IDA

INSTITUTE FOR DEFENSE ANALYSES

Mobile Offshore Base Operational Utility and Cost Study

W. L. Greer, Project Leader

January 2001

IDA Paper P-3573
Log: H 00-002792

This work was conducted under contract DASW01 98 C 0067, Task BA-1-1890, for the Office of the Deputy Under Secretary of Defense (Advanced Systems and Concepts). The publication of this IDA document does not indicate endorsement by the Department of Defense, nor should the contents be construed as reflecting the official position of that Agency.

INSTITUTE FOR DEFENSE ANALYSES

IDA Paper P-3573

Mobile Offshore Base Operational Utility and Cost Study

W. L. Greer, Project Leader

D. A. Arthur
J. T. Buontempo
W. C. Devers
A. I. Kaufman
B. J. McHugh
J. F. Nance

with contributions by

H. R. Brown
J. M. Cook
G. A. Corliss
B. C. McCaffree
D. C. Rendon
S. R. Renn
R. L. Suchan

PREFACE

This paper documents the Mobile Offshore Base (MOB) Operational Utility and Cost Study conducted by the Institute for Defense Analyses (IDA) for the Deputy Under Secretary of Defense for Advanced Systems and Concepts. In May 1999 the Senate Armed Services Committee directed in legislation that the Secretary of Defense initiate an analysis of the operational utility of the conceptual MOB and report these analyses back to the Congressional Defense Committees. The directive specifically identified three items to be provided in the response: (1) a technical feasibility study, (2) an assessment of the operational utility versus life cycle costs, and (3) a recommendation on whether to proceed to pre-development or development activities and which agency would have that responsibility. The Office of the Secretary of Defense (OSD) submitted a technical feasibility study in April 2000 to Congress to satisfy the first directive. This paper provides the requested operational utility and life cycle cost assessment.

The IDA study team benefited from extensive support provided by a large number of Government offices. We wish to thank our study sponsor, Mr. Robert Shields, Jr., for arranging meetings, establishing contacts, and providing data in a timely and useful manner. We are particularly grateful for the data and information provided by the Naval Sea Systems Command and the Naval Surface Weapons Center at Carderock, Maryland. Within OSD, we thank the Office of the Under Secretary of Defense (Acquisition, Technology and Logistics) and the Office of the Director, Program Analysis and Evaluation. We also benefited from discussions with several offices within the Navy and U.S. Marine Corps: the Office of Naval Research; the Naval War College; the Naval Facilities Engineering Service Center (NFESC) at Port Hueneme, California; OpNav (N42, N45, and N85); the USMC Plans Division; and the USMC Combat Development Center. The Army Training and Doctrine Command (TRADOC) provided information on future Army units. Comments were solicited from the Unified Commanders in Chief, and we particularly thank the staff at the US Central Command for its useful and informative discussions during a visit there by the study team.

The study team gratefully acknowledges expert assistance from the IDA Review Committee: Dr. David L. Randall, Dr. L. Dean Simmons, Dr. William J. Hurley, Mr. Stanley A. Horowitz, Mr. Martin A. Lidy, Col. Louis L. Simpleman (USMC, retired), and LTC Joseph Sokol (USA).

CONTENTS

Part I—Introduction and Summary

Part 2—Discussion

Appendixes

(This page is intentionally blank.)

Part 1

INTRODUCTION AND SUMMARY

INTRODUCTION

This paper documents the background, approach, analyses, and findings of the Mobile Offshore Base (MOB) Operational Utility and Cost Study, conducted by the Institute for Defense Analyses (IDA) for the Deputy Under Secretary of Defense for Advanced Systems and Concepts.

A. BACKGROUND

If built, the MOB would be a large seaport or air base afloat at sea and movable under its own power from one theater to another. Its semi-submersible twin-hull design would allow it to operate in high sea states with minimal rolling motions. The MOB is envisioned to provide adequate bases where none currently exist, or where existing ones may not be available during crises, either through enemy action or for political reasons.

The U.S. Congress directed[1] that the Secretary of Defense initiate an analysis of the operational utility of the conceptual MOB and report these analyses back to the Congressional Defense Committees. The directive specifically identified three items to be provided in the response: (1) a technical feasibility study, (2) an assessment of the operational utility versus life cycle costs, and (3) a recommendation on whether to proceed to pre-development or development activities.

The first item, the technical feasibility study,[2] was completed in December 1999 for the Office of Naval Research (ONR) and, after internal review by the Office of the Secretary of Defense (OSD), was submitted to Congress in April 2000. Concurrently, IDA was asked by OSD to begin a study of MOB operational utility and cost. The IDA study, the subject of this paper, uses the feasibility report as a point of departure and then documents its own independent utility and cost assessments. The third response item, the OSD recommendations on if and how to proceed, will be made by a separate OSD report.

---

1 *National Defense Authorization Act for Fiscal Year 2001*, Section 251, October 2000. This updated the initial directive in *National Defense Authorization Act for Fiscal Year 2000*, May 1999.

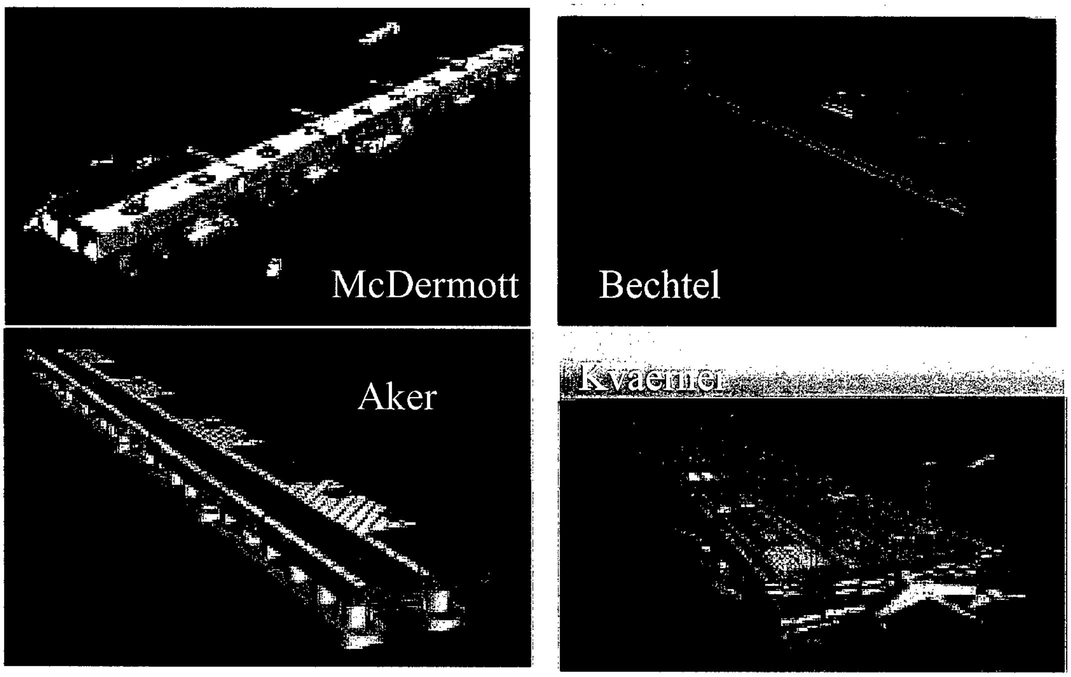
2 *Mobile Offshore Base – An Independent Review*, MCA Engineers, 20 December 1999.

B. SUMMARY OF MOB TECHNICAL FEASIBILITY REPORT

It is important to begin with a clear summary of the ONR technical feasibility report. This report provided a preliminary assessment of four candidate MOB designs in order to establish overall technical feasibility, identify critical technology issues that would need additional attention, and provide a foundation for cost estimates. All designs were explicitly constructed to support the deployment and logistics mission, not combatant missions. Considerable detail can be found in the report and its annexes; for completeness and continuity, the main observations from that report are repeated here.

All four MOB designs are based on semi-submersible hull forms that, when filled with water and ballasted down, minimize ship surface contact with the ocean surface waves, thereby reducing rocking motions relative to monohull ships of comparable size. The designs borrow from engineering experience with large, stable oil-drilling platforms and satellite launch vessels in current use. Moreover, all four designs employ separate MOB modules, called single base units (SBUs), which can be connected to provide a continuous runway surface up to approximately 5,000 feet. Such a connected MOB could be used by C-17 transport planes and by any other conventional take-off and landing (CTOL) aircraft that can use a runway of that length. The main differences among the designs were in how the SBUs would best be connected and what materials to use in the hull construction (steel or concrete).

Examples of the MOB designs are illustrated in Figures 1 and 2. Figure 1 shows all four conceptual MOB designs and the engineering firm providing the design. In these illustrations CTOL aircraft such as the C-17 are shown operating from the MOB, and ships are shown either loading or unloading alongside.



Source: *Mobile Offshore Base - An Independent Review.*

Figure 1. Four MOB Designs

Figure 2 illustrates one of the McDermott-concept SBUs. It is approximately 1,000 feet long and 500 feet wide. When ballasted down, this MOB has approximately a 125-foot draft. These dimensions can be contrasted with those of a modern nuclear powered aircraft carrier (CVN) with a comparable length of 1,100 feet, a much narrower width at the water line of 134 feet, and a much shallower draft of 35 feet. Maximum MOB speeds of advance of up to 15 knots when unballasted (and up to 5 knots when ballasted and assembled) have been projected, although actually encountered sea states would reduce the average speed. We estimate the average speed at 12 knots. CVNs can move at speeds exceeding 30 knots. The figure also shows the flight deck, ship cargo handling equipment, a deck for Landing Craft, Air Cushioned (LCAC) operations, the SBU connectors, and the twin semi-submersible hulls. Other designs have different detailed features, but for the purpose of this report on operational utility, the McDermott concept suffices. For costing, we use all four concepts and show the expected cost range.

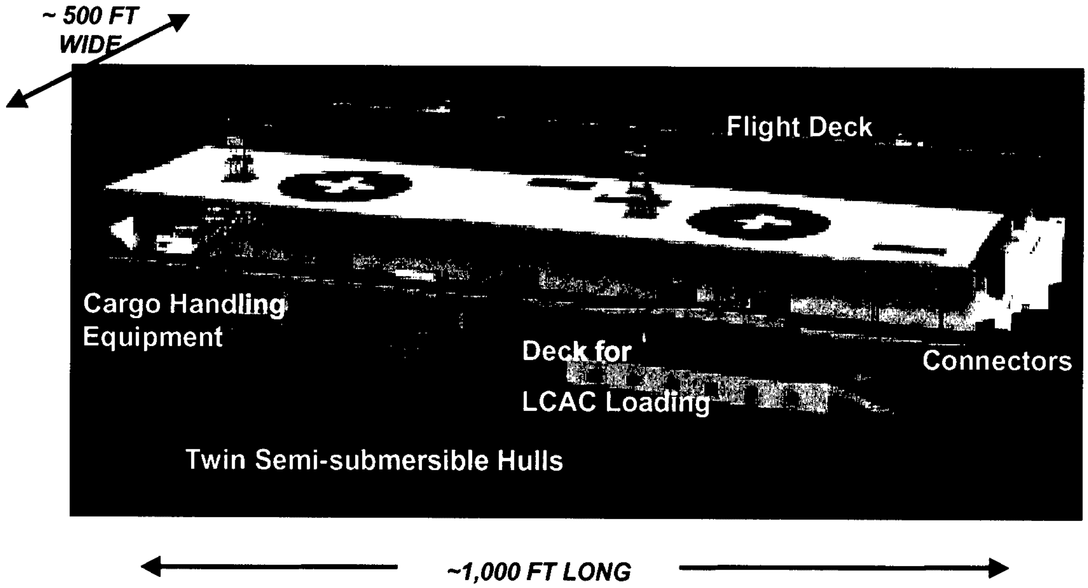


Figure 2. McDermott Design for MOB SBU

The ONR feasibility report concluded that building and operating an SBU such as the one shown in Figure 2 was technically feasible as it represents a modest extension of current engineering technology. The more ambitious 5,000-foot multiple-module MOB was also viewed as feasible pending further work to resolve certain technical issues. These issues centered on the nature and viability of the connectors and dynamic positioning systems, and on the flexible bridges between the SBUs. In addition to these, the report also identified the following areas needing further investigation and definition: cargo handling, performance of the concrete hull, transit stability and speeds, and impact of weapons on the structure and operational capability of the MOB.

C. MISSIONS

The MOB could be used to support any missions that require a large sea base in the theater of concern. The ONR report focuses on the MOB as a logistics asset, not as a combatant. In their view, it would carry minimal defenses and depend largely on other assets for defense. With its emphasis on cargo handling and C-17 accessibility, the technical feasibility report clearly orients the MOB utility toward that of receiving large volumes of cargo and personnel while at sea and serving as an in-theater logistics hub.

But these are not the only missions conceivable and are certainly not the only missions promoted in the past. Any mission that could be supported by a large base in theater is a candidate mission for the MOB. The following missions could be supported by a large sea base such as the MOB:

- Strike
- Missile Defense
- Deployment and Logistics.

1. Strike

The MOB could provide a base for launching and recovering air strikes from fixed- or rotary-wing attack aircraft as well as for launching land-attack or anti-ship missiles. In this role it could serve as a joint resource for basing and operating some U.S. Air Force (USAF) fighters, various naval attack and fighter aircraft, Army and U.S. Marine Corps (USMC) attack helicopters, and future Joint Strike Fighter (JSF) aircraft. The MOB would become the functional equivalent of a joint service aircraft carrier. It could also be used to launch large numbers of unmanned weapons, such as cruise missiles, at targets ashore or afloat. This would duplicate the role of Tomahawk-armed naval cruisers, destroyers, and submarines. This report assesses how well the MOB supports these missions and makes comparisons with land-based and CVN alternatives.

2. Missile Defense

Armed with advanced radars and weapons that can engage incoming ballistic or cruise missiles, the MOB could be considered for use as a large missile defense platform at sea. It could be used to (1) defend a local area at sea, including itself and other nearby naval or commercial ships, (2) protect a larger theater region including land areas as a part of a Theater Missile Defense (TMD), or (3) position itself to defend the United States and allies from strategic ballistic missiles as a part of a National Missile Defense (NMD). Each of these three roles would require progressively longer-ranged weapons as well as the radars and other sensors needed to support engagements.

For local defense, the MOB provides nothing not already available from anti-air warfare (AAW) naval combatants. It also duplicates the TMD role planned for Aegis cruisers and destroyers armed with SM-2 and SM-3 missiles and the SPY-1 radar. Only the NMD mission ushers in a potentially novel capability at sea. The MOB would probably be large enough to carry the required X-band engagement radar, far larger and more capable than the SPY-1 used in the AAW or TMD roles. It should be noted that its use in the NMD role at sea would require a modification to or abrogation of the 1972 Anti-Ballistic Missile (ABM) Treaty between the United States and Russia. The NMD role is currently under investigation in another IDA study on alternatives to the low orbit Space-Based Infrared System (SBIRS). That mission is not analyzed in this report.

3. Deployment and Logistics

Because of its large size, the MOB could be used for prepositioning USMC or Army units at sea, with troops flown directly to the MOB when it arrives in the theater where these forces are needed. After the troops marry up at sea with their equipment and are subsequently deployed ashore, the MOB would then serve as a logistics hub to which cargo and additional troops are brought from outside the theater of operations and from which sustainment and force augmentation in the theater is provided. It could also serve auxiliary functions, such as an in-theater hospital facility and a repair and maintenance depot.

In this study the descriptions and capabilities of the MOB designs from the technical feasibility report are used to examine the utility and cost of such a system. To this end we identify where and under what circumstances a MOB might be used as a logistics platform, and compare its cost and performance capability with those of other ways in which similar logistics operations can be conducted.

D. SCOPE

The nominal time frame for the analyses in this study is 2020. We assume that the current world picture gives us insight into, but does not uniquely define, future conditions in that time period. Thus a certain degree of uncertainty surrounds prudent planning that far in the future. The use of weapons of mass destruction will probably be more likely than today, and the accuracy of missiles, ballistic and cruise, are likely to improve significantly over what is currently available to potential adversaries. The availability of satellite information on the location of objects on the Earth's surface (ground or sea) will almost certainly improve for future adversaries.

Assets that interact with the MOB, such as aircraft and ships, will represent advances over the vehicles used today. In general, the aircraft will depend on short or vertical take-off and the ships will increase in stability and speed. Army and Marine units are likely to be smaller and lighter if current trends are followed.

E. ORGANIZATION OF THIS REPORT

A summary of the report findings follows immediately after this introductory section. The Introduction and Summary constitute Part 1. The next section, Part 2 (Discussion), provides greater detail and context. Even greater detail on specific areas can be found in the chapters in Part 3 (Analyses), which is composed of the following chapters:

- Chapter 1: Technical Descriptions
- Chapter 2: Potential Uses for the MOB
- Chapter 3: MOB Inter-theater Transit and Deployment
- Chapter 4: MOB Vulnerability
- Chapter 5: MOB Motions and Availability
- Chapter 6: Logistics Throughput with a MOB
- Chapter 7: Assessment of MOB Contributions to Logistics Support
- Chapter 8: Cost Analyses
- Chapter 9: The MOB as a Power Projection Asset.

(This page is intentionally blank.)

SUMMARY

The study findings are summarized in this section. We address first the utility of the MOB as a strike platform, then its utility for deploying and supporting ground forces. In both cases, we make comparisons with alternatives. Cost estimates follow at the end.

A. STRIKE BY TACTICAL AIRCRAFT

The MOB has been proposed as a joint sea base from which air strikes could be flown. Today, these missions are accomplished by Air Force tactical aircraft based at overseas airfields, by aircraft carriers, and by heavy bombers operating from the continental United States (CONUS). If access to foreign bases were denied in a future scenario, a MOB could be used to recover some of the Air Force tactical aircraft capability that would otherwise be lost. In such a role, a MOB might generate sorties by F-16 or JSF aircraft equivalent to approximately two to three aircraft carriers under surge conditions. This would provide a significant increase in striking power over carriers and heavy bombers alone, but would fall well short of tactical sortie generation expected in current MTW plans. If air strike operations were conducted from a MOB, some access to local bases would still be required for support aircraft such as E-3 AWACS, which cannot operate from the MOB runway.

Additional limitations to a MOB's utility as a strike platform involve MOB transit times and vulnerability, which are described in detail later in this section. Unless it is fortuitously positioned in "the right place at the right time," strike sorties from a MOB might not be available for several weeks. This may not be acceptable for small-scale contingencies where the incremental addition of the MOB to carriers and heavy bombers could very well tip the balance in favor of U.S. operations. Also, the sortie potential of a MOB would be at risk to a single failure, either as a result of enemy attack or other failure or mishap (e.g., an aircraft crash on deck or module connector failure) since the force would not be spread over several bases or carriers as is the case today.

If access to local airbases is denied, a MOB configured for strike aircraft operation could provide substantial augmentation to carriers and heavy bombers.

However, the availability of this augmentation might be delayed by slow MOB transit speeds; other local basing would be necessary for Air Force support aircraft unable to operate from a MOB, and the concentration of a large number of aircraft in a single location would make the force vulnerable to a single attack.

B. MOB LOGISTICS UTILITY ASSESSMENT

To assess the actual utility of the MOB, as opposed to its general capability, we looked at a scenario in which the MOB would operate approximately 7,000 nautical miles (nmi) from CONUS bases. Our analysis is designed to be generic, but is reflective of situations where the MOB operates in the Sea of Japan or the Indian Ocean in the vicinity of the Pakistan-India border, for example. It could well apply to other remote regions.

The utility of a MOB is a function of its availability—how quickly it can respond to a crisis and what fraction of time it can remain operational—as well as its productivity when operational. These factors are discussed in the following section.

1. Operational Availability of a MOB

a. MOB Transit Times

The MOB moves at about one-half the speed of conventional monohull ships, such as the Large Medium Speed Roll-On/Roll-Off (LMSR) ships used to preposition Army equipment. For this reason, there would probably have to be MOB units at more than one peacetime location to ensure timely response to crises around the world. At an average speed of advance, which we estimate in our analyses to be about 12 knots, the MOB can be present and ready for operations anywhere in the world within 25 days if the SBUs needed to assemble a 5,000-foot MOB are stationed during peacetime at each of these three locations: near Diego Garcia, near Hawaii, and in the Central Mediterranean Sea. One day of this time would be required to prepare the SBUs in their peacetime locations for independent transit and another day would be needed in theater to join the SBUs into the fully connected MOB.

Transit and set-up times can vary from nearly 1 week (repositioning within the Mediterranean) to 3 weeks or more (e.g., Diego Garcia to the west coast of Africa). For a single peacetime location, the issue of where to locate the MOB so it can respond in a timely way during crises is even more critical. The SBUs needed for a single 5,000-foot MOB, if not fortuitously positioned, could require transit times as long as 6 weeks. Of course, if adequate advanced indications of an approaching crisis are available, a MOB could preemptively move toward the crisis scene. *Barring situations with long advanced warning times, multiple peacetime MOB locations will be necessary to ensure even modest strategic responsiveness (2-3 weeks) over a large portion of the world.*

b. Impact of Sea State on Air Operations

The MOB design goal is to conduct air operations up to Sea State 6 (SS 6) in 40-knot winds. Under these conditions, our assessment is that this would allow air operations about 92 percent of the time in the open ocean and essentially 100 percent of the time in sheltered waters, such as the Sea of Japan. *If technical issues (e.g., connectors) can be overcome, a semi-submersible hull design for the MOB would provide adequate stability for assembling a runway for fixed-wing air operations independent of all but the severest sea states.*

c. Impact of Sea State on Surface Operations

The impact of weather conditions on cargo transfer operations at sea is much greater than for air operations. The MOB design goal is to provide cargo transfer from ships alongside and to lighterage through SS 3. Our assessment finds that this condition limits cargo transfers to less than 50 percent of the time. While the MOB is relatively stable in high sea states, the receiving/discharging ship alongside is not. The relative sea motions of the two ships, not the stability of the MOB alone, determine the upper limit of sea conditions for cargo transfer operations. Schemes have been proposed for deploying shields from the MOB to create sheltered areas for lighterage. However, even if the transfer could be effected, the operation of existing lighterage starts to seriously degrade at SS 3 and above. *Despite the MOB's great stability, surface transit operations are constrained by the lower sea state limitations of cargo transfer between ships and the MOB and limitations of the lighterage needed to move cargo between the MOB and shore.*

d. Vulnerability to Enemy Attack

Damage as a result of enemy attack can also reduce the operational availability of a MOB. The MOB is subject to the same threats as any large naval vessel. Its large size is both an advantage and a liability; it is easy to target but hard to put out of action.

Chemical or biological weapons are a potential threat. Although decontamination at sea is typically easier than on land, the MOB design may require chemical or biological weapon countermeasures such as sealed spaces and positive overpressure systems. An additional important consideration is the increased likelihood that nuclear weapons would be used by adversaries in 2020. Since the MOB is an unambiguously military target, located well away at sea from civilian population centers, attacks against it with nuclear weapons might not arouse the international indignation that a similar attack against land-based facilities near cities would.

The MOB will be an easily identifiable and targeted vessel. Even though sinking the MOB with conventional weapons seems unlikely, crippling it in some fashion will likely be a high priority for an adversary, especially if it is the only base available for U.S. military operations. Once hit, operations could be curtailed if there is damage to the runway surfaces, air traffic communications systems topside, surface craft berths, or to the connectors holding separate SBUs together. It will be prudent to provide an escort of naval combatants for air, surface, and subsurface defenses both en route to the theater and after the MOB arrives in the theater. *The MOB will be vulnerable to attack by future adversaries. Although catastrophic loss by such attacks is unlikely unless nuclear weapons are used, damage sufficient to hamper or shut down operations is quite possible. This vulnerability, coupled with the high value of the MOB, will necessitate measures such as the use of escorts and onboard defensive systems.*

2. MOB Productivity – Logistics Throughput

Throughput is a measure of logistics utility, expressed as tons of cargo or numbers of passengers delivered per day. The delivery is in two phases: (1) to the MOB from CONUS or from other overseas bases, and (2) from the MOB to shore. Throughput combines the technical capabilities of the MOB, the capabilities of associated aircraft and ships, and the operational impacts of weather and threat on the MOB. It allows us to answer the following utility questions:

- How large a force can be inserted and when?
- How large a force can be sustained ashore from the MOB?

For illustration, we have selected representative Army units that range in size and mass from a Separate Infantry Brigade (SIB) with fewer than 4,000 personnel and weighing 8,100 short tons up to a Mechanized Division consisting of over 17,000 personnel and weighing 101,000 short tons. The Heavy Armored Cavalry Regiment (ACR) with 4,555 personnel and weighing 31,300 short tons and a Light Infantry Division (LID) with 11,520 personnel and 18,800 short tons lie in between, as would the notional combat divisions envisioned as part of the Army's transformation to a lighter, more lethal force. The objective division will have 9,000 personnel and weigh 28,000 short tons.

a. Unit Deployment

We illustrate deploying units 7,000 nmi away in two limiting cases: equipment prepositioned aboard the MOB and not prepositioned. For the prepositioned case, deployment of troops to the MOB is via C-17, and movement of troops and cargo ashore is via both air and surface craft. In the non-prepositioned case, the entire unit is first flown via C-17 to the MOB, then moved ashore by short-range aircraft and lighterage. These illustrations assume a nominal 21-day transit and set-up time for the MOB. The results can be adjusted for longer or shorter times. Once on station in theater, the MOB begins to receive troops via C-17s in either case. In this example, the MOB is positioned from 50 to 100 nmi off the coast and delivers units to the beach area. Thus both tactical aircraft [assumed here to be 24 Advanced Theater Transports (ATTs)] and surface craft [assumed to be 15 utility landing craft (LCU) 1600s] can be used to move forces ashore. Between 30 and 35 days are needed from the time the MOB is ordered to leave its peacetime location in order to move ashore a prepositioned heavy ACR. Between 45 and 60 days are needed if the units are not prepositioned aboard the MOB. The lighter LID and SIB units could be moved ashore more quickly. If the MOB is under attack and has to shut down operations temporarily to avoid damage to aircraft or ships or to repair runways or cargo loading equipment, additional delays could occur.

In addition to being slow, a lengthy movement ashore phase can present serious tactical problems. A unit is vulnerable to enemy action if it cannot quickly establish combat power ashore. Marine Corps ship-to-shore lift requirements are sized to get the bulk of the assaulting force ashore before the opposition has the opportunity to respond. The pace of MOB-to-shore movement even with advanced tactical lift assets may not meet this criterion. A benign environment would probably be required for the deployment of these units on these timelines. However, if a benign environment is available, it seems equally likely that access to airbases or ports would also be available, making the MOB superfluous. *The time required to move ashore from a MOB is quite long due to long cycle times for and the limited capabilities of MOB-to-shore assets. Such times may not* *be compatible with the necessity for unit integrity and self-protection from threat forces ashore in any but the most benign tactical environments.*

b. Sustainment

Once ashore, units can continue to be sustained from the MOB. Air transport of sustainment would be required if the unit were not accessible by ground transport from the coast. Sustaining large forces ashore would pose greater difficulties. For example, a mechanized division has nearly four times the daily supply requirement of an ACR. From a MOB positioned from 50-100 nmi from the coast (or the unit), the number of tactical lift craft needed becomes prohibitive. *Our analysis indicates a practical limit of about one heavy brigade or light division (or one 2020 objective Army divison) as the maximum force size that can be sustained from a MOB during operations of moderate to heavy intensity.*

C. COMPARISON OF MOB TO OTHER LOGISTICS SYSTEMS

In this section, we examine two logistics systems that could be employed if neither land bases nor MOBs were available in a scenario.

1. Joint Logistics Over the Shore (JLOTS)

JLOTS consists of crane ships, lighterage, and causeways that form a temporary near-shore port for unloading ships over the beach. It currently can conduct cargo transfers through Sea State 2, although a research and development (R&D) initiative currently underway may develop motion-stabilized cranes and other technologies that would provide an SS 3 capability by 2005. If successful, JLOTS augmented with this new cargo handling equipment will be able to transfer cargo under the same sea conditions as the MOB. In fact, since JLOTS operates closer to the shore in more protected waters, it is likely to encounter lower sea states anyway.

The close proximity of JLOTS to the shore results in much greater ship-to-shore throughput than for a MOB positioned far to the seaward. In contrast to the MOB throughput estimates shown earlier, JLOTS throughput is estimated at 400 vehicles and 300 shipping containers of cargo per day. JLOTS also includes an offshore petroleum, oil, and lubricants (POL) terminal for pumping fuel ashore directly from tankers. Its pumping capacity of up to 1.2 million gallons per day is far greater than that which could be carried by MOB-to-shore craft with fuel bladders. There is no air delivery capability with JLOTS, however. Unlike air delivery from a MOB, which can go to inland objectives, JLOTS can only deposit cargo ashore. If necessary, other means must be used to move the cargo forward. Both JLOTS and the MOB require a secure beach area. *A MOB provides a surface delivery capability inferior to that of JLOTS, but provides the capability of air operations that JLOTS lacks. This capability might be desired to directly support forces operating inland.*

2. Large Monohull Ships

Large monohull ships have been proposed as platforms for sea-based logistics. The U.S. Marine Corps is planning to replace the current prepositioning ships with sea bases using monohull ships approximately as long as an SBU. An even larger monohull of 1,200-foot length, 370-foot beam, and 40-foot draft was designed several years ago by a naval architect firm for a similar role. It has the same size runway deck and storage room for cargo and troops as an SBU. It is more susceptible to rolling in high sea states than is the SBU.

In general, the concept of operations for the monohull would be similar to that for a MOB, but their different capabilities allow some differences. *The monohull would have the disadvantage of not being able to operate CTOL aircraft such as the C-17 or C-130. Conversely, a monohull has the advantages of nearly twice the speed of the SBU modules of the MOB, and would have the flexibility to use regular ports for the more likely scenarios where ports are available. The SBU is too large and too tall (when not ballasted down) to use most standard port facilities.*

Logistics throughput ashore when operating in a sea base mode would be similar for the MOB and monohull, provided both operate from the same distances off shore. However, a monohull could approach closer and might even use JLOTS at several miles offshore if the situation permitted. The MOB must stay in waters exceeding 130 feet. If the monohull can operate close to the shore, it can also achieve higher delivery rates than the MOB, since the aircraft and surface lighterage times would be reduced. Although the MOB itself is more stable than a monohull, we saw earlier that lighterage restriction to SS 3 and below acts as the limiting factor in movement ashore.

With the exception of situations where fixed-wing aircraft (e.g., C-17, C-130) operations are necessary, the MOB offers slower response times and less flexibility than the monohull ship sea base concept for sea based logistics operations.

D. COST ASSESSMENTS

To conduct a thorough cost assessment of the MOB and ship alternatives, we developed estimates for the acquisition and operating costs in FY 2004 dollars. We then developed 40-year life cycle cost estimates, including salvage value and disposition charges at the end of life. In this section we summarize how these cost estimates were obtained and what we found. We reviewed the contractor ship and MOB construction cost estimates for the four conceptual MOB designs used in the technical feasibility study. The main items taken into account were weight, labor hours, material costs, and integration and construction support. For the operating and support (O&S) costs, we developed estimates from data we received from the Military Sealift Command (MSC), Naval Sea Systems Command (NAVSEA), the U.S. Navy (USN) Visibility and Management of Operating and Support Cost (VAMOSC) databases, and other appropriate sources. We estimated costs in the following five categories: maintenance, overhaul and replacement, training, fuel, and personnel.

Table 1 summarizes all the costs for a single-MOB fleet (consisting of five SBUs) as well as for a three-MOB fleet. The table includes acquisition costs, annual O&S costs, and 40-year life cycle costs. The 40-year cost of a single MOB fleet would be in the vicinity of $25 billion, of which about $10 billion is needed to conduct R&D and build the five SBU vessels. The range of acquisition cost estimates reflects the differences in designs from the ONR technical feasibility report. A three-MOB fleet, needed to reduce global response times to less than 3 weeks, would cost nearly three times as much.

Table 1. Life Cycle Cost Estimates for MOB

Size MOB Unit	Acquisition Cost Estimate (FY 2004 $B)	Annual O&S Cost Estimate (FY 2004 $B)	Life Cycle Cost Estimate (FY 2004 $B)
5,000-ft (5 SBU) MOB	8 - 13	0.36	22 - 27
3 MOB Fleet (15 SBUs)	22 - 37	1.08	65 - 80

A single SBU costs about $2 billion. Monohull ships are estimated to cost from $0.8 - 1.7 billion. An LMSR (with no air capability) would cost about $0.5 billion.

E. SUMMARY FINDINGS

We have assessed the utility of the MOB as a strike platform and a logistics platform to receive, deliver, and support military units ashore. We have made comparisons with land bases, CVNs, and with alternative design ships (monohull) and JLOTS.

We found that a 5,000-foot MOB could deploy a heavy ACR-sized unit or a future Army objective division within 30 (prepo) to 60 days (not prepo), and sustain it by air. A single 5,000-foot MOB would have an acquisition cost of approximately $10 billion and a 40-year $25 billion life cycle cost. The need for three such fleets to keep response times below 3 weeks would nearly triple the cost estimates. The alternatives to the MOB (CVN, JLOTS, large monohull sea base) are generally more effective and less costly than the MOB itself.

The conditions under which no alternatives exist would be ones for which the following three conditions are *simultaneously* met:

1. No land bases exist within or near the theater, either for air or port operations.
2. Ground forces are needed to meet the crisis and their sustained support is required over a lengthy period of time.
3. C-17s are needed to deliver cargo or troops to the theater (onto the MOB).

Without the first condition, land bases would be preferred to the MOB. Without the second condition, long-range USAF and in-theater naval airpower would be superior to the MOB. If the last condition (C-17 compatibility) is omitted, smaller sea bases such as the large monohull appear superior to the MOB SBUs. Only if all three conditions are met is the MOB with its connected SBUs the potentially superior solution. The low likelihood of these conditions—combined with the high cost of the MOB—makes it difficult to justify an acquisition program.

(This page is intentionally blank.)

Part 2

DISCUSSION

DISCUSSION

A. MOB BACKGROUND AND CAPABILITIES

The emphasis in this report is on the use of the MOB for deployment and logistics, although its potential contribution to supporting strike missions is also addressed.

The MOB concept dates to the 1920s when large, stable, oceangoing Seadromes were proposed to provide way stations for aircraft to cross the Atlantic. The idea became less popular after transatlantic flight was demonstrated by Charles Lindberg without the use of artificial way stations. It received renewed interest briefly during World War II when it was proposed that a landing strip be carved into a large iceberg, which in turn would be towed into the Atlantic as an en route base between Europe and the United States. The iceberg would melt so slowly that considerable military use could still be derived from its presence. This idea also never proceeded beyond the conceptual stages. There was renewed activity in the 60s and early 70s, principally at Navy laboratories and universities, to devise plans for mobile offshore basing structures and offshore ports or cities.

The Defense Advanced Projects Agency (DARPA) funded research into MOB designs and tests up through the mid-1990s, at which point the Navy took over the support. This period of interest coincided with support for the concept from the Joint Chiefs of Staff which drafted (but did not formally approve) a Mission Need Statement for a Joint MOB. Through the Office of Naval Research, a sustaining level of basic technology R&D has continued up through FY 2000. As of this date, DoD has earmarked no additional funds for MOB research in the President's Budget Submission for FY 2001.

The basic MOB concept has been met with skepticism by some and acclaim by others. What some see as the introduction of an intrusive technology that competes with traditional and more capable aircraft carriers and surface combatants, others see as innovative thinking beyond tradition-bound dogma. Although limited, the R&D support over the last decade did provide an opportunity to identify technical issues and to work out some solutions. However, much of the criticism continues to center on the expected cost and lack of clear mission rather than technical feasibility. The Navy did not endorse the concept beyond the ONR research program, which was terminated.

The MOB would provide a large base for storing commodities and personnel at sea and, concurrently, for avoiding large stockpiles ashore. It could serve as an at-sea assembly and staging base for forces other than amphibious assault units. This would allow Army units to assemble while at sea, rather than ashore, and move directly from the MOB to their fighting destinations. U.S. Marine units could also assemble at sea before moving ashore. In general terms, this concept is similar to the Operational Maneuver from the Sea (OMFTS) concept currently endorsed by the U.S. Marine Corps for its future combat operations. By operating completely at sea, the MOB would reduce the logistics footprint ashore while still permitting the selective movement of necessary provisions and resupply there as needed. The entire cargo hold need not be emptied to release a needed item. Instead, that item can be moved out of the MOB and transported ashore when needed. In addition, the multi-module MOB would allow the operation of certain non-arrested fixed-wing aircraft that currently cannot operate from vessels at sea. These would include C-17s, C-130s, F-16s, the planned JSF, and other such craft that can operate from a 5,000-foot runway. Its short runway would exclude C-5s, civilian airliner aircraft, and most USAF aircraft, all of which require more than 5,000 feet for operations.

For the MOB designs presented in the ONR technical feasibility report, the approximate storage capacity of a 1,000-foot SBU for certain classes of commodities and personnel is summarized in Table 2. This size would permit billeting of up to 15,000 troops and storage for all their equipment in a 5,000-foot fully connected MOB. In practice, some of the billeting space would probably be dedicated to hospital or living space facilities.

Table 2. SBU Storage Capacities

Dry Storage Space	1 million square feet
Fuel and/or water storage	17 million gallons
Combat personnel	3,000 troops

The size of the SBU can be gauged by a side-by-side comparison with the Pentagon. Each SBU would be about as long as any side of the Pentagon and considerably taller. This comparison is shown as an artist's rendition in Figure 3 for the McDermott design.

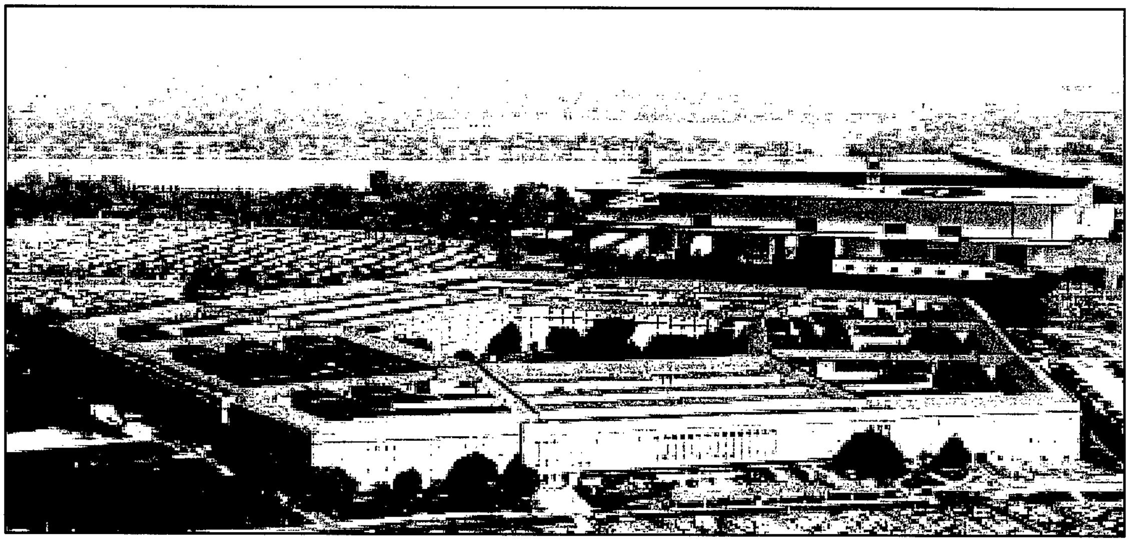


Figure 3. Comparison of Size of MOB SBU with Pentagon

A large sea base such as the MOB can certainly provide new capabilities. The important question to address is how useful these new capabilities will prove. This study moves beyond the generalities just cited and provides specifics that help answer this question.

B. ALTERNATIVES TO MOB

The MOB does not provide any functionality that cannot be provided in some other way. Sea bases and airfields already exist. Prepositioned ships and systems for moving cargo ashore from ships not at pierside also exist. What would be unique is the specific way it achieves this functionality. The alternatives to the MOB can be divided into two categories: those that require 5,000 feet of runway and those that do not. We assess these categories of alternatives when discussing operational utility.

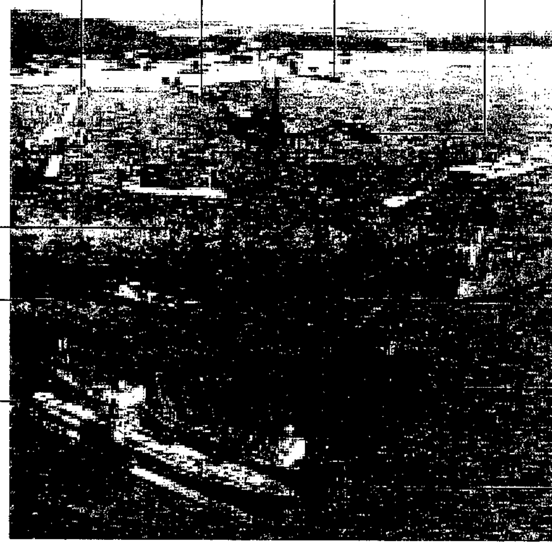
The only alternatives to the fully connected MOB for operating C-17s would be land bases of comparable length. If they are not available in a selected situation, and if emergency landing strips cannot be constructed in theater, then there exist no alternatives.

It is generally thought that C-17s can operate from austere airfields, at least temporarily. Engineer construction groups can also be brought in to enhance the airfields for larger aircraft and for longer use. If airfields exist or can be made available, arguments for the MOB as a necessary logistics base become weaker and revolve around the possibly greater security at sea or just the additional room.

On the other hand, if each 1,000-foot long SBU of the MOB is considered separately as a base, using current and future aircraft that can operate on short runways less than 1,000 feet long, the alternatives increase. Alternatives include not only land bases of comparable length but other large ships designed to conduct air operations as well. An example would be a monohull ship up to 1,200 feet long with a flat top for air operations. The monohull ship would be less stable during high sea states but would be able to move more rapidly under all conditions. Unlike the MOB, the monohull ship cannot be attached serially to other monohull ships to form a long runway. Such a flattop monohull has been designed, both as a general alternative to the SBU and as a more specific platform for use by the USMC as a future prepositioning ship. We introduce these later in the analyses when comparisons are made.

Land-based ports serve as an alternative to the MOB if they are large enough to receive LMSR ships with Army or USMC prepositioned commodities aboard. These are 1,000-foot long ships that require substantial port and pier facilities for operation. Otherwise, JLOTS assets are needed to move cargo from ships to storage areas ashore. JLOTS operates within a few miles of the shore, uses causeways and small lighterage ships to move cargo ashore, and therefore requires a reasonably secure area. The MOB can operate from over the horizon out to several hundred miles (limited by the range of sea craft and aircraft used to move cargo ashore from the MOB), also employs lighterage, and can operate under more severe sea states. Whether the MOB can be connected into a 5,000-foot continuous craft is not important for seaport alternatives. Individual SBUs can serve this function.

Figure 4 shows the composition of JLOTS operating very near the shore. The components include an elevated causeway pier, an offshore petroleum discharge system to pump petroleum products for storage ashore, a roll-on/roll-off (RO/RO) discharge facility, and other equipment for unloading transport and container ships other than at pierside.



Source: Naval Surface Weapons Center, Carderock, MD.

Figure 4. Joint Logistics Over the Shore (JLOTS)

While JLOTS can play a role when deep harbors are inaccessible, most of the parts of the world in which the United States has strategic interests at this time have numerous deep-water ports. These ports can receive the long LMSRs that are used to store and transport Army or USMC propositioned equipment. The LMSR, with a 35-foot draft, docks at the pier and unloads directly to the shore in such circumstances. Cargo is moved ashore to storage locations.

To be useable by an LMSR, a port must meet the following criteria: (1) minimum 39-foot total depth in berth and channel (3-foot clearance under the keel plus 1-foot trim at the stern) at mean high water, (2) channel widths more than 800 feet wide, and (3) at least a 1,000-foot berth length that is also suitable for RO/RO operations. In emergencies, some requirements can be waived, but these represent a medium risk[1] set of criteria for port useage by large military cargo ships.

Figures 5 and 6 show the locations of adequate ports in South West Asia (SWA) and the Western Pacific, respectively. Large airports (not shown) nearby can also be

1 *Sealift Ship Port Accessibility Study,* McCaffery and Whitener, November 1991, UNCLASSIFIED.

used for strategic lift, including civilian airliners and C-5s, neither of which can land on a MOB anyway. These same airbases can also support USAF fighters, tankers, and surveillance aircraft.

