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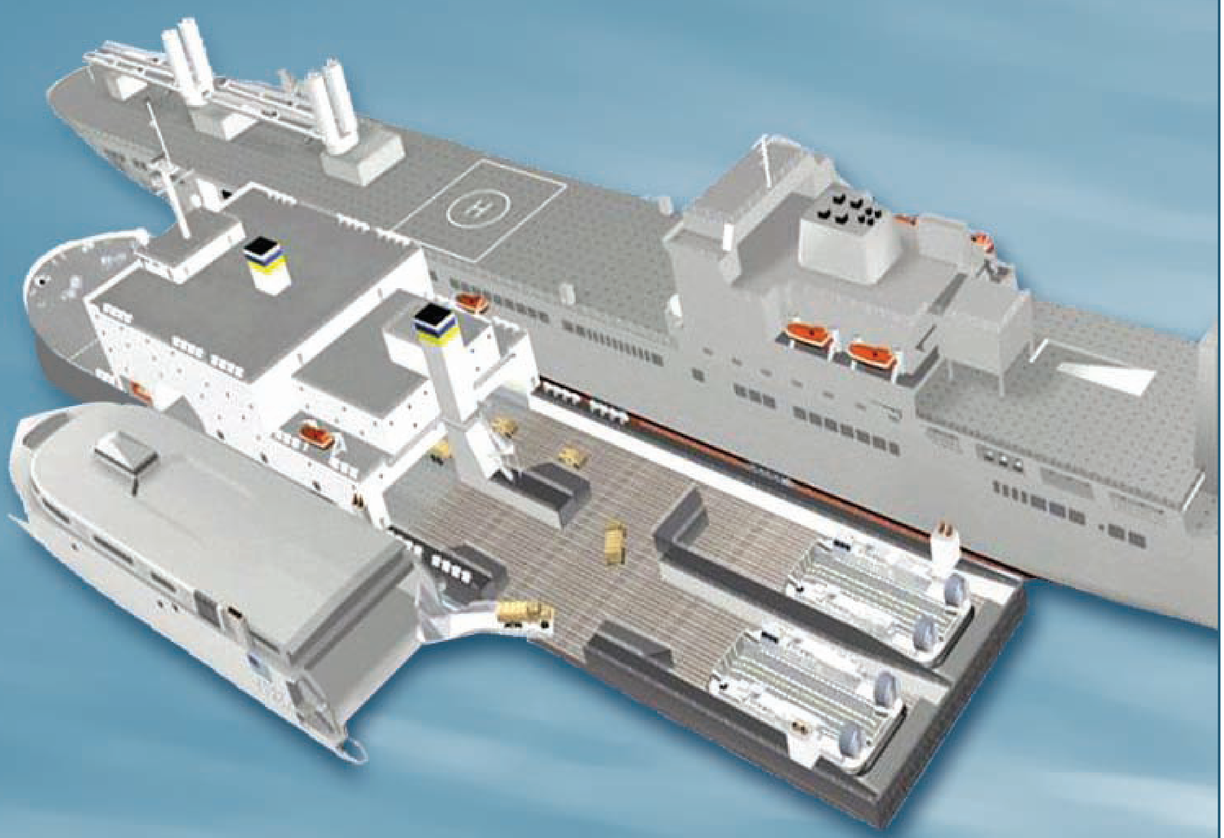
A CBO STUDY

JULY 2007

Sea Basing and Alternatives for Deploying and Sustaining Ground Combat Forces



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The Congress of the United States ■ Congressional Budget Office

Notes

All costs in this study are presented in constant fiscal year 2008 dollars.

The cover illustrates an early U.S. Navy conceptual drawing of a sea base operating in support of ground forces. A large, medium-speed roll-on/roll-off ship (top) and an intratheater high-speed vessel (bottom) are shown alongside a notional mobile landing platform (center) with two air-cushion landing craft parked on its stern.

Preface

The United States Marine Corps and Army have long maintained expeditionary forces organized and equipped to be rapidly moved and inserted into combat with little reliance on access to local bases or infrastructure. Recognizing the vulnerability of forces that are dependent on local access (as U.S. forces have been in Afghanistan and Iraq), the Department of Defense (DoD) is improving its expeditionary capabilities across all of the military services. Prominent among those efforts is the Navy's plan to field a 14-ship squadron—the Maritime Prepositioning Force (Future), or MPF(F)—that would be capable of deploying, employing, and sustaining a Marine expeditionary brigade with little or no need for access to local bases or other infrastructure.

This Congressional Budget Office (CBO) study—prepared at the request of the Ranking Member of the Subcommittee on Sea Power and Expeditionary Forces of the House Committee on Armed Services—looks at the capabilities and costs associated with MPF(F) and sea basing in general as well as other approaches that DoD might take to improve its expeditionary capabilities. The study compares the advantages, disadvantages, and costs of eight alternative systems—five that would involve the sea basing of ground forces and three that would use aircraft to directly deliver forces and supplies. In keeping with CBO's mandate to provide objective, impartial analysis, this study makes no recommendations.

David Arthur of CBO's National Security Division prepared the study under the supervision of J. Michael Gilmore. Raymond Hall and David Newman of CBO's Budget Analysis Division prepared most of the cost estimates under the supervision of Sarah Jennings. Donald Marron and David Moore of CBO, and Robert Work of the Center for Strategic and Budgetary Assessments, provided thoughtful comments. (The assistance of an outside reviewer implies no responsibility for the final product, which rests solely with CBO.)

Christine Bogusz edited the study, and Kate Kelly proofread it. Cynthia Cleveland produced drafts of the study. Maureen Costantino designed the cover and prepared the study for publication. Lenny Skutnik printed copies of the study, Linda Schimmel coordinated the print distribution, and Simone Thomas prepared the electronic version for CBO's Web site (www.cbo.gov).

Peter R. Orszag
Director

July 2007

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Summary

A centerpiece of the Department of Defense's (DoD's) transformation efforts in recent years has been the move toward making ground forces less reliant on access to foreign-controlled facilities such as harbors, airports, or logistics bases on the ground in their area of operations. Circumstances that could limit local access to such facilities might include the following:

- The absence of facilities in less-developed regions of the world;
- The unwillingness of nations to provide access to their facilities because of a lack of a self-interest in (or an opposition to) U.S. military operations; or
- An adversary's military ability to deny facilities to U.S. forces by attacking or by threatening to attack them.

Examples of those circumstances were highlighted during the Afghanistan and Iraq conflicts in 2001 and 2003, respectively. In Afghanistan, operations had to be adapted to central Asia's limited infrastructure; in Iraq, operations were restricted by Turkey's decision to deny transit rights to U.S. Army units bound for northern Iraq. Dependence on local access complicates military planning and makes U.S. forces more vulnerable to external operational constraints.

To help avoid such restrictions in the future, DoD is exploring systems that would provide a greater "access-insensitive" capability for ground forces.[1] Today's access-insensitive ground force systems consist primarily of an Army airborne division and Navy amphibious ships capable of supporting about 2.5 Marine expeditionary brigades (MEBs). The airborne forces can respond to a crisis very quickly—a brigade on alert could be air-dropped anywhere in the world within a few days—but their lack of armored vehicles limits their strength in combat. Amphibious forces take longer to respond: A MEB equipped with armored vehicles and air-support aircraft could take as many as four weeks to assemble and sail to a conflict far from the United States. As a further limitation, sustaining today's airborne and amphibious forces requires establishing logistics operations (bases and supply lines) on land that must subsequently be maintained and defended.

The Joint Integrating Concept for Sea Basing and Plans for the Maritime Prepositioning Force (Future)

A primary DoD effort to improve access-insensitive capabilities is the plan to field sea bases to transport, employ, and sustain ground forces from ships at sea. Current sea-basing plans are centered on the Maritime Prepositioning Force (Future), or MPF(F), as well as concepts and performance objectives defined in the *Sea Basing Joint Integrating Concept* (JIC) published by the Joint Chiefs of Staff.

The performance objectives in the *Sea Basing* JIC are organized along five "lines of operation" for a sea base capable of supporting joint operations. The first line of operation is *closing the force:* rapidly moving personnel and equipment to the area of a crisis. Because equipment usually travels by ship and people travel by aircraft, *assembling the force* follows to integrate personnel and equipment into a functional ground unit on the sea base. (Taken together, closing and assembling the force constitutes the deployment phase of a mission.) The third line of operation is *employing the force*, moving the now combat-ready ground unit ashore to conduct its mission.

1. This study uses the term "access-insensitive" to describe forces that can be operated with little or no reliance on bases or other logistics infrastructure on the ground in their immediate area. Access-insensitive forces are a subset of "expeditionary" forces that are organized and equipped to operate in foreign countries but might still need support bases therein.

Summary Table 1.

Capabilities and Costs of Alternative Systems Examined by CBO

Alternative	Access-Insensitive Capabilities: Employ One Brigade	Access-Insensitive Capabilities: Sustain Two Brigades	Access-Insensitive Capabilities: Reconstitute One Brigade	Approximate Tactical Reach (Percentage of World's Land Area)	Cost (Billions of Fiscal Year 2008 Dollars): Low	Cost (Billions of Fiscal Year 2008 Dollars): High
			Employment and Sustainment			
E1: Maritime Prepositioning Force (Future)	11 to 17 Days	S, M, E, H, C	Yes	20	15	22
E2: Sea Base with New Rotorcraft	11 to 17 Days	S, M, E, H, C	Yes	30	31	39
E3: Amphibious Task Force with Sea-Based Sustainment	25 Days	S, M, E, H, C	No	20	1.8	2.0
E4: Airships	7 Days	S, E	No	90	12	18
			Sustainment Only			
S1: Sea Base with Planned Rotorcraft	n.a.	S, M, E, H, C	n.a.	20	10	14
S2: Sea Base with New Rotorcraft	n.a.	S, M, E, H, C	n.a.	30	13	20
S3: Airdrop	n.a.	S	n.a.	Nearly Unlimited	3.8	4.8
S4: Airships	n.a.	S, E	n.a.	90	5	7

Source: Congressional Budget Office.

Notes: n.a. = not applicable; S = deliver daily supplies (about 1,000 tons/day); M = maintain/repair ground vehicles; E = evacuate wounded/injured personnel; H = provide hospital care; C = provide command and control.

The fourth line of operation, *sustaining the force,* provides for the delivery of supplies and services such as medical care and equipment maintenance to the ground unit ashore (and other friendly forces, as required). *Reconstituting the force,* the final line of operation under the *Sea Basing* JIC, involves returning the ground unit to the sea base and preparing it to be employed again on a different mission.

Beyond those general lines of operation, the *Sea Basing* JIC establishes several specific performance objectives. For example, closing and assembling the force should be completed within 11 to 17 days of an execution order; movement of one brigade ashore should require no more than one period of darkness (8 to 10 hours); and the sustainment of two brigades indefinitely should be possible with the assistance of a land base located no more than 2,000 nautical miles from the sea base.

Although the MPF(F) is designed to support only one MEB ashore, analyses indicate that it could also meet the additional objectives of the *Sea Basing* JIC. It would deliver a force substantially stronger than an airborne brigade in as little as half the time needed to deliver existing amphibious forces, and it could support that brigade plus have sufficient capacity to support an additional brigade with no need for logistics bases on land. Those capabilities would address many of the perceived shortcomings of today's access-insensitive forces.

Under current plans, an MPF(F) squadron would consist of 14 ships loaded with most of a Marine expeditionary brigade's equipment. The ships would be prepositioned at a forward location—probably Guam in the western Pacific Ocean or Diego Garcia in the Indian Ocean. In the event of a conflict, Marines flown from the United States would "marry up" with their equipment aboard the

MPF(F) ships and prepare to move ashore.[2] To achieve those capabilities, the Navy expects to spend about $12 billion (in 2008 dollars) from 2009 through 2014 to purchase the ships needed for the MPF(F) squadron—about 10 percent of the Navy's planned ship construction budget over that period.

Alternative Systems Examined by CBO

This Congressional Budget Office (CBO) study compares the costs and capabilities of the planned Maritime Prepositioning Force (Future) with other access-insensitive means of employing and sustaining ground forces (see Summary Table 1). Five of the alternatives would include some form of a base at sea. The other three would deliver forces and supplies by aircraft. To examine the potential benefits of new technologies, four of the alternatives would develop new systems—rotorcraft able to carry a greater payload of passengers and cargo and with a longer range than existing rotorcraft, and large airships with greater payloads than conventional aircraft.

The eight alternatives are grouped into two sets of four. The first group of four (Alternatives E1 through E4) could both employ one brigade and sustain two brigades; the second group of four (Alternatives S1 through S4) could only sustain two brigades that were already in place. Although the alternatives are generally structured to employ and/or sustain ground forces that are similar in size, their specific capabilities would vary considerably.

CBO's analysis of those alternatives points to several general conclusions.

- The planned MPF(F) would provide a capability similar to today's amphibious task forces but with improved responsiveness—a MEB-sized force could be ready one to two weeks earlier for a conflict in the Persian Gulf or Indian Ocean region—and with a much smaller logistics presence required ashore.

- Alternative systems could provide lesser but still substantial improvements in capability at a significantly lower cost than that of the MPF(F). For example, although Alternative E3 (adding sea-based logistics to amphibious task forces) would not improve response time, it would offer most of the logistics improvements expected from the MPF(F) but at less than one-fifth of the cost.

- Achieving greater capabilities than those currently envisioned for the MPF(F) would probably require significantly higher investment—either larger numbers of systems or new, more capable, and therefore more expensive systems.

The alternatives examined by CBO in this study would satisfy the primary objectives of the third and/or fourth of the JIC's lines of operation (employment and sustainment, respectively). Alternatives E1 through E4 are structured to provide a ship-to-shore delivery capacity sufficient to employ a Marine expeditionary brigade in 8 to 10 hours and to deliver enough supplies per day by aircraft to support the MEB plus an Army light brigade.[3] Alternatives S1 through S4 are structured to deliver enough supplies per day by aircraft to sustain those two types of brigades. The extent to which the alternatives meet the performance objectives for the JIC's other lines of operation varies.

Employment-and-Sustainment Alternatives

Alternatives E1 through E4 would most closely match the capabilities expected of the planned future Maritime Prepositioning Force. Three of the alternatives involve different plans for basing ground forces at sea. The fourth calls for using heavy-lift airships to deliver and sustain forces. CBO did not examine strategic brigade airdrop from conventional aircraft—a capability resident in today's force—because airborne brigades lack the combat power of the MEB that would be employed in these alternatives.

Alternative E1. This alternative is essentially the same as the MPF(F). It would include the 14 ships in the Navy's plan plus an oiler to provide extra fuel for the squadron and up to two high-speed ships to deliver directly from the United States the MEB's helicopters and other equip-

2. Today's Maritime Prepositioning Force typically requires that Marines flown from the United States marry up with their equipment in a secure foreign port and then road march to their operating area.

3. The *Sea Basing* JIC does not specify which types of brigades would be employed or sustained. Consistent with MPF(F) plans, CBO assumed a capability to employ a MEB for Alternatives E1 through E4. The light Army brigade would have the lowest daily supply requirements of the available choices for the second brigade. Army and Marine Corps supplies and other sustainment functions will have to be configured for similar means of storage, distribution, and/or use if a joint force is to be supported.

Summary Table 2.

Composition of Alternative Systems Examined by CBO

		Number of Ships, Landing Craft, or Aircraft							
		Employment-and-Sustainment Alternatives				Sustainment-Only Alternatives			
Purpose of Ship/Craft	**Designation**	**E1**	**E2**	**E3**	**E4**	**S1**	**S2**	**S3**	**S4**
Provide Aviation Support	LHD	1	1			1			
	LHA	2	1			1			
	New Design		3				2		
Provide Ground Vehicles/Air-Cushion Landing Craft Support	MLP	3	3						
Provide Ground Vehicles	T-AKR	3	3						
Store Dry Cargo and Ammunition	T-AKE	3	3	3		3	3		
Provide Items for Sustained Operations	Legacy MPF	2	2						
Provide Fuel	T-AO	1	1			1	1		
Move Rotorcraft to Theater	T-HSS	0 to 2	0 to 2			0 to 2	0 to 2		
Provide Ship-to-Shore Transportation	LCAC(X)	14	14			2	2		
	MV-22	*48*	*57*						
	CH-53K	*20*				20			
	n-HLR		36				26		
Provide Direct Air Delivery	C-17							17	
	Hybrid Airship				46				8

Source: Congressional Budget Office.

Notes: The ships shown for Alternative E3 are in addition to an existing amphibious task force. The MV-22 and CH-53K aircraft in Alternatives E1 and E2 (shown in italics) would be provided by the embarked brigade.

LHDs and LHAs are amphibious assault ships (helicopter carriers); T-AKEs are dry cargo/ammunition ships; T-AKRs are vehicle storage/transportation ships; and T-AOs are fleet oilers.

MLP = mobile landing platform; MPF = Maritime Prepositioning Force; T-HSS = high-speed ship; LCAC(X) = air-cushion landing craft; n-HLR = new heavy-lift rotorcraft.

ment that is not suitable for storage aboard prepositioned ships (see Summary Table 2).[4] Transporting the helicopters by high-speed ship might be necessary because moving them by Air Force transport aircraft could be impractical in some situations (for example, if air-base capacity was severely limited). Alternative E1 also would include new air-cushion landing craft that would deliver the surface-landed portions of the MEB from the sea base to the shore. No aircraft would be purchased under Alternative E1; instead, they would be provided by the embarked MEB.

