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The Director, Medical Resources, Plans, and Policy (N-931) asked CNA to analyze potential alternatives for Navy Medicine's future deployable medical platforms, focusing on the 2015-2025 time frame. Specifically, N-931 directed CNA to:

1. Analyze future operating environments
2. Analyze the medical capabilities required by those environments
3. Describe and analyze generic potential platforms that will supply those capabilities
4. Analyze the requirement-setting process and funding cycle, to draw recommendations for Navy Medicine's actions.

Future operating environments could require Navy Medicine to support a wide variety of missions, including homeland security, operational maneuver from the sea, and managing the consequences of biological and chemical attacks. Our analyses show that there will be a continuing need for both land-based and sea-based medical platforms because no single platform is optimal in all circumstances. Among sea-based platforms, we found that variants or conversions of amphibious ships would be strong candidates for many future missions. Maritime Prepositioning Force Future (MPF(F)) ships should also be considered among potential future medical platforms for echelon II care. Variants of today's fleet hospital could serve Navy Medicine's needs for future land-based options. Navy Medicine needs to begin the process of developing mission needs statements soon because the requirement-setting, funding, and procurement processes take many years.

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Future Deployable Medical Capabilities and Platforms for Navy Medicine

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Contents

Chapter 1: Introduction

The Director, Medical Resources, Plans, and Policy (N-931) asked CNA to analyze potential alternatives for Navy Medicine's future deployable medical platforms, focusing on the 2015-2025 time frame. Specifically, N-931 directed CNA to:

1. Analyze future environments in which Navy Medicine will operate
2. Analyze the medical capabilities required by those future environments
3. Describe and analyze generic potential platforms that could supply those capabilities
4. Analyze the requirement-setting process and funding cycle to draw recommendations for Navy Medicine's actions regarding future deployable medical platforms.

This research memorandum reports the results of CNA's analyses, which are a preliminary step in identifying requirements and options for future deployable medical platforms. Navy Medicine will need to engage NAVSEA, N-42, and other parts of the Navy as it prepares more detailed studies of particular options.

Navy Medicine provides medical care to the Navy and Marine Corps during wartime and other operational contingencies. Its two largest platforms at this writing (early 2002) are the hospital ships (two) and fleet hospitals (ten). Both hospital ships are San Clemente-class tankers that were converted for medical purposes in the mid-1980s; each is equipped with 12 operating rooms, 80 intensive-care beds, and the capability to care for up to 1,000 patients. They are among the largest ships in the Navy—almost 900 feet long; they have one helicopter pad each and steam at about 17 n.mi. per hour. One hospital ship is stationed in San Diego, and the other is in Baltimore.

A fleet hospital is a "tent medical center" designed to support the medical needs of the personnel on the ground. It arrives simultaneously with CINC-delivered supplies that can sustain it for up to 60 days. Each of the 10 fleet hospitals worldwide has 6 operating rooms and 500 beds. A fully deployed fleet hospital can require 28 to 35 acres, and takes a considerable amount of labor and equipment to construct on a new site. Fleet hospitals are in containers on Maritime Prepositioning Force (MPF) ships, as well as prepositioned in containers in strategic areas of the world.

Navy Medicine's hospital ships have a long history, dating back to the Spanish-American War, and they have proved their usefulness in many conflicts [1], including Operation Desert Shield/Desert Storm [2]. Similarly, the fleet hospitals (and their precursors) have been essential tools for caring for wounded Marines and Sailors from the 1800s through Operation Desert Shield/Desert Storm.

Looking to the future, Navy Medicine's hospital ships and fleet hospitals are capable of supplying the large number of beds needed in the event of two nearly simultaneous Major Theater Wars (MTWs). Nevertheless, we need to consider alternative platforms for the future years for the following reasons:

- Changes in the global environment that expand the traditional warfighting mission of the Navy/Marine Corps to include such missions as homeland defense, urban warfare, biological/chemical warfare, and military operations other than war.
- Changes in Navy/Marine Corps warfighting concepts that require the Marines to be supported by sea-based logistics. In addition, the Navy and Marine Corps will move faster over greater distances, and possibly be more interspersed with the enemy than they have been in past conflicts.
- Changes in the helicopters, landing craft, and other equipment with which Navy Medicine's platforms will need to interface, which make it imperative that Navy Medicine's platforms change to continue to be useful.

All three medical services (Army, Air Force, and Navy) are working to develop smaller, more mobile medical platforms and capabilities.

This document is intended to help Navy Medicine plan its future deployable capabilities by (a) suggesting alternative platforms, (b) analyzing the positives and negatives of those platforms, (c) suggesting other pertinent issues to be addressed in considering alternatives, (d) providing analytical input into Navy Medicine's new requirement-setting process, and (e) supplying preliminary analyses of capabilities and rough cost estimates. The capability/engineering and cost estimates that we make in this study are preliminary. This document is an early step in a process that would require more detailed engineering and cost studies of particular options.

To accomplish these purposes, we organized this report in the following chapters:

- Chapter 2 analyzes future operating environments for the Navy and Marine Corps, and describes their required capabilities .
- Chapter 3 analyzes generic potential platforms for supplying the required capabilities.
- Chapter 4 reports the results of scenario-based modeling and gives some detailed requirements .
- Chapter 5 analyzes the current requirement-setting and funding processes of the Department of the Navy.
- Chapter 6 summarizes the major conclusions and observations of this study.

Chapter 2: An analysis of future operating environments and required capabilities implied by those environments

This chapter looks at the operating environments in which future deployable medical platforms must perform. We do this by answering the following questions:

- To what types of *missions* have the Navy and Marine Corps been assigned since World War II?
- What do the Defense Planning Guidance (DPG) and other *guidance* tell us about the future operating environment for the Navy/Marine Corps?
- What new Navy/Marine Corps *concepts* will affect Navy Medicine's deployable platforms?
- What *ships and equipment* must Navy Medicine's new deployable platforms support?

We then summarize the missions, environments, concepts, and ships and equipment that affect the capabilities Navy Medicine needs in its future deployable medical platforms. The chapter summary provides a detailed account of the capabilities needed by Navy Medicine's future deployable platforms.

Navy and Marine Corps missions since WWII

Past missions of the Navy/Marine Corps can provide background on the type of operations that Navy Medicine's platforms will need to support. An analysis of U.S. Military Operations since World War II [3] divided military roles into the following categories:

- ***Forcible entry.*** "The projection of ground forces to seize and hold a military lodgment in the face of armed opposition."
- ***Sustained land operations.*** "The deployment and maintenance of significant armed forces for a period of greater than 30 days, either (1) in support of or in preparation for combat operations or (2) as part of a peace operation in a semi- or non-permissive environment."
- ***Sustained land combat.*** "The use of significant ground forces in combat operations for a period of longer than 30 days."

We will briefly describe the Navy's and Marine Corps' history with each of these roles, and what they are likely to mean for future deployable medical platforms.

Forcible entry

Amphibious capabilities have constituted the Marine Corps' and Navy's major form of forcible entry [3]. Perhaps the most dramatic post-WWII example of forcible entry in major combat operations was the amphibious landing at Inchon in September 1950, which was a turning point in the liberation of South Korea.

Table 1 shows that forcible entry capability has been used in a number of ways, some involving major commitments of troops, and others not. It has been used as a war contingency option (1961, Dominican Republic; more recently in Operation Desert Storm, in which six Iraqi divisions were held to defensive positions against a Marine amphibious assault), to quarantine an island (such as during the Cuban missile crisis in 1962), for a show of force (such as the Yom Kippur War in 1973), for peacekeeping (Lebanon, 1985), and for noncombatant evacuation operations (NEOs) (such as Haiti in 1963, the Liberia evacuation operation in 1990, and securing the U.S. Embassy compound in Somalia in 1991).

The lesson for future deployable medical platforms is that they must be able to support a traditional amphibious assault to fulfill their mission as a flexible deterrent option (FDO). The example of Grenada, in which U.S. military assistance was used to evacuate U.S. citizens from the island, and several of the NEOs, where the time between warning and action was quite short, required that medical capability arrive at a theater of operations very quickly. Historically, this has been achieved through prepositioning and the ability to move at ARG speeds or faster.

Table 1. Categories of forcible entry involvement in crisis response actions [4]

Operation/no operation[a]	Forcible entry role	Examples
		Major force commitment[b]
Yes	Major	Lebanon, 1958; Dominican Republic, 1965; Grenada, 1983; Panama 1989
No	Major	Cuban Missile Crisis, 1962
Either/or[c]	Minor/ none	Quemoy/Matsu, 1958; seizure of USS *Pueblo,* 1968; strikes against Libya, 1986
		Minor force commitment
Yes	Major	NEOs, such as Sharp Edge (Liberia, 1990) and Eastern Exit (Somalia, 1991)
No	Major	Preparation for NEOs (such as Haiti, 1986, 1991; Nicaragua, 1979)
Either/or	Minor/ none	U.S. Navy monitoring of Indo-Pakistani War; minesweeping operations in the Red Sea in 1984

a. By "operation," we mean that there was movement to take an objective—usually a combat operation, such as an invasion or a bombing at sea.

b. For our purposes, a "major" contingency response involved more than 20,000 U.S. personnel.

c. By "either/or," we mean that some of the examples in this category featured an operation, whereas others did not.

Sustained land operations

A sustained land operation is the deployment and maintenance of significant armed forces for a period of greater than 30 days. It does not include forces permanently based overseas or on a standing rotation cycle [5]. It can involve preparation for combat, or peacekeeping operations. Desert Shield is a striking (and the only) post-WWII example of sustained land operation in preparation for combat. In it, the United States and its allies built up forces for a 5-month period, and the ground operation lasted just 100 hours.

Sustained land operations in peacekeeping operations have been numerous. They included the Marine Corps deployments in Lebanon (September 1982 – February 1984), multinational operations (Operation Provide Comfort, 1991), and 1992-1994 operations in Somalia (Operations Restore Hope and Continue Hope).

What does the history of sustained land operations tell us about future deployable medical platforms? The Navy tries to have medical assets in theater and operational as quickly as possible. The hospital ships are charged with being manned and under way within 5 days of activation, and operational with 500 beds upon arrival in theater. The Maritime Prepositioning Forces (MPFs), which carry the fleet hospitals, are stationed and ready for deployment in strategic locations worldwide. Once delivered in theater, the fleet hospitals are charged with being fully operational with 500 beds in 10 days. Operation Desert Storm showed that Navy medical assets, including hospital ships and prepositioned fleet hospitals, arrived in theater and were fully operational within 35 days (see table 2). Fleet Hospital 5 (FH-5) was the first medical asset to receive ambulatory patients (6 September, 29 days after mobilization) because it was prepositioned at Diego Garcia. However, USNS *Comfort* was the first medical asset to be operational with 500 or more beds (on 7 September, 28 days after activation) because FH-5 required additional construction that was completed on 12 September. Additional medical personnel arrived on USNS *Comfort* to make it operational with 1,000 beds by 12 January.

Other lessons revealed weaknesses in the Navy's current medical platforms. In Operation Desert Storm, hospital ships were kept far away from the shore because of their vulnerability to mines or missiles.[1] This is an issue that must be addressed for future medical capability afloat. In the peacekeeping missions, a lack of isolation capabilities

1. First, it was considered possible that the Iraqis would choose to ignore the Geneva Convention rule about medical facilities. A second and more important issue was that with modern search technology, such as radar, it is difficult to differentiate a hospital ship from any other type of ship.

created difficulties in dealing with patients who had communicable diseases.

Table 2. Activation of Navy echelon III facilities in Operation Desert Storm [2]

	Date	Days lapsed
FH-5		
Mobilization ordered	8 Aug	
Operational with 100+ beds	9 Sep	32
Fully operational (500 beds)	12 Sep	35
FH-6		
Mobilization ordered	4 Dec	
Operational with 100+ beds	2 Feb	60
Fully operational (500 beds)	4 Feb	62
FH-15		
Mobilization ordered	4 Dec	
Operational with 100+ beds	9 Feb	67
Fully operational (500 beds)	12 Feb	70
USNS *Comfort*		
Activation ordered	10 Aug	
Arrived on station, operational with 500 beds	7 Sep	28
Fully manned and operational with 1,000 beds	12 Jan	126
USNS *Mercy*		
Activation ordered	9 Aug	
Arrived on station, operational with 500 beds	16 Sep	37
Fully manned and operational with 1,000 beds	8 Jan	123

Sustained land combat

The Korean War (1950-1953) and Vietnam (1964-1972)[2] are the United States' two sustained land combat operations since World War II. They are important to any analysis of medical platforms because of the number of years involved (12 years combined) and because these operations produced the highest numbers of post-WWII casualties—the two major reasons for deployable medical platforms.

2. In Vietnam, 1964 to 1972 were the years when American combat troops were most numerous and experienced their heaviest fighting.

Both hospital ships and land-based hospitals were used to provide care during these times of sustained land combat. Four Navy hospital ships operated during the Korean War, as well as numerous Mobile Army Surgical Hospital (MASH) units, a precursor to the Navy's fleet hospitals. In Vietnam, U.S. Navy Medicine deployed two hospital ships and one fleet hospital. These assets were used effectively in both conflicts. For example, in Korea, the hospital ships were used as on-scene floating hospitals, rather than merely as floating ambulances, as they were in WWII. In the Vietnam conflict, the U.S. Navy vastly improved the methods by which patients were moved to and from the hospital ships, and gave the ships the added responsibility of caring for local citizens as well as military casualties. These two conflicts point out the need for both sea-based and land-based options for providing medical care.

Humanitarian Assistance Operations (HAO)

Earlier CNA work examined past military humanitarian assistance operations and analyzed ways to improve these operations [5, 6, 7]. These studies found that military medicine generally does not have the right type of facilities needed to treat pediatric, OB/GYN, or geriatric conditions. Reference [5] concluded that a reduced logistics footprint would help facilitate humanitarian operations:

> The military should consider reducing its footprint[3] to help mission accomplishment. During most HAOs, logistics-support elements form the largest part of the military footprint. Reducing this footprint can help accomplish the mission by reducing U.S. presence, competition for scarce support resources, and stress on the available infrastructure. Also, a host-nation government may be concerned about how its citizens will respond to a foreign military presence. Reducing the military footprint can help alleviate those concerns.

Similarly, in an analysis of the hospital ships, reference [1] found that the hospital ships have not always been able to easily deal with

3. By "footprint," the authors mean the amount of land space taken up by a particular collection of assets.

humanitarian operations because they aren't configured to handle communicable diseases.

> During the Comfort's use as a Migrant Processing Center in Operation ABLE MANNER, the ship was not able to process large numbers of Haitians suspected of having tuberculosis. As a result, hundreds of Haitians had to remain on the weather deck and the medical personnel on the Comfort came under an increased risk of contracting tuberculosis. With a stated secondary mission of providing humanitarian aid and disaster relief, it is probable that the Mercy and Comfort will face large numbers of patients with contagious diseases in the future.

The lessons for future medical deployable platforms, whether land-based or sea-based, are related to their ability to isolate contagious patients effectively and easily. To conduct humanitarian operations, they need to have more than one method of getting patients on and off the ship, and more than one major pathway to move patients once on board. In addition, they must have medical compartments that are physically separate and have separate ventilation from the rest of the ship.

DPG and other *guidance* regarding the future operating environment

The latest Defense Planning Guidance [4] highlights capabilities rather than specific threats. It calls for better joint command and control, experimentation with innovative concepts of operations, emphasis on new applications of existing capabilities, and:

> Using existing capabilities in new ways, injecting new technology into old systems or developing new systems and/or platforms to perform new missions.

The DPG puts more weight on homeland defense as a military mission. It stresses that the military must develop more flexible, more tailorable combat organizations that can be used to manage crises, forestall conflict, and conduct combat operations.

The DPG outlines three layers of defense for the United States. The first layer of defense is the capability of forward forces. The second layer is the ability to strike with precision at targets throughout the depth of an adversary's territory. The third is active and passive defenses for missiles, defensive information operations, biological defense, and consequence management.

The new DPG [4] charges the Secretary of the Navy:

> to develop advanced concepts for Marine expeditionary warfare. Such concepts will include options for sea basing (including maritime prepositioning, high-speed sealift, and amphibious capabilities). The Secretary of the Navy will develop Marine Corps options to relocate Marine Prepositioning Squadron One from the European Command to the Central Command AOR, and will explore the feasibility of a Littoral Warfare Training Center in the Western Pacific.

The implication for medical platforms from the DPG is that medical should be capable of completing its mission completely from a sea base using maritime prepositioning, high-speed vessels, and amphibious ships. This guidance suggests that medical platforms should consider well their capability to perform in littoral areas, where shallow water and proximity to missiles and mines is a constant danger to all shipping.

Homeland defense

The Defense Planning Guidance puts more emphasis on homeland defense. What are the implications of homeland defense for medical? A variety of types of contingencies could occur in a homeland defense scenario, as shown in table 3.

If there were a bombing that caused a large number of trauma cases and crushing injuries, such as what occurred on September 11, 2001, the medical portion of homeland defense, for survivors, would involve surgery and intensive care units. If, instead, there were massive fires, burn units would be an important medical capability. Epidemics and bioterrorism would put a premium on capabilities for laboratory diagnosis and long-term care of the afflicted, such as ventilators, isolation wards, and decontamination capabilities.

Response to a chemical attack would possibly put more emphasis on decontamination and long-term care capabilities. In summary, homeland defense places a premium on the ability of medical platforms to be tailorable to the particular situation required and to deploy on very short notice.

Table 3. Homeland defense contingencies

Type of medical condition	Homeland defense operational cause of medical condition	Primary medical capabilities needed	Other important medical capabilities required
Massive trauma	Bombing, gunfire	Surgery	Intensive care units
Crush injuries	Building collapse	Surgery	Intensive care units
Burn injuries	Setting fire to public building	Burn units	Intensive care units
Epidemic	Pandemic flu outbreak	Diagnostic laboratory capability	Pharmaceutical stockpiles
Bioterrorism	Bioterrorism--non-contagious	Diagnostic laboratory capability; distribution of pharmaceuticals	Long-term care capabilities, e.g., ventilators
Bioterrorism	Bioterrorism--contagious	Isolation wards; decontamination; distribution of pharmaceuticals; dispensing of vaccines	Long-term care capabilities, e.g., ventilators
Chemical injuries	Chemical terrorism	Decontamination	Long-term care capabilities, e.g., ventilators

Recent Navy/Marine Corps *concepts* that affect Navy Medicine's deployable platforms

The Navy/Marine Corps has developed a list of new concepts of operations that must be considered while designing new medical deployable platforms:

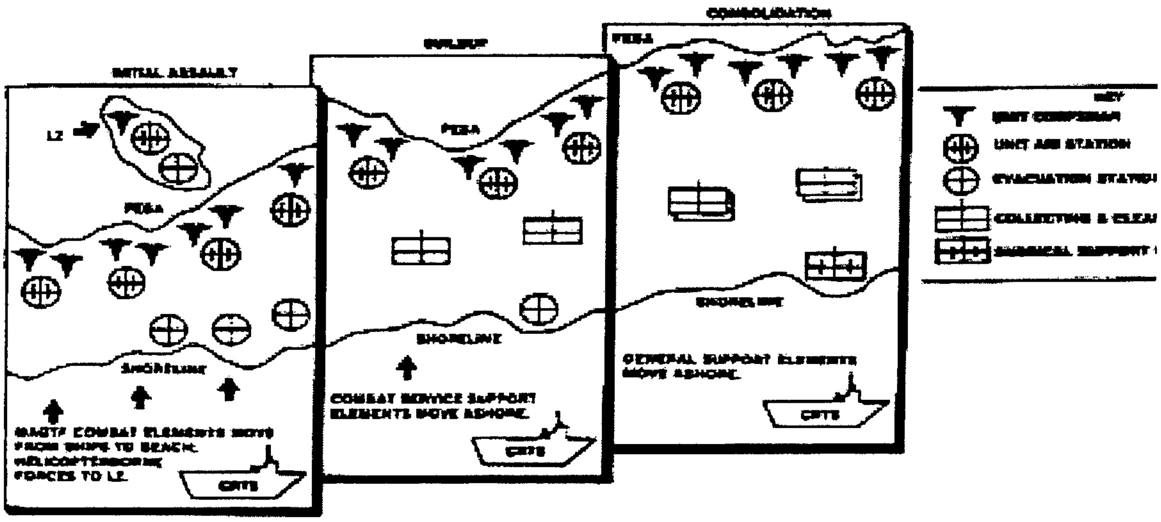
- Expeditionary maneuver warfare/operational maneuver from the sea (OMFTS)
- Urban warfare
- Biological/chemical warfare
- Vulnerability to attack.

Expeditionary maneuver warfare/OMFTS

Earlier in this chapter, we showed that forcible entry capabilities have been important options in many conflicts. For the Navy/Marine Corps, this has meant traditional amphibious operations. Traditional amphibious operations typically involve taking and securing the beach, followed by movement to, and action on, targets inland.

Figure 1 shows the medical support resource for the operation's phases of assault, buildup, and consolidation [8]. Historically, the initial phases of assault and buildup are more costly in terms of deaths and injuries than the consolidation and later phases of the operation.

Figure 1. Stages of a traditional amphibious assault [8, p. 15]



The graphic shows the buildup of medical assets in the three stages of the traditional amphibious assault. The leftmost chart (the "initial assault" stage) shows aid stations and evacuation stations. In the "buildup" stage, casualty collecting and clearing companies are added, taking the place of some of the initial evacuation stations. In the "consolidation stage," surgical support companies are added.

The Marine Corps has published several papers on maneuver warfare.[4] The concept of operational maneuver from the sea will change the traditional initial assault on the beach. This is expected to increase the speed by which an objective can be attained. As described in *Concepts and Issues,*[5] OMFTS involves the ability to move quickly, continuously, and over large distances. Combat Service Support (CSS) is often sea-based under OMFTS and involves less direct buildup ashore. The success of OMFTS depends on advances in speed, mobility, communications, and navigation [11].

The Marine Corps expects that enemies will have a greater ability to detect our forces and more lethal munitions [11]. If they can sense a target, they can destroy or neutralize it. To counteract these greater dangers, the Marines will develop greater sensor capabilities, use more capable weapons, make a smaller footprint, and be able to operate in a battlespace of greater depth and breadth. This will be in addition to the Marines' traditional capabilities.

In future operations, the warfighters can attack from over the horizon, from about 25 to 50 n.mi. offshore, and move to distances as far as 150 n.mi. inland, to win high-priority objectives directly. There may be no ground-based depots or hospitals on shore because this creates a vital area to defend—a weakness that the enemy can exploit [11]. In these cases, the nearest surgical-capable platform might be a big deck amphibious ship, such as an LHD or LHA.

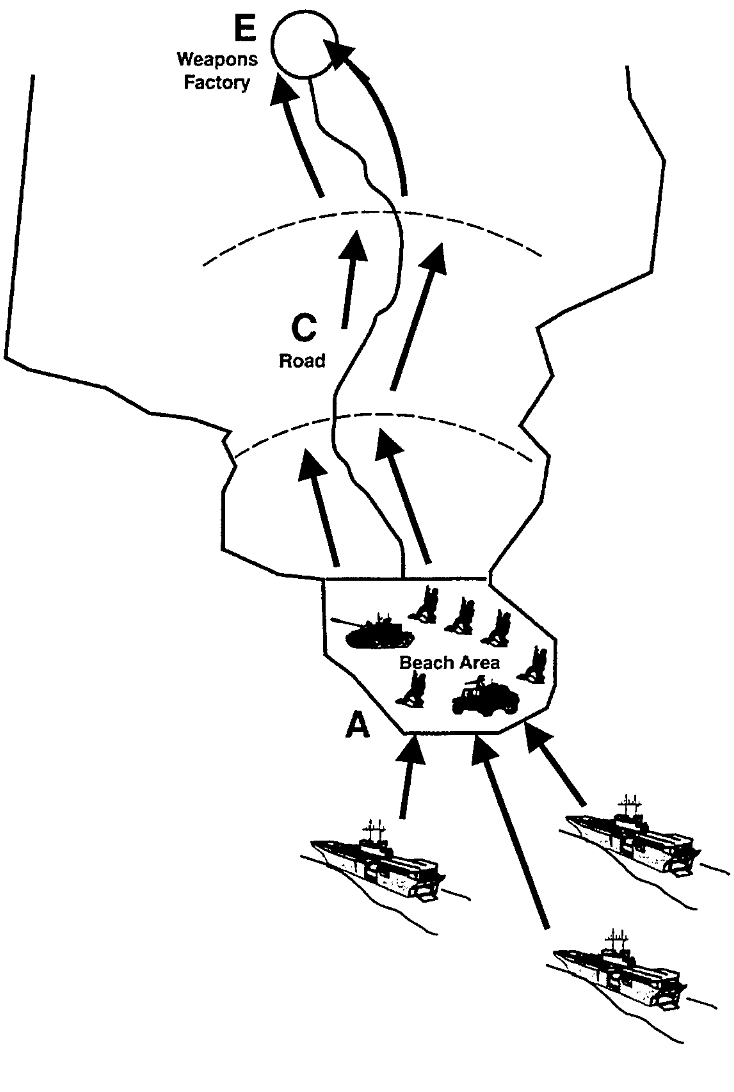
Figures 2 and 3 show the differences between traditional and future operations. Figure 2 gives an example of traditional amphibious assault [11]. Let's say that the primary objective of a battle is to take control of a weapon factory in the center of area E. In a traditional amphibious operation, Marines would move by landing craft and helicopters from the amphibious ships to a suitable nearby beach area (A). They would occupy area A, which would become the base

4. See the following Marine Corps Concept Papers: *Operational Maneuver from the Sea* [9] and *Ship to Objective Maneuver* [10].

5. Headquarters, U.S. Marine Corps Programs and Resources Department, *United States Marine Corps Concepts and Issues '95: A Certain Force for an Uncertain Future.*

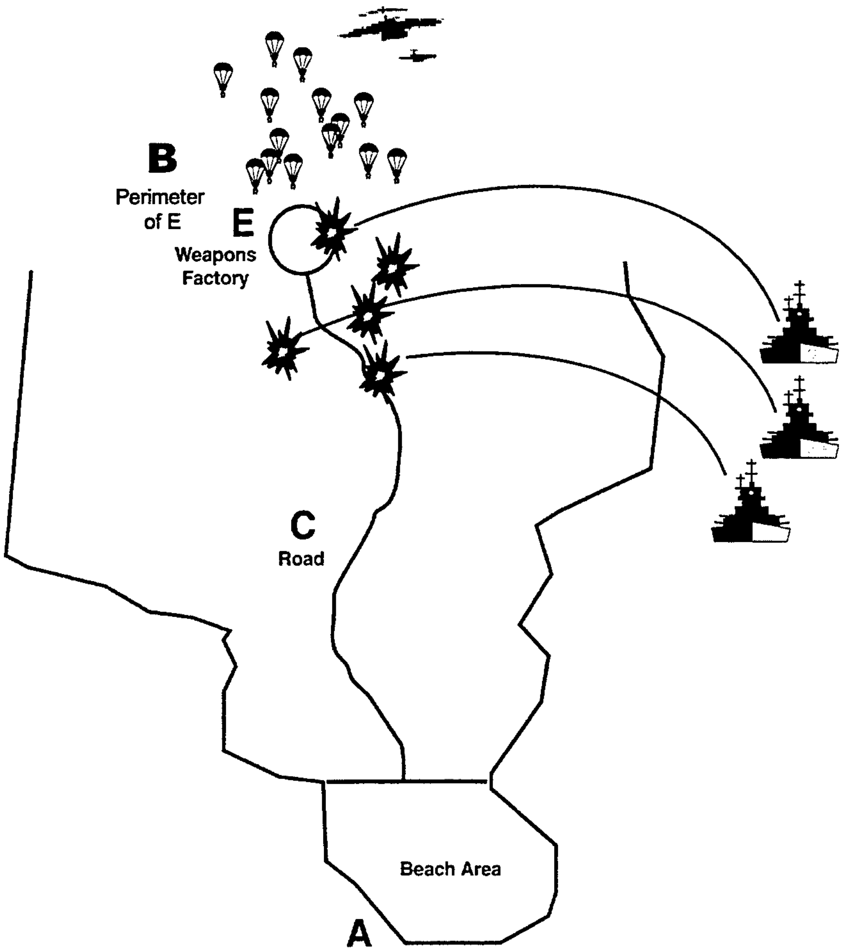
for combat service support, such as supply, medical, ammunition, and fuel. This vital area would need to be protected as Marines maneuver their way from A to the main objective area E. The enemy could bottle up our Marines around the beachhead, putting troops at significant risk and causing delay in reaching the primary target .