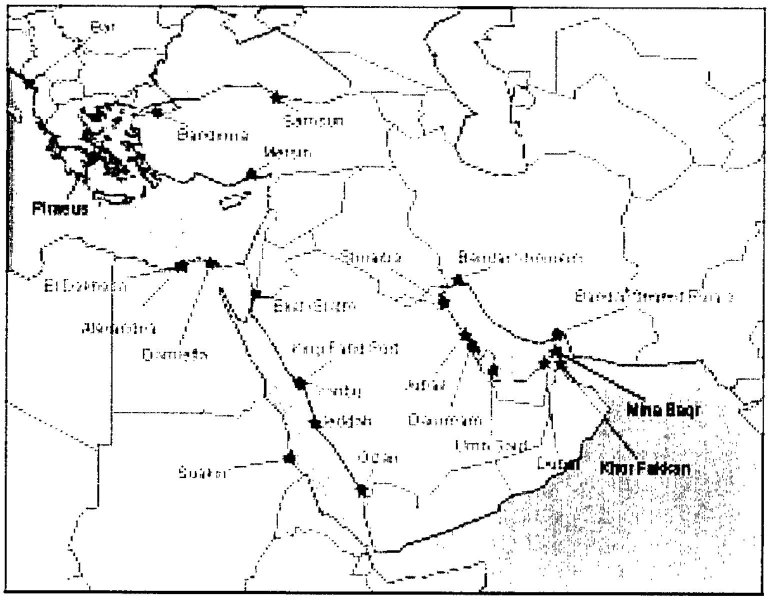


Figure 5. Ports in South West Asia Useable by LMSR

Even though access to these ports and airfields can sometimes provide political and security challenges in peacetime, their access during crises or war is an historical truism and is assumed in mobility plans. If the crisis threatens the countries with these large ports, it is normally expected that the ports will be made available.

Nonetheless, if military threats or political changes in the future prevent these countries from providing harbor and airfield access, the situation could be drastically different than currently assumed. First, access to these bases can be denied by enemy action, especially through the use of chemical weapons in the 2020 time frame. Many nations could likely have access to weapons of this type by then. Even during peacetime, tensions exist now because of a U.S. military presence. Local citizens continue to protest against the U.S. presence on Okinawa. The recent attack against the destroyer USS Cole while in port in Yemen attests to the unpredictability of bases in friendly countries, even during peacetime. In SWA, U.S. presence and bases are currently supported by the local governments, but future political and ethnic/religious pressures could alter that balance and accommodation. In addition, at present there is no reason to assume Japan would not be an ally in future conflicts in the Pacific region, but successful U.S. operations on the Korean peninsula are strongly dependent on that assumption. In either case, if access to land bases became more difficult, a MOB might help to some extent. The analyses later in this section indicate that the level of support expected from a 5,000-foot MOB would be far short of that required in a Major Theater War (MTW). Thus the MOB would help, but only enough for a minor conflict. It would prove insufficient for MTWs that form the backbone of current DoD force structure planning.

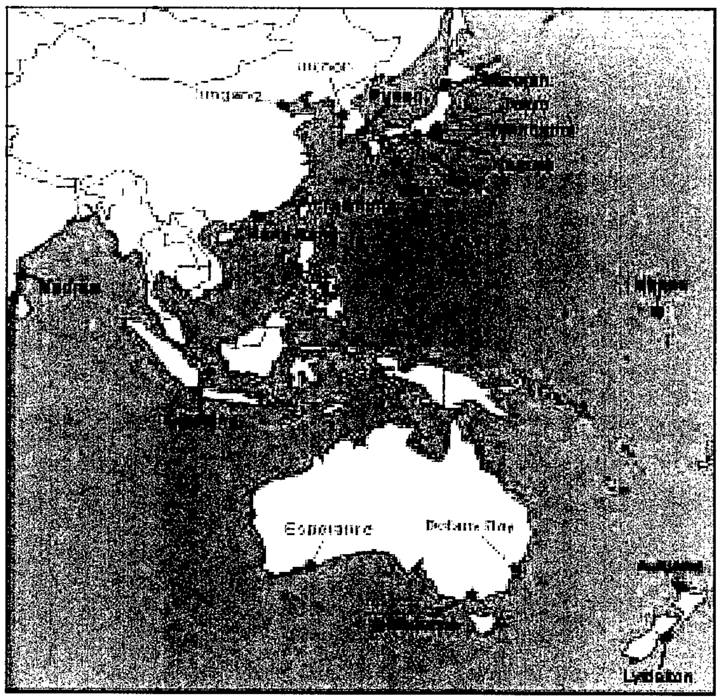


Figure 6. Ports in Western Pacific Useable by LMSR

There are parts of the world lacking large numbers of adequate ports. These are also areas in which crises would probably involve forces much smaller than those needed for MTWs. One area is South America. Figure 7 shows the LMSR-accessible ports in Central and South America. There are a few appropriate ports, but there are also large regions with none.

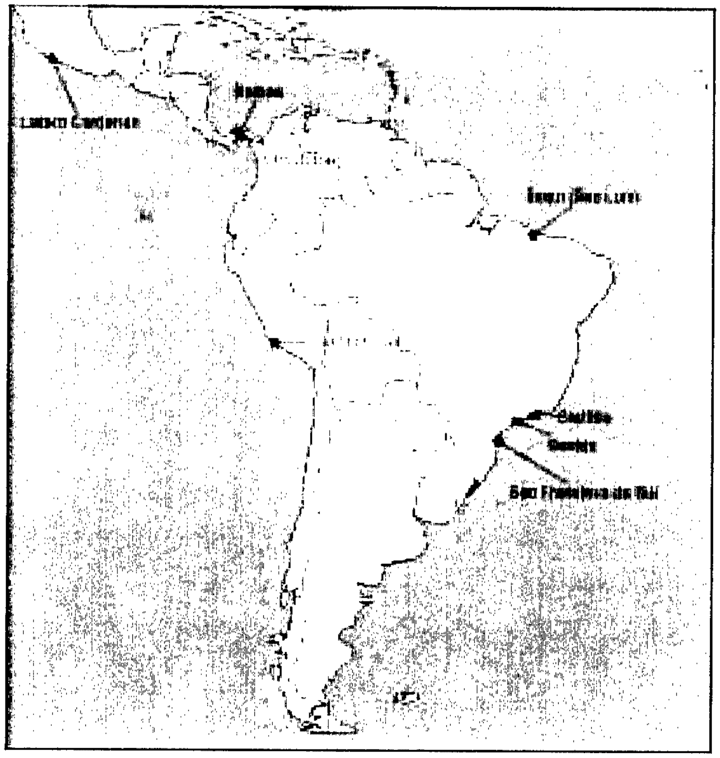


Figure 7. Ports in Central and South America Suitable for LMSRs

Similarly, there are few adequate ports in Africa (other than near South West Asia along the Red Sea in the East). Figure 8 shows the LMSR-accessible ports in that continent.

In summary, the parts of the world in which current vital interests focus—the Middle East, South West Asia, and North East Asia—all have numerous and adequate bases. Only a loss of all or most of these ports would require a MOB as back-up. Even then, as will be shown, the forces supportable by the MOB would be inadequate for an MTW. Adequate ports may not be available for large-scale U.S. military support in parts of Africa or South America.

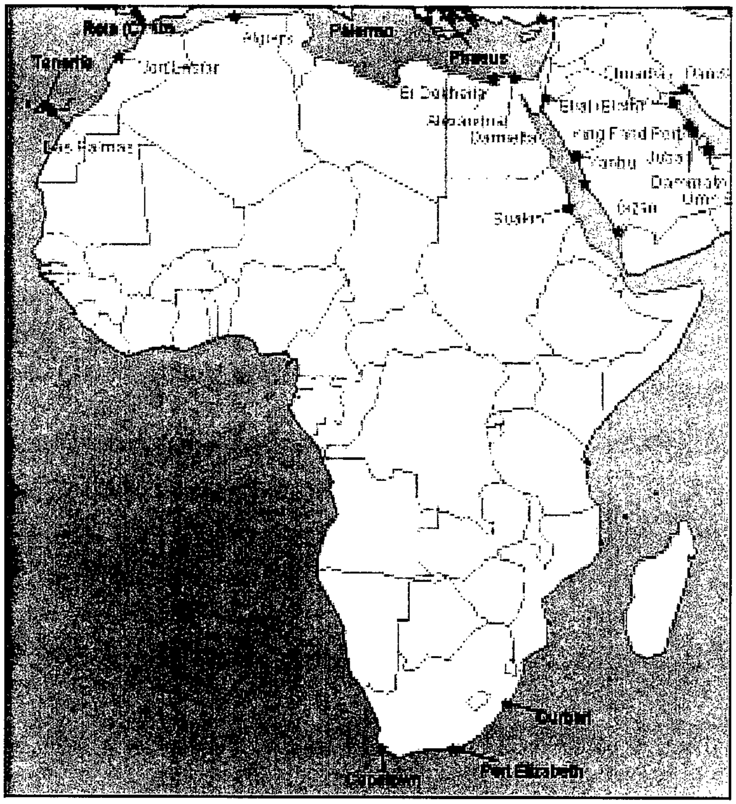
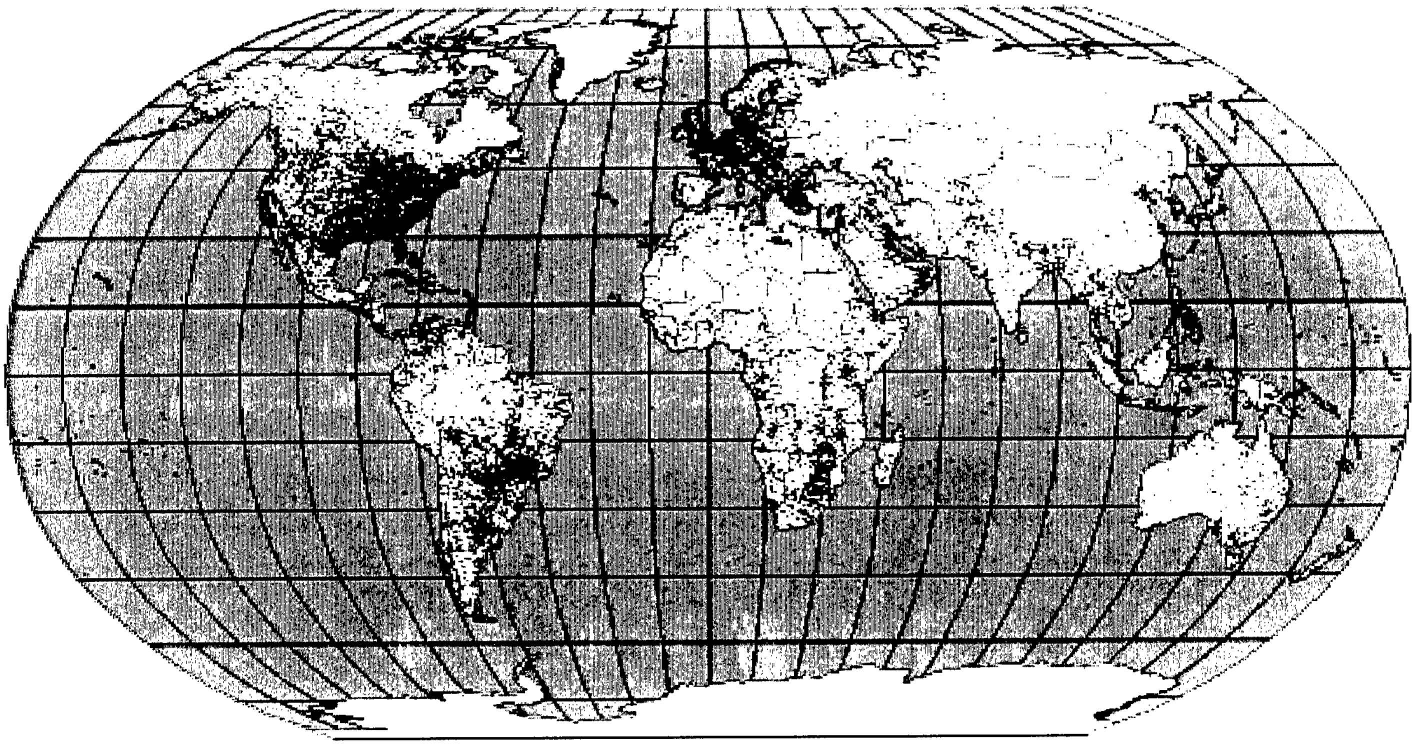


Figure 8. Ports in Africa Suitable for LMSRs

Even where ports are unavailable for large force deployments, U.S. troops can be inserted if there are adequate bases for strategic (C-17, C-5) and tactical (C-130) airlift. Airfield access by C-17s and C-130s is considerably easier than port access, since the criteria are simpler. Figure 9 shows all the airfields in the world that are accessible by C-17s and C-130s (black) as well as those accessible only by C-130s (red). These fields are 3,000 feet or longer. The absence of identified airfields in Russia and China reflects lack of data rather than lack of airfields. Of particular significance is that the areas without deep water ports in South America and non-Sahara Africa do have airfields nearby that can accommodate C-17s. Thus, even though no ports exist for deploying large LMSRs in these regions, smaller units could be delivered directly to the land instead. This weakens the argument for the uniqueness of the MOB for deploying small units where no other alternatives exist.



Source: Boeing Corporation.

Figure 9. Airfields Suitable for C-17 and C-130 Operations

C. MOB UTILITY ASSESSMENT

In this section we consider the fully connected 5,000-foot-long MOB needed to operate CTOL aircraft such as the C-17, C-130, and some strike aircraft. As noted earlier, if C-17 operations are required, the only alternatives in theater are land bases.

To assess the utility of the MOB, we have conducted a throughput estimate for the tonnage delivered to the theater. For this assessment we assume that the MOB is moved from its peacetime anchorage to a region located approximately 7,000 nautical miles from CONUS bases. Our analysis is designed to be generic, but this could put the MOB in the Sea of Japan (if Japanese bases are denied) or in the Indian Ocean in the vicinity of the Pakistan-India border, for example. If it were supporting operations in SWA, it would also likely operate outside the Persian Gulf, so this position could also represent a location supporting SWA operations.[2] The distances would also be representative of those required to support military actions in Africa. Since South America is much closer, the MOB would be closer and could perform better there than we assume for these generic cases.

Figure 10 illustrates the range of operations that a MOB might support. It receives cargo and personnel via strategic aircraft or large ocean-going surface ships and sends these forward into the land via other short-range aircraft and surface ships. While aboard the MOB, the cargo is allotted spaces for storage, maintenance, and repair and the personnel have spaces for billeting, recreation, and medical services. In short, the MOB is a floating base.

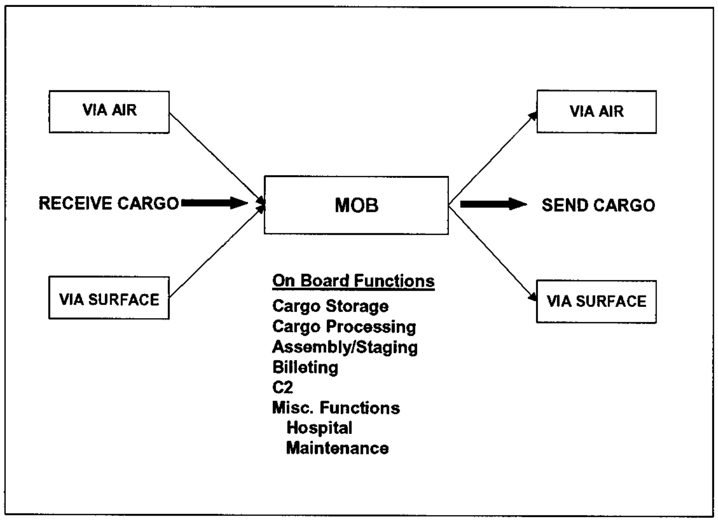


Figure 10. Schematic of MOB Logistics Operations

Strategic air (C-17) can deliver directly to the MOB in its operating location, anywhere in the world. Figure 11 illustrates a possible route for C-17s flying from the

---

2 Its presence inside the Gulf during peacetime could pose legal law-of-the-sea issues, according to a point paper provided by the CENTCOM Judge Advocate General. The size and draft compel the MOB to operate in the middle of the Gulf. Its legal status depends on how the MOB structure is interpreted in international courts. If considered to be a ship, issues surrounding interference with free passage of other ships could be raised. If considered to be an installation, economic zone permission would be needed from all countries bordering the Persian Gulf to permit it to operate within 200 nautical miles from the shore. The United States could contest these issues, but they would need to be addressed before the use of the MOB in confined waters could be allowed.

west coast of CONUS to a MOB operating area in the Sea of Japan. The flight could stop for fuel en route to the MOB at Hickham AFB in Hawaii, then on to Guam for a second refueling before flying directly to the MOB. The C-17 return route can bypass Hickham, since there would be little if any retrograde cargo, so additional fuel could be carried on a lighter aircraft. Japan permits overflight in this figure. If that were not granted, the air routes would have to overfly parts of South Korea instead, but this would not add significantly to the total distances and times required.

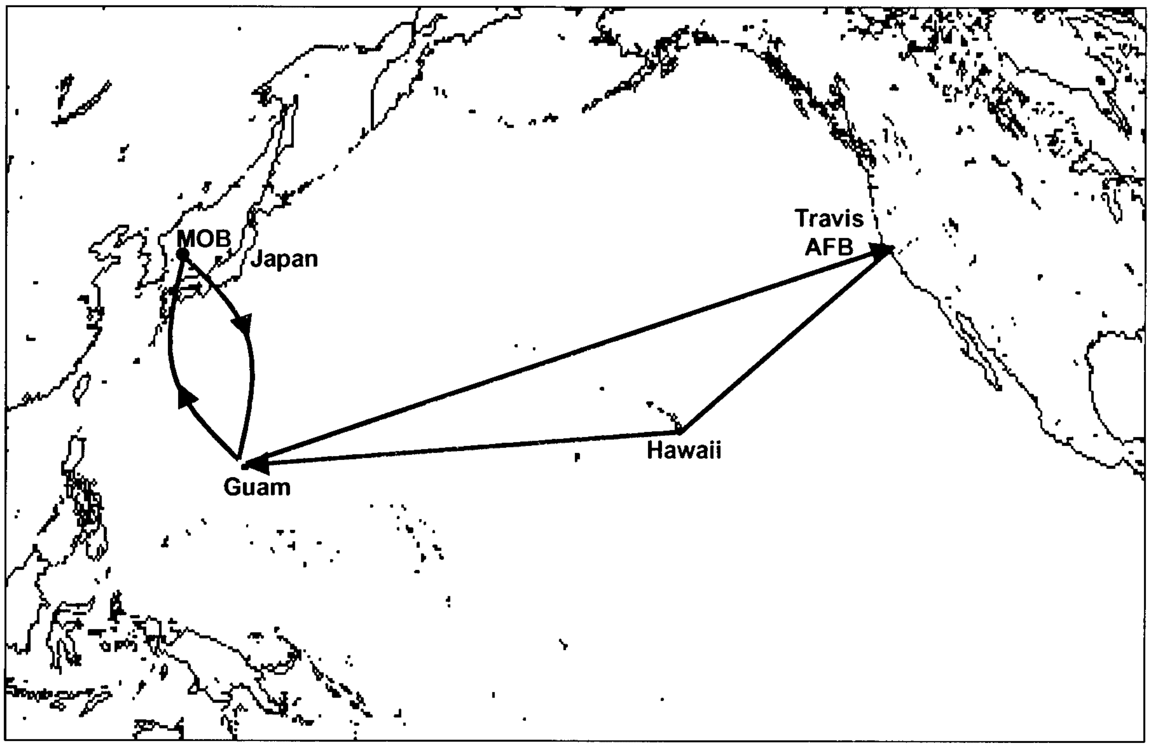


Figure 11. Illustrative Strategic Airlift Mission to a MOB in Sea of Japan

1. Transit Times to Crisis Locations Worldwide

The MOB moves at about one-half the speed of conventional monohull ships such as the LMSR. For this reason, more than one MOB fleet of five or so SBUs would possibly be needed to ensure timely response globally to crises. If the DoD 2020 planning scenario continues to include two nearly concurrent crises, at least two fleets would probably be needed, with a third serving as a backup. To illustrate that point, we have estimated the time required for a MOB to respond from pre-selected operating areas to a crisis at selected geographical locations.

At a speed of advance of 12 knots (average), the MOB can be present and ready for operations in the areas in Table 3 if three MOB units are stationed during peacetime at Diego Garcia, near Hawaii, and in the Central Mediterranean Sea. The total time involves one day to prepare for movement, transit time, and one day in theater to assemble SBUs into the MOB. Such far-separated initial locations provide sheltered secure areas during peacetime and the ability to meet global crises.

Table 3. Transit Times for Three-MOB Fleet

MOB Location	Destination	Distance (nmi)	Total Time (days)
Diego Garcia	Persian Gulf	2,500	11
	East Coast Africa	2,500	11
	West Coast Africa	5,500	21
Hawaii	Korea	4,000	16
	West Coast South America	5,000	19
Central Mediterranean	Eastern Mediterranean	1,000	5
	East Coast South America	6,000	23
	West Coast Africa	5,000	19

As Table 3 shows, transit and set-up times can vary from nearly 1 week (repositioning within the Mediterranean) to 3 weeks or more. The chart in Table 3 assumes a three-MOB fleet, with a total of 15 SBUs (5 at each of the three locations). For a single-MOB fleet, the issue is where to locate it during peacetime so it can respond in a timely way during crises.

If there were only a single MOB fleet, located in Diego Garcia, the longest transit times would be to the West Coast of South America (10,000 nmi and 37 days) and to the Eastern Mediterranean Sea (10,500 nmi and 38 days). Thus, more than a single MOB fleet appears warranted to eliminate delays of a month or more.

2. Impact of Sea State on MOB Operations

Even though the semi-submersible twin hull design of the MOB confers considerable motion control, the MOB does not operate alone. It operates with other assets that may lack this capability: aircraft and ships. Here we explore the limitations imposed on the MOB by these other assets.

a. Air Operations

The MOB design goal is to conduct air operations up to SS 6 in a 40-knot wind. Under these assumptions, this would allow air operations 92 percent of the time in the open ocean and essentially 100 percent of the time in sheltered waters, such as the Sea of Japan. As a strike platform, the MOB would be expected to be able to conduct its missions virtually all of the time.

As a logistics sea base, the MOB would first transit as separate SBUs, then assemble itself into a connected MOB to receive airlifters from CONUS or other bases. Airlift arrivals to a MOB positioned at intercontinental distances from CONUS will primarily consist of C-17 strategic airlift carrying time-critical cargo and passengers (PAX) to link up with any unit equipment prepositioned on the MOB. At the current time, other strategic airlifters such as the C-5, and commercial cargo aircraft such as the Boeing 747-400F, require runways significantly longer than the 5,000 feet available on the MOB. Smaller airlifters such as the C-130 are inefficient for carrying cargo transoceanic distances, although future versions might have a limited version of that capability. For example, concept aircraft (e.g., Boeing's ATT) might have a limited transoceanic capability for carrying large (outsize and oversize) cargo. However, these aircraft are not part of current plans for the future airlift force, and even if developed and procured, would be in high demand for their primary role of intratheater transport, perhaps even as MOB-to-shore carriers. Our analysis will focus on C-17 operations as by far the most likely means for moving time- critical strategic cargo and passengers to a MOB.

b. Sea Operations

The impact of weather conditions on cargo transfer operations at sea is much greater than for air operations. The MOB design goal is to provide cargo transfer from ships alongside and to lighterage through SS 3. This limits cargo transfers to 27 percent of the time in open ocean regions and 50 percent of the time in more sheltered waters. The MOB is relatively stable during high sea states, but the receiving/discharging ship alongside is not. The relative sea motions of the two ships, not the stability of the MOB alone, determine the upper limit of sea conditions for cargo transfer operations. It is possible that transfer between a large monohull ship and the MOB could be conducted even in SS 4. However, the MOB would be unable to transfer cargo to lighterage under these same conditions. Lighterage also cannot operate under SS 4 conditions, even if cargo could be transferred.

The JLOTS alternative to the MOB is more limited. It currently can conduct cargo transfers through SS 2. However, there are R&D efforts underway to develop both a computer-controlled SS 3 crane and a SS 3-capable lighterage system by 2005. The lighterage system is called the Joint Modular Lighterage System (JMLS). This system will replace the Navy's SS 2 limited powered and non-powered causeway sections, called collectively Navy Lighterage (NL). The current NLs are 21 feet wide and 5 feet high. The JMLS sections are projected to be 24 feet wide and 8 feet high. JLOTS augmented with this new cargo handling equipment will be able to handle cargo transfers under the same useable sea conditions as the MOB. In fact, since JLOTS operates closer to the shore in more protected waters, it is likely to encounter lower sea states anyway. Sea states of SS 3 or lower in littoral waters have been observed to occur from 70 to 90 percent of the time.[3,4]

For the MOB to take full advantage of its stability relative to JLOTS operations there would need to be a mechanism for protecting ships alongside from the ambient environmental conditions. The use of the MOB itself to provide a lee side does not appear feasible, since the MOB stability derives from the relative isolation of the MOB from the sea conditions. The MOB could add deployable shields inserted into the water to protect the craft transferring cargo to or from the MOB. Alternatively, the MOB design could incorporate a dock lowered by the MOB into which a ship sails. The dock would then be raised from the sea surface, thereby aligning the relative motions of the MOB and the cargo ship for transfer operations. Once transfer is complete, the ship

---

3 "Joint Logistics Over the Shore Operations in Rough Seas," T.G. Vaughters and M.F. Mardiros, Naval Surface Weapons Center Carderock Division, *Naval Engineers Journal*, May 1997.

4 *The Navy and Marine Corps in Regional Conflict in the 21st Century*, Naval Studies Board, 1996.

would be lowered back onto the surface of the sea for movement onward. While this mechanism can help the MOB receive cargo during high sea states, it does not help in moving cargo ashore. Lighterage needed for that movement could not operate in sea conditions exceeding SS 3.

3. Threats & Vulnerability

Several studies were initiated in the late 1990s at the Naval Surface Weapons Center (NSWC), Carderock Division, on the vulnerability of the MOB to weapon effects. At the time of this writing they have not been completed. Because there is no planned funding for MOB R&D in the future, these studies are unlikely to be finished. Nonetheless, the IDA study team had an opportunity to discuss MOB vulnerability with personnel from the Survivability and Weapons Effect Department at NSWC who worked on the vulnerability assessments. These expert assessments combined with our own computations serve as our threat and vulnerability assessment.

The MOB is a naval vessel and therefore subject to the same threats to which any large naval vessel would be exposed. Its large size is both an advantage and a liability. Because the MOB structure is so large, single hits by conventional warhead munitions are not likely to cause serious damage to mobility and stability.[5] Only a lucky missile hit in the ordnance storage areas could possibly cause serious damage. These can be anticipated and the effects minimized by appropriate damage isolation designs.

For underwater threats, the MOB would probably operate sufficiently far from the shore that it may be outside any expected minefields. Ships approaching ports and running onto the beaches are at greater risk from shallow water mines. Torpedoes could also pose a serious threat, if they entered submerged parts of the MOB that are already partially filled with air for boyancy. Detonations in those regions would probably not seriously impair MOB operations unless propulsion systems were damaged or sufficient water was taken on to cause listing. Experience shows that even detonations in spaces carrying fuel would not be expected to cause serious collateral damage.

On the liability side, the MOB will be a high value unambiguous target. Crippling it in some fashion will be a high priority. There is no need for sophisticated

---

5 Interview with David Wilson, Survivability and Weapon Effects Department, Naval Surface Weapons Center, Carderock, Maryland, October 9, 2000.

seeker discrimination techniques to pick the MOB out from a background of other ships. It will be the largest object in the field of view. Its position is likely to be monitored continuously by overhead systems available even today, not to mention those available to nearly any adversary in 2020. Naval combatants will be needed to provide air, surface, and subsurface defenses both in transit and once the MOB arrives in theater. Once hit, despite the unlikely event of catastrophic damage to the ship itself, air operations could be curtailed if there is damage to the runway surfaces, air traffic communications systems topside, or to the connectors holding separate modules together. Likewise, damage from missile hits on cargo handling systems or ships alongside could curtail sea operations.

We analyze the threat in terms of missile attacks, both ballistic and cruise anti-ship missiles. First we assess how likely it would be that an attack of these kinds against the MOB would succeed in hitting at least one place on the deck or side. Then we assess how a hit translates into damage to air and MOB-to-ship (or vice versa) cargo operations. To obtain an estimate of the susceptibility of the MOB to a ballistic missile attack, we modeled the MOB as a planar target as shown in Figure 12, where L is the length (5,000 feet) and W is the width (500 feet) of the MOB, which is centered at the origin (0,0). We then calculated the probability of the MOB being hit by a ballistic missile. The model assumes that the MOB is within range of the missile, and that the location of the MOB is predictable (within targeting errors) by overhead or other sensors. In addition, for a ballistic missile attack, there is also a dispersion error in the ballistic warhead.

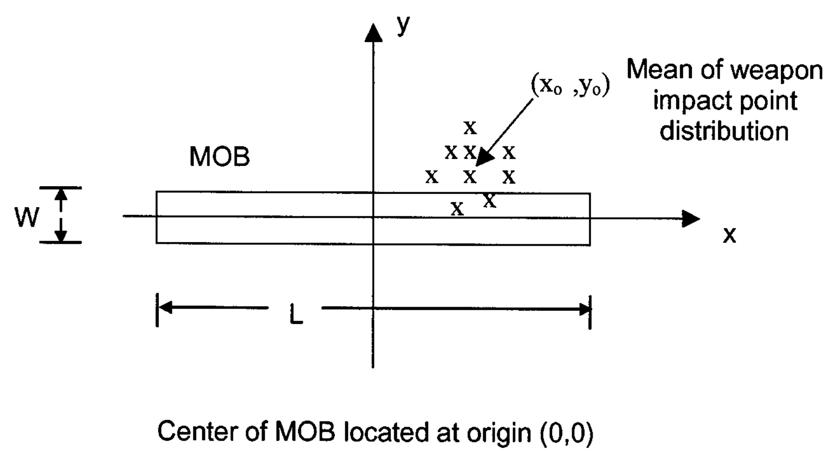


Figure 12. Model Used To Calculate Probability of Hitting MOB with a Ballistic Missile

We model the probability of hitting the MOB with a single ballistic missile armed with a unitary warhead by integrating a bivariate normal probability density function over the surface of the MOB, representing both targeting errors and missile circular error probable (CEP) values.

Figure 13 shows the probability of a ballistic mission hitting the MOB as a function of the missile and targeting CEPs. For example, a missile with 100-meter (m) targeting error and 100-m CEP has a 50 percent probability of hitting the MOB somewhere. The characteristics and numbers of future threat systems are described in detail in the classified annex to this report. In general, the high likelihood of a hit demands an escort of missile defense cruisers or destroyers, and possibly a terminal self-defense system aboard the MOB.

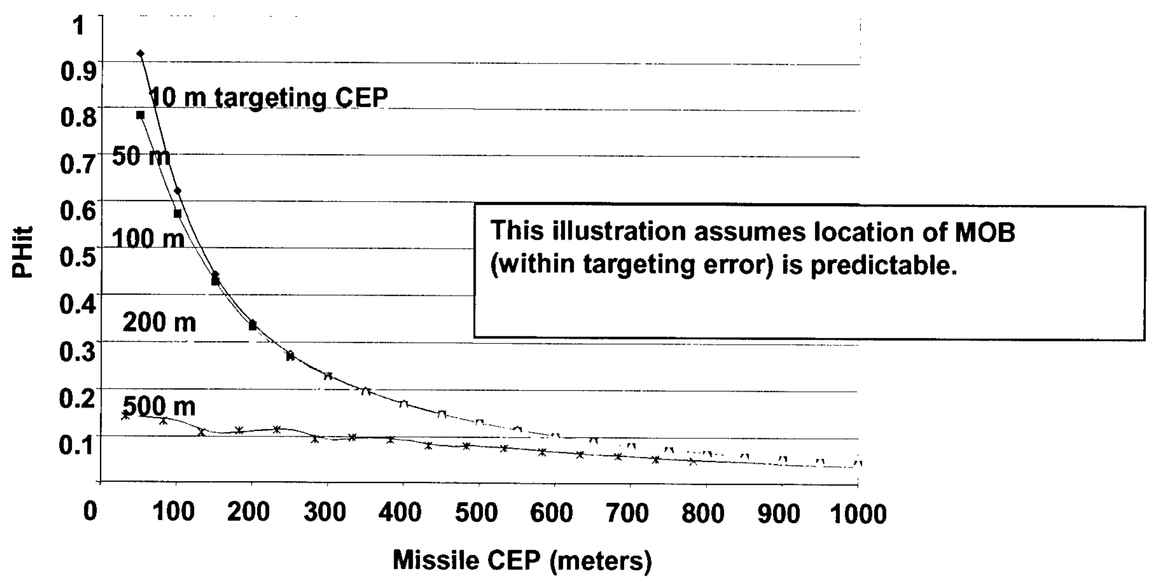


Figure 13. Probability of a Ballistic Missile Hitting the MOB

Future ballistic missiles may proliferate submunition warheads to ensure a wider coverage of area military targets, such as airbases and port complexes. Such warheads also pose a greater defense problem for the defender, who must now attempt to engage the booster or post-boost vehicle in mid-flight before it dispenses submunitions. We examined the probability of at least one submunition from such a ballistic missile hitting the MOB. Figure 14 shows the probability of at least one submunition out of 25 (the number is illustrative, many more might be technically feasible) hitting the MOB as a function of the missile and targeting CEPs. Thus, in this scenario, at least one submunition out of 25 would be almost assured of hitting the MOB, even for poorly aimed and low accuracy weapons available today. The shotgun approach would succeed in scoring at least one hit. Although each submunition would be smaller than a unitary missile warhead, it could do enough damage topside to interrupt air operations for a time.

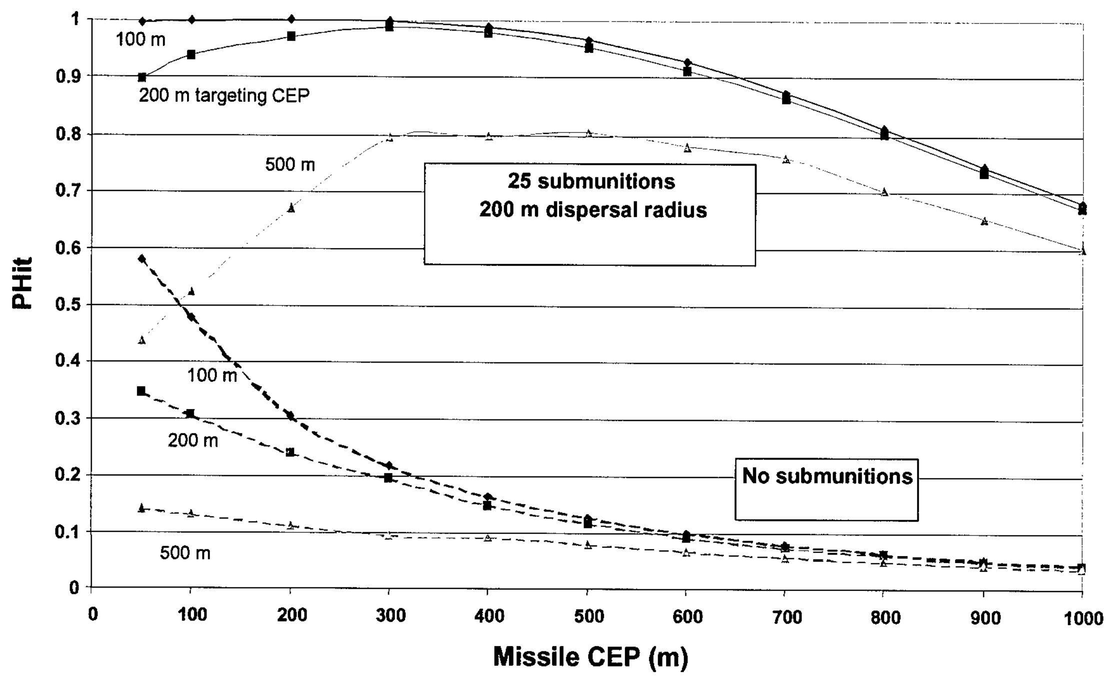


Figure 14. Probability of at Least One TBM Submunition Hitting MOB

Anti-ship cruise missiles (ASCMs) are assumed to unerringly pick out the MOB from preprogrammed targeting and search criteria and, in the absence of defenses, hit it.

To estimate the probability that either ballistic missile or cruise missile hits would still allow the MOB to function, we first estimate how likely the MOB is to sustain hits, and then estimate how long repairs take to restore operating capability. The analysis in Chapter IV of this report calculates the probability of the MOB being in a functioning state when hit at a rate R_H (including assumed defenses provided by Aegis escort ships) while being repaired at a rate R_R. It is given by the formula

$$P_f = \frac{1}{\sum_{missile} \frac{R_H}{R_R} + 1}$$

where the values assumed are discussed in that part of the report.

Table 4 summarizes values for the probability that the MOB is functioning under different assumptions about (1) the intensity of missile attacks against the MOB, and (2) the effectiveness of area defenses in protecting the MOB. With no attacks (or perfect defenses), the air operations and sea transfer operations are 100 percent. For the modestly favorable case shown, in which there is one unitary theater ballistic missile (TBM) and one submunition TBM fired per day along with one ASCM, and for which the defenses are assumed to provide a 90 percent effective shield, the MOB would be functioning nearly 100 percent of the time. One the other hand, in the nominal poorer case (10 unitary TBM shots/day, 10 submunition TBM shots/day, and 10 ASCM attacks/day, with defense effectiveness at $P_{Intercept} = 0.75$), the MOB would be functioning about three-quarters of the time for air operations and about one-half of the time for sea operations.

Table 4. Probability that the MOB Is Functioning and Available for Operations During Attacks

Operation	R_H (/day)			R_R (/day)			P_f
	Ballistic	Submun.	Cruise	Ballistic	Submun.	Cruise	
Air	0.003 - 0.075	0.02 – 0.48	0.02 – 0.50	2	5	2	0.72 – 0.98
Sea			0.05 – 1.25				0.57 – 0.97

4. Availability

Table 5 gives the probability of sea state occurrence in open ocean. From this we can estimate that, in open ocean, MOB air operations would be available 92 percent of the time and MOB sea operations would be available 27 percent of the time. Given that open ocean conditions are among the most severe, these availabilities fall toward the lower end of the range of availabilities for MOB operations. Alternatively, the upper end of the range is represented by the fraction of time that MOB operations could take place in more sheltered waters. For example, the probability of sea state occurrence in the Sea of Japan would allow for air operations to be available 100 percent of the time and sea operations 50 percent of the time. Note that although air and sea operations may be *available* for a certain fraction of time, this does not imply that they necessarily could be operating at full *capacity* throughout the time that they are available. For example, throughput is likely to decline as sea state increases.

Table 5. Probability of Sea State Occurrence
Open Ocean (Average for North Atlantic and North Pacific)

Sea State	Significant Wave Height (m)		Probability (%)
	Range	Mean	
0 –1	0.0 - 0.1	0.05	1.0
2	0.1 - 0.5	0.3	6.6
3	0.5 - 1.25	0.88	19.6
4	1.25 – 2.5	1.88	29.7
5	2.5 – 4	3.25	20.8
6	4 – 6	5.0	14.1
7	6 – 9	7.5	6.8
8	9 – 14	11.5	1.3

Source: *Preliminary MOB Classification Guide*, American Bureau of Shipping, December 1999.

A more comprehensive listing of sea state conditions in geographically diverse regions during each month of the year can be found in Chapter IV.

The availability of MOB air and sea operations, that is, the fraction of time that these operations could take place, is dependent not only on sea state and weather conditions, but on levels of damage sustained by enemy attacks against the MOB. Both are important to MOB utility in a contested theater. Taking the contributions from weather and vulnerability only (other factors such as equipment reliability could also influence availability), the overall availability can be obtained as the product of weather and attack probabilities:

$$A = P_w P_f$$

where P_w is the probability of satisfactory weather, and P_f is the probability that the MOB is functioning during attacks. Using the estimates given above for the probability of satisfactory weather and the estimates given for the probability that the MOB is functioning during missile attacks, we can obtain estimates for the overall availability for air and sea operations.

5. Throughput

Throughput is a measure of logistics utility, expressed as tons of cargo or numbers of passengers per day delivered. The delivery is in two phases: (1) to the MOB from CONUS or from other overseas bases, and (2) from the MOB to shore. Throughput combines the technical capabilities of the MOB, including those of the associated aircraft and ships, with the operational impacts of weather and threat. It allows us to answer the following utility questions:

- How large a force can be inserted and how many days after alert?
- How large a force can be sustained indefinitely ashore from the MOB?

For illustration, we have selected the Army units shown in Table 6. These range in size and mass from a Separate Infantry Brigade with fewer than 4,000 personnel and weighing 8,100 short tons up to a Mechanized Division consisting of over 17,000 personnel and weighing 101,000 short tons. The Heavy Armored Cavalry Regiment and the Light Infantry Brigade lie in between. The Army is planning to develop new, lighter combat units in the future. For example, the notional future objective division will have 9,000 personnel and weigh 28,000 short tons.

Table 6. Deployment Size of Representative Army Units

	Separate Infantry Bde	Heavy Armored Cavalry Regiment	Notional Future Army Objective Div	Light Infantry Div	Mechanized Div
Footprint (sqft)	202,000	524,000	354,182	705,000	1,686,000
Weight (tons)	8,100	31,300	28,000	18,800	101,000
No. Personnel	3,902	4,555	9,000	11,520	17,407

a. Deployment

The rates of movement from the MOB to ashore locations depend on the aircraft and seacraft used. Characteristics of aircraft, both current as well as those proposed for future acquisition, are summarized in Table 7.

Table 7. Summary of Aircraft Characteristics

	Current Aircraft					Proposed Future Aircraft	
	MV-22	CH-53	CH-60	CH-47F	C-130	QTR	ATT
Speed (kts)	215	130	130	130	220	220	220
Payload (stons)	7.3	15	4.5	10	13	15	15
Radius (nmi)	520	500	110	130	1,500	1,000	1,200
Approx. Inventory	360	172	Many	300-480	500	--	--

Characteristics of surface craft that would be used to transport cargo ashore from the MOB are summarized in Table 8.

Table 8. Summary of Surface Craft Characteristics

	LCAC	LCM-8	LCU-1600	LCU-2000
Displacement (Lt, tons)	99	67	191	550
Speed (kts)	40	12	11	11
Payload (stons)	60	65	160	350
Operating Radius (nmi)	100	140	440	4000
Approx. Inventory	91	90	49	35

Figure 15 summarizes the rate at which cargo can be delivered ashore by different air assets. The rate is a strong function of the distance the MOB operates from the objective resupply area. Where curves terminate indicates the maximum range at which that particular aircraft can operate.

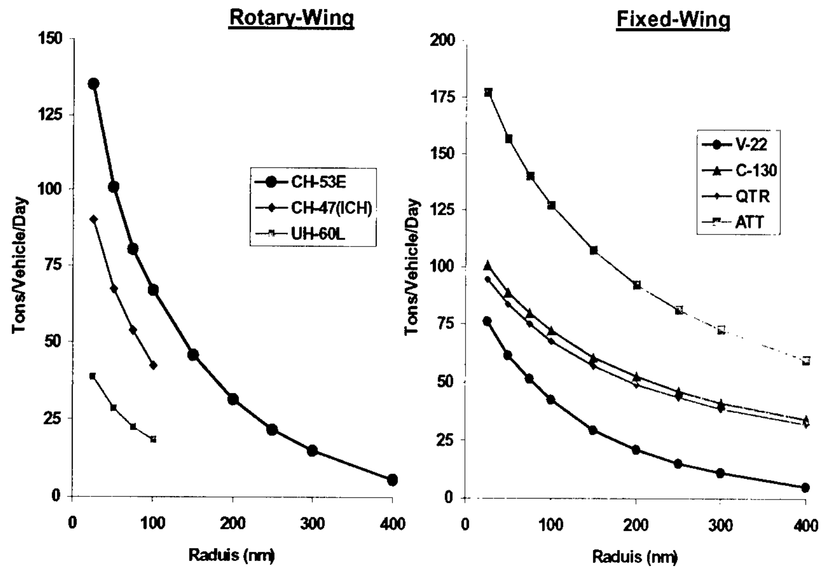


Figure 15. Rate of Air Delivery as Function of Distance of MOB from Destination

We estimate deployment times under two sets of assumptions: the units have equipment prepositioned aboard the MOB and they do not.

