the end of its service life. By increasing the SLEP LCAC's length to 125 feet, the cargo area will increase from 1,800 square feet to 2,850 square feet. Payload will double from 72 tons to 144 tons, and endurance will also double. The proposed HLCAC would be capable of carrying two M1A1 tanks or ten light armored vehicles. This capability will come at the price of roughly halving the ship's LCAC capacities (see Table A.1).

LCU Replacement. The Landing Craft Utility Replacement (LCU R) is the planned replacement for the current LCU. It will be able to operate out of the well decks of current amphibious ships. Table A.1 compares LCAC and LCU with their planned replacements. The other alternatives discussed in this section are too conceptual or have not been tested enough for such comparisons. Payloads are maximum overload in short tons.

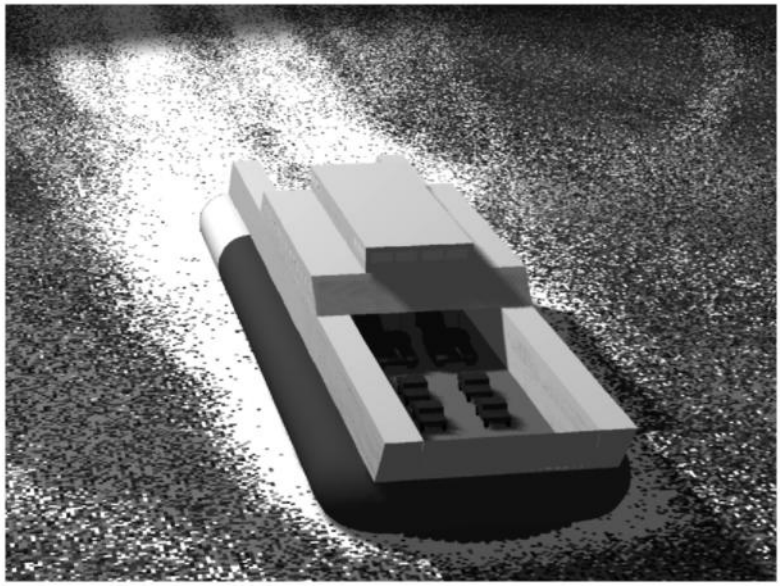
Table A.1
Current Landing Craft and Their Intended Replacements

	LCAC (SLEP)	HLCAC	LCU	LCU(R)
Characteristics				
Length (feet)	88	125	135	132 –134
Width (feet)	48	48	29	40–45
Cargo Area (square feet)	1,800	2,850	2,173	> 2,800
Payload (short tons)	72	144	146	> 212
Operating Radius (nautical miles)	46	100	600	600
Speed Range (knots)	35	35	10	13–15
Ship Capacity				
LPD-4	1	1	1	1
LPD-17	2	1	1	1
LHD/LHA(R)	3	2	2	2
LHA	1	0	4	0
LSD-41	4	2	1	1
LSD-49	2	1	1	1

As noted previously, given a successful LCAC SLEP, LCACs are programmed to remain in service until 2024—an LCAC follow-on would then be used for most of MPF(F) service life. An LCAC follow-on could operate under the existing concept of LCAC employment or under a new concept of employment—possibly with performance gains. The following discussion illustrates the range of possible new concepts of employment. It does not exhaust the list of possible LCAC-follow-on alternatives.

Landing Craft, Tank, Air Cushion. Landing Craft, Tank, Air Cushion (LCTAC) is a NAVSEA design initiative for a self-deploying, hybrid cushion/surface-effect ship landing craft (as illustrated in A.6). It would use steel construction and diesel engine propulsion to reduce cost. The preliminary LCTAC design calls for 10,000 square feet of roll on/roll off vehicle storage (somewhat more than five times the vehicle area of an LCAC, and 40 percent of the vehicle area of an LPD-17). It would be able to transport 350 tons of payload (somewhat less than five times the payload of an LCAC) at

Figure A.6
LCTAC in Loaded Operation



RAND *MG179-A.6*

30 knots over 1,000 nautical miles. Its unloaded range is projected to be 4,000 nautical miles, giving it a significant capability for self-deployment.

In summary, the LCTAC concept is for a self-deploying landing craft with approximately five times the capacity of an LCAC and with comparable speed. The design concept is for a relatively inexpensive vessel. As a hybrid air-cushion/surface-effect ship, it would not match an LCAC's ability to traverse beaches and operate on land. LCTAC distinguishes itself from the other alternatives by having the greatest load capacity and greatest capability for self-deployment.

Zubr (Pomornik). Another alternative to LCAC is represented by the Zubr (Bison)-class air-cushioned landing craft, built by the Almaz Shipbuilding Joint Stock Company in Saint Petersburg, Russia. Ten Zubr-class ships (NATO code-named Pomornik) have been built since 1986. The mission of the vessel, shown in Figure A.7, is to

carry out rapid sealift and beach landing of assault troops and combat materiel on territory held by hostile forces. The ship has a bow and a stern ramp for fast landing of troops and combat materiel. It also provides fire support for troop operations on shore and is capable of laying active minefields. The ship is fitted with light armor plating to provide crew and troops with a degree of protection against ammunition and blast fragments. It also provides protection from nuclear, chemical, and biological weapons. Manufacturer data indicate that the Zubr can carry three medium battle tanks such as the T-80B tank,[7] or eight BMP-2 infantry combat vehicles, or ten BTR-70 armored personnel carriers, or 360 fully equipped amphibious landing troops.

The Zubr's range at maximum speed (60 knots) is 300 miles. Its maximum payload is 130 metric tons (about 140 short tons). The

Figure A.7
The Zubr in a Landing Exercise

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[7] Three such tanks can be carried in an extreme overload condition; the normal limit is two such tanks. These tanks weight about 50 tons apiece.

Zubr concept distinguishes itself by its speed, level of protection, and ability to support forces as they cross a beach.

Air Assisted Catamaran. An Air Assisted Catamaran (AAC) is a hybrid standard catamaran/air-cushion vehicle design that features recesses built into the underside of twin side hulls (see Figure A.8). Air pressure is used to drive water out of the recesses, reducing draft, wetted area resistance, and wave impact.

The leading maker of AAC vessels is SeaCoaster. Air cushions support up to 80 percent of total SeaCoaster vessel displacement. Total power required (including power for blowers) is 60 percent of that for a conventional catamaran, yielding greater speed and endurance. Air pressure is variable, so vessel draft can be changed on demand. The Department of Energy partially funded development and testing of the SeaCoaster prototype vessel, which was launched in 1998, tested, and converted to a 149-passenger U.S. Coast Guard–classed ferry. A primary candidate size for the next SeaCoaster passenger ferry is an 82-foot, 150–250-passenger vessel. Speeds in the 55–60-knot range could be achieved with this design.

Developers of the SeaCoaster concept have created several designs for landing craft using assisted catamaran technology. Figure A.9 shows a notional AAC LCU(R) variant capable of transporting three M1 tanks. The SeaCoaster LCU(R) concept distinguishes itself by its high speed and endurance, sea-keeping ability, good payload, and variable draft.

Figure A.8
Air-Assisted Catamaran Concept, as Seen from Underneath the Vessel

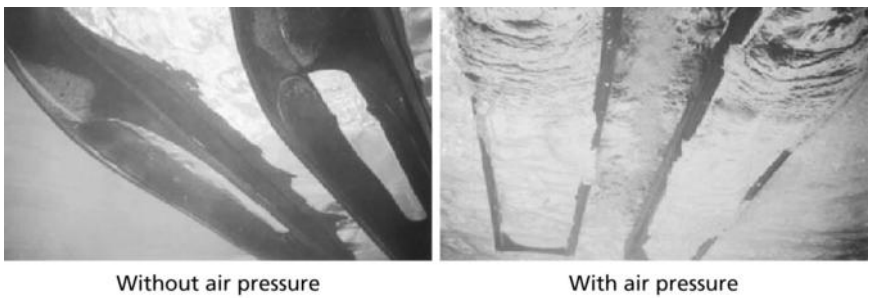

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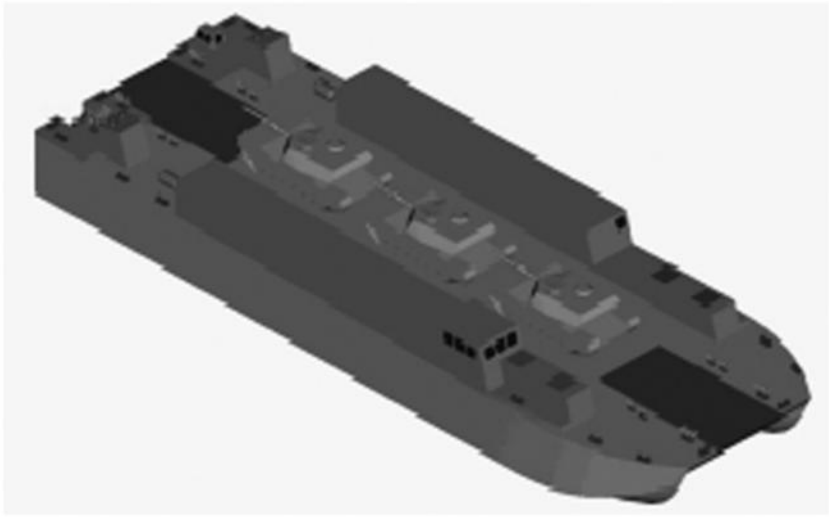
Figure A.9
SeaCoaster LCU(R) Concept Vessel



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High-Speed Theater Support Ships

Current concepts of the multihulled high-speed theater support ship (HSTSS) concentrate on variants of the Australian-designed catamaran ferries. The current Marine Ship to Objective Maneuver (STOM) concept views the HSTSS primarily as a personnel ferry to facilitate the closure rates of Marine personnel to MPF(F) that sail to an objective area before Marine personnel are air lifted. In turn, the Army views the HSTSS as an intra-theater ferry of medium-weight forces, i.e., Stryker Brigade Combat Teams. Like the larger and more conventional monohulled gray and black ships, the multihulled HSTSS have a number of design trade-off issues.