Figure 2. Hypothetical USMC traditional amphibious assault



In contrast to traditional amphibious assaults, figure 3 shows and example of OMFTS. Here, Marines would go directly to the main objective area E [11]. Small teams of Marines might be flown to the perimeter of E. Those small teams would not immediately attack E, but would first gain control of it by directing fires—perhaps from ships—actually taking the target. Fewer troops would be in harm's way, and the costly procedure (costly in terms of life and time) of taking a beachhead would be unnecessary. If Marines had to take a beach by amphibious assault, they would first "shape the battlefield" by knocking out primary avenues for enemy reinforcement. For example, small teams might initially direct fires to road C and cut off an important enemy reinforcement artery.

Figure 3. Hypothetical Marine Corps OMFTS



Although fewer casualties might be expected under future concepts of operation, medical must still be prepared for large numbers of casualties [11]. Under these new concepts, ground units would be more interspersed with the enemy than under a traditional amphibious assault on A. These units might not even have a corpsman, and they would be much farther from ships with surgical capability. The task of directing casualties to appropriate medical care would be made more difficult because of the distances involved, the greater geographic dispersion of casualties, and the interspersion with the enemy. These characteristics make it imperative that superior communication, command, and control exists between the areas where casualties are originated and the deployable medical platforms.

Under the new warfighting concepts, the phases of an operation would differ from those of traditional amphibious assault [11]. Whereas the initial phases of a traditional amphibious assault would have the heaviest casualties, the new concept would put fewer troops at risk, initially. It might not be until further into the operation, if at all, that costlier infantry-on-infantry fighting would occur.

The new warfighting concept would have the following characteristics:

- A potentially smaller number of casualties will be more highly dispersed than in traditional operations. Hundreds of miles could separate casualties. Consequently, the speed of transportation might be more important than carrying capacity.
- Casualties might be more highly interspersed with the enemy; 50 to 200 n.mi. of enemy territory might separate casualties from the closest friendly forces. Therefore, the danger to casualties and those who evacuate them will be even greater than in traditional conflicts.
- A larger proportion of Combat Service Support, including medical, will be sea-based. At times, all combat service support will be sea-based.[6]

6. Lengthy or sustained operations ashore, in contrast, may dictate establishment of shore facilities.

Although the concept of OMFTS is in stark contrast to the traditional linear movement of amphibious battles, the Marine Corps will preserve its ability to apply traditional force maneuvers when necessary. The primary difference between the Marine Corps of the future and today's Corps will be the emphasis on having smaller units of Marines, capable of operating independently for extended periods of time. The emphasis will be on massing our firepower rather than our troops on areas of tactical importance.

Urban warfare

Robert Leitch [12] explains why the military must be prepared to fight in urban settings. In 1950, 15 percent of Africa's population lived in cities; it is estimated that it will be 55 percent by 2010. In South America, 43 percent lived in cities in 1950, and it is estimated that by 2010 it will be 90 percent. He notes that the United States has become quite successful on the traditional, non-urban battlefield. Consequently, "future enemies will want to draw U.S. forces and their allies into an environment in which our technological supremacy in battlefield awareness and precision weapons will be limited" (i.e., the urban battlefield).

The Commandant's Warfighting Lab conducted experiments on new concepts of fighting in urban settings. In summarizing the results of some of those analyses [12], Robert Leitch makes the following points about urban warfare:

- Fighting is vertical, from sewers to the tops of towers.
- Fighting is compartmentalized, as noise and walls can prevent communications between troops even a few feet apart.
- Command and control is difficult to establish.
- Casualties can soar.
- Force protection measures against disease and non-battle injuries will be extremely important because breakdown of water supply, sanitation, and disposal systems is a threat.
- Identifying, locating, and providing initial treatment for casualties can be extremely complicated.

Leitch discusses what equipment, training, and platforms would be best suited to such an environment. He concludes that personal protective gear, forward surgery, and training in first-aid and other lifesaving skills to infantrymen are probably the most important initiatives. He also adds an idea for a possible platform: a quiet, stealthy, night-vision ambulance that would be easy to maneuver in narrow streets [13].

Biological/chemical warfare

Increased interest in the study of chemical and biological warfare in recent years was sparked in part by revelations that the former Soviet Union continued to expand its offensive biological warfare program even as the United States discontinued its offensive program in the early 1970s [14]. It seems likely that, when the Soviet Union collapsed, one or more of its biological weapons experts brought skills and knowledge to organizations that were unfriendly to the United States.

The six biological agents deemed to have the most military importance are anthrax, pneumonic plague, tularemia, botulinum toxin, smallpox, and hemorrhagic fevers (see table 4). The necessary equipment for the detection, treatment, and long-term care differs somewhat for each of these agents. However, there are clear implications for medical deployable platforms in the case of biological warfare:

- Medical platforms must have multiple paths for moving patients on board, so that contamination of one entryway does not shut down the facility's ability to receive more patients.
- There must be a triage area where patients are evaluated before they enter the main medical facility.
- The platform must have decontamination facilities that can be used before patients enter into the medical facility. The stability of many of the biological agents suggests that continual vigilance will be necessary.
- There must be beds that allow isolation of infectious patients from those patients and medical providers who are not infected (e.g., smallpox and pneumonic plague).

- There must be refrigeration capacity to keep antibiotics, antitoxins, and vaccines between 54 and 87 degrees Fahrenheit.
- In the case of botulism, the large need for respiratory support for victims that survive will be great, and they will need this support for months. Surviving patients will not return to duty but will need to be evacuated to OCONUS or CONUS facilities.
- In the case of tularemia, the duration of illness will be more than 2 weeks, so patients will need to be sent to higher echelons of care in OCONUS or CONUS facilities.

Table 4. Biological warfare agent characteristics [15]

Disease	Transmit to man	Infective dose	Incubation period	Duration of illness	Lethality	Persistence	Vaccine available?
Inhalational anthrax	No	8,000-50,000 spores	1-6 days	3-5 days (usually fatal if untreated)	High	Very stable	Yes
Pneumonic plague	High	<100 oganisms	2-3 days	1-6 days (usually fatal)	High unless treated within 12-24 hrs	Up to 1 year in soil, 270 days in live tissue	Yes[a]
Tularemia	No	10-50 organisms	1-21 days (average 3-5)	>=2 weeks	Moderate if untreated	For months in moist soil or other media	Yes
Smallpox	High	Assumed low (10-100 organisms)	7-17 days (average 12)	4 weeks	High to moderate	Very stable	Yes
Viral hemorrhagic fevers	Moderate	1-10 organisms	4-21 days	Death in 7-16 days	High for Zaire strain, moderate with Sudan	Relatively unstable	No
Botulism	No	.001 mg/kg is LD_{50} for type A	1-5 days	Death in 24-72 hours; lasts months if not fatal	High without respiratory support[b]	For weeks in nonmoving water and food	Yes

a. Plague vaccine not protective against aerosol challenge in animal studies.

b. Botulinum toxin is the most toxic compound per weight of agent, requiring only .001 microgram per kilogram of body weight to kill 50 percent of animals in studies. With tracheostomy or endotracheal intubation and ventilatory assistance, fatalities should be less than 5 percent.

Chemical agents include nerve agents, vesicants, and incapacitating agents [15]. **Nerve agents** affect the action of cholinesterase (ChE), and include such compounds as sarin, VX, tabun, and soman. Atropine therapy is a recommended therapy for most nerve agents, and ventilatory support is needed in cases where patients have developed severe symptoms. **Vesicants** produce blisters, and include mustard, lewisite, and phosgene oxime [15]. Decontamination within 1 or 2 minutes is critically important. Patients with severe pulmonary symptoms require intubation. There are often severe long-term effects from exposure to nerve agents and vesicants.

In contrast, **incapacitating agents** are a group of toxins that are meant to affect one's military mission temporarily. An ideal incapacitating agent (for tactical military purposes) very rapidly and severely affects the ability to fight, even if its effects last for only a short period of time. Incapacitating agents include anticholinergics, which can produce tachycardia at rest, blurred vision, slurred speech, hallucinatory behavior, stupor, and coma. Other incapacitating agents include indoles, which may mimic schizophrenic psychosis; cannabinoids, which can affect concentration; and hallucinogens.

The implications of chemical agents for deployable platforms are similar to those for biological agents. Requirements include decontamination facilities, sufficient ventilatory support, beds for patients whose symptoms or long-term affects prevent return to duty, and enough staff to take care of those patients.

Vulnerability to attack

In addition to the concern posed by the enemy's ability to use biological and chemical warfare, enemies on the modern battlefield are expected to have increasingly capable missiles to attack ground-based hospitals and afloat medical facilities. Leitch [13, p. 11] mentions that, during Desert Storm, a Scud missile hit the logistic unit in Chahran and "could just as easily have hit a deployed hospital."

Matthew McCarton [1] suggests that vulnerability to attack was also a problem for the hospital ships during Desert Shield and Desert Storm:

> the *Mercy* and *Comfort* were often kept out of range of helicopters near the front lines during both Operation Desert Shield and Desert Storm because of the threat from enemy mines and missiles....With its significant magnetic and acoustic signature and larger radar cross-section, the *Mercy* and *Comfort* were kept well out of harm's way in the waters off of Kuwait.

Ships and equipment new deployable platforms will support

Central to the operational concepts under OMFTS are the enhanced troop-moving capabilities that will result from the combination of the Landing Craft Air Cushion (LCAC), Advanced Amphibious Assault Vehicle (AAAV), and the V-22 Osprey tilt-rotor aircraft. This trio of mobility assets will allow the warfighter to operate at a much faster pace. These capabilities allow the warfighter to increase the future battle space to as much as 200 n.mi. from their ship base. The delivery and sustainment of troops across this vast battle space will often strain the available lift assets. In addition, the utility of ground transport will be limited by the distances, dispersion of troops, and their interspersion with the enemy.

What does this mean for the ability to evacuate casualties? Although the V-22 will provide greater capabilities for fast medical evacuation, the availability of the V-22 and other air assets may be more constrained because of the increased logistic demands placed on them as a result of seabasing logistics under OMFTS. In table 5, we show the speeds, personnel-carrying capacities, and casualty-moving capacities of craft that may be available as evacuation assets. Because of the uncertainty that surrounds the operational concepts of the future, we have included any craft that has a reasonable troop capacity (10 or more) and, therefore, may be able to transport ambulatory patients, and possibly one or two litters.

Table 5 also shows the availability of transportation assets to amphibious ships. This information gives an indication of the characteristics of primary evacuation assets (such as helicopters and LCACs) that might be available for a given operation.[7] Next, table 6 shows us how

7. An Amphibious Ready Group (ARG) typically supports a Marine Expeditionary Unit (MEU) size force, and will include either an LHA or LHD, and two cargo ships—typically an LPD and an LSD.

many of each of the air evacuation assets can be carried by each type of amphibious ship .

Table 5. Speeds and casualty carrying capacities of current and future transportation assets [9]

	Operational speed	Mission radius	Military lift	Casualty load
Helicopters				
CH-46E (Sea Knight)	137 kt	90 n.mi.	18 troops	15 litters+2 med. attendants
V-22 (Osprey)	250 kt	200 n.mi.	24 troops	12 litters+med. attendants
CH-53E (Super Stallion)	170 kt	115 n.mi.	56 troops	N/A
CH-53D (Sea Stallion)	150 kt	270 n.mi.	38 troops	24 litters
UH-1N (Twin Huey)	110 kt	125 n.mi.	13 troops	6 litters +1 med. attendant
SH-60 Sea Hawk	180 kt	380 n.mi.	11 troops	5 litters +1 med. attendant
Landing craft				
LCAC (Landing Craft Air-Cushion)	40 kt[a], 10 mph	100 n.mi.	60-75 tons and 24 troops	b
LCU 1600 Class (Utility Landing Craft)	11 kt	600 @ 8 kt	170 tons or 350 troops	N/A
LCM 8 Type (Mechanized Landing Craft)	12 kt	95 @ 9 kt	60 tons or 150 troops	N/A
LCM 6 Type (Mechanized Landing Craft)	9 kt	65 n.mi.	34 tons or 80 troops	N/A
LCPL (Landing Craft Personnel)	20 kt	75 n.mi.	17 troops	N/A
RIB (Rigid Inflatable Boat)	25 kt		15 troops, 1,000 lb	N/A
Amphibious assault vehicles				
AAVP-7 (Amphibious Assault Vehicle, Personnel)	6 kt[a]; 30 mph	25 n.mi.; 300 miles	18 troops, 10,000 lb	6 litters
AAAV (Advanced Amphibious Assault Vehicle)	20 kt[a]; 35 mph		18 troops	N/A
Ground transport				
M997 HMMWV, Maxi-Ambulance	105 km/h	240 km		4 litter or 8 ambulatory patients

a. Operational speed over water is reported in knots (kt); over land , it is reported in miles per hour (mph).

Table 6. Air evacuation assets carrying capacity of amphibious ships [9]

Platform	Helicopter stowage	Helicopter spots	LCAC/LCU
LHA	29 CH-46E equivalents	9	4 LCU 1610 or 1 LCAC
LHD	42 CH-46E equivalents	9	3 LCACs
LSD	None	1, 2[a]	3 LCU or 4 LCAC
LPD	None	2	2 LCACs
LPD-17[b]	4 CH-46E equivalents	N/A	2 LCACs

a. The Anchorage class has 1 helo spot; the Whidbey Island class has 2 helo spots.
b. The LPD-17, previously referred to as the LX, will replace the LPD, LSD-36 (Anchorage class), LKA, and LST.

Table 7 looks at which assets were used in historical missions to determine what capabilities we will need to retain in the future. For forcible entry operations, such as traditional amphibious assault, there will still be a need to address large numbers of casualties from a sea base. Grenada, which was similar to an OMFTS operation, required that medical be able to support forcible entry operations from a sea base. Sustained land operations, such as Operation Desert Storm, in contrast, show that land-based medical options are important as well. This is true whether the sustained land operation is in preparation for combat (as Operation Desert Storm was) or peacekeeping (such as Lebanon). Sustained land combat operations, such as Korea and Vietnam, also showed the importance of maintaining land-based medical delivery options. Humanitarian operations, such as Able Manner, revealed that hospital ships must have better isolation capabilities.

Table 8 looks at the capabilities needed—not at particular missions (as did table 7), but at particular concepts. For example, for OMFTS, it would be helpful to have a larger number of smaller, faster platforms. The faster platforms would be useful for split ARG operations performed over vast distances. For urban warfare, it would be useful to have a quiet, stealthy ground ambulance. For biological/chemical warfare, there need to be multiple entrances/exits to medical platforms in case one entrance/exit gets contaminated. Having multiple entrances/exits prevents contamination from ruining the flow of medical operations and patient movement. The concern about missile range (expressed in Operation Desert Storm) suggests that smaller, more maneuverable medical platforms could be useful. Our analysis of the future craft and helicopters, however, suggests that these smaller craft must ultimately be capable of interfacing with future air evacuation assets, such as the V-22 helicopter, a large aircraft, and LCACs and AAAVs.

Table 7. Summary of historical Navy/Marine Corps missions and implied requirements for future deployable medical platforms

Missions	Examples	Lessons for future deployable medical platforms
Forcible entry	Inchon, 1950	Treat mass numbers of trauma cases in direct amphibious assault
	Grenada, 1983	Support from the sea, a heliborne assault
	Grenada, 1983	Arrive at the area of operations relatively quickly
Sustained land operations	Operation Desert Storm, 1991	Serve as first naval medical asset to bring full operational capability to theater
	Operation Desert Storm, 1991	Provide a mix of sea and land-based hospital options
	Lebanon, 1982-1984	Medical must be able to support peacekeeping operations with capabilities in urban environments
	Provide Comfort, 1991	Provide support to humanitarian missions, which requires support to civilian casualties
Sustained land combat operations	Korea, 1950-1953	Land-based hospital options could be important if there is sustained land combat
	Vietnam, 1964-1972	Treat mass numbers of trauma cases; land-based hospital options are important in sustained land combat
Humanitarian operations	Philippines Able Manner, 1987	Have isolation capability to deal with communicable disease

In summary, we have shown that specific requirements vary according to the type of operation. Large amphibious assaults require a large number of beds. OMFTS requires that communication capabilities between casualty origination and deployed platforms be expanded, both day and night operations. OMFTS also emphasizes the mobility and survivability needs of future sea-based medical platforms. Biological/chemical warfare adds the requirement to have special ventilation systems and control of the ship's internal environment. Multiple entry points (sea and air) are especially important in such a biological/chemical environment. Homeland defense puts particular emphasis on the degree to which a deployable platform can be "tailored" in size to different types of contingencies.

Table 8. Summary of future warfighting concerns and implications for future deployable medical platforms

Area of concern	Implications for future deployable medical platforms
Operational maneuver from the sea/ Expeditionary Maneuver Warfare	Medical must be able to support operations from a sea base. There is a lot of pressure on amphibious ships' medical capabilities. A larger number of smaller, faster platforms would add flexibility.
Urban warrior	Quiet, stealthy ambulance would be a useful asset.
Biological/chemical warfare	Multiple entrances/exits to medical platforms are needed in case one entrance gets contaminated. Decontamination facilities are needed on platforms.
	Many casualties will not return to duty, so there needs to be a "back door" from the amphibs, hospital ships, and fleet hospitals.
	Respirator supports, refrigeration, and isolation rooms are needed.
Homeland defense	Capability to be "tailored" for different types of contingencies, from trauma to infectious disease, would be an advantage.
Hospital ships' and fleet hospitals' vulnerability to attack	New platforms are likely to be within missile range, so they need to be smaller, faster, more modular
Interface with future craft and helicopters	New platforms must be ready to accommodate V-22, LCAC, AAAV

Military operations other than warfare (MOOTW) also require the ability to tailor assets and requires that medical have some capabilities to treat pediatric, obstetrical, and geriatric complaints. Special operations emphasize the needs for excellent communications capabilities, survivability, and mobility. Finally, sustained land operations and sustained land combat require excellent patient care capabilities, but do not place as high a premium on mobility or communications.

In the next chapter, we will consider generic alternatives that follow from our scenario-based requirements. We will provide a more quantitative analysis of the types of requirements that we have described in this chapter.

Chapter 3: Generic alternative medical platforms

Introduction

In chapter 2, we concluded that it was important to have both sea-based and land-based medical capabilities. We also identified several challenges that future medical platforms would face and the requirements necessary to meet these challenges, which include:

- Platforms that are smaller and faster and, thus, not as vulnerable to attack
- Tailorability—the ability to quickly tailor a platform or set of platforms to support a number of Navy/Marine operations
- Ability to function in chemical/biological environments
- Ability to accommodate future helicopters, such as the V-22, and watercraft, such as the LCAC and the AAAV.

In this chapter, we will examine the physical characteristics, medical capacities, and rough costs of several generic potential platforms for meeting these needs. We analyze and discuss various new medical platform alternatives. Some are ideas for *replacing* the current Navy medical platforms, and some are ideas for *augmenting* the current medical facilities. For each alternative, we keep in mind satisfying the medical requirements discussed in chapter 2. We consider alternatives for both sea-based and land-based capabilities and outline seven alternatives in detail:

- Sea-based alternatives
  - — The current Mercy-class hospital ships
  - — Current L-class ships for conversion to dedicated hospital ship

    - Future L-class ships, hospital ship variant
    - Faster, smaller *supplemental* watercraft that can provide at least rudimentary medical care (and possibly more).
- Land-based alternatives
    - The current fleet hospital
    - The newly deployed Expeditionary Medical Facility (EMF)
    - Small, fast cargo watercraft that can carry and offload the EMF and secondarily provide limited resuscitative medical care.

We arrange the discussion of these alternatives as follows. First, we review and discuss the history and importance of the current Mercy-class hospital ships, summarize their capabilities and limitations, and make them the base case for the comparisons of our generic alternatives. Next, we present some ideas for platforms that would be useful, not only as replacements for current hospital ships, but also as enhancements to all our current deployable medical capabilities. In this framework, we present our ideas about how current L-class ships might be useful as conversions to dedicated hospital ships, and which of the ships would be best suited for the assignment. We also present a new idea about a high-speed patient transport ship that is able to provide en route medical care. Then, we discuss medical facility requirements being debated in the U.S. Navy's Maritime Prepositioning Force (MPF) 2010, including the fleet hospital and its autonomous component, the Expeditionary Medical Facility.

Throughout this chapter, we review and assess the relative advantages and disadvantages of each alternative according to three key criteria:

1. The potential magnitude of the platform's medical capacity
2. The potential quality of the platform's medical mission performance
3. The relative costs of construction, conversion, and operation of the platform.

Generic alternatives: base case

Modern hospital ships, *Mercy* and *Comfort*

Because it is the foundation of the U.S. Navy's current seagoing medical capability, the giant, modern Mercy-class hospital ship is the base-case alternative for this study. The Navy has two: USNS *Mercy* (T-AH 19) and USNS *Comfort* (T-AH-20). Both were San Clemente-class supertankers that the Navy had converted into hospital ships and commissioned in 1986 and 1987, respectively. USNS *Mercy* is kept in reduced operating status (ROS-5) in its homeport of San Diego, CA. USNS *Comfort* is also in ROS-5 in its homeport of Baltimore, MD. Either ship can make the transition to full operating capability in 5 days. Figure 4 shows USNS *Mercy's* physical characteristics and medical capabilities.

In 1982, the Navy set aside a total budget of $560 million for the acquisition and conversion of the two tankers into hospital ships.[8] In addition, it has been estimated that maintenance costs for each ship are as follows [16]:

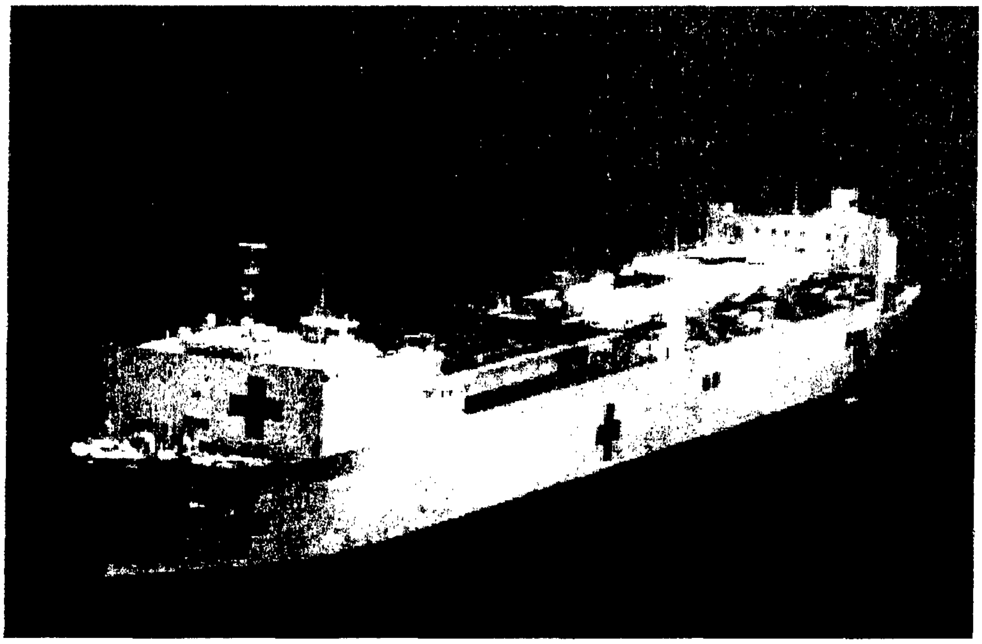
Annual operating costs for ROS-5 standby	$7.2 million
Annual operating costs when active	$20.0 million
Annual operating costs for medical	$ 20.0 million

USNS *Mercy* and USNS *Comfort* are 25 years old. It is likely that both will be retired in the next 15-20 years. Many U.S. Navy leaders are asking whether it would be a good idea to replicate the current hospital ships. To answer that, we look at the ships' strengths and weaknesses.

The Mercy-class hospital ship is quite large, which is both good and bad. The primary benefit of its size is that it can accommodate 1,000 beds and can receive up to 200 patients per day. Because of its size, round-shaped hullform, and high block-coefficient, it is a stable platform that is suitable for performing most surgical procedures in various sea conditions.

8. A brief history of the U.S. Navy hospital ships, leading up to the decision to build the Mercy-class ships, can be found in appendix A.

Figure 4. USNS *Mercy* T-AH 19



Power plant: 2 GE steam turbines; two boilers; 24,500 hp (18.3MW); one shaft

Length: 894 feet (272.6 meters)

Beam: 105.6 feet (32.2 meters)

Displacement: 69,360 tons (70,473.10 metric tons) full load

Speed: 17.5 knots (20.13 mph)

Patient ingress: 1 helicopter platform

Medical capacity:

Operating rooms:	12
ICU beds:	80
Ward beds:	400
Minimal care beds	1,000
Medical personnel:	965

Source:[17].

Of course, these physical characteristics make it somewhat slow, with a maximum speed of just over 17 knots. Also, the large ship is not easily or quickly deployed or docked. Its size gives it a substantial radar signature that, combined with its lack of maneuverability, makes it vulnerable to attack. The Mercy class is much larger (in terms of medical capacity) than is needed for most military operations. Finally, at least partially because of its size, it is classified as a Flexible Deterrent Option (FDO). This limits its usefulness in simple peacekeeping missions because it may create the wrong image about the magnitude of our willingness to sustain American casualties to support U.S. policy.

The supertanker, from which the Mercy class was born, is fairly straightforward to convert because of the simplicity of the tanker's compartment layout. It may be a relatively inexpensive option for a dedicated hospital ship; however, the Mercy-class ships are expensive to maintain for two reasons. First, maintenance cost is a function of surface area of the ship, which is quite vast. Second, because it is such a large medical facility, full medical staffing is time-consuming and pulls medical personnel from necessary shore bases.

Perhaps one of the ship's weakest features is its lack of flexibility in patient movement. It has one helicopter pad for receiving patients and no ability to receive patients from the sea. Patient movement within the ship is limited by the way the ship was converted. Its conversion from an oil tanker was accomplished by removing everything above the top deck, including the deck itself, and building a new top deck and superstructure. Its interior bulkheads were kept; but, because the bulkheads in the lower decks have no hatches,[9] patients must be brought to the top deck if they are to be moved from a lower compartment in one part of the ship to another. The replacement for this ship should more carefully consider patient movement (i.e., patient ingress, egress, and movement within the ship.)

9. The lower bulkheads have no hatches because the lower portion of the oil tanker is used to carry oil. The bulkheads in the tanker prevent oil from sloshing from stem to stern.

The platform matrices: a summary of our generic alternatives

From the previous list of strengths and weaknesses of the Mercy-class hospital ships, and from our wartime scenario analysis of future medical needs, we developed an inventory of generic alternatives. Tables 9 and 10 summarize our ideas regarding seven future medical platform configurations. Column one of table 9 describes the characteristics of the base-case alternative (i.e., that platform by which we will judge our alternatives.) These characteristics fall in one of the following larger categories. First is the *potential magnitude of the ship's medical capacity* as measured by the numbers of the different types of facilities, including beds, operating rooms, and blood banks, and by the number of medical personnel the platform can berth. The second category describes the potential *quality of the platform's medical mission performance,* measured by its ability to get to the area of conflict quickly and move casualties safely, effectively, and efficiently from one platform (including the beach) onto itself. The third category is about the *potential costs* of acquiring, equipping, and maintaining the platform. Official cost estimates for these alternatives would be performed by NAVSEA; the cost estimates that we present are preliminary.