The cost of this alternative would be $15 billion to $22 billion, CBO estimates, depending on the number of ships purchased.

Alternative E2. This alternative represents a greater capability than that offered by the planned MPF(F). It would support the same size force as Alternative E1 but could do so out to twice the distance from the ships—about 220 nautical miles. Providing that greater reach would require

4. The possible need for those additional ships has been identified in recent Navy and Marine Corps analyses of logistics requirements during the early stages of an MPF(F) operation. One high-speed ship would be located on each coast of the United States to support trans-Atlantic or trans-Pacific deployments. (See Chapter 2 for more details.)

a mix of new heavy-lift rotorcraft (n-HLR) and MV-22 tilt-rotor aircraft.

The potential difficulty in developing the n-HLR places Alternative E2 among the more technically risky of the alternatives that CBO examined. (CBO assumed that the n-HLR could be similar in design to the Joint Heavy-Lift Rotorcraft being designed by the Army with participation from the other services.) Because of the time needed to develop the n-HLR, Alternative E2 would probably take longer to field than Alternative E1 would.

The 36 n-HLRs needed under Alternative E2 would have to be purchased for the sea base because MEBs would not be equipped with them.[5] In addition, because the n-HLR would be substantially larger than the CH-53K helicopter, new aviation support ships designed to accommodate it would be needed. The need to purchase larger rotorcraft and larger aviation ships make this the most costly alternative—$31 billion to $39 billion, CBO estimates, or about double the cost of Alternative E1.

Alternative E3. The least expensive alternative at about $2 billion, E3 would purchase three dry cargo/ammunition ships to add an at-sea sustainment capability to existing amphibious task forces (ATFs). The low cost results from the inclusion of existing ATF ships. Alternative E3 could support the same forces as Alternative E1 but would not be as operationally flexible because the more constrained vehicle stowage aboard the ATF ships would limit the ability of ground forces to easily retrieve selected unit equipment for specific missions ashore.

Alternative E4. This alternative would develop and buy 46 heavy-lift airships similar in design to concepts that have been explored by the Defense Advanced Research Projects Agency's Walrus program and by the Naval Air Systems Command. The notional airships would carry more than 10 times the average payload of a C-17 aircraft but would travel at only one-fourth the speed. Lift would be generated both by the buoyant force of the helium inside the airship and by the airfoil shape of the hull, which would act like a wing when the craft was moving forward. That hybrid design would reduce or eliminate the need for large transfers of stabilizing ballast during loading and unloading and would make the airship easier to handle on the ground. High winds could still present control problems during loading, transit, and unloading, however.

As with Alternative E2, this alternative would present greater technical risk than the alternatives that make use of existing systems. Also, the time needed to develop a new airship could delay the fielding of this alternative relative to MPF(F) plans. Including development costs, the airship fleet needed to deliver a MEB in a single lift would cost $12 billion to $18 billion, in CBO's estimation.

Sustainment-Only Alternatives

Alternatives S1 through S4 would provide an access-independent capability to sustain ground combat forces deployed by existing means, such as amphibious assault ships or brigade airdrop.

Alternative S1. This alternative would provide the same sustainment capability as Alternative E1 but would not include the ability to transport and employ a MEB. That reduced capability results in the need for fewer ships (see Summary Table 2). However, because this alternative would not embark a MEB, it would need dedicated aircraft—about 20 CH-53K helicopters, CBO estimates—for moving sustainment supplies ashore.

Including the cost to purchase those aircraft, and depending on the need to purchase high-speed ships to deploy them, this alternative would cost between $10 billion and $14 billion. Those costs would drop by about $1.4 billion if the helicopters could be drawn from existing forces rather than purchased explicitly for this sustainment-only sea base.

Alternative S2. This alternative would be a sustainment-only version of Alternative E2. It would require purchasing nine fewer ships and ten fewer n-HLRs. The fielding date of this alternative would depend on the time needed to develop the heavy-lift rotorcraft.

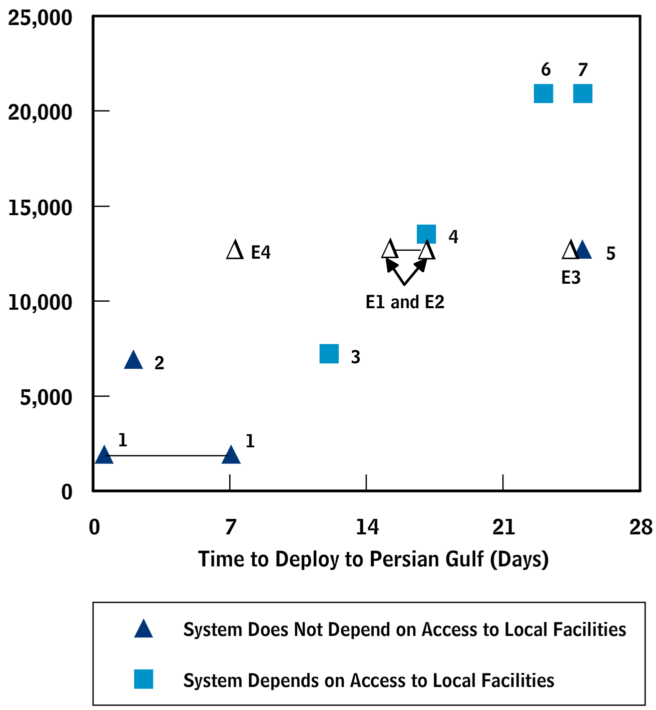
The cost of Alternative S2 would be about $13 billion to $20 billion, CBO estimates. Those costs would drop to between $9 billion and $15 billion if the n-HLRs could be drawn, when needed, from other units equipped with the new helicopter.

5. MEB air wings would retain their CH-53K helicopters when not deployed to the sea base because they would more often require the ability to embark on amphibious ships incapable of accommodating the n-HLR.

Summary Figure 1.

Responsiveness and Capacity of Existing Systems and Selected Alternatives

(Unit weight, in tons)



Source: Congressional Budget Office.

Notes: Two triangles separated by a solid line indicates a range of responsiveness.

The existing systems (denoted by the solid triangles and squares) are as follows: 1, a forward-deployed Marine expeditionary unit (responsiveness varies with required transit distances); 2, strategic brigade airdrop; 3, an Army infantry brigade combat team deployed by air (constrained by air-base capacity); 4, the current Maritime Prepositioning Force; 5, an amphibious task force; 6, an Army heavy brigade combat team deployed by air (constrained by air-base capacity); and 7, an Army heavy brigade combat team deployed by sea.

The alternative systems (denoted by the open triangles) are as follows: E1, the planned Maritime Prepositioning Force (Future) sea base; E2, the prepositioned sea base with new heavy-lift rotorcraft; E3, the amphibious task force with sea-based sustainment; and E4, employment and sustainment by airship.

Unless otherwise noted, deployment times are from the United States.

Alternative S3. This alternative would purchase C-17 aircraft to resupply ground forces by airdrop. About 17 of those aircraft would be needed to supply a MEB and a light Army brigade from an advance base 2,000 nautical miles away. The air-dropped bundles would be guided by the Joint Precision Air Drop System now under development by the Air Force. Because airlift is in high demand early in a conflict, CBO assumed that additional C-17s would need to be purchased under this alternative so as not to reduce the availability of strategic airlift for other missions.

The cost of this alternative would range from about $3.8 billion (if the C-17 aircraft were purchased prior to the end of current production) to about $4.8 billion (if it was necessary to restart the C-17 production line at a later date).[6]

Alternative S4. This alternative would develop and purchase eight hybrid airships, enough to deliver supplies for a MEB and a light Army brigade from an advance base 2,000 nautical miles away. As with Alternative S2, the fielding date would depend on the time needed to develop the new airship.

The cost of this alternative would be $5 billion to $7 billion, CBO estimates.

Capability Improvements Offered by the Alternative Systems

Although the alternatives analyzed in this study were structured to support a common ground force, each would offer a distinct combination of other operational characteristics. Four primary characteristics—strategic responsiveness, geographic reach, vulnerability to enemy defenses, and capabilities for sustainment beyond just the delivery of supplies—are discussed below. (Those and other capabilities are examined further in Chapter 3.)

Strategic Responsiveness

Strategic responsiveness is the ability to get a force to where it is needed in an allotted time. For Alternatives E1 through E4, strategic responsiveness can be evaluated in two dimensions: the strength of the unit deployed and

6. Under current plans, the last of 190 C-17 aircraft were funded in 2007 and will be delivered in 2009. As much as $1 billion could be needed to restart production, CBO estimates.

the time needed to deploy it. In general, smaller and lighter forces can be deployed more rapidly, but they provide less combat power than larger, heavier units offer (see Summary Figure 1). Although a small battalion or light airborne brigade could be deployed from the United States in less than a week, nearly four weeks would be needed for an amphibious deployment of a MEB-strength force.

Alternatives E1, E2, and E4 would improve upon current access-insensitive response times by being able to employ a MEB-sized force more than one week faster than would be possible today. Airships (Alternative E4) would provide the greatest improvement in responsiveness, potentially reducing employment times by up to three weeks. Alternative E3 would not improve responsiveness because it would be limited by the time needed to deploy an existing amphibious task force. (The benefit of Alternative E3 lies in eliminating the need to move the MEB's logistics support ashore.)

The aircraft and ships in Alternatives S1 through S4 would need to be in position no later than when the ground forces that they are to support begin operations. The aircraft and ships in the sea-based sustainment-only alternatives (S1 and S2) could be in position in less time than would be needed for the aircraft and ships in Alternatives E1 and E2 because there would be no need to assemble a MEB at the sea base. That time frame would be quick enough to support all but the three fastest systems shown in Summary Figure 1—the airborne brigade and the forward-deployed Marine expeditionary units. Sustainment by C-17 aircraft (Alternative S3) or hybrid airship (Alternative S4) could be established in only a few days.

Geographic Reach

Geographic reach is the physical ability to get forces to wherever they are needed to meet a theater commander's objectives. Although the ships in the sea-based alternatives would have access to the approximately 70 percent of the Earth's surface that is ocean, the ground forces employed or sustained by them would have access to land areas only within range of their ship-to-shore aircraft. Alternatives E1, E3, and S1 could support flight distances of up to 110 nautical miles from the ships. When other factors are considered, however (such as the distance the ships must remain offshore and the need for aircraft to fly circuitous routes to confound an enemy's air defenses), the actual distance inland could be as little as 50 nautical miles. As a result, only about 20 percent of the world's land area could be covered by the aircraft in those alternatives. The longer-range support offered under Alternatives E2 and S2 would increase geographic accessibility to about 30 percent of the world's land area.

The percentages for geographic reach are higher if measured in terms of the world's population—about 40 percent and 50 percent for the shorter- and longer-range sea-based aircraft, respectively—because human activity, and hence the need for military action, tends to be more concentrated near seacoasts. Sustainment of forces by airdrop (Alternative S3) would not be geographically constrained so long as aerial refueling was available to extend the C-17's range. Airship operations would be limited by their low flight ceilings. Approximately 10 percent of the world's land area would not be accessible under Alternatives E4 and S4 if airships were limited to flying in areas with ground elevations no greater than 5,000 feet above sea level.

Although the fraction of the world's land area and population that can be reached by sea-based aircraft is limited, about 85 percent of the world's nations are not land-locked and would therefore be at least somewhat accessible to the sea-based alternatives. Whether that accessibility would be militarily useful, however, would depend on the particular scenario. Two countries identified as potentially hostile in DoD's 2006 Quadrennial Defense Review illustrate that scenario dependence. North Korea's small size and extensive coastline make its land area particularly accessible to forces based at sea: About 81 percent of the land and 91 percent of the population would be accessible even to the shorter-range ship-to-shore forces included under Alternatives E1, E3, and S1. Large countries such as Iran would be far less accessible to ground forces operating from a sea base. Despite a long coastline on the Persian Gulf and Gulf of Oman, only about 14 percent of the land and 11 percent of the population of Iran would be accessible to the shorter-range ship-to-shore forces included under Alternatives E1, E3, and S1. Twenty-nine percent of the land and 15 percent of the population would be accessible to the n-HLR aircraft included in Alternatives E2 and S2. In terms of distance, all of North Korea and Iran would be accessible to airdrop (Alternatives E4 and S4), although the mountainous terrain in many parts of those countries would present limitations to airship operations. For example, nearly 40 percent of Iran's land area and almost half its population are at elevations greater than 5,000 feet above sea level.[7]

Vulnerability to Enemy Defenses

The preceding discussion of geographic reach assumes that U.S. aircraft would be able to adequately suppress an enemy country's air defenses and operate as planned. The ships and aircraft in all of the alternatives that CBO examined could be vulnerable to an enemy country's maritime and air defenses. Helicopter losses in Operation Iraqi Freedom have highlighted the vulnerability of rotorcraft when flying over hostile territory. Sea-based rotorcraft supporting ground units ashore would be similarly vulnerable.

Airships and C-17 aircraft would be less vulnerable than rotorcraft. Although airships would fly at altitudes and speeds similar to those of helicopters, their large size could reduce their vulnerability because critical areas could be more heavily armored and the large hull could absorb damage without suffering catastrophic loss. C-17s would also be less vulnerable because most of the defensive systems facing low-altitude rotorcraft cannot reach the higher altitudes where C-17s would operate. Higher-altitude air defenses, which tend to be much fewer in number because they are more expensive and require trained crews to be effectively operated, could severely affect air-drop operations. Navy or Air Force defense-suppression operations would be needed to neutralize or destroy those defensive systems.

The ships that form a sea base would be vulnerable to weapons such as naval mines, submarines, strike aircraft, and antiship missiles. In recognition of those threats, DoD's plans call for such ships to remain at least 25 nautical miles offshore, and Navy plans call for improving ships' defensive systems and tactics using the "Sea Shield" concept. As envisioned, Sea Shield will consist of submarines, surface combatants, and aircraft working together to defeat the threats described above. If those defenses failed to prevent attacks from reaching the sea base, certain ships—the dry cargo/ammunition ships, vehicle storage/transportation ships, and mobile landing platform ships under Alternatives E1, E2, S1, and S2—would be especially vulnerable.

Those ships would be more vulnerable because they would be built to commercial standards, as opposed to naval standards, so they would have less compartmentalization to limit the amount of water that could enter the hull from any single hit. They would also have less redundant systems and less robust damage-control capabilities. In addition, because they would be operated by the Military Sealift Command, they would not be equipped with self-defense weapons, which would provide a final layer of defense against missile attacks. In contrast, the amphibious ships in Alternative E3 would have the advantage of naval construction standards and self-defense weapons aboard most or all of the task force's ships.

Sustainment Support

All of the alternatives examined in this study were structured to be able to deliver about 1,000 tons per day of supplies. Beyond that capability, however, the alternatives would have varying abilities to provide other important sustainment support, such as medical care and equipment maintenance (see Summary Table 1 on page viii). The sea-based alternatives—E1, E2, E3, S1, and S2—would be the most capable of providing additional services because they would be able to move people and equipment to and from facilities aboard the ships based at sea, which would be located relatively close to the supported units. (The proximity would be particularly important for medical evacuation missions where transit times need to be as short as possible.) Ships in the area would also be well-suited to provide command-and-control support.

Airships could move cargo and personnel both to and from a supported unit (as in Alternatives E4 and S4), but the potentially long distances back to an advance base—up to 2,000 nautical miles—could make speedy medical care unfeasible. Because airdrop is a one-way capability, the only kind of sustainment support Alternative S3 could provide would be the delivery of supplies.

7. Mountains could also reduce the reach of sea-based helicopters. The accessibility percentages cited for the sea-based alternatives do not include limitations resulting from high terrain.

CHAPTER

1

Expeditionary Ground Forces

A centerpiece of the Department of Defense's (DoD's) transformation efforts in recent years has been the move toward fielding a more expeditionary military force. Expeditionary forces are those equipped and organized to be rapidly moved around the world to conduct operations with little or no need for established infrastructure—facilities such as seaports, air bases, or logistics bases on the ground—in the area of operations. Goals for future forces and operations have included these:

- Improved unit transportability to enable more rapid deployment to distant operations;
- Improved ability to operate in regions with limited local infrastructure;
- Smaller logistics presence on the ground to provide a lower profile in the area and to reduce the need to defend logistics units and ground supply lines; and
- Improved ability to overcome efforts on the part of an adversary to deny U.S. forces access to the area of operations.

This Congressional Budget Office (CBO) study looks at one particular effort that DoD is pursuing to improve its expeditionary capabilities: the plan to field sea-based systems that could be used to transport, employ, and sustain ground combat forces independent of land-based support. This chapter presents the rationale for improving expeditionary capabilities in today's strategic environment and describes the current plan for fielding sea-based ground forces—specifically, the Maritime Prepositioning Force (Future), or MPF(F). Chapter 3 describes eight alternative approaches that DoD could pursue to improve its expeditionary capabilities. Those alternatives illustrate different levels of capability that might be achieved, not merely different ways to obtain the same capability envisioned in DoD's plan. In Chapter 3, the capabilities of those alternative systems are compared with the capabilities of the Administration's MPF(F) sea base as well as with capabilities already resident in today's force.