Survivability. A cruise speed close to 40 knots will afford the HSTSS a measure of passive survivability. Broadly speaking, high speed increases areas of uncertainty (areas in which a target might be located given the limited information available to a searcher or attacker) and decreases engagement time. For sensor-to-shooter cycles

of the same length, high speed will tend to increase aim errors for weapons such as cruise missiles. High speed also reduces time in engagement envelopes and thus reduces opportunities for attack. Put another way, these ships can be thought of as fleeting targets. In the event of a torpedo attack, a cruise speed close to 40 knots will reduce torpedo closure rates by extending the length of the torpedo run and increasing the probability of the torpedo failing before it can hit the ship. Current smaller, multihulled ships are exceedingly fragile. On the other hand, the nonferrous construction materials in high-speed ships gives them low magnetic signatures, so low in fact that developing them as minesweepers is under consideration. The same low magnetic signature should also protect HSTSS against magnetically fused torpedoes.

Air Capacity. HSTSS are relatively stable and spacious for their size. They are nonetheless much smaller than large monohulled air-capable ships (those capable of carrying and launching aircraft) and cannot be considered as competitors to either a gray hull or black hull variant of an air-capable ship.

Versatility. HSTSS are likely to provide a versatile platform for a wide range of shallow-water naval missions. A multihulled ferry has already been used as a "mother ship" to support SOF operations during Operation Iraqi Freedom. However, the relatively fragile nature of multihulled vessels suggests that some of their high-speed-cruising advantages may be nullified by adverse sea state conditions. Given current construction techniques, the range of multihulled ferries may be limited more by the ferries' capacity to manage adverse sea states than by their range and payload. Composite-fiber hull construction could possibly make multi-hulled vessels more robust, but the Navy has not yet invested in the design and production of ships with this technology.

Cost. By taking advantage of current aluminum-based designs, it is plausible that a multihulled ferry can be acquired for less than $100 million a ship. However, the cost of such high-speed ships will escalate sharply if the ships are designed to be much more robust and have a superior range and payload. For example, the Tactical Support

Vessel (TSV) recently proposed by the Army gave everyone "sticker shock" with its $200-million-plus price tag.

New Amphibious Craft and VTOL Aviation

The mix of gray hulls, black hulls, and high-speed ferries may be strongly influenced by the mix of new and old amphibious craft. Although the landing ship tank has disappeared from the Navy's inventory, there is still the need for a variety of vessels to move equipment and personnel from gray-hulled amphibious "mother" ships to shore. Currently, the main vessels for this task are medium-lift (CH-46)/heavy-lift helicopters (CH-53), LCAC and monohulled LCU, and the current amphibious assault vehicle (AAV), the AAV-P7). Current plans call for the replacement of the medium-lift helicopter, the CH-46, with the V-22 VTOL-plane, and the replacement of the AAV-P7 with the Expeditionary Fighting Vehicle.

Another possibility for moving equipment and personnel from amphibious ships is to develop either a "sky crane" variant of the upgraded CH-53 series heavy-lift helicopter or a new-generation heavy-lift helicopter with a 20-ton payload as part of a joint Marine Corps/Army program. A 20-ton lift helicopter would be doubly useful by providing both a logistics over the shore (LOTS) cargo lift capability and a limited-range air-assault platform capable of carrying over short distances either the Stryker class or next-generation medium-weight combat vehicles, such as the Army's proposed Future Combat System (FCS) or the Marine Corps' follow-on to the Light Armored Vehicle (LAV) family. This modernization plan is consistent with the planned buy of the LPD-17 class amphibious ship and its air-capable companion, the follow-on to the LHA class. Currently, the black-hulled ships rely on either an austere jetty or large, self-propelled lighters.

Further innovation in amphibious craft design is possible. Large versions of the LCAC are feasible, based only on the experience Russians have had with such designs. Another design concept of interest is the Landing Craft Tank Air Cushion (LCTAC). This vessel would exploit developments in rigid sidewall/air-cushion technology to produce a high-speed vessel that could carry several hundred tons of

payload from a black-hulled ship to a beach. The design of a larger LCAC or the LCTAC in this decade would open the possibility of different mixes between LPD-17 class gray-hulled ships and MPF(F) black-hulled ships. The latter could be designed to off load onto the large amphibious craft while operating outside the immediate danger range of some 25 miles.

Black Hulls

Maritime Pre-Positioning Force

MPS are part of the Military Sealift Command's Pre-Positioning Program. They pre-position Marine Corps vehicles (including tanks), fuel, equipment, ammunition, food, and water. Sixteen[8] MPS ships compose the Maritime Pre-Positioning Force. The MPS are organized into three squadrons (MPSRONs), each commanded by a Navy captain. MPS Squadron One, usually located in the Atlantic Ocean or Mediterranean Sea, has five ships; MPS Squadron Two, usually located at Diego Garcia, has six ships; and MPS Squadron Three, normally in the Guam/Saipan area, has five ships. Each MPSRON is able to support approximately 17,000 Marines (roughly the equivalent of one Marine Expeditionary Brigade) in initial military operations for 30 days. Each ship can discharge cargo either pierside or while anchored offshore using lighterage carried aboard.

Maritime Pre-Positioning Force Future

Today's MPF ships cannot satisfactorily support the Sea Basing concept (discussed in Chapter One) because they cannot offload selectively and they do not support force reconstitution. They will be replaced under the program of record by MPF(F) ships that have those capabilities. The range of MPF(F) alternatives is illustrated in Figures A.10, A.11, and A.12, with information from the current MPF(F)

[8] Three ships were recently added to the previous 13 MPS ships in the MPF.

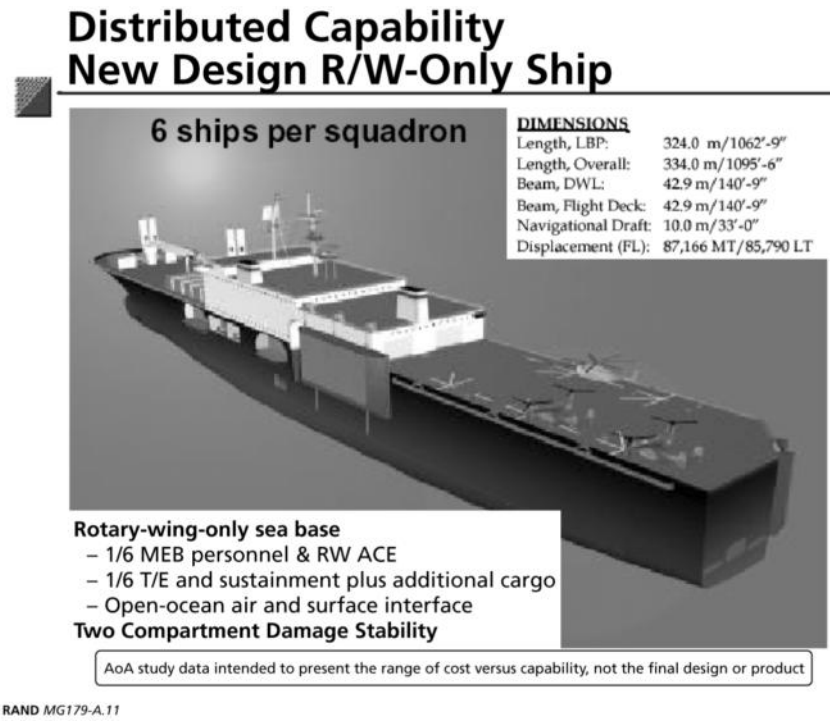
Figure A.10
Replace-in-Kind Large, Medium-Speed Roll-on/Roll-off MPF(F)

Analysis of Alternatives (AoA).[9] Those alternatives are (1) Replacement in Kind, (2) New Design Rotary Wing Only, and (3) Full Air Operations Ship. The Replacement in Kind MPF(F) alternative is designed to be offloaded completely onshore rather than offloaded selectively. It cannot be used to support sea-based operations. The New Design Rotary Wing Only alternative is capable of selective offload; therefore, it is capable of supporting sea-based operations. It is a large ship, comparable to a *Nimitz*-class aircraft carrier.[10] The

[9] "Minutes of the 24 June 2003 MPF(F) Executive Steering Group (ESG) Meeting," MPF(F) AoA Information Memorandum Number 7, CME DOO08628.AI, July 1, 2003.