This list of characteristics was derived from two primary sources. The first is the important study in the late 1970s by the CNO called Feasible Alternatives to Dedicated Hospital Ships [18]. The ADHOS study provides a valuable, detailed outline of the characteristics that make a medical platform effective, as well as a methodology for comparison of alternative platforms. In addition, the ADHOS study provides details about the amount of space needed to provide definitive levels of medical care under various casualty-flow scenarios and specified evacuation policies. The criteria set out in the ADHOS study form a basis for our own list of characteristics described earlier and for the analysis and evaluation of our own recommendations.[10]

10. The ADHOS study also allowed us to stay within reasonable parameters when we estimated potential medical capacity of some of our alternatives. See appendix B for details on the ADHOS study parameters.

Table 9. Sea-based platforms

Platform type / characteristics	Mercy-class T-AH 19/20[A,B] base case	LPD-17 hospital variant[C]	Conversion/ Whidbey Island-class LSD[D]	HSV-32 en route care[E]
Medical capabilities[K,L]				
Operating rooms	12	8	4	1
ICU beds	80	50	50	10
Ward beds	400	200	180	80
Additional space	500 min. care beds	1,722 sq m	Not available	Not applicable
Habitability				
Berthing (MSC crew)	68	71	46	12
U.S. Navy augment	301	33	25	6
Medical personnel berthing	1,207	365	256	58
Mobility[M]				
Speed (maximum)	17+ kt	22+ kt	21+ kt	42+ kt
Close to shore	32.8-ft draft	23-ft draft	20' draft	11.4-ft draft[E]
Stability	High	Medium	Medium	High
Range at cruising speed	13,500 nm[F]	10,000 nm[G]	Not applicable	1,250 miles[H]
Adaptability				
Potential level of medical care	Definitive	Definitive	Definitive	Underway rescucitative and maintenance
Readily deployable	ROS-5	ROS-5	ROS-5	Immediate deployment
Availability of platform	2 units in 5-day standby	Ready for construction 2011	Available for conversion 2016	Available for conversion now
Accessibility				
Helicopter capability	1 CH-53	2 V-22	2 CH-53	1 SH-60 Sea Hawk
At sea ingress	None	2 LCACs	2 LCACs	None
Compatibility				
Docking capacity	894-ft wl length	661-ft wl length	580-ft wl length	312-ft wl length
Docking capacity	32.8-ft draft	23-ft draft	20-ft draft	11.4-ft draft
Vulnerability to mines or attack				
Radar signature	Large	Medium, modern	Medium	Small
Maneuverability	1 shaft	2 shafts	2 shafts	2 Jets
Damage control		U.S. Navy state of art	U.S. Navy standard	1 compartment

Table 9. Sea-based platforms (continued)

Platform type / characteristics	Mercy-class T-AH 19/20[A,B] base case	LPD-17 hospital variant[C]	Conversion/ Whidbey Island-class LSD[D]	HSV-32 en route care[E]
State of the art				
Propulsion system	2 steam turbines 1 shaft	4 diesel, 2 shafts	4 diesel, 2 shafts	4 diesel 2 water jets
Removable modular medical spaces	Not available	Not applicable	Not applicable	With proper interface
Estimated costs				
Acquisition		$815M[M]	None	$50 M[I]
Conersion	$230M each[B]	Not applicable	< Mercy conversion	Approx. $50[I]
Annual op, standby	$7.2 M[A]	Proportional toT-AH size and capacity	Proportional toT-AH size and capacity	
Annual op, active	$20M plus	Proportional toT-AH size and capacity	Proportional toT-AH size and capacity	
Annual op, medical	$20M plus	Proportional toT-AH size and capacity	Proportional toT-AH size and capacity	

A. Source: [16].

B. Source: [19].

C. Source: [20]. All cost estimates for the LPD-17 variant, LSD conversion, and HSV-32 are preliminary. Official cost estimates would be performed by NAVSEA 017.

D. Source: [21] and appendix C.

E. Source: [22].

F. Source: [23].

G. Source: [24]. This assumes that the LPD-17 will be built with about the same range on a tank of fuel.

H. Source: [25].

I. Source: [26].

J. Source: [1].

K. Source: [27].

L. Source: [18]. The directive authorized a study of feasible alternatives to dedicated hospital ships in support of Navy amphibious operations.

M. Source:[28].

Table 10. Land-based platforms

Platform type / characteristics	Fleet hospital (FH)[B,C]	Expeditionary medical facility (EMF)[B,C]	HSV-32 EMF carrier[A]
Medical capabilities			
Operating rooms	6	2	NA
ICU beds	80	20	4
Ward beds	420	96	40
Stored units	414 ISO containers, 89 vehicles	63 ISO containers; 4 vehicles	EMF - 63 ISO containers; 4 vehicles
Habitability - berthing			
Support (crew) personnel	241	32	12
Medical personnel	737	196	24
Mobility of transport			
Speed (maximum)	MPF ships 17+ kt	MPF ships 17+ kt	42+ kt
Close to shore	Requires a large dock	Dock need depends on type of delivery vessel	Almost any dock 11.4-ft draft[E]
Stability	Not applicable	Not applicable	High
Range at cruising speed	12,000 miles	12,000 miles[E]	1,250 -1,500 miles[D]
Adaptability			
Potential level of medical care	Definitive	Resuscitative/ limited definitive	Limited care/ casualty transport
Readily deployable	Immediate deployment/ 10-day assembly	Immediate deployment/ 36- to 48-hour assembly	Immediate deployment
Availability	Ten active units world-wide[B]	Six active units worldwide[B]	Available for conversion now
Accessibility			
Helicopter capability	All	All	1 SH-60 Sea Hawk
At sea ingress	Not applicable	Not applicable	None
Compatibility			
Base requirement	28-35 secured acres of land	2-3 secured acres of land	Can dock most harbors
Docking capacity	21'- 25' draft on MPS[F]	21'- 25' draft on MPS[F]	11.4-ft draft
Vulnerability to attack			
Area to defend	28- 35 acres	2-3 acres	Small target High maneuverability
State of the art			
Equipment	Utility services and some lab spaces modular	Utility services, some lab and operating spaces modular	

Table 10. Land-based platforms (continued)

Platform type/ characteristics	Fleet hospital (FH)[B,C]	Expeditionary medical facility (EMF)[B,C]	HSV-32 EMF carrier[A]
Estimated costs			
Acquisition	$30M to $35M[E]	Not applicable	$50[G]
Conversion			Approx. $50M
Annual operating, standby	$8M to $10M 5-year overhaul		
Annual operating, active	Delivery by cargo ship, about $25,000/day	Delivery by cargo ship, about $25,000/day	
Annual operating, medical	Not applicable	Not applicable	

A. Source: [22].

B. Source: [29].

C. Source: [30].

D. Source [25].

E. Phone discussion with Ed Dofflemyer at BUMED-04, 25 Oct 2001.

F. Source: [31].

G. Source: [26].

Throughout this chapter, we review and assess the relative advantages and disadvantages of each alternative according to the three criteria listed in the introduction to this chapter.

The second source of characteristics used for our comparisons came from the historical reports of strengths and weaknesses of the current Mercy-class hospital ships. For example, we noted that USNS *Mercy* is relatively slow, with a potential speed of only 17 knots. A faster hospital ship would be able to get to its mission area more quickly and would be more effective as a casualty transport vessel (seagoing ambulance). Thus, we consider a hospital ship's speed an important attribute.

In developing our list of alternatives, we chose to focus on these seven described in tables 9 and 10 for two reasons. First, they give us both land-based and sea-based options to consider. The first four are sea-based alternatives (table 9) and the last three are land-based alternatives (table 10). Second, they would allow Navy Medicine to integrate its efforts with already-planned initiatives from the rest of the Navy. For example, the LPD-17 is a ship that is already being built and that has been studied as a potential medical platform. The HSV is a ship that is now in experimental stages as a troop carrier. It is just a conceptual step to adding medical capacity.

Working from left to right in the platform matrix, the four sea-based alternatives are the current Mercy-class hospital ship, which is our base case alternative, the LPD-17 variant, an LSD conversion option, and an HSV-32 wave-piercing catamaran. Table 10 describes land-based alternatives—the current 500-bed fleet hospital, the EMF (a smaller, more mobile land-base alternative), and a concept of employing the HSV as a means of transporting the land-based EMF.

L-class ships, construction and conversion to dedicated hospital ships

One potential source for new hospital ship(s) is conversion of older L-class ships (i.e., those that have lived their useful lives as warships) into dedicated hospital ships. This concept offers some advantages. First, the amphibious ships are designed to be personnel carriers, and as such already have built-in comfort facilities, such as berthing, mess, and toiletry, for large numbers of people. In addition, they have large cargo spaces that could be used for medical equipment storage. They already have the speed and mobility to keep up with an amphibious ready group (ARG). Perhaps most important, many of the L-class ships have multiple methods for bringing troops and casualties aboard.

In tables 11 and 12, we list the undisposed L-class ships that could become available for conversion (i.e., become 30 years old) in the next 25 years. Several writers have offered suggestions for which would make the best converted hospital ships. For example, in his widely cited critique of the Mercy-class hospital ships [16], CDR Pete Marghella recommended that we convert the available LSTs to hospital ships. He correctly points out that, compared to the Mercy class, the LSTs are smaller and quicker, enabling them to more easily deploy with the fleet, to dock at many more beaches, and to produce a far smaller target signature. The LST's stern gate and RO/RO capability could better facilitate patient movement than the current hospital ships. Finally, without the FDO designation, the medical LST would be free to deploy in routine and crisis operations.

Table 11. Amphibious ships—descriptions and availability (dimensions in feet)

Ship type and number	Ship class	Size: (length x beam x draft)	Engine type	Max. speed and hp	Aircraft and LCAC stored	Activity status	Period available
LHA 1-5	**Tarawa**	820 x 106 x 27	2 steam turbines, 2 shafts	24 kt 70,000	9 CH-53s, 12 CH-46s, 6 AV-8B 1 LCAC	Active	2006 - 2010
LHD 1-4	**Wasp**	844 x 106 x 28	2 steam turbines, 2 shafts	20+ kt 70,000	42 CH-46s 5 AV-8B 3 LCAC	Active	2019 - 2024
LPD 4-6	**Raleigh**	570 x 84 x 23	2 steam turbines, 2 shafts	21 kt 24,000	2 CH-46/ or CH-53, or 2 AV-8B 1 LCAC	Active	1995 - 1996
LPD 7- 10, 12, and 13	**Cleveland**	570 x 84 x 23	2 steam turbines, 2 shafts	21 kt 24,000	Same as above	Active	1997 - 1999
LPD 14-15	**Trenton**	570 x 84 x 23	2 steam turbines, 2 shafts	21 kt 24,000	Same as above	Active	2001
LSD 36, 37, and 39	**Anchorage**	553 x 85 x 20	2 steam turbines, 2 shafts	21 kt 24,000	One small (100 x 85) helo pad 4 LCAC	Active	1999 - 2002
LSD 41-48	**Whidbey Island**	609 x 84 x 21	4 16-cyl. diesels, 2 shafts	20+ kt 33,000	212 x 84 deck with 2 helo pads 4 LCAC	Active	2015 - 2022
LSD 49-50	**Harpers Ferry**	609 x 84 x 21	4 16-cyl. Diesels, 2 shafts	20+ kt 33,000	Same as above	Active	2024 - 2025
LST 1182-1183, 1184, 1187, 1190, and 1191	**Newport**	522 x 70 x 19	6 Diesels, 2 shafts	20 kt 16,000	One v. small (70 x 60) helo pad No LCAC	Inactive; except *Frederick*	Currently available

Table 12. L-class ships availability[a] report summary

Ship	Number
Available now	
LPDs Raleigh class	3
LPDs Cleveland class	6
LSTs USS *Frederick* (active reserve)	1
LSTs Newport class (inactive reserve)	5
LSDs Anchorage class	3
Available before 2015	
LHAs Tarawa class	5
LPDs Trenton class	2
Available 2015 - 2020	
LHDs USS *Wasp*	1
LSDs Whidbey Island class	6
Ships available 2021 - 2025	
LHDs Wasp class	3
LSDs Harpers Ferry class	2
LSDs Whidbey Island class	2

a. A ship is defined as "available" when it is ≥ 30 years old.

The LSTs have significant disadvantages as choices for conversion to hospital ships. First, all are over 30 years old; only USS *Frederick* is still active. LCDR Richard Guzman and LT Youssef Aboul-Enein, MSC, USN, pointed out that the LST's flat-bottom hull would not facilitate medical and surgical care while under way [32]. Guzman and Aboul-Enein also note that, at just over 500 x 70 feet, the LSTs may be too small to handle high casualty rates, which may require that several of them be converted to handle expected future conflicts.

Guzman and Aboul-Enein suggest that the larger Tarawa-class LHAs or Iwo Jima-class LPHs would be better choices for conversion to hospital ships. They highlight the ships' larger size, which would give them better seakeeping properties than the LSTs. Also, the Tarawa-class LHAs are all less than 25 years old now, and would have longer useful life spans as hospital ships.[11]

11. Though the LHAs are less than 25 years old, all the Iwo Jima-class LPHs, except *Tripoli*, have been disposed of already. *Tripoli*, which is over 35 years old, has been deactivated and leased to the Army.

One significant disadvantage of the LHAs is their steam-powered engines. Steam engines become unreliable when they are placed in reduced operating status. Because the Navy is phasing out its steam engines, there will soon be a dearth of Navy machinists capable of maintaining them.

It is also not clear that the larger size of the LHAs would be an advantage. As noted earlier, some of the problems of the T-AHs are related to their large size. First, it makes them FDO ships, meaning that they could not deploy except in the most severe conflicts for fear of sending the wrong message. Second, many maintenance and operation costs increase in direct proportion to ship size.

We considered other L-class ship types for conversion to hospital ships. The current LPDs, for example, have attractive size, speed, power, and stability for becoming hospital ships. They are all over 30 years old, however, and they all have steam-powered engines. The LHDs are about the right age for the 2015- 2025 time frame, but they are almost as large as *Mercy* and they have steam engines. As a result, we emphasize two choices of L-class for conversions or modifications to hospital ships: a medical ship conversion of the Whidbey Island class and/or Harpers Ferry class LSDs, or a hospital ship modification of the forthcoming LPD-17s.

The LSD conversion option

A practical choice for a dedicated hospital ship would be to convert one or more of the Whidbey Island or Harpers Ferry class LSDs. The advantages would be as follows. First, they are the right ages; the ships will begin turning 30 years old in 2015. Second, with length and beam of about 600 X 84 feet, they could be small enough to avoid FDO status, but large enough to handle most conflict scenarios. In addition, with its relatively shallow draft of 20 feet, the LSDs could pull up to a wide variety of piers. They are powered by four 33,000-hp diesel engines and can go 20+ knots, giving them the speed and maneuverability to travel with an ARG, and engines that could be maintained by MSC and contracted machinists for many years. To facilitate safe and swift patient ingress and egress, they hold two LCACs in their well decks and have two helicopter landing pads that could handle anything from an SH-60 Sea Hawk to a V-22 Osprey.

Figure 5 shows a picture of the LSD-48 with the ship's specifications and potential medical capacity if it were converted.

Figure 5. LSD-48, USS *Ashland*, Whidbey Island-class

General Characteristics of Whidbey Island-class LSD

Power plant:	Four turbo-marine Colt-Pielstick diesels, two shafts
Waterline length:	580 feet
Waterline beam:	84 feet
Navigational draft:	20 feet
Displacement:	Approx. 16,000 tons full load
Speed:	In excess of 20 knots (23.5 mph)
Patient ingress:	Launch or land up to two MV-22 Osprey tilt rotor aircraft; can land and hold two LCACs in its well deck.

Medical Capacity[a]

Operating rooms:	4
ICU beds:	50
Ward beds:	180
Medical personnel:	256
Medical vehicle space:	1,500 sq ft

a. This is a rough estimate: calculations are found in appendix C.

The disadvantages of using any aged L-class ship are that its useful life as a hospital ship would be limited, and estimation of its conversion costs is uncertain and therefore hard to predict. Also, because the smaller L-class ships are shallow-drafted, they are perhaps not as sea-friendly as one would prefer a dedicated hospital ship to be.[12]

The LPD-17 hospital variant

An alternative that has been discussed and studied is a modification of the new LPD-17 class ship. The LPD-17 is a newly designed troop and vehicle transport ship. It is being touted as the most survivable amphibious ship ever put to sea.[13] Its design incorporates state-of-the-art C4I (Command and Control, Communications, Computers, and Intelligence Gathering) equipment. The ship's profile facilitates a reduced radar cross-section signature. Its design also includes reduced operational costs, an improved ability to incorporate technological advances over its 40-year life, a total ship training system, and integrated engineering and damage control systems. It contains the latest quality-of-life standards for personnel, including sit-up-berth, ship services mall, and the flexibility to accommodate mixed gender Sailors and Marines. The LPD-17 has the ability to carry two LCACs. It can launch/land two CH-53 or V-22 helicopters *at the same time;* it can hold four of these helicopters at any time. These characteristics make the LPD-17 a very capable platform. They would maximize ship's safety and personnel comfort and would facilitate ease of patient egress and ingress, making the ship a superb candidate for a dedicated hospital ship.

A recent study by analysts at NAVSEA suggests that only a few, relatively simple design changes would transform the LPD-17 to a

12. Compare this to the current Mercy-class hospital ships with a 33-foot draft. Another measure of ship stability is its block coefficient, the ratio of the ship's actual displacement and its block displacement, which is the ship's waterline length times its waterline beam times its draft. The L-class ships have block coefficients ranging from 0.46 to 0.6, whereas the Mercy-class block coefficient is 0.78, giving it more stability, albeit at the cost of its potential speed and its ability to dock in many ports.

13. See [17] under "Surface Ships – LPDs."

dedicated hospital ship [33]. The only major design modifications would be the removal of the existing ship and troop accommodations, combat systems, and the upper vehicle stowage area. These spaces would be replaced with hospital-level medical facilities, ship's crew accommodations, and Navy administrative and medical personnel offices and accommodations. The existing well-deck facilities, aircraft hangar, and aviation facilities would be retained to facilitate effective patient movement by air and sea. The main vehicle stowage area and both lower vehicle stowage areas would be retained to provide transport capability for medical vehicles and supplies.

A major disadvantage of using a modified repeat of the LPD-17 is that it is estimated to cost about $815 million to build each unit. That figure may be low; $815 million is the unit cost of the LPD-17 under the current contract for 12 ships.[14] There are some economies to scale in shipbuilding. A shipbuilder constructing many identical ships experiences large learning economies, resulting in lower unit cost. Any modifications to the design could result in higher costs if the new design is unable to take advantage of all of these economies. Still, for the reasons cited earlier, the LPD-17 hospital variant may be the least cost choice for a new dedicated hospital ship.[15]

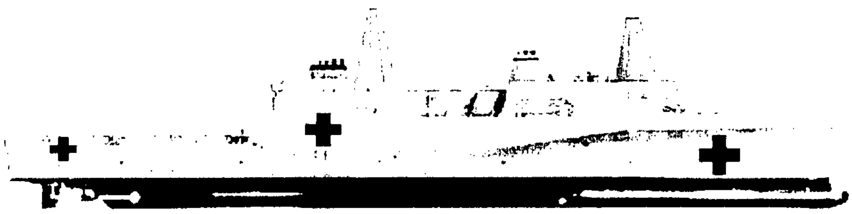
The Navy has ordered 12 of the LPD-17s for construction by FY08. It would be politically difficult to persuade the Navy to give up 1 of these 12 for a new hospital ship. Thus, a 13th (and 14th, if practical) modified repeat(s) of the LPD-17 would be the most likely scenario. That would require the Navy to extend its contracts for the LPD-17s past the FY08 deadline. It is possible that the deadline for such an extension has passed. However, as long as the production line is still open, a new contract could be signed and the Navy would still gain the benefits of a modified repeat of the LPD-17.

Figure 6 shows the notional picture of the LPD-17 hospital variant with ship's specifications and potential medical capacity.

14. See [17] under "Surface Ships – LPDs." This assumes that the hospital variant of the LPD-17 is not inherently more costly to build than its warship counterpart.

15. All specifications for the characteristics and medical capabilities of the LSD and LPD-17 hospital variant are outlined in table 9.

Figure 6. LPD-17 hospital ship variant



General Characteristics of LPD-17

Power plant:	Four turbo-marine diesels, two shafts
Waterline length:	661 feet
Waterline beam:	97 feet
Navigational draft:	23 feet
Displacement:	Approx. 24,900 tons full load
Speed:	In excess of 22 knots (26 mph)
Patient ingress:	Launch or land two CH-53Es/MV-22s at the same time; can carry two LCACs in its well deck.

Medical Capacity of Hospital Variant

Operating rooms:	8
ICU beds:	50
Ward beds:	200
Medical personnel	398
Medical vehicle space:	1,700 sq ft

Options that complement current capability

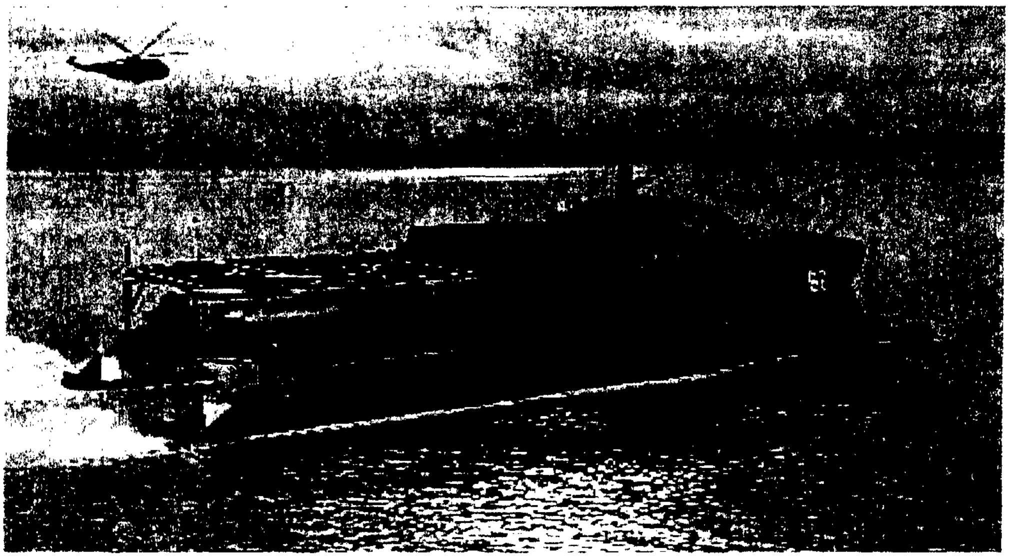
Medical catamaran (HSV medical modification)

In this section, we introduce a set of platforms, which act as an augment to modern medical care capacity, to solve specific problems or medical care gaps in our present set of assets. For instance, we propose a solution to the problem of distance between echelons of care, necessitating a patient transport vessel that has a longer range than our helicopters and can provide en route medical treatment. In addition, we propose a platform that provides a method for quickly and inexpensively transporting a land-based component of the modern Fleet Hospital, the Expeditionary Medical Facility (EMF). In each case, we suggest using a high-speed, modified catamaran (HSV) for two reasons. First, its potential range and speed could effectively solve the problems just cited. Second, the Navy is already testing the HSV, albeit for other purposes, but that testing allows us to use the Navy's data to evaluate the HSV's potential effectiveness as a medical vessel. Figure 7 shows the U.S. Navy and U.S. Army Joint experimental HSV with its specifications and potential capacity as a notional troop transport vessel.

The two HSVs in this analysis are the 96-meter INCAT 046 and the 101-meter HMS Jarvis Bay, both built by INCAT of Australia. The U.S. Navy and U.S. Army are currently involved in a joint experiment with the Incat 046 for use as a troop and military vehicle carrier (HSV-IX). Its main advantage in this capacity is that it is capable of carrying over 325 troops and 450 tons of cargo, including light armored vehicles and trucks, over 1,100 miles at an average speed of 35 knots[16] in sea state three [36]. A CNA study of a Navy and Marine Corps joint test of a 101-meter catamaran in ferry configuration [25] found the following. First, commercial versions of the HSV attained maximum speeds of up to 60 knots with small payloads and for short distances. Second, its normal cruising speed was around 35 knots, at which its range was about 1,250 miles, without using its 20-percent fuel reserves.

16. The 35-knot estimate is being tested as of January 2002. Tests might show that structural failures and extreme seasickness can occur at these high speeds [34, 35].

Figure 7. High-speed catamaran HSV-IX notional troop carrier



General Characteristics[a]

Class:	HSV-IX, U.S. Navy/U.S. Army Joint Venture
Builder:	INCAT of Australia
Power plant:	Four 9,500-hp diesel engines powering transom-mounted waterjet propulsors
Length:	96 meters (312 feet) total
Beam:	23 meters (75 feet)
Draft:	3.42 meters (11.2 feet) fully loaded
Range:	1,250 miles at 35 knots with payload / 1,000 miles full speed
Speed:	43+ knots (50+ mph; 80+ kph) with full load
Load capacity:	240 privately owned vehicles, 900 passengers
Military lift:	Equivalent to one small Marine battalion with complement of light vehicles
Comparative advantage:	High speed, maneuverability, short draft, and low cost
Cost:	Two-year lease contract—\$20.5M; estimated purchase price est. \$50M, additional investment for conversion est. \$50M

a. Sources: [22, 26, 37, and 38].

Medical evacuation and enroute medical care

The essential problem of en route care is this. Echelon two medical facilities, such as the L-class ships, are successfully stabilizing patients before they are transferred to a higher level facility. Nevertheless, if maintenance medical care is not provided on the ride to the next level, the patient's condition could degrade. In this section, we introduce and critique an idea to modify and use a U.S. Navy HSV as a potential en route medical care platform. The purpose of a modified HSV would be to provide high-level medical care while performing as a high-speed casualty ferry.[17]

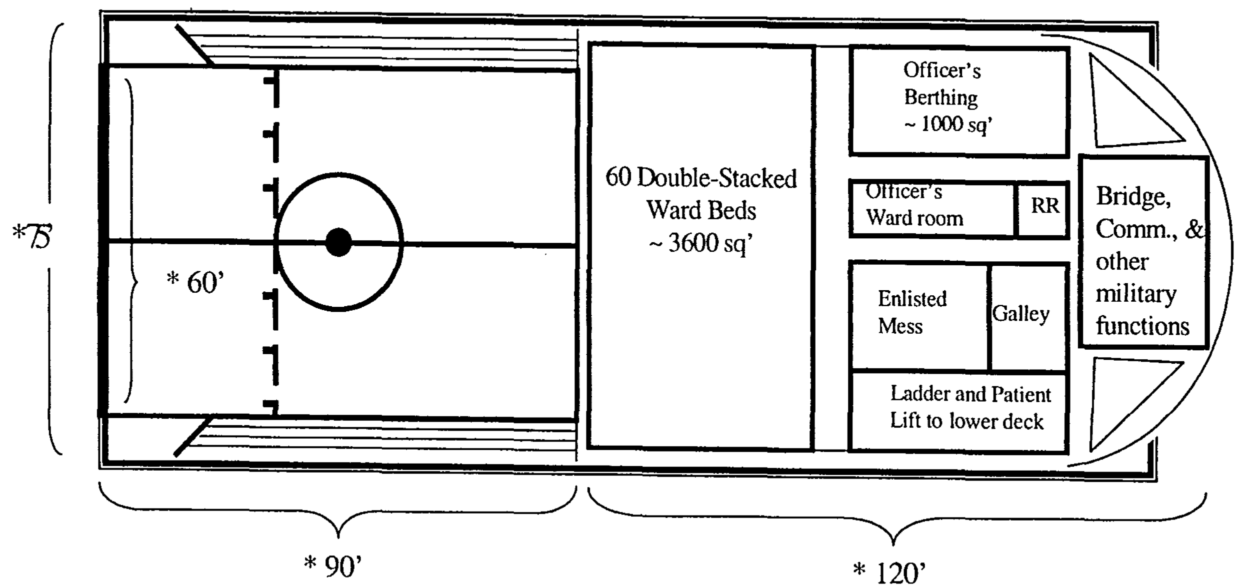
We propose that en route medical care could be one of the HSV's comparative advantages. The HSV is not large enough to carry a definitive care facility. However, its high speed and shallow draft, joined with a limited medical care capability, could make it a candidate for providing patient ambulance services.