The Evolution of U.S. Expeditionary Capabilities

The United States' success in the far-flung theaters of World War II required military forces with unprecedented expeditionary capabilities. In particular, U.S. forces needed:

- Transportability, so they could be employed anywhere on the globe;
- A forcible-entry capability from the sea, so forces could gain initial footholds on enemy-held territory; and
- A robust logistics force structure, so those combat units could be supported with equipment and supplies from the United States.

Every major ground campaign during World War II took place far from the continental United States. After the defeat of Japan, expeditionary forces were dramatically reduced as part of the general downsizing of the Navy. Large-scale expeditionary operations were deemed less necessary because U.S. and other North Atlantic Treaty Organization forces were able to face off against forces of the Warsaw Pact countries from fixed bases in Western Europe. If conflicts erupted elsewhere, it was assumed that U.S. military forces would be granted access by countries with the common self-interest in resisting Communist expansion. Over time, forces organized and equipped for forcible entry were reduced to an Army airborne division and a Marine Corps amphibious force equivalent to about three Marine expeditionary brigades (MEBs)—a total of roughly 50,000 personnel.

The collapse of the Soviet Union in 1991 reduced the need for a large force stationed in Europe, and the strategic focus of the U.S. military shifted to rapidly transporting combat forces and their supporting logistics units anywhere they might be needed. Although DoD recognized that the location of future conflicts had become more uncertain, it was still widely assumed that access to local bases would be granted by regional allies. Toward the end of the 1990s, however, concern began to grow about the possibility of encountering what were called antiaccess scenarios—those in which U.S. freedom of action could be severely restricted by having little or no access to regional bases. The reasons that access to local ports and air bases might be lacking could include:

- The simple absence of such facilities in less-developed regions of the world;
- The unwillingness of local nations to provide access because of a lack of a self-interest in supporting U.S. military operations; or
- An adversary's military ability to deny facilities to U.S. forces by attack or by the threat of attack.

The conflicts in Afghanistan and Iraq in 2001 and 2003, respectively, heightened that concern. In the case of Afghanistan, local infrastructure was lacking, and DoD had to scramble to establish basing access in neighboring countries. Even in countries where access was obtained, many of the facilities were primitive and required significant improvements to support U.S. forces. In Iraq, the risks of taking for granted the availability of local infrastructure were highlighted by two events: the reluctance of Saudi Arabia to offer host-nation support to the United States of the magnitude it had during the first Gulf War, and the decision by Turkey to deny passage to U.S. Army units bound for northern Iraq. To get ground units into the north of Iraq, the Army had to air-drop troops onto the airfield at Bashur, Iraq, a classic forcible-entry operation (although there was little resistance in that case).[1] Those events reinforced an already growing sense among military planners that the assumption of assured access should be reexamined.

As a result of that concern, attention has shifted toward systems and operational concepts that would make the transportation and employment of ground combat forces less sensitive to access constraints. Desired characteristics for future systems include the following:

- The ability to deliver combat-ready ground units directly to their area of operations independent of local permission (implying a forcible-entry capability) or local infrastructure (implying systems that require neither ports nor air bases);
- The ability to support those forces for extended periods of time independent of local permission or infrastructure (implying an access-independent ability to deliver supplies, provide medical care, and maintain equipment, for example); and
- The ability to withdraw ground forces from an area of operations and to quickly reconstitute that force for subsequent use elsewhere in the area or in a new theater.

Harkening back to the sea-borne operations of World War II, sea basing emerged as an approach that could offer those expeditionary capabilities. Sea basing would take advantage of the freedom to operate in international waters. Assuming naval forces could provide protection, sea-based forces could be positioned close to any area of operations with a proximity to the sea. From that location, ground forces could be sent directly over the beach by short-range systems such as landing craft and helicopters and sustained in a like fashion with little or no logistics presence on the ground.

Because they are designed for forcible-entry operations, amphibious forces were a logical starting point for considering sea-basing alternatives. However, DoD's existing amphibious forces are not well-suited to act as at-sea logistics bases because limitations in cargo space, cargo hold configuration, and cargo-handling equipment usually require that logistics bases be established ashore to

1. The 173rd Airborne Brigade that was inserted at Bashur comprised 1,000 troops air-dropped the first night and about 1,000 more air-dropped over the next several days. That force was small compared with the size of the force that was initially bound for the north of Iraq (up to 35,000 troops of the 4th Infantry Division, Mechanized).

support the ground force.[2] A somewhat different approach would be needed to field a true sea-basing capability.

Operational Capabilities Desired for a Sea Base

In the 1990s, there was broad debate among military planners about how to improve expeditionary capabilities. Sea basing emerged as a favored concept, and by 2005 Navy and Marine Corps work on the Maritime Prepositioning Force (Future) and Joint Staff work on the *Sea Basing Joint Integrating Concept* (JIC) were converging on what level of sea-basing capability DoD should pursue. The JIC established the following measures of performance as threshold requirements for five "lines of operation" at a "Joint Sea Base":

- *Close* the force by moving equipment, supplies, and personnel to a joint operations area to support major combat operations within 10 to 14 days of an execution order.

- *Assemble* and integrate the various components of the sea-based force to make it ready to support major combat operations within 24 to 72 hours of arrival in the joint operations area.

- *Employ* from the sea base at least 25 nautical miles (nm) offshore a minimum of one brigade for a joint forcible-entry operation within one period of darkness (8 to 10 hours).

- *Sustain* joint sea-based operations, including up to two joint brigades operating ashore, for an indefinite period using one or more secure advance bases up to 2,000 nm away; also provide maintenance and medical facilities within the sea base.

- *Reconstitute* one brigade from ashore to the sea base and be able to reemploy it within 10 to 14 days.

Concurrently, the Navy and Marine Corps had been working on sea-basing concepts as part of their efforts to rethink naval doctrine for the 21st century. Two manifestations of sea basing in addition to the JIC's Joint Sea Base emerged from those efforts. One was the overarching concept of the "sea as a base" that envisioned rendering all naval operations independent from the shore as much as possible. The other was the more concrete plans for a Maritime Prepositioning Force (Future). Those plans, which were published in June 2005, described a squadron of specific ships organized to serve as an at-sea base of operations for ground forces as well as the operational concepts for employing them.

Equipment Plans for the MPF(F) Sea Base

Current Navy plans for the MPF(F) squadron call for a mix of existing or otherwise planned ship types plus one new design to form the first sea base (see Table 1-1). Recent analyses have indicated that other ships, in addition to those planned for the MPF(F), might be needed to fully support sea-based ground forces. Those other ships could include tankers and high-speed ships for special cargo.

The ships that make up the sea base would be prepositioned at a forward location such as Guam or Diego Garcia to reduce the sailing time needed to reach a conflict. The bulk of the equipment for a Marine expeditionary brigade would be stored aboard those ships. The remainder of the equipment—in particular, the aircraft—and the Marines (plus additional naval support personnel) would be transported to the sea base once it was activated for operations.

The planned MPF(F) squadron is sized to carry and support a MEB's contingent of about 12,000 people, 1,300 vehicles, 48 MV-22 tilt-rotor aircraft, 20 CH-53E/K helicopters, and other aircraft in the MEB's air wing.[3] The MEB and its aircraft would not strictly be part of the sea base but rather would be embarked on the sea base much like carrier air wings are separate units embarked on aircraft carriers. That is an important distinction with regard to the operation of the MPF(F) as a Joint Sea Base because support of the second brigade (as called for in the

2. Amphibious ships are loaded to allow vehicles and supplies to be rapidly, sequentially off-loaded during an assault. Because of that arrangement, cargo can be stowed more densely. At-sea logistics bases require that individual types of cargo be accessible at any time, however. For that reason, they must be able to selectively off-load, a constraint that requires less dense stowage (to leave corridors for removing specific cargo) and more-capable cargo-handling systems (for retrieving specific items from the ship's hold).

3. If the air wing includes Joint Strike Fighters, they are assumed to operate from other ships. The MEB's attack helicopters are assumed to operate from forward positions established ashore.

Table 1-1.

Ship Types in the Planned Maritime Prepositioning Force (Future) Sea Base

			Approximate Capacities					
Primary Purpose of Ship/Craft	Type	Quantity	Berths	Vehicles (Thousands of square feet)	Cargo (Thousands of cubic feet)	Aircraft Operating Spots	LCAC Spots	Medical (ORs/Beds)
				Ships in Navy's Plan				
Aviation Support	LHD	1	2,700	30	145	9	3	6/60
	LHA	2	2,600	14	175	9	0	2/24
Ground Vehicles/LCAC Support	MLP	3	900	50	0	1	6	0
Ground Vehicle Storage	T-AKR	3	850	220	300	2 to 4	0	0
Dry Cargo, Ammunition Storage	T-AKE	3	200	0	850	1	0	0
Items for Sustained Operations	MPS	2	130	150	0	1	0	0
				Additional Ships That May Be Required				
High-Speed Cargo Transportation	T-HSS	0 or 1	TBD	TBD	TBD	TBD	0	0
Fuel Supply	T-AO	1	100	0	0	0	0	0

Source: Congressional Budget Office based on data from the Navy and the Marine Corps.

Notes: The categories of amphibious lift shown here are the number of troops a ship can carry; its vehicle stowage area (or vehicle square), its cargo stowage volume (or cargo cube), the number of aircraft operating spots, the number of spots for air-cushion landing craft (known as LCACs), and the size of its medical facilities, measured by the number of operating rooms (ORs) and beds.

LHDs and LHAs are amphibious assault ships (helicopter carriers); T-AKRs are vehicle storage/transportation ships; T-AKEs are dry cargo/ammunition ships; and T-AOs are fleet oilers.

MLP = mobile landing platform; MPS = maritime prepositioning squadron; T-HSS = high-speed ship; TBD = to be determined.

JIC) would have to be provided by aircraft belonging to the first brigade (the MEB). The MEB's air wing would be able to provide that support because the aircraft needed to deliver the air-landed portion of the MEB in one period of darkness (as demanded by MPF(F) requirements) would be more than adequate to sustain two brigades. Aircraft supporting the second brigade would not be available to the MEB for other uses, however.

The proposed MPF(F) squadron would be made up of fourteen ships of six different types.

- **Three aviation ships** to support rotary-wing aircraft operations; one of the three would be a *Wasp*-class LHD, either newly constructed or drawn from one of the eight LHDs in the current amphibious force.[4] The other two would be new ships of the LHA-6 class [previously known as the LHA(R)], which are being developed to replace the *Tarawa*-class (LHA-1) ships. (LHDs and LHAs are amphibious assault ships, also known as helicopter carriers.) Although based on battle force ship designs, the three aviation ships in the MPF(F) would, like the ships in today's MPF, be part of the Military Sealift Command (MSC) under current plans and would thus operate with largely civilian crews. Those ships would also house the bulk of the ground force personnel and provide additional services such as hospital care.

- **Three large, medium-speed roll-on/roll-off (LMSR) ships** for storing and transporting the ground force's vehicles; designated as T-AKRs, each of those ships would have over a quarter-million square feet of vehicle storage space. Special modifications from current

4. The ability to pull an LHD from the amphibious force will depend on various factors—in particular, the number of expeditionary strike groups (ESGs) the Navy will operate in the future and the number of new LHAs that will be purchased for the amphibious force. Having fewer ESGs or a larger number of new LHAs would increase the likelihood that the LHD for the MPF(F) could be pulled from the existing force.

Figure 1-1.

Experimental Mobile Landing Platform and Cargo Ship

Source: U.S. Navy.

LMSR designs would include berthing for over 800 embarked personnel as well as possible changes to the vehicle-loading ramps to allow the ships to interface better with the next type of ship in the squadron.

- **Three mobile landing platform ships** to carry and operate surface-landing craft and to act as the platform for transferring vehicles from the T-AKRs to those landing craft. One proposed design for the ship would have a large deck area at the stern to accommodate several landing craft (see Figure 1-1). Early specifications indicate that each ship could have berthing for over 900 embarked personnel.

- **Three *Lewis and Clark*-class advanced auxiliary dry cargo (T-AKE) ships** to carry dry stores such as food and ammunition; with a bulk storage capacity of over 1 million cubic feet per ship and extensive equipment for rapidly and selectively moving cargo from their holds, the T-AKEs would play a primary role in sustaining the ground force once it came ashore. Helicopters could pick up shore-bound supplies from the landing spots in the stern of the ships, or supplies could be transferred by crane to the mobile landing platforms and be sent ashore in surface-landing craft.

- **Two smaller T-AKR ships** to carry additional equipment that ground forces would use primarily to support sustained operations ashore. Those ships, referred to as legacy Maritime Prepositioning Ships, could be drawn from the existing Maritime Prepositioning Force.

Navy and Marine Corps analyses have identified the potential need for several additional ships to support the squadron's operations. One is a high-speed ship designed to carry high-value and technically complex equipment—especially the MEB's helicopters that would not be prepositioned—from the United States to the MPF(F) squadron. The helicopters—in particular, the CH-53K heavy-lift helicopters that are needed to move heavy items for the ground force—are ill-suited for long-term storage aboard the prepositioned ships, and they lack the endurance to be flown over long distances. (The MV-22 has sufficient range and speed to self-deploy from the United States.) Consequently, helicopters would be based at home with their units and only moved to the sea base when it was activated for use in a conflict.

Helicopters could be moved to the sea base either by high-speed ship or by strategic airlift. (If DoD decided to rely entirely on strategic airlift, then the high-speed ship would not be needed.) A high-speed ship would have the advantage of being able to sail directly to the sea base. Marine Corps studies have indicated that a dedicated ship capable of sustained speeds of at least 37 knots could deliver the helicopters (and several tons of other critical equipment) in a more timely fashion while also freeing up airlift resources for moving other components of the joint force to the theater.[5] Strategic airlift is capable of moving the CH-53Ks, but the helicopters must be partially disassembled to fit into C-17s or C-5s, flown to an advance reception base in the theater, then reassembled and flight-tested before being flown to the sea base. Similarly, other cargo delivered by air would have to be shuttled to the sea base, or the ships in the sea base would have to stop at the advance reception base to pick it up.

Tankers would also be needed to support the squadron's operations. The fuel-storage capacity available in the 14 core MPF(F) ships would be insufficient to support the intensive aircraft and landing craft activity that would accompany the rapid movement of the MEB ashore and its subsequent support. Analyses by the Chief of Naval

5. Reported to the Congressional Budget Office in a briefing by the Studies and Analysis Division, Marine Corps Combat Development Command Mission Analysis Branch, July 2006.

Operations' staff have estimated that two tankers with a capacity similar to that of current fleet oilers would be adequate to supply fuel to the sea base and the ground units it would support ashore.[6] One tanker could be prepositioned to meet initial demands for fuel. The other tanker could be sent from the United States.[7] During operations, the two tankers would be able to maintain a shuttle rotation between the sea base and a fuel source up to 2,000 nm away. More tankers would be needed if the fuel source was farther away.

Employment Concept for the MPF(F) Sea Base

The detailed concept of operations for the planned MPF(F) sea base closely follows the five lines of operation defined in the *Sea Basing Joint Integrating Concept.* Additionally, the anticipated performance of the ships and other systems planned for the MPF(F) sea base would satisfy the JIC's threshold measures of performance (such as the time to close and assemble the force and the size of the ground force that could be supported) described earlier in the chapter. This section describes how each major phase of the MPF(F)'s employment concept could be executed from the perspective of the JIC's lines of operation.

Close and Assemble the Force

At the onset of operations, most of the MPF(F) ground force's equipment and initial store of supplies would be aboard ships prepositioned at a forward location, and most of the personnel and some high-value equipment—in particular, helicopters—would be located in the United States. The closure and assembly phases encompass the MEB's deployment—the transportation of its components to the area of operations and the integration of those components into a force ready for employment ashore. Those two lines of operation could occur sequentially or concurrently depending on the particular circumstances of the scenario. Because of the different starting locations and specific transportation requirements, closure and assembly for each portion of the squadron—the prepositioned components and the U.S.-based components—would have distinct characteristics.

Prepositioned Components. Current plans call for prepositioning the ships of the sea base at forward locations. Upon activation, those prepositioned ships would move to the area of operations. As with today's MPF ships, the prepositioned ships would be loaded with most of the equipment and several weeks' supplies needed for a MEB. Prepositioning is necessary for the MPF(F) to satisfy the JIC's requirement of closing and assembling the force in 11 to 17 days. To meet that time constraint, the ships of the sea base that are sailing from the United States would need much higher speeds than current cargo ships (see Figure 1-2).

For example, a modern LMSR ship moving at 24 knots would take about 17 days to sail 10,000 nm, a distance typical of deployment from the east coast of the United States to the Persian Gulf or parts of the Indian Ocean. The time needed to load a large ship with hundreds of vehicles and traverse shipping chokepoints such as canals would add several days to that time. Assuming a three-day loading time and a one-day delay to transit the Suez Canal, a ship traveling from the United States would need a sustained speed of about 41 knots to meet the upper-end force closure time in the JIC. That speed would be faster than what is available with today's large cargo ships and even faster than the 37-knot estimate for the high-speed ships that would deliver helicopters and other critical equipment from the United States. The faster speed would be needed for ships carrying several hundred ground vehicles because they would need more time to load than would a high-speed ship slated to carry 50 or so helicopters (mainly CH-53Ks, AH-1 attack helicopters, and UH-1 utility helicopters) and a few tons of high-value equipment.