[10] U.S. Navy, "Aircraft Carriers—CV, CVN," *Fact File,* January 14, 2004 (www.chinfo.navy.mil/navpalib/factfile/ships/ship-cv.html, last accessed November 2004). The *USS*

Figure A.11
New Design Rotary Wing Only MPF(F)



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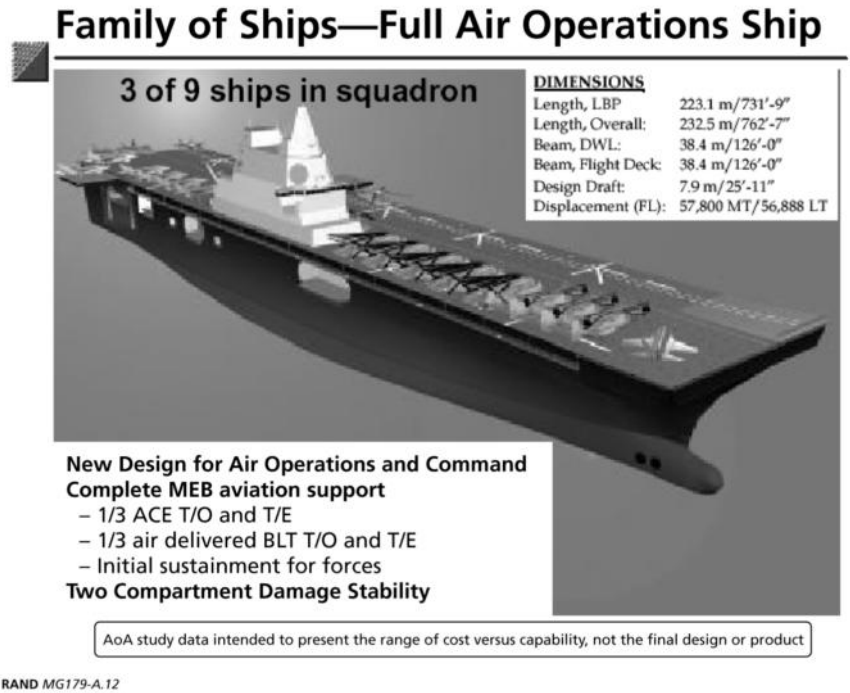
Full Air Operations MPF(F) would be added to a squadron of more-conventional MPF(F) to enhance the squadron's air wing capability. The CNA has stated that MPF(F) characteristics may change significantly; therefore, these designs should not be used for further analysis.

Given the level of uncertainty about the design of MPF(F), any detailed analysis that relies on single-ship characteristics would be fruitless. To some extent, we avoided this problem with single-ship data by assuming that MPF(F) will be designed to meet the requirement that each of the three MPSRONs will provide lift for one MEB.

Nimitz (CVN 68) is 1,092 feet long, with a 252-foot beam, and displaces approximately 95,000 tons. The New Design Rotary Wing Only concept is 1,063 feet long, with a 141-foot beam. It displaces approximately 86,000 tons.

Figure A.12
Full Air Operations Ship MPF(F)



By dealing with MPF(F) as much as possible at the MPSRON level (i.e., conducting analysis at an aggregated level), and by conducting sensitivity analyses and employing other analytic techniques, we avoided having to use single-ship characteristics. The techniques used to manage these uncertainties are discussed in Chapter Three.

The mixes of black hulls and gray hulls presented in Chapter Three largely use the New Design Rotary Wing Only alternative. The New Design Rotary Wing Only MPF(F) is designed such that a squadron of six New Design Rotary Wing Only MPF(F) can carry and support a MEB—each ship can support one-sixth of a MEB. The current MPF(F) AoA includes ship designs with an LCAC-sized dry well and an LCU(R)-sized wet well. We chose an LCAC-sized dry

well as a baseline for our analysis.[11] The MPF(F) unit cost estimates are not firm. A rough order of magnitude estimate, provided by ASNRDA, is $1.75 billion.

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[11] "Minutes of the 24 June 2003 MPF(F) Executive Steering Group (ESG) Meeting," 2003, p 2.

APPENDIX B

The Static Lift and Dynamic Lift Models

This appendix is designed to provide more details on the two models RAND developed to conduct the evaluation described in this report: the Static Lift model and the Dynamic Lift model.

The Static Lift Model

The Static Lift model was developed for this study as an analytic tool to answer the following questions:

- What will be the total L-class ship lift for each fingerprint by year?
- When black hulls are substituted for gray hulls, what will be the total L-class and ESS lift for each fingerprint by year?

The inputs for the model are as follows:

- MEB lift requirements by fingerprint. The user can select the MEB of interest (such as the 1991 or 2015 MEB) from the database.
- The number of L-class ships and black hulls substituted for those ships in a given year.
- The capacity, by fingerprint, of each L-class ship and black-hull substitute.

The Static Lift model is conceptually simple. It first builds a table of capacities by fingerprint, for the years of interest, by ship class (aggregating capacity over the class). It then sums lift over the ship classes to derive lift, by fingerprint, for the years of interest. Dividing lift totals by MEB requirements, in terms of fingerprints, yields MEB lift level by fingerprint.

The Static Lift model is written in the high-level programming language C++. Output is written using a file format that is easily read by Microsoft Excel. Excel is then used to find the minimum lift level across fingerprints (and was used to generate the graphs in Chapter Three).

The Dynamic Lift Model

The Dynamic Lift model was developed for this study as an analytic tool to answer the following questions:

- How quickly can amphibious forces for Joint Forcible Entry Operations be assembled?
- What resources (ESGs, MPSRONs and other possible assets) would be committed to this effort?
- What are the characteristics of the assembled force?

Overview of Model

Like the Static Lift model, the Dynamic Lift model is written in the C++ programming language to facilitate data sharing between the two models and to provide the quick turnaround and flexibility needed for the hundreds of cases considered in this evaluation. The code for the model is divided into two parts: one that sets up the initial conditions and another representing the buildup process itself. After initial conditions are set, buildup is conducted as quickly as possible while the five lift fingerprints are monitored. The buildup is complete and halted when all fingerprint requirements have been met.

The model can also monitor terms in addition to the fingerprints to provide answers to questions about the characteristics of the

assembled force. For example, for this analysis, the model was used to track the *actual* number of LCACs built up in addition to the required LCAC-spot fingerprint. Other terms of interest, such as fixed-wing aircraft operational spots, cruise-missile defense systems, and so on, can also be tracked.

Outputs include time to achieve force buildup and a record of fingerprint and resource levels, and other terms of interest, over time.

Setup Procedure

Setup begins with the definition of transit distances for selected locations around the globe. These locations include ports (such as San Diego and Norfolk), deployment regions, and potential crisis regions selected on the basis of the information in Chapter Two. Transit-distance inputs were provided by the Navy or were generated by the transit portion of RAND's Joint Integrated Contingency Model (JICM).[1]

Next, the setup process defines force-buildup requirements in terms of MEBs. For this study, the model was run with the requirement of building up a single MEB. We had several reasons for making this choice. First, buildups significantly smaller than one MEB are not sufficiently challenging to illuminate the appropriate mix of black and gray hulls. Also, the Marine Corps has stated that the minimum Marine Corps force for sustained forcible entry operations is the MEB. Finally, rapid buildups of forces much larger than a MEB would be unachievable with the forces normally available under the Global CONOPS.

Setup data include data on ESGs (their location, whether or not they are in port, days to get under way, and speed of advance under way). These data items were developed in cooperation with the Navy. A similar process is performed for the MPSRONs. Time for MPSRONs to get under way is computed knowing that future

[1] The JICM is used heavily by RAND in studies and exercises for the Air Force, Army, Office of the Secretary of Defense (OSD), and Joint Staff sponsors. It is also used directly by some war colleges, by OSD (PA&E), by the Korean Institute for Defense Analyses, and by the Korean armed forces.

MPSRONs may be held in port while troops are flown to those MPSRONs as part of troop closure. A corresponding process is performed for any other forms of sealift (such as an LCAC transport).

Next, carrying capacities are determined. For ESGs, mean carrying capacities across the fingerprints are derived from data files shared with the Static Lift model. MPSRON capacities are assigned squadron by squadron. This process allows for comparison of the effects of taking up MPF(F) ships from selected MPSRONs. For near-term operations, current squadron capacities are used. Other forms of sealift are defined on a case-by-case basis.