Figures 8 and 9 show a notional drawing of a medical HSV.[18] On the top deck are all the ship's navigational and military functions, as well as the crew's berthing and mess areas. Also on the top deck are the ship's medical ward beds and kitchen and dining facilities for the hospital patients. On the lower deck are the medical compartments, a few of which we have portrayed as modules. Each compartment is constructed to perform a specific medical function and is set in a configuration that facilitates an efficient and effective flow of patients. The method we use to estimate these medical capabilities is detailed in appendix D. Because of their speed and the versatility provided in part by the modular concept, the medical HSVs could be useful for a wide range of conflict situations.

17. Admiral Arthur, Deputy Navy SG, in regard to the joint armed forces' Force Health Protection (FHP) 2010. The general goal of the FHP 2010 is to improve the armed forces' ability to provide health care to all service people. Within that directive, it has the goal of improving the armed forces' ability to provide medical care in-theatre, and within that goal, to improve en route medical care capabilities

18. This notional drawing is quite elementary. It is almost, but not exactly, to scale; medical capacity estimates reflect only rudimentary knowledge of medical facility requirements based on the ADHOS study calculations.

Figure 8. HSV-IX high-speed catamaran upper deck—notional medical ward and ship's functions



60' x 90' Helicopter Landing Deck:

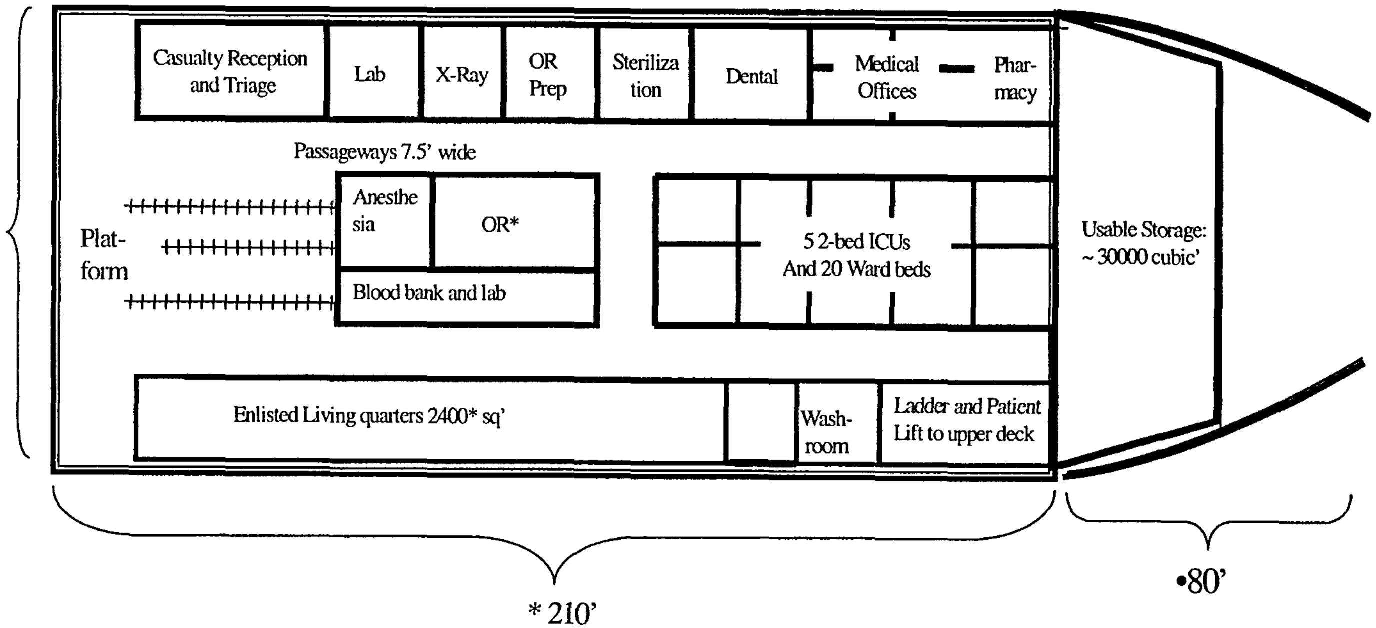
- SH-60G Pave Hawk (54'W x 65'L)

Manpower:

• Line Officers	4
• Medical Corps	16
• Nurse Corps	8
• Ship's Crew	14
• Medical Techs and HMs	34

* **Note:** All size specifications on this and the next page are estimates based on artist conceptions of HSV-IX. Because the pictures are not exactly to scale, the specs here make assumptions about pad size needs SH-60 helicopters. Specifications are from INCAT Tasmania Pty. Ltd. Description of 96 meter Incat 050 catamaran.
** **Note**: this picture shows only a conceptual configuration of <u>some</u> of the medical and ship's crew rooms; the actual design and arrangement of rooms will require the services of medical and naval architects.

Figure 9. HSV-IX high-speed catamaran lower deck—notional medical ward and ship's functions



*Module basic size 8' x 20'
Can be joined to make rooms sized as multiple of basic size**.

+++++ Tracks for guiding modules and facilitating modular arrangement of special operating room facilities

** Note: this picture shows only a conceptual configuration of <u>some</u> of the medical rooms; the actual design and arrangement of rooms will require the services of medical and naval architects.

* Note: Measurements are close but not exactly to scale.

Following are potential advantages to the Navy and Marine Corps of a medical version of the HSV. First, having a dedicated echelon II level medical platform available could take medical mission pressure off the Navy's large-deck amphibious ships. The medical HSVs could augment the L-class ships' mission as casualty receiving and treatment vessels. They could be used for shuttling patients in certain circumstances. For example, the HSV might be useful for shuttling patients from echelon II care on amphibious ships to higher level care at OCONUS facilities if the hospital ship is not yet available. (We are assuming that patients would be transferred from L-class ships to HSVs by air. See appendix E for an analysis of the number of HSVs needed to perform this mission for scenarios with MEU-, MEB-, and MEF-sized forces in the Pacific Theater.) If testing shows that they have adequate seakeeping capabilities, the medical HSVs could provide medical resuscitative and stabilization medical care simultaneously with patient transport—something that Navy/Marine Corps helicopters could not do. The medical HSVs could facilitate small-footprint search and rescue missions, by providing medical care in a small vessel very close to shore, something for which the deep-draft L-class ships are too large. Finally, the medical HSV could more efficiently move large numbers of patients than helicopters, reducing pressure on the single landing pad of the hospital ship.[19]

If desired and practical, the Medical HSVs might be constructed to support a medical module concept inside its lower deck. In our notional model, modules would slide on installed tracks, to facilitate the organization of medical modules in ways that are specified for a given conflict scenario. For example, if the conflict were one of standard arms and artillery, we could install modules that are specialized for trauma and surgery. If the conflict included the use of chemicals, we could use modules specialized for chemical cleaning and isolation.[20] This flexibility could be useful in a multidimensional mission. For example, the HSV could load casualties near the front, using modules in its trauma

19. This assumes that a method is developed to move patients directly from the HSV to the hospital ship.

20. It is not necessary that the CAT support medical modules. They are just one option for CAT employment.

configuration, and quickly transport them to an OCONUS hospital. It could drop off the casualties, remove some of the modules and replace them with modules designed for disease quarantine or burn units (to give two examples) and race to provide collateral humanitarian aid in a contiguous area.

EMF transport

Another potential use for HSV could be to carry an Expeditionary Medical Facility (EMF) to in-theater operations. The EMF is a 116-bed, portable, modular version of the fleet hospital.[21] It is designed to provide limited medical care in low-intensity combat, operations other than war, or disaster/humanitarian relief operations. The EMF is relatively new, and the method of its transport to in-theater operations is still being debated. Its expeditionary purpose seems to invite a high-speed method of transport. In the following paragraphs, we look at the area volume and the deadweight cargo capacity of the HSV to determine the feasibility of its use as an EMF carrier.

The HSV appears to have sufficient area volume and deadweight cargo capacity to carry an EMF. The EMF is shipped in 63 ISO containers, which includes medical equipment, utility modules, tent sections, general-purpose tents, and some nonperishable supplies [29]. It also has four vehicles. Each container is about 8 feet wide x 20 feet long and would require 160 square feet of space; each vehicle would need about 300 square feet of parking space. Consequently, a ship would need about 11,000 to 11,500 square feet of cargo space to handle the containers and vehicles. The cargo hold in the 96-meter HSV is roughly 14,000 square feet, which results in a stow factor of 78 to 82 percent, may or may not be sufficient for the task at hand.[22] The 96 meter HSV may be just barely large enough to handle an EMF, but there are an assortment of HSV sizes, from 96 to 120 meters.

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21. We discuss the EMF and the fleet hospital in detail in the last section of this chapter.

22. This conclusion also depends on an assumption that devices required to secure all containers to the cargo deck would not require much additional cargo space.

In addition to the right amount of space, the HSV must have the ability to handle the weight of an EMF. The heaviest of ISO containers weighs a little less than 3 tons empty.[23] In addition, the four vehicles weigh about around 10 tons. Total weight of the 63 empty containers and vehicles is about 200 tons. According to our calculations, the deadweight cargo capacity will be in the region of 750 - 170 ≅ 580 tons.[24] Subtracting the known weight of the containers leaves about 380 tons, or an average of about 6 tons per container of medical equipment. If the total weight of the medical equipment is less, the HSV would be physically able to carry the weight of the EMF. Figures 10 and 11 show the HSV in its notional EMF carrying capacity. Some limited medical capability is added in the upper deck (figure 10) so that the HSV can serve dual purposes in this configuration.[25]

Another issue is loading the EMF onto and off the HSV. Containerized fleet hospitals are typically loaded and offloaded by crane onto and off a large cargo ship. That is a speedy and effective way to do it. On the HSV, however, the containers would be loaded and offloaded via a rear well deck. Because that would be more time-consuming, loading and offloading is a potential weakness of the HSV. Furthermore, the ability of the decks to support the point loads of the wheels of container handlers would require further analysis.

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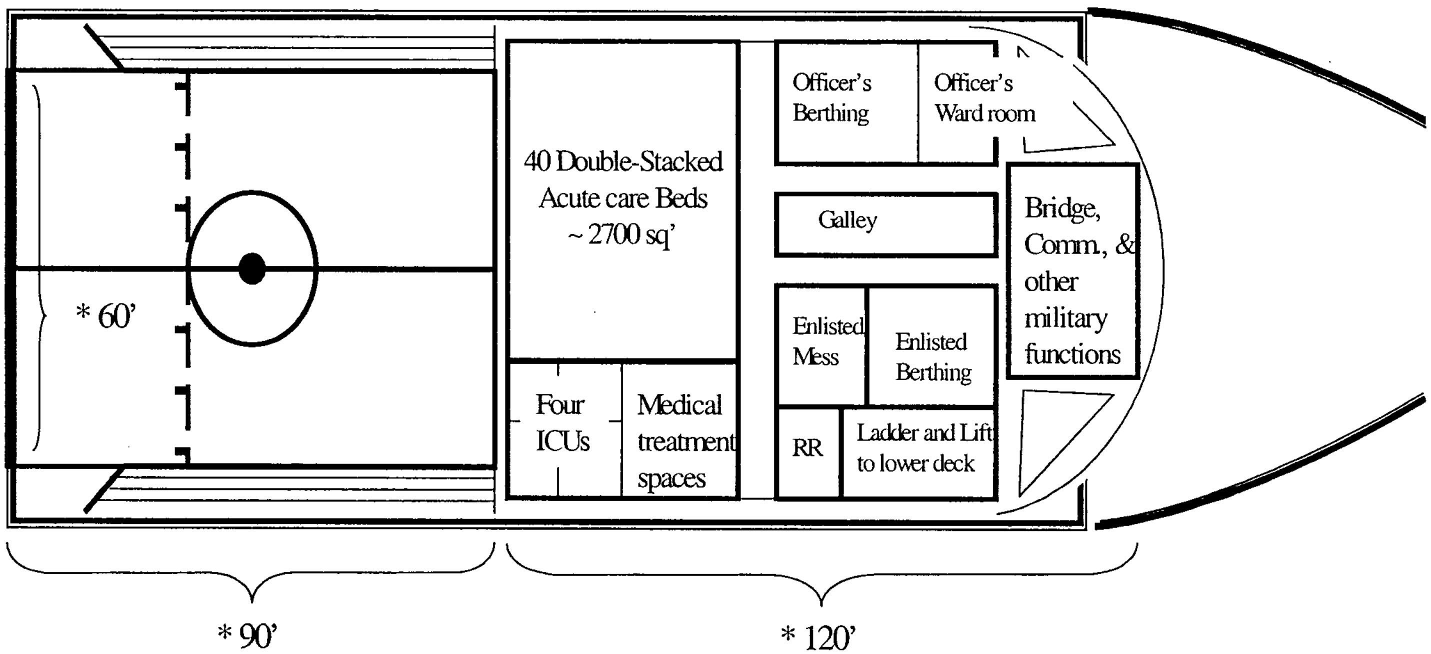
23. Container specifications are found at ISOCONTAINERS.com corporate website. There are many types of materials used in the manufacture of containers, such as steel, aluminum, and several kinds of plastics and epoxies. The heaviest steel containers are about 5,600 pounds each. A refrigeration unit would add about 800 pounds to the container.

24. The manufacturer's literature claims that the 96-meter catamaran has a deadweight capacity of 750 tons. Its fuel tanks hold 160 cubic meters (about 5,600 cubic feet) or about 40,000 gallons of fuel, which weighs nearly 160 tons. It also holds 10 cubic meters, or about 350 cubic feet, of other liquids, such as water and sewage. That would weigh about another 10 tons. Add another few of tons of navigational equipment and supplies and 5 tons of people (60+ personnel at 150 pounds each), and the total operational weight the ship carries would be roughly 160 or 170 tons.

25. All specifications for the characteristics and medical capabilities of the HSV are outlined in tables 9 and 10.

Figure 10. HSV-IX high-speed catamaran upper deck—notional limited medical ambulance and ship's functions



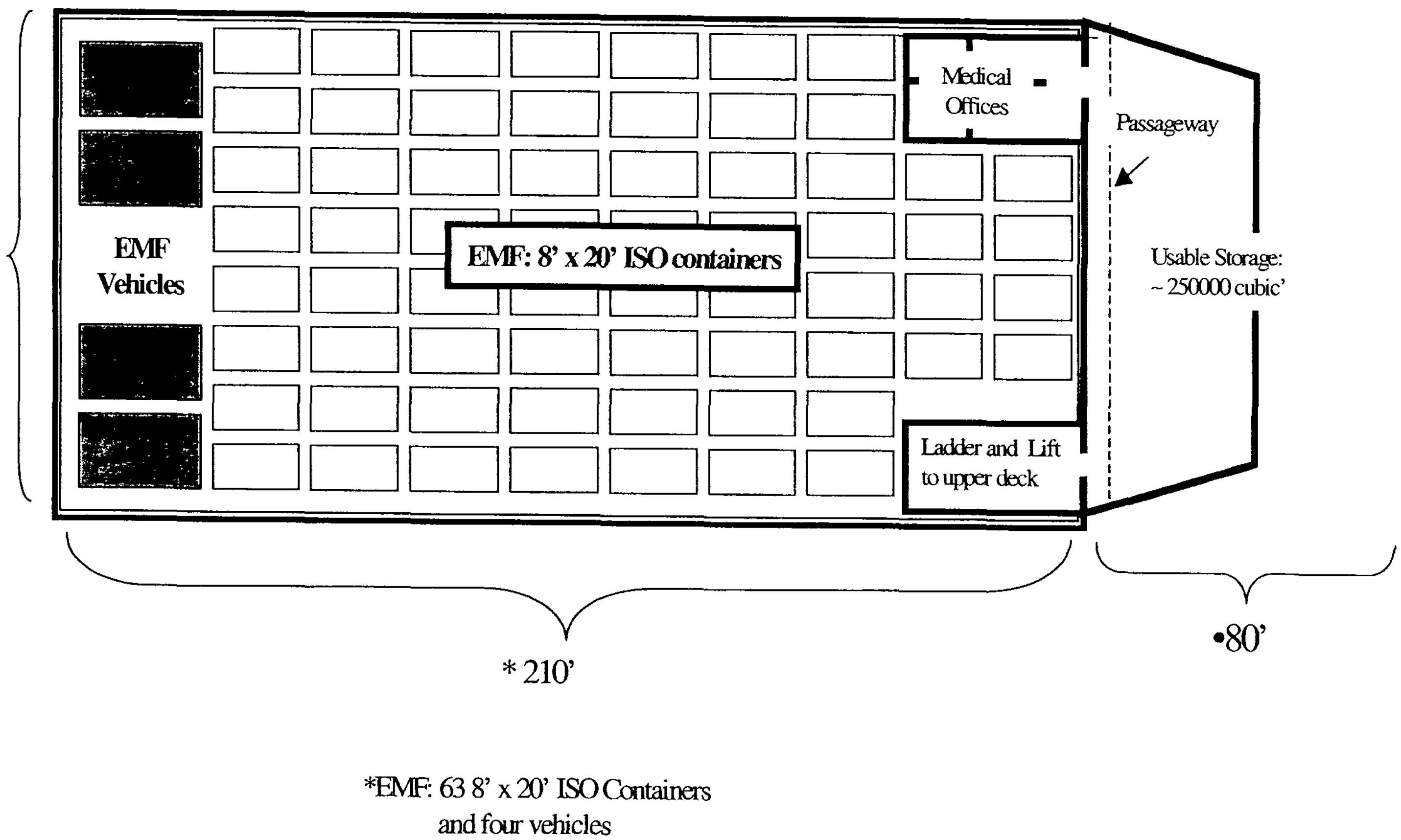
60' x 90' Helicopter Landing Deck:
- SH-60G Pave Hawk (54'W x 65'L)

Manpower:

• Line Officers	4
• Medical Corps	2
• Nurse Corps	4
• Ship's Crew	14
• Medical Techs and HMs	14

* **Note:** All size specifications on this and the next page are estimates based on artist conceptions of HSV-IX. Because the pictures are not exactly to scale, the specs here make assumptions about pad size needs SH-60 helicopters.

Figure 11. HSV-IX high-speed catamaran lower deck—notional EMF carrier and ambulance layout



The HSV is probably physically capable of carrying, loading, and off-loading the EMF. But even if the HSV *could* perform the job, our task is to help the Navy answer questions about whether it *should* do it, and under what scenarios it would be practical and effective. For example, a question arises as to what the HSV would do once the EMF is off-loaded. We will explore some potential uses in chapter 4.

Potential problems with HSV military medical modification

A myriad of issues must be resolved before the HSV En Route Care Medical Modification could be a practical platform. First and foremost is the matter of *moving patients from the battlefield to the HSV.* It is not large enough to land the V-22 Osprey or CH-53 Sea Stallion helicopters; however, it can land an SH-60 Sea Hawk helicopter, which is used primarily for search and rescue missions, and could probably transport five or six casualty litters in a sortie.

It would be useful to be able to get patients on board the HSV directly from shore; however, the HSV's 14-foot draft would prevent beach landing, meaning the ship must be docked. Fortunately, the ship's small size and relatively shallow draft means that most docks could accommodate the HSVs. There are no known means to transport patients from beach to HSV by means of a watercraft. We considered floating causeways, but they are slow and cumbersome and would be awkward to bring to shore and use during critical periods in a conflict.

An artifact of the HSVs ferry design is that, while the passenger compartments in the top deck are vibration-isolated from the rest of the ship (for comfort), the vehicle carrying lower deck is not. If, as in our notional design, the lower deck would be used for medical surgeries, intensive care, and patient recovery, it is critical that it be vibration isolated from the rest of the ship.

There are some problems that must be resolved before the catamaran could be effectively used as a military vessel of any kind. First, the ship does not have U.S. Navy level of watertight integrity. The ship's pontoons are the only part in the water. Each of them is divided into eight compartments, and, in accordance with international safety regulations, three of these compartments could fill up before the ship loses stability. Once it loses stability, however, water could enter the cargo bay. Because the cargo bay has no bulkheads, it could fill up quickly, resulting in catastrophic loss.[26] The Military Sealift Command does operate ships that are built to a one-compartment standard, so the HSV would not necessarily need to be modified for increased watertight integrity. Further, it would be very hard and expensive to add watertight bulkheads into an existing vessel. One could, however, modify an existing design before it is built, if that is the direction the Navy takes.

Finally, in its current ferry design, because it is required to travel only short distances, the HSVs are not outfitted with underway refueling capability. As we stated earlier, the HSVs can travel about 1,250 miles on a tank of fuel, at cruising speed, without using its 20-percent reserve. Although this is adequate for a number of missions, there are many in which it would not be adequate. For example, the CNA study showed that most U.S. Navy bases in the western Pacific region are much farther apart than the HSV's maximum range [25]. In fact, of the 11 western-Pacific naval bases in the CNA study, only 3 are less than 1,250 miles from Okinawa, Japan. On the other hand, most bases in countries on the Mediterranean Sea are within the 1,250-mile limit, as are most in the Southwestern Asian areas.

It is true that there are many refueling bases in all the regions of the world. Still, we estimate that it would take about 10 hours to refuel the HSV [25]. It seems contradictory to build a vessel whose primary benefit is its speed, only to slow it down by requiring it to stop for a long refueling.

A relatively recent exeriment has placed a cloud of doubt over the entire concept of using the commercially built HSVs for military use.

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26. The ship was designed as a passenger and vehicle ferry. As such, a more dangerous problem is fire, primarily due to vehicles carrying fuel. Safety would require that crew be able to see all cargo, and that passengers could quickly egress in the event of a fire. Thus, in its ferry design, commercial code requires the cargo portion of the HSV to have no bulkheads.

Maritime Prepositioning Forces (MPF)

Here we turn our attention to land-based medical platforms. The medical platform alternatives we discuss in this section are the fleet hospital (FH), a 500-bed tent medical center, the Expeditionary Medical Facility (EMF), a 116-bed subcomponent of the FH, and a new idea for using the HSV as an EMF transport vehicle and ambulance. We consider these alternatives primarily in the context of the Maritime Prepositioning Forces (MPF) concept because that is method by which the Marine Corps delivers its first medical assets (along with its fighting assets) to the area of the conflict. We also discuss an idea being considered by the U.S. Marine Corps for changes in the MPF concept. Specifically, the USMC seeks to make the MPF more flexible, maneuverable, and organic to the fighting forces.

Current MPF operations are conducted by flying the personnel of a MAGTF and Naval Support Element (NSE) into an arrival and assembly area of a host nation to join with equipment and supplies prepositioned aboard forward-based Maritime Prepositioning Ships (MPSs). Here, the MPSs are floating warehouses that carry a 30-day supply of provisions for a MAGTF of anywhere from 2,000 to 20,000 or more Marines.

We must make an important distinction between current MPF and amphibious operations. The latter provides the means for forcible entry. The former permits rapid deployment into areas where introduction of military forces is unopposed and expected to remain so at least through the arrival and assembly stages of the operation. Thus, in its current form, MPF relies heavily on the existence of a secure land area that allows for arrival and offload of ships and aircraft, and the assembly of personnel and material.

MPF medical care

Medical care for current MPF is provided in one of two ways. The first method is the FH. Fleet hospitals are portable, containerized, modular hospitals used by the Navy and Marine Corps in land operations. These 500-bed hospitals are stowed in a ready-to-assemble state in 414 ISO containers (8 x 20 feet) and carried to areas of operation by container-carrying MPF ships. Once offloaded, the FH is assembled by component staff personnel and organic equipment—in other words, by whomever and with whatever equipment is available on site. The FH requires 28-35 well-secured, level acres of lând and is directed to take around 10 days to assemble once it is offloaded [30]. It has space and equipment to support around 6 operating tables, 80 ICU beds, and 420 acute care ward beds [29]. It is staffed with 737 medical and 241 support personnel.

The FH must be capable of:

- Providing command and control to monitor fleet and Marine Corps medevac operations
- Being transported by road, rail, or sea, which implies that every part is containerized except vehicles and specialized equipment that are too large to fit.

When an FH is stationed in a communication zone, it must be ready to provide space, equipment, and medical specialists to perform:

- 39 surgical operations per day
- 50 total admissions per day
- 166 outpatient clinic visits per day.

If it is in a combat zone, the FH must be ready perform:

- 27-54 surgical operations per day
- 40-80 total admissions per day
- 39-78 outpatient clinic care visits per day.

A subset of the FH is the Expeditionary Medical Facility (EMF). This is a small, portable modular version of the FH, designed to provide limited medical care in low-intensity combat (LIC), operations other than war (OOTW), or disaster/humanitarian relief operations [30].

The EMF's medical core functional areas include a casualty receiving area, an operating room preparation and hold area, and rudimentary laboratory, radiology, and blood bank facilities. It provides 2 operating tables, 20 ICU beds, and 96 acute care beds. Its water, sewage, fuel storage, and mess management functions are task organized in containerized modules. The EMF requires only 2 or 3 secure acres of land and is directed to take 36–48 hours days to assemble once it is offloaded.

The EMF is staffed with 196 medical and 32 support personnel, and is capable of providing:

- 14 surgical operations per day
- 30 total admissions per day.

The other method of medical care provision in the MPF is by MSC hospital ship, either USNS *Mercy*, T-AH 19, or USNS *Comfort*, T-AH 20. Each of these ships is capable of providing up to 1,000 beds, with 12 operating tables, 80 ICU beds, 400 acute care ward beds, and 500 minimal care beds. The hospital ships require 5 days of predeployment (to light their steam-powered engines and bring medical personnel and equipment aboard) but can cruise to the prepositioning site at the same speed as the MPS. Once on site, the hospital ships can handle definitive care for up to 150 patients per day.

The FH, the EMF, and the MSC hospital ship are all designed to provide definitive, also called echelon III, medical care. Thus, in its current form, MPF envisions that casualties will be transported directly from the battlefield surgical stations to definitive care, either the fleet hospital or the hospital ship. The advantage of the fleet hospital relative to the hospital ship is that patient movement is much easier because it is land based. The disadvantages are that it requires a large footprint (28 to 35 acres of secured land), and it cannot be moved easily once set up. The EMF requires only a small secured base, but it can handle only a small casualty flow. The nature of the conflict will determine which will be most effective.

MPF 2010

MPF 2010, also called MPF Future, anticipates a scenario in which there is no secure land base available for landing Marines. MPF 2010 envisions the MAGTF and NSE personnel and materials meeting and assembling at sea. To accomplish this, we would have maritime prepositioning ships that can carry and house both men and materials. Because MPF 2010 envisions that there will be no secure land to assemble a MAGTF or to install a fleet hospital, it must provide medical care on its own, or find itself wholly dependent on the arrival of the MSC hospital ships.

In a recent study by Advance Marine Enterprises for CNA [33], the group developed a model in which resuscitative (echelon II) medical care is provided on board the MPSs. Each MPS would have on board at least 2 medical and 2 dental operating rooms, 24 ICU and acute care ward beds, and 90 minimal care (overflow) beds. It would devote roughly 6,500 square feet of space to medical care and would be able to accommodate around 40 casualties per day (see table 13 for more detailed information on the medical spaces and table 14 for estimates of manpower envisioned in the MPS in MPF 2010). The total medical capability of the MPF would depend on the size of the MPF. The largest MPF configuration would have six to eight MPSs and could handle 240 to 320 casualties per day.