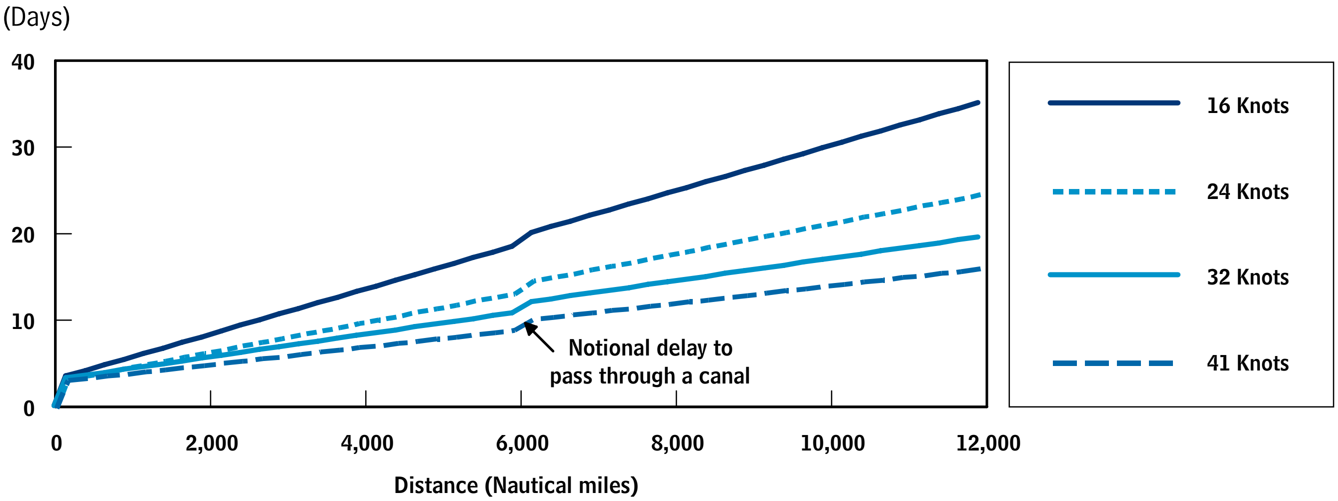
At some point during the transit from the prepositioned location to the area of operations, the prepositioned ships would "marry up" with the high-value equipment and personnel sent from the United States. That integration could occur at any point in the ships' transit, from before they depart the prepositioned location to after they reach the final area of operations. Individual circumstances would determine where that assembly occurred.

6. "Joint Seabasing Logistics" (briefing prepared for the 3rd Annual Sea Basing Conference, February 2007).

7. To account for the uncertainty as to whether the additional ships (the high-speed ships and tankers) would be needed, the sea-based alternatives presented in the next chapter include high and low estimates for costs and capabilities that add or do not add them, respectively.

Figure 1-2.

Closure Times for Sealift Missions



Source: Congressional Budget Office.

Note: Today's cargo ships typically travel at speeds between 16 and 24 knots.

U.S.-Based Components. Equipment and personnel from the United States could either be directly delivered to the MPF(F) ships or transported first to an advance reception base and then shuttled to the MPF(F) ships. Direct delivery to the sea base could only be accomplished by ships such as the high-speed ship described earlier because the aviation ships in the planned MPF(F) will not be large enough to receive aircraft capable of delivering cargo over intercontinental ranges. A high-speed ship from the United States could join the MPF(F) at any point during its movement to the operations area. Once with the MPF(F), the aircraft delivered by the high-speed ship could be used to transfer the other cargo to the sea base.

An advance reception base would be needed if strategic airlift was to be used to move high-value cargo and personnel from the United States. High-value cargo would be moved by Air Force C-17 or C-5 aircraft that have cargo doors large enough to accommodate CH-53K helicopters, and personnel would be moved by commercial passenger aircraft, either chartered for the operation or called up from the Civil Reserve Air Fleet. The Marine Corps estimates that 165 C-17 missions and 28 Boeing 747 missions would be needed to deliver the personnel, helicopters, and 4,000 tons of additional high-value cargo to an advance reception base. The rate at which cargo and personnel could be airlifted into the theater would most likely depend on the capacity of the advance reception air base(s) to receive aircraft. Typical planning estimates call for a maximum-on-the-ground capacity of two to four C-17 equivalents for constrained scenarios.[8] Delivering the fly-in portion of a MEB would take 7 to 14 days for that range of air-base capacity.

After reaching the advance reception base, cargo and personnel must be moved to the MPF(F) ships for assembly into the combat-ready force. That final leg of the deployment would be simplest if the ships were able to stop at a port colocated with or near the advance reception base. In some circumstances, the fly-in components of the force could be delivered to the squadron's prepositioned location and join the ships before they sailed. Alternatively, the ships could stop at the advance reception base while en route to the operations area.

If the ships cannot stop at the advance reception base, it would become necessary to shuttle the fly-in components of the force out to them. For that to be feasible, however, the ships must pass fairly close to the advance reception base. For example, if the shuttles were to be accomplished by the helicopters delivered with the MEB, the shuttle distance could not exceed about 200 nm. At that range, it would take the MEB's aircraft about four days to move

8. Maximum-on-the-ground is a measure of air-base capacity defined as the number of a particular aircraft type that can be simultaneously handled within a planned ground time. It is usually measured relative to the C-17.

the high-value cargo and personnel to the MPF(F) ships, with the aircraft refueling both at the advance reception base and on the ships. One disadvantage of that type of shuttle operation is that it would require a very high operational tempo for the aircraft. Such a tempo could adversely affect the availability of aircraft to employ the ground force later in the operation by fatiguing air and ground crews and causing wear on the aircraft. Another disadvantage to the aircraft shuttle would be the need for the MPF(F) ships to slow down or stop for the several days they must remain close to the advance reception base.

If the MPF(F) ships could not get close enough to the advance reception base to make shuttling by the MEB's aircraft feasible, the final leg to the sea base would have to be accomplished by surface vessels. A surface shuttle mission could be accomplished with chartered local ships or with U.S. ships in the area. The Joint High Speed Vessel (JHSV) being developed by the Navy and Army is frequently mentioned for that role.[9] Even with a fast ship such as the JHSV, however, the MPF(F) ships must still pass fairly close to the advance reception base for the shuttle mission to be feasible. The Navy's fiscal year 2008 budget plans include the purchase of three JHSVs, and the Army may purchase them as well. Assuming each JHSV could carry about 1,000 troops, it would take about 11 missions to shuttle the fly-in portion of a MEB out to the sea base. The time required to complete the shuttles would depend on the number of JHSVs available and the distance to the MPF(F) ships. For example, the entire projected Navy JHSV fleet would need about six days to shuttle the fly-in portion of a MEB from an advance reception base 1,000 nm out to the MPF(F).

The preceding discussion highlights the importance of having an advance reception base to allow for the intermediate staging of equipment and personnel. Although the JIC specifies the availability of an advance base only as part of the sustainment line of operation, the assembly of the sea-based force in the area of operations will quite probably rely on such a base as well. The timelines indicate that the ships that make up the sea base must, at some point in their movement, come close enough to the advance reception base to allow for a timely shuttle operation. (The advance base for sustainment, by contrast, could be up to 2,000 nm away, according to the JIC's requirements.)

The use of an advance base to assemble the force differs from the way in which traditional amphibious forces assemble. With amphibious task forces, personnel and equipment typically assemble at their home base and embark aboard amphibious ships at ports on the east or west coast of the United States before sailing to their destination. An amphibious task force might "assemble" with an expeditionary strike group after reaching the theater, however.

Employ the Force

After the sea base has assembled in the area of operations, the embarked ground force would be available for employment ashore. The employment of the sea-based ground force would resemble that of a modern amphibious assault because both would use similar ground forces and ship-to-shore craft. One battalion of the sea-based Marine expeditionary brigade would be inserted by aircraft as far as 110 nm from the sea base, and two battalions would be delivered by surface craft to the beach. The air-landed battalion and the first surface-landed battalion would be delivered in no more than 8 to 10 hours to give an adversary insufficient time to organize a counterattack during the initial landing, when the force being inserted is most vulnerable. A second surface battalion would be available to go ashore shortly thereafter.

The ships that form the sea base would be located about 25 nm or more from the shore to put them beyond the range of many shore-based weapons and make it more difficult for an adversary to locate and track them. Operating from over the horizon would also give the defensive systems on Navy ships assigned to defend the sea base—cruisers and destroyers, for example—sufficient time to detect and engage weapons that might be launched against the sea base.

Sustain the Force

Although the employment of the sea-based ground force would be similar to traditional amphibious assaults, the subsequent sustainment operation would differ significantly. Most notably, instead of troops having to rapidly establish a large supply base ashore, supplies would be kept at sea and transported ashore only as needed. In support of that concept, the sea base would include cargo ships loaded so that particular items could be selectively

9. The JHSV is being developed to move troops and cargo within a theater. It is expected to be based on commercial ferries with catamaran hulls for higher speed. See the last section in this chapter for more information about high-speed vessels.

retrieved from the ships' holds and moved ashore. As was described earlier, that approach differs from past concepts in which cargo was densely packed aboard ships and had to be moved ashore in bulk before it could be sorted and subsequently distributed to the ground force.

Keeping supplies afloat for distribution by helicopter will require that the supplies of both Army and Marine Corps units supported by a sea base be configured for storage and selective off-loading from the sea base. Configuring that cargo on the ships could present difficulties, however. For example, a configuration that would best store supplies that are packed in containers might not be compatible with a configuration that would allow the selective off-loading of break-bulk cargo. Means must be provided for helicopter transport of all types of supplies. In particular, provisions will be needed for moving large quantities of bulk fluids such as fuel and water ashore by helicopter. Such movement via helicopter-borne bladders or drums will be more difficult than current practices, such as delivering fuel to logistics bases ashore in fixed-wing tanker aircraft or pumping it ashore from tankers via temporary pipelines that are part of the Offshore Petroleum Discharge System.

Sustaining operations indefinitely, as called for in the JIC, would require that the ships in the sea base be periodically replenished with additional supplies. Current concepts favor a shuttle-type operation, with the sea base's T-AKE cargo ships leaving that station to sail to an advance base, where they would be refilled with supplies sent from the United States on standard container ships (or by air).[10] In that scenario, two T-AKEs would remain at the sea base while the third would rotate to the advance base to reload.[11] Another approach would have the container ships join the sea base and transfer their cargo at sea. That approach would allow the sea-base ships to remain on station but would require the capability to conduct large-scale ship-to-ship transfers of cargo at sea.

Reconstitute the Force

Reconstituting the force (essentially, the employment phase in reverse) involves taking the ground force brigade back aboard the sea-base ships and preparing it for re-employment elsewhere. Two facets of the MPF(F) concept should make such reconstitution feasible. First, because the ships have a large amount of stowage space (to allow selected items to be quickly off-loaded), reloading vehicles from shore should be somewhat easier than it would be on conventionally loaded ships, with their careful dense packing of cargo. Second, because the logistics operation is based aboard ship, reconstitution should simply involve reloading the supply ships at an advance base. There would be no need to retrieve a large quantity of supplies that had been moved ashore and restow those supplies aboard ship.

Other Means of Employing Expeditionary Ground Forces

Approaches other than sea basing could provide most (and perhaps all) of the expeditionary capabilities that DoD envisions for the future. This section briefly describes several such alternatives.

Amphibious Forces

Traditional amphibious forces bear the closest resemblance to current concepts for sea basing. Today, battalion-sized amphibious forces—Marine expeditionary units, or MEUs, with about 2,200 personnel—are forward-deployed as part of expeditionary strike groups. MEB-sized forces on a par with those envisioned for a sea base would be assembled from forward-deployed MEUs and additional ships and Marines sent from bases in the United States. In conjunction with air support and naval artillery support, MEBs are trained and equipped for forcible-entry operations. In many war plans, early amphibious operations are aimed at seizing ports and airfields for use by follow-on forces. Because of their smaller size and limited endurance ashore, MEUs are typically slated for operations such as amphibious raids or noncombatant evacuations, where longer-term presence on the ground is not needed.[12] For major operations, MEBs and MEUs can be assembled into larger Marine expeditionary forces, or MEFs.

For the employment of the ground force, amphibious forces use the same types of ship-to-shore systems envi-

10. That advance base would not necessarily be the same one as the advance reception base used to close the force.

11. Such a rotation assumes that the sea base would be sustaining a MEB plus a light Army brigade and that the transit distance to the advance base would not exceed about 2,000 nm.

12. An exception occurred during the invasion of Grenada in 1983. The 22nd Marine Amphibious Unit (as MEUs were previously known) led the operation, although it was soon reinforced with airborne forces flown from the United States.

sioned for the MPF(F)—air-cushion landing craft, MV-22 tilt-rotor aircraft, and CH-53K helicopters—to move a MEB ashore in one 8- to 10-hour period of darkness. Beyond that core similarity, however, a sea base and an amphibious force differ significantly. Sustainment of the ground force ashore from a sea base would incorporate the selective off-loading and special cargo-handling capabilities described earlier. In contrast, cargo aboard today's densely packed amphibious ships must be rapidly moved to a potentially vulnerable logistics base ashore—a process often referred to as a "dump exercise"—for subsequent distribution to the force. If prepositioned, a sea base could also offer better strategic responsiveness than an amphibious force that must be assembled in the United States and then sail to its destination.

Airdrop of Forces and Supplies

Airdrop is another established forcible-entry technique. It was first used extensively in World War II, most notably to drop allied forces behind the Normandy beaches on the night before D-Day and into the Netherlands to seize bridges on the Rhine for use by advancing armored units. As the high casualties suffered by airborne forces in World War II showed, however, airborne assaults are high-risk operations when conducted against significant opposition forces. That vulnerability results largely from the limitations in what and how much can be delivered by aircraft over hostile territory.

- Airborne operations are limited to light forces because it is impractical to carry large numbers of heavy vehicles and deliver them by parachute.

- Fire support can be limited to that provided by aircraft because the drop may be beyond the range of naval gunfire and, as with vehicles, it may be impractical to drop more than a modest artillery force.

- Sustainment operations are limited to the delivery of supplies by parachute until more robust logistics can be established by, for example, seizing an air base.

Despite those risks, modern militaries continue to field airborne forces because of their ability to be rapidly sent into combat anywhere transport aircraft can be flown. For the fastest response, the Army has maintained a brigade of the 82nd Airborne Division in ready status at Fort Bragg, North Carolina. With the support of Air Force strategic transport aircraft, that ready brigade had been capable of being employed anywhere those aircraft can safely fly within 36 hours. (Now, however, the need to supply forces for operations in Iraq and Afghanistan has precluded the maintenance of that ready brigade.)

Direct-Delivery Strategic Transportation Systems

Strategic transportation systems such as airlift aircraft and sealift ships have typically been used for deployment rather than employment of ground forces. Vehicles and equipment (mostly on ships) and personnel (mostly on aircraft) would travel separately to their destination (deployment) and, upon arrival, the troops would marry up with their equipment and the unit would prepare for employment. That arrangement is efficient for several reasons: Ports and air bases are designed to rapidly receive people and cargo, transport ships can be made less costly if they do not need berthing spaces for large numbers of troops, and travel by air spares troops several weeks at sea.

Because ports, airfields, and staging areas for the marrying-up process can no longer be assumed to be secure, some military planners have suggested that troops and equipment should travel together (much like amphibious task forces do), ready for immediate employment upon arrival in a theater. Those troops and equipment could travel directly to their destination either by fast ships or by large airships.

DoD is conducting ongoing experiments with high-speed vessels based on commercial ferry designs. That work is part of a joint Army/Navy effort to field those vessels for transportation within a theater. Ships for intratheater transportation such as the *Westpac Express* and the *Swift* have proved their utility for moving small forces over regional distances (a few hundred miles). Those vessels usually move at high speeds (greater than 35 knots), have storage space for vehicles and accommodations for people, and are able to load and unload in austere ports. Extending that concept to the transoceanic distances needed for deployment from the United States is expected to be costly, however. Maintaining high speeds over long distances requires vessels with long, slender hulls made from lightweight materials, very powerful engines, and large fuel tanks. Those three characteristics result in designs for large ships with much smaller payloads than what slower ships of a similar size can carry. Additionally, operations costs tend to be higher for faster vessels because they consume more fuel and need more maintenance (for their advanced propulsion systems, for instance) than other vessels do.

Combat-ready units could also be delivered directly to a theater using large airships. DoD is considering several designs with payloads of at least 500 tons that could operate from unimproved locations and transport loads anywhere in the world in a few days. One design envisions an airship roughly 1,000 feet long and 300 feet wide. Its structure would probably consist of a nonrigid hull to hold the helium and a gondola slung underneath to carry cargo and troops. Lift would be provided by the buoyancy of the helium as well as from the airfoil shape of the hull while in forward flight.[13] Estimates of achievable speeds for large airships range from about 80 knots to 120 knots.