Time of arrival is found for ESGs, MPSRONs, and other forms of sealift using transit distances, SOAs, and time to get under way. For ESGs, these factors are known in advance. For MPSRONs, the number of troops that would be carried by MPF(F) is computed as the difference between the troop requirement and the number of troops embarked on ESGs. The MPSRON that is best able to transport those troops is identified, and the time to marry up those troops with that MPSRON is found.[2] That time is used to delay the departure, and hence the arrival, of the selected MPSRON and the troops it transports.

The Dynamic Lift model sets up conditions at C-day; thus, it does not model force movement prior to C-day. This was a deliberate decision that was made for several reasons. First, modeling force movement prior to C-day obscures differences between amphibious force alternatives and can make identifying performance thresholds difficult. Second, all data available for verification against Navy models (including war game results) were generated without early force movement. Third, movement prior to C-day creates an additional problem dimension. What if movement begins at C-1? Or at C-2? Therefore, modeling early force movement would have added a substantial layer of complexity to the analysis.

If need be, consideration of early force movement could be accomplished with the existing model by stipulating the results of that

[2] Based on troop movement results of a recent Navy JFEO war game.

movement in terms of conditions at C-day. For example, ESG deployment before C-day can be accounted for easily in the model's data.[3]

Force Buildup Procedure

In principle, the force buildup process is simple. Known times of arrival are compared against an advancing calendar ticking off days to determine which assets have arrived day by day and to add the fingerprint capacity of those assets to the buildup. At the same time, any other terms being tracked (such as the actual number of LCACs in theater) are also accumulated on a day-by-day basis. At the end of each day, if all fingerprint requirements have been achieved, the buildup is halted.

Two problems complicate this process. First, consider a case with MPSRONs that lack LCAC spots. If all fingerprint requirements other than LCAC spots have been met, additional MPSRON arrivals would not be beneficial. Thus, it would be incorrect to include additional MPSRONs as assets required for the force buildup. As a second example, suppose that a single ESG can meet the balance of force buildup requirements and that, by coincidence, the next two ESGs will arrive on the same day. Again, it would be incorrect to say that both ESGs are required for the force buildup. As a last example, suppose that a scenario requires a sea base during the period when some, but not all, MPSRONs have converted to MPF(F). Current MPSRON ships are not capable of selective offload and, therefore, cannot support sea-based operations. The problem then is to prevent the arrival of assets that cannot contribute to unmet fingerprint requirements. As the Dynamic Lift model checks to see if fingerprint requirements have been met, it screens assets that are under way and halts movement of any asset that cannot contribute to unmet fingerprint requirements.

A second problem complicating the force-buildup process is the strongly stated preference for reserving at least one MPSRON to

[3] Movement before C-day can be regarded as a negative departure delay and the resulting term can be entered as data.

preserve operational flexibility in other theaters. This preference is accommodated in the buildup process by examining assets in descending order of preference. ESGs are treated first, followed by other forms of sealift, such as LCTAC, and then finally MPSRONs. In combination with the process for screening platforms underway to assure that they are relevant to the problem, this step prevents the use of MPSRONs that are not essential to the fastest-possible force buildup.

Output from the Dynamic Lift model allows users to determine how long a force buildup would be delayed by outside constraints. This capability is illustrated by the following sample output.

Sample Output

The following sample output from the Dynamic Lift model was generated during an analysis of the effects of taking up two MPF(F) ships from MPSRONs for a MEB buildup in the Philippines. The output begins with the date and time of the model run, the crisis location, MEB requirement, and available assets. It displays transit distances, times to get under way, speed of advance, and arrival times generated in the model setup process. The subsequent lines of output were generated by the buildup portion of the model.

The somewhat verbose style of this output was meant to verify that the model works as intended and for verification against other models. It also helps to promote understanding of the results.

```
Aug 19 2003 06:08:15

Crisis location: 11

MEB requirements:   12700    300    560    260     31
Secondary considerations:    1

Requirements:
        Scenario requires sea basing
        MEB buildup level: 1.0
        Lift req:  12700   300   560   260    31

Scenario assets:
        6 ESGs deployed/deployable
        3 MPF squadrons
        0 other forms of lift

ESG data are for year 2025
```

```
Mean ESG lift capacities: 2924.7  64.0 196.9  53.2   8.2
                                8.2
ESG 0
        transit distance is 6671 nm;
        transit begins C+0;
        transit SOA is 18 kt;
        total time 15.4 days
ESG 1
        transit distance is 4573 nm;
        transit begins C+0;
        transit SOA is 18 kt;
        total time 10.6 days
ESG 2
        transit distance is 11626 nm;
        transit begins C+3;
        transit SOA is 18 kt;
        total time 29.9 days
ESG 3
        transit distance is 11626 nm;
        transit begins C+5;
        transit SOA is 18 kt;
        total time 31.9 days
ESG 4
        transit distance is 6253 nm;
        transit begins C+4;
        transit SOA is 18 kt;
        total time 18.5 days
ESG 5
        transit distance is 2024 nm;
        transit begins C+2;
        transit SOA is 18 kt;
        total time 6.7 days

MPF Squadron 0
        transit distance is 6671 nm;
        transit SOA is 16.0 kt;
        transit time is 17.4 days;
        capacities:   8525  1275  4020   195     5

MPF Squadron 1
        transit distance is 3650 nm;
        transit SOA is 16.0 kt;
        transit time is 9.5 days;
        capacities:  10230  1530  4824   234     6

MPF Squadron 2
        transit distance is 1048 nm;
        transit SOA is 16.0 kt;
        transit time is 2.7 days;
        capacities:   8525  1275  4020   195     5

MPSRON Delays
        Troop requirement: 12700
        Deployed troops: 8774
        MPSRONs need to carry 3926 troops

        MPSRON 0 delayed 0.0 days; arrival day = 17.4
        MPSRON 1 delayed 0.0 days; arrival day = 9.5
        MPSRON 2 delayed 3.9 days; arrival day = 6.7
```

```
 1 0 0 0       0  0.00      0  0.00      0  0.00     0  0.00    0  0.00
    0.0
 2 0 0 0       0  0.00      0  0.00      0  0.00     0  0.00    0  0.00
    0.0
 3 0 0 0       0  0.00      0  0.00      0  0.00     0  0.00    0  0.00
    0.0
 4 0 0 0       0  0.00      0  0.00      0  0.00     0  0.00    0  0.00
    0.0
 5 0 0 0       0  0.00      0  0.00      0  0.00     0  0.00    0  0.00
    0.0
 6 0 0 0       0  0.00      0  0.00      0  0.00     0  0.00    0  0.00
    0.0
ESG 5 has arrived from location 13
MPSRON 2 has arrived from location 0
 7 1 1 0   11450  0.90   1339  4.46   4217  7.53   248  0.96   13  0.43
    8.2
 8 1 1 0   11450  0.90   1339  4.46   4217  7.53   248  0.96   13  0.43
    8.2
 9 1 1 0   11450  0.90   1339  4.46   4217  7.53   248  0.96   13  0.43
    8.2
MPSRON 1 has arrived from location 6
10 1 2 0   21680  1.71   2869  9.56   9041 16.14   482  1.86   19  0.63
    8.2
ESG 1 has arrived from location 10
11 2 2 0   24604  1.94   2933  9.78   9238 16.50   535  2.06   27  0.88
   16.3
12 2 2 0   24604  1.94   2933  9.78   9238 16.50   535  2.06   27  0.88
   16.3
13 2 2 0   24604  1.94   2933  9.78   9238 16.50   535  2.06   27  0.88
   16.3
14 2 2 0   24604  1.94   2933  9.78   9238 16.50   535  2.06   27  0.88
   16.3
15 2 2 0   24604  1.94   2933  9.78   9238 16.50   535  2.06   27  0.88
   16.3
ESG 0 has arrived from location 3
16 3 2 0   27529  2.17   2997  9.99   9435 16.85   589  2.27   36  1.15
   24.5
```

Rather than attempt to dissect the entire output, we will focus on just the last three lines. The first line indicates that an ESG has arrived from the Eastern Mediterranean Sea (location 3).[4] The next line indicates that day 16 is complete—consistent with the expectation that the ESG from the Mediterranean Sea would take somewhat more than 15 days to arrive. The digits 3, 2, and 0 indicate that a total of three ESGs have contributed to the force buildup, along with two ESGs, and no other forms of sealift were described in the data.

[4] This ESG is labeled "ESG 0." In the C++ programming language, numbering always begins with zero; this is the first ESG in the list of ESGs.

Next, the model indicates the maximum number of troops that could be built up (27,529) when using assets to their fullest. This is more than twice the requirement of 12,700 troops[5] specified in the data. Vehicle and cargo fingerprints are shown over the next seven columns. They exceed requirements (by up to a factor of 16).[6] We see that 589 CH-46 spot equivalents of VTOL space are available (more than twice the requirement). Finally, the line indicates that 36 LCAC spots have been built up, 1.145 times the 31 LCAC spots required. With all fingerprint requirements met, the model should not and does not go on to calculate requirements for another day.