Table 13. MPF 2010 notional medical care facilities[a]

MPS medical facilities[a]	No.
Operating rooms	
Major medical	2
Dental	2
Intensive care unit beds	6
Acute care ward beds	18
Overflow beds	90
Ancillary	
Lab/ X-ray	Yes
Pharmacy	Yes
Blood banks	Yes

a. Sources: [27 and 33].

The MPF 2010 medical requirements study envisioned the MPS would only have capability to provide resuscitative care (echelon II), in a manner equivalent to between a primary and secondary casualty receiving and treatment ships (CRTSs), depending on the size of the MPF.[27] Thus, MPF 2010 medical facilities cannot replace the fleet

27. At present, resuscitative (or second-echelon) care is provided in amphibious operations by the L-class ships.

hospital. If a land base cannot be secured, its only source of definitive care will be the MSC hospital ship, at least until a land site can be secured.

Table 14. MPF 2010 notional medical manpower[a]

MPS medical manning	Routine care	PCRTS M+1 augmentation
Medical corps	1	10
Anesthesiologist	0	3
Medical service corps	1	2
Nurse corps	0	20
Medical techs	2	14
Hospital corpsmen	12	25
Total	16	74

a. Sources: [27 and 33].

Other medical resources

Some additional resources that can augment Navy and Marine Corps Medicine are the Advanced Suite for Trauma Casualties (ASSTC), the TransHospital, and the Marine Emergency Rescue Center (MERC). All of these medical facilities are designed to provide emergency surgical capability in small, quick, and easy-to-deliver packages.

The ASSTC [39] is a collapsible, highly mobile, self-contained operating room. It is a 30 x 30 x 12 tent, with a framework that can allow it to be collapsed and stored in a 5 x 5 x 10 box (all measurements are in feet). According to its designer, Duvall Design, the ASSTC includes mechanical leveling devices for use on even ground, cam-lock release mechanisms for instant tent deployment, and a fabric duct, which delivers filtered air. The unit, which can be set up in 30 minutes or less, has medical applications for civilian health and disaster relief, as well as for military use. Weighing less than 400 pounds, it can be transported by truck, jeep, or helicopter. In our view, the ASSTC might be an effective enhancement to echelon I level care, especially in situations where the battlefield quickly moves from location to location. It can also facilitate medical care in situations where the need is small (only a few serious casualties) but time-critical, or provide medical care in the time prior to delivery of more extensive medical facilities, such as the FH, the EMF, or the hospital ships.

The Marine Emergency Rescue Center (MERC) [40] and the TransHospital [41] are fully portable emergency hospitals, consisting of specialized, container-sized, fully operational medical units. They are both similar to the Marine Corps' EMF, in the sense that they are designed to be portable, they are stored in ISO-sized containers, and they are easily assembled. However, theTransHospital contains built-in operating rooms and isolation/decontamination rooms, and can flexibly become a hospital of just about any size, from 50 to 200 beds. The MERC consists of 26 specialized, container-sized medical units (as compared to 63 in the EMF). It, like the TransHospital, has built-in operating and isolation/decontamination rooms. However, the MERC is designed specifically to interface with a ship in a way that converts the ship into a hospital ship.

Chapter 3 summary and conclusion

In this chapter, we have looked in detail at some generic platforms for providing future Navy/Marine Corps medical capability. Our analysis shows that each of these potential platforms has a potential range of missions, major strengths, major limitations, and unknowns. Tables 15 and 16 summarize these major features of the sea-based and land-based alternatives, respectively.

In the next chapter, we will take the descriptions in this chapter and analyze how the seven generic alternatives could perform in particular operational scenarios. Whereas the emphasis in chapter 3 has been on the physical characteristics of the alternatives, chapter 4 will look at what those physical characteristics might mean to particular situations.

Table 15. Summary of sea-based generic potential medical deployable platforms[a]

	USNS Mercy-class hospital ships	LPD-17 hospital variant	Conversion of Whidbey Island-class LSD	HSV-32 Wave-piercing catamaran (en route care)
Potential range of missions	Potentially high-casualty producing missions that can be anticipated with 5 or more days' lead time	Replacement of Mercy class; approx. three to equivalency w/ Mercy; capable of moving with rest of ARG/fleet.	Replacement of Mercy class; similar to LPD-17, but approx. 2/3 of its capacity;	Supplement and tailoring capability of other medical platforms. Especially useful for missions where speed of 40 + kt is critical.
Major strengths	Large number of beds, arrival in theater with full operational capability; best for use when land-basing is not an option; sufficient space for full array of medical services	Speed, radar signature, communications package	Lower investment cost than LPD-17 with many of its operational advantages.	Speed of 40+ kt; provision of en route care in high-speed casualty transport; relatively low acquisition cost during current favorable supply-demand situation.
Major limitations	Lack of sea-based patient transfer; operational vulnerability because of its large radar signature; accessible to few ports; lack of secure communications; lack of isolation capability.	High investment cost; window of opportunity might be past.	Might be investing in obsolete technology; 30-year-old vessel's useful life is likely to be short.	1. Lack of ability to easily transfer patients from L-class ship, Mercy-class ship, beach. 2. 1,200-mile range on tank of fuel. 3. Inability to handle V-22 or CH-53 helicopter. 4. Inconvenient loading. 5. Weak loading ramps

a. A fifth alternative is MPF 2010, or MPF Future, also described in this chapter. MPF 2010 would be able to provide echelon II care. The MPF Future could, more likely than the four options in this table, be within helicopter range of the fighting troops or be a "lily pad" for transferring casualties out to the existing hospital ships.

Table 16. Summary of land-based generic potential medical deployable platforms[a]

	Fleet hospital	Expeditionary medical facility	HSV-32 carrying an EMF
Potential range of missions	Land-based operations	Land-based operations where smaller number of beds and/or more portability needed	Short-notice land-based operations where moderate number of beds needed and speed of setup critical
Major strengths	Large number of beds, particularly useful during sustained land operations	Tailorable land-based option	Tailorable land-based option; speed to delivery of EMF.
Major limitations	Large land space requirements, lack of mobility, time to construct, slowness to arrive in theater unless it is prepositioned	Relative lack of mobility	May be slow to load and offload, relative to cargo ships w/ cranes; also loading ramps need strengthening; short range on tank of fuel
Unknown factors	Capabilities in chem/bio environment	Capabilities in chem/bio environment	Capabilities in chem/bio environment.

a. Advanced Suite for Trauma Casualties (ASSTC), the TransHospital, and Marine Emergency Reserve Center (MERC) are also briefly described in this chapter.

Chapter 4: Scenario-based requirements

Introduction

Chapter 3 described seven generic options for medical deployable platforms: the current Mercy-class hospital ships, LPD-17 variant, conversion of a Whidbey Island-class LSD, using HSV-32 for en route care, the current fleet hospital, the current Expeditionary Medical Facility (EMF), and using the HSV to carry an EMF to the scene where it is needed.

Medical scenarios

In this chapter, we will look at five medical scenarios, for the purpose of developing rough quantitative requirements for the generic medical deployable platforms. Each of the following scenarios represents a qualitatively different type of mission for medical support:

- Operational maneuver from the sea (OMFTS)
- Biological warfare
- Homeland defense
- Sustained land operations
- Noncombatant evacuation operation (NEO).

In each scenario, we will present a map and a brief description of a sample tactical situation. We will then present a casualty stream and draw preliminary conclusions about the usefulness of the seven generic alternatives that we have described for the particular scenario. This chapter ends with a summary of the requirements that are implied by the five scenarios.

OMFTS

In chapter 2, we described OMFTS as a concept of operations in which Marines move directly to their objective, without first establishing a land base. OMFTS is a critical concept of operations for the Navy and Marine Corps and is emphasized in the last Defense Planning Guidance (DPG). For this reason, the first scenario in this chapter will look at how medical might support an OMFTS operation.

For our example of OMFTS, we use Project Culebra [42], which was a joint project of CNA and the Concepts and Plans Division, Marine Corps Combat Development Command (MCCDC). Project Culebra's mine countermeasures (MCM) and follow-on war games played a ship-to-objective maneuver scenario that gave the Project Culebra team the opportunity to analyze Combat Service Support requirements for OMFTS. The Project Culebra scenario was similar to those used for the DPG, but it was a generic scenario used with the states of California and Oregon making up Blueland, the U.S. ally. The aggressor, Orangeland, was represented by the state of Washington. The distances and other features of the scenario are similar to those along the eastern coast of Korea. Figure 12 shows the relative positions of towns near the main engagements in Culebra.

Project Culebra [43] assumed that, in addition to amphibious ships, there would be the two hospital ships *(Mercy* and *Comfort)* to care for patients. Using the amphibious ships and the two hospital ships, there were 210 total ICU beds in theater. This serves as a base case against which we compare alternatives.

We used a casualty stream from earlier CNA research [43], which can be seen in table 17. The classes of conditions were generated by LPX-Med, a casualty modeling software, which is a precursor to the current MAT [44]. The casualty stream provides a fairly challenging scenario, with a large number of casualties created each day.

Figure 12. Main engagement sites in Culebra's follow-on war games [42]

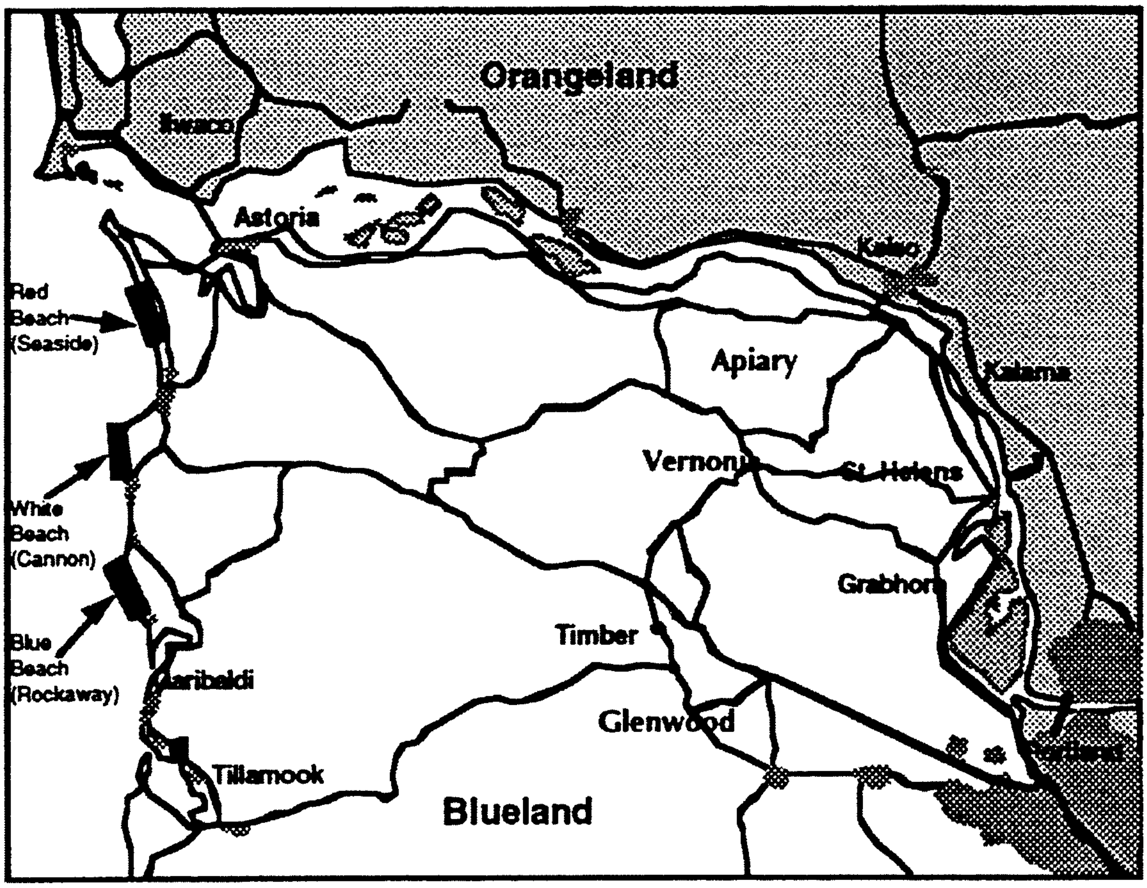


Figure 13 shows the number of beds that are used by day, versus those that are available It shows that, with the beds in theater, there is one shortfall: the number of ICU/RR beds on days 2, 3, 6, 7, and 8. The shortfall days are as follows:

- Day 2 (D+1): 116 ICU bed, or 55-percent shortfall (326 ICU beds needed vs. in-theater capability of only 210)
- Day 3 (D+2): 61 ICU bed, 29-percent shortfall (271 needed)
- Day 6 (D+5): 85 ICU bed, 40-percent shortfall (295 needed)

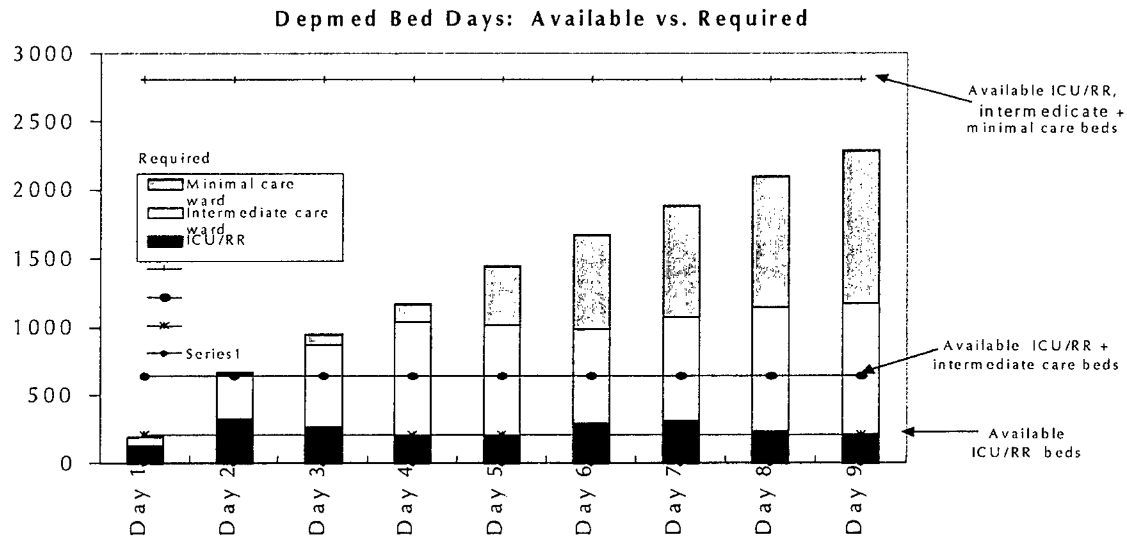
- Day 7 (D+6) 109 ICU bed, 52-percent shortfall (319 needed)
- Day 8 (D+7): 23 ICU bed, 11-percent shortfall (233 needed)
- Day 9: (D+8) 7 ICU bed, 3-percent shortfall (217 needed).

Table 17. Casualty stream from Project Culebra [43][a]

	Incoming patients by day								
	1	2	3	4	5	6	7	8	9
MIW: mult injury WIA	32	16	9	12	11	7	9	8	7
UXW: up. extrem. WIA	58	27	14	21	18	14	14	13	13
CHW: chest WIA	42	20	10	17	13	10	10	10	9
LXW: lower extrem. WIA	101	47	25	38	31	25	23	25	22
SFL: superficial	89	42	22	34	28	22	22	21	21
MXW: misc WIA	8	5	2	3	3	2	2	2	2
HED: Head WIA	7	4	2	3	2	3	1	2	2
HNC: head WIA and NBI	62	30	15	24	19	16	15	14	15
SBN: burns NBI	22	12	6	9	7	6	6	6	5
SG1: 1st surgery WIA/NBI	13	7	3	6	4	4	3	3	4
SPI: spine NBI	4	2	1	2	1	2	1	1	1
BFO: battle fatigue	10	11	10	10	10	10	10	10	11
MII: mult injury NBI	0	0	0	0	0	0	0	0	0
UXI: upper extrem. NBI	0	0	1	0	1	0	0	1	0
CHI: chest NBI	0	0	0	0	0	1	0	0	0
LXI: lower extrem. NBI	0	1	1	0	1	1	0	1	1
SPR: sprains	6	4	2	4	3	2	3	3	2
MXI: misc NBI	0	0	1	0	1	0	1	0	1
Env: environmental	0	1	1	1	1	1	1	1	1
RES: respiratory	32	34	32	31	32	31	31	31	32
GAS: gastro. dis.	21	22	21	20	21	20	21	20	20
IND: infectious dis.	7	8	8	8	7	8	7	8	7
STD: sex. trans. dis.	5	7	6	6	5	6	6	6	6
MXD: misc. dis.	24	26	25	24	24	24	23	24	24
Totals	543	326	217	273	243	215	209	210	206

a. WIA = wounded in action; NBI = non-battle injury.

Figure 13. Culebra scenario bed requirements and availabilities



Conclusions for OMFTS

Looking at the tables of the seven generic alternatives presented in chapter 3 (tables 9 and 10), we can see that the significant suppliers of ICU beds are the Mercy-class hospital ships and the fleet hospitals: Each of these platforms provides up to 80 ICU beds. However, in an OMFTS scenario, a 500-bed fleet hospital is tactically impossible, given its need for 10 days' assembly time and 28 to 35 acres of secured land.

Therefore, the OMFTS scenario suggests the following conclusions:

1. Future afloat medical deployable platforms might need to have up to 50 percent more ICU beds than in the present Mercy-class hospital ships.

2. Because they could have at most 10 ICU beds per vessel, each HSV-32 wave-cutting catamaran supplies only 10 percent of the ICU bed shortfall. It would require 10 HSV-32s to make up for the shortfalls of over 100 ICU beds.

3. The fleet hospital and EMF alternatives are not tactical possibilities in the OMFTS scenarios.

Biological warfare

In recent work performed under a grant from the Centers for Disease Control and Prevention (CDC), CNA analysts developed a model of the casualty stream that would occur if anthrax, tularemia, or plague were used against an unprepared population [45]. The purpose of the model was to simulate how long medical planners would have to provide prophylaxis for the affected population, and to develop a metric of "preventable deaths" to demonstrate the usefulness of differing speeds of medical response. Table 18 shows the assumptions underlying the simulations. In contrast,

Figure 14 shows the output of the model for anthrax for a population of 1,000. We assumed that this attack occurred on D+2, when Orangeland began a counteroffensive in the vicinity of Timber. Because the incubation period of anthrax is at least a day, if this were to occur, the casualty stream would not change until D+3, when 50 casualties would be added to the stream that we showed in table 17.

This secondary transmission rate is based on a small epidemic that occurred in Oakland, CA, in 1919. Much larger transmission rates were observed during the large-scale plague outbreaks in China and India during the 20th century. However, certain conditions (such as crowded living spaces) existed during these epidemics that may not necessarily apply to an epidemic in the United States.

We assumed that one of the infantry battalions in the Project Culebra scenario, of about 1,000 personnel, was infected with anthrax. If this were to occur, the casualty stream used in Project Culebra would require considerably more beds than shown in figure 13. In fact, assuming that patients were in ICU beds for the 24 hours before they died, the shortfalls of ICU beds would be considerably increased in the biological scenario (table 19).

Table 18. Assumptions underlying casualty intervention simulation model [45]

Agent	Incubation period for majority of cases[a]	Fatality rate without intervention[b]	Intervention program	Intervention success rate	Secondary transmission rate without intervention[c]	Illness duration in days (mean/std)[d]
Anthrax (inhalation)	2-4 days	50-85%[e]	ciprofloxacin or doxycyline[f]	90%	N/A	3.2 / 2.1
Tularemia (typhoidal)	2-5 days	7.5%	streptomycin or gentamicin	95%	N/A	16 / 5
Plague (pneumonic)	2-4 days	57%	streptomycin or gentamicin[g]	90%	2:1[h]	3.4 / 0.7

Notes:

a. The model inputs are epidemic curves—the percentage of cases presenting with symptoms each day. For example, the anthrax epidemic curve that we used is 5 percent on day 1, 20 percent on day 2, 35 percent on day 3, 20 percent on day 4, 10 percent on day 5, 5 percent on day 6, and 1 percent each on days 7 through 11.

b. These fatality rates assume that victims would be very sick and, thus, would seek medical attention. However, they would not necessarily be receiving the optimal treatment. Actual untreated fatality rates are much higher, approaching 100 percent for anthrax and plague.

c. In our plague scenario, we halted secondary transmission once intervention was begun. The model also allows this assumption to be varied.

d. Illness duration for each case that died was drawn randomly from a distribution with these parameters. Whenever possible, we used empirical distributions constructed from the actual data. When the data were not sufficient, we developed distributions based on the data.

e. For anthrax, the model input is a fatality rate curve that varies by the day of symptom onset.

f. Must be started before symptomatic.

g. Must be started within one day.

Figure 14. Output of casualty simulation model based on anthrax exposure of 1,000 people [45]

Day	It 1	It 2	It 3	It 4	It 5	It 6	It 7	It 8	It 9	It 10	Avg	Std.	Cum deaths	New cases	Cum sick
1	0	0	0	0	0	0	0	0	0	0	0	0.00	0	50	50
2	8	8	8	8	8	8	8	5	5	5	7	1.45	7	200	243
3	44	38	38	38	38	38	38	31	31	31	37	4.22	44	350	556
4	86	93	93	93	93	93	93	108	108	108	97	8.02	140	200	660
5	125	138	138	138	138	138	138	132	132	132	135	4.48	275	100	625
6	106	95	95	95	95	95	95	111	111	111	101	7.75	376	50	574
7	79	64	64	64	64	64	64	63	63	63	65	4.87	441	10	519
8	34	36	36	36	36	36	36	45	45	45	39	4.53	480	10	490
9	35	31	31	31	31	31	31	23	23	23	29	4.32	509	10	471
10	15	24	24	24	24	24	24	20	20	20	22	3.07	531	10	459
11	16	15	15	15	15	15	15	14	14	14	15	0.63	546	10	454
12	11	9	9	9	9	9	9	9	9	9	9	0.63	555	0	445
13	4	12	12	12	12	12	12	4	4	4	9	4.13	564	0	436
14	1	2	2	2	2	2	2	1	1	1	2	0.52	565	0	435
15	1	0	0	0	0	0	0	0	0	0	0	0.32	565	0	435
16	0	0	0	0	0	0	0	0	0	0	0	0.00	565	0	435
17	1	1	1	1	1	1	1	0	0	0	1	0.48	566	0	434
18	0	0	0	0	0	0	0	0	0	0	0	0.00	566	0	434
19	0	0	0	0	0	0	0	0	0	0	0	0.00	566	0	434
20	0	0	0	0	0	0	0	0	0	0	0	0.00	566	0	434
21	0	0	0	0	0	0	0	0	0	0	0	0.00	566	0	434

Scenario	Anthrax
Day of intervention	5
Initially infected	1,000

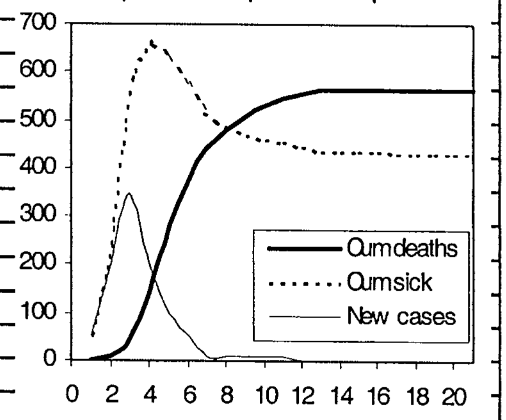


Table 19. Additional bed needs by day in Culebra scenario if infantry battalion exposed to anthrax on D+2

	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9
Additional beds		50	200	350	200	100	50
Additional ICU beds			37	96	135	101	65
Percentage of additional ICU requirement			18%	33%	42%	43%	30%
Total percentage ICU shortfall			15%	86%	116%	59%	34%

Conclusions from adding a biological attack to the Project Culebra scenario

The addition of biological casualties makes the potential need for beds considerably higher because biological attack can affect very large numbers of people simultaneously. In the example we showed here, an attack on one infantry battalion could increase ICU bed requirements by 18 to 43 percent, and the ICU shortfall was already large. The size of the shortfall of ICU beds peaks 4 days after the anthrax attack (Day 7), with a total shortfall of 244 beds. The biological scenario does not affect our choice among platforms, but it does illustrate how providing either more ICU beds or the ability to convert to ICU beds could provide deployable medical platforms with a greater ability to meet requirements:

1. Future afloat medical platforms might need to have a larger number of ICU beds for a given amount of medical capacity.
2. It is important to have decontamination capabilities aboard deployable medical platforms.
3. It is important to have the ability to isolate contagious patients aboard deployable medical platforms.
4. It would be desirable to have more than one avenue of entrance and exit from a deployable medical platform. For example, if smallpox patients were to board the ship by sea only, it would allow the simultaneous boarding of patients from the helo deck without worrying about cross-contamination.

5. Other capabilities, such as the HSV-32 wave-cutting catamaran, fleet hospital, and EMF, are not able to supply enough ICU beds to address the ICU bed shortfalls.

In other words, the addition of a biological scenario adds only to the ICU bed shortfalls that might occur in an OMFTS scenario.

Homeland defense

Consider a bombing in New York that produces 1,000 trauma casualties. Also condsider that lack of hospital capacity, coupled with difficult traffic situations in New York, makes it imperative that additional trauma capability be brought to New York immediately (see figure 15). Here, we do not have a casualty stream, because all casualties are created simultaneously.

Conclusions from homeland defense scenario

The casualty treatment capabilities of the current Mercy-class hospital ships would make it an important medical asset in this homeland defense scenario. Assuming that whatever afloat, medical capability is home ported in Baltimore, what can we conclude from this scenario?

It is about 425 n.mi. from Baltimore to New York (sailing south to the mouth of the Chesapeake, then continuing north along the coast). The current Mercy-class hospital ships, which average 17 knots/hour, take a minimum of 25 hours to make this trip. If there were an LPD-17 or converted LSD, which average 22 knots/hour, the trip would be reduced to about 19 hours, or 3/4 of the time.

1. The LPD-17 or converted LSD would appreciably improve the speed of afloat medical capability to get to the scene from Baltimore.

2. The fleet hospital is a non-starter for homeland defense that required fast reaction because of its 10-day setup time.

3. The EMF is also too slow to be a major player in quick-reaction homeland defense because it requires 48 hours to setup.

Thus, in homeland defense, a converted amphibious ship would enhance sea-based medical care because it is much faster than the current hospital ship.

Figure 15. Route hospital ship would take from Baltimore to New York [46]

Sustained land operations

In sustained land operations, such as Operation Desert Storm, distances among assets will be important for determining the degree to which particular medical platforms are used. Figure 16 shows a map of southwest Asia. In Desert Storm, Fleet Hospital 5 (FH-5) was placed at Al Jubayl, Saudi Arabia, close to significant troop concentrations. In an operation like Desert Storm, there could be a casualty stream and patient movement operations much like that summarized by table 20.