13. See Congressional Budget Office, *Options for Strategic Military Transportation Systems* (September 2005), for more details on design and operational considerations related to large airships and high-speed transport ships.

CHAPTER

2

Description of Access-Insensitive Systems for Employing and Sustaining Ground Forces

The Navy's current plan for the Maritime Prepositioning Force (Future) is to field a squadron of ships capable of supporting Marine Corps operational concepts for sea-based employment of a Marine expeditionary brigade. That plan would satisfy the threshold performance requirements established in the *Sea Basing Joint Integrating Concept* (outlined in Chapter 1).

This chapter describes several alternatives to the MPF(F) that would also improve the military's capabilities to employ and sustain ground forces with no reliance on access to local land bases or other facilities. The alternatives would provide different capabilities than those offered by the current plan and would require different levels of investment. Some of the alternatives have more modest capabilities (and hence, lower costs) than the current plan, and some have greater capabilities (and hence, higher costs).

In Chapter 3, the Congressional Budget Office examines the advantages and disadvantages of the alternatives, considering not only their costs but also the military implications of having greater or lesser access-insensitive capabilities to employ and sustain ground forces.

Structuring Access-Insensitive Systems to Employ and Sustain Ground Forces

The Department of Defense's goal as delineated in the JIC for the size of the ground forces that must be supportable is the employment of one brigade and the sustainment of two brigades. Although the JIC does not specify particular systems to provide that support, details within the JIC point to ship-based solutions—namely, sea bases—as the preferred way to employ and sustain ground forces. In crafting alternatives that could provide the same or similar capabilities, CBO took a broader perspective, looking at systems that would provide access-insensitive capabilities without necessarily presupposing the development and fielding of a sea base.

As with the Navy's and Marine Corps' MPF(F) requirements and the JIC's performance thresholds, the alternative systems examined by CBO focus on supporting brigade-sized ground units. Force sizes smaller than brigades are not typically well-suited for extended independent operations. The Navy and Marine Corps already routinely deploy sea-based battalions as part of their expeditionary strike groups, but those forces are not usually expected to conduct extended combat operations. The type of brigade (or brigades) to be supported is an important consideration for structuring employment-and-sustainment systems because the quantity of equipment that must be moved and the rate at which supplies must be provided during operations varies significantly for different types of brigades (see Table 2-1).

CBO structured its alternatives to be capable of providing different levels of support to a MEB plus an additional brigade (specifically, a light Army brigade). That force size is the smallest that satisfies both the MPF(F) requirements (to employ and sustain a MEB) and the JIC's performance threshold for the sea base (to employ one brigade and sustain two brigades). Fielding a heavier or larger access-insensitive ground force could be achieved by building additional systems with similar capabilities.

Although each of the alternatives examined by CBO would offer the ability to support a MEB plus a light Army brigade, the type and quality of that support would differ widely. This study considers eight alternatives, five of which would include some form of a sea base (see Table 2-2). Four of the eight alternatives, E1 through E4,

Table 2-1.

Approximate Size and Sustainment Requirements for Ground Units

Force	Personnel	Number of Vehicles	Weight of Vehicles (Tons)	Sustainment Requirement (Tons/day) Surge Intensity	Sustainment Requirement (Tons/day) Sustained Intensity
Sea-Based MEB (Ground-combat element)	5,000	1,300	13,000	734	470
Army Light BCT	3,200	500	2,200	272	217
Army Stryker BCT	3,500	900	9,300	338	280
Army Heavy BCT	3,800	1,400	25,000	613	344

Source: Congressional Budget Office based on data from the U.S. Army and U.S. Marine Corps.

Notes: MEB = Marine expeditionary brigade; BCT = brigade combat team.

would be capable of employing and sustaining a MEB and a light Army brigade. The other four, S1 through S4, would provide only sustainment support for those two types of brigades. Alternatives S1 through S4 would act as a complement to existing means of employment (such as airdrop or amphibious assault) by allowing forces employed by those means to operate without having to rely on ground bases and ground supply lines for sustainment.

The specific systems that make up the alternatives examined by CBO were determined primarily by the rates at which unit equipment and personnel must be moved ashore during a MEB's employment (for Alternatives E1 through E4) and the rates at which supplies must be provided to the two brigades operating ashore (for all of the alternatives). The numbers of sea-based ship-to-shore aircraft, air-drop aircraft, and airships are also based on those factors. In the case of the sea-based alternatives, the ships included with each alternative are those needed to transport, house, and handle the required vehicles, other equipment, personnel, and supplies and to operate the ship-to-shore aircraft and landing craft.

For the employment-and-sustainment alternatives, CBO based its estimate of the number of aircraft required on the ability to move a MEB's air-delivered battalion ashore in one period of darkness. For the sustainment-only alternatives, CBO based its estimate of the number of aircraft required on Army and Marine Corps estimates of the rate at which supplies are consumed by brigades operating in high-intensity, or surge, conditions.

The MEB and light Army brigade to be supported under CBO's alternatives would require about 1,000 tons of supplies per day under surge conditions. CBO used information on the range and cargo capabilities of several types of rotorcraft to estimate the number of each type that would be needed to maintain that delivery rate as a function of mission radius (see Figure 2-1).

Because the need for surface-landing craft would be constant across Alternatives E1 through E4, CBO assumed that each sea-based option would include an air-cushion landing craft capability comparable to that of the planned MPF(F).[1] Although Alternatives S1 through S4 would not require surface-landing craft because all sustainment would be conducted by air, CBO included two LCACs in Alternatives S1 and S2 to provide the flexibility to move heavy cargo on the surface if necessary.

Alternative Systems Examined By CBO

The following sections describe the alternatives shown in Table 2-2 that would improve the access-insensitive employment-and-sustainment capabilities of U.S. ground forces. The sustainment-only alternatives are presented first, followed by the more capable employment-and-sustainment alternatives.

1. Current plans for the MPF(F) call for 21 LCACs. The Navy is developing a new LCAC(X) that could be up to 50 percent larger than today's models. CBO estimated that 14 of those larger LCACs would offer a similar net capability. The cost of 14 new LCACs is included in Alternatives E1 and E2.

Table 2-2.

Composition of the Alternative Systems Examined by CBO

		Number of Ships, Landing Craft, or Aircraft							
		Sustainment-Only Alternatives				Employment-and-Sustainment Alternatives			
Purpose of Ship/Craft	Designation	S1	S2	S3	S4	E1	E2	E3	E4
Provide Aviation Support	LHD	1				1	1		
	LHA	1				2	1		
	New Design		2				3		
Provide Ground Vehicles/Air-Cushion Landing Craft Support	MLP					3	3		
Provide Ground Vehicles	T-AKR					3	3		
Store Dry Cargo and Ammunition	T-AKE	3	3			3	3	3	
Provide Items for Sustained Operations	Legacy MPF					2	2		
Provide Fuel	T-AO	1	1			1	1		
Move Rotorcraft to Theater	T-HSS	0 to 2	0 to 2			0 to 2	0 to 2		
Provide Ship-to-Shore Transportation	LCAC(X)	2	2			14	14		
	MV-22					*48*	*57*		
	CH-53K	20				*20*			
	n-HLR		26				36		
Provide Direct Air Delivery	C-17			17					
	Hybrid Airship				8				46

Source: Congressional Budget Office.

Notes: The ships shown for Alternative E3 are in addition to an existing amphibious task force. The MV-22 and CH-53K aircraft in Alternatives E1 and E2 (shown in italics) would be provided by the embarked brigade.

LHDs and LHAs are amphibious assault ships (helicopter carriers); T-AKEs are dry cargo/ammunition ships; T-AKRs are vehicle storage/transportation ships; and T-AOs are fleet oilers.

MLP = mobile landing platform; MPF = Maritime Prepositioning Force; T-HSS = high-speed ship; LCAC(X) = air-cushion landing craft; n-HLR = new heavy-lift rotorcraft.

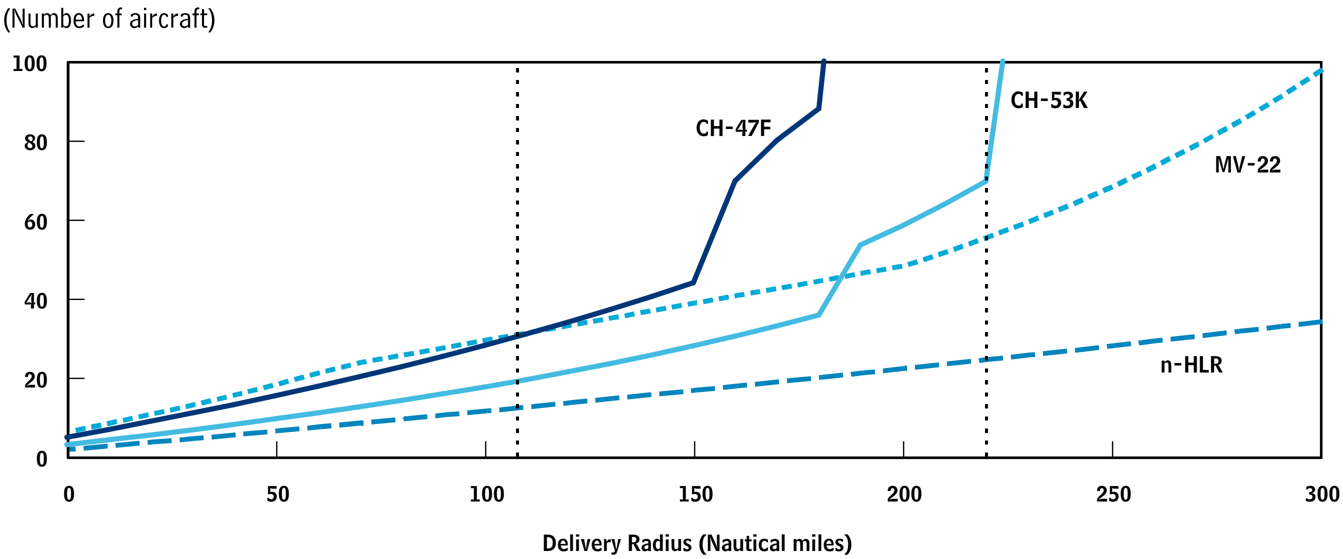
Alternative S1: Sustainment-Only Sea Base with Planned Rotorcraft

The sea base envisioned in Alternative S1 would be able to sustain a MEB and a light Army brigade up to a maximum radius of about 110 nautical miles from the ships that form the sea base. Under this alternative, the Department of Defense would purchase two aviation ships (LHAs), three dry-cargo/ammunition ships (T-AKEs), an oiler, 20 CH-53K helicopters, and two LCACs. Compared with the ship requirements under the planned MPF(F), there would be no need for the three T-AKRs to store the MEB's vehicles and other equipment and, consequently, no need for the three mobile landing platform ships to transfer vehicles from the T-AKRs to the landing craft.

The cost for the ships and aircraft in this alternative would be about $10 billion, CBO estimates (see Table 2-3). That cost would rise to about $14 billion if two high-speed ships—one for deployments from the east coast of the United States and one for deployments from the west coast—were needed to support the squadron by delivering equipment not suitable for prepositioning aboard ship.

Figure 2-1.

Number of Aircraft Needed for Cargo Throughput of 1,000 Tons per Day



Source: Congressional Budget Office.

Notes: The n-HLR is a heavy-lift rotorcraft still in the conceptual stage (described as part of Alternative S2). The other aircraft--the MV-22 tilt-rotor aircraft and CH-47F and CH-53K helicopters--are currently in design or use.

The dotted vertical lines indicate the force ranges (110 and 220 nautical miles) examined in this analysis.

CBO assumed that dedicated aircraft would be required for ship-to-shore transportation under Alternative S1 because there would be no embarked MEB, and the unit ashore might not have aircraft capable of maintaining the necessary flow rates. (Under current MPF(F) plans, aircraft would be provided by the embarked MEB, not the sea base itself.) To support a MEB and a light Army brigade from up to 110 nm away during surge conditions, numerous aircraft would be needed—about 20 CH-53K helicopters, or 31 CH-47F helicopters, or 32 MV-22 tilt-rotor aircraft. Although all three types of aircraft could accomplish the mission, CBO selected the CH-53K to provide ship-to-shore lift in Alternative S1 because its design is optimized for shipboard operations (unlike the CH-47F) and its large payload would offer a better capability to transport heavier vehicles to and from the units ashore than would the MV-22 or CH-47F. That heavy-lift capability would be needed to enable vehicles damaged ashore to be transported to the sea base for repair (or replaced by others stored there). If dedicated helicopters were not included (if, for example, the Marine Corps was required to furnish rotorcraft for any sea-based operation), the cost under Alternative S1 would be about $1.4 billion lower.[2]

Alternative S1 would require fewer aircraft than the MEB would provide under current plans because resupply operations would be less demanding than the employment mission. As a consequence, fewer aviation ships would be needed to support the smaller contingent of aircraft: CBO included one LHA and one LHD in this alternative. Although some Navy data indicate that up to 22 CH-53Es could operate from an existing LHD, today's LHDs typically carry at most 16 of those aircraft because of weight and other constraints—fewer than the number needed for this alternative.

Alternative S2: Sustainment-Only Sea Base with Advanced Heavy-Lift Rotorcraft

Alternative S2 would be a sustainment-only sea base with the ability to support a MEB and a light Army brigade out to 220 nm, twice the distance as in current plans and as under Alternative S1. That increased reach would give ground forces supported by a sea base the ability to

2. The alternatives are generally structured to require no more support from external sources than the planned MPF(F) would. The primary exception to that approach is Alternative E3, which produces a sea-basing capability by melding an existing amphibious force with additional ships.

Table 2-3.

Costs of the Alternative Systems Examined by CBO

Alternative	Cost (Billions of fiscal year 2008 dollars) Low	High	Difference Between Low and High Estimates
S1: Sustainment-Only Sea Base with Existing Aircraft	10	14	Addition of two high-speed ships
S2: Sustainment-Only Sea Base with Longer-Range Aircraft	13	20	Uncertainty in cost of long-range rotorcraft and new aviation ship
S3: Sustainment by Airdrop	3.8	4.8	Cost to restart C-17 production line
S4: Sustainment by Airship	5	7	Uncertainty in cost of hybrid airship
E1: Planned Maritime Prepositioning Force (Future)	15	22	Addition of two high-speed ships; purchase of LHD aviation ship instead of transfer from existing force
E2: Sea Base with Longer-Range Aircraft	31	39	Addition of two high-speed ships; uncertainty in cost of long-range rotorcraft and new aviation ship
E3: Amphibious Task Force with Sea-Based Logistics	1.8	2.0	Potential shipbuilding cost growth
E4: Employment and Sustainment by Airship	12	18	Uncertainty in cost of hybrid airship

Source: Congressional Budget Office.

operate over substantially greater areas, increasing the probability that such a force could be employed where it is needed. To achieve that increased reach, the 20 CH-53Ks in Alternative S1 would be replaced by 26 new heavy-lift rotorcraft with greater ranges and payloads. (DoD is considering similar rotorcraft in its Joint Heavy-Lift Rotorcraft Program.) Although the MV-22 could support deliveries out to 220 nm, it would be operating near the limits of its endurance when carrying a sizable payload. To support those larger aircraft, the LHA and LHD in Alternative S1 would be replaced with two newly designed aviation ships. Up to two high-speed ships would also be included under this alternative because the n-HLR might not be suitable for long-term storage aboard ship and would almost certainly be too large to deploy by strategic airlift. The other elements of Alternative S2's sea base would be the same as under Alternative S1.

The cost for this alternative would range from about \$13 billion to \$20 billion, CBO estimates.[3] That wide range results from uncertainty in the design and cost of the n-HLR and new aviation ships.

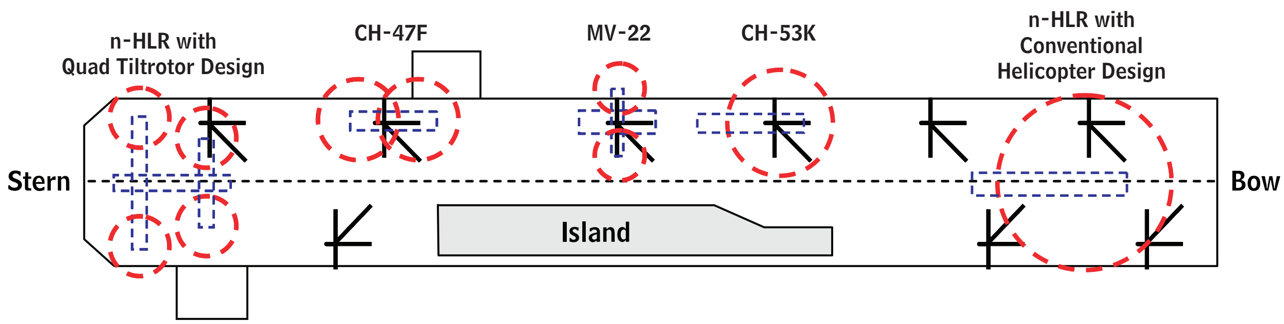
The heavy-lift rotorcraft that is integral to Alternative S2 has yet to be designed and produced. CBO based its notional rotorcraft on designs in RAND Corporation analyses that explored heavy-lift vertical takeoff and landing alternatives for the Army and the Marine Corps.[4] Those studies considered various designs, including very large conventional or tandem helicopters, a four-engine

3. That estimate does not include the costs to research, develop, and test the n-HLR. CBO assumed that Alternative S2 (as well as Alternative E2, which also includes n-HLRs) would only be pursued if a new heavy-lift rotorcraft were developed independently for broader applications across the military services. Development costs for the rotorcraft would probably be prohibitive (\$7 billion to \$13 billion) for sea-based applications alone. Additionally, the time required to develop such an aircraft would most likely delay the date by which it could be put into service relative to the planned service date for the MPF(F). Alternative E2 would be similarly delayed.