Figure 16 summarizes the arrival times of different Army units to the shore via the MOB located 7,000 nmi from CONUS with en route refueling stops for the C-17s. In this example, equipment is prepositioned aboard the MOB, so the rate limiting step is the arrival of troops to the MOB. The MOB is assumed to have a nominal 21-day transit to the theater (the actual time depends on relative peacetime and theater locations at which point it begins to receive troops via C-17s). The MOB operates from 50 to 100 nmi[6] off the coast and delivers all units to the beach area. Thus both tactical aircraft (assumed here to be 24 ATTs) and surface craft (assumed to be 15 LCU 1600s) can be used to move forces ashore. If units needed to move directly inland and bypass the beach, only the 24 ATTs would be used and the deployment times would grow considerably. Between 30 and 35 days are needed for a pre-deployed Heavy ACR, depending on how

---

6 A range of distances of the MOB to its destination is used for illustration purposes. In Appendix B we summarize the minimum distances the MOB would have to operate in different parts of the world. They range from a few miles offshore to over 100 miles.

far off shore the MOB operates. Lighter units deploy in shorter periods of time, as the figure shows.

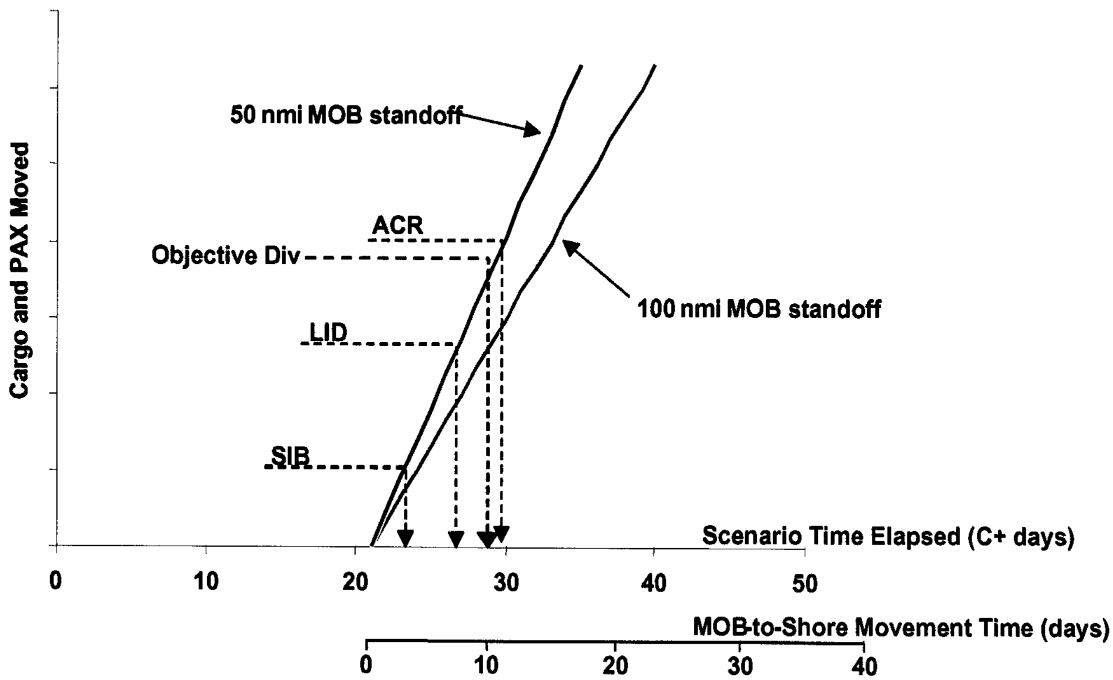


Figure 16. Unit Deployment Times if Equipment Is Prepositioned on MOB

One concept proposed for the MOB is as a logistics hub without prepositioned equipment. Its use in this manner reduces the storage costs of equipment at sea. Any units needed in a theater are moved directly and entirely first to the MOB, then to the shore. To illustrate the consequences of this deployment concept, we show in Figure 17 the deployment times for full units transferred via C-17s to the MOB, and then via ATTs and LCUs ashore. The line marked "A" represents the delivery rate of units directly to the shore as soon as they arrive on the MOB, in stream. The lines marked "B" and "C" indicate the delivery rates of cargo and equipment that first must close on the MOB before moving ashore. Line "B" represents the rate of delivery if the MOB is 50 nmi off shore; line "C" represents the same for a MOB at 100 nmi. Thus a LID with 11,520 personnel requires from 39 to 48 days to be deployed via the MOB in this manner. If the ACR has to arrive at the MOB via C-17s, up to 60 days are needed.

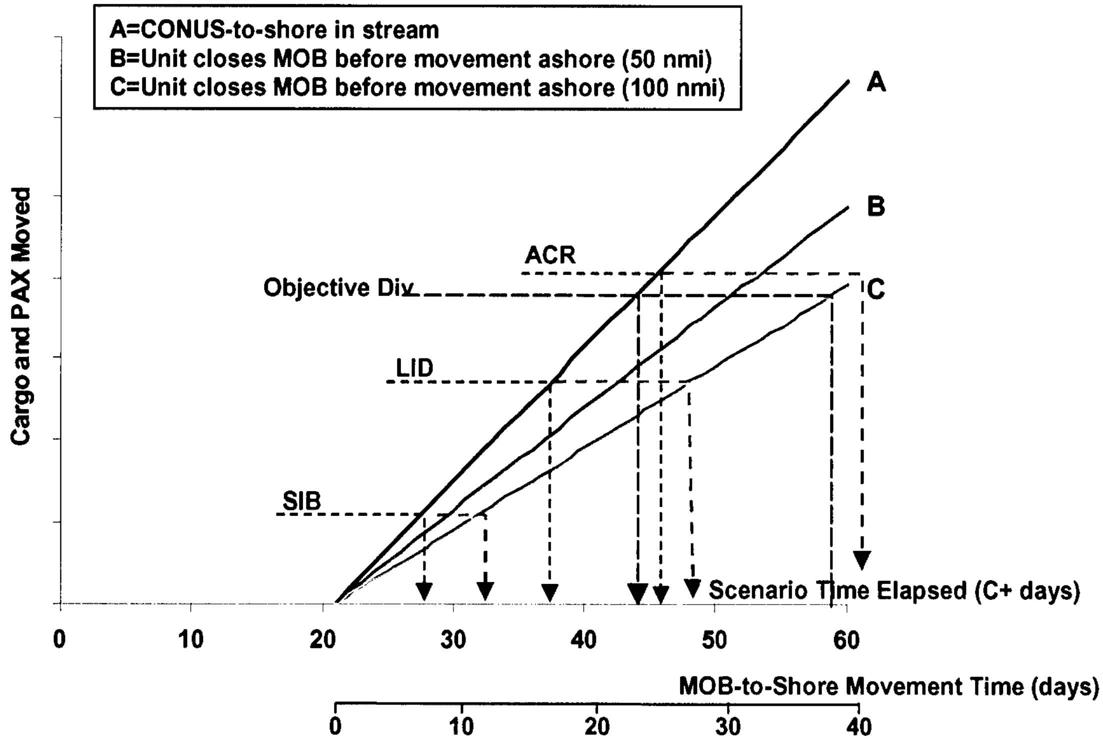


Figure 17. Unit Deployment Times via C-17 via MOB to Theater

b. Sustainment

Table 9 summarizes how many tons per day of cargo are needed to sustain different military units.

Table 9. Short Tons Required per Day To Sustain Selected Units

	Separate INF BDE	Heavy ACR	Light INF Division	Mech. Division
POL	97	632	440	1708
Ammo	78	288	270	1462
End Items	6	19	12	62
Misc. Bulk	157	189	478	693
Total	338	1128	1200	3925

Figure 18 shows how different sized units can be sustained from a MOB. As the analyses show, once the forces are ashore, even relatively large units such as a light infantry division can be sustained if they operate within about 200 nmi of the MOB. This is true even if the MOB is not 100 percent available every day. A 66 percent availability is shown for reference in the figure. For this illustration we assume the troops are well inland and need air-resupply.

An important caveat is that maintaining troops ashore requires continuous and assured resupply. We have been treating the problem in terms of average availability. In fact, on some days there will be perfect availability and on others, none. Thus, units ashore need to be supplied initially with adequate supplies to ensure that they can go several days without resupply if conditions force it.

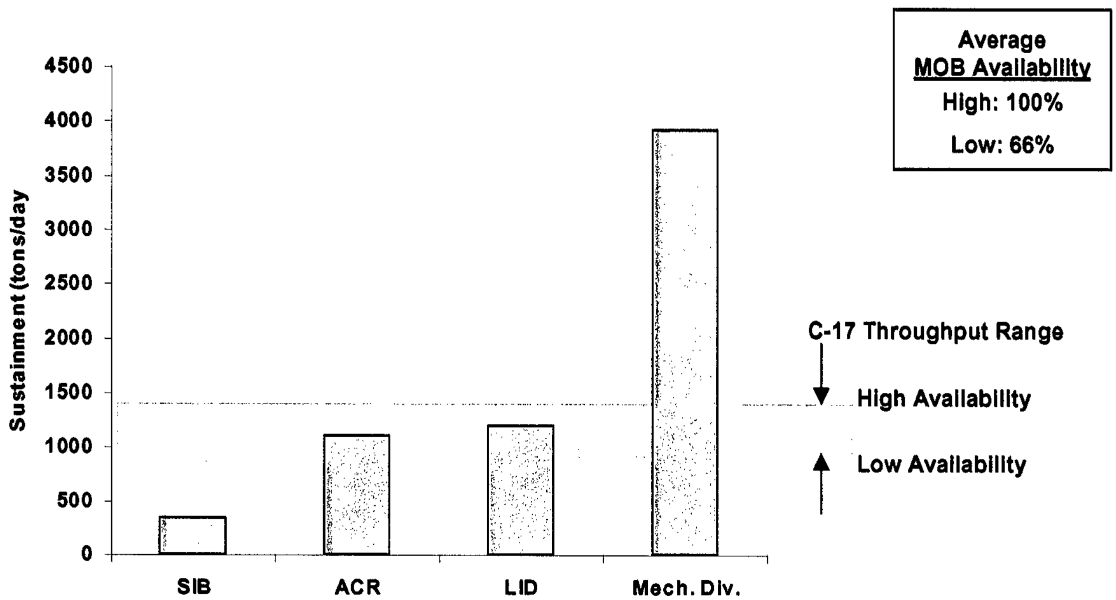


Figure 18. Unit Sustainment of Selected Units

The MOB can deliver and sustain U.S. military forces that consume less than about 1,200 short tons of commodities per day. This could be an ACR or LID or other units of the future with comparable demands. This sustainment from the MOB might be marginal for the notional objective division if it consumes much more than 1,200 short tons per day. The troop size would vary with the unit mission, but force levels between 4,500 and 12,000 troops appear to be sustainable. To assess how well these troops would fare in combat in selected scenarios is beyond the scope of this report, but we have assembled a list of possible conflict countries along with the opposition force levels that could be encountered.

In Table 10, we summarize the army force levels of 19 countries in Asia, the Middle East, and sub-Saharan Africa. The list includes all the countries in these areas that have been determined by the United States to support terrorism or terrorist organizations or to harbor terrorists or terrorist organizations. The State Department list of such countries consists of Cuba, Iran, Iraq, Libya, North Korea, Sudan, and Syria. We have also included Ethiopia and Eritrea because of the ongoing war, India and Pakistan because of the ongoing tensions between these two countries, and the Peoples Republic of China because of the tensions over Taiwan. Finally, we have included all non-landlocked countries with standing armies of over 10,000 that are experiencing ongoing civil wars and/or recent civil unrest. This category includes Angola, Indonesia, Myanmar/Burma, Nigeria, Russia, Senegal, Sri-Lanka, and the Sudan.

All countries not in Table 10 either are friendly, have no civil or military conflict, are land-locked, or have armies with fewer than 10,000 troops.

Table 10. Military Force Levels

Region	Country	Army	Armd	Infantry	Arty	Misc.
Middle East	Iran	350,000	4 div	6 div	5 grps	1 AB bde,1 cdo div,1 SF div, 1 AB bde Army avn
	Iraq	375,000	3 div 2 RG div	13 div 1 RG div		7 cdo bde, 2 SF bde, 6 mech inf div, 4 repub guard bde, 3 mech div 3 RG mech div
	Libya	35,000	10 bn	21 bn	22bn	15 cdo bn, 8 AD bn, 8 mech inf div,
	Syria	215,000	7 div 1 tk regt	4 bde	2 bde	3 mech div, 1 Republican Guard, 1SF div,1 border guard bde,2 ATK bde 9 SF regt, 3 SSM bde, 1 cstal def bde
Asia	China	1,830,000	10 div 12 bde	44 div 13 bde	5 div 20 bde	7 hel regt, 13 inf bde
	India	980,000	59 bn	319 bn	190 bn	8 AB bn, 3 cdo bn, 2 SAM gp, 15 SAM regt., 25 mech inf bn, 14 hel sqn
	Indonesia	230,000	2 bn	3 bde	6 bn	3 AB bde, 2 engr bn, 1 AD regt 1 helo sqn
	Myanmar	325,000	4 bn	245 bn	7 bn	2 AA arty bn

Table 10. (Continued)

Region	Country	Army	Armd	Infantry	Arty	Misc.
Asia	North Korea	950,000	15 bde	27 div	35 bde	2 AB bde,1 AB bn,9 MRL bde
				14 bde		17 recce, 8 recce bn, ,12 lt inf bde
						6 hy arty bde, 1SCUD bde, 1SSM regt
	Pakistan	520,000	2 div	19 div	9 bde	3 SF bn, 7 engr bde, 1 area comd,
			7 bde	9 bde		3 recce regt., 1 AD comd
	Russia	348,000	6 TD div	20 MRD	4 MG/arty div	4 AB div, 11 MR bde, 1 tk bde
					4 arty bde	2 AB bde, 7 SF bde, 9 ATK bde
						21 hel regt, 21 SAM bde
						32 ATK arty bde, 13 SSM bde
	Sri Lanka	95,000	1 regt.	10 div	4 actv	1 mech inf div, 4 fd eng regt,1 SF bde
				23 bde	1 res	1 air mobile bde, 3 armd recce
Sub-Saharan Africa	Angola	100,000				35 armd+ inf -str vary
	Ethiopia	350,000		6 div		3 mech bde, reserve div of 6 bde
	Eritrea	180,000		4 div		1 cdo div
	Nigeria	79,000	2 bde			1mot inf bn,1amph bn,1AB bn,1AB bde
						2 mech div, 1 Presidential Guard,
	Senegal	10,000	4 bn	6 bn	1 bn	1 engr bn, 1 cdo bn, 1 AB bn
	Sudan	90,000	1 div	6 div	10 bde	1 mech inf bde, 1 AB div
				24 bde	3 regt	1 recce bde, 1 engr div, 1 border gd div

Source: *Military Balance 2000*, Institute for Strategic Studies, London.

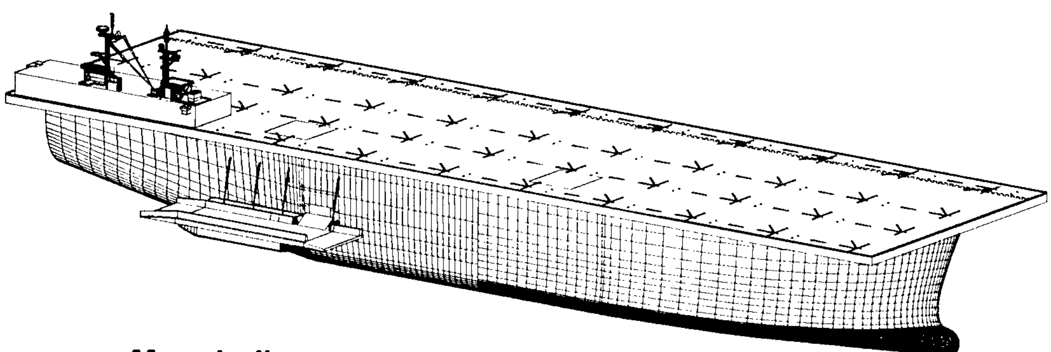
Abbreviations:

AB – airborne; actv – active; AD - air defense; amph – amphibious; arty – artillery; ATK - anti-tank; avn – aviation; bde- brigade; bn- battalion; cdo- commando; div – division; engr – engineer; fd – field; gd – guard; hel – helicopter; hy – heavy; mech – mechanized; mot – mortar; MRD - motor rifle div; MRL- multiple rocket launcher; recce – reconnaissance; regt –regiment; res – reserve; RG - Republican Guard; SAM – surface-to-air missile; SF - Special Forces; spt – support; SSM – surface-to-surface missile; str – strength; tk – tank.

D. SBU UTILITY ASSESSMENT

In this section we examine the utility of single MOB modules. If C-17 operations are required to and from the MOB, the SBUs must be connected to provide a continuous 5,000-foot runway. On the other hand, if short take-off and landing aircraft can be used instead or if the movement of cargo onto the MOB can be handled by ship-to-MOB operations, then single SBUs can operate independently and need not connect into a MOB. There are many alternatives to the single modules, but we consider one here to make a comparison.

A monohull of 1,200-foot length, 370-foot beam and 40-foot draft was designed several years ago as an alternative to the SBU module. It has the same size runway deck and the same storage room for cargo and troops. It is a monohull design and is therefore somewhat more susceptible to rolling in high sea states than is the MOB. A picture of the conceptual monohull is in Figure 19. The dimensions of other large naval vessels (LMSR and CVN) are shown for comparison.



	Monohull Ship	LMSR	CVN
Length (ft)	1,200	970	1,100
Beam (ft)	370	150	134
Draft (ft)	40	34	35

Design: Band, Lavis & Associates

Figure 19. Notional Monohull Ship Alternative to MOB for Sea Base

The monohull is shown in Figure 20 side-by-side with a fully connected MOB (a 6-SBU one in this particular Band, Lavis and Associates drawing).

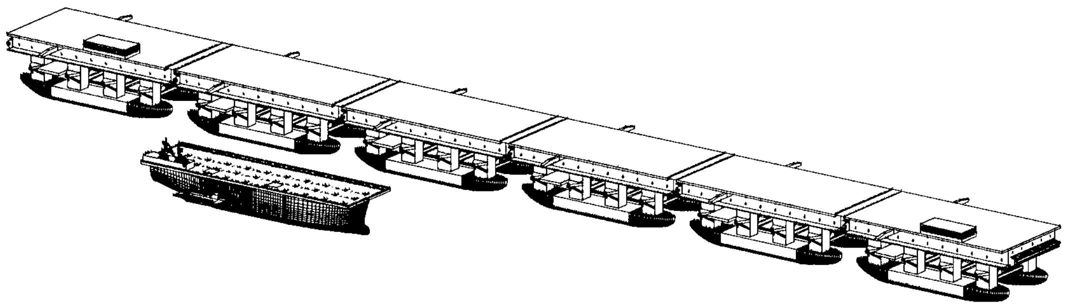


Figure 20. Relative Size of Monohull Sea Base and a 6-SBU MOB

The concepts of operations for the monohull would be similar to those for the MOB module, but their different capabilities allow some differences. The SBU would receive all troops and cargo from ships or boats and from short takeoff and landing (STOL) or vertical takeoff and landing (VTOL) craft. The monohull could receive the same forces in the same way or could pick up forces en route at a deep-water port. The SBU can possibly go into the port if it is not ballasted down and if the width permits, but it would tower above the pier and not be able to discharge cargo in a rapid fashion. For all practical purposes, the MOB or any of its SBUs would not go into ports.

The throughput ashore, either deploying forces or sustaining them, would be the same for the MOB and monohull, provided both operate from the same distances off shore. The monohull can approach closer (shallower draft) and even use JLOTS or deliver directly to pier-side if the ports permit. The MOB must stay in waters exceeding 130 feet. If the monohull can operate close to the shore, it can deliver faster than the MOB, since the aircraft and LCU turnaround times are shorter if the transit time is shorter.

The MOB is more stable than any monohull. If the research program into automated cranes provides benefits desired (SS 3 transfer operations), then the additional stability provides no additional military utility. The lighterage still is restricted to SS 3 and below.

The monohull sea base has already found support in the USMC Concept of the Maritime Prepositioning Force-Future (MPF-F). The MPF-F concept, initially designated as MPF 2010 and beyond, was first articulated during the Marine Corps MPF 2010 and Beyond Required Operational Capabilities Project and was further refined in a top-level concept paper developed by the Commanding General, Marine Corps Combat Development Command (MCCDC) and promulgated by the Commandant of the Marine Corps.

The current MPF is a deployment option that allows a Marine Expeditionary Brigade (MEB), including a ground combat element (GCE), aviation combat element (ACE), command element (CE), and combat service support element (CSSE), to be rapidly deployed by air and united with prepositioned stocks of equipment and supplies stored in ships located in either of three forward theaters. The ships offload their stored equipment and supplies at an available port, or in-stream using organic lighterage. These ships are designed for point-to-point delivery of administratively loaded containers and rolling stock. A large area on the beach is required to unload containers and associate the correct equipment and supplies with each unit. This process takes about 10 days in a benign environment before the MPF Marine Air Ground Task Force (MAGTF), a force of 17,000 Marines, is combat ready.

The goal of MPF-F is to provide a sea base from which combat-ready Marines can be deployed and sustained, thereby eliminating the need for host nation support facilities. The MPF-F ships will require capabilities that are not on the current ships, like accommodations for embarked Marines, assembly and staging areas, and facilities for command and control. Such a sea base permits Marines who deploy by the ships in an MPF-F squadron to participate in OMFTS and Ship-to-Objective Maneuver (STOM). The forces committed ashore will be resupplied from the sea base, and the sea base will be replenished by Navy combat logistics ships or commercial ships.

In 1998, the Center for Naval Analyses (CNA)[7] completed a Mission Area Analysis (MAA) on the MPF-F concept. This study bounded a wide-ranging set of requirements. The study also translated the operational requirements into technical

---

7 *MAA for MPF Future Sea-Basing Concepts: Volume I, Final Summary Report*, Center for Naval Analyses Research Memorandum 98-29, Jun 1998, UNCLASSIFIED.

descriptions and identified the key cost drivers. The MAA then developed capability options that covered the range of capabilities from the lower to the upper bound. Replacement with capability similar to today's MPF squadrons is the lower bound, and a MOB represents the upper bound.

For each capability option, CNA developed a corresponding operational concept, based on capability and current MPF planning practice. They analyzed deployment time lines and sustainment for each option. The LMSR ship (T-AKR ship) design was modified to meet the low-end replacement capability. Working independently, two ship design agents developed designs for the intermediate capability options. These intermediate capabilities were achieved with large monohull ships. CNA used the McDermott MOB for the high end option. They developed measures of effectiveness and life-cycle cost estimates for each option.

The MAA found that the MPF-F sea-basing concept is technically achievable within the current state of the art, i.e. with monohull ships, and that innovative designs can reduce overall capability cost. Any amount of sea basing offers a substantial operational enhancement over the current MPF capability. The time to complete the deployment allows a 24-knot ship to meet the requirements for MPF-F. Fast ships are expensive and are not needed for MPF-F. Deployment time for the MOB is not better than any of the other options offering seabasing capability. The MOB has no host nation support requirements in the theater of operations, but other less-expensive monohull options have no host nation support requirements either. Thus, the MOB is more costly and no more effective than some of the other monohull options for the MPF-F mission. Furthermore, current MPF employment plans require more than one MPF force respond to major regional conflicts. Because the MOB operates with a slow transit speed, and cannot go through the Suez Canal, it is not effective for inter-theater MPF operations. The monohull ships used to meet the intermediate capability option requirements were large ships about 1,000 feet in length and varying in displacement from 60 to 100 thousand long tons.

E. MOB AS STRIKE PLATFORM

The emphasis in this report has been on the use of the MOB as a logistics hub and as a base for deploying and sustaining ground forces ashore. The designs in the ONR technical report are oriented toward the use of a MOB in those roles. Nonetheless, the

MOB could also provide a base for launching and recovering manned air strikes and for launching cruise missiles. In this role it could serve as a joint resource for basing and operating aircraft from all services: F-16s, F-22s, various naval attack and fighter aircraft, Army and USMC attack helicopters, and future JSF aircraft. It could also carry and launch Tomahawk or other land-attack or anti-ship cruise missiles. In this strike support role, the MOB would become the functional equivalent of a joint service aircraft carrier.

As shown in Chapter IX of this report, the MOB could contribute measurable military capability. If deployed in North East Asia, it could keep the entire territory of North Korea under imminent threat of air to ground attack and could do the same over a significant portion of eastern coast of China. If deployed to the Persian Gulf region, the MOB could keep large portions of both south Iraq and south Iran under threat of attack but would be unable to reach Baghdad and Tehran. Roughly the same coverage would be provided by the same aircraft flying out of the friendly airbases available in the corresponding theater. The difference is that the land bases cover the area by dint of their dispersion, while the MOB does so by its mobility. Thus the MOB, located in a single location at any given time, cannot cover the same areas simultaneously.

Once a decision to strike has been made, the MOB could generate a significant number of sorties each day from its 400 strike aircraft aboard. These sorties could provide close air support to the fighting on land and occasionally could strike specified targets inside enemy territory. For a comparable number of aircraft, land bases or aircraft carriers could generate roughly twice as many sorties a day as the MOB.

It appears therefore that while potentially of military use, the MOB is not quite as effective as the alternatives currently available. There are essentially three reasons for this. First, the actual area covered by the MOB is less than that covered by the set of friendly airbases available in the theater because at any given time the MOB is all in one place, while the airbase set is distributed over a larger portion of the theater. Second, the MOB can not approach the shore any closer than the prevailing 140-foot depth line because it needs at least that depth to be able to ballast down for maximum stability. In general, CVNs can approach much closer.

Finally, from calculations provided in Chapter IX, the MOB generates fewer sorties than either the land base or the CVN alternatives. The main reason for this is that the MOB has only one runway, while airbases have at least two and the CVNs have two. Despite the large number of aircraft that can be placed in a MOB, there is just not enough time in the day to generate as many sorties as one could at an airbase or on a CVN. The number of runways limits the maximum number of sorties that could be generated. With two runways and a takeoff or a landing every minute, one can launch and land aircraft simultaneously and could, therefore, generate as many as 1,440 sorties per day under ideal conditions. With a single runway one must share the same runway for taking off and landing aircraft and thus could only generate 720 sorties each day. Less than ideal conditions would reduce both, but proportionately.

As shown in the costing section of this report, the cost to acquire and operate a CVN over its lifetime is approximately one-half that of a MOB configured and manned for strike operations. Two or three CVNs provide strike firepower comparable to that of a MOB, although the full cost of the CVN should not be attributed to strike. The cost of an airbase is hard to assess, but such airbases would likely be host nation assets and would cost significantly less than a MOB. Consequently, the MOB appears to be less cost-effective in the performance of strike operations than the alternatives.

F. COST ASSESSMENTS

To conduct a thorough cost assessment of the MOB and ship alternatives, we developed estimates for the acquisition and operating costs. Costs are all expressed in FY 2004 dollars, the earliest date that could be effected by a program. These are then used to develop 40-year life cycle costs, including salvage value and disposition charges at the end of life. In this section we summarize how these cost estimates were performed and what we found. First we summarize the major elements of the approach, followed by more detail on all.

We reviewed the contractor ship and MOB construction cost estimates for the four conceptual MOB designs used in the ONR technical feasibility study. The main items taken into account were weight, labor hours, material costs, and integration and construction support.

For the operating and support costs, we developed estimates from data we received from the MSC, NAVSEA, VAMOSC, and other appropriate sources. We estimated costs in the following five categories: maintenance, overhaul and replacement, training, fuel, and personnel.

1. Acquisition Costs

To estimate acquisition costs, we first allocated the material weights provided by contractor designs into categories of the standard Navy ship work breakdown structure (SWBS) used for estimating ship costs. We used contractor-supplied material cost estimates, adjusted to FY 2004 dollars. We then used factors from the Naval Center for Cost Analyses (NCCA) to estimate production hours and labor costs, engineering and support hours and costs, margin, and profit. NCCA historical trend factors were then applied to estimate cost of change orders, facility cost of money (FCOM), escalation, and other miscellaneous items.

The estimates are based ultimately on the MOB designs offered to the technical feasibility study. These designs employ commercial shipbuilding standards and do not contain costs that add material for strength and military conditions. We do not include costs for aircraft that would use the MOB, lighterage to transport cargo ashore, and defensive systems.

Factors used in the cost assessments are summarized on Tables 11 through 12. Table 11 summarizes the labor costs and Table 12 the production costs.

Table 11. Summary of Labor Cost Factors

Production Hours Per Ton			
SWBS	**Title**	**Lead (%)**	**Follow (%)**
100	Hull	59.88	59.88
200	Propulsion	52.32	52.32
300	Electric	355.66	355.66
400	Command & Surveillance	430.11	430.11
500	Auxillary Systems	187.45	187.45
600	Outfit & Furnishings	313.85	313.85
700	Armament		
Other Hours as Percent of Production Hours			
SWBS	**Title**	**Lead (%)**	**Follow (%)**
800	Engineering	36.47	3.31
900	Support Services	40.12	28.06
Labor Rates			
Type	**Base ($/hr/man)**	**Overhead Rate (%)**	**Burdened Rate ($/hr/man)**
Production	15.11	135	35.50
Engineering	21.58	130	49.64

Table 12. Summary of Production Cost Factors

Other Material Percent of Production Material		
SWBS	**Title**	**Lead (%)**
800	Engineering	2.39
900	Support Services	8.31

Other Factors			
Title	**Base**	**Lead (%)**	**Follow (%)**
Margin	SWBS 1 thru & Cost	10.00	10.00
Profit	SWBS Cost	10.00	15.00
Change Orders	Basic Ship Construction	10.00	5.00
FCOM	Labor Cost	2.39	2.39
Escalation	Basic Ship Construction	8.00	8.00
Other	Basic Ship Construction	2.00	2.00

Table 13 summarizes the acquisition costs estimates we made for the McDermott MOB. A learning curve of 97 percent was applied to each successive SBU, and a historical 8-percent escalation was added to include anticipated cost increases over the manufacturing period. The total cost for a five-module MOB is $9.59 billion.

Table 13. MOB Acquisition Cost Estimates

Unit	Acquisition Cost (FY 2004 $B)
1	2.12
2	1.74
3	1.71
4	1.69
5	1.67
Subtotal	8.94
8% Escalation	0.64
Total	9.59

We applied similar analyses to the details supplied for the other three MOD designs in the technical report. The other designs varied in cost between $8-13 billion when rounded off to the nearest billion dollars, so the McDermott design represents a middle estimate. The design using concrete pontoons costs the least.

2. O&S Costs

The O&S costs were obtained by analogy with other large ships from data maintained in the VAMOSC database. The primary analogy used was the LHD (general purpose amphibious assault ship). Adjustments were made to depot maintenance, material and sustaining support costs in terms of cost per ton displacement, and operating tempo.

While the displacement weights are easy to determine, the operating tempo requires assumptions. By analogy to Maritime Prepositioning Ships, we assume that the MOB will spend 75 percent of the time during peacetime in the standby mode. The remaining 25 percent will be spent steaming to support peacetime training and exercises. According to the C-17 command in Charleston, SC, CTOL crews would need to land twice per year to maintain proficiency in at-sea operations. These training costs are included in the O&S estimates.

Table 14 summarizes the annual O&S cost estimates for the five-SBU single MOB fleet. As the table shows, most of the costs are associated with maintenance and POL. The number of crewmembers needed to operate the MOB is unclear at this writing. No staffing assumptions were made as a part of the ONR technical report. We assume that 1,250 active duty military personnel are needed to support wartime operations and to meet peacetime training needs. This estimate is based on the current requirements for crews on five amphibious ships. Personnel costs account for slightly less than 15 percent of the total annual MOB O&S costs, so if a smaller crew size could be used during peacetime with augmentation during crises, the personnel costs could be reduced, but the total O&S costs would not be appreciably changed.

Table 14. Operating and Support Cost Estimates for MOB (based on McDermott Design)

O&S Cost Element	Estimated Annual O&S Cost ($M FY 2004)
Depot Maintenance	135
Sustaining Support	54
Intermediate Maintenance	18
Ship POL	68
DLRs/Repair Parts/Supplies/Purchased Services	30
Mission Personnel	52
Indirect Support	3
Total Annual O&S Cost	**360**

3. Total Life Cycle Costs

Combined with the acquisition costs, we have also computed the 40-year life cycle cost. We include a single MOB fleet (with five SBUs) as well as the three-MOB fleet discussed earlier to ensure global response in 3 weeks or less. These cost estimates are summarized in Table 15. As Table 15 shows, the single MOB fleet would cost somewhere between $8-13 billion to build and would cost between $22-27 billion over its 40-year life. The corresponding three-MOB fleet would cost almost three times as much, between $65-80 billion over a 40-year period.

Table 15. Life Cycle Cost Estimates for MOB

Size MOB Unit	Acquisition Cost Estimate (FY 2004 $B)	Annual O&S Cost Estimate (FY 2004 $B)	Life Cycle Cost Estimate (FY 2004 $B)
5,000-ft (5 SBU) MOB	8 - 13	0.36	22 - 27
3 MOB Fleet (15 SBUs)	22 - 37	1.08	65 - 80

4. Costs of Alternatives

Alternatives to the SBU that have comparable size have been discussed. We include their acquisition cost estimates here in Table 16. In general they will be lower in cost than the SBU. We include the large monohull ship as well as the slightly smaller MPF-F designs, both of which can conduct air operations similar to that of the SBU (but not those of the full MOB). In addition, we also show the LMSR, which is comparable in size but cannot conduct the air operations discussed.

Table 16. Comparison of Acquisition Costs for Similar Sized Sea Bases

Platform	Length x Width (ft)	Estimated Acquisition Cost (FY 2004 $B)
SBU for MOB	1,000 x 500	2.0
Large Monohull Ship	1,260 x 370	1.7
MPF Future	1,000 x 175	0.8
LMSR	1,000 x 150	0.5

When compared against an aircraft carrier in a strike role, the O&S cost of the MOB would be much larger than for a logistics role. Table 17 summarizes the cost of a Strike MOB and a CVN. Additional manpower and peacetime training would be needed to operate the MOB if it is to be used as a strike platform.

Table 17. Comparison of Life Cycle Costs of Strike MOB and CVN

Ship	Acquisition Cost Estimates (FY 2004 $B)	Annual O&S Cost Estimates (FY 2004 $B)	
Strike MOB	8-13	0.50	28-33
CVN	5	0.23 + $2 B (recore)	16

G. CONCLUDING COMPARISONS OF MOB WITH ALTERNATIVES

We conclude with Table 18, a comparison of some of the positions cited in the past in favor of the MOB and the corresponding arguments against the MOB and for some of the alternatives discussed here.

Table 18. Comparison of MOB with Alternatives

Arguments Presented In Favor of MOB	Arguments for Alternatives to MOB
MOB hedges against potential unavailability of land bases.	Land bases would probably always be available during crises, or seized by force if denied. MOB will only be useful in parts of world where inadequate bases continue to exist in 2020, therefore of limited U.S. interest.
MOB hedges against potential insecurity of land bases. Because of more controlled access, MOB reduces (relative to land bases) the susceptibility to attack.	Naval forces at rest are susceptible to attack during peacetime. The latest incident with the USS Cole points to ship vulnerability from terrorists. More restrictive rules of engagement used to protect naval assets can also be applied to land bases, so there is no clear advantage to sea bases for security reasons.
MOB exploits maneuver space provided by the sea and may prove more survivable than land bases.	During operations, MOB is essentially motionless (5-knot maneuvering) and may be easily identified and targeted. Faster ships are needed to take advantage of sea maneuver space.
---	MOB may be slow in arriving in theater unless prepositioned judiciously or unless several 5,000-ft MOB fleets are procured. Conventional ships move at twice MOB speed.
MOB provides stable platform, using designs proven in the oil rig industry. This allows the MOB the ability to operate aircraft in high sea states.	Sea Base stability may be less critical in 2020 if automated cranes overcome relative motions during cargo transfer at sea. Lighterage movement of cargo ashore from a sea base is the limiting issue, not sea base platform stability. Advances in lighterage would help all logistics concepts, including monohull design and MOB.
---	Ballasted MOB requires deeper water than conventional monohull ships; MOB stationing further to sea decreases rate of delivery of forces or sustainment ashore relative to conventional ships.

(This page is intentionally blank.)

Part 3

ANALYSES

I. TECHNICAL DESCRIPTION[1]

A. INTRODUCTION

In 1996 the Office of Naval Research, Code 334, Ship Structures and Technology, with support from the Naval Facilities Engineering Service Center (NFESC), Port Hueneme, began a Science and Technology (S&T) program with the goal of establishing the technical feasibility and cost of a MOB. This program spent $37 million from 1996 to 1999, issuing 75 contracts and grants to 50 different research and industrial teams.

To help establish overall technical feasibility, identify critical technology problems, and support cost estimating for what would be the largest floating structure ever constructed, the ONR MOB S&T program conducted a preliminary assessment of four candidate MOB concepts. The four concepts are based on three to five floating modules that could be aligned with each other to form a structure approximately 1,500 meters long and 150 meters wide with an aircraft runway running the entire length. The runway would be about 45 meters above the ocean surface and would be capable of supporting a variety of CTOL aircraft, including the C-17.

B. DESIGN

Each module would consist of a box-type upper deck structure supported by columns which in turn are supported by two pontoons. As an example, Figure 21 shows a MOB module envisioned by McDermott Technology. The modules would have port facilities, including cranes and RO/RO ramps, for receiving cargo from ships and for loading cargo onto lighterage. Figure 21 also shows a landing ramp for accommodating LCACs. Rolling stock and dry cargo would be stored on the lower decks while liquids (fuel and potable water) would be stored in the pontoons and columns. McDermott

---

1 This section is based on the report *Mobile Offshore Base - An Independent Review,* produced by MCA Engineers for the Office of Naval Research, 20 December 1999.

estimates that each module would have about 1 million square feet of configurable cargo space and would be able to carry over 17 million gallons of liquid.

Figure 21. MOB Module Envisioned by McDermott Technology

The modules are based on the semi-submersible hull form that has been employed by the offshore oil industry. With this design, the pontoons could be submerged below or riding on the water surface. In transit to a theater of interest, each module would be deballasted until the tops of its pontoons were just above the water's surface (to a draft of about 14 to 16 meters). Then each module would transit independently on the ocean surface. Each module also would transit under its own power using a dynamic positioning system consisting of a power generation facility and eight fully rotating (azimuthing) variable speed thrusters.

Once on site, each module would be ballasted down (to a draft of about 35 to 42 meters) by flooding appropriate portions of the pontoons until the pontoons are submerged below the water surface. In this state the modules would be highly stable platforms (in the sense that they would exhibit relatively little motion) because they would present to surface waves a minimum surface area (surface waves would interact only with the columns). While ballasted down, the modules could be aligned to produce the approximately 1,500-meter-long structure. The two key differences in the four concepts are the methods employed to align the modules, and the materials (steel vs. concrete) used in their construction, as highlighted in Table 19.

Table 19. Candidate MOB Concepts

Manufacturer	Number of Modules	Module Length (Meters)	Materials	Multi-module Alignment
Aker	4	380	Steel deck	Connectors
			Concrete columns and pontoons	Short flexible bridges
Bechtel	3	488	Steel	Dynamic positioning
				Short flexible bridges
Kvaerner	3	258	Steel	Two, 430-meter floating flexible bridges
McDermott	5	300	Steel	Connectors
				Short flexible bridges

McDermott Technology, Inc., designed a MOB (Figures 21 and 22) in which the modules are kept in alignment via connectors located between pairs of modules and in which short flexible bridges span the gaps between the modules. Since a rigid connection between two modules results in enormous loads on the connector, the connector design envisioned by McDermott trades reduced loads for increased relative motions. Their connector design is a system of three connectors located on the ends of the upper deck structure. One connector, located on the centerline, is a large "universal" ball joint that prevents translation while allowing relative rotation along all three rotational axes. In addition to this centerline connector, two nonlinear, compliant connectors are located on the port and starboard sides of the end of the upper deck structure. These connectors contain elastic elements (large rubber cones) that help maintain runway alignment but limit maximum loads on the connectors in a storm (in which case the runway would not be used). Some concerns with this connector concept include the ability of the connectors to limit relative module motions while not overloading, the manufacturability of the large rubber cones, the ability to connect and disconnect the modules without damage, the fatigue and corrosion performance of the connectors, and the ability to maintain the connectors at sea.

Figure 22. McDermott Technology MOB Concept

The design of Aker Maritime (Figure 23) would use connectors and short flexible bridges between modules in a manner similar to McDermott. However, Aker's primary emphasis has been on investigating the use of post-tensioned concrete to construct the pontoons and columns (while maintaining a steel deck structure to limit weight). Although concrete is very strong in compression loading, it is very weak in tension and post-tensioning improves its performance. The advantages of using concrete for the pontoons and columns include reduced fatigue, higher durability, greater corrosion resistance, and lower life-cycle costs. Some concerns with the use of concrete include the potentially deeper draft, higher power requirement and lower speed associated with the heavier concrete structure, the performance of concrete in the presence of an underwater explosion, particularly at the column/pontoon joints, and the fact that Navy experience is limited to steel structures.

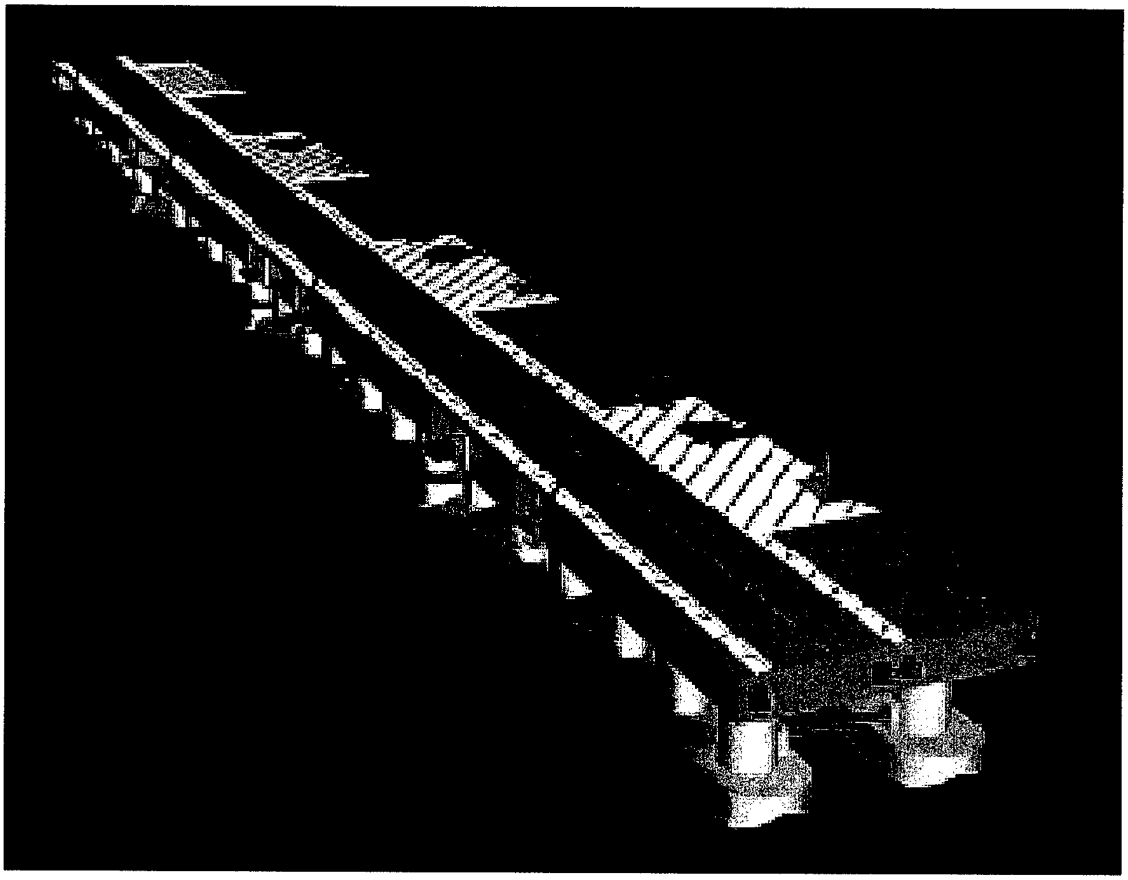


Figure 23. Aker Maritime MOB Concept

The concept of Bechtel National Inc. (Figure 24) does not use inter-module connectors at all, but rather uses active dynamic positioning (DP) to keep close alignment between modules. The DP system consists of a power generation facility (gas turbine electric generators), fully rotating (azimuthing) variable speed thrusters (eight per module), sensors to monitor relative module motions, displacements and environmental factors, and an automatic control system. In operation, when the modules are about 100 to 200 feet apart, the DP system would be given control and it would then move the modules together until their separation is about 35 feet and hold them there to within ±15 feet tolerances. Short flexible bridges would span the gaps between the modules. Some concerns with this concept include the ability of the DP system to adequately limit motions along all 6 degrees of freedom in order to maintain runway alignment and, given that the DP system would be in constant heavy use, system fatigue and reliability and high fuel consumption.