The final line consists of the cryptic output 24.5, which indicates the actual number of LCACs anticipated.[7] With a notional requirement for 31 LCACs and 24.5 LCACs in theater on average, the model indicates a potential shortfall of six or seven LCACs, which would have to be made up by LCAC transports, LCTAC, or some other means.

Scrutiny of the preceding output indicates that with an alternative means of bringing LCACs into theater, or with an alternative to LCACs, one fewer MPSRON would be needed to achieve the buildup. Also, looking back to day seven, following the arrival of the first ESG and the first (troop-carrying) MPSRON, all fingerprint requirements, with the exception of the LCAC fingerprint, are met at the 90-percent level or above. With 13 LCAC spots and eight actual LCACs expected in theater, this force is not usable.

---

[5] The 2015 MEB, as discussed in Chapter Three, is planned for this number of troops.

[6] Vehicle square footage and cargo cubic footage have been adjusted downward by a "packing density" factor consistent with capability for selective offload and reconstitution. Measures of these two fingerprints were also adjusted downward by exclusion of area and volume devoted to follow-on assault echelon support.

[7] Many other terms of interest could be tracked here. However, the code has no way of knowing what is being tracked and therefore cannot label it.

APPENDIX C

Details on Force Closure Analysis

The Static Lift portion of the analysis done for this report measured the Navy's ability to meet the fiscally constrained programming goal of 2.5 MEB(AE) lift. As discussed in this report, meeting the programming goal depends only on MEB characteristics and the number and capacity of ships by class. This analytic effort produced a relatively small number of cases, and most of them were covered in Chapter Three.

In contrast, the force closure portion of the analysis considered combinations of black-hull for gray-hull substitutions (such as one-for-one or one-for-two); initial force dispositions under the Global CONOPS; force closure locations; and LCAC follow-on basing alternatives and speed of advance. The program of record was used as a baseline and to ensure that performance gains achieved under the program were preserved by the selected alternatives. We also found it informative to look at the current amphibious force. Additionally, sensitivity analysis to manage uncertainty (such as in the number of VTOL spots on an MPF(F) ship or the SOA of an LCAC follow-on) created additional cases for analysis. In all, we analyzed some 400 cases for the force closure analysis.

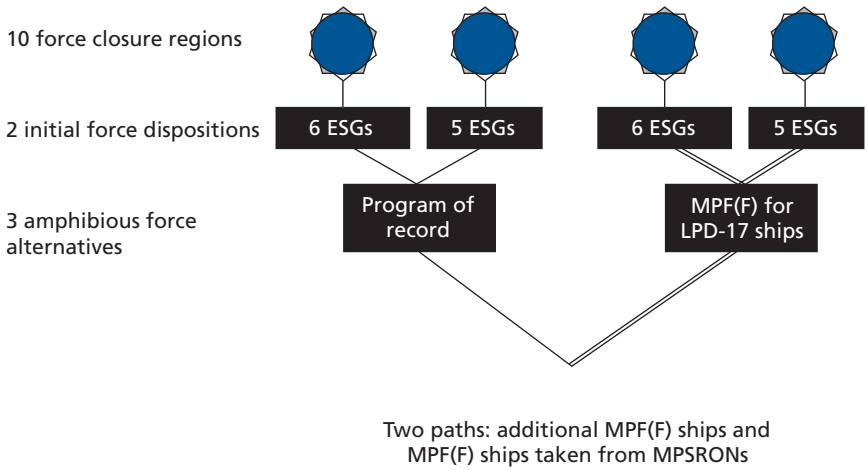
The analysis used three metrics: time for force closure, number of ESGs, and MPSRON(F) required for earliest closure. Addressing every case in this report would be impractical. As a result, we summarized the results and presented representative cases in Chapter Three. In this appendix, we explore the results of our analysis in more detail, showing results by force closure location, initial force disposition, and other measures to shed more light on the analysis. In this discussion,

we emphasize force closure time to a greater degree than assets required for earliest force closure.

Roadmap of Amphibious-Force Alternatives Used for Basic Analysis

We used roadmaps to negotiate the 400-plus cases we analyzed. The map shown in Figure C.1 illustrates the three amphibious-force alternatives we selected for this analysis: the program of record as defined by the 30-year Shipbuilding and Conversion, Navy plan; the program of record modified through the substitution of additional black hulls for gray hulls; and the program of record modified through the substitution of black hulls taken up from future MPSRONs for gray hulls.

Figure C.1
Map Used in Basic Amphibious-Ship Substitution Analysis



RAND *MG179-C.1*

Each of the four objects at the top of Figure C.1 represents the ten force-closure regions. The ten regions have two initial force dispositions—six ESG and five ESG. For those two force dispositions, there are three amphibious force alternatives: the program of record, and the two parallel amphibious-ship substitution paths—additional MPF(F) ships and MPF(F) ships taken from MPSRONs. The map does not show force-closure analysis results under the current force, which were generated as a basis for comparison.

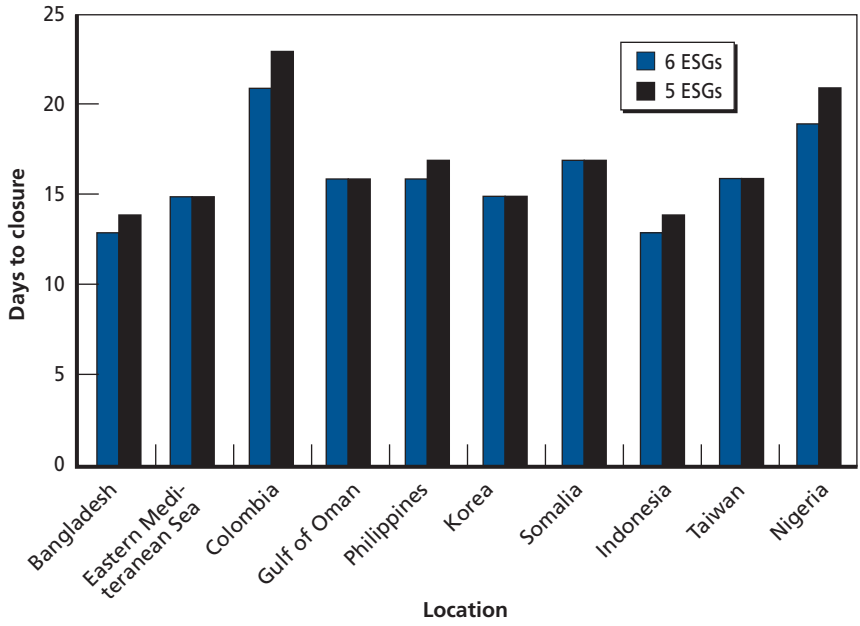
Basic Results

Time to Achieve Force Closure

For the program-of-record alternative, when six ESGs are deployed or are ready to surge, the earliest closure among the ten force-closure locations is achieved in Bangladesh and Indonesia (13 days). Closure takes longest in Nigeria (19 days) and Colombia (21 days). For the Eastern Mediterranean Sea, Gulf of Oman, Philippines, Korea, Somalia, and Taiwan, closure is achieved in 15 to 17 days (as shown in Figure C.2). Sixteen days turns out to be a representative length of time; mean closure time across the ten locations is 16.1 days, and the median closure time is 16 days.

We next consider the cases in which five ESGs are deployed or ready. With one fewer ESG available, the earliest closure takes an additional day in Bangladesh and Indonesia (14 days). Closure takes an additional two days in Nigeria (21 days) and Colombia (23 days). For the Eastern Mediterranean Sea, Gulf of Oman, Philippines, Korea, Somalia, and Taiwan, closure is still achieved in 15 to 17 days. With one fewer ESG, mean closure time across the ten locations is 16.8 days; the median closure time remains 16 days.

Figure C.2
Closure Times for Program of Record, by Location



RAND *MG179-C.2*

These results are consistent with those presented in the publication *Naval Operating Concept for Joint Operations*.[1] The similarity in the results reflects the cooperation of OPNAV N7 in developing the Dynamic Lift Model and its inputs.