4. See Jon Grossman and others, *Vertical Envelopment and the Future Transport Rotorcraft*, publication no. MR 1713 (Santa Monica, Calif.: RAND, 2003); and John Gordon and others, *Assessment of Navy Heavy-Lift Aircraft Options*, publication no. DB472 (Santa Monica, Calif.: RAND, National Defense Research Institute, 2005).

Figure 2-2.

Sizes and Potential Placement of Rotorcraft on Large-Deck Amphibious Ships



Source: Congressional Budget Office based on data from John Gordon and others, *Assessment of Navy Heavy-Lift Aircraft Options,* publication no. DB472 (Santa Monica, Calif.: RAND, National Defense Research Institute, 2005).

Note: n-HLR = new heavy-lift rotorcraft.

tilt-rotor aircraft known as a quad tiltrotor, and other, more exotic concepts.

Regardless of its specific design, a new heavy-lift rotorcraft would be much larger than current rotorcraft. As a consequence, it is unlikely that n-HLRs would be able to operate from the LHDs or LHAs that are part of the current sea-basing plans. The overall height of the n-HLR would probably be too great to fit in the hangar decks of those ships, its weight would probably be too great for the aircraft elevators on those ships, and its overall dimensions with rotors turning would probably prevent it from operating abreast of the "island" found on the starboard side of LHD and LHA decks (see Figure 2-2). According to RAND's estimates, an n-HLR with a conventional helicopter design—a single main rotor for lift and a vertical tail rotor to counteract torque—would have a main rotor diameter of about 120 feet. (Today's CH-53E has a main rotor diameter of 80 feet.) As the schematic helicopter on the LHD's bow in Figure 2-2 illustrates, that diameter would span the width of the flight deck. The estimated external dimensions of a quad tiltrotor design would be similar. (The figure shows the four smaller rotors positioned at the ends of the front and rear wings.) If limited to operating at the bow and stern, only two of the n-HLRs could be located on an LHD's deck at any given time (versus the nine spots that would be available for smaller rotorcraft).

For those reasons, CBO assumed that a new type of aviation ship would be needed under Alternative S2 to accommodate the larger rotorcraft. CBO estimated the number and overall size of those new ships by scaling up the relative characteristics of the ships and aircraft that would be used for the planned MPF(F). The empty weight of 26 n-HLRs would be almost 1,000 tons, or about 90 percent of the total weight of MV-22s and CH-53Ks in the planned MPF(F). The aircraft in the planned MPF(F) would be spread over three aviation ships; each ship would hold 23 aircraft and 780,000 pounds of aircraft, on average. In Alternative S2, the 26 n-HLRs would be spread over the two new ships, so each ship would hold 13 aircraft and about 975,000 pounds of aircraft. The new ships would be proportionally larger than the existing aviation ships to accommodate the heavier load and the larger external dimensions of the n-HLRs. The ships would be similar in size to some developed for the MPF(F) Analysis of Alternatives (AoA) by the Center for Naval Analyses and the LHA Replacement AoA by the Naval Sea Systems Command.[5] The new ships would have a lightship displacement—the weight of the ship and its equipment, excluding fuel, stores, cargo, and crew—of 40,000 to 50,000 tons (versus 28,600 for the LHD). To provide a sufficient number of aircraft operating spots for the n-HLRs, the new ships would probably need to have their islands—if they have them at all—at the bow or stern.

Alternative S3: Sustainment by Airdrop

Airdrop is the only existing capability that can be used to supply ground forces in the absence of nearby bases and

5. Center for Naval Analyses, *MPF(F) Analysis of Alternatives: Final Summary Report* (February 2004); and Naval Sea Systems Command, "LHA(R) AoA Life Cycle Cost Estimate Review" (briefing prepared for Congressional Budget Office staff, August 2003).

ground supply lines. Under this alternative, DoD would purchase 17 additional C-17 aircraft to provide an airdrop capability to sustain a MEB and a light Army brigade without reducing the number of aircraft available for other airlift tasks. (Airlift is typically in high demand early in a conflict, at the same time when airdrop would most likely be needed to sustain early-arriving ground units.) Purchasing those aircraft would cost $3.8 billion to $4.8 billion, CBO estimates. The low estimate assumes that production of the C-17 is extended without interruption. If Boeing closes the C-17 line (which it is now preparing to do, because of a lack of orders), costs to restart the C-17 line (based on historical experience with the restart of the C-5 production line in the 1980s) would be about $1 billion.

In the past, large-scale airdrop of supplies has been inefficient because unguided parachutes would scatter over a large area, requiring extensive collection efforts by the troops on the ground. However, a new system—the Joint Precision Air Drop System, or JPADS—may be able to counter that inefficiency. Using the Global Positioning System, JPADS is expected to guide airdrop deliveries precisely, to within less than 100 meters of their targets. That accuracy would enable individual bundles to be tailored for and delivered directly to units dispersed on the battlefield.[6] Because JPADS is expected to be capable of delivering loads of up to 60,000 pounds, the system could also be used to deliver replacement vehicles.

For a given aircraft payload, the number of C-17s needed to support a particular flow rate of supplies would depend on the distance between the air base and the ground forces being supported. Assuming the C-17s could operate from a base 2,000 nm away and carry a useful payload of about 40 tons, CBO estimates that 17 aircraft could supply a MEB and a light Army brigade.[7] For longer missions of 7,000 to 8,000 nm (the approximate flight distances from the United States to the Middle East), 64 C-17s, or about one-third of the Air Force inventory currently planned, would be needed.

As has been noted earlier, airdrop can also be used to employ units. Airborne units, however, are more lightly equipped than the MEB that would need to be employed to meet this study's criteria for alternatives capable of employing a ground force. The number of C-17s needed to deliver the more than 2,500 vehicles and trailers in a MEB would be prohibitive. As a consequence, CBO did not examine an air-drop alternative for employment.

Alternative S4: Sustainment by Heavy-Lift Airship

Under Alternative S4, DoD would develop and field a hybrid airship. The goals for the performance of that airship are similar to those of the Defense Advanced Research Projects Agency's Walrus program—an aircraft with a payload of at least 500 tons that could operate from unimproved locations and transport its load anywhere in the world in a few days.

Eight airships would be purchased under this alternative, the six needed to deliver 1,000 tons of cargo per day from an advance base 2,000 nm away plus two spares. (Seventeen airships operating from the United States would be needed to supply a MEB and a light Army brigade operating in the Middle East, CBO estimates.) This option would have a total cost of $5 billion to $7 billion, in CBO's estimation—about $3 billion to $4 billion for development and testing and the rest to purchase the eight airships. Because existing airships are smaller and less complex than the ones envisioned in Alternatives S4 and E4, there are no analogous systems upon which to base an independent cost estimate for the hybrid airship. Consequently, CBO based the cost estimates for the airships on information from various sources, including aerospace industry contractors.[8] As with the n-HLR, the time needed to develop the airship could delay the fielding of this system past the date currently planned for the MPF(F).

Hybrid airships differ from conventional airships (such as blimps) in that they derive lift from more than just the buoyancy of helium in their hull. The hull's airfoil shape would provide additional lift, essentially acting as a wing when the airship is moving forward. Design concepts for such an airship vary but, roughly speaking, the static

6. Achieving such highly focused logistics would require effective logistics command-and-control systems to relay a unit's location and supply needs to the advance logistics base(s).

7. The maximum payload of a C-17 would be higher than 40 tons, but allowance must be made for the weight of the parachutes and energy-absorbing packaging to cushion the cargo on impact. Allowance must also be made for less dense cargo bay packing that may be needed to ensure that air-drop bundles do not interfere with each other as they slide out of the aircraft.

8. For additional details, see Congressional Budget Office, *Options for Strategic Military Transportation Systems* (September 2005).

lift provided by the helium-filled bags in the hull would support the weight of the airship and its fuel, and the dynamic lift provided by the hull's shape would offer the extra lift to allow the ship and its payload to make the transition to flight. As with current airships, propellers would provide forward speed and maneuverability.

Specific dimensions for hybrid airships could vary significantly, but conceptual designs envision an airship roughly 1,000 feet long and 300 feet wide. Its structure would probably consist of a nonrigid hull to hold the helium and a gondola, slung underneath the ship, to carry cargo and troops. Estimates of achievable speeds for hybrid airships range from about 80 knots to 120 knots. For this analysis, CBO assumed an average speed of 100 knots.

Alternative E1: the Planned Maritime Prepositioning Force (Future)

The composition of Alternative E1, the planned MPF(F) sea base, was discussed in detail in Chapter 1 and is summarized in Table 2-2.

The cost for Alternative E1 would range from about $15 billion to $22 billion, CBO estimates.[9] The lower end of that estimate does not include any cost for the squadron's LHD aviation ship, under the assumption that possible reductions in the amphibious force could free up an LHD for use in the MPF(F). The lower estimate also does not include the potential cost of high-speed ships for transporting the MEB's helicopters to the sea base; airlift would be used instead. Those parameters are consistent with shipbuilding plans in the Navy's budget submission for fiscal year 2008. (The Navy estimate quoted earlier includes the cost of the LHD but not the high-speed ships.) The higher end of CBO's estimate includes the cost of purchasing two high-speed ships.

Alternative E2: Sea Base with Advanced Heavy-Lift Rotorcraft

Under Alternative E2, DoD would be capable of employing a MEB and sustaining it plus a light Army brigade up to 220 nm from the sea base. The greater aircraft reach possible under this alternative would have several advantages over the planned MPF(F): It would increase the area over which the air-landed battalion could be employed, increase the supportable area for both air-landed and surface-landed forces, and allow the sea base to be positioned farther from shore if geography or an adversary's ability to attack the sea base made it necessary.[10]

The number and quantity of ships purchased under Alternative E2 would be similar to those for the planned MPF(F) squadron, but one of the planned LHAs would be omitted and three aviation ships of new design (like those described above) would be added to support operations for the new heavy-lift rotorcraft (see Table 2-2).

The sea-based aviation component under Alternative E2 would be a mix of n-HLR rotorcraft and MV-22 tiltrotor aircraft. CBO's estimate of that mix was based on two primary constraints:

- The aircraft must be able to carry or deliver, on average, the same amount of cargo (measured in tons per day) to a radius of 220 nm that the planned force (48 MV-22s and 20 CH-53Ks) could deliver to a radius of 110 nm, and
- The aircraft must provide the same heavy-lift capability (measured in missions per day) to a radius of 220 nm that the planned force (20 CH-53Ks) could deliver to a radius of 110 nm.

The former constraint ensures sufficient aggregate throughput to satisfy the employment timeline.[11] The latter constraint ensures that there will be a sufficient number of heavy-lift sorties to move vehicles or other large equipment ashore. According to CBO's estimates, the planned ship-to-shore airlift force is capable of an average throughput of about 2,500 tons per day and about 100 CH-53K missions per day to a radius of 110 nm. About 36 n-HLR rotorcraft would be needed to provide 100 missions to a radius of 220 nm because of the

9. For comparison, the Navy's current estimate for the ships in the MPF(F) is about $12 billion. Most of the difference arises from CBO's slightly higher cost estimate for each LHA and from CBO's including the cost of the LCACs in the total for Alternative E1.

10. If the sea base had to be positioned farther to seaward, however, its ability to deliver the surface-landed force would be jeopardized. Additional surface-landing craft would be needed to deliver the surface-landed force from a greater distance because transit times would be longer. The force under Alternative E2 would have the same surface ship-to-shore transportation capability as in current plans because the number of surface-landing craft and MLP ships would be unchanged.

11. CBO assumed that the n-HLRs would have sufficient troop-transport capacity to also ensure that personnel could be moved ashore within the required timelines.

longer flight times needed.[12] (The n-HLR quantity of 36 is not double the CH-53 quantity of 20 because the ground-time component of an n-HLR mission would be larger than, but not double that of, the CH-53K. Consequently, total n-HLR mission time out to 220 nm would not be double the CH-53K mission time out to 110 nm.) About 57 MV-22s would be needed to complete the aviation force under Alternative E2. CBO assumed that those aircraft would be provided by the embarked MEB. Alternative E2 would need one LHA and one LHD (for MV-22s and to provide a well deck for LCACs) and three new-design aviation ships to support the 36 n-HLRs and the MV-22s that might not fit on the LHA and LHD.

The cost to procure the ships and aircraft under Alternative E2 would range from about $31 billion to about $39 billion, depending on the cost of the n-HLR and the need for high-speed ships to deploy them.

Alternative E3: Amphibious Task Force with Sea-Based Logistics

Of all the alternatives that CBO examined, Alternative E3 would have the lowest cost—$1.8 billion to $2.0 billion, CBO estimates. Under this alternative, DoD would purchase three T-AKE cargo ships and use them to provide at-sea logistics support to traditional amphibious task forces. An oiler would not be needed because one would have time to sail from the United States with the task force.

Alternative E3 coupled with an amphibious task force and its embarked MEB would satisfy the requirement that a sea base be able to employ a MEB and sustain the MEB and a light Army brigade, but it would have difficulty satisfying other objectives, such as the 10- to 14-day deployment time. The implications of those shortcomings are discussed in Chapter 3.

Alternative E4: Employment and Sustainment by Heavy-Lift Airship

Under this alternative, DoD would purchase a sufficient number of the heavy-lift airships described in Alternative S4 to both employ a MEB-sized ground combat force and sustain it plus a light Army brigade. With a payload of about 500 tons, those airships could deliver all items of equipment associated with any type of ground unit. About 40 airships would be needed to deliver a MEB-sized force in a single lift. (Six additional airships would be purchased as spares.)

The cost to procure the airships under this alternative would be about $12 billion to $18 billion, CBO estimates. As with Alternative S4, the time needed to develop the airship could result in this alternative being fielded later than current plans for the future Maritime Prepositioning Force.

12. That quantity assumes that the n-HLR would be a helicopter with a speed similar to that of the CH-53K. Fewer quad tiltrotors would be needed because of their higher speed when not carrying an external load (probably when returning empty from shore). Developing a quad tiltrotor is expected to be more technically challenging and costly than developing a heavy-lift rotorcraft with a conventional helicopter design, however.

CHAPTER

3

Comparison of Access-Insensitive Systems for Employing and Sustaining Ground Forces

In the first two chapters of this study, the Congressional Budget Office described various systems that could be used to employ and sustain ground forces. Four of the systems would be limited to sustainment of troops only; the other four, including the Navy's planned Maritime Prepositioning Force (Future), would be capable of both employment and sustainment.

Although the alternatives were structured around the common objective of supporting a Marine expeditionary brigade plus a light Army brigade, there are nevertheless significant differences in other aspects of the capabilities they would provide. In this chapter, the relative advantages and disadvantages of the alternatives are examined with respect to several measures of military operational effectiveness: sensitivity to access limitations, geographic reach, strategic responsiveness, and the capability to sustain a ground force.

Sensitivity to Access Limitations

The current interest in sea basing stems primarily from the perceived need to enhance U.S. forces' freedom of operation in so-called antiaccess or denied-access scenarios. Lack of access can arise for various reasons, including the unavailability of local infrastructure in undeveloped parts of the world, the lack of nations willing to grant basing or transit permission in a region, and military action on the part of an adversary to prevent the use of such bases or to directly attack U.S. forces as they are being deployed. This section of the chapter compares the ability that the sea-based alternatives and other employment-and-sustainment systems examined by CBO would have to operate in the face of such constraints. Two potential access constraints are considered: lack of access to local support resources (such as air bases, port facilities, or airspace), and active military action on the part of an adversary to deny access.

Access to Foreign Infrastructure and Transit Rights

All of the alternatives examined in this study were structured to be insensitive to diplomatic or political restrictions that foreign governments might impose in the immediate area of operations. Each alternative would have no need for land facilities nearer than an advance base up to 2,000 nautical miles away. Despite that common general capability, constraints could still arise along the logistics supply line that would stretch from the United States, through the advance base, and to the ground units being supported.[1] Such constraints would affect the systems in each alternative differently.

The Advance Base. Consistent with the Department of Defense's plans for sea basing, the alternatives examined in this study are predicated on the assumption that an advance base located within 2,000 nm of the supported ground units would be available as part of the logistics pipeline that would have to be established from the United States. Some of the alternatives that CBO examined, however, would require more substantial support from an advance base than would others. An alternative is sensitive to access at an advance base to the extent that the support needed is critical to accomplishing the mission.