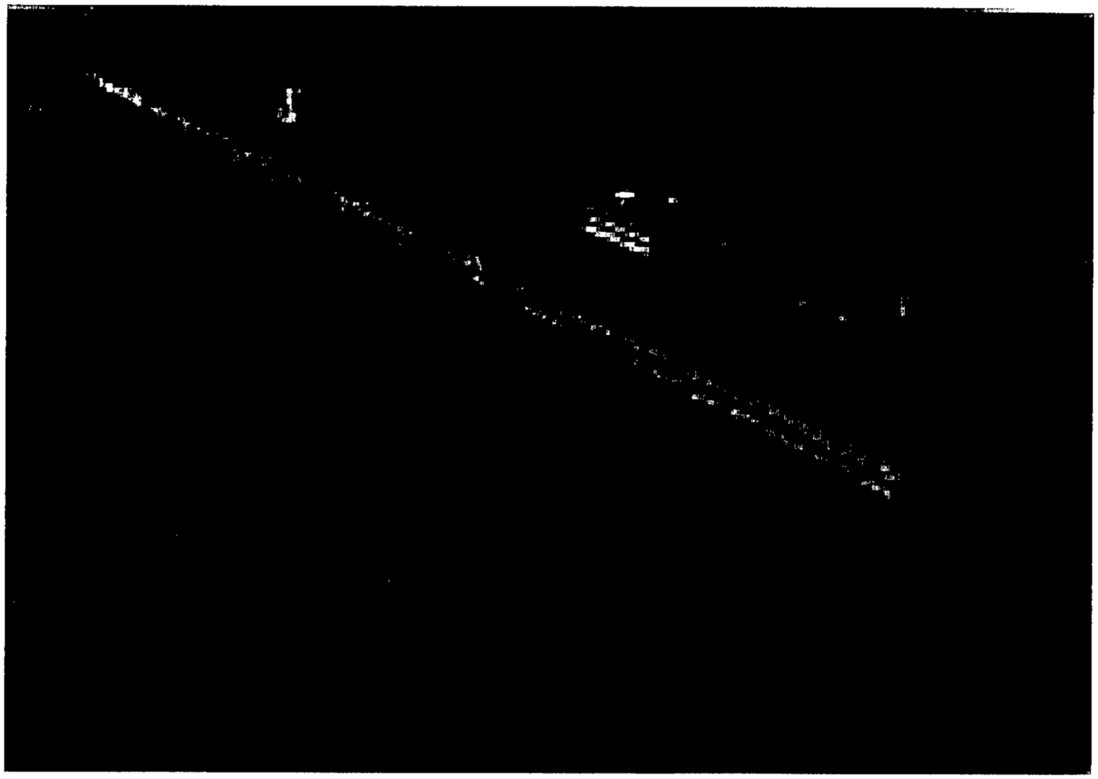


Figure 24. Bechtel Notional MOB Concept

Although the Bechtel concept is the only one of the four to rely on a DP system to maintain module alignment without any type of physical connection, it is important to note that all four concepts require a DP System for station-keeping and individual module deployment. Also, in practice a concept that employs a physical connection might use the DP system to assist in maintaining module alignment if this did not inadvertently add unintended stresses on the connectors.

All three of the above concepts require short flexible bridges to span the gaps between modules. These bridges would be about 200 feet long and would provide for a continuous runway but would not support any structural forces. It is still not clear that these bridges would be able to accommodate relative module misalignment and motion while maintaining minimal runway discontinuity over such a short distance. In addition, work is needed to ensure that they could be deployed and retracted in operating conditions. The most severe demands on such a bridge are encountered in the Bechtel concept where relative module motions are totally unrestrained by connectors. In this case the bridge would have to accommodate not only relative pitch, roll, and yaw module misalignment and motion, but also heave, surge, and sway.

Kvaerner Maritime envisions a much different concept (Figures 25 and 26) from those above. In their design, three modules are *rigidly* connected by two 430-meter-long floating, highly flexible bridges that would be ballasted down onto keyed connections in the modules. Thus relative module misalignment and motion would be taken up by the flexibility of these very long bridges. The bridges would have the minimum hull girder torsional and bending rigidity necessary for transit, and the bridge truss would include damping elements to mitigate resonance. The advantage of this design is that the runway is continuous in translation, rotation, and slope, and therefore is the straightest, flattest runway of all four designs discussed here. Some concerns with the Kvaerner concept include the slow bridge transit speed (2-4 knots), the reliability of the damping elements (especially underwater), and bridge truss fatigue in higher sea states.

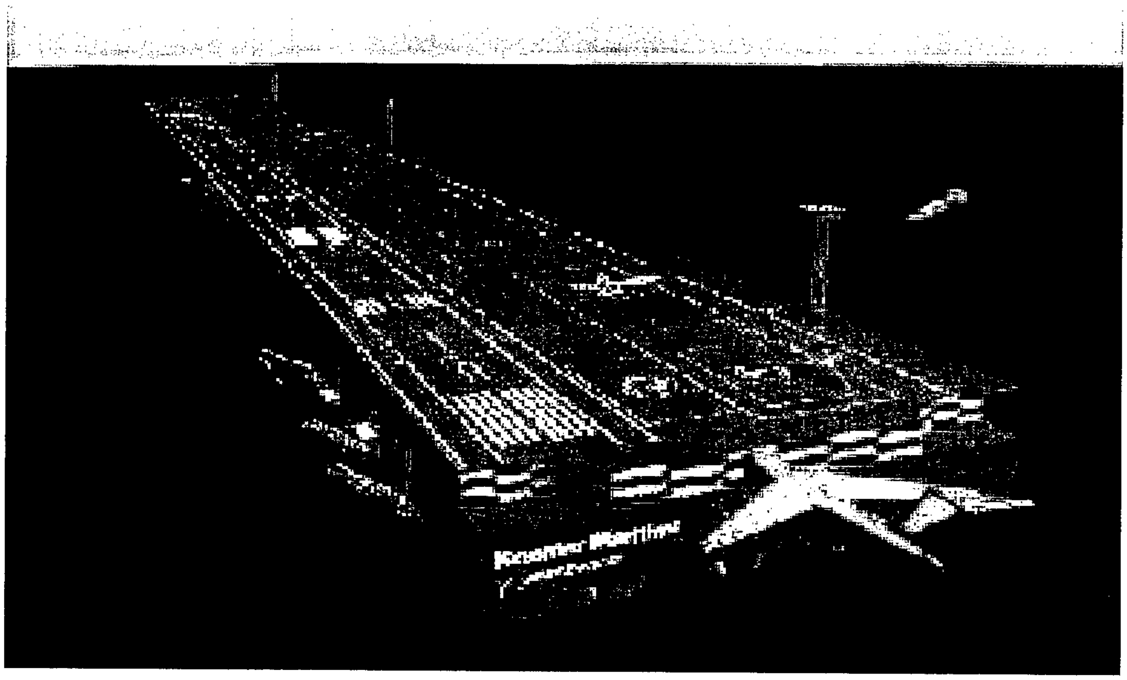


Figure 25. Kvaerner Maritime MOB Concept

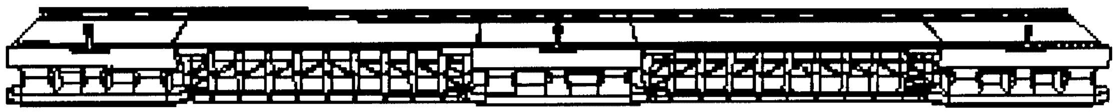


Figure 26. Kvaerner Maritime MOB Concept (Side View)

These four MOB designs are still in the conceptual stage, and much of the design work has relied on computational modeling. ONR's research and development effort has been successful in improving existing computational hydrodynamics tools to enable them to handle a problem as large and complex as the multi-module MOB. This computational work has involved response analyses which are necessary to (1) predict structural loads (using force and stress calculations) to assess the structural adequacy of modules, connectors, etc., and the ability of the design to survive storms, and (2) ensure that a design is able to fulfill its mission (e.g., launch and receive aircraft) given the motions that it will experience. To begin to verify the computational results, limited validation testing with preliminary data reduction is underway at the Naval Surface Warfare Center, Cardrock Division, where hydroelastic testing is being done on a 1/60th-scale five-module model, and at the Naval Academy, where studies of transit stability, nonlinear wave response effects, and air gap are being done on a stiff, single semi-submersible being towed at speed.

C. CONCLUSIONS

Based on the work carried out in ONR's S&T program, MCA Engineers concluded that a single MOB module is technically feasible, and that thus far nothing has been found to prove that the multi-module MOB, required for aircraft such as the C-130 and C-17, is not feasible. The main technical risks associated with the multi-module MOB center around the performances of the elements required to keep the modules aligned. These elements, including connectors, dynamic positioning system, flexible bridges spanning the gaps between modules, and long floating flexible bridges, have been examined mainly through computer models and therefore their performance must be confirmed. Other issues that would need further investigation include the performance of concrete columns and pontoons, module transit stability and speeds, cargo handling capabilities, and the effects of weapons on the structure.

D. RESEARCH SPIN-OFFS[2]

The main objective of the MOB S&T program has been to establish the technical feasibility and cost of a MOB. However, along the way the program also has advanced a number of technologies that may be able to improve the general design and analysis capabilities for large offshore structures, including floating runways and floating bridges. For example, the program has advanced design standards for large ocean structures and computer analysis tools for modeling the wave-induced responses of such structures. Furthermore, building an offshore platform as big as the MOB would require the ability to appropriately balance reduced structural stresses with increased inter-module motion. Toward this end, the program has advanced component concepts including connectors that control relative motion while limiting stress and that are capable of connect/disconnect operations, and a dynamic positioning system that operates over multiple modules to hold relative positions between the modules and to move the modules as a single entity. In addition, the program has assembled a meteorological-oceanographic (metocean) specification that provides a unique compilation of the wind, wave, and current environments around the world. Finally, studies of the spatial and temporal coherence of ocean waves are underway. These characteristics are important for long floating structures like the MOB because, if the ocean waves are coherent in space over the length of the structure and in time, they can induce vertical bending, horizontal bending, and torque resonances in the structure.

---

2 *Mobile Offshore Base – Research Spin-offs,* Robert Zueck, Paul Palo, Robert Taylor and Gene Remmers, International Offshore and Polar Engineering Conference, Brest, France, 30 May 1999.

(This page is intentionally blank.)

II. POTENTIAL USES FOR THE MOB

This chapter addresses the potential uses for the MOB described in the preceding chapter. It is not intended to pass judgement on the relative operational desirability of these potential uses; that would require a critical examination of operational limitations and military utilization, both of which shall be done in subsequent chapters. Identifying potential uses requires an examination of relevant operational features of a MOB and relevant operational circumstances in which a MOB may find itself. Consequently, this chapter starts with two sections (A and B), one discussing the operational features that characterize a MOB, and one that lays out the strategic assumptions DoD uses in planing for war. Section C then identifies the potential operational uses of a MOB by intersecting the information put forth in the previous two sections.

Section D considers a strategic and operational environment different from the planning one to highlight the leverage of those operational features that are unique to the MOB. Although this set of future circumstances—in which access is denied our forces anywhere within useful distance from the battle field—is currently considered quite unlikely, one can not decisively argue that it is impossible; one should therefore consider the issue of how a MOB may provide the nation with the hedge it needs against the eventuality that we cannot set foot in the relevant theater.

A. OPERATIONAL CHARACTERISTICS OF A MOB

In generic terms, the MOB is an instrument of war that offers our military a relocatable, three-dimensional footprint on the sea anywhere in the world. The surface area and the volume capacity of this footprint stand ready to be used for a variety of military applications. Thus, the surface area could be employed to operate an airfield or locate both offensive and defensive missile and gun systems. The volume capacity could be used practically for any activity requiring an enclosed space. In that space, one could set up a repair and maintenance facility for servicing any number of military systems, build a hospital for treating the wounded, house troops or a large number of U.S. nationals that need to be evacuated from a danger area, install a cargo-handling operation, or establish a command and control center. With the addition of specialized equipment needed to load and unload surface ships, the volume capacity available on the MOB could also be used to set up and operate a modest port facility.

The capabilities listed above could be combined to generate any number of alternative platforms capable of performing a variety of military missions. While all these options are equally possible, they may not all be equally meaningful from an operational point of view. To learn which of them are, we explore next the way in which these capabilities could be employed within the strategic and operational context DoD uses to plan its forces.

B. THE STRATEGIC ENVIRONMENT ASSUMED IN PLANNING

The planning documents employed by the U.S. military envision a strategic environment that is both promising and dangerous. The promise comes from the unprecedented opportunities to shape the strategic environment created by the fast receding threat of a global war against a peer competitor and by the apparent willingness of former adversaries to cooperate with us. By concentrating its military power to assure allies and friends, to redress imbalance, and eventually to reestablish stability through deterrence or victory, the United States attempts to ensure that no critical region is dominated by hostile powers and can discourage any potential regional hegemon from threatening stability in its area of influence.

However, the potential for conflict among states and groups of states remains a serious security challenge; Iran, Iraq, and North Korea currently pose such a challenge and there appears to be no guarantee that these threats will soon diminish significantly. Numerous other regional powers have increasing access to wealth, technology, and information, potentially giving them greater military capability and influence. To challenge U.S. superiority in traditional military force, some may attempt to develop asymmetric capabilities, including nuclear, biological, and chemical weapons of mass destruction (WMD) and the means to deliver them; these asymmetric capabilities have the potential to threaten the U.S. homeland and population directly and to deny us access to critical overseas infrastructure.

The security environment is further complicated by challenges that transcend national borders. Human emergencies other than war—extremism, ethnic disputes, international organized crime, illegal trade in weapons, strategic materials, or drugs, massive refugee flows, and threats to the environment—each have the potential to put

U.S. interests at risk and may issue from entities that are increasingly harder to distinguish amongst themselves.

Finally, a number of "wild card" threats could emerge to put U.S. interests at risk. Such threats range from the emergence of new technologies that neutralize some of our military capabilities, to the loss of key allies or alliances and the unexpected overthrow of friendly regimes by hostile parties. Particularly serious is the possibility that we may have to confront a combination of several such threats, a combination that could critically undermine U.S. will, credibility, access, and influence in the world.

C. JOINT VISION 2020 AND POTENTIAL USES FOR A MOB

The U.S. concept of operations is based on the assumption that direct combat against an enemy's armed forces is the most demanding and complex set of requirements we have to face. According to this assumption, therefore, other operations, from humanitarian assistance in peacetime through peace operations in a near hostile environment, are executable using forces optimized for wartime effectiveness.

The Joint Vision (JV) 2020, the current evolution of JV 2010, is the conceptual template for joint operations and warfighting that fit the strategic environment assumed in planning. The key enablers underpinning these concepts of operation are information superiority and technological innovation. These enabling capabilities will change the way the United States conducts its most intense operations. Instead of relying on massed forces and sequential operations, U.S. forces will rely on improved command and control based on fused, all-source, real-time intelligence combined with precision targeting and higher lethality weapons to achieve massed effects through tailored application of joint combat power. Needless to say, these new capabilities will not obviate the ultimate need for "boots on the ground" in many operations. However, in all operations technological advances and the use of information are designed to give our warfighters at the individual, crew, and small unit levels major qualitative advantages over potential adversaries.

The current operational concepts of maneuver, strike, protection, and logistics will thereby be transformed through JV 2020 into the new concepts of dominant maneuver, precision engagement, focused logistics, and full-dimensional protection.

1. Dominant Maneuver

Dominant maneuver is the multidimensional application of information, engagement, and mobility capabilities aimed at achieving positional advantage and decisive speed. To that end, dominant maneuver employs widely dispersed joint air, land, sea, and space forces to exploit a significant enemy weakness and deal a decisive blow. Therefore, operational maneuver is generally directed against enemy centers of gravity, something that is essential to the enemy's ability to effectively continue the struggle. These centers of gravity may be physical objects, such as a military force or a city, a source of supplies, or an intangible but essential element of political or moral force that keeps our enemies fighting. Dominant maneuver will require information superiority and forces that are adept at conducting sustained and synchronized operations from dispersed locations. Information superiority will provide a clear picture of enemy and friendly locations on the basis of which joint commanders will be able to combine attacks from widely dispersed units into one decisive blow to the enemy.

Since the strategic vision underlying U.S. planning gives priority to fighting in the littorals, one of the central elements of dominant maneuver will come from the sea. Extensive use of the sea is the corner stone of the USMC's planned concept of operations. This concept, called Operational Maneuver from the Sea, is predicated on the expectation that improvements in the precision of long-range weapons and the decrease in the fuel requirement of military land vehicles would lead to a significant reduction in the logistic tail of landing forces. Should that expectation be realized, the USMC expects that ship-to-shore movement will take significantly less time than it does today and that subsequent operations ashore will be able to start without the traditional "buildup phase." Landing forces will thus be able to move directly from the sea to their objectives, whether those objectives are located on the shoreline or deep inland, and subsequently just as quickly be re-embarked. Under the circumstances, landing forces will be able to avoid combat offered on unfavorable terms, to avoid obstacles that stand in the way of decisive action, and to make use of the element of surprise.

The idea of replacing the traditional sequence of ship-to-shore movement and tactical and operational maneuver of units ashore with maneuver in which units move, without interruption, from ships at sea to their inland objectives and back, fundamentally depends on the availability of sea bases. One way of providing such basing would be to build and then employ a MOB. From such a mobile offshore base, the USMC could marry prepositioned equipment with forces arriving from CONUS by C-17 transport, operate these forces against enemy centers of gravity, recover them at the end of the operation, and provide local repair and maintenance for both equipment and humans. When the strategic needs require it, the MOB could then be relocated to another position in the theater to fight another day.

2. Precision Engagement

Precision engagement is a system of systems that enables forces to locate the objective target, provide responsive command and control, generate the desired effect, assess their level of success, and retain the flexibility to reengage with precision when required. Information operations would be needed to tie together high fidelity target acquisition, prioritized requirements, and command and control of joint forces within the entire battlespace. If successfully implemented, this combination will provide a greater assurance of delivering the desired effect, lessen the risk to U.S. forces, minimize collateral damage, and thereby favorably shape the battlespace.

The naval component of this system of systems will likely consist of aircraft carrier battle groups, submarines, and land-attack destroyers. Alternatively, the function of these components could be integrated onto a MOB structure. As ADM Owens suggested in his book *High Seas*, the MOB could generate tactical aircraft sorties associated today only with large airfields ashore and might do so in a relatively cost-effective way. Under the Admiral's concept, this "war-fighting" carrier would be joined by a recognizable extension of today's nuclear-powered carriers and big-deck amphibious ships, a platform he calls a "presence" carrier; the role of the latter would be to execute the overseas presence mission in our strategy, while the former would be employed in actual warfighting.

3. Full-Dimensional Protection

The primary function of full-dimensional protection operations is to control the battlespace. Such a controlled battlespace would ensure that U.S. forces can maintain freedom of action during deployment, maneuver, and engagement while providing multi-layered defenses to gain and maintain the initiative required to execute decisive operations.

Like much of everything else in the planning concept of operations, full-dimensional protection will almost certainly rest upon information superiority; this will provide multidimensional awareness and assessment, as well as identification of all forces in the battlespace. Information warfare will support this effort by protecting our information systems and processes, while denying an adversary the similar capability. Upon this information base, we will employ a full array of active and passive measures at multiple echelons.

Active measures will include battlespace control operations to guarantee the air, sea, space, and information superiority needed to gain control. They also include an integrated theater air and missile defense that will exploit Service-unique capabilities to detect, locate, track, and deny enemy attacks on our forces. Passive measures will include the inherent protection provided by information superiority and dispersal of our forces. Moreover, new sensors and information dissemination systems will be deployed to detect chemical or biological attack at greater ranges and provide warning to specific units that may be affected by such attacks. Finally, passive measures include enhanced deception and camouflage, increased individual and collective protection, and a joint capability against the effects of WMD. The combination of these active and passive measures will provide a more seamless joint architecture for force protection.

A MOB could play a useful role within this full-dimensional protection operation. First of all, it could contribute to any air and missile defense operation undertaken by the alliance and do so with considerable mass. Next, it could contribute to any land attack operation by deploying extensive fire power on its large deck area. Finally, it could serve as a WMD warning and recovery center offering both the warning capability and the facilities needed to treat affected personnel.

4. Focused Logistics

Focused logistics is the fusion of information, logistics, and transportation technologies to provide rapid crisis response, to track and shift assets even while enroute, and to deliver tailored logistics packages and sustainment directly at the strategic, operational, and tactical levels of operation. It should be fully adapted to the needs of increasingly dispersed and mobile forces providing support in useful times and for as long as necessary.

Information technology will enhance existing airlift, sealift, and pre-positioning capabilities by lightening deployments loads, assisting pinpoint delivery systems, and extending the reach and longevity of systems currently in the inventory. It is expected that the combined impact of these improvements will be a smaller, more capable deployed force, a force that will require less continuous support with a smaller logistics footprint, thus decreasing the vulnerability of our logistics lines of communication.

One can see two distinct applications of a MOB to focused logistics. On the one hand, with its long runway and large storage and handling capacity, the MOB could serve as a reception point for select airlift flights in a manner that would allow for more focused delivery to the front than would existing airfields. On the other hand, the MOB can serve as a theater logistics hub from which all naval forces could be serviced and resuplied and from where one might more efficiently transmit material to the forces fighting the land battle.

5. Alternative MOB Platforms

We are now ready to collect, by way of summary, the various MOB concepts that suggested themselves in our discussion above. First of all, the MOB can be employed as a power projection platform. In this capacity, it could act as an aircraft carrier, the so-called "warfighting carrier" of ADM Owens, or as a large amphibious ship deploying and supporting Marines over the beach. Second, the MOB can operate as an air-defense ship engaged either in tactical or theater level missile defense. Third, the MOB can be employed as a sea-base staging area where the Marines arriving by airlift could marry up with their pre-positioned equipment prior to engaging the enemy. Fourth, the MOB could operate as a logistics hub on which one could repair, maintain, hospitalize, and recreate our forces, a "home away from home" facility located away from the fight but within easy reach of the battle front. Finally, the MOB can maintain a long-term U.S. military presence in forward areas.

D. THE MOB IN A WORLD WITHOUT ACCESS

We refer to subsequent chapters where we analyze the cost and the effectiveness of a MOB structure employed in the manner indicated in section C of this chapter. It follows from there that, within the planning scenario at least, many may conclude that the MOB comes too late, brings too little, and does so at an exorbitant cost. Before thereby dismissing the MOB option in favor of existing programs, one ought to inquire if there might not be some utility to a MOB outside the planning universe.

As it appears from a careful reading of Joint Vision 2020, the military strategy assumes availability of access; allies and friendly nations are always assumed to provide bases, overflight rights, and host nation support to U.S. forces. If that turned out not to be true, the nation would most probably have to choose between two undesirable alternatives: to initiate a major military operation aimed at wresting control of the entire region, or forgo involvement. Interestingly, however, it is precisely under these conditions that a MOB, which by its very nature requires no access, would provide some measure of capability when other forces could not. Therefore, the MOB alternative would be able to restore some flexibility by offering a third alternative.

The idea is to establish a protected "island" within useful distance of critical centers of gravity and use this independent and relatively permanent footprint to stage military operations designed to show determination and disuade enemy adventurism. Such an island could hardly be built without the unique technology characterizing a MOB.

III. MOB INTER-THEATER TRANSIT AND DEPLOYMENT

A. INTRODUCTION

MOB modules would travel independently to a theater, even if the theater command required the aligned modules (forming a runway capable of supporting CTOL aircraft such as the C-130 and C-17). Thus, if the modules were already aligned prior to being sent to theater, they first would be separated and then each module would be deballasted until the tops of its pontoons were just above the water surface (to a draft of about 14 to 16 meters). At this point each module would transit across the ocean in a manner similar to a conventional surface ship: under its own power using a dynamic positioning system consisting of a power generation facility and eight fully rotating (azimuthing) variable speed thrusters. Once on site each module would be ballasted down (to a draft of about 35 to 42 meters) by flooding appropriate portions of the pontoons until the pontoons were submerged below the water surface. Therefore, the deployment from peacetime location to theater (or between theaters) consists of three segments: prepare to transit, transit, and onsite setup.

Preparation will include a number of activities, including disconnecting and deballasting the modules. Likewise, onsite setup may include a number of activities, including ballasting down and connecting the modules. McDermott estimates that ballasting down a module would require about 10-11 hours, and that connecting five modules, which could occur only in Sea State ≤ 5, could take about 5 hours. This appears optimistic for overall preparation time and setup time; we will use the estimates of 24 hours each as suggested by Whitney, Bradley & Brown, Inc.[1]

---

1 *Mobile Offshore Base Transit Speed Requirements Analysis*, Whitney, Bradley & Brown, Inc., 30 November, 1998.

B. TRANSIT SEGMENT

Two important considerations that affect the transit segment are transit speed and the size and location of the MOB fleet.

1. Transit Speed

Table 20 shows the maximum module transit speeds achievable in calm seas as claimed by the designers, along with some other module transit specifications. Note that Aker and Kvaerner estimate a maximum module transit speed of only 10 knots even in calm water. Furthermore, Kvaerner estimates that their 430-meter floating flexible bridge could attain a transit speed of only 2-4 knots in calm water. Finally, Bechtel needs 200,000 horsepower per module not because this would be required for transit, but rather because it would be required for the concept of using the dynamic positioning system to keep multiple modules aligned on site.

Table 20. MOB Module Transit Specifications According to Manufacturers

Manufacturer		Speed * (knots)	Draft (meters)	Displacement (metric tons)	Horsepower
Aker		10	15.7	522,000	64,000
Bechtel		15	14	417,000	200,000
Kvaerner	Module	10	15.5	304,000	NA
Kvaerner	Bridge	2-4	9.5	266,000	NA
McDermott		15	13.5	240,000	63,000

*Claimed maximum module transit speed in calm water.

The Center for Naval Analyses has estimated the horsepower required to achieve a transit speed of 15 knots by a module similar to that of the McDermott concept.[2] The CNA estimate is based on the results of preliminary measurements made at the Naval Surface Warfare Center, Carderock Division, of the resistance experienced by a module moving through water. These measurements were made on an approximately $1/60^{th}$ scale model with clean, bare hulls towed in both calm water and in SS 4 head seas. The results, extrapolated to full scale, gave a resistance of 350 metric tons in calm water and

2 *MAA for MPF Future Sea-Basing Concepts: Volume III: Ship Design Technical Reviews,* Center for Naval Analyses, August 1998.

430 metric tons in SS 4 head seas. In addition to the resistance due to water, the CNA analysis estimated the resistance due to wind acting on the module's large rectangular upper deck structure and vertical columns. Using these resistances, and assuming a propulsive coefficient of 0.65 (representing the efficiency with which power is transferred to the propeller) and an operating horsepower set at a liberal 90 percent maximum, we can infer from the CNA estimate that the module would require 72,500 horsepower in calm water and 96,800 horsepower in SS 4 to achieve a transit speed of 15 knots.

These results suggest that the McDermott module, with a design specification of 63,000 horsepower, could not achieve a transit speed of 15 knots even in calm water. Increasing the horsepower to increase the speed is not simply a matter of increasing the power of the onboard power generation plant. One of the main limitations is the power capacity of the thrusters, and the MOB would be pushing the state of the art (with consequences for cost and reliability). For example, in order to realize the concept of using the dynamic positioning system to keep multiple modules aligned, Bechtel estimates that it would require 200,000 horsepower per module. Although Bechtel envisions using eight thrusters each rated at 25,000 horsepower (18,650 kW), only one company, ABB, has experience with "several installations" of thrusters "up to 25,000 hp."[3] Thus, taking McDermott's 63,000 horsepower at face value, we conservatively estimate that the maximum transit speed that the module could achieve in calm waters is 14 knots.

The maximum module transit speeds discussed above are in calm seas and, in general, would not be attainable in open ocean. A module's speed (like that of any sea-going vessel) would be reduced with increased sea state due to platform stability, slamming loads, the effects of motion on cargo and humans, and difficulty maintaining heading. Stability is especially critical for a MOB module in transit, as the module would be riding high on its pontoons. At some point, perhaps at SS 7, the module would have to fully ballast down and wait out the high seas. Based on experience, we estimate that the module transit speed in open ocean would be about 2 knots lower than that in calm water. Thus, we estimate an overall open ocean transit speed of a McDermott-type MOB

---

[3] *Mobile Offshore Base: Propulsion System Configuration Study,* Nautex Inc., under subcontract to Bechtel National, Inc., February 1998.

module to be about 12 knots. For comparison, maritime prepositioning ships (MPS) can transit at about 24 knots.

Some perspective on the maximum transit speed of a MOB module can be found in the Gabrielli-von Karman Technology Limit Line.[4] This limiting line, established from empirical evidence, is given by the equation

$$P/W = 0.0013v^2$$

where P is power (in horsepower), W is weight (in short tons) and v is the maximum speed (in knots).

Gabrielli and von Karman noted that to design a vehicle of a given weight for a given maximum speed, at least as much power has to be installed as is given by the equation. Figure 27 shows the Gabrielli-von Karman Technology Limit Line. The line segment labeled "Merchant Ships" is taken from the original Gabrielli and von Karman paper, and represents the maximum speed attainable by merchant ships of the time. Also included on this chart are McDermott's claimed 15-knot maximum transit speed, our estimate of 12 knots for the McDermott module's maximum transit speed, and a range of values obtained from CNA's calculation of the horsepower required for a transit speed of 15 knots, bound below by the calm water value and above by the SS 4 value. Finally, for comparison Figure 27 includes the T-AKR 310 class (*Watson* class) LMSR with 64,000 horsepower, a displacement of 70,161 tons (62,644 long tons), and a speed of 24 knots. The data in this figure suggest that 12 knots is approaching the technological limit for a McDermott-type MOB module with 63,000 horsepower, and that to achieve a transit speed of 15 knots the module would require on the order of 100,000 horsepower.

---

4 "What Price Speed? Specific Power Required for Propulsion of Vehicles," G. Gabrielli and Th. von Karman, *Mechanical Engineering*, 775, October 1950.

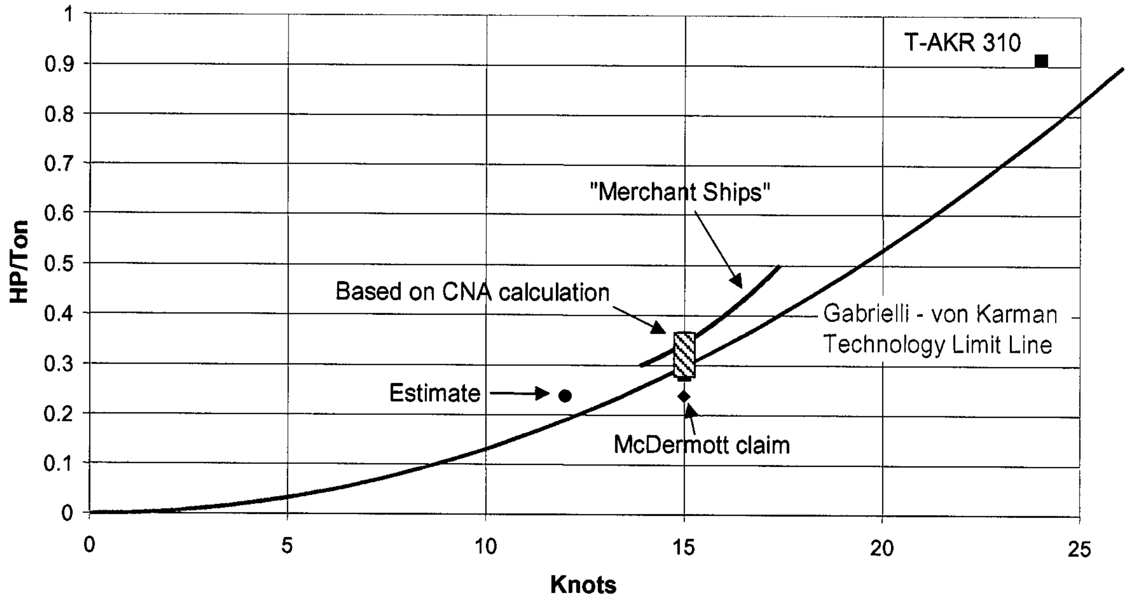


Figure 27. HP/Ton vs Maximum Speed

2. MOB Fleet Size and Locations

In addition to the transit speed of a MOB module, the transit time depends on the number of MOBs in the MOB "fleet," their dispersed peacetime locations, and the distances they must travel. For analysis purposes, we examined notional fleets of one MOB stationed at Diego Garcia; two MOBs, with one stationed at Diego Garcia and one at Hawaii; and three MOBs stationed at Diego Garcia, Hawaii, and in the central Mediterranean Sea. These locations are similar to those used by the Marine prepositioning force. In our case Hawaii was chosen, rather than Guam, to give better access to South America.

From these starting locations we examined the transit times (with the MOB modules traveling at 12 knots) required to arrive at the Persian Gulf, Korea, the east and west coasts of central Africa, the east and west coasts of central South America, and the eastern Mediterranean Sea. The MOB modules would not be able to pass through the Panama Canal or the Suez Canal, and therefore transit between the Atlantic and Pacific Oceans would require travel around the southern tip of South America and transit between the Atlantic Ocean or the Mediterranean Sea and the Indian Ocean would require travel around the southern tip of Africa. Transit between the Indian and Pacific Oceans would likely occur through the Straits of Malacca.

C. MOB DEPLOYMENT

Tables 21, 22, and 23 show the transit times and the total times for deployment for the one-, two-, and three-MOB fleets, respectively. The total time for deployment is the full timeline, that is, the transit time plus the estimated 2 days needed for preparation (24 hours) and onsite setup (24 hours). For the two- and three-MOB fleets, only the initial locations closest to the destinations are shown. Going from one MOB stationed at Diego Garcia to two MOBs, with the second stationed at Hawaii, significantly shortens the deployment times to Korea (by 9 days) and the west coast of central South America (by 18 days). We added a third MOB in the central Mediterranean mainly to deal with the long transit times (36 days) from Diego Garcia to the eastern Mediterranean due to the inability of the MOB to pass through the Suez Canal, though it also helps to cut the transit times to the west coast of central Africa (by 2 days) and the east coast of central South America (by 5 days).

Overall, the data indicate that the relatively slow 12-knot transit speed results in long transit and deployment times for the MOB. Although this is mitigated somewhat if multiple MOBs are available, this strategy may be very costly. In general, the best situation with respect to the transit capability of the MOB would be a scenario that has a lengthy strategic warning. Such might be the case, for example, in building up for a major theater war. However, in such a case the MOB's assets might make up only a small percentage of that needed, and therefore might not make a major contribution to the war. On the other hand, the MOB's assets might suffice in a small-scale contingency, but in this case a lengthy strategic warning may not be available.

Table 21. Deployment Times for a One-MOB Fleet

Initial Location	Destination	Distance (nmi)	Transit Time (Days)	Total Time (Days)
Diego Garcia	Persian Gulf	2,500	9	11
Diego Garcia	Korea	6,500	23	25
Diego Garcia	E. Coast Africa	2,500	9	11
Diego Garcia	W. Coast Africa	5,500	19	21
Diego Garcia	E. Coast S. America	7,200	25	27
Diego Garcia	W. Coast S. America	10,000	35	37
Diego Garcia	Eastern Mediterranean	10,500	36	38

Table 22. Deployment Times for a Two-MOB Fleet

Initial Location	Destination	Distance (nmi)	Transit Time (Days)	Total Time (Days)
Diego Garcia	Persian Gulf	2,500	9	11
Hawaii	Korea	4,000	14	16
Diego Garcia	E. Coast Africa	2,500	9	11
Diego Garcia	W. Coast Africa	5,500	19	21
Hawaii	E. Coast S. America	7,200	25	27
Hawaii	W. Coast S. America	5,000	17	19
Diego Garcia	Eastern Mediterranean	10,500	36	38

Table 23. Deployment Times for a Three-MOB Fleet

Initial Location	Destination	Distance (nmi)	Transit Time (Days)	Total Time (Days)
Diego Garcia	Persian Gulf	2,500	9	11
Hawaii	Korea	4,000	14	16
Diego Garcia	E. Coast Africa	2,500	9	11
Central Mediterranean	W. Coast Africa	5,000	17	19
Central Mediterranean	E. Coast S. America	6,000	21	23
Hawaii	W. Coast S. America	5,000	17	19
Central Mediterranean	Eastern Mediterranean	1,000	3	5

(This page is intentionally blank.)

IV. MOB VULNERABILITY

A. INTRODUCTION

The MOB would be an attractive target. Given its role, its cost, and its collection of a significant number of assets in one place, the MOB would provide a focal point for enemy attack. In addition, the MOB would be a relatively easy target. First, it would have large visual, radar, and acoustic signatures[1] and therefore would be easy to identify, track, and target. Furthermore, while onsite the MOB would be stationary or, if not, would be slow (moving at < 5 knots) and would have limited tactical maneuverability. Finally, the MOB would not have much armor and may lack organic defenses.

The MOB would be vulnerable to the full spectrum of threats: ballistic missiles, cruise missiles, torpedoes, mines, weapons of mass destruction (nuclear, chemical and biological), and terrorist attacks (e.g., suicide missions in small boats or freighters). These threats can be delivered from land-based, air-based, or sea-based platforms. Submarines, which can launch torpedoes and cruise missiles, would be especially troublesome. For example, diesel submarines are difficult to detect, especially at the low speeds that would be required to track the MOB. In addition, because of the MOB's large signatures a submarine could attack the MOB from further away than it could a ship. Furthermore, a submarine could attack while the MOB is in transit.

Because of the issues discussed above, the MOB would have to operate in a highly protected environment. First, it would have to be positioned far from shore to limit exposure to land-based threats. Second, it would need the protection that could be provided by Navy escorts. In fact, like an aircraft carrier, the MOB may require battle group escorts to protect it not only in theater but also in transit. Third, although not currently planned, the MOB may require some level of organic defenses against missiles,

1 *Vulnerability Analysis of Mobile Offshore Base (MOB),* NSWCCD, 3 December 1994.

small boat raids, etc. However, given its size, it may need a large number of such defensive systems to provide complete coverage.

Although the size of a MOB would make it an attractive and easy target, it also would make it highly survivable. Only a few threats would place the MOB at risk, including some large mines, threat weapons hitting onboard ordnance, and severe fire damage.[2,3] The extent of damage caused by a torpedo attack would depend on where the torpedo hit. Because some portions of the pontoons already would be filled with water or fuel, a hit in these areas may have only limited effects on the MOB. If, however, the torpedo hit a ballast compartment, the MOB may not be able to fully deballast for transit. Even worse, if the torpedo hit air-filled portions (required for buoyancy) of a pontoon and this resulted in flooding, then the MOB would have potentially serious problems with listing. At the very least, this would exert severe forces on the connectors holding multiple modules together.

Although a weapon hit probably would not jeopardize the integrity of the MOB, it would likely cause local damage that may halt operations and result in downtime while the damage was being repaired. Operations could be affected by hits to the runway (mainly a problem for CTOL aircraft), aircraft elevators, radar, communications and other electronics systems, thrusters (which also would affect mobility and station keeping), connectors, RO/RO ramps, cranes, and pontoons (causing listing and also affecting mobility).

The rest of this chapter concentrates on the full 1,500 x 150-meter MOB while it is in theater conducting operations, and on the effects that cruise and ballistic missile strikes would have on air and sea operations.

B. MISSILE THREAT AND DEFENSES

Details on the missile threat and defenses circa 2020 can be found in the classified annex to this report.

---

2 *Vulnerability Analysis of Mobile Offshore Base (MOB)*, NSWCCD, 3 December 1994.

3 David Wilson, NSWCCD, Private communication, 10/16/00.

C. SUSCEPTIBILITY TO BALLISTIC MISSILE HITS

To obtain an estimate of the susceptibility of the MOB to a ballistic missile attack, we modeled the MOB as a planar target as shown in Figure 28, where L is the length (1,500 meters) and W is the width (150 meters) of the MOB, which is centered at the origin (0,0). We then calculated the probability of the MOB being hit by a ballistic missile. The model assumes that the MOB is within range of the missile, and that the location of the MOB is known (within targeting errors).

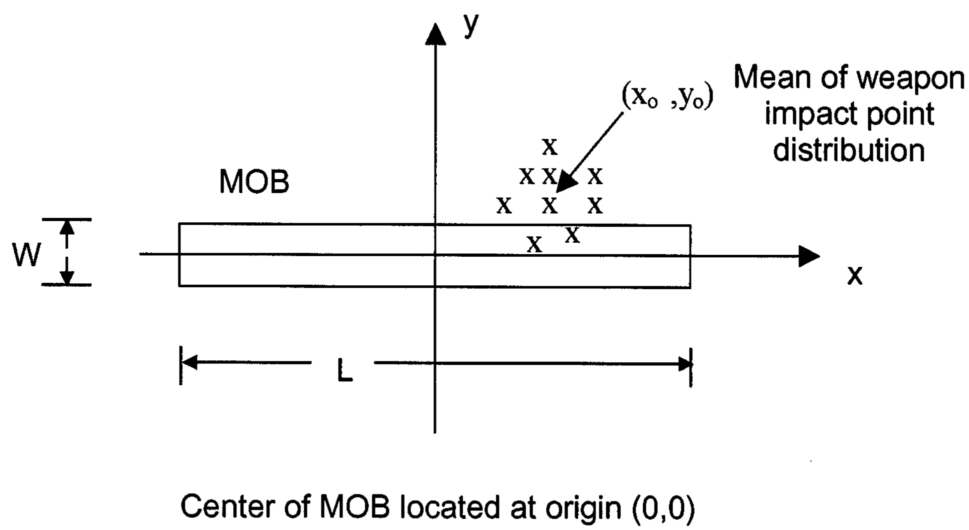


Figure 28. Model Used To Calculate the Probability of Hitting the MOB with a Ballistic Missile

The probability of hitting the MOB with a single ballistic missile is

$$P = \iint_{MOB} p(x, y)\,dxdy$$

where $p(x, y)$ is the probability density function of the weapon impact points, and the integral is taken over the surface of the MOB. We assume that $p(x, y)$ is a bivariate normal probability density function

$$p(x,y) = \frac{1}{2\pi\sigma^2} \exp\left(-\frac{(x-x_0)^2 + (y-y_0)^2}{2\sigma^2} \right)$$

where (x_0, y_0) is the mean of the impact point distribution (as shown in Figure 28), and σ ($=\sigma_x = \sigma_y$) is the standard deviation of the impact point distribution and is related to the missile CEP_m by

$$\sigma = CEP_m / 1.1774.$$

Thus, the probability of hitting the MOB in Figure 28 with a single ballistic missile is

$$P = \frac{1}{2\pi\sigma^2} \int_{-L/2}^{L/2} dx \exp\left(-\frac{(x-x_0)^2}{2\sigma^2} \right) \int_{-W/2}^{W/2} dy \exp\left(-\frac{(y-y_0)^2}{2\sigma^2} \right)$$

This equation can be numerically integrated for any given (x_0, y_0). With perfect targeting, x_0 and y_0 would be equal to zero. However, to account for targeting errors a random (x_0, y_0) was generated according to a normal distribution centered at (0,0) and with standard deviation related to the targeting CEP by $\sigma = CEP_t / 1.1774$. Thus the above equation was numerically integrated with a random (x_0, y_0), and an average was obtained over 200 random draws from the distribution for (x_0, y_0). Thus, the resulting average probability of a ballistic missile hitting the MOB is

$$\langle P \rangle = \left\langle \frac{1}{2\pi\sigma^2} \int_{-L/2}^{L/2} dx \exp\left(-\frac{(x-x_0)^2}{2\sigma^2} \right) \int_{-W/2}^{W/2} dy \exp\left(-\frac{(y-y_0)^2}{2\sigma^2} \right) \right\rangle_{(x_0,y_0)}$$

Figure 29 shows the average probability of a ballistic missile hitting the MOB as a function of the missile and targeting CEPs.