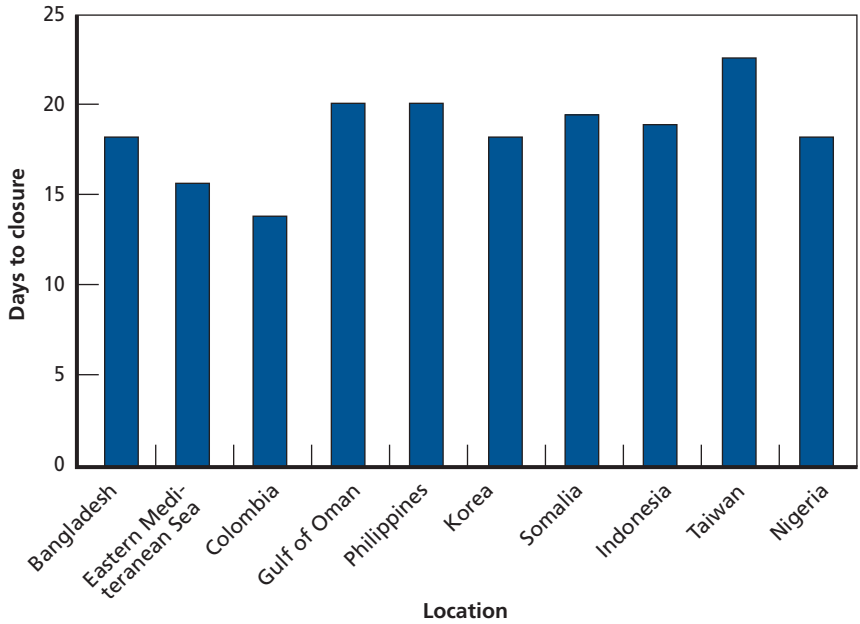
As shown in Table 3.5 in Chapter Three, on average, 6.06 ESGs from the current amphibious force are needed to provide vehicle square-footage lift for a single 2015 MEB(AE). Without selective offload, MPSRON vehicle square footage cannot be counted toward total lift at a sea base. Strictly speaking, six ESGs cannot achieve the required buildup. Waiving the 1 percent vehicle square-footage shortfall (6.06 = 6 x 1.01), we generated closure times to a sea base given

[1] Clark, Admiral Vern, and General Michael W. Hagee, *Naval Operating Concept for Joint Operations,* Department of the Navy, United States Marine Corps, September 22, 2003, p. 18

the current force (L-class ships and MPS). With six available ESGs, closure times range from 22 days to 31 days (see Figure C.3). The mean time for force closure is 29.5 days, and the median is 30 days. With five ESGs available, the shortfall approaches 20 percent for vehicle square footage and exceeds 10 percent for VTOL spots; we did not generate closure results.

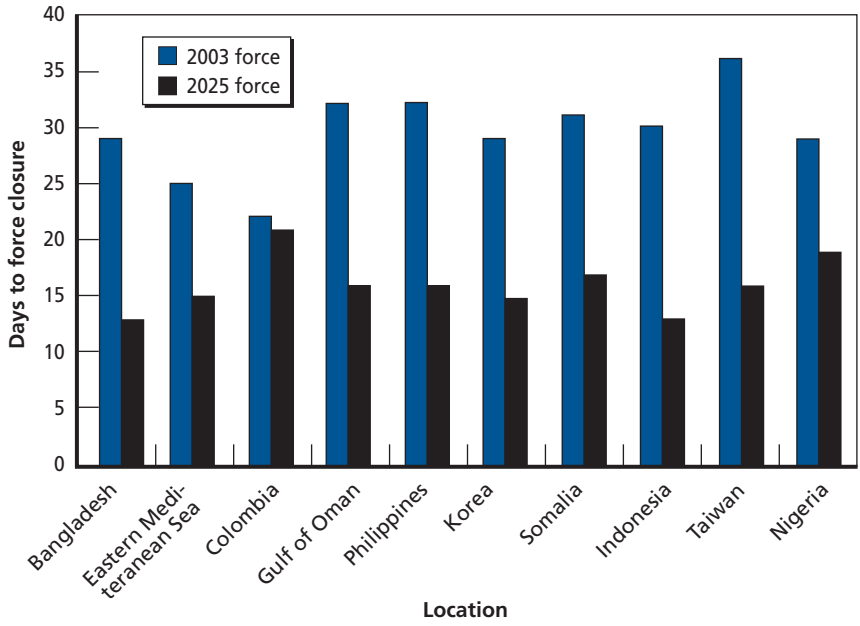
Force closure times for the 2003 force and the 2025 force under the program of record are compared across locations in Figure C.4. The figure indicates that closure time is reduced under the program of record by at least 50 percent for five of the ten locations selected. Within the zone of instability, closure time is reduced by 40 to 55 percent. Greatest gains are achieved for Indonesia, Bangladesh, and Taiwan. Almost no gain is achieved for Colombia.

Figure C.3
Closure Times for Current Force, with Six ESGs Initially Deployed or Ready, by Location



RAND *MG179-C.3*

Figure C.4
Comparison of Closure Times for 2003 and 2025 Forces, by Location



RAND *MG179-C.4*

Moving to substitution of MPF(F) ships for LPD-17s, we present the results for the case of two additional MPF(F) ships, or ESS, substituting for four LPD-17s. This substitution scheme (as seen from the "9 LPD17/2 MPF(F)" line in Figure 3.6 in Chapter Three) is favorable in terms of achieving the 2.5 MEB(AE) lift requirement as soon as possible. As was done in the analysis of the previous alternative, this analysis begins with an initial disposition of six ESGs that are deployed or ready. Closure times for this case are identical to the corresponding cases for the program of record (shown in Figure C.2).

We now move to MPF(F) ships from MPSRON(F) to substitute for LPD-17s. The primary question raised prior to the analysis is, would the MPF(F) squadrons' reduced contribution to a sea base extend closure time beyond that expected with the program of record? An analysis to determine the MPF(F) squadrons from which the two MPF(F) ships should be taken found it advantageous to take one

MPF(F) ship from the Mediterranean Sea MPSRON(F) and one from the Guam MPSRON(F).

This choice of MPSRON(F) is logical. Within the zone of instability (from West Africa to Indonesia), the Diego Garcia MPSRON(F) can arrive before the ESGs that make up the sea base. This is true even when the Diego Garcia MPSRON(F) is held in Diego Garcia for troop arrival. With a sea base that is achievable using three ESGs and a single MPSRON(F), and with the Diego Garcia MPSRON(F) unaffected under this concept, it stands to reason that closure times in the zone of instability would be unchanged. The Dynamic Lift Model confirmed this logic, showing no changes to closure times observed anywhere. Our reasoning did not depend on the initial number of ESGs that are deployed or ready. By extension, closure times in the zone of instability should be unchanged in the instance of five ESGs initially deployed or ready. Again, the Dynamic Lift Model confirmed this logic, and no changes to closure times were observed anywhere.

On the basis of the above findings, we offer the following conclusions:

- In terms of the metric of time to achieve force closure for one MEB(AE), there is no penalty (or advantage) in substituting two ESS for four LPD-17s.
- By the same metric, there is no penalty or advantage in substituting two MPF(F) ships from MPSRON(F) for four LPD-17s.
- In terms of the ability to achieve 2.5 MEB(AE) lift, substituting two ESS for four LPD-17s is advantageous (as shown in Figure 3.6 in Chapter Three).
- By the same metric, removing four LPD-17s worsens the lift shortfall for the baseline case (also shown in Figure 3.6).

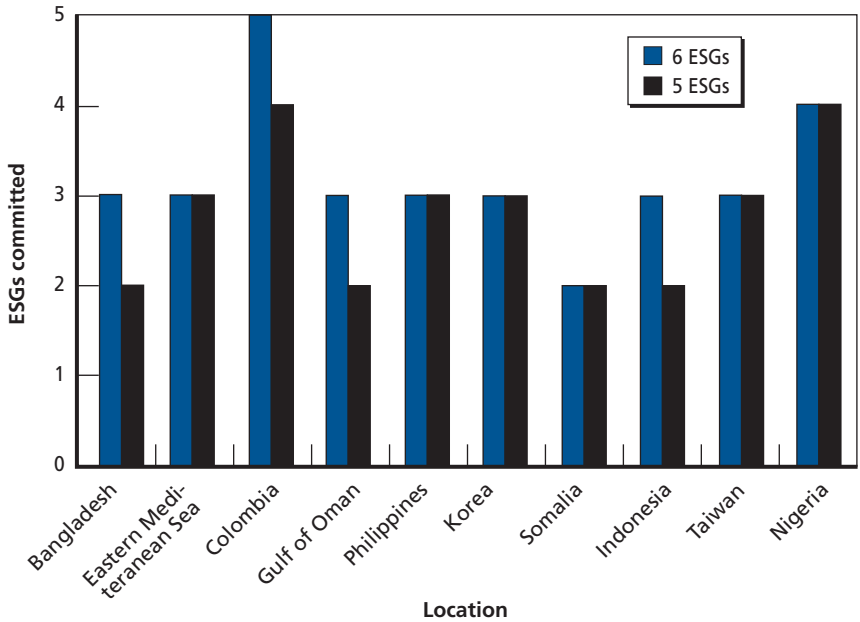
Resources to Achieve Force Closure

Resource requirements for the earliest possible force closure relate directly to operational flexibility under the Global CONOPS. Given five or six ESGs committed to one location, there would be no flexibility to respond to crises in any other region. Likewise, committing

two or three MPF(F) squadrons to one location would compromise response flexibility.