Figure 16. Desert Storm area of operations [47]

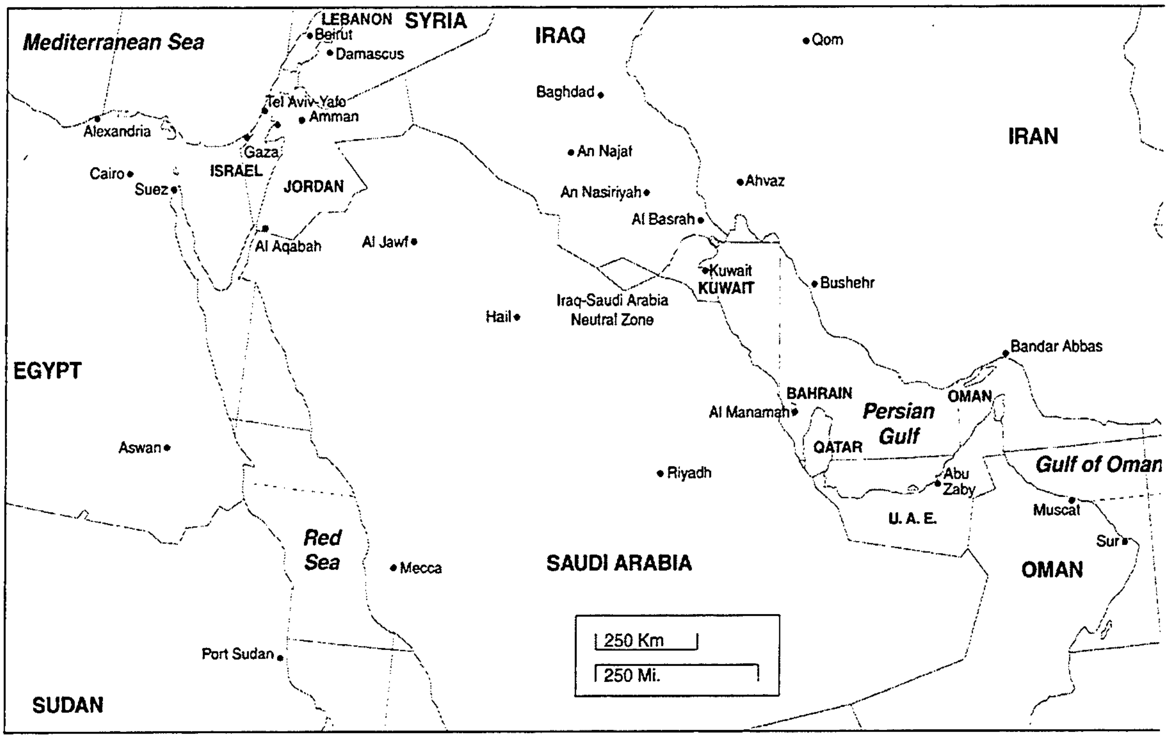


Table 20. Medical statistics for Navy echelon III facilities in Operation Desert Storm [2]

	USNS *Comfort*	USNS *Mercy*	FH-5	FH-6	FH-15	Total
Inpatients	718	650	4,347	201	697	6,613
Outpatient visits	8,000	6,050	28,942	2,340	8,101	53,433
Surgeries	357	290	584	23	239	1,493
Helicopter overheads/landings	2,100	1,300	873	20	83	4,376
Patient evacuations (out)	553	a	1,501	122	417	2,593[b]

Source: Medstat reports and unit statistics

a. Patient evacuations not available for USNS *Mercy*

b. Patient evacuation total does not include USNS *Mercy*

Conclusions for sustained land operations

The Operation Desert Storm scenario numbers lead to the following observations about our generic platforms:

1. FH-5 was a very useful asset. It supplied over twice as many outpatient visits as did the two hospital ships combined, and cared for three times the number of inpatients. This was because the fleet hospital was deployed in strategic position close to where the ground troops were stationed.

2. Because it was strategically located on land, FH- 5 required only 25 percent as many helicopter overheads/landings as did the two hospital ships. This occurred despite the fact that FH-5 took care of so many more patients than did the hospital ships.

3. At the time of actual ground combat, the fleet hospital was not mobile enough to keep up with the quickly moving situation, as was other logistical support.

4. The hospital ship was the first to the scene of Desert Storm, but then did not provide a large amount of the in-theater medical support partly because of how far away it had to stay to be out of harm's way.

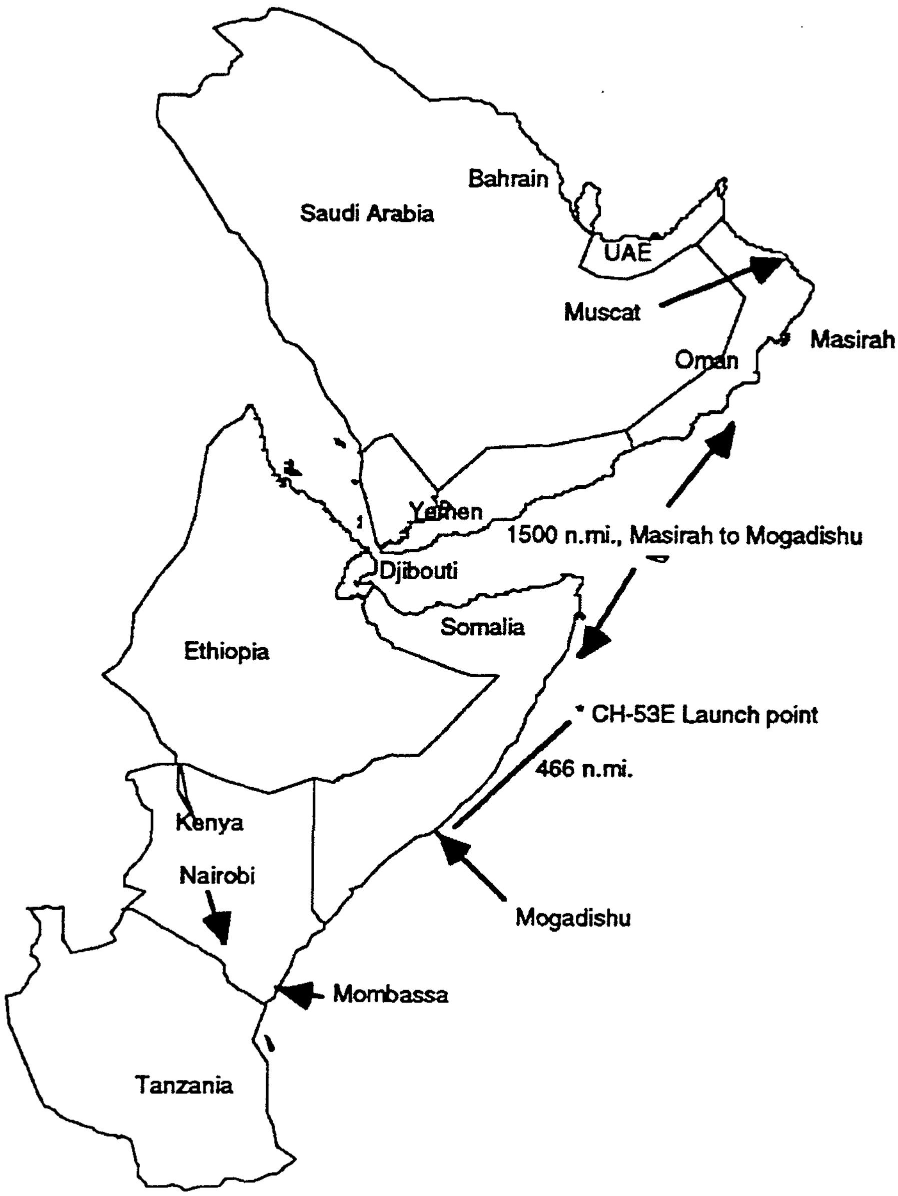
5. In this case, the HSV might be more useful than were the Mercy-class ships, because it does not have the "large slow target" characteristics that made the hospital ships have to stay such a distance away. Of course, this is only useful in case the number of casualties was small, as they were in Operation Desert Storm.

Noncombatant evacuation operation (NEO) [48]

In a fascinating description of the Mogadishu operation (also known as Operation Eastern Exit), Siegel describes the evacuation of the embassies in Mogadishu just as the Marines needed to return to Operation Desert Storm as quickly as possible [48]. The general chronology of events for Operation Eastern Exit was as follows (see figure 17):

- On 5 December 1990, Ambassador Bishop recommends departure of non-essential U.S. personnel from Mogadishu.

Figure 17. Distances and routes taken in Operation Eastern Exit, Mogadishu, 1991 [48]



- On 19 December, the official U.S. personnel have been reduced from 147 to 37.

- On 30 December, full-scale fighting between official Somali and rebel forces commences in Mogadishu.

- On 2 January 1991, Ambassador Bishop requests military assistance for evacuation; *Guam* (an LPH) and *Trenton* (an LPD) get under way at 2330 from the North Arabian Sea.

- On 4 January, gun battle between U.S. Embassy personnel and looters; Italian and Soviet attempts to evacuate via aircraft fail.

- On 5 January, CH-53Es launched from *Guam*, 466 nautical miles from Mogadishu, inserted a 60-man evacuation force, and returned to *Guam* with 61 evacuees aboard.

- On 6 January, four waves of CH-46s evacuate the remaining 220 evacuees and the 60-man evacuation force in the early a.m.; mission declared complete.

- On 10 January, baby born aboard *Guam*.

- On 11 January, evacuees offloaded in Muscat, Oman.

In summary, the example of Operation Desert Storm shows that fleet hospitals can still be very important assets in sustained ground operations because they can be put in a place that is very close to the ground troops. In a situation where sea operations are particularly risky, as they were in Operation Desert Storm, a ground capability such as the fleet hospital is required.

Table 21 shows the population of evacuees that could have produced a casualty stream. Although there were no serious casualties in the Mogadishu operation, there was great danger in this operation. The main portion of the operation, on January 5, involved two in-flight refuelings by the CH-53Es en route to the embassy, and there were pressure seal leaks that could have foreshadowed greater problems. The number of personnel involved in the operation, plus the danger inherent in such operations, made it imperative that medical and surgical capability be available.

Table 21. Eastern Exit evacuees

Country	Men	Women	Children	Total
Belgium	1	0	0	1
Canada	0	1	0	1
Colombia	1	0	0	1
Denmark	5	1	0	6
Ethiopia	1	0	0	1
France	2	0	0	2
Germany	11	7	8	26
Ghana	1	0	0	1
India	4	2	0	6
Italy	15	0	0	15
Kenya	10	3	4	17
Kuwait	1	3	3	7
Liberia	1	0	0	1
Netherlands	1	0	0	1
Nigeria	5	0	0	5
Norway	1	0	0	1
Oman	2	0	0	2
Pakistan	0	1	0	1
Philippines	2	0	0	2
Portugal	2	0	0	2
Qatar	1	0	0	1
Somalia	8	14	3	25
Sri Lanka	0	1	0	1
Sudan	17	6	3	26
Sweden	1	0	0	1
Tanzania	0	1	0	1
Thailand	1	0	0	1
Turkey	5	0	0	5
United Arab Emirates	2	0	0	2
United Kingdom	10	3	4	17
United States	31	19	11	61
USSR	22	16	1	39
Total	162	82	37	281

Note: Some columns do not add to the total because some evacuees were not placed with a particular country.

Conclusion regarding medical platforms for NEOs

By most criteria, Eastern Exit was an extremely successful example of a NEO. However, we are using it as an example of what a NEO is like. If there had been serious casualties among the 281 evacuees from the embassy, there would have been no real capability to perform casualty care en route while the CH-53Es and CH-46s carried the casualties back to *Guam* and *Trenton* (approximately 3 hours). One way to have provided such en route care, if it had been needed, would have been with the HSV.

If there had been an HSV on the scene, or with the ARG that traveled toward Mogadishu, the HSV could have transported patients to the amphibs while giving care to those patients. Of course, the HSV would have required 10 hours for the more than 300-mile transit from Mogadishu to the ARG. So why not use the helicopters instead, which could perform the mission in about 3 hours? The helicopters couldn't perform the mission in 3 hours: the CH-46's limited carrying capacity required **four** waves of helicopters to carry evacuees. If there had been an HSV, the entire evacuation could have been performed in one trip. And, as we mentioned before, any casualties could have received medical care while en route to the ARG.

Chapter conclusions and summary

This chapter has given some preliminary scenario-based requirements for medical deployable platforms. Table 22 summarizes our major observations about the different generic platforms as a result of our analyses:

1. **OMFTS**: the current Mercy-class primary asset is its mobility and its large number of beds. If the constraint of a large number of ICU beds is relaxed, the LPD-17 variant and converted LSD are preferable because of their speed.

2. **Biological warfare**: Not one of the seven options we have reviewed is ideal for biological warfare, but the LPD-17 and the converted LSD are the best options because they can accept patients from a wide range of helicopters and from the sea.

Table 22. Major observations regarding scenario-based requirements

Scenario	Conflict scenario	USNS Mercy-class hospital ship	LPD-17 hospital ship variant	Conversion/ Whidbey Island-class LSD	HSV-32 wave-cutting catamaran, en route care	Fleet hospital (FH)	Expeditionary Medical Facility (EMF)	HSV-32 wave-cutting catamaran EMF carrier
OMFTS	Culebra [42]	Very valuable for its beds, but limited by its lack of ability to keep up with the fleet	Valuable for its greater speeds, but not as many beds at Mercy class	Valuable for its greater speeds, but not as many beds as Mercy class	Insufficient beds. Lack of ability to accept casualties from any except small helicopters	Not tactically possible	Not tactically possible	Not tactically possible
Biological warfare	Culebra + biological model [45]	Very valuable for its beds, but it needs more isolation capability	Valuable, but it needs more beds and isolation capability	Valuable, but it needs more beds and isolation capability	Insufficient beds	Not tactically possible if an OMFTS biological scenario	Not tactically possible insufficient beds	Not tactically possible, insufficient beds
Homeland defense	New York bombing	Very valuable for its beds. Also as a platform for mass prophylaxis for biological	Very valuable, and faster response than USNS Mercy class	Very valuable, and faster response than USNS Mercy class	Valuable if need to move small numbers of patients quickly	Not tactically possible	Tactically feasible, but it needs to be moved by air to be realistically within time constraints	Tactically feasible, in cases where homeport close-to-homeland defense need
Sustained land operations	Operation Desert Storm [2]	First on the scene, but tactical liability because of radar signature	Potentially valuable	Potentially valuable	Potentially valuable	Very valuable	Very valuable	Potentially valuable
NEO	Mogadishu, 1991 [48]	Too large, slow	Too large	Too large	Requires ability to accept helos	Not tactically possible	Not tactically possible	Not tactically possible

3. **Homeland defense** missions favor the LPD-17 and converted LSD for large missions, and the wave-cutting catamaran for small missions (provided the HSV-32's patient transfer problems can be resolved).

4. **Sustained land operations** favor the fleet hospital (FH) when it is placed near troops that stay stationary. The EMF is more mobile than the FH but at a cost of significant medical capacity.

5. **NEOs** favor the LPD-17 and converted LSD because of their speed; the HSV-32 would be a useful option for NEOs if the patient transfer problems could be addressed.

In closing, table 23 provides a rating system for the generic alternatives. It shows that in OMFTS, the Mercy class, LPD-17, and LSD are the most useful deployable platforms. In biological warfare, the LPD–17 and LSD are the best options because they can bring patients aboard in multiple ways. For homeland defense, the HSV becomes an important option because of its speed and en route care. For sustained land operations, the fleet hospital and EMF are the most useful platforms. Finally, the HSV's strengths really come to the fore in noncombatant evacuation operations.

Table 23. Summary of generic alternatives versus five classes of scenarios

Scenario	Example used	Mercy-class hospital ship	LPD-17 hospital ship variant	Conversion/ Whidbey Island-class LSD	HSV-32 wave-cutting catamaran, en route care	FH	Expeditionary Medical Facility (EMF)	HSV-32 wave-cutting catamaran EMF carrier
OMFTS	Culebra [42]	+++	+++	+++	++	-	-	-
Biological	Culebra + bio. model [45]	++	+++	+++	++	-	-	-
Homeland defense	New York bombing	++	+++	+++	++	-	++	+
Sustained land ops	Oper. Desert Storm [2]	++	++	++	+	+++	+++	+
NEO	Mogadishu, 1991 [48]	-	++	++	+++	-	-	-

Legend:

+++ The option is extremely useful for that class of scenarios.

++ The option is very useful for that class of scenarios.

\+ The option is useful for that class of scenarios.

\- The option is not useful for that class of scenarios.

Chapter 5: The requirements and funding process

Introduction

The purpose of this chapter is to briefly describe the process for commissioning a new Navy hospital platform at some future date. For example, the Navy may decide to replace the current hospital ship with a more modern and smaller version, perhaps in 2015. Generally speaking, this will require that the total procurement cost of the Navy hospital ship appear as a line item in the final defense budget approved by the President of the United States and Congress for a fiscal year 5 or 6 years before the anticipated ship commissioning date. For a new hospital ship to be commissioned in fiscal year FY 2015, the total procurement cost of this ship needs to be a line item in the final FY 2009 Defense Budget approved by the President and Congress.

Of course, all final budget decisions are made jointly by Congress and the President. This chapter does not discuss how these final decisions are made. Instead, we describe the steps necessary to get a new Navy hospital ship, or some other medical platform, included in the President's defense budget for some fiscal year in the future.

The first step in commissioning a new Navy hospital ship is to develop a series of requirements documents to facilitate having the hospital ship included in the Navy's Program Objectives Memorandum (POM). The POM is sent annually by the Chief of Naval Operations (CNO) to the Office of the Secretary of Defense (OSD) and includes a 5-year forward-looking plan for the U.S. Navy. The second step is to have the new Navy hospital ship included in the Future Years Defense Program (FDYP) sent annually by OSD to the President. The FDYP is also a 5-year forward-looking plan for the Department of Defense. The third step necessary to commission a new Navy hospital ship is to have the ship included as a line item in the President's Budget for the Department Defense in the appropriate fiscal year. The final step is to have Congress approve the President's Budget in the appropriate fiscal year with the hospital ship included.

The Department of the Navy requirements generation process for POM

In the Navy, the requirements generation process operates entirely under the direct supervision and leadership of the CNO and the Assistant Secretary of the Navy for Research, Development and Acquisition (ASN RD&A). The Secretary of the Navy designates a sponsor in the Office of the Chief of Naval Operations (OPNAV) to (1) "act as the user representative" and (2) "prepare the necessary requirements documentation."[28] The CNO, Warfare Requirements and Programs (N7) coordinates the requirements generation process for achieving Mission Needs Statement (MNS) and Operational Requirements Document (ORD) validation and approval. OPNAV program sponsors (within the N7 organization) actually draft the MNSs and distribute them for comment and coordination. Once the N7 sponsor and the Assessments Division (N81) agree on an MNS or ORD, they take it to the three-star level (N7 an N8) for signature. After this approval, the NROC (chaired by the VCNO) must approve the MNS or ORD. Those MNSs and ORDs that pass the NROC are then forwarded by the VCNO (with N81 support) to the Joint Requirements Oversight Council (JROC) for JCS approval.

To get the new hospital ship included in the Navy's POM, several documents are required. The purpose of these documents is to argue the case for both the need and cost-effectiveness of a new hospital ship. Material from chapters 1 through 5 of this CNA report will be useful in preparing these documents. A brief description of these documents follows.

28. SECNAVIST 5000.2B, p2, paragraph 2.3.3.1.

Mission Area Analysis (MAA)

A Mission Area Analysis is required by the Department of Defense before developing an MNS and an ORD. The MNS describes required operational capabilities and constraints to be studied in the first acquisition phase for a new hospital ship. An MAA is the first in a long series of analyses and documentation needed to establish the requirement for a new system and move it into the acquisition process. The main purpose of an MAA is to define the mission requirements satisfied by the current class of hospital ships and then to define any future requirements that the hospital ship replacements will have to satisfy. A secondary purpose is to identify and bound the hospital ship replacement alternatives that would be considered in an Analysis of Alternatives (AOA).

The MAA not only establishes the requirements, it also postulates alternative ways of satisfying these requirements. One way of conducting the MAA is to set up working groups composed of the various "stakeholders." These stakeholders then come up with a set of future requirements and postulate alternative ways to fulfill these requirements. In this case of the replacement hospital ships, these working groups might comprise the Surgeon General of the Navy (N093), NAVSEA, the Marine Corps Combat Development Command (MCCDC), and various local and national civil authorities, such the Centers for Disease Control (CDC).

Mission Needs Statement (MNS)

As stated above, the Mission Need Statement (MNS) takes the MAA and formally describes the required operational requirement for a new system. If the MAA is an elaborate document, then the MNS is simple extensions of the analysis performed by the MAA. In some cases, the MAA is merely a brief description of the issues involved. In these cases, the MNS has to make formal arguments with regard to the need for a new hospital ship.

Analysis of Alternatives (AOA)

The analysis required after the MNS and ORD is the Analysis of Alternatives (AOA), formerly referred to as the Cost and Operational Effectiveness Analysis (COEA). The purpose of the AOA is to help resolve the Milestone Decision Authority (MDA) and to provide analytical insight and a basis for establishing operational characteristics. In the AOA, the detailed cost and effectiveness of alternatives are determined and compared.

The effectiveness issue is determined by simply looking at the MNS and making computations to determine whether the various alternatives meet these requirements. For example, the MNS may state that the alternative must have a certain number of beds, be able to deploy in a certain amount of time and reach a certain speed. The alternatives can then be compared on the basis of total ownership costs (TOC) to see if they can achieve these mission needs.

Keeping in mind that some of these alternatives may not be hospital "ships" per se, to make cost comparisons, the average annual TOC of each alternative is computed from:

TOC = SPC + total ship O&S cost + total medical O&S,

where SPC denotes the total ship procurement cost, including the disposal cost. Here "total ship O&S" is the average annual operating and support cost of the non-medical portion of the alternative times the service life of the ship, and "total medical O&S" is the average annual medical operating and support cost of the alternative times the service life of the ship.

Operational Requirements Document (ORD)

Assuming the AOA validates the MNS, an ORD is developed to provide detailed performance requirements of the proposed platform, such as speed and range. The ORD is used by the Naval Sea System Command (NAVSEA) to develop design specifications.

The DoD resource allocation system

The Department of Defense manages resource allocation through a process called the Planning, Programming and Budgeting System (PPBS). All DoD components (each of the three military services along with defense agencies) has the same submission requirement with regard to the PPBS process: Each year they must produce a program, called a POM, a budget estimate, called a Budget Estimate Submission (BES), and finally a President's Budget for the upcoming fiscal year. All these need to be written in the formats dictated by DoD and the Congress. The Director of Program Analysis and Evaluation (PA&E) serves as the focal point within the DoD for the POM deliberations. After the BESs are reviewed by the Comptroller in the Office of Secretary of Defense (OSD), a final President's Budget is determined and sent to Congress.

The process of determining the President's Budget is as follows: Each summer the Director for PA&E in the OSD reviews components' POMs and prepares the Program Decision Memorandum (PDM) that, upon approval by the Deputy Secretary of Defense, is used to update the Future-Years Defense Program. The military services and Defense agencies then use the PDM to update their force and financial plans and create their BESs. They submit the BESs to the Office of the DoD Comptroller where they are reviewed in the fall. The Comptroller generates the Program Budget Decisions (PBD) documents that will ultimately determine the President's Budget based on BESs for the coming fiscal year and a "plan" (POM) for 5 additional years. For FY 2003, the POM and President's Budget for FY 2003 are being submitted at the same time in the fall of 2002. It is not known at this time whether this concurrent process will continue in the future. Historically, the POM is sent to OSD in April and the President's Budget follows in the fall.

Time line of steps needed to commission a new Navy hospital platform

Suppose the Navy wants to have a single hospital ship[29] on line in FY 2015. Rather than a conversion, as was the case with *Mercy* and *Comfort,* assume that the Navy decides to build a new 1,000-bed state-of-the-art hospital ship. To be on the safe side, let's say it takes 6 years to design, procure, and build this single large-displacement ship. To have the hospital ship on line in 2015, it will have to be a fully funded line item in the final FY 2009 Defense Budget submitted to the Congress by the President. To accomplish this, Navy Medicine (N9) needs to adhere to the following time line:

1. In FY 2002 and 2003, prepare the necessary documents (MNS, AOA, ORD, etc.) to justify to the CNO that a new hospital ship will be required in 2015.

2. In FY 2004, get the hospital ship placed on the Navy's 5-year POM that is submitted to the PA&E within OSD.

3. In FY 2004, assign someone to work closely with N81 to get the hospital ship approved by OSD. If successful, this will mean the hospital ship is in the Future (Five) Year Defense Program (FDYP) sent to the President in 2004.

4. Each following fiscal year from 2005 to 2008, the FDYP will be reviewed by PA&E. N9 needs to justify its case for a hospital in each of these fiscal years, perhaps with updates to the NMS, AOA, and ORD to reflect changes in the threat or mission. In the first few fiscal years, it may not be hard to keep the hospital ship in the FDYP, but the justification will come under very close scrutiny in 2008.

29. If the MNS and AOA indicate a requirement other than a single new ship, such as building six smaller hospital ships or converting a retired Navy ship into a single hospital ship, the proposed time line would be different than the one discussed here.

5. The summer of calendar year 2007, the FDYP for the FY 2009 budget will be finalized. This is a crucial period for keeping the hospital ship in the FDYP.
6. The final date is the most important. The hospital ship needs to be a line item in the Navy's budget for the FY 2009 Defense Budget sent to the President by the OSD Comptroller in the **fall of calendar year 2007.**

Chapter 6: Summary, conclusions, and recommendations

The purpose of this study was to help the Navy and Marine Corps to develop options for deployable medical platforms that could effectively perform in future contingency and humanitarian operations. To do this, we studied historical Navy and Marine Corps operations, and generated ideas for improving the performance of medical missions. We also looked at Navy and Marine Corps concepts for future conflicts to generate ideas for modernizing current medical capabilities. We suggested alternatives for both sea-based and land-based platforms.

For *sea-based alternatives* that could replace the T-AH, we proposed an LSD hospital ship conversion and an LPD-17 hospital ship variant. The current Mercy-class hospital ship is a stable platform with enormous medical capacity. However, there are design issues in the T-AH that reduce its effectiveness and efficiency in its medical mission. Our alternatives were chosen to fill these gaps. For example, the current Mercy-class hospital ships lack speed and maneuverability. Both the LSDs and the LPD-17 are faster and more maneuverable than the Mercy. The current hospital ship has one helicopter pad, and no ability to move patients from the sea. The LSD and the LPD-17 have two helicopter pads, and the ability to take and hold two LCAC watercraft, greatly improving patient movement. The LSD and the LPD-17 both would be useful in all five of our generic scenarios: OMFTS, biological warfare, homeland defense, sustained land operations, and NEO. The current T-AHs are useful for the first four, but would be too large and slow to be effective in the NEO scenario.

How would we compare the LPD-17 hospital ship variant and the LSD conversion? The LPD-17 would be a brand new ship; it could have as many as 45 productive years as a hospital ship. Conversely, the LSDs could be as much as 30 years old when they are converted, meaning they would only have 15 or so good years as a medical platform. The LSDs are already owned by the Navy, would be relatively simple to convert to medical use, and thus would require only a modest investment. Conversely, the LPD-17 could cost $800 million or more to build. To correctly compare costs, however, one should calculate and contrast the investment over the lifetime of the LPD-17 hospital variant with that of the LSD conversion. The LSDs, because they would be already 30 years old, could be expected to last perhaps 15 years. If we assume that they could be converted for about half the expense of the current T-AHs, the total investment for the LSD would be $150 million to $160 million.[30] Consequently, spreading the investment over the life of the ship, the LSD would cost between $10 million and $11 million per year per ship. The LPD-17 is estimated to cost over $800 million to build, and could last 45 years. The investment cost would be between $18 million and $19 million per year per ship, or about 80 percent greater than that of the LSD. However, the LPD-17 would be expected to have about 60 percent more medical capacity than that of the LSD (see appendix C).

Thus, the difference in lifetime investment between the LPD-17 and the LSD is not great. To decide between the two, we should ask which would have the greater overall value in terms of mission effectiveness and other important criteria. The LPD-17 would be a new unit, meaning that downtime and repair costs would be less. Also, the LPD-17 would have the most modern communications equipment, the most up-to-date enhancements for reducing radar signature, and the most modern engine. The major drawback of the LPD-17 is its upfront cost, and the fact that it is late in the procurement process to increase production of the LPD-17.