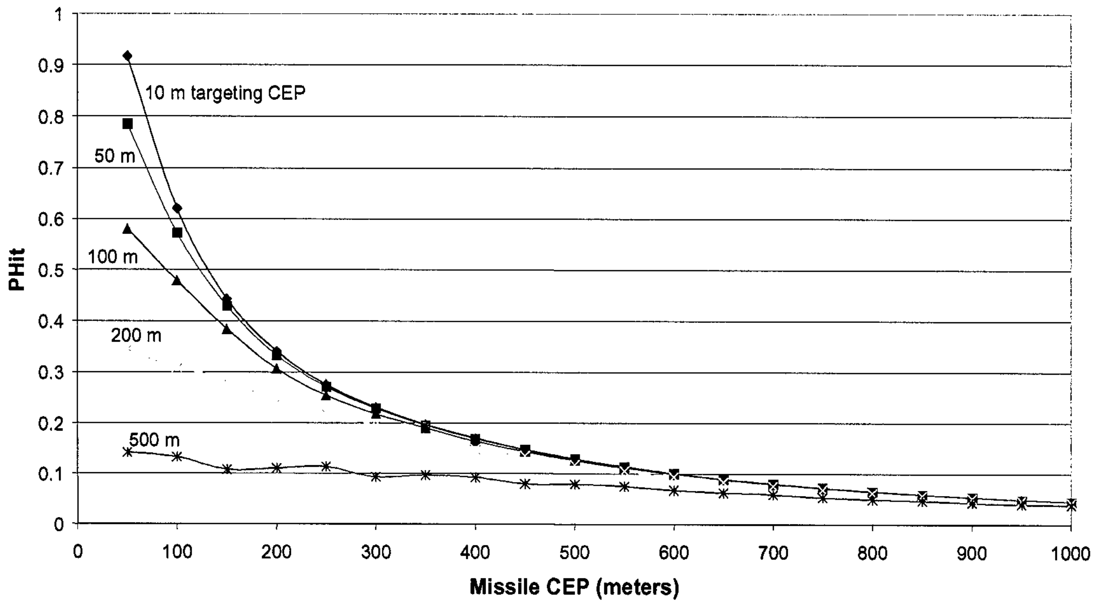


Figure 29. Probability of a Ballistic Missile Hitting the MOB

For submunition warheads, we also examined the probability of at least one submunition from a ballistic missile hitting the MOB. If the missile has S submunitions distributed randomly (x_S, y_S) within a circle centered at (x_0, y_0) and with some given dispersal radius, then for each submunition the probability of hitting the MOB is

$$P_S = \frac{1}{2\pi\sigma^2}\int_{-L/2}^{L/2} dx \exp\left(-\frac{(x-x_S)^2}{2\sigma^2}\right)\int_{-W/2}^{W/2} dy \exp\left(-\frac{(y-y_S)^2}{2\sigma^2}\right)$$

and the probability of *at least* one of the submunitions hitting MOB is given by

$$P = 1 - \prod_{s=1}^{S}(1 - P_S)$$

Figure 30 shows the average probability of at least one submunition out of 25 hitting the MOB as a function of the missile and targeting CEPs. Thus, in this scenario, at least one submunition would be almost assured of hitting the MOB. Although the submunition would be smaller than a missile warhead, it could do enough damage to interrupt operations.

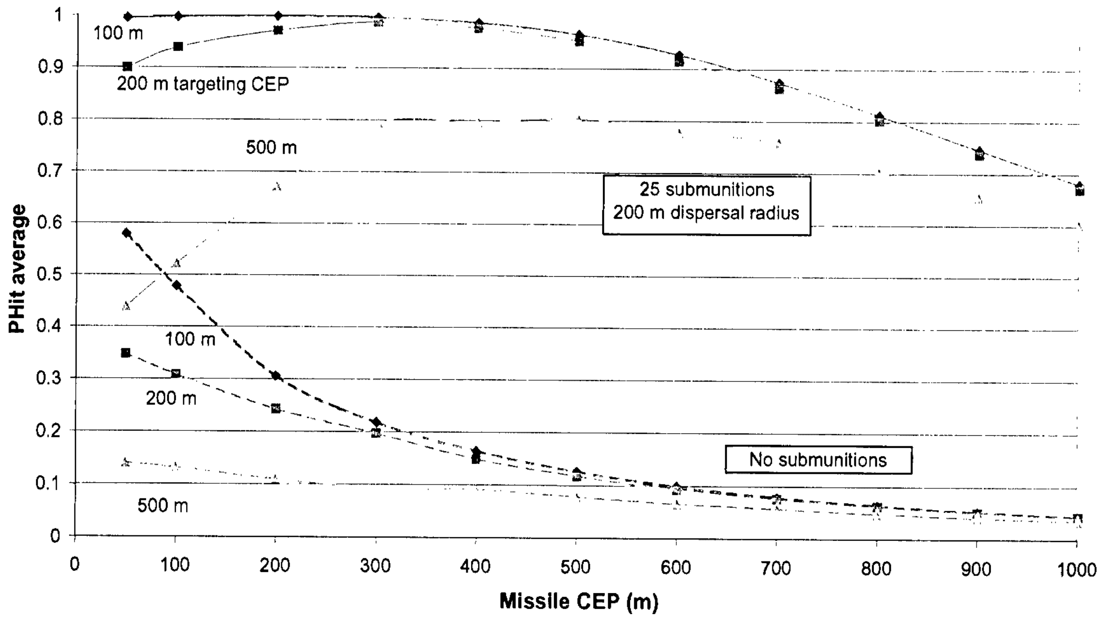


Figure 30. Average Probability of at Least One Submunition Hitting the MOB

D. EFFECT OF MISSILE HITS ON OPERATIONS

With the above estimates of the susceptibility of the MOB to being hit by a cruise or ballistic missile (with and without submunitions), we examined the possibility that a missile hit would cause sufficient local damage to halts operations. For example, sea operations would be affected by hits to RO/RO ramps, cranes, cargo ships, etc., while air operations would be affected by hits to the runway, connectors, aircraft elevators, etc. The disruption to air operations would affect mainly CTOL aircraft that rely on the long runway.

To assess the magnitude of the effect that missile hits would have on MOB operations, we first estimated the rate of missile hits that affect either CTOL air operations or sea operations according to

$$R_H = \left(\frac{Shots}{Day}\right) P_{Hit}\left(1 - P_{Intercept}\right) P_{op}$$

where R_H is the rate of missile hits that disrupt air or sea operations, P_{Hit} is the probability of a missile hitting the MOB in the absence of defenses (as discussed above),

$P_{Intercept}$ is the probability of a defensive system intercepting a missile, and P_{Op} is the probability that a missile hit affects air or sea operations. Our estimates for these parameters are shown in Table 24, where shots/day and $P_{Intercept}$ have a range of possible values. The ballistic missile was chosen to have a CEP of 450 m resulting in a $P_{Hit} = 0.15$ for targeting CEPs which could range from 10 – 200 m. Since the MOB is not likely to have sufficient, if any, organic defenses, the defensive systems used to intercept incoming missiles most likely would have to be supplied by other ships. The resulting range of values for R_H runs from a low value representing a good case for the MOB (1 shot/day and $P_{Intercept} = 0.90$) to a high value representing a bad case for the MOB (10 shots/day and $P_{Intercept} = 0.75$).

Table 24. Rate Of Missile Hits (R_H) that Disrupt Air or Sea Operations

Missile	Shots (/day)	P_{Hit}	$P_{Intercept}$	P_{Op}		R_H (/day)	
				Air*	Sea	Air	Sea
Ballistic Missile	1-10	0.15	0.75 – 0.90	0.20	0.20	0.003 - 0.075	
Submunition		0.95			0.20	0.02 – 0.48	
Cruise Missile		1			0.50	0.02 – 0.50	0.05 – 1.25

*Probability of affecting CTOL air ops.

The probability that a missile hit affects air operations can be estimated as the ratio of the area of the runway to that of the MOB weather deck. The assumption here is that a ballistic missile, submunition, or cruise missile would hit from above. For sea operations, a ballistic missile or a submunition was assumed to hit from above and to affect sea operations if it hit an area on either side of the MOB weather deck representing 10 percent of the total area of the deck (for a total probability of 0.20). The cruise missile was assumed to hit from the side and to affect sea operations if it hit the side of the upper structure of the MOB, cranes, ramps, or the landing deck for LCAC operations, representing some 50 percent of the total side profile.

In addition to the rate of missile hits that disrupt air or sea operations, the rate of repair of the resulting damage is important in determining the magnitude of the effect that missile hits would have on MOB operations. The rate of repair is simply

$$R_R = (\text{mean time for repair})^{-1}$$

Based on experience with the amount of time required for ship repair, we estimate that a 10-foot hole in the runway might take on the order of 0.5 days to repair, so R_R = 2/day for either a ballistic missile or cruise missile hit to the runway. Since a submunition would produce less damage, we let R_R = 5/day for a submunition hit to the runway. Finally, we assume the same rates of repair for the structural work required to repair damage that impairs sea operations.

With R_H and R_R for each type of missile, we can derive a method for calculating the probability that the MOB is functioning, and thus available for air and sea operations. Rather than following one MOB over time, this analysis employs a large number of identical MOBs at some fixed point in time. The relevant states that these MOBs can occupy are shown in Figure 31, where N_F is the number of functioning MOBs and N_H is the number of hit MOBs (as discussed above, R_H is the rate of missile hits that disrupt air or sea operations and R_R is the rate of repair). There is an N_H, R_H and R_R for each missile type, and the total number of MOBs is $N = N_F + \Sigma N_H$.

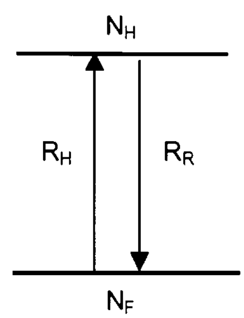


Figure 31. Relevant States for the MOB

The rates of change for the MOB states are given by

$$\frac{dN_F}{dt} = \sum_{missile}(N_H R_R - N_F R_H)$$

and, for each missile type, by

$$\frac{dN_H}{dt} = N_F R_H - N_H R_R$$

At equilibrium,

$$\frac{dN_F}{dt} = 0$$

thus,

$$\sum N_H R_R = N_F \sum R_H$$

Using the specific case of the three missile types, and substituting

$$N_H^3 = N - N_F - N_H^1 - N_H^2$$

gives

$$N_H^1\left(R_R^1 - R_R^3\right) + N_H^2\left(R_R^2 - R_R^3\right) + NR_R^3 = N_F\left(R_H^1 + R_H^2 + R_H^3 + R_R^3\right)$$

Finally, substituting in

$$N_F R_H = N_H R_R$$

from the other equilibrium relations,

$$\frac{dN_H}{dt} = 0$$

gives

$$\frac{N_F R_H^1}{R_R^1}\left(R_R^1 - R_R^3\right) + \frac{N_F R_H^2}{R_R^2}\left(R_R^2 - R_R^3\right) + NR_R^3 = N_F\left(R_H^1 + R_H^2 + R_H^3 + R_R^3\right)$$

which, upon rearranging, gives the probability that the MOB is functioning

$$P_f = \frac{1}{\sum_{missile} \frac{R_H}{R_R} + 1}$$

The data given previously for R_H and R_R are shown in Table 25, along with the corresponding probability that the MOB is functioning. Thus, in the good case (each missile has 1 shot/day and $P_{Intercept}$ = 0.90), the MOB would be functioning nearly 100 percent of the time. One the other hand, in the bad case (each missile has 10 shots/day and $P_{Intercept}$ = 0.75), the MOB would be functioning about three-quarters of the time for air operations and about one-half of the time for sea operations. These data will be used in the following chapter, which examines the overall availability of the MOB.

Table 25. Probability that the MOB Is Functioning and Available for Operations

Operation	R_H (/day)			R_R (/day)			P_f
	Ballistic	Submun.	Cruise	Ballistic	Submun.	Cruise	
Air	0.003 - 0.075	0.02 – 0.48	0.02 – 0.50	2	5	2	0.72 – 0.98
Sea			0.05 – 1.25				0.57 – 0.97

V. MOB MOTIONS AND AVAILABILITY

A. INTRODUCTION

Waves, currents, and wind cause a vessel at sea to undergo translational motions (heave, sway, and surge) and rotational motions (pitch, roll, and yaw). Perhaps the most important feature of the MOB conceptual design is the semi-submersible hull, which dramatically reduces these motions. Although a MOB module would ride on its pontoons in transit (for increased speed at the expense of reduced stability), on site it would ballast down so that its pontoons are completely submerged and its water plane area is reduced. This reduction in the area available to interact with surface waves results in reduced motion as compared to that experienced by ships or barges with similar displacements.

B. AIR OPERATIONS

The main benefit of this reduction in motion is hoped to be the capability to run a stable 1,500-meter-long runway along aligned multiple modules to enable CTOL aircraft such as the C-130 and C-17 to operate (as well as, for example, cargo transfer operations between modules). The idea is to reduce relative module motions enough to hold off the development of kinks in the runway that would interfere with aircraft operations, and to reduce the loads on connectors and DP systems so that the modules would not have to separate from one another. The design goal for the MOB is to limit its motions sufficiently to enable air operations through SS 6. This should be sufficient because, accompanying SS 6, there are other factors—including winds with 28-47 knot sustained speeds (mean: 37.5 knots) and gusts—that would likely halt air operations before MOB motions. Thus far these motions have been studied with computer models and the results are being verified using towing tanks. Eventually they would need to be confirmed at full scale.

Currently there are no alternatives that enable C-130 and C-17 aircraft to operate at sea. Thus, if the MOB's reduced motions were able to translate into an effective 1,500-meter-long runway at sea, then the MOB would be the only vessel to allow such operations. The question then would revolve around the need, both operationally and technically, for such strategic airlift operations at sea. Operationally, the overall contributions of such operations to the warfighter would need to be assessed (this is done in a subsequent chapter). Technically, the potential for the development of airlift aircraft such as the ATT and the Quad Tilt Rotor (QTR) in the future may lessen the need for long runways.

The MOB also would be capable of conducting operations with VSTOL aircraft, which currently are operated from aircraft carriers, large deck amphibious ships, etc. Although in general the MOB would exhibit reduced motions compared to these ships, this would probably not translate into any real advantages for conducting operations at sea with VSTOL aircraft. This is because winds, gusts, and other factors usually limit aircraft operations before vessel motions. Thus, the reduced motions of the MOB would not significantly increase the operating envelope for VSTOL aircraft.

C. SEA OPERATIONS

In addition to air operations, the MOB would undertake sea operations, both as a receiving "port" for large cargo ships and as a platform for loading lighterage to move cargo ashore. Here lighterage refers to LCUs or LCACs, for example, and not causeway ferries. To accomplish these objectives, the MOB would be equipped with cranes and RO/RO ramps, as well as means for docking ships and lighterage, and perhaps a platform for landing LCACs. The design goal is to enable the MOB to conduct sea operations through SS 3. This is the lowest design goal of any MOB operation.

Reaching the goal of conducting sea operations through SS 3 would be made easier by the reduced motions of the MOB. The reduced motions would provide for somewhat reduced relative motions between the MOB and ships or lighterage, and also for a stable crane platform and RO/RO discharge platform. On the other hand, some difficult issues still must be addressed. For example, the MOB may not provide a significant amount of protection from waves and wind for ships and lighterage docked alongside.[1] Indeed, the MOB does not really have a lee side, because the very purpose of the semi-submersible hull is to be "transparent" to waves. To complicate the situation

---

1 *Feasibility of Small Vessel Loading Mobile Offshore Base Technology Assessment Report,* Bechtel National Inc., in ONR report, p.B-11 to B-16.

further, computational studies have found that waves can be amplified near the columns supporting the upper deck structure. High winds would impact vessels, especially lighterage, cargo transfer operations, and crane loads. Although wind may be blocked somewhat by the columns, it also may be amplified between the columns.

If wind and waves prove to be a problem, strategies may be available to reduce the magnitude of the wind and waves near the MOB. For example, deployable walls could be located between the columns. In transit these walls would be stowed under the upper deck structure, and on site they would be deployed between the columns, reaching down below the surface of the ocean. In addition, harboring and mooring strategies could be developed that might help to reduce the effects of waves on ships and lighterage.

Thus researchers still are uncertain if the MOB would be able to conduct sea operations through SS 3. For cargo transfer from large ships to the MOB, SS 3 seems likely and operations may be able to take place to some extent even in SS 4. However, the capability of cargo transfer from the MOB to lighterage still has to be confirmed. Although the MOB provides a reduced-motion platform, it may not provide much protection for the lighterage from waves and wind (as discussed above). Even if it could do so, lighterage will continue to have difficulty operating in high SS 3 or greater on its journey to and from the MOB, and therefore would be the weak link in the ship-to-shore chain.

The benefit of conducting sea operations via the MOB would be to enable ship-to-shore cargo transfer operations in the absence of viable ports. Cargo would be unloaded from a large cargo ship onto the MOB, and then transferred to lighterage that would move the cargo ashore. An alternative method for conducting ship-to-shore cargo transfer operations in the absence of a port is JLOTS. The MOB and JLOTS alternatives are shown schematically in Figure 32. JLOTS consists of a number of assets, including the Auxiliary Crane Ship (T-ACS), the RO/RO Discharge Facility (RRDF), the Offshore Petroleum Discharge System (OPDS), and lighters and causeways, which allow containerized cargo, military vehicles, and fuel to be transferred from ships anchored offshore to the beach.

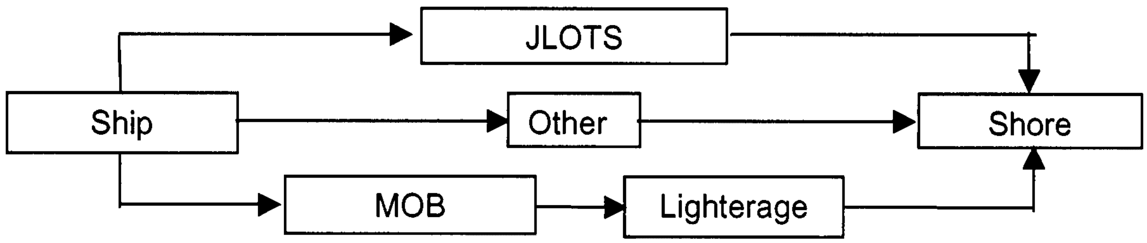


Figure 32. Alternatives for Ship-to-Shore Sea Operations in the Absence of Ports

Currently JLOTS operations are limited to SS 2, mainly because of the relative motion at the interface between the large ships and the JLOTS assets. However, the Navy, the Army, and DARPA are developing new technology with the goal of expanding JLOTS capability through SS 3 by 2005.[2] These R&D programs are leading to the development of motion-controlled cranes; more stable RO/RO discharge platforms, lighters, and causeways; fendering, mooring, and ramp interfaces to reduce the motion at the interface between the large ships and the JLOTS assets; better means of controlling ship heading; and methods such as the rapidly installed breakwater (RIB) to mitigate sea conditions. Much of this new technology looks promising, though work is still underway to determine if it will enable JLOTS to conduct ship-to-shore cargo transfer through SS 3.

In comparing the capabilities of JLOTS and the MOB in conducting ship-to-shore cargo transfer operations, the reduced motions of the MOB do not seem to provide it with more capability than JLOTS if both are able to conduct operations through SS 3. The problem for the MOB is that even if its reduced motions combined with strategies for sheltering lighterage enable cargo transfer to be conducted in higher sea states than that possible with JLOTS, the lighterage still would have difficulty on its journey to and from the MOB, and therefore would be the weak link in the chain from ship to shore. Furthermore, the MOB may even be at a disadvantage because, compared to JLOTS, it may have to be much further out from the shore due to its deep draft (about 35 to 42 meters) and its vulnerability. If this were the case, the MOB would force long lighterage transit and cycle times, would potentially operate in worse sea conditions, and would make difficult the task of pumping fuel ashore via underwater pipes.

---

2 "Joint Logistics Over the Shore Operations in Rough Seas" T. G. Vaughters and M. F. Mardiros, NSWCCD, *Naval Engineers Journal*, 385, May 1997.

To summarize thus far, the ability of the MOB to operate on site with reduced motions in response to waves and wind is one of its key benefits. This ability would be quite valuable in establishing a long runway at sea to enable air operations for CTOL aircraft such as the C-130 and C-17. Whether or not this is important depends on whether or not heavy airlift operations are required at sea and, if so, whether or not the future brings aircraft (e.g., the ATT and QTR) that could provide the heavy airlift capability without the need for a long runway. Besides these CTOL operations, however, the reduced motions of the MOB do not appear to provide a significant benefit to air and sea operations. This is because weather affects aircraft and lighterage directly and this usually limits operations before platform motions become an issue.

D. MOB AVAILABILITY

Assuming the design goals of enabling air operations though SS 6 and sea operations through SS 3 could be achieved, the fraction of time that air and sea operations would be available (due to sea state and weather conditions only) can be determined given the probability of sea state occurrence. Thus, the availability of MOB air operations, that is, the fraction of time that air operations could take place, would be equal to the probability of occurrence of SS 6 or better conditions. Likewise, the availability of MOB sea operations would be equal to the probability of occurrence of SS 3 or better conditions.

Table 26 gives the probability of sea state occurrence in open ocean. From this we can estimate that, in open ocean, MOB air operations would be available 92 percent of the time and MOB sea operations would be available 27 percent of the time. Given that open ocean conditions are among the most severe, these availabilities fall toward the lower end of the range of availabilities for MOB operations. Alternatively, the upper end of the range is represented by the fraction of time that MOB operations could take place in more sheltered waters. For example, the probability of sea state occurrence in the Sea of Japan[3] would allow for air operations to be available 100 percent of the time and sea operations 50 percent of the time. Note that although air and sea operations may be *available* for a certain fraction of time, this does not imply that they necessarily could be

---

3 *Example Application of Preliminary Operational Availability Model for MOBs*, Fig. 3-6, Bechtel National, Inc., September 1998.

operating at full *capacity* throughout the time that they are available. For example, throughput is likely to decline as sea state increases.

Table 26. Probability of Sea State Occurrence in the Open Ocean (Average for North Atlantic and North Pacific)

Sea State	Significant Wave Height (m)		Probability
	Range	Mean	(%)
0 – 1	0.0 - 0.1	0.05	1.0
2	0.1 - 0.5	0.3	6.6
3	0.5 - 1.25	0.88	19.6
4	1.25 – 2.5	1.88	29.7
5	2.5 – 4	3.25	20.8
6	4 – 6	5.0	14.1
7	6 – 9	7.5	6.8
8	9 – 14	11.5	1.3

Source: *Preliminary MOB Classification Guide,* American Bureau of Shipping, December 1999.

A more detailed assessment of sea states can be seen in Table 27. In this table the wave heights and gale probabilities are shown on a monthly basis for selected coastal regions. In general, the winter months are the worst. The exception is the India-Pakistan area where monsoons make the summer months the worst.

Table 27. Wave Heights and Gale Probabilities of Selected Coastal Regions

Month	Persian Gulf	India/Pakistan	Yellow Sea	Sea of Japan	Taiwan Straight	East Coast Taiwan
Jan	0.6/0.6 1%	0.6/0.8 0%	1.1/0.7 2%	1.5/1.0 3%	2.2/1.4 8%	2.1/1.2 3%
Feb	0.8/0.8 0%	0.5/0.7 0%	1.1/0.7 1%	1.3/0.6 3%	2.4/1.6 4%	1.8/1.0 2%
Mar	0.8/0.7 0%	0.6/0.6 0%	0.9/0.9 1%	1.2/0.9 1%	1.9/1.5 5%	1.8/1.0 4%
Apr	0.6/0.7 0%	0.6/0.5 0%	0.7/0.6 0%	1.0/0.7 1%	1.4/1.1 2%	1.4/1.0 1%
May	0.7/0.7 0%	1.1/0.5 0%	0.6/0.6 0%	0.7/0.6 0%	1.1/0.9 1%	1.2/0.8 0%
June	0.6/0.6 0%	1.9/0.9 0%	0.6/0.5 0%	0.9/0.8 0%	0.8/0.6 0%	1.2/0.7 0%
July	0.4/0.5 0%	2.1/1.0 3%	0.9/0.7 0%	0.7/0.6 1%	0.9/0.7 1%	1.1/1.1 0%
Aug	0.4/0.5 0%	1.9/0.8 0%	0.9/0.7 0%	0.7/0.6 0%	0.7/0.7 2%	1.2/0.9 0%
Sept	0.4/0.5 0%	1.0/0.7 0%	0.9/0.8 0%	1.1/0.9 0%	1.5/1.2 3%	1.8/1.4 0%
Oct	0.4/0.5 0%	0.5/0.6 0%	0.9/0.7 1%	1.0/0.8 0%	2.2/1.5 9%	2.0/1.4 6%
Nov	0.6/0.7 0%	0.6/0.5 0%	0.8/0.7 1%	1.2/1.0 1%	2.5/1.6 12%	2.2/1.4 4%
Dec	0.7/0.7 0%	0.6/0.5 0%	1.0/0.8 1%	1.4/0.8 6%	2.5/1.6 10%	2.1/1.3 3%

Notes: 1. Wave data quoted in mean/std dev format.
2. All heights are in meters.
3. Gale probability is the probability of SS 8 or higher.
4. Quoted data are based on a typical coastal region (grid cell) measuring $5^0 \times 5^0$.
5. Source: *U.S. Navy Marine Climatic Atlas of the World*, v. 1.1, by Fleet Numerical Meteorology and Oceanography Detachment, Asheville, NC, August 1995.

In general, the availability of MOB air and sea operations, that is, the fraction of time that these operations could take place, is dependent not only on sea state and weather conditions, but other factors as well. For example, the previous chapter examined the probability that a missile hit would cause local damage and result in downtime while the damage was being repaired, and calculated the percentage of time the MOB would be functioning and thus available for air and sea operations. Other issues, not explicitly considered in this report, include system reliability, maintenance downtime, and training commitments.

Taking the contributions from weather and vulnerability only, the overall availability can be obtained as

$$A = P_w P_f$$

where P_w is the probability of satisfactory weather and P_f is the probability that the MOB is functioning. Using the estimates given above for the probability of satisfactory weather and the estimates given in the previous chapter for the probability that the MOB is functioning, we can obtain estimates for the overall availability for air and sea operations as shown in Table 28. For both air and sea operations the table shows a "high" and "low" point on the range of availabilities. As discussed above, open ocean conditions represent the lower end for the probability of satisfactory weather, and the conditions in more sheltered waters, specifically the Sea of Japan, represent the upper end. As discussed in the previous chapter, the low end for the probability that the MOB is functioning is represented by each of three missiles having 10 shots/day and $P_{Intercept} = 0.75$ and the high end is represented by each missile having 1 shot/day and $P_{Intercept} = 0.90$. The values shown in Table 28 for the overall availabilities will be used in the following chapter.

Table 28. Overall Availability Due to Weather and Vulnerability

Operation	Case	P_w	P_f	Availability
Air	Hi	1.00	0.98	0.98
	Low	0.92	0.72	0.66
Sea	Hi	0.50	0.97	0.48
	Low	0.27	0.57	0.15

VI. LOGISTICS THROUGHPUT WITH A MOB

The MOB is envisioned as an area of sovereign U.S. territory that can act as a base of operations. A potential role for a MOB would be logistics operations, both deploying or supporting units ashore. Figure 33 illustrates many of the logistics activities that might be associated with a MOB.

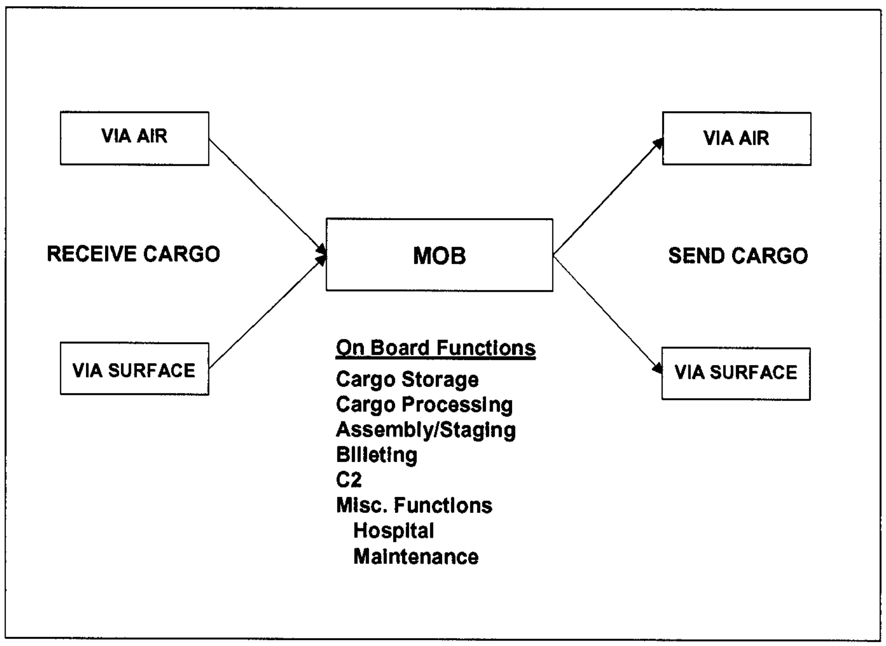


Figure 33. Illustrative Schematic of MOB Logistics Operations

The general functions that might be performed are primarily determined by the facilities located on a MOB. For example, the ability to act as an in-theater hospital is not inherent in the MOB itself, but requires the dedication of space, equipment, and medical personnel to that function. However, the *magnitude* of functions supported by a MOB will be dependent on (and perhaps limited by) both the size and configuration of the structure, as well as details of its operational employment. Three inherent factors critical to a MOB's utility as a logistics platform are listed below.

- The physical size of the MOB, which will determine the space available for operations as well as the types of systems that can operate from the platform
- The ability to receive, handle, and stow cargo and receive and support personnel at a MOB prior to deployment ashore or operations from the MOB itself
- The ability to move cargo and personnel to their in-theater destinations from a MOB platform.

Collectively, the latter two define the logistics throughput for a MOB, although adequate space for cargo movement, configuration, and loading can also be important to throughput. Logistics throughput is, therefore, influenced by the specific characteristics of the MOB (e.g., MOB length determines what aircraft types can be used), by the performance of other systems necessary to accomplish the various missions (e.g., landing craft speeds and payloads can limit the ability to move cargo ashore from a MOB), and by external constraints particular to a given scenario (e.g., geographic or threat concerns can limit the ability to position the MOB in a desired location). This chapter assesses the potential productivity or capacity of a MOB in the role of a logistics base. The next chapter puts this into context with an assessment of how a MOB might support specific forces. At that point, issues such as the balance between storage capacity, rate of arrivals, and rate of departures become important.

A. OPERATIONAL LIMITATIONS IMPOSED BY THE PHYSICAL DIMENSIONS OF A MOB

The physical dimensions of a MOB limit both the types of craft (especially aircraft) that can be operated as well as the magnitude of operation that can be conducted. Since the primary roles envisioned for a MOB are those of an airfield and a staging base independent of foreign control, two dimensions of great interest are runway length and overall space available that can be configured for desired logistics base operations. In this section we briefly describe how the size of a MOB might limit the operations conducted thereon.

1. Limitations Due to Runway Length and Deck Area

Runway length and deck area determine the types of aircraft that can operate from a MOB and the number that can do so simultaneously. Because of its modular design, several runway lengths might be possible for a MOB. Using the McDermott five-module design as a representative configuration, runway lengths of 1,000 feet to 5,000 feet are possible. Figure 34 illustrates which aircraft types can operate from a MOB of different lengths.

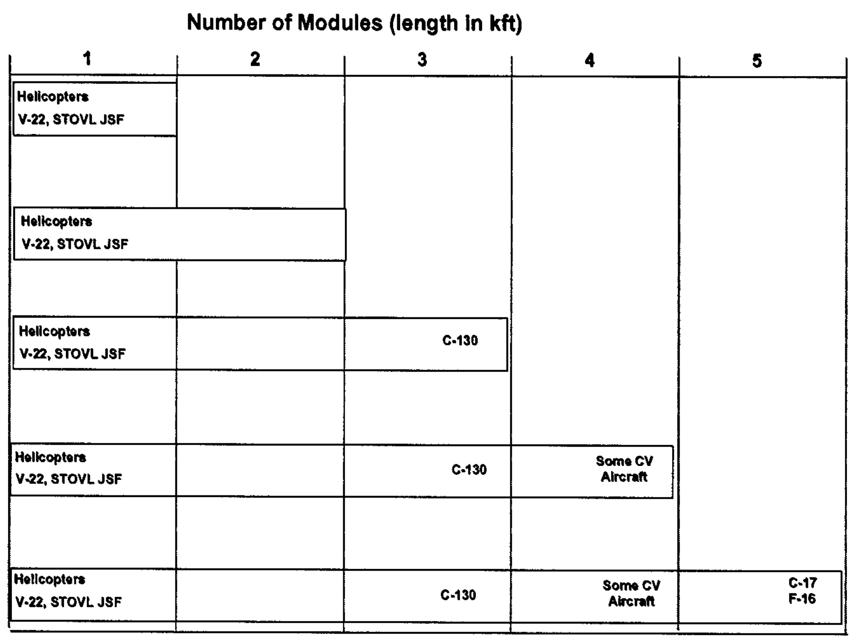


Figure 34. Aircraft Operations vs. Runway Length

In this chapter we are concerned with transport aircraft. A single-module MOB would be limited to helicopter or V-22 operations. Since these aircraft have relatively short ranges, single module MOB air operations would probably consist of only MOB-to-shore movement. Air movement of cargo to the MOB from distant bases or CONUS would be impractical if not impossible, although a single module could still receive cargo from sealift ships.

At three modules, C-130 operation becomes possible on a MOB. This increases the flexibility to receive air cargo, perhaps from intermediate near-theater staging bases. At 5,000 feet a MOB can receive air cargo or passengers from CONUS via C-17 aircraft.

Given the inefficiencies of large-scale cargo transfer at intermediate bases, any air cargo arrival of significant volume will likely be limited to the C-17, with the possibility that small quantities of special cargo might arrive by C-130. Consequently, we limited our detailed assessment of airlift arrivals to the C-17 and a 5,000-foot MOB.

At 5,000 feet in length and 500 feet in width, a MOB would have a deck area of about 2.5 million square feet. McDermott has estimated that 10 C-17s could be simultaneously serviced on a MOB while maintaining an open runway. Alternatively, large numbers of small aircraft such as helicopters could be supported. Although an exact number would depend on the final deck configuration, for comparison, an LHA-class amphibious assault ship with a deck area of about 90,000 square feet has 10 operational spots for helicopter operations. The MOB may also have provisions such as elevators for moving aircraft to hanger space below the flight deck. C-17s and C-130s are probably too large for such accommodation. In actual practice, some balance of flight deck space allocation to arriving and departing aircraft will need to be established.

For fixed-wing operations, the width of the MOB is probably inadequate for a runway, parallel taxiway, and services areas. Consequently, the C-17 and C-130 will probably have to use the runway for taxiing, which could constrain the frequency of takeoffs and landings.

2. Limitations Due to Availability of Configurable Space

The availability of space below the flight deck is not a likely limit to pure logistics operations on a MOB. The McDermott MOB design has an estimated configurable area of about 1 million square feet *per module.* To put this into context, Table 29 lists the areas nominally associated with a wide variety of military systems and units.

Table 29. **Areas Provided or Required by Military Systems/Units**

System/Unit	Space (sqft)
MOB Module	~1,000,000
MPS Ship (T-AK)	150,000 (RO/RO)
LMSR (T-AKR)	380,000
MEB (stow)	620,000
Mechanized Div. (stow)	1,700,000
Heavy ACR	525,000

A multiple-module MOB will easily have adequate space to support large units and operations. However, just having the space is not enough. The space must also be configured with the appropriate climate control, power, lighting, etc., in order to make it more useful than a large, dark, metal cave. As the size of supported units increases, billeting for the personnel involved will increase also. With adequate area available, configurable space on a MOB becomes a cost issue.

B. ABILITY TO RECEIVE CARGO AND PERSONNEL ON A MOB

As a logistics base, a MOB must be able to receive cargo and personnel that arrive in theater via strategic lift. Even if a MOB is envisioned primarily as a prepositioned force asset, it will need the capability to receive personnel and selected equipment in the event the prepositioned force is activated.

The ability to receive cargo must be balanced by the ability to either store it or move it ashore. The ultimate logistics utility of a MOB is primarily measured by its ability to project assets ashore. This may be limited by MOB-to-shore movement rates, in which case arrivals at the MOB must be slowed, or by the ability to receive cargo, in which case departures ashore would be constrained. In this section we look specifically at arrival rates. The next section addresses MOB-to-shore movement. Chapter VII will assess the balance that might be possible between reception, storage, and forward movement of cargo and personnel from a MOB in the context of possible logistics scenarios.

Cargo and personnel can arrive at a MOB by two primary means: sealift and strategic airlift. The rate at which cargo can be received is dependent on several factors, the most important of which are the number of arriving ships and aircraft that can be simultaneously unloaded, the rate at which they can be unloaded, and the fraction of the time the MOB is available for reception and unloading. The last of these factors—MOB availability—was detailed in Chapter V. Chapter VII merges the effect of productivity and availability in an assessment of possible scenario timelines.

1. Sealift Arrivals

Most MOB designs have accommodations for berthing and unloading large sealift ships. These accommodations include large cranes for unloading standard shipping containers or general break-bulk cargo, plumbing for receiving bulk fuel from tankers, plus platforms and ramps for unloading vehicles from RO/RO ships. Cargo handling at sea, even to and from a platform as stable as a MOB, will probably require special equipment to compensate for relative ship-MOB motions. The engineering community views such developments as within current technical capabilities.

a. Number of Ship Berths

The number of individual ship berths will depend on the number and location of cranes and ramps that are ultimately installed on the MOB. However, the dimensions of the MOB provide a rough upper bound. The MOB is generally envisioned to be about 5,000 feet long. This length will limit the number of ships that might be berthed on each side. Table 30 shows the dimensions of the primary sealift ship classes currently used by the Military Sealift Command. These ships range in length from 615 to 956 feet.

Table 30. Dimensions of Military Sealift Ships

Ship Type	Length (ft)	Beam (ft)
MPS Ships (T-AK)	675-821	90-105
LMSR (T-AKR)	906-956	106
LASH (T-AK)	820-893	100-106
FSS (T-AKR)	946	106
Transport Tanker (T-AOT)	615	90

Although actual MOB operational concepts have not been formulated, an upper limit of three ships per side of the MOB seems likely. In principle, for a five-module MOB, one ship per module could be positioned alongside. However, at five to a side there would be little separation between the larger sealift ships; maneuvering a ship into such a confined space would be difficult and might actually require assistance from tugs.

Figure 35 illustrates these situations for a five-module MOB and larger (T-AKR sized) MSC ships.

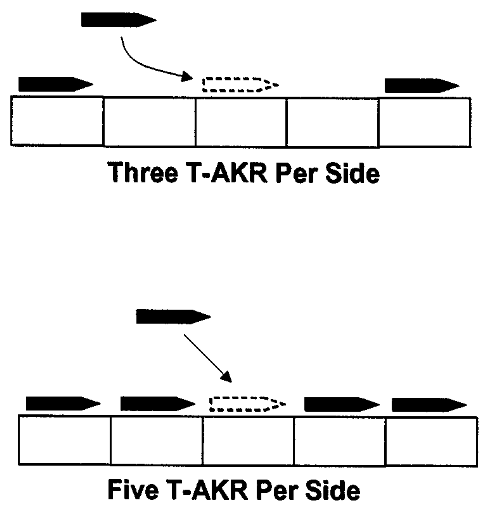


Figure 35. Sealift Ships (T-AKR) Approaching a MOB

Movement of the MOB relative to an approaching ship would further complicate docking maneuvers. In a port, the pier is stationary and harbor currents are usually quite predictable. The MOB will most likely be stationed in one location or move slowly in a direction favorable to both air operations and platform stability. This could create a moving target for approaching ships, resulting in a tricky parallel parking problem. Even if the MOB were to drift with the wind and ocean current, its deep draft and large sail area would almost certainly result in a relative drift significantly different from an approaching ship. Additionally, ships moored alongside a MOB will have to conform to its movement, creating further incentive for a safe separation between ships.

An additional question is whether sealift ships will be allowed to moor on both sides of a MOB. To provide adequate tarmac and taxiway space for large-fixed wing aircraft, the MOB runway will be located to one side of the upper deck. With an approximate height of 100 feet above the water, the MOB's runway will be below the 120- to 150-foot mast height of many sealift ships. Their masts and perhaps their superstructures could become obstacles positioned just off the side of the runway. This potential geometry is illustrated in Figure 36. Given the wingspan of the C-17, landings off the runway centerline could risk collision with ships moored alongside.

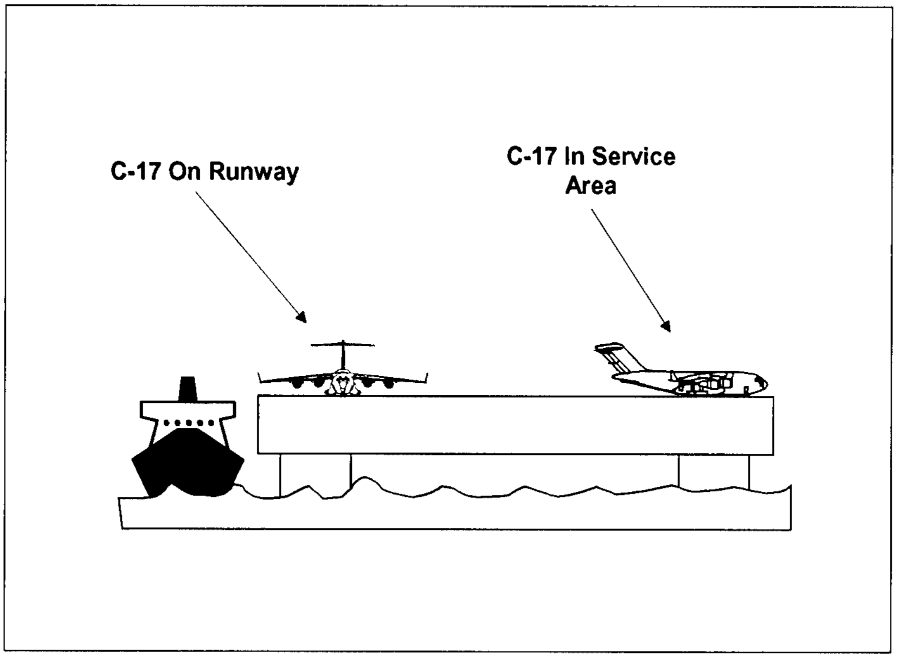


Figure 36. Schematic End View of MOB with Docked Ship(s)

A detailed analysis by the Boeing Company, however, determined this risk to be negligible.[1] Boeing used the International Civil Aviation Organization's (ICAO) Collision Risk Model to estimate the probability of collision given a missed Category II instrument landing system (ILS) approach. The study found the risk to be well below already stringent standards for land airfields.

Another limitation to ship berthing is the need to simultaneously execute MOB-to-shore operations with surface craft. Barring the development of revolutionary new airlift aircraft, some surface movement of cargo to the shore will be necessary if an operation of significant size is to be supported ashore (See Section C in this chapter).

---

1 *Analysis of the Collision Risk for Aircraft Operation On a Mobile Offshore Airfield*, J. Polky and J. Held, The Boeing Company, presented at the Marine Facilities Panel Conference, October 1998.