We return to the starting point in the map in Figure C.1, this time looking at the 2025 force under the program of record and comparing it against the 2003 force. For the 2025 force, two or three ESGs committed to a location are required to achieve the earliest possible force closure (see Figure C.5). With six ESGs available, the best solution according to the Dynamic Lift Model typically commits three ESGs to a location. With five ESGs available, the Dynamic Lift Model typically would call for using two ESGs and making up the lift shortfall by using two MPF(F) squadrons, an unattractive alternative. We noted earlier that six ESGs from the current force would be required for force closure to a sea base.

Figure C.5
ESGs Required for Earliest Force Closure, by Location



RAND *MG179-C.5*

These two findings—the introduction of MPF(F) increases the efficiency with which ESGs can be used, and the introduction of MPF(F) creates new sea-basing options—in combination produce a third finding—the program of record will significantly increase operational flexibility as compared with the 2003 force. This third finding has a downside in that the additional flexibility comes at the occasional cost of committing two MPF(F) squadrons to a region (and protecting them, a significant additional burden on the Sea Shield concept described in Chapter One) or delaying force closure until a third ESG arrives from the Continental United States (CONUS).

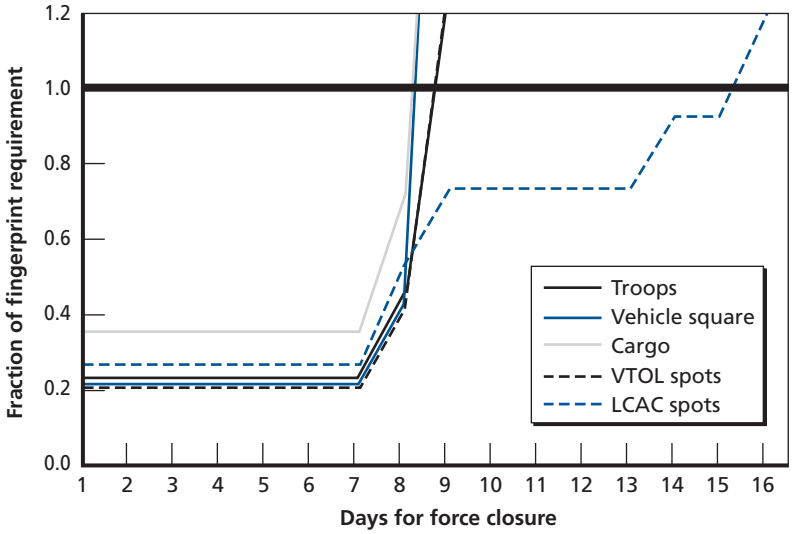
We now move to substitution of MPF(F) ships for LPD-17s. In this case, we found that the use of additional MPF(F) ships, or ESS, or the use of MPF(F) ships taken from an MPSRON(F) does not change the number of ESGs required for earliest closure. It does occasionally reduce the number of MPF(F) squadrons required for earliest closure.

Observations

The lift fingerprint driving these results is LCAC spots. Figure C.6 illustrates fingerprint levels for the Gulf of Oman force closure (seen here as being typical in terms of closure time). As shown in the figure, fingerprint levels increase in synchrony as an ESG arrives on day eight. All fingerprint requirements other than LCAC spots are met by day nine with the arrival of an MPSRON(F). Troop closure has also occurred by day nine. An additional week passes before the LCAC spot requirement is met. By then, L-class ships have provided 25 of the LCAC spots; the other LCAC spots are from MPSRON(F) and presumably would not hold amphibious-assault landing craft. Additional MPF(F) squadrons would be brought in for their LCAC spots, not their loads of vehicles and cargo.

These observations suggest new concepts for predeploying landing craft or deploying these craft as units in an ESG. The result would be a combination of landing craft deployed in well decks and predeployed/self-deploying craft. This situation points to a couple of

Figure C.6
Fingerprint Levels, 2025 Program-of-Record Force, Gulf of Oman



RAND *MG179-C.6*

key questions: Could closure be achieved earlier by eliminating the LCAC-spot bottleneck? Could the situation of LCAC spots without amphibious-assault landing craft be eliminated?

Results of LCAC Service-Life Extension Program Follow-On Analysis

This analysis treats large LCAC(SLEP) follow-ons as having LCAC spots according to their carrying capacity. The Landing Craft, Tank Air Cushion (LCTAC), for example, has the carrying capacity of approximately five LCACs; therefore, it is treated as having five LCAC spots. With this idea in mind, any alternative LCAC follow-ons deploying with ESGs would obviously synchronize LCAC-spot arrival rates with the arrival rates of the other lift fingerprints. The question now is, outside of LCAC follow-ons deploying with ESGs, where could LCAC follow-ons be based, and what SOA would they need to achieve the same result as the program of record? This section exam-

ines the requirements for LCAC alternatives that would *not* deploy with ESGs.

For self-deploying alternatives such as LCTAC, the key performance parameters are endurance and SOA. For transport options, such as a heavy-lift carrier, load/offload time and SOA are the key performance parameters. No such platform is being suggested; thus, the analysis considers only basic feasibility.

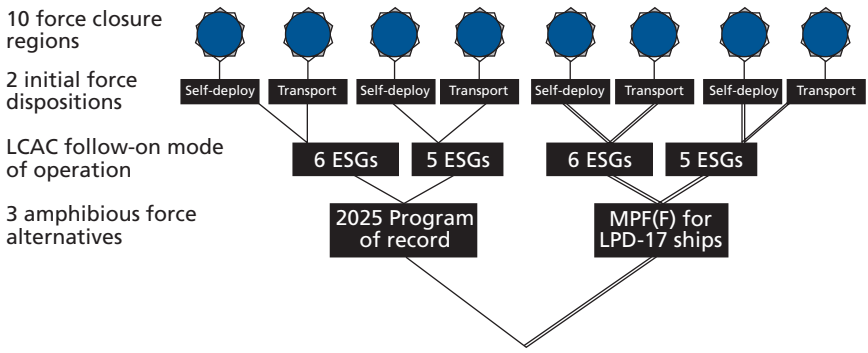
LCAC(SLEP) Follow-On Analysis Map

The map used in the analysis of LCAC(SLEP) follow-ons (see Figure C.7) extends the basic map in Figure C.1. It does not show the excursions needed to analyze basing or key performance parameters.

Self-Deploying Alternatives

Basing and Key Performance Parameter Analysis. Three bases were used for this analysis of force closure. Tables C.1, C.2, and C.3 chart the force-closure results for Norfolk, Diego Garcia, and Guam, respectively, using self-deploying craft with SOAs of 20 to 35 knots (kt). It is not clear that SOAs in excess of 35 kt could be achieved for

Figure C.7
Map Used in Analysis of LCAC Follow-Ons



RAND *MG179-C.7*

Table C.1
Norfolk Basing Results

Location	6 ESGs Initial Force			5 ESGs Initial Force		
	SOA of 20 kt	SOA of 30 kt	SOA of 35 kt	SOA of 20 kt	SOA of 30 kt	SOA of 35 kt
Bangladesh			■			■
E. Medit. Sea	■	■	■	■	■	■
Colombia	■	■	■	■	■	■
Gulf of Oman		■	■		■	■
Philippines						■
Korea		■	■		■	■
Somalia		■	■		■	■
Indonesia			■			■
Taiwan						
Nigeria	■	■	■	■	■	■

Table C.2
Diego Garcia Basing Results

Location	6 ESGs Initial Force			5 ESGs Initial Force		
	SOA of 20 kt	SOA of 30 kt	SOA of 35 kt	SOA of 20 kt	SOA of 30 kt	SOA of 35 kt
Bangladesh	■	■	■	■	■	■
E. Medit. Sea	■	■	■	■	■	■
Colombia		■	■		■	■
Gulf of Oman	■	■	■	■	■	■
Philippines	■	■	■	■	■	■
Korea	■	■	■	■	■	■
Somalia	■	■	■	■	■	■
Indonesia	■	■	■	■	■	■
Taiwan	■	■	■	■	■	■
Nigeria	■	■	■	■	■	■

Table C.3
Guam Basing Results

Location	6 ESGs Initial Force			5 ESGs Initial Force		
	SOA of 20 kt	SOA of 30 kt	SOA of 35 kt	SOA of 20 kt	SOA of 30 kt	SOA of 35 kt
Bangladesh						
E. Medit. Sea						
Colombia						
Gulf of Oman						
Philippines						
Korea						
Somalia						
Indonesia						
Taiwan						
Nigeria						

the transit distance of interest. Cells in dark gray represent cases in which force closure *would not be delayed* until the arrival of the self-deploying craft. Cells in light gray represent cases in which force closure *would be delayed.*

It should be no surprise that Norfolk is not the best support base for operations in the zone of instability. However, Norfolk is the best support base for operations in Colombia and Nigeria.