The LSD option would involve converting a ship that was originally built for another purpose. Conversions can take longer and be more expensive than originally anticipated. Converting a ship can uncover

30. The current hospital ships each cost a total of approximately $230 million for acquisition and conversion. The cost of acquiring the tankers was $30 million, so conversion was aboout $200 million. Half of that is $100 million; adjusting for roughly 3 percent annual inflation since 1986 is about $156 million.

small but significant design features that hinder the full usefulness of the ship for the new intended purpose. Despite their disadvantages, both the LPD-17 hospital variant and the LSD conversion could be desirable choices for Navy Medicine. They both would be able to sail with an ARG, would have both sea-based and helicopter-borne methods of receiving patients, and would have relatively modern communications and command and control systems.

The HSV medical catamaran is a sea-based option that would be useful for augmenting our current medical assets, filling some gaps in their ability to effectively and efficiently complete their missions. For example, Navy Medicine depends heavily on the use of air assets for moving casualties. These assets typically have dual missions, moving troops as well as moving casualties, and can often be unavailable for moving casualties. The helicopters can really travel only 400 to 700 miles, and may not be able to transport casualties to the next level of care. Finally, the helicopters cannot provide en route medical care. The HSV can hold up to 100 casualties, up to ten times that of the larger helicopters. They can travel about 1,500 miles on a tank of fuel, without modification from its present commercial use. The HSVs can be built to provide a high level of resuscitative medical care en route to a definitive care facility. Finally, the HSVs can be made as dedicated casualty transport vessels, taking the stress from the helicopter forces.

Certain issues need to be addressed before the HSV can be considered a serious contender. In its present configuration, an HSV cannot accommodate a V-22 helicopter, nor can it accept patients from a large-deck amphib or from a current Mercy-class hospital ship. The original HSV was not intended for extended open-sea voyages as a Navy vessel. It is only one-compartment watertight, and additions of armor would likely slow down the vessel, mitigating an important attribute.

The HSV would be an effective supplement to a hospital ship, rather than a replacement. We make this judgment because the HSV does not have the geographical range or the potential medical capacity of the LPD-17 hospital modification, an LSD conversion, or even of historical Navy hospital ships. We would see HSV as potentially valuable in situations where air transport of casualties over long distance is not feasible or desirable, and where en route care in necessary to save lives. We expect that the HSV's primary usefulness would be in short-term operations, such as NEOs.

Another sea-based alternative that should be considered is the Maritime Prepositioning Forces (MPF) Future, or MPF(F). This concept anticipates a scenario in which there is no secure land base available for landing Marines. It envisions Marine Air Ground Task Force (MAGTF) and naval support equipment (NSE) personnel and materials meeting and assembling at sea. Each Maritime Prepositioning Ship (MPS) would have on board at least 2 medical and 2 dental operating rooms, 24 ICU and acute care ward beds, and 90 overflow beds. It would accommodate around 40 casualties per day, providing echelon II (resuscitative) care. The total medical capability of the MPF would depend on its size. The largest MPF configuration would have six to eight MPSs and could handle 240 to 320 casualties per day.

We would see the MPF(F) to be potentially valuable in two classes of situations. The first would be to provide echelon II care to supplement the capabilities of the L-class ships. A second would be to serve as an intermediate patient transfer point between the battlefield and further out to the T-AHs or nearby LHDs. As we understand the plans, the MPF Future ships would not be capable of providing echelon III care, which the current T-AHs provide. As such, MPF(F) would provide a qualitatively different type of capability than would the other sea-based options we have described.

We now turn our attention to *land-based platforms*. The basic land-based medical platform is the fleet hospital (FH). It is a large platform, with ample medical capacity for sustained land-based conflicts. However, its size also makes it unsuitable for some wartime scenarios. For example, the FH—with its 414 ISO containers—is costly to transport, requiring the use of a full-sized cargo vessel. It is also costly to assemble, requiring 28 to 35 acres of secured land area and 10 days of assembly time with a large contingent of manpower. Once it is in place, it cannot be easily moved.

To address some of these issues, Navy Medicine has developed the Expeditionary Medical Facility (EMF). It is a subset of the FH, made up of 63 of the FH's containers, which are tagged as EMF during the FH's 5-year overhaul. The benefits of the EMF are that it requires only

2 to 3 acres of secured land space and less than 2 days to assemble. Thus, it can be used in a wider range of locations, and it is significantly more portable for relatively small conflicts where the battlefield frequently moves. Another potential use of the EMF is in homeland defense scenarios if we expect there to be as many as 50 to 75 casualties per day.

Because the EMF is relatively small, a vessel that is smaller than a cargo ship could be used to transport it. One such vessel could be the HSV in its cargo configuration. As we showed in figure 11, the cargo hold of a 96-meter or larger HSV could have enough area volume, however, it is not known whether it would have enough deadweight carrying capacity to transport an EMF. If it has the physical capacity, the HSV is fast, maneuverable, and can be docked in the vast majority of harbors. Thus, it could facilitate a quick, relatively inexpensive[31] deployment of the EMF, increasing its portability.

Both the FH and the EMF are delivered into theatre by Maritime Prepositioning Forces. In MPF, equipment and supplies are prepositioned aboard forward-based MPSs. The MPSs are floating warehouses that carry a 30-day supply of provisions for 2,000 to 20,000 Marines. In the event of a conflict, one or more MPSs fly the personnel of a MAGTF and their attending NSE, including the Fleet Hospitals into the arrival and assembly area of host-nation.

Currently, an MPF requires the existence of a large, secure land area. MPF Future anticipates a scenario where there is no secure area to land marines and their equipment. MPF Future envisions the MAGTF and NSE personnel and materials meeting and assembling at sea in MPS ships that can carry and house both men and materials.

Each of the MPF Future ships would devote about 6,500 square feet of space to providing medical care. It would have 3 or 4 operating

31. It has been estimated that to send the FH or the EMF in a full-sized cargo ship costs about $25,000 per day. The HSV uses a lot of fuel to run at 35 knots and may cost about the same per day. However, because its cruising speed is more than twice that of the cargo ship, it requires less than half as many days, and thus half the cost.

rooms and more than 100 ward beds. Each ship would be able to land up to six MV-22 tilt-rotor helicopters, and be capable of loading LCACs in up to sea state three. Thus, each ship would be able to move and accommodate around 40 casualties per day. The largest MPF Future configurations would have six to eight of these ships and could handle about 240 to 320 casualties per day. However, MPF Future envisions that the ships would have the capability of providing only resuscitative (echelon II level) medical care. Because MPF (F) would not have the fleet hospital, definitive care (echelon III level) would be provided by hospital ships or nearest OCONUS or CONUS hospitals.

Some additional resources that can augment Navy and Marine Corps medicine include the Advanced Suite for Trauma Casualties (ASSTC), the TransHospital, and the Marine Emergency Rescue Center (MERC). All of these medical facilities are designed to provide emergency surgical capability in small, quick, and easy-to-deliver packages. ASSTC is a collapsible, highly mobile, self-contained operating room in a tent. In our view, the ASSTC might allow medical care to proceed in situations where the need is small (only a few badly hurt people) but time-critical, or to facilitate medical care in the time interval before delivery of more extensive medical facilities, such as the FH, the EMF, or the hospital ships.

The MERC and the TransHospital are reported to be fully portable, modular, and containerized emergency hospitals. The TransHospital and the MERC are similar to the EMF, in the sense that they are designed to be portable, stored in ISO-sized containers, and easily assembled. However, the TransHospital contains built-in operating rooms and isolation/decontamination rooms. The MERC consists of 26 specialized medical units (as compared to 63 in the EMF). Like the TransHospital, the MERC has built-in operating and isolation/decontamination rooms. However, the MERC is designed specifically to interface with a ship in a way that converts the ship into a hospital ship.

In conclusion, we wrote this research memorandum to provide important background on the process of getting Navy Medicine the new medical platforms it needs to fulfill its missions. If there are to be new platforms deployed in the 2010-2020 time frame, Navy Medicine should soon begin pursuing sea-based and land-based alternatives, beginning with the writing of a Mission Needs Statement.

Appendix A: History of hospital ships—a brief summary

When war broke for America in 1941, the U.S. Navy had insufficient medical capacity. It was fortunate that USS *Solace* AH-5, which had just been commissioned earlier that year in anticipation of war, stood ready at Pearl Harbor on December 7. However, the period following Pearl Harbor revealed the difficult and time-consuming effort needed to assemble a strong medical capability afloat for a major war [1]. By war's end, however, the Navy had 15 dedicated hospital ships in the Pacific theater of operations, and the Army had 20 in the European theater of operations. Once the hospital ship program was installed, the WWII hospital ships showed their value throughout the war. They were used for the following purposes:

1. To provide medical supplies and medical consultation services to other ships and to small, in-theater medical staffs
2. To evacuate casualties from advance bases or fleet hospitals to hospitals in the rear
3. To evacuate casualties from combat zone and to perform or complete treatment en route to advanced base, fleet, and rear hospitals
4. To serve as floating stationary hospitals for units of the fleet
5. To serve as floating hospitals directly off landing beaches during amphibious assault.

The U.S. military in WWII saw the lowest mortality rates in the history of warfare: 12 percent of American wounded died in WWI, but by the end of WWII only 2.2 percent died of their wounds. Hospital ships accounted for a large part of this successs.

The Korean conflict provided lessons and advances. First, because the conflict came soon after WWII, there were hospital ships in reserve that were quickly deployed to the conflict, revealing the value of having dedicated hospital ships on reserve. In this conflict, helicopters became useful for transporting casualties, reducing the need for trains, trucks, and landing craft previously used. Because of this change, the amphibious ships changed from secondary casualty movement ships to primary casualty receiving and treatment ships.

Technological and procedural advances continued in the Vietnam conflict. The United States improved on its ability to transport patients and medical supplies by helicopter. We vastly decreased patients' times to treatment, reducing the overall mortality rate and giving seriously wounded patients a higher quality of life after recovery. During this conflict, American hospital ships also treated Vietnamese citizens and their families, paving the way for our hospital ships to become involved in more humanitarian operations.

The historical steps and missteps have taught the U.S. Navy many lessons regarding the hospital ships:

1. Maintaining dedicated hospital ships is preferable to having limited MCA at the onset of conflict.
2. Reactivating dedicated hospital ships is quicker than converting vessels to medical use.
3. Dedicated hospital ships can contribute to a fleet's ability to stay at sea by preserving manpower.
4. Only a dedicated hospital ship can provide comprehensive medical care afloat to a large number of casualties.
5. Only a dedicated hospital ship has immunity from attack (to the extent that anything is immune to attack) via the Hague and Geneva Conventions.
6. It is quite costly for a dedicated hospital ship to regularly deploy with the fleet during peacetime.

In this spirit, BUMED determined that Navy Medicine needed medical care afloat capability of 2,000 beds and to be able to handle up to

200 patients per day. Many options were discussed, including the following. They considered recommissioning of the hospital ships *Repose* and *Sanctuary*. However, they were built during WWII and used through the Korean and Vietnam conflicts. This option was rejected because of their material condition.[32] In 1978, the CNO conducted an analysis of alternatives to dedicated hospital ships (ADHOS), which generated several options for providing the above medical capacity with a converted cruise ship, a converted aircraft carrier, and several types of converted cargo ships. Some results of this study are detailed in appendix B. In the early 1980s, after an intense bidding process, BUMED decided to proceed with the conversion of two San Clemente oil tankers into 1,000-bed hospital ships.They were commissioned as USNS *Mercy* in 1985 and USNS *Comfort* in 1986. They remain the primary means of medical care afloat in the armed services.

32. In fact, on 8 August 1977, an INSURV Board found USS *Sanctuary* materially unfit for service.

Appendix B: The CNO's ADHOS Study, 1978: development of bed and space requirements

In late 1977, the CNO directed a study to determine the value and feasibility of alternatives to dedicated hospital ships. One of the many characteristics that the study considered critical for any medical platform was its potential capacity. Any medical ship alternative discussed was required to have the capacity to contain at least one core medical facility, a unit known as a Definitive Care Facility (DCF). BUMED had identified an optimal DCF, which followed from a prescribed patient admission rate of 50 patients per day, and a 15-day, in-theater evacuation policy. The basic DCF would be composed of 292 patient beds and 80,845 square feet of space for the three principal divisions of (1) medical, (2) medical support, and (3) non-medical support functions. From this basic unit, necessary medical capacity for any wartime configuration can be estimated [18].[33]

Note that base case DCF was the minimum of the ADHOS criteria from which alternatives were evaluated. Given that each alternative satisfied this minimum, their evaluation included, among other factors, an analysis of the following broad categories:

1. Areas of service operation (e.g., in-theater, afloat/ashore)
2. Availability and response time in peacetime and wartime
3. Platform control of administration and operations
4. Intraservice and interservice compatibility
5. Compatibility for emergency/lifesaving and definitive medical care
6. Life-cycle costs.

33. The definition of the base case DCF is in Chapter 5.

The ADHOS study planning factors were developed from battle scenarios and patient flows. From the planning factors, the study group developed bed and space requirements. For example, they generated bed space requirements for :

1. Recovery spaces – about 132 sq feet each
2. Intensive care units – about 115 sq feet each
3. Medical operating rooms – 400 to 500 sq feet each
4. Dental operating rooms – 120 sq feet each
5. Blood bank – approximately 700 sq feet, typically only one aboard
6. Anesthesia equipment and workroom – 200 to 225 square feet
7. Nursing stations – approximately 150 sq feet
8. Casualty reception areas where patients are sorted and delivered to treatment spaces—approximately 20 sq feet for each patient, times the potential number of patients-per-day.

As discussed earlier, a base case DCF is a medical facility that is designed to handle 50 patients per day with a 15-day evacuation policy. The following were the requirements for the numbers of each of the above medical room types required in one base case DCF:

1. Recovery spaces –8
2. Intensive care units – 24
3. Medical Operating rooms – 4
4. Dental Operating rooms – 4
5. Blood Bank – 1
6. Anesthesia Equipment and workroom – 1
7. Nursing stations – 1 at recovery, 1 at ICU, 8 in the acute care ward
8. Casualty reception areas where patients are sorted and delivered to treatment spaces – 50.

The study examined several ship conversion alternatives and compared them to a new construction option. In the study, each hospital ship alternative had a different DCF capacity, measured as a function of medical capacity and medical space. For example, the converted carriers (CVTs) were rated at 2.8 DCF,[34] the SS *United States* at a 1.9 DCF, and the cargo ships all at less that 1.5 DCF. The study group thought that the correct measure of comparison of cost effectiveness among alternatives was on a cost-per-DCF basis. By this measure, the CVT choice was somewhat lower than the rest at $21 million per DCF, with the rest running between $25 million and $30 million per DCF.

In this, the clear winners were the CVT and SS *United States* with 10-year operating costs of $8.4 million and $15 million per DCF, respectively. The cargo ships all were expected to incur 10-year operating costs of $25 million to $30 million per DCF, making them high-cost choices among the conversion choices. The highest cost choice was the new construction at $41M per DCF.

34. The carriers in the ADHOS study would be fully converted to medical uses.

Appendix C: Analysis of LSD hospital ship conversion

Documentation of medical capability estimations for the LSD conversion option

In this appendix, we investigate the possibility of converting an LSD 41/49 class ship into a Military Sealift Command manned (ROS 5) hospital ship. Here we attempt to determine the following:

- How much area is available on the platform
- How much medical capability the platform could have
- What would be involved in the conversion

The assumption going into this part of the study was that either a LSD 41 or 49 class ship could be used for the conversion, but that the final converted configuration would have the well deck and the vehicle stowage area (located on the 2nd Deck) of the LSD 49. This would facilitate casualty receiving by landing craft and would provide about 12,000 ft^2 of stowage area for medical vehicles and supplies. In addition, at least one of the helicopter landing spots would be retained for receiving casualties via rotary winged aircraft.

LSD 41/49 Available Area

To determine the available area on the platform, we consulted several sources, including the following:

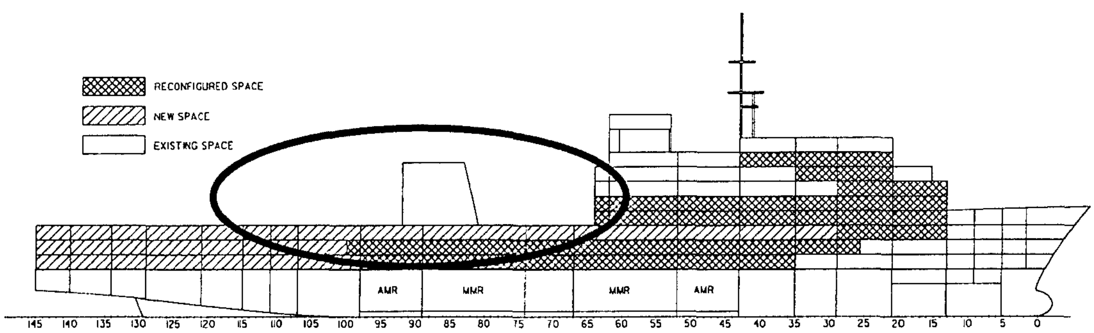
- LSD-41 General Arrangement Contract Drawings, 1 Oct. 1983
- LSD-49 Booklet of General Plans, May 1994
- JCC(X) LSD 41/49 Variant ROM Study, NAVSEA 05D1, 5 May 1997.

We used these sources and identified all of the amphibious mission spaces and ship's crew habitability spaces that were available for conversion. This totaled approximately 73,700 ft^2 (gross area).

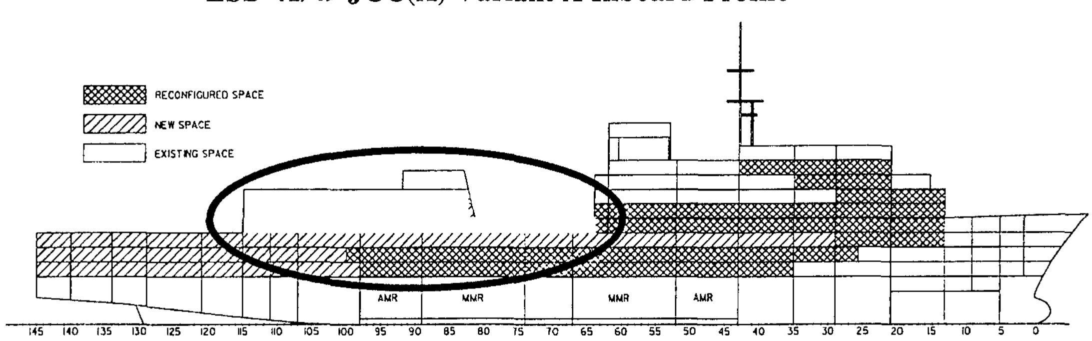
During the initial phases of the JCC(X) Program, a Rough Order of Magnitude (ROM) study was performed to see if an LSD 41/49 would make a good JCC(X) platform. As part of this study the forward aircraft landing spot was eliminated and a superstructure was designed to provide additional enclosed area. Figure 18 shows both a variant with and without the additional superstructure. The new superstructure (highlighted in yellow) provided an additional 38,500 ft^2 of gross usable area.

Because the LSD 41/49s are not capable of landing/launching two CH-53Es/MV-22s at the same time, we assumed that a similar superstructure could be placed over the existing forward aircraft spot, without reducing the mission capability of the platform.

Figure 18. LSD 41/49 JCC(X) variants



LSD 41/49 JCC(X) Variant A Inboard Profile



LSD 41/49 JCC(X) Variant B Inboard Profile

Therefore, we determined that the total available gross area within the platform is between 73,700 ft^2 and 112,200 ft^2. Once allocations have been made for passageways and unassigned area margins, there is between 56,375 ft^2 and 85,850 ft^2 available for the MSC and Navy personnel spaces and the medical mission spaces.

Proposed medical capability

To estimate the medical capability that the LSD 41/49 platform could have, we needed to estimate the size of the MSC crew. After reviewing other MSC manned ships, which are either prepositioned or held in ROS, we estimated a MSC crew of 14 officers, 7 CPOs, and 25 unlicensed crew for the LSD 41/49 hospital ship. Using COMSCINST 9330.6D and other rules of thumb, we determined that about 23,950 ft^2 of net area was required for all of the MSC habitability and ship spaces. This left between 32,425 ft^2 and 61,900 ft^2 of net area available for the medical personnel spaces and mission spaces.

Using NAVSEA 05D1's LPD 17 Hospital Variant ROM Study as a baseline, we estimated that the LSD 41/49 hospital ship's medical capability could be sized at 4 surgical operating rooms, 1 dental operating room, and 180 ward beds. We then calculated the required area for such a capability. Table 24 lists the spaces included in the proposed facility and the total net area required for the facility.

Based on table 24 and the NAVSEA LPD 17 study, we estimated the medical personnel required for the ship to be: 89 officers, 9 CPOs, and 158 enlisted.

In addition to the medical personnel, we used both the Navy Air Department (2 officers, 1 CPO, 18 enlisted) and the Navy Chaplain Department (2 officers, 2 enlisted) from the NAVSEA LPD 17 study. We then used the same habitability standards that were used to design LPD 17 to estimate the required habitability spaces for the Navy personnel. This equated to approximately 21,240 ft^2 of net required area.

Adding both the medical facility's required area and that required for Navy personnel, we arrive at 39,010 ft^2. This falls between the two calculated available areas of 32,425 ft^2 and 61,900 ft^2.

Table 24. Proposed LSD 41/49 Medical Facility

Space	Quantity	Area/space (ft^2)	Required area (ft^2)
Decontamination Area	1	430	430
Morgue	1	195	195
Main Laboratory	1	775	775
Pharmacy	1	225	225
Central Sterile Receiving	1	775	100
Medical SupplyService/Medical Repair	1	775	100
Intensive Care Ward (50 beds)	1	5,135	5,135
Physical Therapy	1	345	345
Operating Complex	4	280	1,120
Recovery Room	1	345	345
Radiological Services	1	194	194
Casualty Reception	1	1,400	1,400
Hospital Administration	1	260	260
Intermediate Care Ward (50 beds)	1	2,315	2,315
Lens Lab	1	215	215
Dental Service (1 OR, 1 X-ray, 1 Lab, 1 App. Rm., 1 CSSR)	1	300	300
Light & Limited Care Ward (80 beds)	1	2,715	2,715
Nourishment Rooms	2	800	1,600
Total Required Net Area			17,769

From this we conclude that the LSD 41/49 hospital ship could have the capability listed in table 24, by adding a small superstructure similar to the one highlighted in figure 18.

The conversion

This study looked at converting the LSD 41/49 platform to a hospital ship from an enclosed area and capability perspective. Other studies are required before the conversion could be deemed feasible. These studies include:

- *Electric Load Analysis* – to determine if the ship's electrical generation system is adequate to meet the ship's new mission
- *HVAC Load Analysis* – to determine if the ship's HVAC plant is adequate for the converted configuration and mission requirements

- *Weight and Stability Analysis* – to determine the conversion's impact on the ship's displacement and stability characteristics
- *Structural Analysis* – to determine the feasibility and impact of the new superstructure and internal configuration
- Other studies as required.

Until the foregoing studies are complete, it is impossible to say with any confidence how difficult the conversion will be and or what it will cost. If both the electrical and HVAC plants do not require major component upgrades, the conversion would be primarily limited to the structural erection, bulkhead erections/conversions, and the outfitting of spaces. If one or both of the systems need to be upgraded, the conversion gets more complicated because the additional machinery must be identified and then located within the platform.

Other conversion items depend upon the condition of the ship at the time of conversion. If the selected ship(s) have been properly maintained and the hull, machinery, and deck systems are in good operating condition, then little work in these areas will have to be performed. If they are in poor working order, no longer manufactured, or have a history of failure, then a decision as to replacement might have to be made. Only through comprehensive ship checks can these unknowns be sorted out.

Comparing the LSD conversion with the LPD-17 HV

As we discussed in chapter 3 and above, both the LPD-17 hospital ship variant (HV) and the LSD hospital ship conversion are attractive replacement candidates for the current hospital ships. The LPD-17 HV is about 50 percent larger and is equipped with modern propulsion and survivability technology, but the major difference between these two options is the upfront investment cost. Because it is a new ship, the LPD-17 is expected to cost $815 million or more to build.[35]

35. Refer to the Navy Fact File [17]. We assume that the hospital ship variant of the LPD-17 will not cost more than the first of the San Antonio class LPDs. This would be true if internal modifications of the original LPD-17 design were modest, and if the medical equipment would not be more expensive than the combat equipment it replaces (see [20]).

Conversely, the LSDs are already owned by the Navy, could be relatively simple to convert to medical use, and thus could require a smaller investment, perhaps in the \$132- to \$220-million range.

To correctly compare costs, however, one must calculate the investment over the expected lifetimes of the LPD-17 HV and the Converted LSD. The annualized investment estimates are highly dependent on the assumption one makes regarding the years of productive service you expect to get from the ships. Table 25 shows annualized cost estimates per unit for several expected life spans for each alternative.

Table 25. Annualized cost per unit of LPD-17 HV and Converted LSD

Ship type	Upfront cost/unit: (LPD-17 = 1.6 LSDs)	Annualized investment (AI): at expected lifespan (E)	AI: at E + 5	AI: at E + 10
LPD-17 HV	\$815M	45 years \$18.1M/year	50 years \$16.3M/year	55 years \$14.8M/year
Converted LSD (point estimate)	\$176M	15 years \$11.7M/year = 65% of LPD-17	20 years \$8.8M/year = 54% of LPD-17	25 years \$7.0M/year = 47% of LPD-17
Converted LSD (point ± 25%)	\$132M to \$220M	\$8.8M - \$14.7M = 49% - 81% of LPD-17	\$6.6M - \$11M = 40% - 67% of LPD-17	\$5.3M - \$8.8M = 36% - 59% of LPD-17

The estimates in table 25 are based on three assumptions.

Assumption 1

An estimate of the total cost of converting the LSD into a hospital ship can be found by comparing the cost of converting an LSD to that of converting the San Clemente supertankers into the current hospital ships. Further, the conversion cost is proportional to the relative sizes of the ships, within a range of uncertainty. Some important sources of the uncertainty concern such factors as the following [49]:

- The feasibility and cost of making the LSD's electrical and HVAC systems adequate to meet the new demands;
- The effect of design changes on the LSD's stability and seakeeping ability, as well as changes in its structural integrity that occur as a result of new decks and bulkheads.

In the third row of the table, we used the estimated investment costs that follow from assuming that the cost of converting an LSD would be about one-third that of converting the San Clemente supertankers into the Mercy class hospital ships in current dollars. The current Mercy class hospital ships each cost about $230M in 1985 dollars for acquisition and conversion. The cost of acquiring the tankers was $30M, so conversion was about $200M. One-third of that is roughly $68M. Adjusting for annual inflation since 1986 gives us a current conversion cost estimate of $110M.[36]

This conversion estimate is quite rough. Consequently, in the fourth row of the table, we also consider a range of estimates equal to the point estimate plus or minus 25 percent.

Assumption 2

The LPD-17 HV would have a medical capacity of 1.6 of a Converted LSD. The ratio calculation is the result of rough-order-of-magnitude (ROM) studies conducted by Mr. Bryan Tomer, a Naval Architect at CNA [20, 49]. In these two ROM studies, he uses ships' blueprints to estimate the amount of space available for a medical facility and personnel berthing. The consequence is that, if converting one LSD into a hospital ship costs about $110M, an investment of $176M would buy the same medical capacity as one LPD-17.

36. According to the Statistical Abstracts of the United States, 2002, by the U.S. Bureau of Census, the CPI for 1986 was 109.6 (1982 = 100), and the CPI for 2000 was 172.3. If we assume that the inflation rate was the same in 2001 as in 2000, the 2001 CPI would be 178.1. The cost, in current dollars, of converting one LSD is $68M * 178.1/109.6 = $110M.