Loading and launching the necessary lighterage will consume mooring space. Specific details of the space required will depend on the specifics of the operation being supported.

b. Ship Unloading Rate

Unloading cargo from a MOB will be dependent primarily on the type of cargo being handled (e.g., containers, vehicles, break bulk), the capacity of cranes and other cargo handling equipment provided to remove cargo from the ship, and the ability of systems on the MOB to move the cargo away for storage or transfer to shore-bound craft. Table 31 shows some nominal offload rates for ships at land ports. These figures are representative of ports with adequate cargo handling equipment plus adequate means of efficiently moving unloaded cargo away from the pier to either storage areas or the cargo's final destination. Consequently, they should be considered an upper bound to a potential MOB capability. Rates of thousands of tons and hundreds of vehicles per day should be achievable by a MOB if several ships can be simultaneously unloaded. By comparison, Desert Shield/Storm cargo ship deliveries averaged 42,000 tons per day.

Table 31. Nominal Rates for Unloading Ships at a Well-Equipped Port

Cargo Type	Offload (per day)	Approx. Time per Ship (days)
Container	1,000-1,500 TEU	1-2
Break Bulk	1,000-1,300 ston	3-4
Vehicles (on RO/RO)	400-1,000 vehicles	2-3
Bulk POL	80-100k bbl	~2

Future operations are likely to predominantly consist of vehicle and containerized cargo. Although final MOB cargo handling provisions have not been established, there have been proposals for up to two heavy cranes on one side of a module, and the size of a MOB makes provisions for multiple RO/RO ramp interfaces very feasible. Since actual unloading rates may hinge on the rate at which cargo can be moved ashore, the implications of specific rates will be discussed in the summary at the end of this chapter where they can be compared to estimates for MOB-to-shore throughput.

2. Airlift Arrivals

Airlift arrivals to a MOB positioned intercontinental distances from CONUS will primarily consist of C-17 strategic airlift carrying time critical cargo and possibly large numbers of passengers to link up with any unit equipment prepositioned on the MOB. At the current time, other strategic airlifters such as the C-5, and commercial cargo aircraft like the Boeing 747-400F require runways significantly longer than the 5,000 feet available on the MOB. Smaller airlifters such as the C-130 are inefficient for carrying cargo transoceanic distances. Concept aircraft like Boeing's ATT might have a limited transoceanic capability. However, these aircraft are not part of current plans for the future airlift force, and even if developed and procured, would be in high demand for their primary role of intratheater transport, perhaps even as MOB-to-shore carriers. Our analysis will focus on C-17 operations as by far the most likely for time-critical strategic cargo and passenger movement to a MOB.

Assuming that adequate cargo or passengers are available for transport, the arrival rate of C-17s at the MOB is dependent on the number and performance of C-17s assigned to the operation, the location of the MOB relative to initial cargo locations (usually CONUS), and the ability of the MOB to receive and unload the aircraft.

The number of C-17 aircraft assigned to the mission and the length of the airlift cycle determine the maximum arrival rate possible at a MOB. Figure 37 shows possible airlift cycles for the two primary MTW scenarios in the Defense Planning Guidance (DPG).

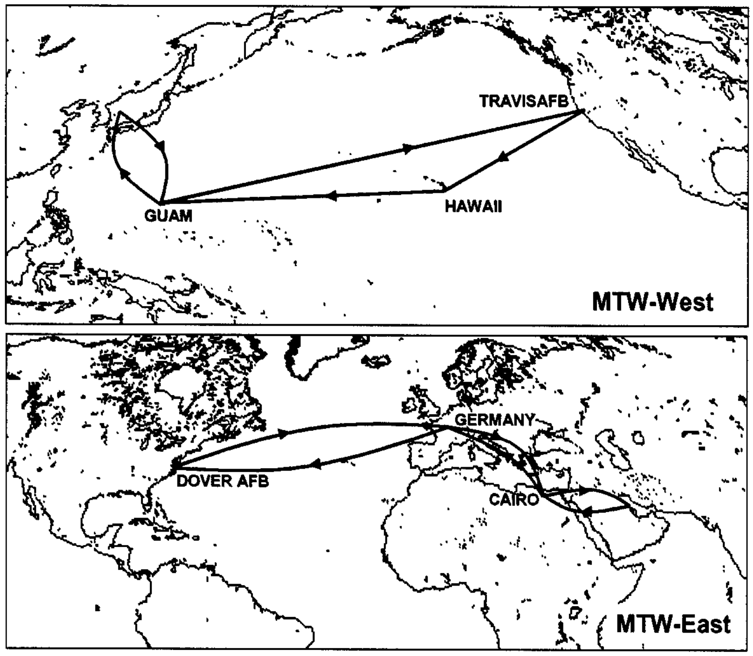


Figure 37. Representative MTW Airlift Routes

Assuming standard C-17 ground times, the roundtrip time for a C-17 to either of these theaters is approximately 2 days, i.e., each C-17 could deliver a load every other day. However, even if all C-17s (approximately 92 out of a total 120 when depot maintenance is considered) are committed to the operation, the fleet-wide utilization rate of the C-17, which captures factors such as crew availability and aggregate aircraft reliability, constrains the fleet to an average of one delivery per aircraft in the fleet every 2.5-3 days. With this range of arrival rates, three to four aircraft, on average, would be unloading or receiving service on the MOB. The space available on a MOB could certainly handle this traffic. For example, McDermott estimates a Maximum on Ground (MOG) capacity of 10 C-17s on its MOB concept. If adequate material handling, fueling, and servicing provisions were provided, the C-17 flow would not be constrained at the MOB. Indeed, significant deck space would remain for the servicing of other aircraft (e.g., MOB-to-shore aircraft).

With an average payload of 42 tons, and with the 92 available C-17s dedicated to MOB deliveries, the maximum delivery rate to a MOB for the two DPG MTW scenarios would be 1,300-1,500 tons/day. If passenger missions only are flown, 3,400-3,600

PAX/day. By comparison, if the entire military airlift fleet plus the Civil Reserve Airlift Fleet (CRAF) were delivering cargo to unconstrained bases in the DPG MTWs, a delivery rate of about 4,400 tons per day could be expected, nearly three times that for C-17s alone.

A hybrid case, with C-5s, some C-17s, and CRAF aircraft flying cargo from CONUS to an intermediate base (Guam and Cairo in our notional routes), followed by transfer to the remaining C-17s for the final movement to the MOB, might boost throughput from 1,400 to about 3,100 tons/day. In this case, a maximum service capacity of 10 C-17 aircraft at a time on the MOB would be the constraining factor. If half the deck were required for other air operations, the hybrid case's throughput would drop back to about 1,600 tons/day, little more than the C-17-only case. The hybrid case has the disadvantage of adding an unload/load cycle at the intermediate base. Additional investments in material handling equipment would probably be necessary for the hybrid scenario. Figure 38 summarizes each of these cases for different MOG assumptions.

		Basic Cycle	MOB Only	Hybrid
No MOG Restriction	Cargo Flow (Tons/PAX per day)	4,400/ N/A	1,400/3,400	4,000/9,700
	MOG for C-17 @ MOB	N/A	4	13
All MOG at MOB used by C-17 (Surface craft to shore)	Cargo Flow (Tons/PAX per day)	4400/ N/A	1,400/3,400	3,100/7,500
	MOG for C-17 @ MOB	N/A	4	10
Half MOG at MOB used by C-17	Cargo Flow (Tons/PAX per day)	4400/ N/A	1,400/3,400	1,600/3,900
	MOG for C-17 @ MOB	N/A	4	5

Figure 38. Strategic Airlift Delivery Rates to a MOB (Nominal DPG MTW Locations)

In no case can a single MOB meet the strategic airlift reception capacity currently envisioned for an MTW-sized conflict.

C. ABILITY TO DELIVER CARGO AND PERSONNEL FROM A MOB

As with strategic arrivals, MOB-to-shore movement can be accomplished with either surface lift or airlift. Airlift has the advantage of speed plus the ability to place cargo and troops at inland objectives. Surface lift, although slower, can usually carry larger loads, especially heavy vehicles such as tanks that cannot be lifted by existing tactical airlift aircraft.

The total MOB-to-shore throughput will be the sum of the air and surface throughputs. These are assessed separately in the following sections. In this portion of the chapter, we focus on *per-vehicle* throughput, for example, how many tons per day on average could one V-22 move to an objective 200 nmi from the MOB. Total MOB-to-shore throughput is, of course, dependent on the number of vehicles that are or that can be committed to the operation and the number that can be operated on the MOB conjointly with other MOB operations. This is discussed later in the report.

1. MOB-to-Shore Airlift

For airlift arrivals to a MOB we were able to focus on a single aircraft, the C-17. For MOB-to-shore movement, a wide variety of both rotary- and fixed-wing aircraft, from the small UH-60 Blackhawk up to the C-130 or C-17, might be employed. Additionally, future aircraft such as Bell's proposed QTR or Boeing's ATT might operate from a MOB. The QTR is a C-130-sized aircraft with four propellers. The propellers are positioned at each end of a forward and aft wing, with nacelles that rotate like those of the V-22 for transition from vertical to horizontal flight. The ATT is envisioned to have an outsize capable cargo compartment, and four turbo prop engines mounted on a wing that can be tilted to a higher angle of attack for low speed approaches into short runways. A brief overview of the aircraft we considered is shown in Table 32. These data, as with subsequent vehicle performance data, are approximate. Actual combat performance ultimately depends on a wide array of situation specific parameters such as temperature, wind direction, safe ingress and egress routes, etc. Our intent here is to merely estimate the magnitude of throughput ashore that might be obtained from an off shore base such as a MOB.

Table 32. Characteristics of Tactical Transport Aircraft

	MV-22	CH-53E	CH-60	CH-47F	C-130	QTR	ATT
Speed (kts)	215	130	130	130	220	220	220
Payload (stons)	7.3	15	4.5	10	13	15	15
Number of PAX	24	37	11	33	92	80 (est.)	100 (est.)
Radius (nmi)	520	500	110	130	1,500	1,000	1,200
Approx. Inventory	360	172	Many	300-480	500	--	--

Characteristics for nominal conditions. Payloads may be for missions shorter than radii shown. Actual performance will vary with specific situation.

Of the aircraft listed, all but the C-130 and the ATT have vertical take-off and landing capability. This renders their operation independent of MOB length, and independent of airstrips ashore. They only require a suitable area in which to set down. The C-130 and ATT would require access to small unimproved airstrips or straight stretches of roadway. Neither would require a full 5,000-foot MOB.

The productivity of aircraft operating between a MOB and shore depends on the range-payload characteristics of the aircraft, the distance between the MOB and the objective, and the availability of the aircraft. Availability encompasses factors such as reliability, service times, and crew availability. The results shown here assume there is no MOB down time due to poor weather or enemy attack. We capture the impact of availability—with standard Service planning factors for these parameters—in the next chapter's force-level assessment

In the context of operating from a MOB, range payload characteristics are of particular importance for these aircraft. As sortie distances approach the maximum range of the aircraft, the payload that can be carried to those ranges drops rapidly. As an example, Figure 39 shows the range payload curve for two large helicopters, the Navy/Marine Corps CH-53E and the Army CH-47.

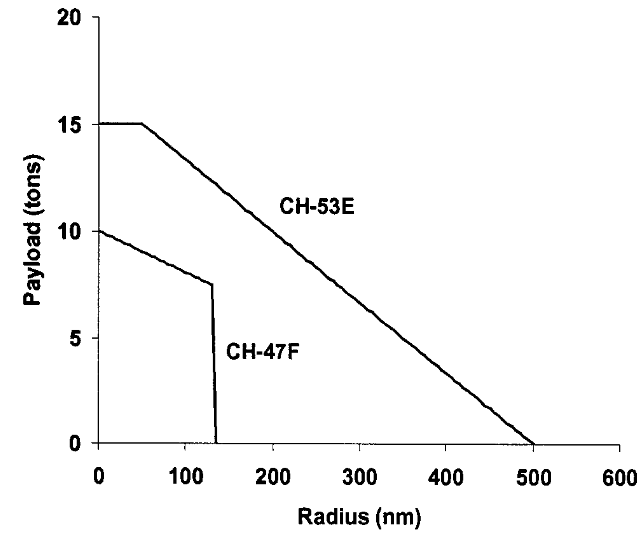


Figure 39. Range-Payload for CH-53E and CH-47F

Since the MOB-to-objective (and even the MOB-to-shore) distance is situation specific, we present our throughput results as a function of range. Figure 40 summarizes the daily productivity of the different MOB-to-shore aircraft. These totals assume 12-hour-per-day operations, and no suspension of operations due to external factors such as poor weather. (Twelve hours per day is an optimistic assumption. For sustained operations, some argue 6-8 hours per day is more realistic.) Although the MOB itself will probably provide an area suitable for 24-hour operations, landing areas ashore are likely to be very austere and hence less well suited to round-the-clock operation. Additionally, crew rest requirements might limit the length of time 24-hour operations, if practical, could actually be sustained.

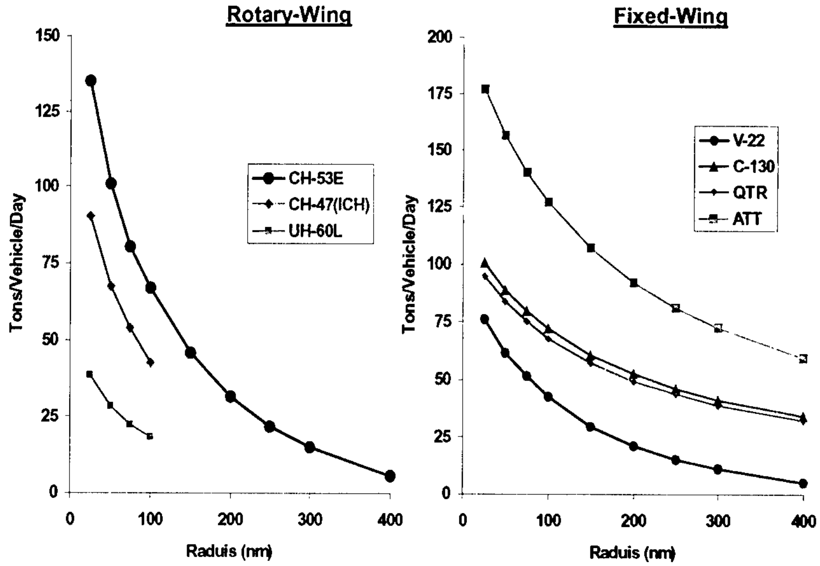


Figure 40. Daily Cargo Throughput for MOB-to-Shore Aircraft

At ranges of about 100 nmi, throughputs of about 50-100 tons per day are achieved for most of the tactical transport aircraft we considered. The ATT does significantly better, but it is only a concept aircraft at this time. Conversely, the Army helicopters are right at the limit of their range in this case. These aircraft were designed to operate over distances scaled to the ground units they support rather than long hauls from bases positioned out at sea. In general, MOB standoff range and the distance inland forces can be inserted, supported, or extracted will be constrained by the ranges of the supporting aircraft.

Passenger delivery rates follow a similar behavior as a function of range, and are shown in Figure 41. Although we show possible passenger throughput for each of our aircraft types, in practice some aircraft types would be favored as passenger carriers. For example, in a Marine Corps scenario, the CH-53E would probably be primarily assigned. cargo missions while V-22s would carry most of the Marines.

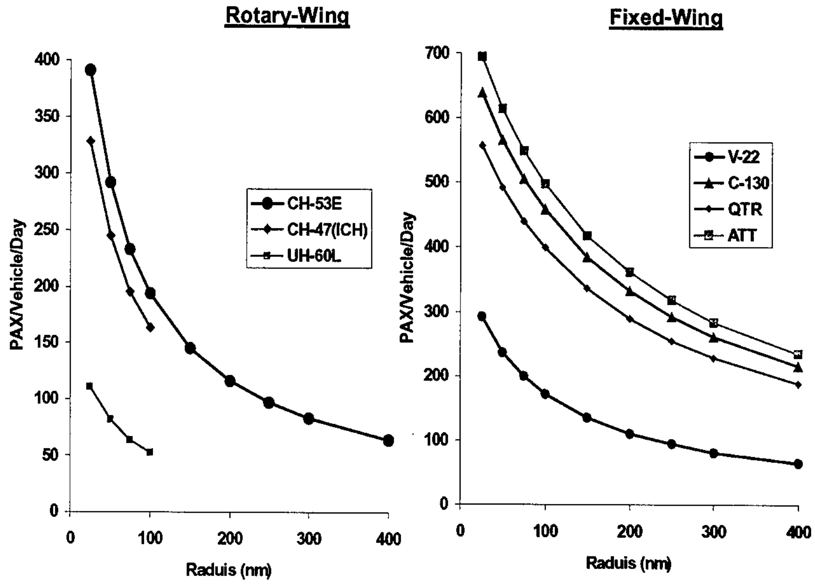


Figure 41. Daily Passenger Throughput for MOB-to-Shore Aircraft

The data above are for single aircraft. The total air throughput that can be achieved will be the sum of the contributions of all aircraft committed to the operation. In the next chapter we examine the impact of different MOB-to-shore fleet sizes in the context of several representative logistics operations.

2. MOB-to-Shore Surface Lift

The factors impacting the daily throughput for surface craft are similar to those for aircraft. Surface craft typically carry larger payloads than aircraft, but this advantage can be offset by their slower speed. Each cycle delivers more but takes longer to complete. We assumed that surface craft could operate on a 24-hour-per-day schedule rather than the 12-hour operations for aircraft.

Although essential for delivering heavy equipment like tanks and other armored vehicles, sea surface lift is limited to delivery to the shore. It cannot move equipment and personnel to inland objectives. Other means must be used to move forward from the beach. Table 33 shows the surface lighterage vehicles that might be used for MOB-to-shore transport. The mechanized landing craft (LCM)- and LCU-class are standard displacement craft, and the LCAC is an air cushion craft.

Table 33. Characteristics of Lighterage

	LCAC	LCM-8	LCU-1600	LCU-2000
Displacement (Lt, tons)	99	67	191	550
Speed (knots)	40	12	11	11
Payload (stons)	60	65	160	350
Number of Passengers	24	200	350	350
Radius (nmi)	100	140	440	4,000
Approximate Inventory	91	90	49	35

Characteristics for nominal conditions. Payloads may be for missions shorter than radii shown. Actual performance will vary depending on specific situation.

Figure 42 shows per vehicle productivity for the lighterage types we examined.

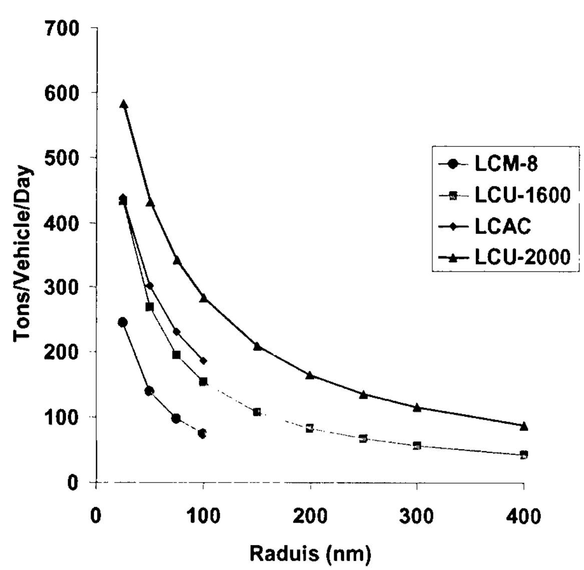


Figure 42. Daily Cargo Throughput for MOB-to-Shore Surface Craft

Daily per vehicle passenger throughput is shown in Figure 43. Although these surface craft have the capability to do so, they were never really designed to move people long distances of open ocean. With the exception of the LCAC, which rides on its air cushion, these craft do not provide a comfortable ride as the sea state increases. With their low speeds, transits from a distant MOB will be several hours at a minimum, which could seriously debilitate embarked personnel. Aircraft would probably be the preferred mode of passenger transit, with surface craft dedicated to heavy cargo transit.

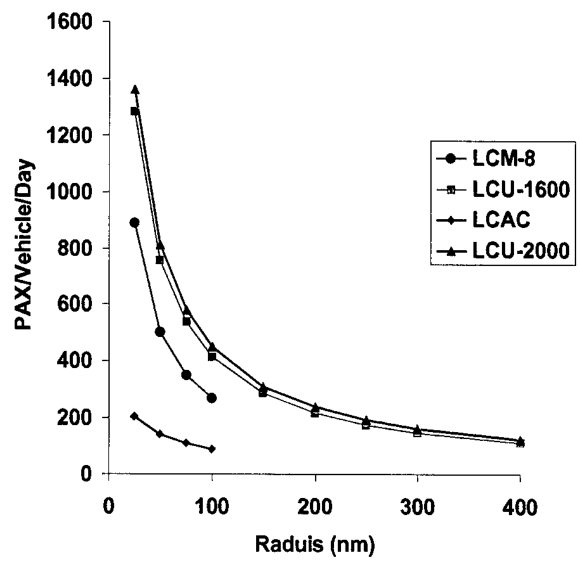


Figure 43. Daily Passenger Throughput for MOB-to-Shore Surface Craft

(This page is intentionally blank.)

VII. ASSESSMENT OF MOB CONTRIBUTIONS TO LOGISTICS SUPPORT

The preceding chapters have evaluated the availability and logistics productivity that might be expected of a MOB under different scenario and environmental conditions. In this chapter, we tie together these individual snapshots of MOB performance to obtain an end-to-end assessment of how a MOB might contribute to logistics support of military operations.

To make this assessment, we evaluated the ability of a MOB to deploy and sustain representative military units under a variety of scenario and environmental conditions. Scenario and environmental conditions are primarily captured in the MOB availability calculations from Chapter V. Table 34 reprises the ranges of availability expected for a MOB once it is on station. These data reflect the probabilities that MOB operations might be suspended due to poor weather or enemy action. When the additional factor of MOB transit timelines is considered, the scenario-level availability of a MOB can be estimated.

Table 34. Ranges of MOB Availability

Availability Level	Air Operations	Surface Operation
Low	0.66	0.15
High	0.98	0.48

It is worth noting from the outset that a MOB cannot, on its own, support an MTW-sized operation. Results from Chapter VI indicated much more modest logistics capacities than are required for an MTW. Desert Shield/Storm, for example, included logistics operations at several large, modern ports; air operations from many large airbases in Saudi Arabia and other Gulf Coalition countries; and vast areas of real estate for the marshalling of the ground forces deployed.

A MOB does have the potential, however, to supplement MTW operations, or to support smaller operations or operations other than war (OOTW) in the absence of land bases. In this chapter we assess the magnitude and timing constraints of such operations.

A. REPRESENTATIVE GROUND COMBAT UNITS

As a benchmark for measuring MOB contributions to logistics operations, we defined several types of ground combat units that might rely on a MOB for deployment and sustainment. We chose both light and heavy forces (e.g., mechanized and infantry units) ranging in size from brigade to division. Forces smaller than brigade size, such as battalions, are already supported with existing expeditionary lift in the form of Marine Expeditionary Units (MEUs). Brigade and division forces, with troop strengths measured in the thousands to nearly 20,000 begin to represent a level of combat power commensurate with the size and expense of a MOB.

The following two sections define our representative units and identify factors important to assessing how well a MOB might support their operation. Later in the chapter we place these units into illustrative scenario contexts.

1. Deployment of Ground Combat Units

Deployment of ground combat units encompasses the activities required to place the units ashore at a desired location. Table 35 shows the representative units we used to assess deployment via a MOB. The units range from a light brigade to a heavy division. Specifically, we considered a SIB, a heavy ACR, a LID, and a full mechanized division (Mech.Div.). The new medium combat units the Army is planning to field as part of their transformation will fall within the bounds established by our representative units.

Table 35. Characteristics of Representative Ground Combat Units

	Separate Infantry Bde[a]	Heavy Armored Cavalry Regiment[a]	Notional Future Army Objective Div[b]	Light Infantry Div[a]	Mechanized Div[a]
Footprint (sqft)	202,000	524,000	354,182	705,000	1,686,000
Weight (stons)	8,100	31,300	28,000	18,800	101,000
Personnel	3,902	4,555	9,000	11,520	17,407

Source: [a]Current Forces: *Deployment Planning Guide*, MTMCTEA Reference 97-700-5, July 1997.

[b]Notional Future Forces: Army Transformation War Game 2000.

For unit deployment via a MOB, critical parameters are the time required to get the MOB in position (transit plus module link-up) and the rate at which unit equipment and personnel can flow ashore via the MOB.

2. Sustainment of Ground Combat Units

Table 36 shows the sustainment level required for our representative ground combat units during periods of moderate to heavy intensity.

Table 36. Sustainment Requirements for Ground Combat Units (stons per day)

	Sep Inf. Bde	Heavy ACR	Lt. Inf. Div.	Mech. Division
POL	97	632	440	1,708
Ammo	78	288	270	1,462
End Items	6	19	12	62
Misc. Bulk	157	189	478	693
TOTAL	338	1,128	1,200	3,925

Source: CASCOM Logistics Factors Files.

For sustainment cargo, we assume the MOB is already in place, and focus on cargo flow rates to and from the platform.

3. Availability of Lift Assets

We saw in Chapter VI how the rate of strategic airlift flow to a MOB might be limited by the number of C-17s in the Air Mobility Command fleet. A similar problem may face the MOB-to-shore movement of units and cargo. Only selected ground units have the capability to move themselves via air or water, a critical requirement for deployment from offshore. These units include many MAGTFs and Army airmobile units. If deployed via a MOB, these types of units would have the ability to, under most circumstances, get themselves ashore. Other units, however, would require additional tactical lift assets if they are to be deployed via a MOB.

As we will see in the coming section, movement ashore from a MOB will require substantial tactical lift.

Unfortunately, the availability of such lift is limited. Tables 32 and 33 in the previous chapter showed current inventory numbers for many types of tactical lift vehicles. Many of these, however, are organic to just the units described above, or are employed around the world for day-to-day operations or training. Assembling a critical mass of these dispersed assets on a MOB in time of need would at best be a time-consuming process that could significantly delay operations.

If a MOB with the ability to deploy and sustain ground units is to be fielded, it may be necessary to equip it with lift assets of its own, which would add considerably to the life cycle cost of the MOB system. It is similar to including the cost of a carrier air wing as part of total aircraft carrier cost. For this analysis we assume that units supported by a MOB have available lift assets consistent with current inventory constraints, and commensurate with units of their general size.

B. DEPLOYMENT OF GROUND COMBAT UNITS VIA A MOB

Units are deployed to a theater of operations by either airlift or sealift. Although mechanized units can, in principle, deploy via outsize-cargo-capable airlifters, they would most likely transit via surface lift. Light units are more likely to be deployed by air. For analytical purposes, we consider both modes for all unit types.

We assessed timelines for two types of deployment. The first, deployment of a CONUS-based unit, involves moving unit equipment, personnel, and supplies to the MOB, followed by transit ashore. The second, deployment of a prepositioned unit, is basically a subset of the first. It assumes only personnel and some high value equipment must be moved to the MOB for marry up with the majority of equipment already located there.

Deployment via a MOB can be split into two distinct steps: movement to the MOB followed by movement ashore from the MOB. We describe each separately, and then combine them for a comparison with deployments not requiring a MOB.

1. Deployment to a MOB

The deployment of a unit, whether by sea or air, consists of a series of phases:

1. Assembly and movement to embarkation point (seaport and/or airbase)
2. Transit and debarkation from strategic lift (seaport, airbase, or MOB)
3. Reception, staging, onward movement, and integration (RSO&I).

These phases are often referred to as "fort to port, port to port, and port to foxhole." The employment of a MOB primarily impacts the "port to port" and "port to foxhole" phases of the deployment process.

a. Deployment by Strategic Airlift

In the previous chapter we established cargo and personnel flow rates for movement to a MOB via strategic airlift. Figure 44 shows the resulting times needed for the C-17 deployment of our representative units to a MOB. Because of its size and the limited availability of C-17s, air deployment of a mechanized division takes considerably longer than would even be expected for sealift.

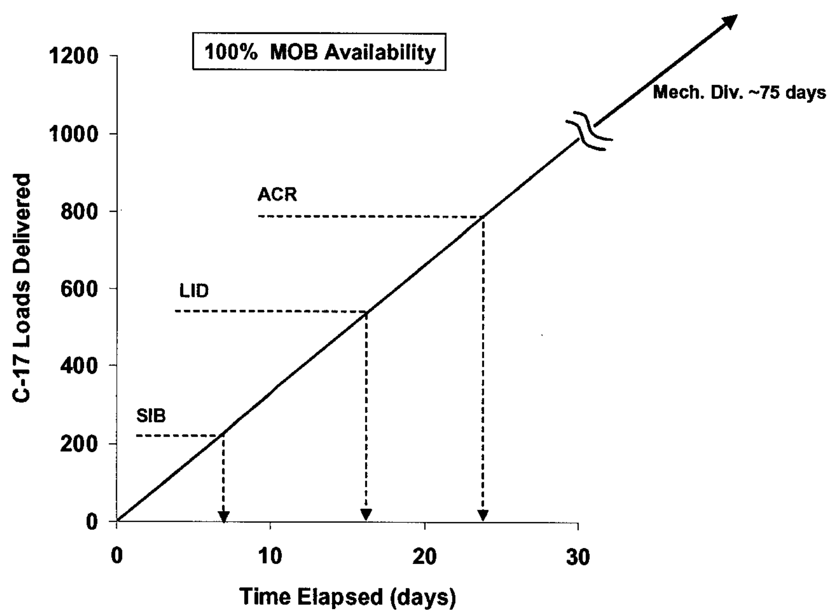


Figure 44. Unit Transit Times for Strategic Airlift to a MOB

The elapsed times in Figure 44 assume 100 percent MOB availability starting at time zero. In fact, we expect a range of availability as bounded in Table 34, plus some delay due to MOB transit. If we use a nominal MOB transit/assembly time of 21 days (see Chapter III), unit deployment timelines are better represented by those shown in Figure 45. Unit movement begins at C+21 and proceeds within a range of flow rates defined by the gray wedge in the figure. For our MOB transit assumption, deployment times range from 27 days for a light brigade to nearly 60 days for the ACR. Different MOB transit times are easily assessed by translating the gray wedge to the appropriate starting point (MOB on-station time) on the time axis.

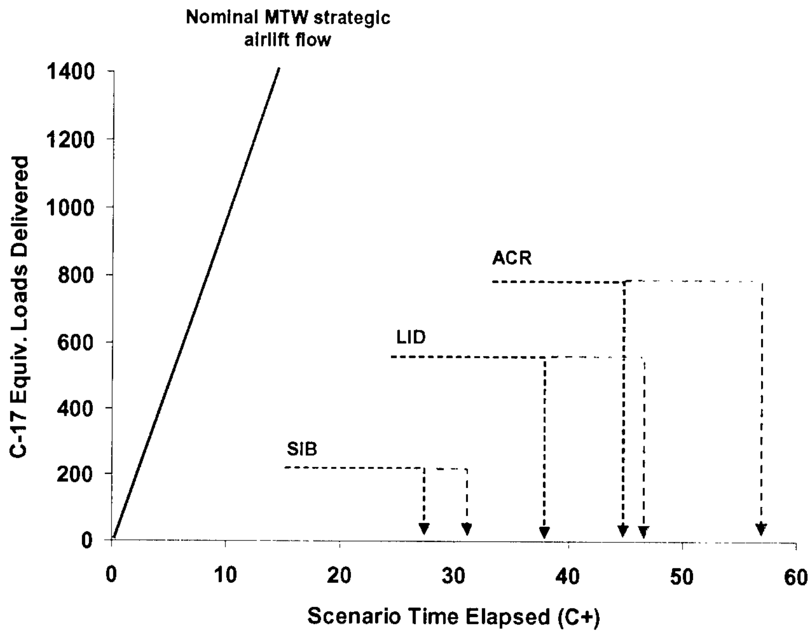


Figure 45. Deployment Timelines for Strategic Airlift of CONUS-Based Units to a MOB

This timeline is significantly shorter for units that have most of their equipment prepositioned on the MOB. Personnel-only movement requires far fewer airlift loads. Personnel arrival times range from 1-2 days for a SIB up to 5-8 days for the mechanized division (after MOB arrival). In the case shown in Figure 45, the total timeline for personnel movement to a MOB would be dominated by the 21-day transit time of the MOB itself.

b. Deployment by Strategic Sealift

Timelines for strategic sealift deployment to a MOB will also depend on the specific situation. For sealift deployment from CONUS, in many cases a MOB will be able to reach its operating area in a time frame similar to the arrival of the sealift ships. In this situation, the cargo will reach the MOB at about the same time it would reach a regular seaport.

There is potential, however, for sealift to reach theater before a MOB. If the scenario requires a particularly long MOB transit (transit times in Chapter III were as long as 38 days) or if the arriving sealift is composed of prepositioned forces such as the Marine Corps' MPF or the Army's afloat prepositioned force, the MOB transit could be the rate-determining factor. Nominal planning factors have the Army afloat prepositioned brigade closing in about 15 days, and similar assumptions hold for the MPF.

2. Movement Ashore from a MOB

As we saw in Chapter VI, movement ashore from a MOB is dependent on the distance from the MOB to the objective as well as the type and number of transport craft available. In that chapter we assessed general, per-vehicle movement rates. Here we look at moving our representative units.

As part of the overall deployment, the MOB-to-shore movement can be thought of as the initial step in the "port to foxhole" phase. Depending on where the units are delivered, additional staging and onward movement might be required. For example, equipment moved ashore via surface lift may need to move to objectives inland, whereas air transit may be able to deliver a unit very near its objective.

The difficulty in estimating MOB-to-shore timelines lies in the wide variability in possible MOB-to-shore vehicle quantities and mixes. We present here the general results of this analysis as a function of the numbers of craft committed, but add specific examples with notional MOB-to-shore fleet mixes.

As with deployment to a MOB, MOB-to-shore movement can be accomplished with either air or surface vehicles. We described the characteristics of common tactical air and surface transport craft in Chapter VI. Although the CH-53 is capable of limited transport of trucks and other vehicles, practically speaking, all but the lightest of units will require some surface transport. We assume that current armored vehicles must all transit via surface craft. We show representative results for different units and transport modes in this section.

Figure 46 shows the time required to move a heavy ACR ashore from a MOB positioned different distances from the coast, and assuming 100 percent availability. With what would probably be a best-case MOB proximity to shore (~25 nmi), an ACR can be moved ashore in a few days to a week if 10-20 LCU-1600 craft are assigned the mission. Similar results are obtained for movement by LCAC. At greater distances the time increases substantially. This unit would not be a candidate for air deployment because it contains many armored vehicles, although troops and light items might be moved by air for subsequent link-up on the beach.

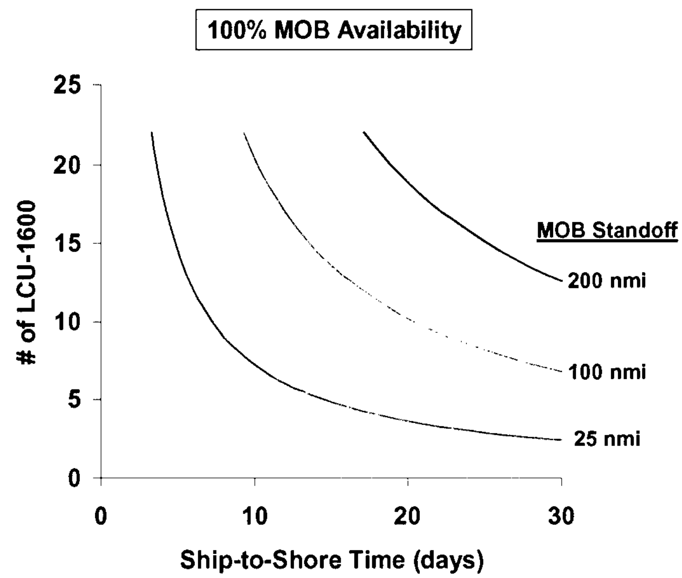


Figure 46. MOB-to-Shore Surface Movement of Heavy ACR via LCU-1600 (No Availability Degrade)

The situation becomes considerably worse when MOB availability is factored in the timelines. We saw in Chapter V that because of sea state limitations to lighterage operations, the expected fraction of time available for surface transit ashore ranges from 15-48 percent. For a long-term operation, this has the potential to a least double, and perhaps increase by a factor of six, the time required to move a force ashore. For smaller deployments, it may be possible to operate within a window of good weather and avoid the increase in deployment duration.

Timelines for movement of a mechanized division would be at least three times longer than the ACR for given scenario conditions. Shortening these timelines would require moving the MOB closer to shore or dedicating a larger number of craft to the operation. Moving the MOB closer to shore may be both tactically infeasible because of vulnerability to threat action as well as physically impossible if water depths or transit chokepoints hinder movement or ballasting down. For example, Persian Gulf waters are constrained, congested, and shallow. Depending on the threat environment, a MOB might be limited to operations in the Gulf of Oman, which would render surface MOB-to-shore transit impractical with existing landing craft.

Figure 47 shows the time required to move an SIB ashore from a MOB positioned different distances from the coast. As a light unit, the SIB is better suited to air transport, although some equipment may exceed the capacity of available tactical airlifters. As with the ACR/Mech.Div. comparison, deployment of an LID can be expected to take a proportionally longer amount of time.

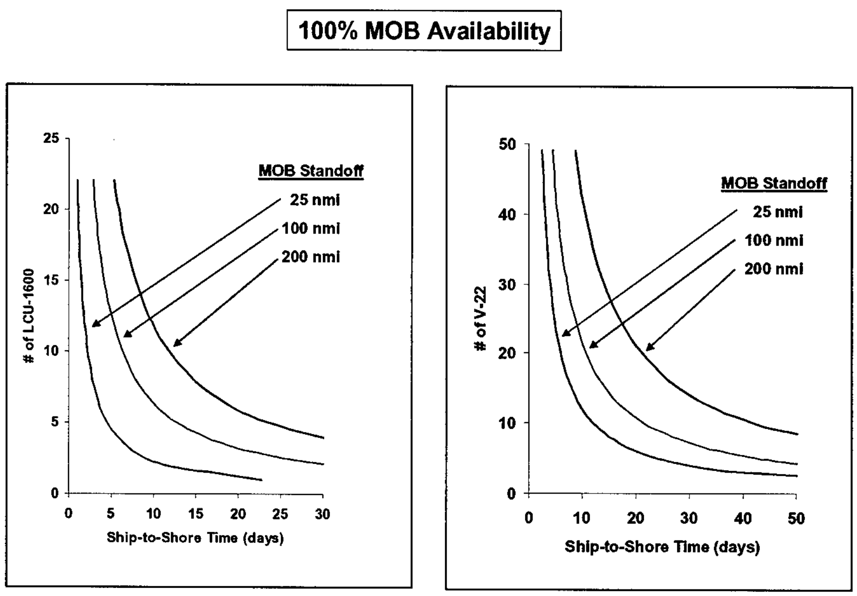


Figure 47. MOB-to-Shore Movement of SIB (No Availability Degrade)

3. Implications of Full Deployment Timelines

Definitively establishing general unit deployment timelines is not possible since, as we saw above, a wide array of scenario variables can have substantial impacts on the final result. The result is a range of possible times for each step of the deployment. These ranges are summarized in Table 37, and combine results from this chapter and results for single MOB transit times from Chapter III. The Nominal row assumes 21-day MOB transit and the low end of the time range for the other two steps. These numbers drop somewhat for the case of unit equipment prepositioned on the MOB. The Nominal total also assumes that the MOB-to-shore movement does not begin until the entire unit has closed on the MOB. If cargo and troops are pushed ashore immediately after arrival on the MOB, the MOB-to-shore time can be subtracted from the total for all but the Mech.Div since the strategic leg of the deployment is rate determining. The MOB-to-shore tactical leg is rate determining for this unit.

Table 37. Timelines for Phases of Deployment from CONUS (Days)

	Sep Inf. Bde	Heavy ACR	Lt. Inf. Div.	Mech. Division
MOB Transit/ Unit Assembly	0-38	0-38	0-38	0-38
Movement to MOB	6-10 (Air)	21-36	17-25	21-28 (ship)
Movement Ashore (100 nmi)	3-7	10-20	9-21	30-60
TOTAL Range	9-55	31-94	26-84	51-106
Nominal	30	52	47	72

These timelines are quite long when compared to timelines for deployment between ports and airbases located on land. In those timelines there are no delays in the availability of said ports and airbases, the deployment is able to use the entire strategic airlift fleet plus additional commercial aircraft (rather than just the C-17), and the MOB-to-shore portion of the deployment is avoided altogether.

In addition to being generally slow, the lengthy movement ashore phase can present serious tactical problems. A unit is vulnerable to enemy action if it cannot quickly amass combat power ashore. Marine Corps ship-to-shore lift requirements are sized to get the bulk of the assaulting force ashore before the opposition has the opportunity to respond. The pace of MOB-to-shore movement from 100 nmi with current tactical lift assets does not meet this condition. A benign environment would probably be required for the deployment of these units on these timelines. However, if a benign environment is available, it seems likely that access to airbases or ports would also be available. Advanced tactical lift vehicles, both air and surface, may eventually solve the MOB-to-shore dilemma, but the fielding of such systems will be costly and is, at best, far in the future.

C. SUSTAINMENT OF GROUND COMBAT UNITS VIA MOB

For our assessment of the ability of a MOB to sustain forces ashore we assumed the MOB is present in theater when the sustainment operation commences. The problem then becomes one of comparing the rate of consumption of units ashore with the rate at which MOB-to-shore lift can deliver said supplies.

In the case of deployment we were concerned with the time required to deliver a fixed amount of cargo and number of personnel. For sustainment, we are concerned with the continuous flow of cargo and troops. Despite the difficulty of deploying forces from a MOB shown in the previous section, a MOB could still be used to sustain forces otherwise deployed or previously in place. Sustainment capability also reflects a measure of the ability to support humanitarian relief operations with the delivery of food, fuel, medicine, and other supplies.

The impact of MOB availability on sustainment is different than on deployment. Periods of unavailability serve to lengthen deployment times. In so far as the strategic situation can accept delay, the ability to select a window of favorable weather, or to wait until threats are adequately suppressed, can help mitigate this problem. This flexibility does not exist in the context of an interruption in sustainment of a unit already committed ashore. Depending on the situation and the amount of supplies on hand, a unit faced with several days' interruption in supplies could be in serious jeopardy. This problem is not specific to the MOB, since supply lines can be cut in any context if the enemy has the means to do so. However, the particular vulnerability of interruption in surface transport from MOB-to-shore (availabilities from 15-48 percent) make it particularly risky for sustainment operations. Fortunately, most sustainment cargo is suitable for air transport, which has a much higher associated MOB availability. Although we show sustainment results for both surface and air transport ashore, the air mode will usually be the preferred mode. The calculated rates in the following sections are for periods when the MOB is available, they are not weighted averages of up time and down time.

1. Sustainment Cargo Stored on MOB

For supplies stored on the MOB, the sustainment problem reduces to a straight comparison of MOB-to-shore capacity with unit consumption. This is also the case if sustainment supplies are regularly arriving by ship, since ship capacities and unloading rates are large enough to stay ahead of MOB-to-shore movement. As long as enough ships are committed, their delivery can easily outpace the ability to move cargo ashore. Consumption rates for our representative units are in Table 36 earlier in this chapter.

Figure 48 illustrates the MOB-to-shore assets needed to sustain a separate infantry brigade. Air transport would be required if the unit were not accessible by ground transit from the coast. In either case, sustainment of the SIB is possible with a reasonable number of assets. For example, only a fraction of a 48-aircraft Army CH-47 battalion could sustain the SIB so long as the unit were within range and did not require any items beyond the capacity of the aircraft.

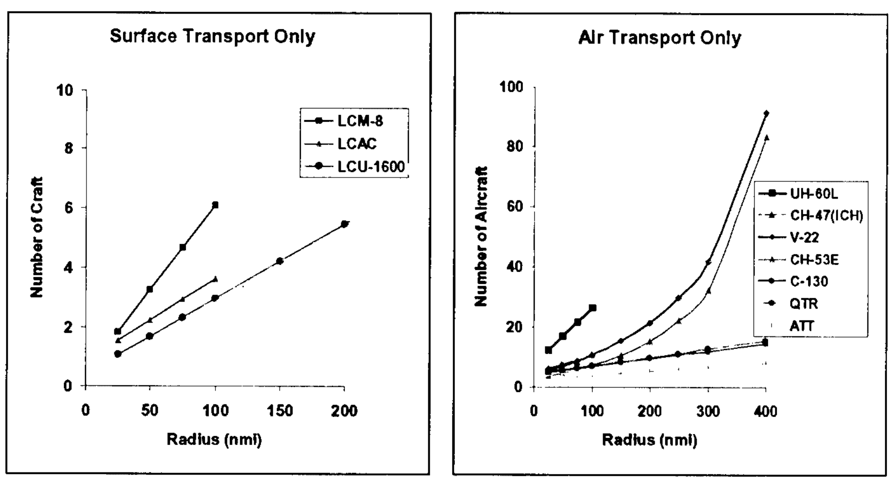


Figure 48. SIB Sustainment from a MOB

Sustainment for a heavy ACR presents a greater problem. Despite only having about 10 percent more troops, the ACR has a higher fuel demand (for its heavy vehicles) and ammunition (for its heavier armament). For similar reasons, the light infantry division has a total sustainment requirement (on a tonnage basis) similar to the ACR despite nearly a fourfold greater troop strength. Figure 49 illustrates the MOB-to-shore assets needed to sustain an ACR.