Self-Deploying-Alternative Force-Closure Results. There is little difference between Diego Garcia and Guam in terms of the force-closure results shown in Tables C.2 and C.3; both bases require 30-knot SOAs. Guam was selected for use in the analysis based on its suitability for naval operations.

To generate the basing and SOA results in Tables C.1, C.2, and C.3, platform speed was increased until the LCAC-spot fingerprint was not delaying force closure. We next present the resulting force closure times, which depend on initial force disposition, but do not depend on basing provided that the self-deploying LCAC(SLEP)

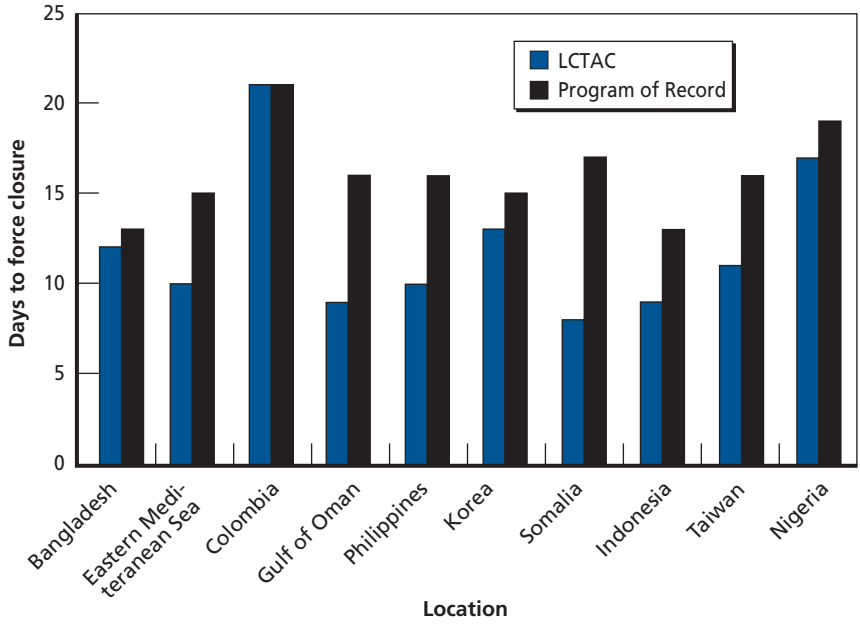
follow-on SOA is at least 30 knots. Figures C.8 and C.9 indicate the reductions in force-closure times that could result from a self-deploying LCAC(SLEP) follow-on. The figures indicate significant closure-time reductions in some locations (notably the Gulf of Oman, Philippines, and Somalia).

Landing Craft Transports

We addressed two questions in the landing craft transport analysis:

- What combinations of load/offload times and SOAs would be required to match the force-closure times shown in Figures C.8 and C.9 for self-deploying landing craft?

Figure C.8
Closure Times for LCTAC and Program of Record, Six ESGs Initially Deployed or Ready



RAND *MG179-C.8*

- What combinations of load/offload times and SOAs would be required to provide self-deploying landing craft at times matching the force-closure times for the program of record?

To answer both questions, time and distance requirements are known for a given transport base—Guam—to provide a basis for comparison. It is then a simple matter to subtract load/offload time from the time available and to convert the remaining time to an SOA requirement. The results are shown in Figure C.10 for all ten locations.

Figure C.9
Closure Times for LCTAC and Program of Record, Five ESGs Initially Deployed or Ready

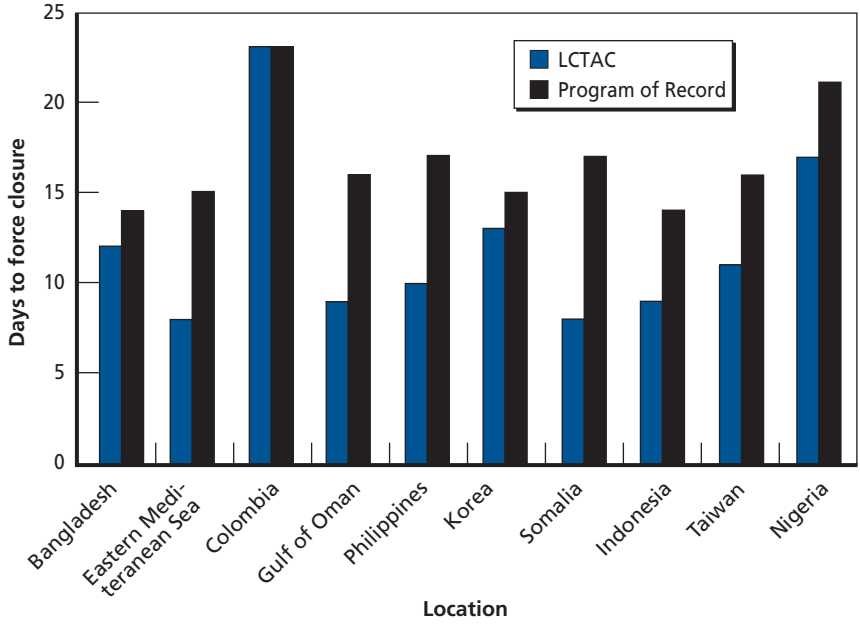


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Figure C.10
Landing Craft Transport Requirements by Location to Match SOA Requirements of Self-Deploying Landing Craft

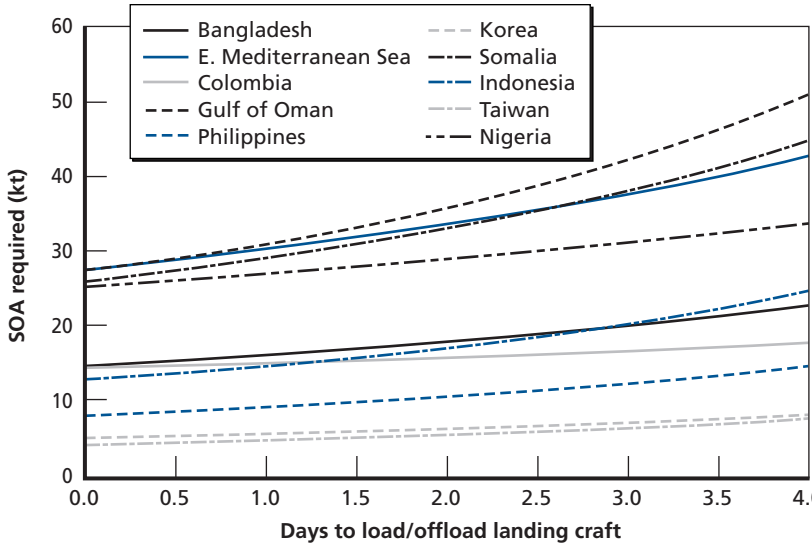

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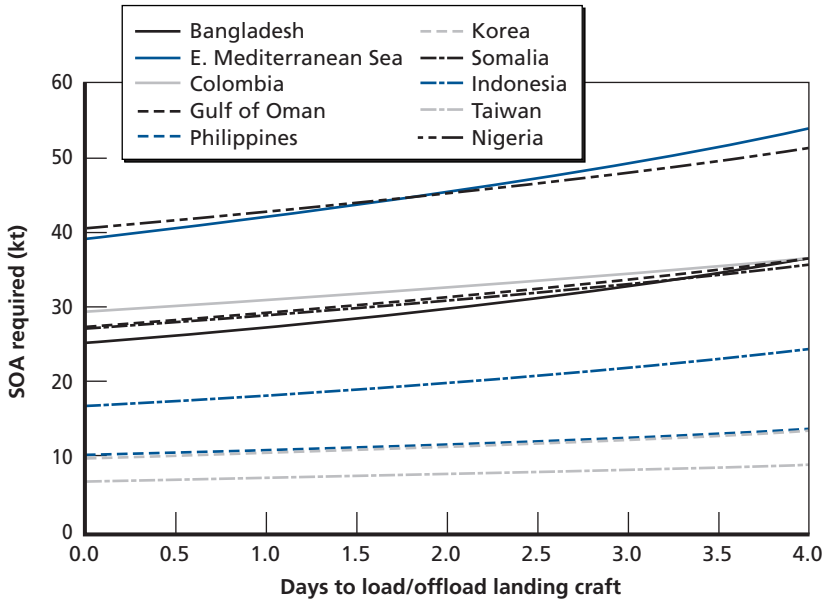
Figure C.10 can also be interpreted in the light of self-deploying landing craft. Rather than looking at it as the transport SOA required for time to load/offload landing craft, it can be viewed as the SOA required for a self-deploying landing craft as a function of time to get under way. For example, a 30-kt SOA is required, with up to a half day to get under way.

SOAs required to support closure times that are achievable through the program of record (see Figure C.11) are lower than those for self-deploying landing craft. (The summary results in Chapter Three simply show the maximum SOA across all locations.)

Figure C.11
Landing Craft Transport Requirements by Location to Match Program of Record



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