Alternatives E1 and E2 (the planned future MPF and the sea base equipped with new heavy-lift rotorcraft, respectively) rely particularly on an advance base. For those

1. It might be necessary to establish more than one advance base to support a single operation. For example, an air base and a port might be needed to receive supplies sent from the United States on aircraft and ships. For simplicity, references to "the advance base" in this study are meant to encompass one or more bases.

alternatives, the advance base must be immediately available to support the closure and assembly phases of a force deployment. Additionally, the advance base for Alternatives E1 and E2 must be capable of receiving large numbers of personnel and cargo: The Marine Corps estimates that nearly 200 missions by large aircraft (Air Force C-17s and commercial 747s) would be needed to deliver the fly-in portion of a MEB. The advance base must have adequate airport facilities to receive those aircraft as well as the capacity to move people and cargo from the airport to the sea base (if the ships that formed the sea base were to stop at a nearby port) or to intratheater transports that would travel to the sea base. If the MEB's helicopters arrive via airlift, hangar space must also be available to assemble and test them. Alternatives E3 and E4 (the amphibious task force with sea-based sustainment and the employment and sustainment by airship, respectively) would not require an advance base to support employment operations because the ground force would be both assembled and embarked in the United States and then transported directly to the area of operations.

All of the alternatives except E4 would require an advance base during sustainment operations. Alternative S3 (sustainment by airdrop) could deliver only 1,000 tons per day of supplies over distances up to 2,000 nm, so it would require access to an advance base from the outset. As was noted in Chapter 2, the number of aircraft needed under Alternative S3 would have to nearly quadruple if missions had to be flown from the United States to the Indian Ocean region. Similarly, Alternative S4 (sustainment by airship) would need about triple the number of airships—seventeen versus six—to provide sufficient supplies from the United States if an advance base was unavailable. Alternative E4 would not require an advance base because the 40 airships needed to deliver a MEB in a single lift would be enough to support sustainment from the United States.

The sea-based alternatives would need an advance base with port facilities capable of receiving container ships and transferring their cargo to the T-AKEs that would shuttle back and forth from the sea base. Some time would be available to establish the advance base because supplies stored on the T-AKEs would be adequate for the early days of sustainment operations. (Analyses conducted by Navy staff suggest that it might be as long as two weeks before the first T-AKE must depart the sea base for resupply at an advance base.)

The more substantial the required support, the more limited the number of locations that might be available to provide it. The magnitude of operations required at an advance base under Alternatives E1 and E2 could exceed that available at any single base and might require access to multiple locations. Additionally, deployment under Alternatives E1 and E2 would have a higher diplomatic profile because more than 10,000 Marines would pass through the advance base. For example, instead of a quiet cargo transfer operation on a military air base, it might be necessary to move large numbers of troops from an airport and through town to a seaport for embarkation on the sea base's ships or intratheater shuttle ships. Foreign nations might be less likely to provide access to advance bases for such high-profile operations.

Transit Rights. The need for access to a foreign nation's airspace or territorial waters could also constrain U.S. efforts to deploy and operate ground forces. Restricted access to territorial waters would be unlikely to have a significant impact on the alternatives examined by CBO, however. There are few shipping chokepoints around the world (a major canal such as the Suez is an example), and the ships in Alternatives E1, E2, S1 (the sustainment-only sea base with existing aircraft), and S2 (the sustainment-only sea base with new heavy-lift rotorcraft) could be prepositioned in a location that would minimize the chance that transiting such a chokepoint would be necessary. The ships in Alternative E3 would have a greater chance of encountering restrictions at shipping chokepoints because they would sail from the United States. That constraint could result in delays of several days if the task force must sail a longer route (for example, around the Cape of Good Hope). Most shipping chokepoints are in international waters and would not be vulnerable to restricted access by a foreign nation. Once in their area of operations, the ships in the sea-based alternatives would be expected to remain 25 nm offshore, in international waters.

Landing craft going ashore would probably only enter the territorial waters of the nation where the U.S. ground forces would be operating. Similarly, ship-to-shore aircraft would most likely fly only in the airspace of the nation where ground operations were being conducted. That may not be the case for the alternatives that rely on the direct delivery of supplies by air (Alternatives E4, S3, and S4). If access to airspace is restricted, then air-drop missions will have to travel significantly longer routes. That complicates mission planning and increases the resources that must be dedicated to the operation. For example, an air-drop mission from an advance base in Kuwait would have about a 1,400 nm flight distance down the Persian Gulf and up over Pakistan to serve a ground unit operating near Kandahar in Afghanistan. The direct distance over Iran would only be slightly more than 900 nm. The longer distance would increase the number of C-17s required to maintain a given flow rate of supplies by about 50 percent and would probably introduce a greater need for airborne tankers to support the air-drop aircraft.

Airship operations (as in Alternatives E4 and S4) could be particularly sensitive to airspace restrictions. Because airships fly at relatively low speeds, a given increase in flight distance would result in a greater increase in transit time compared with conventional aircraft. Additionally, foreign nations might be more reluctant to grant transit rights to airships because of the higher profile such transits would have. The transit of cargo aircraft cruising above 30,000 feet would have a much lower profile than the transit of airships the size of several football fields flying at well below 10,000 feet.

Vulnerability to Enemy Defenses

Another factor that could limit the use of the systems examined in this study is military action or the threat of military action by an adversary. Indeed, the threat of military action against advance bases in a region could deter otherwise friendly nations in the region from allowing access to U.S. forces. This section of the chapter considers the potential impact of direct threats to U.S. forces operating in a region. The vulnerability of the systems examined in this study to an enemy's defenses can be split into two categories: threats to ships in the sea-based alternatives and threats to aircraft in all of the alternatives.

Antiship Threats. Several types of weapons could be used to attack the ships at a sea base. Those weapons include antiship cruise missiles, strike aircraft, submarines, and naval mines. The first layer of defense against those threats is distance: Sea-based ships would be expected to remain at least 25 nm offshore, or "over the horizon." At that or greater distances, an enemy would need more-sophisticated systems to detect and track sea-based ships. In addition, the deeper water usually found farther from shore would make it more difficult to for an enemy to plant effective minefields, and enemy submarines would be more easily detected in deeper water. Finally, being over the horizon from shore could aid U.S. forces in defending against cruise missiles because defensive radars are better able to detect and engage incoming missiles when they are not masked by the background signal reflected from a nearby coastline.

Despite the advantages of remaining far offshore, sea bases will nonetheless need robust defenses because a single hit could render inoperable a significant fraction of a base's capability. The Navy is developing "Sea Shield" to provide that defense. As currently envisioned, Sea Shield will consist of surface combatants, submarines, and aircraft working together to defeat the threats described above. If those defenses failed to prevent attacks from reaching the sea base, the ships built to commercial survivability standards—the T-AKRs, T-AKEs, and mobile landing platforms—would be especially vulnerable. Those ships would be more vulnerable because, compared with ships built to naval standards, they typically have less compartmentalization to limit the amount of water that can enter the hull from any single hit. They also have less redundant systems and less robust damage-control capabilities. In addition, ships operated by the Military Sealift Command are not currently equipped with self-defense weapons (such as the Rolling Airframe Missile or the Close-In Weapon System), which would provide a final layer of defense against missile attacks.

The commercially designed ships carrying large numbers of Marines in Alternatives E1 and E2 could be particularly vulnerable. Twelve of the fifteen prepositioned ships in Alternative E1 would be built to commercial standards; only the two LHAs and the LHD would be built to naval standards. If the three new-design aviation ships under Alternative E2 were built to commercial standards, only two of seventeen ships would have the higher survivability construction. Ships in Alternative E3 would have a much better chance of survival in an attack because only the three T-AKEs would be of commercial design. The fifteen or so ships in the amphibious task force would be of naval design, and those ships would be armed with self-defense weapon systems.

Although a catastrophic loss would be less likely for a naval ship than for a commercial ship, even naval ships could be rendered inoperable if hit. Such a "mission kill" against a ship in a sea base could seriously degrade the support that could be provided ashore. For example, damage to one of the aviation ships in any of the sea-based alternatives could substantially reduce the base's ability to move sustainment supplies ashore. Thus, even while ashore, supported ground units would be critically dependent on the survivability of the ships offshore.

Antiaircraft Threats. Perhaps more problematic than antiship threats would be air defenses that an adversary could use to damage or destroy U.S. aircraft delivering troops or supplies. Because sea-based operations would include large numbers of rotorcraft moving to and from fairly predictable locations, an adversary would know the location of the ground unit and would probably have at least a general idea of the location of the sea base. Helicopter losses in Operation Iraqi Freedom have highlighted the potential vulnerability of those aircraft to even unsophisticated defenses.

Certain tactics could improve the survivability of sea-based aircraft. Those tactics include operating at night as much as possible and flying varied and circuitous routes. Even using those tactics, however, it would probably be impossible to fully suppress low-altitude threats because they are hard to detect and can be widely spread over the battlefield. Moreover, using those tactics would reduce the effectiveness of aircraft operations by decreasing the time available each day for flight operations and by limiting the effective distance to which ground forces could be supported.

The air-drop aircraft in Alternative S3 can operate at higher altitudes, above the reach of most of the threats facing lower-altitude rotorcraft. Higher-altitude air defenses tend to be much fewer in number because they are more expensive and require trained crews to operate them effectively. Also, because higher-altitude air defenses usually rely on radar to engage their targets, those threats are easier to locate and suppress with electronic jammers or attack with antiradiation missiles. The vulnerability of large transport aircraft would require that enemy defenses be thoroughly suppressed before airdrops could begin. Depending on the availability of Navy or Air Force defense-suppression aircraft, resupply via airdrop could be severely hampered by those air defenses.

The hybrid airships in Alternatives E4 and S4 could have unique advantages in terms of survivability. On the one hand, their large size, low altitude, and slow speed would make airships very easy to detect, track, and shoot at. On the other hand, proponents argue, although an airship might be easy to hit, it could operate successfully in a threatening environment, for several reasons:

- A large airship could easily carry an extensive set of defensive systems, such as missile countermeasures and even air-to-air missiles to defend against hostile aircraft.
- The cargo compartments could be armored with materials that are too heavy or bulky for use on conventional aircraft.
- The low speed of an airship means that if it was hit, it would not be susceptible to the severe dynamic stresses that can cause conventional aircraft to break up in flight when damaged.
- The helium in the compartments of the hull would be at only a slightly higher pressure than the ambient atmosphere, so it would leak very slowly out of any holes shot in the hull. Consequently, if an airship was hit by ground fire, it would not pop (like a rubber balloon) but rather lose buoyancy slowly (like a Mylar balloon).

Investigating the validity of such claims would be an important part of any program to develop a heavy-lift hybrid airship.

Defending airship landing zones could pose problems as well. Although the airships would not require access to infrastructure (such as air bases), simultaneously unloading 40 airships would require access to a very large area. For example, access to a total of more than four square miles of defended landing zones would be required if each airship needed three times its length and width for safe maneuvering while landing and unloading a brigade under Alternative E4. Similarly, each delivery location for sustainment supplies would need a large open area to accommodate an airship under Alternative S4. That need for so much space to employ and sustain troops would pose greater tactical complications than would employment and sustainment by airdrop or aircraft from a sea base because those systems would be able to deliver smaller loads into more constrained areas.

Geographic Reach

Although access can be limited by factors such as political restrictions and enemy defenses, an overarching constraint on accessibility is determined by operational reach—the physical ability to get forces to wherever they are needed to meet a theater commander's objectives. The reach offered by military systems stems from two primary factors: the flexibility to establish bases of operation where they are needed around the world, and the radius of operation from those bases. For example, heavy bombers are able to reach targets anywhere in the world from bases in the United States because of their long range and the availability of airborne tanker support. By comparison, short-range Navy fighters achieve nearly global reach by having access to bases—aircraft carriers—that can be located around the world. Because those bases are limited to major bodies of water contiguous with the word's oceans, however, there are practical limits to the inland reach of naval fighters.

Constraints on Operational Reach for the Alternatives CBO Examined

Sea-based operations would be subject to geographic constraints. Although the sea bases themselves would have access to the approximately 70 percent of the Earth's surface that is ocean, ground forces employed or sustained by them would have access only to land areas within range of their ship-to-shore aircraft. Sea-based Alternatives E1, E3, and S1 were structured to support operations with flight distances up to 110 nautical miles from the ships. Alternatives E2 and S2 were structured to support operations with flight distances up to 220 nm. In practice, however, the actual reach inland for the sea-based aircraft would be considerably shorter, for several reasons. First, the ships in a sea base would be expected to remain at least 25 nm offshore to make them more difficult to detect and attack. Second, the sea-based ships could not always be positioned perpendicularly offshore (for the shortest distance) from supported ground units. Third, once over land, aircraft are likely to fly evasive flight paths to make it more difficult for an adversary to position defenses along their routes. Increases of roughly 30 percent in flight distances can be expected if efforts must be made to avoid air defenses. Those considerations could reduce the effective operational reach inland to as little as about 60 nm for planned aircraft and about 130 nm for the longer-range new heavy-lift rotorcraft. High terrain in the vicinity of the coast could further limit operations because the performance of rotorcraft decreases with increasing altitude.

Employment and sustainment by airdrop or airship would not be subject to the geographic constraints on sea-based operations. The C-17 aircraft postulated under Alternative S3 could reach any point on the Earth with suitable air bases and aerial refueling. Heavy-lift airships would also have the range to reach any point on the Earth, but their estimated maximum altitudes of about 6,000 feet above sea level could constrain operations at higher elevations or force the airships to fly circuitous routes around high terrain.

Implications of Geographic Constraints

Limits on operational reach have broad implications for where expeditionary forces can or cannot be employed as well as more scenario-specific implications for how effectively forces could be employed in a given conflict.

Global Implications. On the basis of data from Columbia University, CBO estimates that approximately 20 percent of the Earth's land surface is within 54 nm (100 kilometers, or km) of coasts, and about 30 percent is within 108 nm (200 km). Those inland distances roughly correspond to the two sea-based aircraft distances (110 and 220 nm) described above (see Figure 3-1).[2] Those percentages do not vary substantially among the continents. Thus, the ground forces supported by the sea-based alternatives examined in this study would be limited to operating on approximately those fractions of the world's continents.

Sustainment of forces by airdrop (Alternative S3) would not be geographically constrained, provided aerial refueling was available to extend the C-17's range. About 10 percent of the world's land area would not be accessible to airships (Alternatives E4 and S4) if airships were limited to flying in areas with ground elevations no greater than 5,000 feet above sea level. (A ground elevation of 5,000 feet would give the airships about 1,000 feet of clearance.)

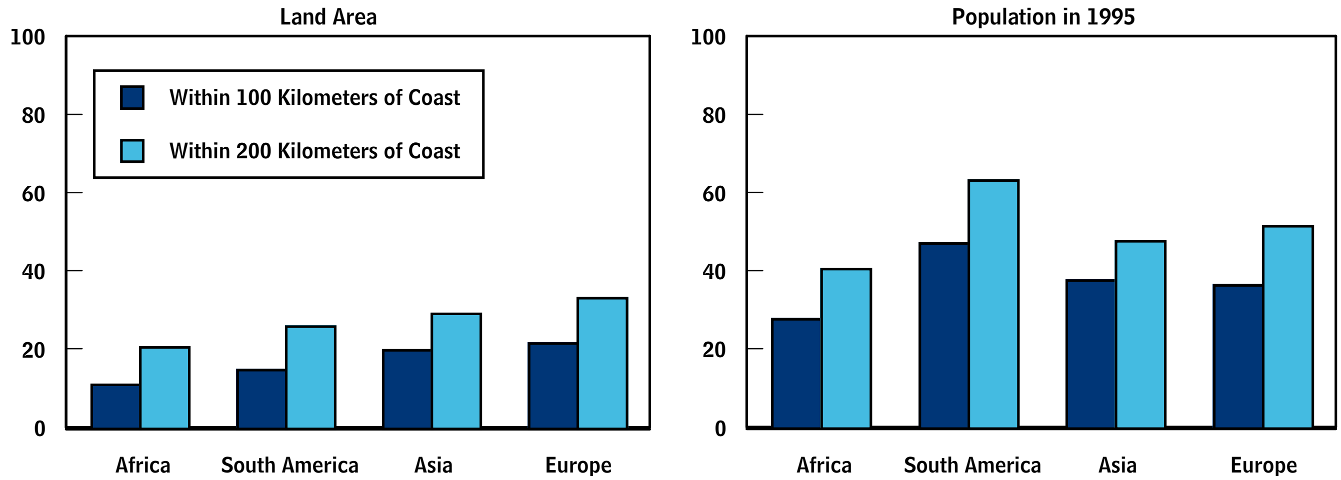
The ability to operate in regions of greater population density provides a different perspective on the effective reach of sea-based ground forces. Military forces may be needed more frequently in regions with greater concentrations of people because such areas are more likely to experience political instability. Also, in the event of a conflict, such areas are more likely to have the economic resources to field military forces of sufficient strength to require the commitment of substantial U.S. military

2. Those percentages exclude Antarctica. See Columbia University, Socioeconomic Data and Applications Center, Population, Landscape, and Climate Estimates (PLACE) data, available at http://sedac.ciesin.columbia.edu/.

Figure 3-1.