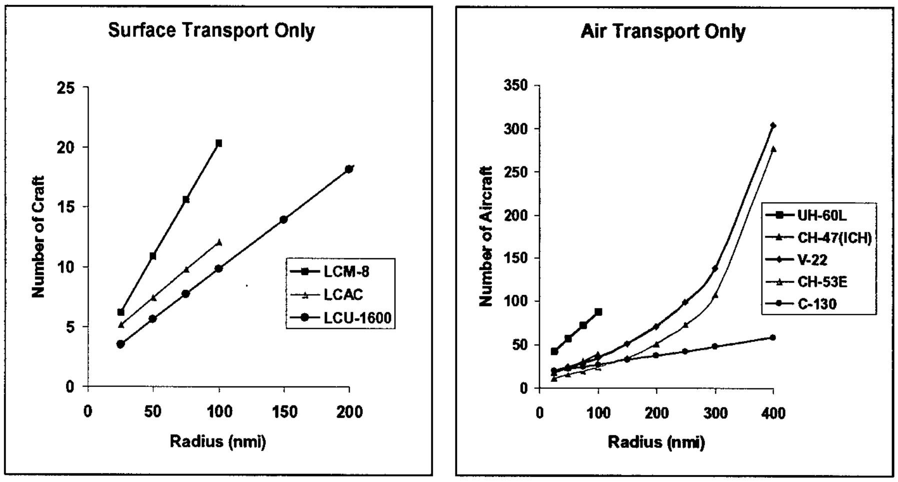


Figure 49. ACR Sustainment from a MOB

With its greater fuel and ammunition requirements, sustainment of a full mechanized division from a MOB is considerably more demanding of MOB-to-shore assets. The daily tonnage requirement is nearly a factor of four larger than the ACR. From a MOB positioned 100 nmi from the coast or the unit, the numbers of tactical lift craft—well over 100 aircraft of the types shown, or nearly 40 surface craft—become prohibitive. For example, the current inventory of LCU-1600s is only 49. These numbers suggest a practical limit of about one heavy brigade or light division as the maximum force size that can be sustained from a MOB during operations of moderate to heavy intensity.

2. Sustainment Cargo in Continuous Airlift Flow from CONUS

For sustainment operations where the cargo being delivered from the MOB is arriving continuously from CONUS via strategic airlift, there is the potential for the strategic leg to be the bottleneck. Figure 50 compares the capacity for airlift arrivals of cargo to a MOB with the demands of our representative units. The vertical bars show each unit's sustainment demand. The horizontal band is the range of arrival rates attainable at a MOB. The entire C-17 fleet is needed to generate this flow.

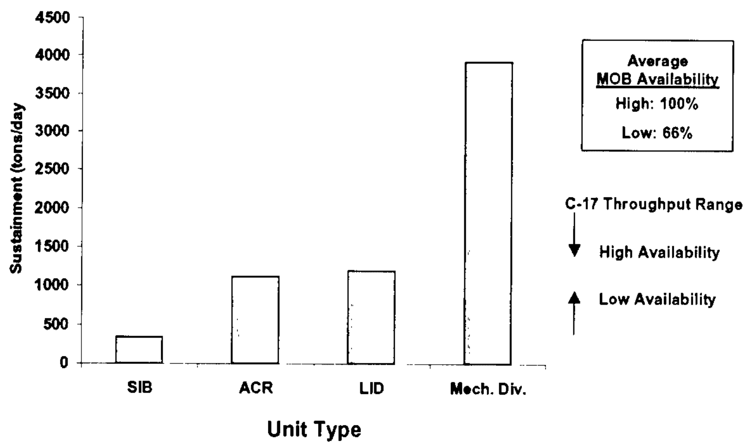


Figure 50. MOB-to-Shore Movement of SIB

The SIB can easily be supported by airlift from CONUS, the ACR and LID can be supported if availability is ranging on the high side, and the Mech.Div. is too heavy to support in this fashion.

VIII. COST ANALYSES

This chapter presents the MOB cost analyses. Relevant costs include those to procure a single MOB and to operate and maintain the system for 40 years. Cost estimates were developed using available ship construction cost factors and O&S cost data from the Navy, contractor design and cost data, information from historical studies, and independent IDA assessments, as appropriate. The cost estimate is presented in three sections: the overall groundrules and assumptions used in the cost analysis, the acquisition cost estimates for each of the contractor designs, and the O&S cost estimate for a single design.

A. GROUNDRULES AND ASSUMPTIONS

The estimates are in FY 2004 dollars and uses the Navy's SWBS for acquisition costs and the OSD Cost Analysis Improvement Group's (CAIG's) O&S Cost Element Structure for Ships. The ship construction costs are based on factors provided by the NCCA. The Navy VAMOSC for ships was used to derive MOB O&S costs. We did not perform a structured risk analysis, and there are substantial cost risks associated with our estimate of MOB life cycle costs (LCC). The risks arise from using preliminary designs that include new types of construction (use of concrete) and mating techniques that may not be representative of recent ship construction experience. There is no pre-determined concept of operations for either wartime employment or peacetime operations. We did not apply any economies of scale in both construction and O&S costs resulting from designs that are substantially larger in size than historical ship experience. We have tried to be conservative in the cost estimates, but there are still substantial risks associated with MOB LCC.

B. ACQUISITION COST

Acquisition costs for the different MOB alternatives were estimated using weight data from contractor documents and from the SWBS cost factors provided by the NCCA. Although only one of the contractors, McDermott, actually submitted weight data in the

Navy's SWBS format, by reviewing the various technical and weight documentation of the three remaining contractors, along with studies performed by other independent agents, we were able to construct what we believe to be an accurate representation, at the one-digit SWBS level, of the weight distribution of all of the other alternatives. Table 38 shows the results.

Table 38. SWBS Weights (Tons) per MOB Module

		Aker SBU (4)	Bechtel SBU (3)	Kvaerner SBU (3)	Kvaerner Bridge (2)	McDermott SBU (5)
100	Hull	129,800	228,733	185,990	165,750	157,041
100X	Hull Concrete M3	144,000				
100X	Hull Concrete Tons	346,329				
200	Propulsion	1,021	3,700	10,500	6,030	2,128
300	Electric	1,139	3,100	2,080	2,080	1,825
400	Command & Surveillance	49	1,700	800	120	917
500	Auxiliary Systems	1,155	13,800	11,955	3,950	9,258
600	Outfit & Furnishings	1,212	11,300	18,140	10,640	4,512
	Total Weight 1-7	480,705	262,333	229,465	188,570	175,681

A few words of explanation are required regarding the weights shown in Table 38. First, the weights are for an SBU, not the entire MOB. The number of SBUs required to make up a complete MOB, or in the case of Kvaerner, the number of SBUs and connecting bridges, is a function of the various design concepts and is shown in parenthesis below the individual contractor. Second, while the weights shown for Bechtel, Kvaerner, and McDermott are all steel, Aker's weight for SWBS 100 includes 346,000 tons of concrete in SWBS element 100X. Finally, while there is significant variation among the contractors in terms of the weights associated with the various SWBS elements, particularly for elements 200 through 600, we are treating these variations as a function of the contractor's design. We have made no attempt to develop a "correct" weight for a particular contractor, but have based our estimates strictly on the designs as submitted.

With a common SWBS weight breakdown for each of the contractors, the next step in our analysis was to estimate a Basic Ship Cost (BSC) for the lead and follow-on modules. This was done primarily by applying NCCA cost per ton factors to the weights shown in Table 38 to arrive at estimates for:

- Production hours and production labor costs
- Engineering and support hours and costs
- Other material costs
- Margin
- Profit.

The actual factors used are presented in Tables 39 through 43. While the tables are relatively straightforward, it should be pointed out that the percentage factors in Table 40 are applied to total production hours in order to arrive at an estimate of Engineering and Support Service hours, while those in Table 42 are applied to production material costs in order to estimate Engineering and Support Service material costs.

Table 39. Production Hours Per Ton

SWBS	Category	Lead	Follow-on
100	Hull	59.88	59.88
200	Propulsion	52.32	52.32
300	Electric	355.66	355.66
400	Command & Surveillance	430.11	430.11
500	Auxiliary Systems	187.45	187.45
600	Outfit & Furnishings	313.85	313.85

Table 40. Other Hours

SWBS	Category	Lead (%)	Follow-on (%)
800	Engineering	36.47	3.31
900	Support Services	40.12	28.06

Table 41. Labor Rates

Type	Base ($/hr/man)	Overhead Rate (%)	Burdened Rate ($/hr/man)
Production	15.11	135	35.50
Engineering	21.58	130	49.64

Table 42. Other Material Costs

SWBS	Category	Factor (%)
800	Engineering	2.39
900	Support Services	8.31

Table 43. Other Basic Ship Cost Factors

Cost Category	Base	Lead (%)	Follow-on (%)
Margin	SWBS 1 through 7 Cost	10.00	10.00
Profit	SWBS 1 through 9 Cost	10.00	15.00

The NCCA also provided a cost per ton factor for estimating material costs. Their material cost factor is an *average* over *all* SWBS elements. However, the ratio of the weight of SWBS 100, which has the lowest material cost per ton, to the remaining SWBS elements, which have a much higher material cost per ton, is significantly greater in an SBU than in a traditional ship. The use of the NCAA average material cost per ton would overestimate the cost of an SBU. Therefore, we confirmed the reasonableness of the contractor's cost estimates for selected items and used the contractor's estimate. In the case of the one contracter that did not identify material costs (Bechtel), we estimated costs using SWBS material cost per ton factors derived from McDermott's estimate and applied them to their (Bechtel's) SWBS weights.

Because NCCA's factors are based on steel hulls, we had to use a different source to evaluate costs for working with the lower-cost concrete. The Aker hull design uses concrete extensively. In this case we examined both R.S. Means' *Building Construction Cost Data* and Craftsman's *National Construction Cost Estimator* to asses Aker's hours and rates. The data in these sources are for building construction. The total cost (labor and material) per cubic meter of concrete is $2,436 in the Aker estimates. The most expensive cost for concrete we could find in our sources was $1,920 per cubic meter. We used Aker's higher costs in our calculations to be conservative and to incorporate the impact of different materials and working conditions.

Tables 44 and 45 illustrate the results of applying the rates in Tables 39 through 43 to the SWBS weights in Table 38 to arrive at a BSC cost for both the lead and follow-on SBUs for the McDermott design. Calculations for the remaining contractor designs can be found in Appendix A.

Table 44. McDermott Lead Ship

		Weight (tons)	Prod. Hrs	Production Costs ($K)	Material Costs ($K)	Total Cost ($K)
100	Hull	157,041	9,404,039	333,854	233,141	566,995
200	Propulsion	2,128	111,334	3,952	84,462	88,415
300	Electric	1,825	649,087	23,043	17,463	40,506
400	Command & Surveillance	917	394,414	14,002	14,235	28,238
500	Auxillary Systems	9,258	1,735,418	61,609	206,855	26,8464
600	Outfit & Furnishings	4,512	1,416,075	50,272	35,028	85,301
	Total 1-6	175,681	13,710,366	486,733	591,185	1,077,918
	Margin					107,792
800	Engineering		5,000,366	248,202	14,129	262,332
900	Support Services		5,500,728	195,282	49,127	244,409
	Total 8-9		10,501,094	443,484	63,257	506,741
	Total 1-9		24,211,460	930,218	654,442	1,692,451
	Profit					169,245
Basic Ship Construction						1,861,696

Table 45. McDermott Follow-On

		Weight (tons)	Prod. Hrs	Production Costs ($K)	Material Costs ($K)	Total Cost ($K)
100	Hull	157,041	9,404,039	333,854	233,141	566,995
200	Propulsion	2,128	111,334	3,952	84,462	88,415
300	Electric	1,825	649,087	23,043	17,463	40,506
400	Command & Surveillance	917	394,414	14,002	14,235	28,238
500	Auxillary Systems	9,258	1,735,418	61,609	206,855	268,464
600	Outfit & Furnishings	4,512	1,416,075	50,272	35,028	85,301
	Total 1-6	175,681	13,710,366	486,733	591,185	1,077,918
	Margin					107,792
800	Engineering		454,131	22,542	14,129	36,671
900	Support Services		3,847,079	136,576	49,127	185,703
	Total 8-9		4,301,209	159,117	63,257	222,374
	Total 1-9		18,011,575	645,851	654,442	1,408,084
	Profit					211,213
Basic Ship Construction						1,619,297

The NCCA also provided factors for estimating a number of end cost increments reflecting selected programmatic costs and anticipated cost growth during the period of ship construction. The combination of BSC and these end cost increments is the total ship acquisition cost. Table 46 shows the end cost factors, along with the base to which they are applied.

Table 46. End Cost Factors

Title	Base	Lead (%)	Follow-on (%)
Change Orders	Basic Ship Construction	10.00	5.00
FCOM	Labor Cost	2.39	2.39
Escalation	Basic Ship Construction	8.00	8.00
Other	Basic Ship Construction	2.00	2.00

Table 47 shows the total pre-escalation cost for McDermott's lead and follow-on SBUs. The contributions from the separate costs categories can be seen in that table.

Table 47. McDermott Design Lead and Follow-on SBU Construction Costs

	Lead ($)	Follow-on ($)
Basic Ship Construction	1,861,696	1,619,297
Change Orders	186,170	80,965
FCOM	37,209	64,772
Other	37,234	32,386
Total Pre-Escalation Cost	2,122,309	1,797,419

After discussions with NCCA, we decided to incorporate a 97 percent learning slope in our estimates. The remainder of this section demonstrates how the additional cost factors and the learning effect are applied to arrive at a total acquisition cost for the McDermott design. As with the BSC estimate, cost calculations for the designs of the other three contractors can be seen in Appendix A.

Normally the T1 cost would be the cost of the first unit, or in this case the lead SBU. However, the difference between the cost of the lead SBU and the follow-on SBU involves unique onetime costs that are not appropriate to include in the learning calculations. For this reason we calculated the learning adjusted cost for units 2 through 5 using the estimated cost of the follow-on SBU as our T1 value. The results of this process are shown in Table 48.

Table 48. Complete Five-Unit MOB Pre-Escalation Cost

Unit	Cost ($)	T1 Cost ($)
1	2,122,309	1,797,419
2	1,743,497	
3	1,712,707	
4	1,691,192	
5	1,674,690	
Total	8,944,394	

The final step is to apply NCCA's escalation factor, the actual cost growth over the life of the particular shipbuilding program. Since the base for estimating escalation is the total estimated BSC for all units being constructed, we applied our 97 percent learning curve to the BSC portion of our estimate (after once again correcting for onetime costs), summed the results, and then applied an 8 percent escalation factor to come up with an estimated cost as shown in Table 49.

Table 49. Escalation Cost for Five-Unit MOB

Unit	BSC ($)	BSC T1 ($)
1	1,861,696	1,619,297
2	1,570,718	
3	1,542,979	
4	1,523,596	
5	1,508,729	
Total BSC	8,007,719	
Escalation @ 8%	640,618	

Adding the escalation cost from Table 49 to the total from Table 48 gives a total estimated cost of $9,585,012 for McDermott's five-unit MOB.

All design cost estimates are summarized in Table 50.

Table 50. Summary of Construction Cost Estimates for Each Contractor's Design

Contractor	Cost ($ FY94 K)
Aker	7,793,340
Bechtel	9,406,775
Kvaerner	12,810,705
McDermott	9,585,012

C. OPERATING AND SUPPORT COST

Since the MOB is an ocean going modular floating base, up to 5,000 feet long and made up of serially aligned and mated modules, that uses semi-submersible hulls to minimize wave-induced motion, naval ships were judged to be the best surrogates to estimate O&S cost. We developed O&S cost estimates using data from MSC, NAVSEA, VAMOSC data system, and other appropriate sources.

Specifically, operating costs for the Navy CVNs 65 and 68CL, CV 63CL, and LHD 1CL were extracted from the Navy's on-line VAMOSC data for FYs 97, 98, and 99 in the CAIG O&S cost format. The aircraft carriers (CV & CVN) were chosen because they are big and have a lot of the same equipment and requirements that are to be found on the MOB. The LHD, although smaller, performs functions similar to the proposed MOB and was used as another surrogate. The Military Sealift Command's LMSRs were not used as surrogates because their O&S costs were not available in the VAMOSC system.

All of the costs were extracted in FY 2001 constant dollars and then were adjusted to FY 2004 dollars. We computed a simple average of the operating and support costs based on the CAIG format as an initial estimate. We analyzed the data and concluded that personnel related costs such as Mission Personnel and Indirect Support were better estimated using a cost per person factor. The other parts of the CAIG display were better estimated using a cost per displacement ton factor, which was scaled for weight and operating tempo in our final estimate. These factors were developed by ship type and then averaged across the three types of ships considered. The projected total displacement of 1,880,000 metric tons for the McDermott design along with their crew of 1,250 permanent personnel were used as the independent variables to estimate the costs for the MOB. For a single MOB, we assumed active duty military personnel to support wartime operations including damage control and to meet peacetime training. If more than one MOB was procured it would be possible to assign them to the reserve component; however, a reserve component MOB was not estimated in our analysis.

This initial estimate was examined for consistency. Some costs were removed because the MOB would not be a warship and therefore not require costs such as Training Munitions/Expendable Stores and Naval Aviation Depot Costs. Other costs were modified to more clearly reflect the size and lack of complexity of large parts of the MOB. The following cost elements were reduced to approximately one-sixth of their initial values, based on the smaller cost per construction ton that the MOB is expected to have relative to an amphibious assault ship. They were further reduced to account for the expected lower MOB operating tempo.

- Depot Maintenance
- Depot Level Reparables
- Repair Parts
- Sustaining Support
- Central Procurement of Materiel

- Purchased Services.

To estimate POL useage, we assumed that the MOB would be operating in standby status 75 percent of the time and would be underway 25 percent of the time to support peacetime training and military exercises. After discussions with Air Force pilots from the Air Mobility Command, it is our assessment that aircrews, who would be using the MOB in contingency or wartime operations, would need at least two landings per year per crew to be qualified.

Table 51 provides the average annual O&S costs for the major cost elements for each class of ship used as a reference system and the average cost for all of the reference systems over the period FY 1997 to FY 1999.

Table 51. Reference Systems Average Annual O&S Costs for the Period FY 1997-FY 1999

	Annual Costs (FY 2004 Dollars Millions)				
Element Description	**CV-63CL**	**CVN-65CL**	**CVN-68CL**	**LHD-1CL**	**Avg for Ship Types**
Mission Personnel	110.39	122.33	113.25	44.14	97.53
Unit Level Consumption					
Ship POL	21.36	0.11	0.37	6.56	7.10
DLRs/Repair Parts/Supplies/ Purchased Services	15.53	14.83	13.80	6.24	12.60
Intermediate Maintenance	1.72	0.78	1.06	0.93	1.12
Depot Maintenance	48.29	63.47	68.21	16.27	49.06
Sustaining Support	16.49	20.33	10.83	3.85	12.87
Indirect Support	8.43	8.43	7.53	2.80	6.80
Totals	222.21	230.29	215.04	80.79	187.08
Crew Complement (number)	3,150	3,350	3,200	1,108	2,702
Displacement (metric tons)	80,800	89,600	97,000	40,500	76,975

To develop the MOB O&S cost estimates, we estimated military personnel and fuel costs. As discussed above, we assumed that the crew complement would be 1,250 personnel. For fuel, there are five modes through which the MOB operates. Table 52 reflects the percentage of operation time and load requirements we assumed for each mode.

Table 52. MOB Operational Mode Time Factors

Mode	Percentage of Operation Time	Time Factor (hrs/yr)	Total Load Requirement (kW)
Survival	1.25	109.5	61696.4
Operation	12.5	1095	45414.6
Disconnect	3.75	328.5	11157.37
Transit	7.5	657	59774
Standby	75	6570	6049.53

The load requirement was acquired from the McDermott MOB load analysis table for one SBU. (One MOB consists of five SBUs.) For a conservative estimate, the winter load requirement totals were used in the calculations.

Table 53. MOB Fuel Rates at 59°F for Various Power Values

Block Horsepower (Bhp)	Fuel Consumption Rate (lb/hr)
3,000	2975
6,000	3868
9,000	4810
12,000	5719
14,200	6379
20,000	8113
25,000	9621
29,5000	11096

The load requirement for each operational mode was converted from kilowatts (kW) to horsepower (hp), and Table 53 was then used to assign a fuel rate to each operational phase. (For power exceeding 29,500 hp, the fuel consumption rate was extrapolated.) The fuel rates were then multiplied by their respective time factor in Table 52 to calculate the annual fuel requirement for each mode in pounds. After converting the fuel rate into kilograms, the density of JP-5 fuel (0.845 kg/l) was used to calculate the volume of the fuel requirement, which was then converted to gallons. Using a fuel cost factor of $1.03 per gallon of JP-5 fuel, it was estimated that one SBU would consume fuel at a rate of approximately $12.5 million per year. This implies that the entire MOB (composed of five SBUs) would need approximately $62.4 million annually in fuel costs expressed in FY 2001 dollars.

Table 54 provides our estimate of the annual O&S costs for a single MOB after scaling for size and operating tempo and incorporating the estimates for military personnel and fuel.

Table 54. Estimated MOB Annual O&S Costs
FY 2004 Dollars Millions

Element Description	$
Mission Personnel	52.18
Unit Level Consumption	
Ship POL	67.66
DLRs/Repair Parts/Supplies/Purchased Services	29.61
Intermediate Maintenance	18.00
Depot Maintenance	135.50
Sustaining Support	53.76
Indirect Support	3.15
Totals	359.87
Crew Complement	1250
Tons Displacement	1880000

IX. THE MOB AS A POWER PROJECTION ASSET

A. INTRODUCTION

Projection of one country's military power onto another country can be accomplished from land or sea bases in several ways:

- Air strikes
- Surface fire power in the form of missiles or gun fire
- Deployment of striking forces into the country.

We will address each in turn.

B. AIR STRIKES

There are two advantages that accrue from maintaining a strike capability; first, one can keep large areas of enemy territory under continuous threat of attack, and second, one can actually visit destruction on any site within that area whenever the need arises. This attack can be either a one-time strike aimed at a given target or a continuous operation aimed at supporting land forces from the air. The later is likely to be significantly the more popular option in the foreseeable future. Therefore, we shall measure the military utility of an airstrike posture by evaluating both the area of enemy territory that can be kept under air threat and the number of sorties a day that the posture can provide for close air support of our land forces.

1. Area Coverage

Evaluating the first of these measures is relatively straightforward if one is given the location of all the bases from which one intends to strike and the combat range of the aircraft employed. Indeed, one then draws a combat circle around each and every one of the bases, constructs the envelope of these circles, and then intersects the resulting area with the area of enemy territory. Since this construct is clearly location specific, we shall evaluate the coverage area for each of three relevant theaters of war: the Persian Gulf theater, the Korean theater, and the Pakistani-Indian theater.

We begin with the Persian Gulf theater. Figure 51 shows the result of having carried through the program indicated above for the geography at hand. Each land base employed is indicated by a black dot: seven in Saudia Arabia, one in Bahrain, one in the U.A.E., and one in Oman. The combat range used corresponds to a F-16 aircraft. The resulting envelope is shown in small dash.

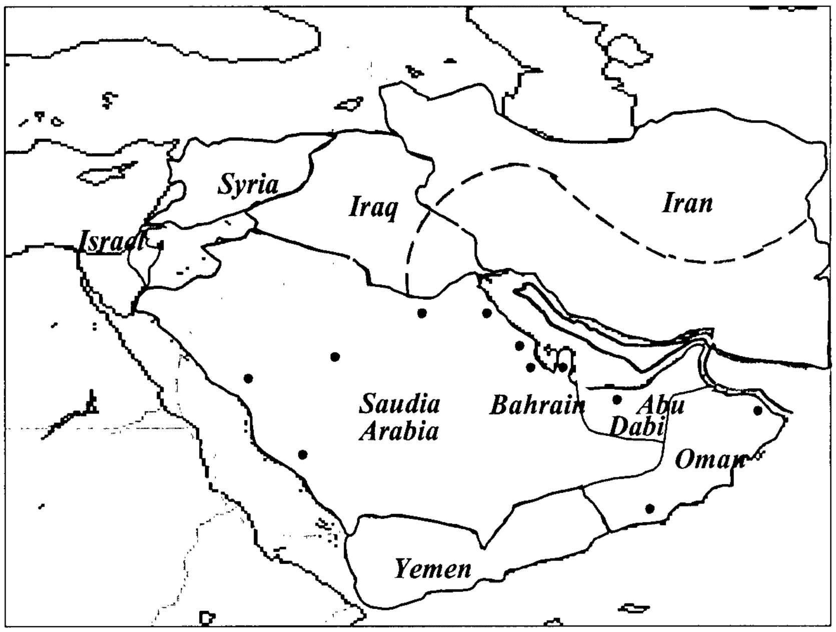


Figure 51. Area Under Threat of Airstrike in the Gulf

If a MOB were available, it could operate the same aircraft from the sea. However, because it requires at least 40-m depth of water to settle in its most stable position, the MOB would approach the coastline no closer than the solid line indicated in the figure. Although it would be imprudent to enter the Gulf with such a large and cumbersome platform, we do show in large dash the outer envelope that aircraft operated from the MOB could reach if the sea base were located anywhere along the 40-m depth line in and out of the Gulf. Aerial refueling is not considered here for either the airfield or the MOB because, while its use would extend the possible ranges for strikes from land bases, it would sharply reduce the overall sortie rate. Strike ranges from a MOB would not improve significantly with aerial refueling since the MOB is already positioned quite close to the edge of friendly airspace beyond which tankers do not typically venture.

As can be seen from the figure, F-16 aircraft operated from the MOB would hold a somewhat larger area of Iran under threat of airstrikes than they would if operated from land bases. In Iraq, the reverse is true. In any event, neither option is able to hold the entire territory of Iran and Iraq under threat.

Figure 52 shows what happens in the Korean theater. The seven airfields in South Korea, together with the two airfields in Japan—one in Kyushu and one in Okinawa—would provide F-16 strike coverage up to the small dash line shown. The corresponding sea-based alternative would provide coverage to the large dash line. Both alternatives provide more than enough coverage over North Korea. The MOB option, however, would provide much larger coverage over China, a fact that might be significant if China ever became the enemy.

Figure 52. Area Under Threat of Airstrike in Korean Theater

Finally, if a conflict started between India and Pakistan over Kashmir, and the Allies would like to try and control the situation, aircraft operated from a MOB deployed anywhere along the 40-m depth line would serve; as shown in Figure 53, the coverage line indicated by large dashes falls well short of the region of interest.

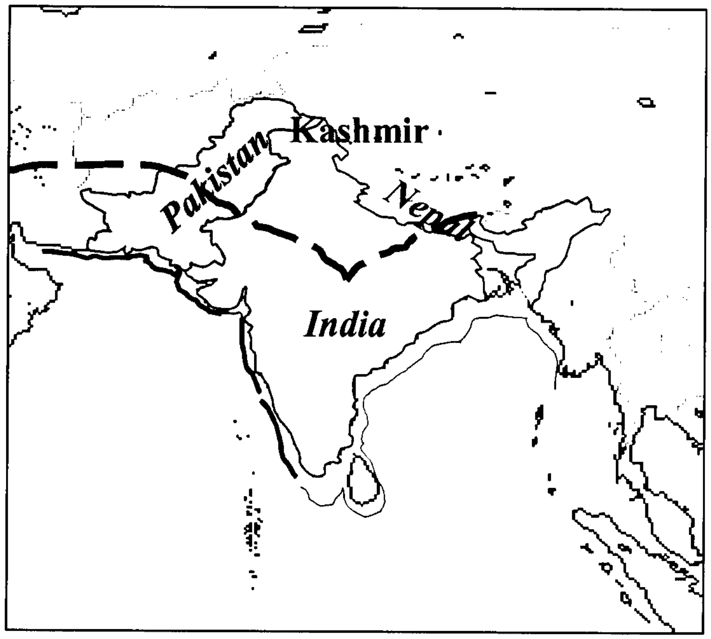


Figure 53. Area Under Threat of Airstrike in Indian Theater

What, if anything, would happen if the same aircraft would be deployed from land is not shown in the figure because, absent an authoritative scenario, we do not know which airfields would be friendly.

2. Strike Intensity

Evaluating the intensity of the strike operation is a significantly more complicated job. To determine the number of sorties that could be generated each day, one would have to model the entire complexity of air strike operations at an airfield. The effectiveness of these operations could be limited by the difficulty of maintaining a well organized air schedule, by the need to repair damaged or malfunctioning aircraft in real time, by the conduct of other simultaneous activities, and by enemy attacks on the base.

In what follows, we shall only evaluate the upper bound of the sortie generation capability by ignoring all the real life complexities mentioned above. The only considerations that shall not be ignored are aircraft availability and time. Since one can not fly more sorties from the base than the product between the total number of aircraft available and the sortie rate characteristic to the aircraft employed, the number of sorties generated each day by N aircraft against a target set located R miles away from the base is given by:

$$\sigma_a = \frac{24N}{2R/v + \tau}$$

where v represents the speed of the aircraft and τ stands for the total time needed to refuel and rearm a returning aircraft. Averaging over the unknown range to the target, assuming that all ranges are equally likely, we get:

$$\sigma_a = \frac{12Nv}{R_M - R_m} \ln\left(\frac{2R_M/v + \tau}{2R_m/v + \tau} \right)$$

where R_M and R_m are the maximum, correspondingly the minimum strike distance characterizing the aircraft.

Figure 54 shows this upper bound as a function of N. To obtain the graph referred to in the figure as the "Aircraft Limit," we used 400 nmi for the maximum range, 100 nmi for the minimum range, 300 kts for the aircraft speed, and 4 hours for the time to turn the aircraft around. According to this graph, the larger the number of aircraft, the larger the number of sorties. Clearly, however, this can not be true in general. Sooner or later in the continuous increase of N, the number of aircraft becomes so large that there are not enough minutes in the day to correspondingly increase the number of sorties.

The bound imposed by the available time is called in the figure "Time Limit." If we assume that in the ideal case, when everything in the strike operation works perfectly, the airfield can handle one event—either a launching or a landing—each minute, the total number of sorties that can be generated a day is driven by the number of runways. Indeed, if there are at least two runways at the airfield, one can conduct a launch at one of them and simultaneously a landing at the other each minute, and should therefore be able to generate 1,440 sorties a day, corresponding to the total number of minutes available. This number generated the line called "Land Base Time Limit" in the figure.

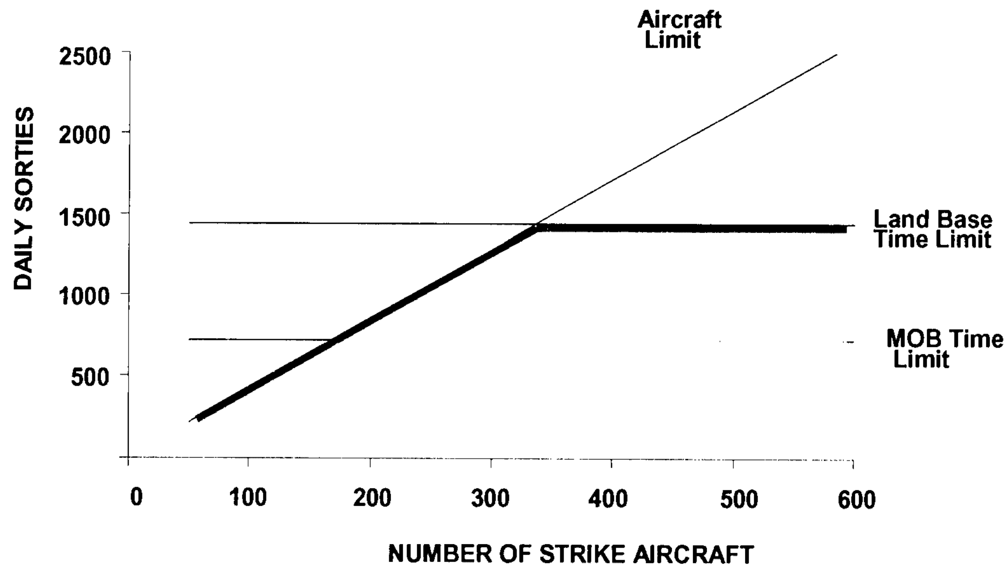


Figure 54. Upper Bounds on Strike Intensity

The time limit line for a MOB platform is different from that for a land base. The reason for this is that a MOB has only one runway and therefore cannot generate both a launching and a landing each minute; it can only do one or the other. Therefore the time limit line for the MOB stands at 720, half the number of minutes in the day.

As can be seen from Figure 54, the MOB has the same upper bound with a land base if the number of aircraft available is small. As the number of aircraft increases, the upper bounds for the two platforms separate with the land base being allowed to generate twice as many sorties a day as the MOB. It becomes important, therefore, that we try to estimate just how many strike aircraft could be housed and operated from the MOB. Figure 55 describes an ideal way of housing aircraft on the lower decks of the MOB.

In the figure, four aircraft are parked together in an area of size $4L^2$, where L represents the safe parking dimension of one strike aircraft. Adjacent parking areas are arranged in such a way as to allow corridors of size $\sqrt{2}$ L between them. The surface area of one floor can therefore accommodate as many quadruples of aircraft as many times as $\left(2L+\sqrt{2}L\right)^2$ enters into the area of that floor. For $L = 60ft$, the number of aircraft per floor is 200. Since there are two floor on the MOB, the maximum number of strike aircraft one can operate under ideal conditions is therefore 400.

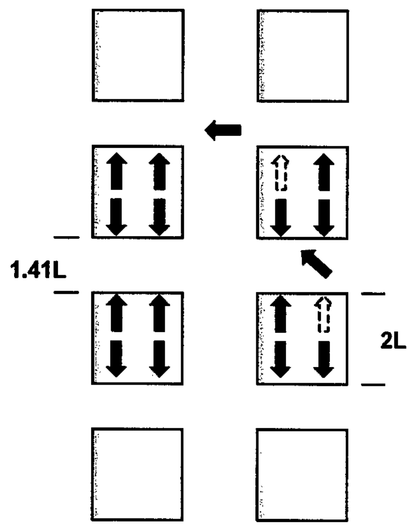


Figure 55. Ideal Housing Scheme

With 400 strike aircraft on board the MOB, Figure 54 provides an upper bound for the intensity of the strike of 720, half the upper bound for the intensity of a strike generated by the same number of aircraft operated from a land base. In reality, of course, the upper limit is never achieved; constraints such as aircraft maintainability, pilot availability, and fuel availability serve to decrease actual achieved sortie rates below the bound. Additionally, other aircraft operations such as aerial resupply are usually required at a base during periods of sustained strike operations. These operations draw off base resources, reducing the effective sortie rate that might otherwise be achieved.

However, if we are willing to assume that the actual number of sorties generated from both bases degrades similarly as the realistic operating conditions mentioned above are taken into account, a land base would, in fact, be twice as effective as the MOB.

Strike aircraft could be placed at sea even in the absence of a MOB if aircraft carriers were available. Since a full MOB consists of five SBUs, it appears reasonable to compare the MOB to five carriers. Since each carrier operates about 50 strike aircraft, each with a maximum combat range of 350 nmi, and uses two runways, the operative upper bound from Figure 54 is 324, which provides for 5 carriers an upper bound of 1,620 sorties; this is more than twice the upper bound for the equivalent MOB. The coverage provided by five carriers is also significantly larger despite the fact that Navy strike aircraft have a somewhat shorter combat range than the Air Force ones because the five carriers can operate separately from each other while the five SBUs cannot.

Comparing sortie rates and costs between CVNs and the MOB can be difficult. From the sortie perspective, about 2.2 CVNs (rounded up to 3 CVNs) are needed to generate the same daily strike intensity as one MOB. From a life cycle cost perspective, the cost of 3 CVNs is $48 billion, while that of the Strike MOB is about $30 billion. The comparison needed, however, is a cost per mission area, not a cost per platform. The MOB is a pure strike platform in this scenario, while the CVN conducts AAW, strike, and anti-submarine warfare (ASW) missions, at many times simultaneously. There is inadequate room aboard the MOB to serve as a logistics ship when used with the all-consuming strike intensity used in these calculations. The CVN strike squadrons share space with AAW and ASW aircraft, as well as with strike support aircraft, although we assume for the calculations here that strikes are priority missions during this period of the war. The U.S. Navy is reluctant to associate costs of missions proportionately to multipurpose ships, such as CVNs. However, even if the strike mission cost is associated with one-half of the cost of the CVN, a very high estimate given the other missions, the CVN alternative is less costly than the MOB for the same sortie intensity.

3. Other Considerations

In addition to the constraints described above, there are other considerations that tend to make a MOB less attractive as a strike platform despite its reasonably large sortie generation capacity. First, unlike land bases or carriers, the MOB will be unable to operate several types of support aircraft necessary for strike operations. A carrier is able to launch the E-2C early warning aircraft and the EA-6B air defense suppression aircraft, and land bases the E-3 early warning aircraft and EA-6B. The MOB runway is too short to operate these aircraft. For significant strike operations in a hostile environment, a land base or carrier would be necessary to support strikes flown from a MOB.

Another downside to strike operations from a MOB is the need to put a large number of aircraft in one location, increasing the potential impact of a successful attack against the platform. Although we discussed strike intensity from land bases in terms of a single base, several bases may in fact be available. This was illustrated earlier in the section with the coverage examples for the Persian Gulf and Korean scenarios, where many land bases were available. It is advantageous to disperse air forces at several bases to mitigate vulnerability to attack as well as ease logistics burdens at any one location. In Desert Storm, for example, there were never more than two fighter wing (~144 aircraft) bases at a single location. The Navy's carrier force, of course, achieves dispersion by virtue of basing in several independent battle groups.

Finally, the low transit speed of the MOB increases the likelihood that initial strike operations will be delayed relative to carrier or land based operation, if available. Carriers are well known to provide rapidly relocatable airpower to crisis areas. Similarly, the Air Force's focus on expeditionary operations has resulted in an improved ability to respond to crises. As with logistics support, the MOB can only provide a rapid strike capability if it is fortuitously positioned at the onset of a crisis.

C. SURFACE STRIKE

Surface firepower from naval vessels is in general of two types. The first type is from very long ranges to attack fixed land targets, like buildings or runways. The weapon used is the Tomahawk Land Attack Missile (TLAM). TLAMs are distributed among ships and submarines so that attacks can be coordinated to come from different platforms in different areas. Since this mission is not the primary mission for the ships and submarines, the number of TLAMs in each platform does not constitute a significant portion of the vessel's Vertical Launch System (VLS) cells or magazine. Also, large numbers are not needed in an individual naval vessel. When TLAM is launched in a surgical strike, large numbers are not required. When large numbers are needed, the attack can be coordinated with air strikes or TLAMs from other vessels. There is no requirement at this time to substantially increase this number of TLAMs deployed on naval vessels. Thus, unless future requirements for TLAM strikes far exceeds the number on other naval vessels, the MOB, which could sea base a large number of TLAMs in one place, is not an appropriate candidate for this long range strike naval mission.

The other surface strike mission is to provide fire support to ground forces. The weapons are primarily naval guns. While missiles are under consideration for this mission, the gun will probably remain the major contributor due to the relative costs of the weapons and rounds.

The Naval Surface Fire Support Cost and Operational Effectiveness Analysis (COEA)[1] used a concept of operations in which the destroyers are distributed along the

---

[1] *NSFS COEA,* Center for Naval Analyses (U), Report 210, October 1994, SECRET.

coast to cover the areas described in the COEA scenarios. Requirements for range into the hostile country can require the ships too close to the coast to overcome the limited range of the guns. Approaching the coast can expose the ships to coastal defense systems. Thus, naval fire support ships need to be able to protect themselves and move quickly when the situation warrants. The Navy is building a new class of destroyer, the DD-21, to support this mission. The DD-21's Operational Requirements Document calls for a draft of no more than 28 feet. Also, the DD-21 is being designed with low signatures or "stealth" to substantially decrease the likelihood of detection by enemy sensors. The procurement cost objective for this ship is $750 million. To enhance effectiveness in Joint littoral operations, the DD-21 will feature active and passive survivability features, such as in-stride mine avoidance and full-spectrum signature reduction. These features allow the ship to operate closer to the shore to hit targets further inland and survive. The MOB does not fit easily into this scheme of maneuver. The MOB is not easily distributed up and down the coast. It has an operating draft of 140 feet, making approach to the coast problematical as discussed in the previous section on Air Strikes. The MOB is not stealthy nor can it move quickly if needed. For these reasons, we conclude that surface strike is not an appropriate mission for the MOB.

D. DEPLOYMENT OF MARINE FORCES

Deployment of Marine striking forces into a hostile environment is another example of power projection. In this section, we consider the MOB as a prepositioned asset to support the deployment of Marine forces in the power projection mission.

1. Current Maritime Prepositioning Force (MPF) Program for the Marine Corps

The Marine Corps currently has three squadrons of ships prepositioned at Diego Garcia, Guam, and in the Mediterranean Sea. Each squadron is loaded with equipment and supplies to support the deployment of a MEB of about 17,000 Marines. The Marines and certain equipment and supplies, collectively known as the fly-in-echelon (FIE), deploy from CONUS in strategic lift aircraft to an aerial port of debarkation (APOD) near the port or beach where the MPF squadron ships are offloaded. A port is not required since the ships carry lighterage that can be used to move the material from the ships to a beach. This is a short transit of up to about 5 nmi since the lighterage is not capable of open ocean transit. It takes about 10 days to offload the ships, unload the containers, and associate vehicles, equipment, and supplies with the correct units. At this point the MEB is ready for combat. A benign or protected environment on the beach is needed for this stand-up operation until the MEB is combat-ready.

The ships in the current MPF squadrons are commercial cargo ships capable of point-to-point delivery of containers and rolling stock. These ships are operated by the Military Sealift Command with civilian crews. An Offload Preparation Party (OPP), consisting of a small number of Marines, may embark the squadron ships en route to the offload site in order to prepare vehicles for offload. There are only about 400 accommodations in the entire squadron for the OPP personnel.

2. MPF-F Concept

From the capabilities in these ships, it is apparent that Marines deploying via the current MPF cannot participate in OMFTS and STOM. OMFTS is a cornerstone concept developed by the Marine Corps in 1996. In OMFTS, maneuver space on the sea is added to the maneuver space on the ground and in the air for deploying and employing Marine forces. The STOM concept indicates that Marine forces move from the sea base directly to the objective without a pause at the beach to build up a large footprint (consisting of supplies and material). The forces are generally sustained from the sea base. To conduct OMFTS and STOM a sea base is needed. This feature is missing in the current MPF squadron but could be provided with a MOB.

Subsequently, the Marine Corps developed the concept of MPF-Future that requires some amount of sea basing within the MPF-F squadron. The Marine Corps' concept paper, *MPF 2010 and Beyond*, signed by the Commandant on 31 December 1997, describes four pillars for future operations. The name was subsequently changed from MPF 2010 to MPF-F. The four pillars are:

- Force Closure: to provide at-sea or en route arrival and assembly.
- Amphibious Task Force (ATF) Integration: to participate in OMFTS and to allow Marine forces to deploy via and be supported from the MPF-F sea base.
- Indefinite Sustainment: to serve as a conduit for logistics so that Marines deploying via the MPF-F sea base can be sustained for an indefinite period from the sea base. This includes delivering sustainment to the deployed force from MPF-F sea base and replenishment of the sea base itself.

- Reconstitution and Redeployment: to have the capability to reload the MPF-F force into the MPF-F ships, reconstitute the force in the sea base in theater, and redeploy the MPF-F force to another area.

The pillars clearly imply that MPF-F requires a sea base from which a force can be deployed and sustained. This feature could be provided with a MOB.