Assumption 3

An LPD-17 HV would be expected to last 45 to 55 years, and a converted LSD could last 15 to 25 years as a hospital ship. This follows from a 1999 LPD-17 report, which states that the LPD-17 is expected to last 40 years. The LPD-17 is a warship, and would be deployed on a regular basis, whereas its hospital ship variant would be in reduced operating status (ROS) much of its life and could be expected to last longer. The expected lifespan of an LSD follows from the fact that it would be converted from a 30-year-old LSD, and that its total expected life would be the same as the LPD-17.

As shown in table 25, the difference in lifetime investment costs between the LPD-17 and the LSD could be significant and would increase with expected length of life. To decide between the two ships, we should ask which would have the greater overall value in terms of mission effectiveness and other important criteria. The LPD-17 would be a new unit, meaning that downtime and repair costs could be less. Also, the LPD-17 would have the more modern communications equipment, the more up-to-date enhancements for reducing radar signature, and the more modern propulsion system. Developing a variant of a ship that is in production ensures that there will be a cadre of crewmembers that know how to work with this ship's propulsion plant and other features for many years. The major drawback of the LPD-17 is its upfront cost.

The converted LSD option would have many of the same advantages of the LPD-17 HV in terms of its effectiveness in its medical mission. In fact, its smaller size may be preferable, given forecasts for smaller conflicts in the future. In addition, given the speed with which technology advances, one might prefer a ship with only a 15- to 25-year expected life rather than one that could last 45 or 50 years. However, the LSD would lack some of the modern technology of the LPD-17. More importantly, it would involve converting a ship that was built for another purpose. Converting a ship can sometimes take longer and be more expensive than originally anticipated. Conversion can uncover small but significant design features that hinder the full usefulness of the ship for its new intended purpose.

Despite these disadvantages, both the LPD-17 hospital variant and the LSD conversion could be desirable choices for Navy Medicine. They would be able to sail with an Amphibious Ready Group (ARG), would have both sea-based and helicopter-borne methods of receiving patients, and would have relatively modern communications systems.

Appendix D: Documentation of medical capability estimations for notional HSV en route medical care vessel

Calculations for the medical catamarans follow. Total room space in the 96-meter HSV is about 21,000 square feet. Subtracting 15 percent for passageways and such, 30 percent for living space, another 15 percent for military functions and miscellaneous spaces, gives us 40 percent, or 8,400 square feet for medical spaces. Of this, we devote 1/3 to medical wards dedicated to transporting patients. The other 2/3, or about 5,600 square feet, we use for medical spaces designed for providing resuscitative, or echelon II-level care. To calculate the ship's potential medical capabilities, we compare this to the medical spaces on the LHA, one of the Navy's L-class, casualty receiving and treatment ships. It has four operating rooms, 18 ICU rooms, and 48 acute care ward beds built in about 15,000 square feet of space. Because the HSV's total available medical space is 1/3 that of the LHA, we calculate that the HSV's medical capability should also be about 1/3. Thus, we estimate that the HSV would have 1 operating room, 6 to 8 ICU rooms, and 16 acute care ward beds (in addition to the ward space described above).

Appendix E: Using the HSV for medical evacuation

Current Navy medical doctrine focuses on the use of large medical platforms for large-scaled contingencies and assumes that medical assets, including these same large platforms, can be used for smaller-sized contingencies, such as we might be seeing in Afghanistan. As an alternative, we will propose a few circumstances in which the HSV might be useful. This appendix presents some examples of how the HSV could be used to evacuate patients receiving care on the L-class ships (mainly the LHAs and LHDs) to a level III facility for additional care. We postulate that these patients were casualties of an amphibious assault who were evacuated first to one of the L-class ships, mainly for stabilization, but still require more care. As we will describe, one must adjust the usual scenarios regarding the kinds of platforms or air evacuation assets to find appropriate employment during a conflict.

In most current scenarios, helicopters are the simplest method for transporting personnel from the L-class to the T-AH, which would presumably be close enough (i.e., within 150 n.mi., but more likely as close as 20 n.mi.). Our analysis, however, uses scenarios in which the T-AH is not present in theater or not close enough to provide the care. Why might that be? For small enough forces, a Marine Expeditionary Unit (MEU) or even a Marine Expeditionary Brigade (MEB), the casualties might be too few to warrant the use of such a large sea-based medical platform as the T-AH.

When the CINC employs a Marine Expeditionary Force (MEF)—a large landing force—it typically deploysa T-AH. Thus, it is harder to make a case for why there is no T-AH in such a conflict. The number of troops and expected casualties associated with the deployment of such a large force as a MEF usually means that all medical platforms, including the T-AHs and fleet hospitals (FHs), would be required. However, we'll assume that, even for a large-sized amphibious assault employing a MEF, the T-AHs would not be available. That does not mean we see no need for level III care of combat casualties. A shore-based fleet hospital might be available, but these platforms usually provide support for the shore-based forces, such as the ashore MEF. It would be unusual to send a patient back to sea for treatment on the L-class ship, and then evacuate him to shore to be treated at an FH.

Where might the patient receive treatment? In our stylized scenarios, we assume that patients requiring more than level II care must be evacuated to an OCONUS facility or, if these facilities are too far away, to a land-based site, such as Darwin, Australia. Our main goal here is to present a few simple scenarios for different Marine Air-Ground Task Forces (MAGTFs) and estimate the number of such shuttles that would be required. These HSVs are somewhat outside the standard doctrine of medical support. Consequently, our scenario incorporates several assumptions that would lead to cases in which the HSVs would be useful.

In the case of an amphibious landing by a MEF, we'll assume that the assault occurs somewhere off the coast of Korea and casualties requiring additional care must be transported 800 to 900 miles to Naval Hospital (NH) Okinawa. This distance is too far for helicopters, and possibly too far for the V-22 that will enter service over the next several years (though if refueling assets are available, air-based evacuation is an alternative to the HSV). But the HSV can make a trip at this distance, averaging 35 to 40 knots,[37] implying the transit will take a day or less. This scenario may also be appropriate for a smaller force, such as a MEB, but the Korea scenario probably makes little sense for a much smaller force, such as a MEU.

A MEU, or perhaps a MEB, might be employed when dealing with a local uprising as might occur in the Philippines or Indonesia. For example, a MEU or possibly a smaller than usual MEB might land a force on Basilan Island in the southern part of Mindanao province

37. We based our assumption of 35–40 knots on published articles [36, 37]. This estimate is being tested in January 2002. These tests might show that there can be structural failures at these high speeds [34, 35], in which case our assumptions regarding speed would need to be altered.

where the Abu Sayaf guerillas hold several American hostages. Casualties that require transport to level III facilities, but for whom air transport is too difficult, might be moved by sea to NH Guam, which is about 1,500 miles away. Alternatively, a landing on East Timor in Indonesia might require sending casualties to Darwin, Australia, a much shorter trip of about 438 miles.[38]

Depending on distances involved, among other factors, an HSV could be useful in the foregoing scenarios. A trip of about 900 miles or less can be accomplished in a day or so, even taking into account the time to move patients on and off the shuttle. If the distance is roughly 1,500 miles, the current craft's capabilities would be tested, but the craft represents a reasonable possibility for medical evacuation by sea. Our current assumption is that 1,500 n.mi. represents the longest distance for which the HSV would be practical. One caveat is that a trip of this length would probably mean transit and unloading time of 2 days and at least another 2 days before that craft is available again for taking on patients. The longer it takes to complete the round trip, the greater the number of HSVs that would have to be purchased in any of our scenarios. We'll provide an example of this later.

A simple model of medical evacuation

In these scenarios, we have relied on the same types of models and assumptions that are used to generate medical wartime requirements for level III facilities (i.e., the T-AHs and FHs). These models, represented by the Medical Planning Module (MPM) and more recently by the Medical Analysis Tool (MAT), begin with assumptions concerning the population at risk (PAR) and the expected casualty rates (wounded in action (WIA) and disease, non-battle injury (DNBI)). We incorporate these and other assumptions in our model to have a realistic sense of how many casualties occur and how many require

38. See [25] for the calculated approximate sailing distances for WESTPAC intratheater sites (in nautical miles). The author also provides values of 1,765 n.mi. between Dili, East Timor, and Apra Harbor, Guam; and 1,834 n.mi. between Guam and Pohang, Korea. Unfortunately, he does not calculate the distance between the Philippines and Guam. The number above is based on our simple calculation.

evacuation to higher levels of care. We recognize that these models are usually used to determine the requirements for level III (and in earlier years, for level IV) facilities, which we are not concerned with here, but they do provide a simple framework for examining the expected number of evacuees resulting from some form of conflict.

We will draw from the assumed casualty rates that are used in MPM or MAT. But, we must input two important planning factors. The first is the size of the forces involved, which we referred to earlier as the PAR. Table 26 shows the notional sizes of a MEU, MEB, and MEF, in terms of the personnel contained in each. Each has a command element (CE), ground combat element (GCE), air combat element (ACE), and the combat service support element (CSSE).

Table 26. Marine Air-Ground Task Force personnel

	MEU	MEB	MEF
CE	177	964	2,658
GCE	1,299	6,305	17,658
ACE	409	6,750	14,055
CSSE	316	3,195	7,967
Total	2,201	19,415	42,338

The total size of these three respective forces varies significantly from just over 2,200 to well over 42,000. Note that the actual size of the forces employed is likely to differ from these notional values. For an amphibious assault, the MEF employed is likely to have fewer personnel than would be used in an ashore (i.e., land-based) MEF. Also, we must recognize that the ACE varies with the mission and would undoubtedly not experience the same kinds of casualties as the ground forces, particularly those storming the beach. Nonetheless, our model is designed to be flexible and conservative and, at this point, simple and illustrative. Overstating the force involved and number of casualties as a starting point is probably better than understating them. As assumptions become more refined and the parameter values used in the calculations become more accurate, our final numbers can also be easily refined.

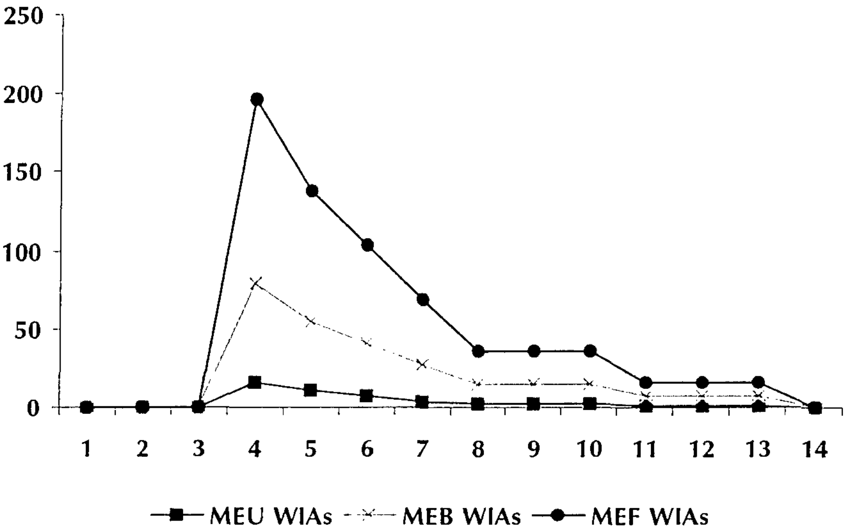
One of the more controversial sets of assumptions in any kind of warfare analysis concerns the casualty rates assumed. We wanted plausible yet unclassified values because we are designing a model to show how the number of shuttlecraft might be calculated. Therefore, we chose values and a time period that are loosely based on an OPLAN, but that have been changed sufficiently to make it unclassified for our simple example. Storming beaches in the Philippines or as part of an OPLAN must be examined carefully, and we didn't have the detailed knowledge or resources to be perfectly accurate. Nonetheless, we designed a 14-day period for the conflict, starting at C+1 and ending on C+14, with the highest casualty rate occurring on the day of the assault, which we assumed began on C+4. The rates then declined after that day, with all casualties ending by C+14.

We also recognized that, similar to the current requirements models, troops in different sectors of the battlefield experience very different casualty rates. Accounting for this point without making the model too complicated, we assumed one set of rates for combat troops and a lower set of rates for support troops. We used the numbers in table 24 to represent the PAR by combining the GCE and ACE to represent combat personnel (even though this assumes that the ACE and those infantrymen storming the beach have the same WIA rates) and by combining the CE and CSSE to represent support personnel.

Figure 19 presents the calculated values for the number of daily WIA casualties for the three sizes of forces we've assumed. We assumed the same WIA and DNBI rates (per 1,000 personnel) for the MEF and MEB, with the only difference being the number of personnel to which these rates were applied. For the MEU, which is a much smaller force, we assumed that this smaller force might face a more dangerous mission, or just be more vulnerable, and so multiplied these rates by 1.5, representing a 50-percent higher casualty rate. To the extent that these assumptions need to be changed, we can do so easily.

The outcome of all of our assumptions is that the numbers of WIA casualties for each sized force has a spike on day 4, but the number gradually declines. We assume no WIA casualties for the first 3 days of the conflict and none or small numbers by the end.

Figure 19. WIA values for the three MAGTFs



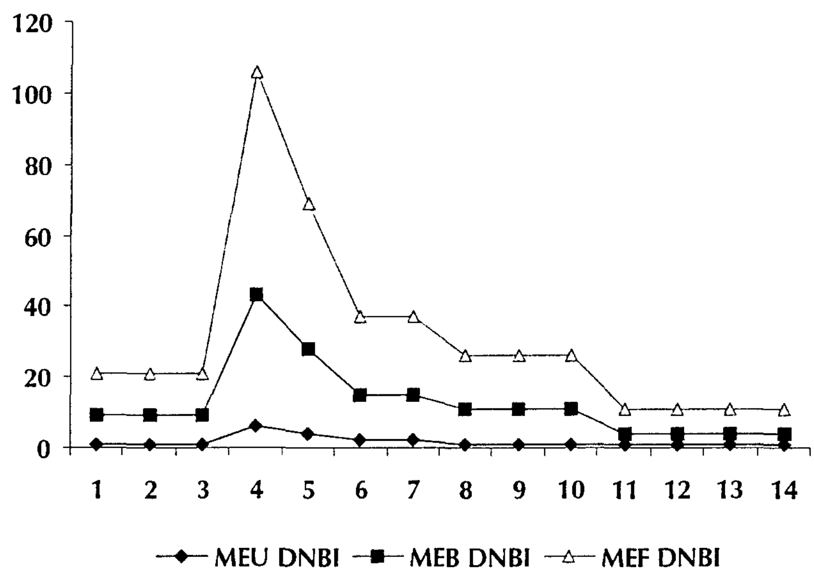
We can contrast this with the projected number of DNBI casualties, which we show in figure 20. We assumed lower rates when compared to the WIA; however, the DNBI rates are related to the intensity of combat, so they too hit a peak on day 4.[39] The peaks for the MEF and the MEB are slightly more than half that of the number of WIA casualties. Yet the total number of casualties, made up of both WIAs and DNBIs, is only part of what is needed for determining evacuees. Not all casualties are evacuated for further treatment. Some of the casualties return to duty (RTD) if their time at a medical facility is less than the evacuation policy in force for that level of care.

In our examples, casualties occur at the battlefield, or level I. Some will RTD, but many must be sent to the L-class ships for treatment, the

39. At the peak on C+4, the WIA rate is 5.5 per 1,000 for combat troops and 3 per 1,000 for support troops. The DNBI rate is 3 per 1,000 and 1 per 1,000, respectively. Over the 14-day period, there are WIAs on 10 of the days, but DNBI casualties on all 14 days, although the DNBI rates are relatively low, at the beginning and end of the time period.

level II facility. Here, too, some RTD and those who require further treatment will now be first evacuated to the shuttle, a short ride by helicopter to the shuttlecraft.[40] In other words, the shuttle does not need to take all of the casualties we show, just a portion of them. To determine how many there might be, we need to make other assumptions, which we turn to next.

Figure 20. DNBI values for the three MAGTFs



How many total casualties do we project in our simple examples? For the case assuming a MEF assault, we project a total of 664 WIAs over the 14-day period (although there are none during the first 3 days and the last day) and 434 DNBI casualties. The day of the assault, there are 196 WIA casualties and 106 DNBI casualties, declining

40. Note that we are assuming that casualties are moved from the L-class ships to the HSV by helicopter, which at present means the CH-46. When these aircraft are taken out of service, either a relatively small helicopter (such as the SH-60) must be used or a modified shuttle must be built to handle larger aircraft.

through the rest of the 10-day period. Given our assumptions of the same casualty rates, but lower PAR for the MEB, this case would have a total of 272 WIAs and 177 DNBI, with the highest daily total of 80 and 43, respectively. The last case, the MEU assault, leads to a total of 51 WIAs and 24 DNBI, with day 4 (the day with the highest number) showing 16 WIAs and 6 DNBIs.

Determining the number of evacuees

We've just shown the number of battlefield casualties that occur day-by-day, arising from both wounds and illness or injury. This number is different from the number of potential evacuees that one or more shuttlecraft must take to the nearest level III facility. To determine how many must be evacuated, we must make some additional assumptions concerning the evacuation rates and delay times that would be associated with level I and level II medical facilities. As noted earlier, these assumed values are important because they change both the number and timing of when casualties occurring on day *t* must be moved on the shuttlecraft and then to the level III OCONUS site.

Table 27 presents our assumed values. To obtain them, we borrowed values from earlier runs of the MPM and MAT, even though these models really referred to evacuation from theater, not from the battlefield. The models assumed an 83-percent WIA theater-level evacuation rate and a 38-percent DNBI theater-level evacuation rate. In our case, multiplying the 92-percent level 1 evacuation rate (for WIAs) by the 90.2-percent level II evacuation rate leads to the 83-percent rate we're assuming for evacuation to the level III facility. A similar calculation can be made for the DNBI rates. What these assumed evacuation rates imply, for example, is that of the total of 1,098 battlefield casualties previously mentioned, a total of 899 must be evacuated to the L-class (611 WIAs and 288 DNBIs), but only 718, or slightly less than two-thirds of the total number of casualties, must be evacuated on the shuttlecraft to the level III facility at NH Okinawa.

We have just described the total numbers of casualties to be moved, but not the timing of the moves. The last value shown in table 27, the evacuation delay time, will help us determine when patients must be moved. This number refers to the delay time before someone receiving care either at a level I facility (which really means at or near the battlefield) or level II facility (on the L-class and HSV) must wait before being evacuated to the next level. As the table indicates, we assume 1 day at level I. This means that a casualty occurring on the ground on day 1 must wait until the next day to be evacuated to the L-class. This delay simply recognizes the time involved in treatment at that level, the time it takes to get to the transit point, the time waiting for an evacuation asset to be made available, and the time in transit to the next level. This delay time recognizes that during war nothing can be planned to happen instantaneously, but also that patients may die or at the least face increased risks of morbidity and mortality if they don't receive care before too long. Therefore, by assuming a 3-day delay time at level II, we are really specifying an "upper bound" that patients can be made to wait on the combination of the L-class ship and HSV before they reach their needed level III facility.

Table 27. Parameter values assumed for determining evacuees

	Level 1	Level 2
WIA		
Evacuation rate	0.92	0.902
RTD rate	0.08	0.098
DNBI		
Evacuation rate	0.67	0.567
RTD	0.33	0.433
Evacuation delay time (in days)	1	3

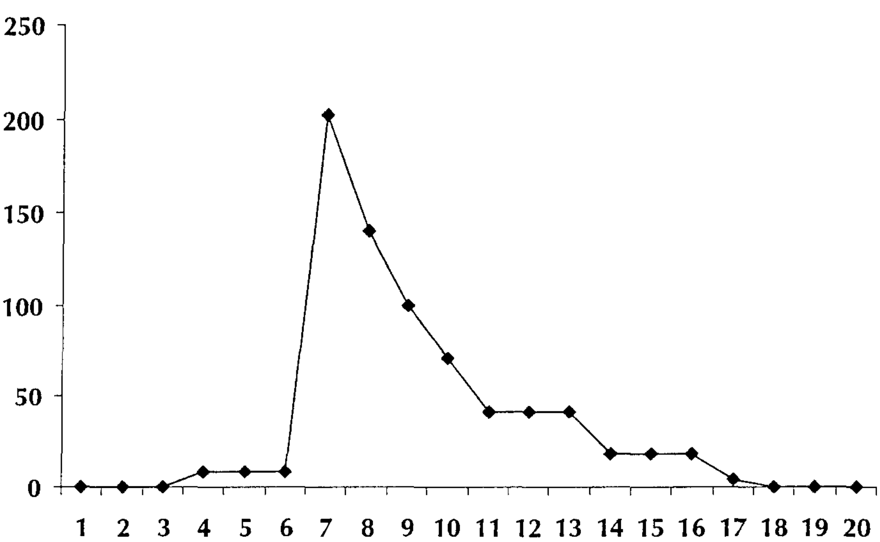
The upper bound on the time allowed before the patient reaches the OCONUS facility, implies the following. With 1-day treatment time on the L-class ship and a 1-day transit time to OCONUS, as we've assumed for the trip to NH Okinawa, the HSV can linger for two 2 before it must start transporting patients. If the trip takes 2 days, as it might be between the Philippines and NH Guam, it can only wait 1 day before leaving.[41]

41. We add 1 day on this value to account for the travel time before the next level is reached. Thus, with a 3-day delay and a 1-day trip, the shuttle must leave by the end of the third day. With a 2-day trip, the shuttle must leave by the end of the second day, which means it only has 1 day to receive patients from the L-class ships.

This kind of constraint is important when casualties occur over time, but at varying rates, as one would expect. If a few patients arrive before the amphibious assault with disease or non-battle injury, a decision must be made to leave with only a few or wait until more arrive. Our model suggests that it would be efficient to wait a day for D-day casualties, but future patient flow is unknown in the real world.

Different assumptions can lead to different numbers of ships that are required. Under most circumstances, the difference will be trivial, but it could necessitate an additional shuttlecraft or two. At about $100 million per craft, that can be expensive. Our goal is simply to indicate the kinds of factors that must be considered when estimating how many would be required. Figure 21 shows the pattern of evacuees arriving on the shuttlecraft, given our assumptions. The total number of evacuees is just under 900. The figure indicates that most of these occur on days C+4 through C+10. The issue now is how many shuttle-crafts would be required to handle the numbers we've shown here. Assuming a medical capacity of about 80 beds and a 2-day round trip, we must determine how many HSVs would be needed to support the evacuation to the level III facility at NH Okinawa.

Figure 21. Pattern of MEF evacuees to level III facilities over time



Our method for calculating required number of HSVs is simple. A 3-day delay period means that a shuttle can wait a day or so to take on more patients, but no longer. Otherwise, the patient's condition could deteriorate. In the real world, the commanding officer of the shuttlecraft in conjunction with the CO of the medical facility can override this rigid rule; however, for modeling purposes, we follow it precisely.

To show how we compute requirements, we use a simple table rather than a set of equations. Table 28 presents the time period, beginning with day C+1 and continuing through C+18. Evacuees begin to be moved aboard the shuttlecraft on C+4, the day hostilities begin. Note, however, that these are not WIAs, but DNBI casualties from C+1.

Table 28 is designed to illustrate when casualties must be moved, on which specific HSVs, and how many HSVs would be required. We show the pattern of when the HSVs leave and return with the use of an arrow to the right of the column that depicts the specific HSV's number of evacuees onboard. The arrow begins on the day the craft leaves its location, presumably near the "beach" where the action took place, and ends when it returns to pick up new evacuees. Note that HSV #1 has only 16 patients on board before it must leave for NH Okinawa. HSV #2, also on station, picks up the next day's evacuees of 8 more patients but can wait for more on the next day. Day C+7 represents the day when most evacuees are received—there are more than 200 new evacuees. It loads the next 77, which now gives it a total of 85, its capacity, and so it sets off for Okinawa. HSV #3 takes on its 85 patients and leaves, but the remaining 40 patients are placed on HSV #4. It can wait 1 more day. The next day it receives another 45 patients and leaves. On that day, HSV #1 has returned and can take on 85 of the remaining 95 patients. That leaves 10 patients, so HSV #6 would be required because HSV #2 and #3 will not return until the next day, C+10.

The conclusion we reach in this simple way is that a total of six HSVs would be required under our MEF scenario.

Table 28. Calculating the number of HSVs required for support of a MEF

Day	Evacuees	HSV # 1	HSV # 2	HSV # 3	HSV # 4	HSV # 5	HSV # 6
1							
2							
3							
4	8	8					
5	8	8					
6	8		8				
7	202		77	85	40		
8	140	85			45	10	
9	100					75	25
10	71		11				60
11	41		30				
12	41						
13	41						
14	18						
15	18						
16	18						
17	4						
18	0						

Table 29 presents the analogous table for the MEB, also showing the expected number of evacuees and the required number of HSVs. In this case, we'll assume a 4-day round trip, which implies that the shuttlecraft would not be available again until the fifth day. What this means is that, with a 3-day evacuation delay time, the ship should not wait around even for an extra day before leaving. It stays for 1 day to pick up patients, but must leave by the end of that day. This kind of rule would lead to as many as five HSVs, each of which might leave with very few patients. For example, following the rule strictly implies that the first HSV would have to leave with only three patients. We relaxed this rule on the first day because it seemed unrealistic for the ship to leave with only three patients on board. We also allowed HSV #1 to wait an additional day on C+10 so that the four HSVs would be able to handle the patient load. Then, on day C+12, the 17 patients waiting for evacuation to an HSV must wait for HSV #2 to return on the following day and 34 patients (including those from C+13) could be evacuated to it. Because of the additional day in transit each way, our own rule of when the HSVs must leave had to be relaxed in order for a total of four HSVs to be required. Thus, even though there are far fewer casualties than we saw in the previous case, the longer distance dictates almost as many shuttlecraft. If, on the other hand, the round trip only took 2 days, as in the previous case, we would estimate that three HSVs would be required, and possibly as few as two if the patients could remain on board longer without undue degradation in their condition.

Table 29. Calculating the number of HSVs required for support of a MEB

Day	Evacuees	HSV # 1	HSV # 2	HSV # 3	HSV # 4
1					
2					
3					
4	3				
5	3	6			
6	3		3		
7	70		70		
8	63			63	
9	46				46
10	29	29			
11	19	19			
12	17				
13	17		34		
14	9			9	
15	7				7
16	7				
17	2				
18	2				

The final case is that for a MEU. This represents the case with the fewest casualties and evacuees, the latter peaking at 16 and in total only 61, which is fewer than can be accommodated on one HSV. The problem as we've shown is that the evacuees come in only a few at a time and we've limited the amount of time before they must leave. As in the previous case, there is one scenario with a round trip of 2 days (from Dili to Darwin) and another with a round trip of 4 days (from the Philippines to Guam). This case is hard to calculate with any accuracy, but we will say that two to three HSVs would probably suffice, though with some thought required as to how long the shuttle can linger before it must leave.

In conclusion, we estimate that the Navy would need at least two HSVs to support a MEU-sized force for patient evacuation within the Pacific theater. MEB- and MEF-sized forces would require at least four and six HSVs, respectively.

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MED-27	CAPT Bloom
MED-03	RADM Nancy Lescavage
MED-05	RADM Rodrigo Melendez
MED-06	RDML D. Woofter
MED-06B	CAPT K. Wright
MED-07	RADM Lynch
MED-07B	CDR Richard Delaquis
MED-71	LCDR Michael Hartford
MED-82	CAPT Patricia Bull
TMO	RDML Hufstader

NAVMEDLOGCOM	CAPT George Crittenden (3 copies)
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DTIC-OCQ 12 September 2002

MEMORANDUM FOR Defense Technical Information Center (DTIC-OCQ), 8725 John J. Kingman Road, Suite 0944, ATTN: (Larry Downing), Fort Belvior VA 22060-6218

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a. CAB D0004631.A2	ADB278520	Region 11 Health Care and Administrative Costs.
b. CRM D0005085.A2	ADB277170	Future Deployable Medical Capabilities and Platforms for Navy Medicine.

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