Worldwide Proximity of Land Area and Population to the Seas

(Percent)



Source: Congressional Budget Office based on Population, Landscape, and Climate Estimates (PLACE) data from Columbia University's Socioeconomic Data and Applications Center.

forces. Figure 3-1 shows that the fraction of the world's population living in areas accessible to sea-based forces is significantly higher than the fraction of land area. For example, more than 45 percent of South America's population in 1995 was estimated to live on the 15 percent of land located within 100 km of a coast. Averaged worldwide, about 38 percent of the population in 1995 lived on the 20 percent of land within 100 km of a coast, and almost 50 percent of the population lived on the 30 percent of land within 200 km of a coast.[3]

Scenario-Specific Implications. Although the fraction of the world's land area and population that can be reached by sea-based aircraft is limited, a much higher fraction of the world's nations—about 85 percent—are not landlocked and would therefore be at least somewhat accessible to sea-based aircraft. Whether that accessibility would be militarily useful, however, would depend on the particular scenario. Small countries and countries with lengthy coastlines would be more accessible to sea-based forces than large countries with little or no coastline. For example, on the basis of flight distances, nearly all of North Korea would be accessible to the aircraft that would be operated under the sea-based alternatives (see Figure 3-2). Mountainous terrain in North Korea could reduce accessibility somewhat, however.[4] All of North Korea would be accessible to airdrop, and well over 90 percent of that country's land area and population would be accessible to airships.

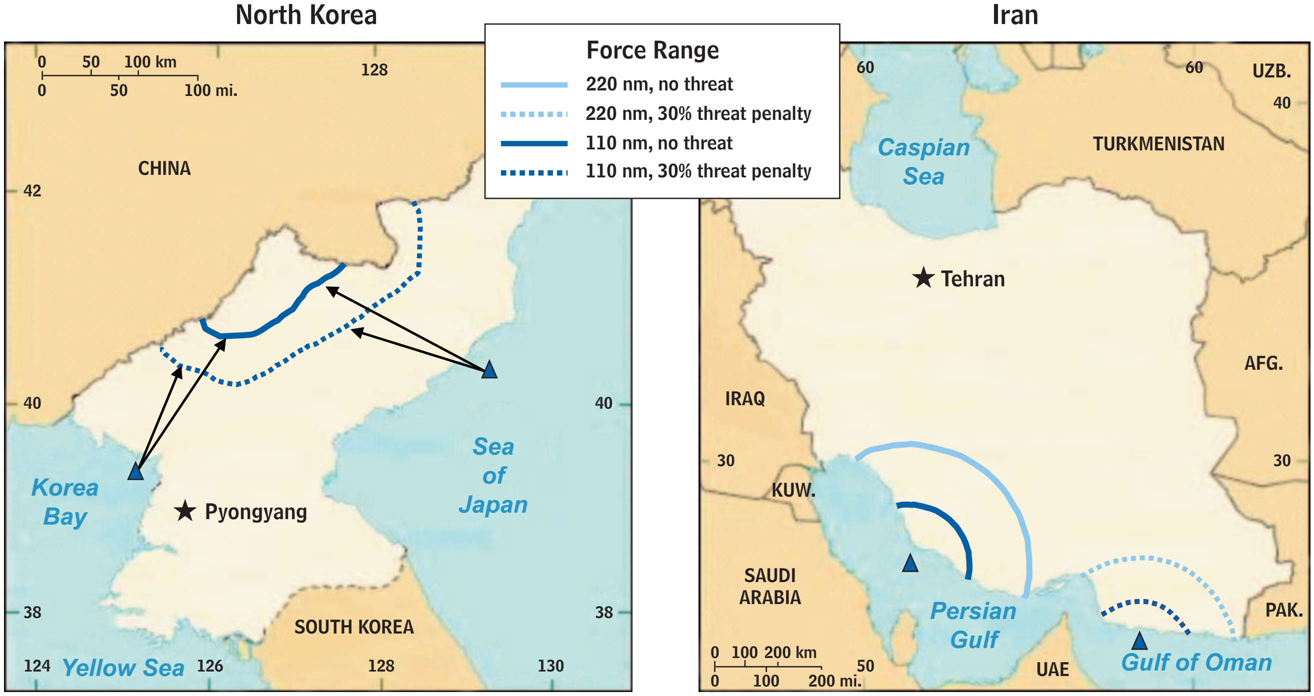
A large country such as Iran would be far less accessible to ground forces operating from a sea base. Despite a long coastline on the Persian Gulf and Gulf of Oman, only about 14 percent of the land and 11 percent of the population would be accessible to the shorter-range ship-to-shore aircraft forces included under Alternatives E1, E3, and S1. Twenty-nine percent of the land and 15 percent of the population would be accessible to the n-HLR aircraft included in Alternatives E2 and S2. As with North Korea, all of Iran would be accessible to airdrop. Many parts of Iran are mountainous—for example, nearly 40 percent of Iran's land area and almost half its population are at elevations greater than 5,000 feet above sea level—and thus would present limitations to airship operations.

3. Demographic trends since 1995 have shown a continued concentration of human populations at the coasts of the world's oceans and other major bodies of water.

4. In those examples, it was not practical for CBO to include detailed flight performance as a function of altitude for aircraft operating on specific flight paths.

Figure 3-2.

Areas of Operation Supportable by Sea-Based Aircraft



North Korea

Accessibility with 30% Threat Penalty	110 nm Force	220 nm Force
Land Area	81%	99%
Population	91%	99%

Iran

Accessibility with 30% Threat Penalty	110 nm Force	220 nm Force
Land Area	14%	29%
Population	11%	15%

Source: Congressional Budget Office.

Notes: nm = nautical mile.

A threat penalty is the additional distance an aircraft would need to fly to avoid potential air defenses.

Strategic Responsiveness

Strategic responsiveness is the ability to get a force to where it is needed in an allotted time. For the alternatives that are designed to deploy and employ ground forces (E1 through E4), these three aspects of strategic responsiveness are particularly important:

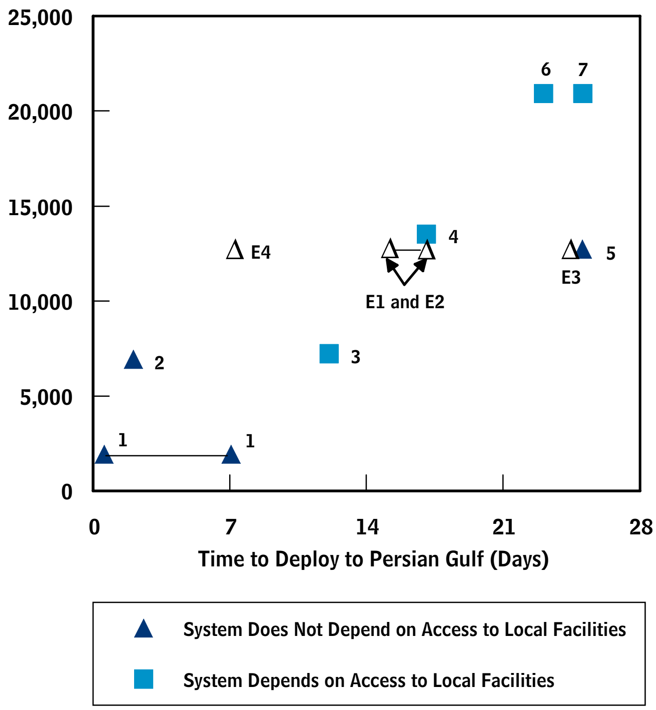
- The time required to get the force into position to commence operations,
- The size of the force that can be moved in the allotted time, and
- The type of force (light, medium, or heavy) that can be moved in that time.

The latter two characteristics, in combination, reflect the strength of the force that can be employed. In general, smaller and lighter forces can be deployed more rapidly because they can be assembled more easily and require fewer transportation resources to move. For the sustainment-only alternatives (S1 through S4), strategic responsiveness is better measured by the ability to be in position no later than when the ground force that is to be supported begins operations.

Figure 3-3.

Responsiveness and Capacity of Existing Systems and Selected Alternatives

(Unit weight, in tons)



Source: Congressional Budget Office.

Notes: Two triangles separated by a solid line indicates a range of responsiveness.

The existing systems (denoted by the solid triangles and squares) are as follows: 1, a forward-deployed Marine expeditionary unit (responsiveness varies with required transit distances); 2, strategic brigade airdrop; 3, an Army infantry brigade combat team deployed by air (constrained by air-base capacity); 4, the current Maritime Prepositioning Force; 5, an amphibious task force; 6, an Army heavy brigade combat team deployed by air (constrained by air-base capacity); and 7, an Army heavy brigade combat team deployed by sea.

The alternative systems (denoted by the open triangles) are as follows: E1, the planned Maritime Prepositioning Force (Future) sea base; E2, the prepositioned sea base with new heavy-lift rotorcraft; E3, the amphibious task force with sea-based sustainment; and E4, employment and sustainment by airship.

Unless otherwise noted, deployment times are from the United States.

Responsiveness of Employment-and-Sustainment Alternatives

As Figure 3-3 shows, the responsiveness and capacity of Alternatives E1 through E4 would vary. Alternative E1, the planned MPF(F), and Alternative E2, the sea base with new heavy-lift rotorcraft, would be capable of access-insensitive employment of a MEB within 15 to 17 days of activation to seacoasts almost anywhere in the world. (Access-insensitive capabilities are shown with triangles in Figure 3-3, and access-dependent ones are shown with squares.) Alternative E3, existing amphibious forces coupled with T-AKEs to provide sustainment from the sea, would be able to deliver a MEB independent of access but it would take longer—an additional week or more might be needed to reach a distant theater—because of the need to sail from the United States. The airship fleet in Alternative E4 could deliver a MEB-sized force in about seven days if the MEB could be ready to load in no more than 48 hours. (Alternatives S1 through S4 do not appear in the figure because they are unable to employ ground units.)

Figure 3-3 plots both the response time to deploy plus the strength of the ground unit deployed as represented by the total weight of the unit's equipment. That surrogate for unit strength captures both the size of the unit (larger units would typically have more vehicles) and the type of unit (stronger units typically have more armored, and hence, heavier, vehicles).

Figure 3-3 also illustrates how Alternatives E1 through E4 would compare with existing means of employing ground forces. From the perspective of deployment and employment, Alternatives E1 and E2 could deliver a MEB in about the same time as current MPF squadrons, but they would have the advantage of not needing access to local infrastructure such as ports and air bases. The access-insensitive employment capabilities in the current force that are more responsive than the employment-and-sustainment alternatives are only capable of delivering units that are lighter or smaller than the medium-weight MEB. An airborne brigade could be kept on alert for deployment within hours, but the constraints of air transport limit the unit's equipment to light vehicles and artillery. The brigade would lack the armor and heavier fire support available to a MEB. Marine expeditionary units forward-deployed as part of expeditionary strike groups could respond very quickly; indeed, they might even be on the scene as a crisis erupted. Forward-deployed MEUs, although equipped with some armored vehicles, are only battalion-sized and they lack the MEB's additional aviation, fire support, and logistics capabilities.

There is currently no access-insensitive means of delivering a force heavier than the MEB envisioned for the MPF(F) or Alternatives E1 through E4. Heavy Army brigades can be deployed by air or by sea, but those means of deployment would require access to bases in the theater and would take more time than Alternatives E1 through E4—about three to four weeks at best, CBO estimates.[5] Employment of heavy forces from a sea base would have to be accomplished by surface-landing craft delivering the force over the beach because armored vehicles such as the Abrams tank and Bradley fighting vehicle are too heavy even for the n-HLR postulated under Alternative E2. (The heavier MEB vehicles such as M-1 tanks also go over the beach under Alternatives E1 and E2.) Airships could deliver a heavy brigade, but over 70 airships would be needed to do so.

Responsiveness of Sustainment-Only Alternatives

The responsiveness of the sustainment-only alternatives that involve sea bases, Alternatives S1 and S2, would probably be somewhat better than the responsiveness of the corresponding employment-and-sustainment alternatives (E1 and E2) because less equipment and fewer personnel would need to be deployed. Basic crews aboard prepositioned ships could immediately set sail for their destination, and additional people (such as the aircraft crews and maintenance personnel) could be called up and flown to the region. Depending on the time it took the ships to reach their destination, those sea bases could probably be ready for operations in well under a week, which would most likely be faster than the deployment of the forces they would support.

The sustainment-only alternatives that do not involve a sea base—the air-drop alternative (S3) and the airship alternative (S4)—could also begin deliveries of cargo within a few days. Although strategically responsive, Alternatives S3 and S4 would be less tactically responsive—a particular item would take much longer to reach the ground force than it would from a sea base because of the longer distance that would need to be flown. Whereas a sea base would only be 100 to 200 nm away, a base for air-drop aircraft or airships could be thousands of miles away. Tactical responsiveness is discussed later in this chapter.

Capability to Sustain a Ground Force

The sustainment of ground forces can include providing supplies such as food, water, fuel, and ammunition as well as other support, such as maintaining equipment or providing medical services. The ability to provide supplies is largely determined by the cargo flow rates that can be established to the ground forces. The other sustainment activities depend on the availability of facilities such as hospitals or repair shops in the theater as well as the ability to move equipment and people from the combat area to where those facilities are located.

Capacity of Cargo Throughput to Supported Ground Units

All of the alternatives examined by CBO would be capable of maintaining the approximately 1,000 tons per day of cargo throughput needed to support a MEB plus a light Army brigade either from ships located offshore (as in Alternatives E1, E2, E3, S1, and S2) or from an advance base 2,000 nm away (as in Alternatives E4, S3, and S4). In addition, all of the alternatives could deliver vehicles at least as large as those that could be delivered by the planned MPF(F).

The sustainment-only sea-based alternatives include sufficient numbers of ship-to-shore aircraft to meet the delivery target of 1,000 tons per day out to the specified radius of operation. The sea-based alternatives capable of deploying a MEB would have a substantially larger throughput capacity because the capacity needed to move the air-landed portion of a MEB ashore in one period of darkness would be greater than the capacity needed to supply two brigades.

The aircraft throughput capacity inherent in the three employment-and-sustainment sea bases (Alternatives E1 through E3) would be about 2,500 tons per day, CBO estimates, more than double that of the sustainment-only alternatives. That rate could not be maintained indefinitely, however, unless additional cargo ships—T-AKEs, in particular—were added to maintain an adequate stock of supplies at the sea base. The Navy estimates that, for supporting a MEB and a light Army brigade, adequate

5. Air delivery could, in principle, be faster than that. An earlier CBO analysis indicated, however, that actual air-movement of ground units would most likely be constrained by air-base capacity in-theater. See Congressional Budget Office, *Options for Strategic Military Transportation Systems* (September 2005).

stocks of dry cargo and ammunition could be maintained indefinitely at a sea base with two T-AKEs on station and a third rotating to an advance base no more than 2,000 nm away for reloading. An increase in the number or size of supported ground units would require more ships to maintain that rotation. Alternatively, the T-AKEs could be reloaded from standard cargo ships sent directly to the sea base. The Navy is exploring ship-to-ship cargo transfer techniques to support large-volume transfers of that sort.

Tactical Responsiveness for Resupply

In addition to the ability to deliver cargo to ground forces daily, the ability to quickly move items that might suddenly and unexpectedly be needed ashore—so-called tactical responsiveness—is a useful attribute for logistics systems. Although the air-drop and airship alternatives (S3, S4, and E4) could provide adequate flow of cargo, the long flight times from distant air bases would make those alternatives less tactically responsive than the alternatives involving sea bases. For example, a CH-53K helicopter operating from a sea base could make an emergency delivery in less than two hours, whereas a C-17 aircraft operating from an advance base 2,000 nm away would take nearly seven hours. Airships would need even longer to respond to special cargo requests—it would take about a day for an airship to reach a ground unit 2,000 nm away—because they would fly at much lower speeds than the C-17s. In addition, because each airship's payload would be very large, delivering supplies to dispersed units would require several stops, further lengthening delivery times.

Tactical responsiveness can also be important for other support missions, such as carrying wounded personnel back to medical facilities. That type of support is discussed in the next section.

Other Sustainment Support

In addition to delivering supplies to sustain troops ashore, the sea-based alternatives examined in this study would be capable of other support functions. Maintenance and medical services could be provided within the sea base itself, thus eliminating the need to have those facilities located ashore. A sea base is well-suited for providing those services because the rotorcraft used to move supplies to the troops can also return damaged equipment and injured troops to the sea base. Because a sea base would be located relatively close to the ground forces, those return flights would be fairly short, improving the likelihood of survival for seriously injured personnel. Each of the sea-based alternatives considered by CBO—Alternatives E1 through E3 and S1 and S2—could be configured to offer similar levels of that support.

The other alternatives examined by CBO—E4, S3, and S4—would not be as capable of providing medical and maintenance support. Airdrop is only suitable for delivering supplies—there are no means (short of establishing air bases on land) for getting injured troops or damaged equipment back to facilities elsewhere in the theater. Airships could be used to evacuate injured troops and damaged equipment, but their slow speed could result in unacceptably long flights back to a hospital. Although those alternatives could not in and of themselves provide medical support, such support might still be available in the theater despite the lack of a sea base. Medical support could be furnished from the hospital facilities aboard aircraft carriers or amphibious ships that might be in the vicinity, although that support would be limited (in terms of the numbers of operating rooms and hospital beds). Alternatively, it might be possible to base mobile Army and Navy/Marine Corps medical facilities that are usually established ashore on ships in the area. Air transportation would still be needed between such makeshift hospital ships and the forces ashore, however.