3. The MOB as an MPF-F Option

To assess the MOB in this role, we use a study completed in 1998 at the Center for Naval Analyses.[2] The CNA study was sponsored by the Director, Operational Logistics/Strategic Mobility Division (N42) and by the Director, Expeditionary Warfare Division (N75). The objective was to develop material options and costs that meet the MPF-F/sea-basing requirements for MPF 2010 (subsequently changed to MPF-F). This study was pre-milestone zero, and the results ultimately supported the development of a Mission Need Statement for MPF-F.

4. MPF-F Capability Options in the CNA Study

The approach taken by CNA in conducting the MPF-F MAA was to bound the capabilities that had been broadly stated by the Marine Corps with upper and lower bound capability options. They then developed intermediate capability options representing reasonable operational capabilities between the upper and lower bounds.

The lower bound, called Option A, simply replaces the current ships with new ships of comparable capability. Option A has no sea basing capability and offers no ability to conduct OMFTS.

The next level up, Option B, adds the capability to operate the rotary-wing aircraft from the decks of the MPF ships, while keeping the long-term basing ashore in the theater. The rotary-wing assets of the MPF-F MAGTF consist of 36 MV-22 tilt rotor aircraft, 8 CH-53E, 18 AH-1W, and 6 UH-1N helicopters. The total is 68 rotary-wing aircraft.

---

2 *MAA for MPF Future Sea-Basing Concepts: Volume I, Final Summary Report,* Center for Naval Analyses, CRM 98-29, June 1998, UNCLASSIFIED.

Option C adds the capability to base, maintain, and operate the 68 rotary-wing aircraft on the MPF-F sea base.

Option D adds the capability to base, maintain, and operate the 60 V/STOL-type JSFs on the MPF-F sea base.

Option E is the upper bound. In this option, the capability to receive and launch the C-17 strategic lift aircraft is added. Only a MOB has this capability. The MOB also serves as a base for the 68 rotary-wing and 60 JSF aircraft in the previous options.

When the MAA determined the personnel accommodations needed in the MPF-F sea base to support each option, they found that 400 were needed for Option A; 10,600 for Option B; 13,500 for Option C; 16,400 for Option D; and 17,000 for Option E. Since the increase from Option A to B was so large, an Option B(-) was added with 4,600 accommodations.

In the CNA study, a concept of operations was developed for each capability option. Aviation units not based on the MPF-F sea base are based at an aviation land base in the theater of operations. Ships called aviation support ships are added to the sea base ships to complete the MPF-F squadron. The aviation support ships carry the equipment and supplies needed for the land-based aircraft to the land base area (a port or beach staging area). For example, in Option C the fixed-wing JSF aircraft were land based. CNA added another option, called Option C(+), in which the fixed-wing support is not provided as part of the MPF-F squadron capability. In this option, fixed-wing support may be provided to the MPF-F MAGTF by carrier based aircraft in the theater of operations. The sea base for Options C and C(+) is the same.

The MPF-F capability options are summarized in Figure 56. The figure includes the aircraft based on the sea base and the runway length needed for each option. The V/STOL JSF is projected to require 600 feet of runway for loaded take-off. The columns contain the elements of the MPF-F MAGTF that are accommodated on the MPF-F sea base. The designations GCE(-) and ACE(-) indicate a part of (but not all of) the GCE and ACE, respectively.

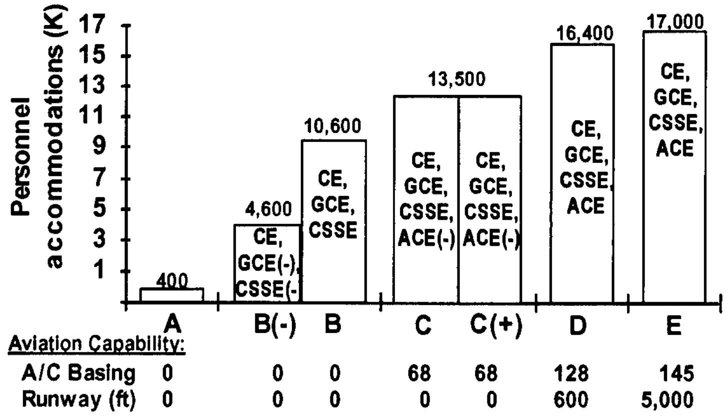


Figure 56. Capability Options for MPF-F

5. Concept of Operations in the CNA Study

The concept of operations for Option A is the concept for the current MPF. An APOD is needed in theater to receive the strategic airlift aircraft that carry the FIE. Also, a staging area is needed as described previously. An air base is also needed in theater to base the aviation assets. A Naval Support Element (NSE) is required for this option to conduct the offload of the ships. The NSE consists of about 1,000 personnel.

Options B(-), B, and C have similar concepts of operation since they all have portions of the aviation assets based at a land base in theater. The aviation support ships deliver the prepositioned material for the land-based units to them. The remainder of the MPF-F squadron ships transit to an Intermediate Staging and Embarkation Point (ISEP), which is a port en route between the squadron home port and the theater of operations. The rest of the MPF-F MAGTF personnel (non-land-based aviation units) and their fly-in material arrive by strategic airlift at an air base near the ISEP. If no en route ISEP is available, the MPF-F homeport will be used with the resulting penalty in arrival time for the MPF-F MAGTF in the theater.

In Options C(+) and D, there is no air base in theater required, so all the FIE (personnel and fly-in material) arrive by strategic airlift and embark the MPF-F ships at the ISEP.

In Option E, the MOB is the MPF-F squadron. The MOB SBUs transit to the area of operations and assemble into a fully functioning MOB that is 5,000 feet in length and capable of C-17 operations. The MPF-F MAGTF deploys directly onto the MOB via airlift and forms a combat-ready MAGTF on the MOB. In the MAA, the MOB SBU transit speed of 10 knots was the principal driver for the deployment time for Option E. In the CNA study, the airlift started before the MOB was completely assembled. The aircraft were held at the last refueling stop en route until the MOB assembly was complete.

6. Theater Footprint on Land by Option

The concepts of operation show a decreasing requirement (as the options increase from Option A) for in-theater land to support the deployment of Marine forces. For Options C(+), D, and E (the MOB), the footprint in theater is zero. The number of MPF-F MAGTF personnel on land in theater decreases from 18,000 in Option A to 4,000 in Option C to zero for Options C(+) and above.

7. Deployment Time Lines

In the CNA study, the the time-phased flow of the Marine forces and equipment from CONUS bases was examined in detail. The calculation was based on historical data from Operation Desert Storm, current strategic airlift planning factors, and discussions with current MPF force planners. Time lines were developed for the flow of personnel, self-deploying JSF and MV-22 aircraft, and the helicopters and equipment that must be shipped by strategic lift cargo aircraft.

Three regional scenarios were evaluated: Balkans, Far East, and the Persian Gulf. The seven capability options were evaluated in each scenario.

The CNA study found that a 24-knot MPF-F ship speed was sufficient because in all cases the ships were at the ISEP prior to the arrival of the leading edge of the strategic airlift. The distinguishing factor with respect to deployment time among the capability options was the number of personnel and the amount of material that had to flow to and through the ISEP. When they compared the ability of a sea base to support the deployment of Marine forces using the principles of OMFTS and STOM with the present capability (Option A) with no sea base, they concluded that sea basing adds a significant operational capability. The CNA study found that the MOB has a longer deployment time than other options considered due to the MOB's slower transit speed.

The CNA study also found that the sea base reduced the vulnerability of forces deploying via MPF-F as well as the dependence on shore-based infrastructure in the theater of operations.

The CNA study also evaluated an independent operation in which the MPF squadron uses its organic lighterage to offload all its cargo in-stream 3-4 nmi from the beach. This is like the offload operation of the current MPF. Again, the MOB's transit speed allowed the other options to complete the deployment sooner.

8. Port Accessibility

If a port is available and the situation permits, the current MPF ships can offload pierside as they did in Operation Desert Storm. This feature is one that is desired in the MPF-F options also. The monohull options (Options A thru D) evaluated in the CNA study were designed to allow the ships to enter the ports they are expected to use. These ports include their homeports and Blount Island, Florida, where the maintenance site for the prepositioned equipment is located. Since the MOB cannot get into any port, this desired feature of MPF-F operations is not available with the MOB.

9. Ship-to-Shore Analysis

CNA analyzed the time to deploy the landing force via surface lift assets (LCAC) and airlift (MV-22 and CH-53E aircraft). The landing force of 6,800 Marines and 1,700 vehicles was offloaded in 2 days using LCAC from the ATF being reinforced for the primary surface lift asset. The Advance Amphibious Assault Vehicles (AAAVs) were launched from the MPF-F platforms and swam ashore. The ships were initially at 25 nmi from the beach and the objective was 60 miles inland. In a follow-on study,[3] CNA found another surface lift asset that could be prepositioned on MPF-F was more effective than the LCAC for this landing operation. Since all the options have the same organic airlift and surface lift assets in the CNA study, there is no substantial difference along the options in ship-to-shore effectiveness.

---

[3] *Surface Lift for MPF 2010 and Beyond: Volume I, Final Summary Report,* Center for Naval Analyses, CRM 98-158, March 1999, UNCLASSIFIED.

10. Sustainment Analysis

CNA calculated the daily sustainment for food, water, ammunition, and fuel for the units in the 6,800 Marine landing force. They then determined that there were sufficient organic (to the MPF-F MAGTF) rotary-wing air assets to deliver this sustainment to the forces ashore at a separation distance of 85 nmi. Additional aircraft remained available for troop movement, medevac, and delivery of maintenance contact teams from the MPF-F sea base. Since all the options have the same set of organic airlift assets in the CNA study, there is no substantial difference among the options in sustainment.

11. MPF-F Squadron Design Considerations

The dry cargo lift for MPF-F is about 860,000 square feet of rolling stock and 3 million cubic feet of cube cargo, most of which is in containers. This is more than is in the current MPF since the FIE equipment and supplies are included. Also, to move to a tactical load as opposed to an administrative load, material is not mobile loaded in MPF-F. Selective offload is required and adds to the stowage volume for both square and cube cargo. CNA[4] also calculated the staging and assembly area needed to offload combat-ready Marine units. This amounted to 50,000 square feet of space in the MPF-F squadron. Hangar and maintenance space for the aviation units based on MPF-F were determined. The space needed for vehicle maintenance was also determined. These are examples of the ship requirements that CNA developed in the MAA for the MPF-F options. CNA provided these design requirements to the ship design agents to use in designing the intermediate option ships (Options B(-) thru D). Their goal was to develop viable, cost-effective ship concepts to be used in forming MPF-F squadrons.

The two design agents, AME and BLA, worked independently and determined very different solutions. Both solutions met the requirements. One of the AME designs is shown in Figure 57. This is one of the six sea base ships needed for the AME Option C solution.

---

4 *MAA for MPF Future Sea-Basing Concepts: Volume I, Final Summary Report,* Center for Naval Analyses, CRM 98-29, June 1998, UNCLASSIFIED.

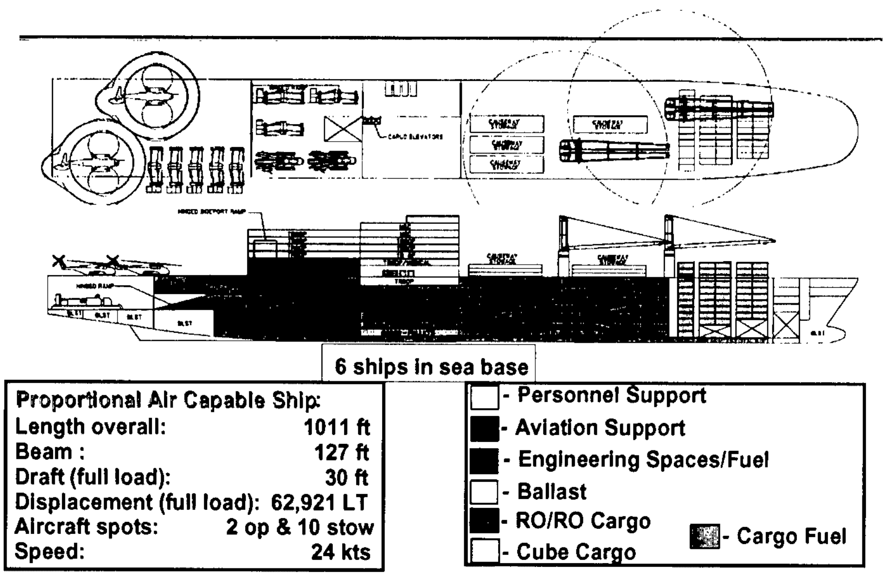


Figure 57. AME Ship Design for MPF-F Option C

The AME ship in Figure 58 is just over 1,000 feet in length and its full-load displacement is about 60,000 long tons.

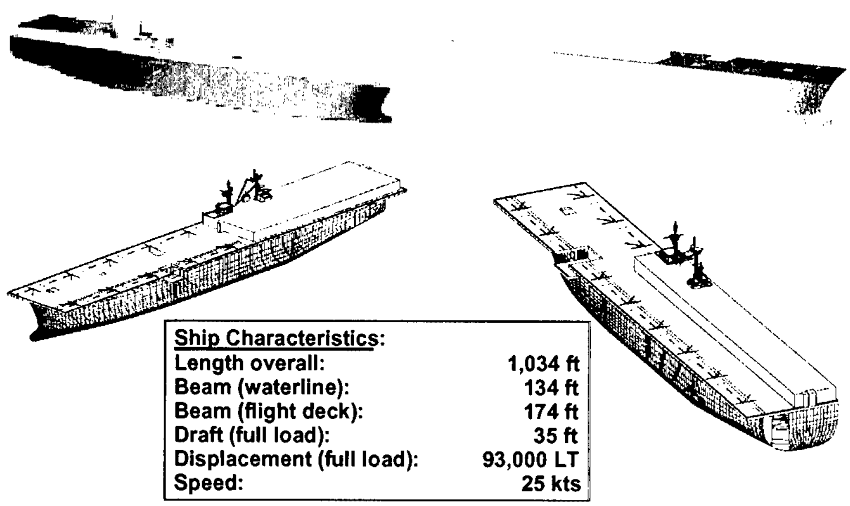


Figure 58. BLA Ships Designed for MPF-F

The BLA designs are about the same length but their displacement is about 90,000 long tons. Figure 58 shows examples of the BLA ship designs for MPF-F.

12. MPF-F MAA Capability Option Cost-Effectiveness Summary

Figure 59 provides a summary of the cost and effectiveness of the seven capability options developed by CNA for the MPF-F MAA. The MOB acquisition cost in the CNA study is within the range of cost estimates in the current report ($8-13 billion), although the $17 billion LCC is lower. Our current report estimates the LCC at $22-27 billion for 40 years.

Option	Host Nation Support (personnel)	Deployment Time (days)		Cost to Acquire (RDT&E plus SCN) (FY 2004 $B)		Life Cycle Cost (FY 2004 $B)	
		Ind.Op.	OMFTS	AME	BLA	AME	BLA
A	18,300	15	31	2.3		5.8	
B(-)	14,000	15	13	4.0	2.8	8.4	5.2
B	7,300	15	15	4.4	2.8	8.9	5.4
C	4,100	15	17	5.1	3.8	10.3	7.2
C(+)	0	15	17	4.3	3.0	8.7	5.5
D	0	15	19	6.3	3.9	12.2	7.3
E	0	20	19	12.6		17.2	

Figure 59. Summary of Cost and Effectiveness for MPF-F Options from the MAA

The measures are host nation support required, deployment time, and acquisition and life cycle cost. The host nation support required is measured by the number of MPF-F MAGTF personnel that need to be stationed in a host nation facility in the theater of operations. This measure goes to zero for Options C(+) and above, indicating independence from theater support requirements. Deployment time is measured in days from the start of the deployment to the delivery of the combat forces on the objective ashore. Results for two deployment options into the Persian Gulf are shown. The first option, indicated as "independent option," is a shore-based deployment at a host nation support facility similar to the current MPF capability with no sea basing. The second deployment option, indicated as "OMFTS," is for a deployment using sea basing and applying the principles of OMFTS and STOM. The Persian Gulf scenario was the most stressing of the scenarios analyzed by CNA.[5] The cost numbers are in FY 2004 dollars for both the acquisition and 40 years of life-cycle costs.

The results show that the MPF-F mission can be accomplished in a cost-effective manner with large monohull ships that the United States has the capability and experience to build. The results also show that a MOB is not a cost-effective solution for the MPF-F mission.

---

5 *Surface Lift for MPF 2010 and Beyond: Volume I, Final Summary Report,* Center for Naval Analyses, CRM 98-158, March 1999, UNCLASSIFIED.

Appendix A

ACQUISITION COST CALCULATIONS FOR MOB CONTRACTORS

Appendix A
ACQUISITION COST CALCULATIONS FOR MOB CONTRACTORS

This appendix summarizes the cost estimates for three MOB designs: those proposed by Aker, Bechtel, and Kvaerner. The McDermott design cost estimates are given in Chapter VIII of the main report. In all cases data provided in the ONR feasibility study are used.

The Aker cost estimates can be found in Tables A-1 through A-4.

The Bechtel MOB design cost estimates are provided in a similar format in Tables A-5 through A-8.

The Kvaerner cost estimates are given in Tables A-9 through A-17.

Table A-1. AKER (Four SBUs) Estimated Cost Lead and Follow-On SBUs

SWBS	Title	Long Tons	Prod Hrs	Prod $	Material $	Total $	Prod Hrs	Prod $	Material $	Total $
100	Hull (Steel)	129,800	7,772,774	275,942,188			7,772,774	275,942,188		
101	Hull (Contrete) CM	144,000	2,736,000	97,131,061			2,736,000	97,131,061		
101	Hull (Contrete) LT	346,329								
200	Propulsion	1,021	53,417	1,896,369			53,417	1,896,369		
300	Electric	1,139	405,101	14,381,547			405,101	14,381,547		
400	Command & Surveillance	49	21,076	748,206			21,076	748,206		
500	Auxillary Systems	1,155	216,505	7,686,187			216,505	7,686,187		
600	Outfit & Furnishings	1,212	380,382	13,503,977			380,382	13,503,977		
	Total 1-6	480,705	11,585,256	411,289,535	691,074,752	1,102,364,287	11,585,256	411,289,535	69,074,752	1,102,364,287
	Margin					110,236,429				110,236,429
800	Engineering		4,225,308	209,730,853	16,516,687	226,247,540	383,740	19,047,657	16,516,687	35,564,343
900	Support Services		4,648,114	165,013,243	57,428,312	222,441,555	3,250,780	115,406,340	57,428,312	172,834,651
	Total 8-9		8,873,442	374,744,096	73,944,998	448,689,095	3,634,521	134,453,996	73,944,998	208,398,995
	Total 1-9		20,458,677	786,033,632	765,019,750	1,661,289,810	15,219,776	545,743,531	765,019,750	140,999,710
	Profit					166,128,981				213,149,957
	Basic Ship Construction					1,827,418,791				1,634,149,667
	Change Orders					182,741,879				81,707,483
	FCOM					31,441,345				65,365,987
	Other					36,548,376				32,682,993
	Sub Total					250,731,600				179,756,463
	Total					2,078,150,392				1,813,906,130

Table A-2. Pre-Escalation Cost with 97 Percent Learning

Unit	Total Cost ($)	T1 Cost ($)
1	2,078,150,392	1,813,906,130
2	1,759,488,946	
3	1,728,416,897	
4	1,706,704,278	
Sub Total	7,272,760,514	

Table A-3. Escalation with 97 Percent Learning

Unit	BSC ($)	BSC T1 ($)
1	1,827,418,791	1,634,149,667
2	1,585,125,177	
3	1,557,132,340	
4	1,537,571,422	
Sub Total	6,507,247,730	
Escalation @ 8 %	520,579,818	

Table A-4. Total Cost of Four-SBU MOB (dollars)

Pre-Escalation	7,272,760,514
Escalation	520,579,818
Total Cost	7,793,340,332

Table A-5. BECHTEL (Three SBUs) Estimated Cost Lead and Follow On SBUs

SWBS	Title	Long Tons	Prod Hrs	Prod $	Material $	Total $	Prod Hrs	Prod $	Material $	Total $
100	Hull	228,733	13,697,150	486,264,134	343,099,500	829,363,634	13,697,150	486,264,134	343,099,500	829,363,634
200	Propulsion	3,7000	193,578	6,872,248	146,856,292	153,728,540	193,578	6,872,248	146,856,292	153,728,540
300	Electric	3,100	1,102,558	39,142,050	29,663,500	68,805,550	1,102,558	39,142,050	29,663,500	68,805,550
400	Command & Surveillance	1,700	731,193	25,958,160	26,390,660	52,348,821	731,193	25,958,160	26,390,660	52.348,821
500	Auxillary Systems	13,800	2,586,160	91,834,958	308,338,541	400,173,499	2,586,819	91,834,958	308,338,541	400,173,499
600	Outfit & Furnishings	11,300	3,546,463	125,903,420	87,726,183	213,629,602	3,546,463	125,903,420	87,726,183	123,629,602
	Total 1-6	262,333	21,857,761	411,289,535	942,074,677	1,718,049,647	21,857,761	775,974,970	942,074,677	1,718,049,647
	Margin					171,804,965				171,804,965
800	Engineering		7,971,837	395,696,653	22,515,585	418,212,238	723,998	35,936,983	22,515,585	58,452,567
900	Support Services		8,769,540	311,328,482	78,286,406	389,614,887	6,133,208	217,735,739	78,286,406	296,022,145
	Total 8-9		16,741,377	707,025,135	100,801,990	807,827,125	6,857,206	253,672,722	100,801,990	354,474,712
	Total 1-9			1,483,000,105	1,042,876,667	2,697,681,736		1,029,647,692	1,042,876,667	2,244,329,323
	Profit					269,768,174				336,649,398
	Basic Ship Construction					2,967,449,910				2,580,978,722
	Change Orders					296,744,991				129,048,936
	FCOM					59,320,004				41,185,908
	Other					59,348,998				51,619,574
	Sub Total					415,413,993				221,854,418
	Total					3,382,863,903				2,802,833,140

Table A-6. Pre-Escalation Cost with 97 Percent Learning

Unit	Total Cost ($)	T1 Cost ($)
1	3,382,863,903	2,802,833,140
2	2,718,748,146	
3	2,670,735,866	
Sub Total	8,772,347,915	

Table A-7. Escalation with 97 Percent Learning

Unit	BSC ($)	BSC T1 ($)
1	2,967,449,910	2,580,978,722
2	2,503,549,360	
3	2,459,337,427	
Sub Total	7,930,336,697	
Escalation @ 8 %	634,426,936	

Table A-8. Total Cost of Three-SBU MOB (dollars)

Pre-Escalation	8,772,347,975
Escalation	634,426,936
Total Cost	9,406,774,851

Table A-9. KVAERNER (Three SBUs and Two Bridges) SBUs
Estimated Cost Lead and Follow On

SWBS	Title	Long Tons	Prod Hrs	Prod $	Material $	Total $	Prod Hrs	Prod $	Material $	Total $
100	Hull	185,990	11,137,583	395,396,669			11,137,583	366,426,491		
200	Propulsion	10,500	549,344	19,502,325			549,344	18,073,416		
300	Electric	2,080	739,781	26,263,053			739,781	24,338,795		
400	Command & Surveillance	800	344,091	12,215,605			344,091	11,320,584		
500	Auxillary Systems	11,955	2,240,972	79,557,024			2,240,972	73,727,988		
600	Outfit & Furnishings	18,140	5,693,172	202,113,985			5,693,172	187,305,368		
	Total 1-6	229,465	20,704,944	735,048,660	1,057,926,988	1,792,975,649	20,704,944	681,192,642	1,057,926,988	1,739,119,630
	Margin					171,804,965				173,911,963
800	Engineering		7,551,388	374,826,903	25,284,455	400,111,358	685,813	34,041,602	25,284,455	59,326,057
900	Support Services		8,307,019	294,908,460	87,913,733	382,822,193	5,809,731	206,251,966	87,913,733	294,165,699
	Total 8-9		15,858,407	669,735,363	113,198,733	782,933,550	6,495,545	240,293,568	113,198,188	353,491,756
	Total 1-9		36,563,350	1,404,784,023	1,171,125,176	2,755,206,764	27,200,488	921,486,210	1,171,125,176	2,266,523,349
	Profit					275,520,676				339,978,502
	Basic Ship Construction					3,030,727,440				2,606,501,851
	Change Orders					303,072,744				130,325,093
	FCOM					56,191,361				104,260,074
	Other					60,614,549				52,130,037
	Sub Total					419,878,654				286,715,204
	Total					3,175,085,418				2,893,217,055

Table A-10. Pre-Escalation Cost with 97 Percent Learning

Unit	Total Cost ($)	T1 Cost ($)
1	3,175,085,418	2,606,501,851
2	2,528,306,796	
3	2,483,657,653	
Sub Total	8,187,049,867	

Table A-11. Escalation with 97 Percent Learning

Unit	BSC ($)	BSC T1 ($)
1	3,030,727,440	2,606,501,851
2	2,528,306,796	
3	2,483,657,653	
Sub Total	8,042,691,889	
Escalation @ 8%	643,415,351	

Table A-12. Total Cost SBUs (dollars)

Pre-Escalation	8,187,049,867
Escalation	643,415,351
Total Cost	8,830,465,218

Table A-13. KVAERNER (Three SBUs and Two Bridges) Estimated Cost Lead and Follow On

SWBS	Title	Long Tons	Prod Hrs	Prod $	Material $	Total $	Prod Hrs	Prod $	Material $	Total $
100	Hull	165,750	9,925,557	352,368,396			9,925,557	352,.368,396		
200	Propulsion	6,030	315,480	11,199,906			315,480	11,199,906		
300	Electric	2,080	739,781	26,263,053			739,781	26,263,053		
400	Command & Surveillance	120	51,614	1,832,341			51,614	1,832,341		
500	Auxiliary Systems	3,950	740,430	26,286,093			740,430	26,286,093		
600	Outfit & Furnishings	10,640	3,339,325	118,549,769			3,339,325	118,549,769		
700	Amament									
	Total 1-6	188,570	15,112,187	536,499,577	709,338,355	1,245,837,913	15,112,187	536,499,557	709,338,355	1,245,837,913
	Margin					171,804,965				173,911,963
800	Engineering		5,511,630	273,579,803	16,953,187	290,532,989	5,005,636,299	24,846,	16,953,187	41,799,575
900	Support Services		6,063,152	215,248,686	58,946,017	274,194,703	4,240,424,496	150,539,814	58,946,017	209,485,831
	Total 8-9		11,574,782	488,828,489	75,899,204	564,727,693	6,495,545	175,386,202	75,899,204	251,285,406
	Total 1-9		26,686,970	1,025,328,046	785,237,559	1,810,565,561	19,853,175	711,885,759	785,237,559	1,497,123,319
	Profit					181,056,561				224,568,498
	Basic Ship Construction					1,991,622,166				1,721,691,817
	Change Orders					199,162,217				86,084,591
	FCOM					41,013,122				28,475,430
	Other					39,832,443				34,433,836
	Sub Total					280,007,782				148,993,585
	Total					2,090,573,387				1,646,117,176

Table A-14. Pre-Escalation Cost with 97 Percent Learning

Unit	Total Cost ($)	T1 Cost ($)
1	2,090,573,387	1,646,117,176
2	1,596,733,661	
Sub Total	3,687,307,048	

Table A-15. Escalation with 97 Percent Learning

Unit	BSC ($)	BSC T1 ($)
1	1,991,622,166	1,721,691,817
2	1,670,041,062	
Sub Total	3,661,663,228	
Escalation @ 8%	292,933,058	

Table A-16. Total Cost Bridges (dollars)

Pre-Escalation	3,687,307,048
Escalation	292,933,058
Total Cost	3,980,240,106

Table A-17. Total MOB Cost (dollars)

SBUs	8,830,465,218
Bridges	3,980,240,106
Total Cost	12,810,705,324

(This page is intentionally blank.)

Appendix B

COASTAL BATHYMETRY AND NEAR-SHORE MOB OPERATIONS

Appendix B
COASTAL BATHYMETRY AND NEAR-SHORE MOB OPERATIONS

In this appendix we discuss constraints imposed on MOB operations by coastal bathymetry in some of the strategically important regions of the world. As was discussed earlier, the MOB cannot operate in its stabilized, ballasted mode in depths less than 130 feet. This constraint has the effect of limiting the minimum coastal approach distance. To determine how severe a problem this might represent, we present some bathymetry charts for the Sea of Japan, Yellow Sea, Persian Gulf, India-Pakistan border coastal region, the East Taiwanese coast (Philippine Sea), and the Taiwan straight. These charts were created using DBDB 4.0, a Web interface to Navoceano's Data Warehouse.

First we consider the bathymetric constraints around the Korean peninsula. In Figure B-1, we see that the Sea of Japan off the east coast of the Korean peninsula exhibits a steep slope as one moves away from the coastline into the deep surrounding water. The bathymetry contours indicate that the MOB would typically be able to operate within 10 nmi of the shore.

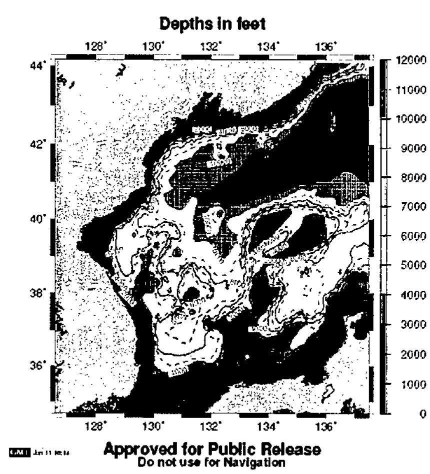


Figure B-1. Bathymetry Contours for the Sea of Japan Near the Korean Peninsula

By contrast the Yellow Sea, off the west coast of the Korean peninsula, is much more shallow with depths that do not exceed about 270 feet. In this case a typical minimal approach distance would be about 20 nmi. This is shown in Figure B-2

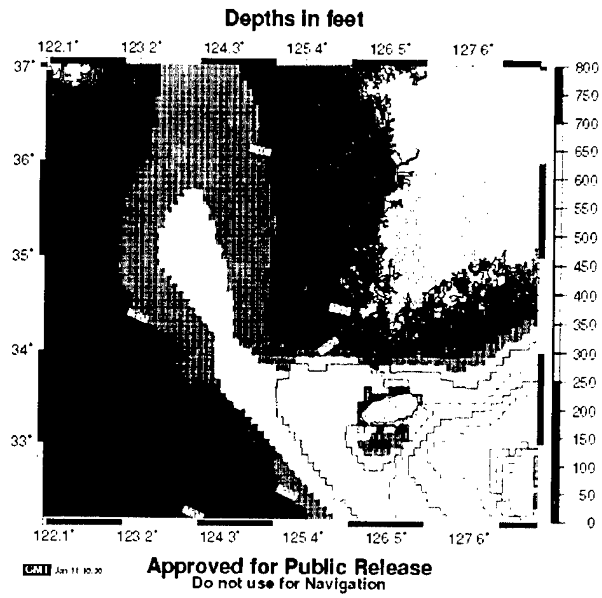


Figure B-2. Bathymetry Near the Southern Tip of Korea

Next we turn our attention to the Persian Gulf region. The bathymetry plot in Figure B-3 shows that the MOB will be able to operate from about 100 nmi south of the Iraqi border down to the Straights of Hormuz and into the Gulf of Oman. Depending on the location of the operating area, the MOB would be able to operate within a few miles of the Iranian coastline.

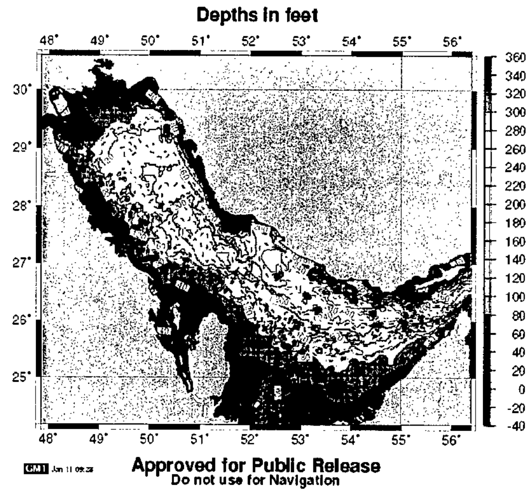


Figure B-3. Bathymetry of the Persian Gulf

Figure B-4 shows a coastal region near the India-Pakistani border. In the coastal region above the 24th parallel as far east as 67 degrees longitude, the continental shelf is steeply sloped so MOB access within 20 nmi of the coastline is easily achieved. However, further east one finds a much more gently sloped continental shelf. As a result, the closest MOB approach expands to over 60 nmi throughout much of the east coast of India. See Figures B-5 and B-6.

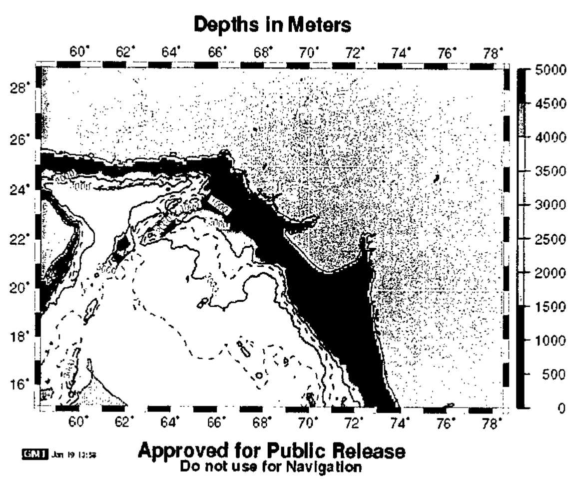


Figure B-4. Bathymetry Near the Pakistan and Northern India Coastline

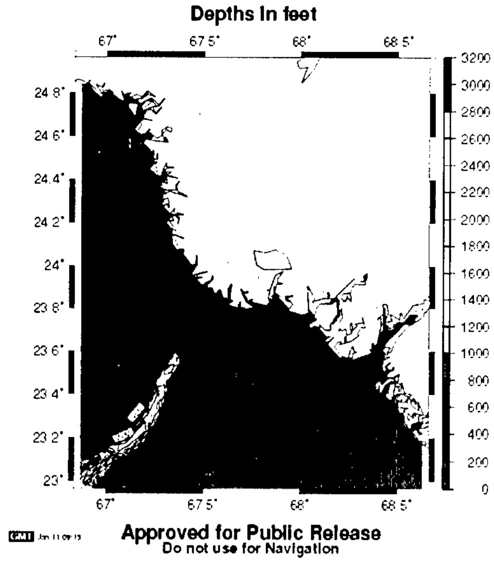


Figure B-5. Close-up View of the India-Pakistan Border

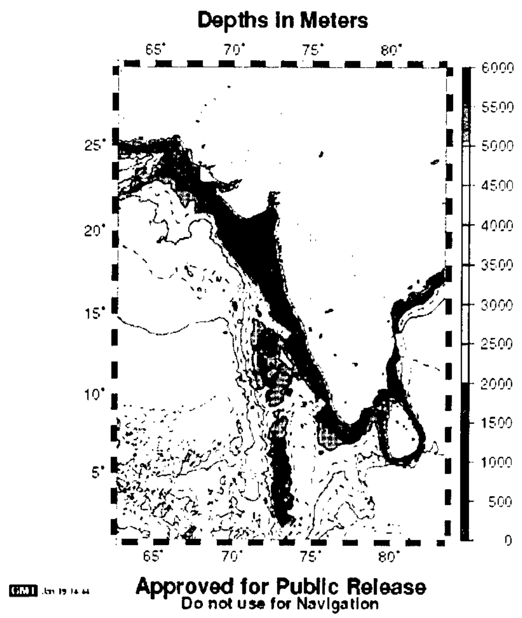


Figure B-6. Bathymetry of West Coast of India

Finally, we consider the bathymetric constraints in the Taiwan region. On the east Taiwanese coast, the Philippine Sea is steeply sloped (see Figure B-7). For this reason, the MOB will be able to get within about 5 nmi of the coastline. By contrast, the

Taiwan straight is a rather shallow region with depths that typically do not exceed 300 feet. Nevertheless, the measurements based on Figure B-8 indicate that the MOB will also be able the get within 5 nmi of the Taiwanese coastline.

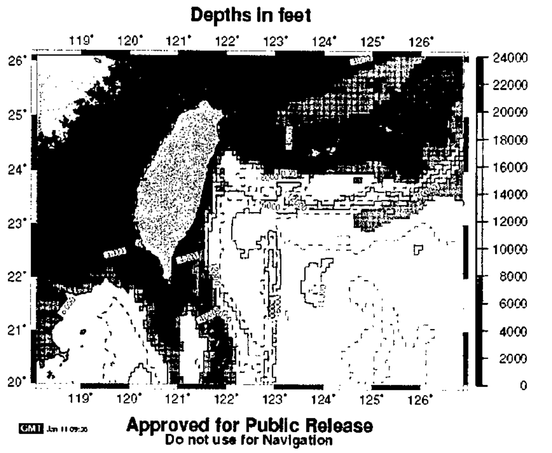


Figure B-7. Bathymetry of Area to West of Taiwan

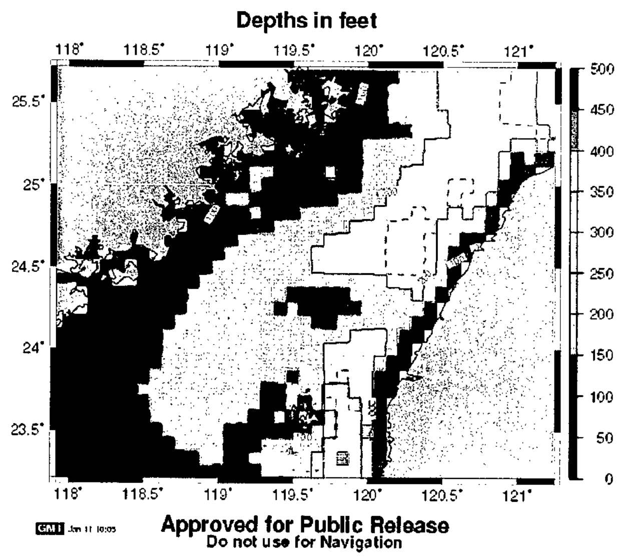


Figure B-8. Bathymetry of the Taiwan Straight

Table B-1 summarizes the discussion of the bathymetric constraints on coastal operations.

Table B-1. Estimated MOB Approach Distance

Region	Maximum Water Depths (ft.)	Estimated Approach Distance (nmi)
East Coast of Taiwan	4000-16000	5
India/Pakistan Border Area		20
Persian Gulf	160 -200	100[a]
		5[b]
Sea of Japan	<12000	10
Straight of Taiwan	150-200	5
Taiwan Straight	300	5
Yellow Sea	<270	20

[a]From Iraq.

[b]From Iran.

Appendix C

GLOSSARY

Appendix C
GLOSSARY

AAAV	Advance Amphibious Assault Vehicle
AAW	Anti-Air Warfare
ABM	Anti-Ballistic Missile
ACE	Aviation Combat Element
ACR	Armored Calvary Regiment
APOD	Aerial Port of Debarkation
ASCM	Anti-Ship Cruise Missile
ASW	Anti-Submarine Warfare
ATF	Amphibious Task Force
ATT	Advanced Theater Transport
BSC	Basic Ship Cost
CAIG	Cost Analysis Improvement Group
CE	Command Element
CEP	Circular Error Probable
CNA	Center for Naval Analyses
COEA	Cost and Operational Effectiveness Analysis
CONUS	Continental United States
CRAF	Civil Reserve Airlift Fleet
CSSE	Combat Service Support Element
CTOL	Conventional Take-Off and Landing
CVN	Aircraft Carrier, Nuclear Powered
DARPA	Defense Advanced Projects Agency
DLR	Depot-Level Reparable
DP	Dynamic Positioning
DPG	Defense Planning Guidance

FCOM	Facility Cost of Money
FIE	Fly-in-Echelon
GCE	Ground Combat Element
hp	horsepower
ICAO	International Civil Aviation Organization
IDA	Institute for Defense Analysis
ILS	Instrument Landing System
IOC	Initial Operational Capability
ISEP	Intermediate Staging and Embarkation Point
ITA	Initial Threat Availability
JLOTS	Joint Logistics Over the Shore
JMLS	Joint Modular Lighterage System
JSF	Joint Strike Fighter
JV	Joint Vision
kg/l	kilograms/liter
kts	knots
kW	kilowatt
LCAC	Landing Craft, Air Cushioned
LCC	Life Cycle Costs
LCM	Landing Craft, Mechanized
LCU	Landing Craft, Utility
LHD	General Purpose Amphibious Assault Ship
LID	Light Infantry Division
LMSR	Large Medium Speed Roll-on/Roll-off
m	Meter
MAA	Mission Area Analysis
MAGTF	Marine Air Ground Task Force
MCCDC	Marine Corps Combat Development Command
MEB	Marine Expeditionary Brigade

MEU	Marine Expeditionary Unit
MOB	Mobile Offshore Base
MOG	Maximum on Ground
MPF-F	Maritime Prepositioning Force-Future
MPS	Maritime Prepositioning Ship
MSC	Military Sealift Command
MTW	Major Theater War
NAVSEA	Naval Sea Systems Command
NCCA	Naval Center for Cost Analyses
NFESC	Naval Facilities Engineering Service Center
NL	Navy Lighterage
NMD	National Missile Defense
nmi	Nautical Miles
NSE	Naval Support Element
NSWC	Naval Surface Weapons Center
O&S	Operating and Support
OMFTS	Operational Maneuver from the Sea
ONR	Office of Naval Research
OOTW	Operations Other Than War
OPDS	Offshore Petroleum Discharge System
OPP	Offload Preparation Party
OSD	Office of the Secretary of Defense
PAX	Passengers
POL	Petroleum, Oil, and Lubricants
QTR	Quad Tilt Rotor
R&D	Research and Development
RIB	Rapidly Installed Breakwater
RO/RO	Roll-On/Roll-Off
RRDF	RO/RO Discharge Facility
RSO&I	Reception, Staging, Onward Movement, and Integration

S&T	Science and Technology
SBIRS	Spaced-Based Infrared System
SBU	Single Base Unit
SIB	Separate Infantry Brigade
SRBM	Short-Range Ballistic Missile
SS	Sea State
STOL	Short Takeoff and Landing
STOM	Ship-to-Objective Maneuver
SWA	South West Asia
SWBS	Ship Work Breakdown Structure
T-ACS	The Auxiliary Crane Ship
TBM	Theater Ballistic Missile
TLAM	Tomahawk Land Attack Missile
TMD	Theater Missile Defense
USAF	U.S. Air Force
USMC	U.S. Marine Corps
USN	U.S. Navy
VAMOSC	Visibility and Management of Operating and Support Cost
VLS	Vertical Launch System
VTOL	Vertical Takeoff and Landing
WMD	Weapons of Mass Destruction

Appendix D

LIST OF FIGURES AND TABLES

Appendix D
LIST OF FIGURES AND TABLES

FIGURES

TABLES

(This page is intentionally blank.)

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	January 2001	Final

4. TITLE AND SUBTITLE
Mobile Offshore Base Operational Utility and Cost Study

5. FUNDING NUMBERS
DASW-01-98-C-0067
BA-1-1890

6. AUTHOR(S)
William L. Greer, David A. Arthur, Joseph T. Buontempo, Waynard C. Devers, Alfred I. Kaufman, Bernard J. McHugh, Jack F. Nance

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Institute for Defense Analyses
1801 N. Beauregard Street
Alexandria, Va 22311-1772

8. PERFORMING ORGANIZATION REPORT NUMBER
IDA Paper P-3573

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Assistant Deputy Under Secretary of Defense
(Advanced Systems & Concepts) for
Dominant Maneuver
3700 Defense Pentagon
Washington, D.C. 20301-3700

FFRDC Programs
2001 N. Beauregard St.
Alexandria, VA 22311-1772

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

This paper documents the background, approach, analyses, and findings of the Mobile Offshore Base (MOB) Operational Utility and Cost Study conducted for the Deputy Under Secretary of Defense for Advanced Systems and Concepts. This study responds to the portion of the National Defense Authorization Act for Fiscal Year 2001 that directs the Secretary of Defense to provide an analysis of the operational utility and life cycle costs of the MOB. The assessment addresses power projection, missile defense, and logistics missions for the MOB circa 2020, with an emphasis on force deployment and logistics. Several alternative design concepts are identified and costed.

14. SUBJECT TERMS
mobile offshore base, MOB, sea base, joint logistics over the shore, JLOTS, maritime prepositioning ships

15. NUMBER OF PAGES
222

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMIT OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	Unlimited