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ABSTRACT

The US Navy is at a critical juncture in determining the types and numbers of ships it will acquire, retire, and sustain to support an evolving US military strategy. In addition to determining how many aircraft carriers, cruisers, amphibious assault craft, fighters, and helicopters it will need, the Navy must determine how it will confront maritime irregular warfare. Assuming an environment of resource scarcity, where new vessel acquisition to support maritime irregular warfare may be increasingly difficult or unlikely, we introduce a method for evaluating the capability and costs of candidate vessels that are in the current Department of Defense inventory, or widely available from the commercial sector to conduct such a mission. Our method combines wargaming with cost analysis to aid Navy leadership in developing maritime irregular warfare concepts of operation as well as resource allocation decisions.

INTRODUCTION

As the US military increasingly focuses its attention on irregular warfare (IW), each of the Services—Army, Air Force, Navy, Marines—is struggling with how they can best leverage resources and capabilities to address current and emerging asymmetric threats. Conventional nation-to-nation conflicts are not the norm in warfare. The United States has used military force more than 300 times since the American Revolution, and that includes only 11 declared wars and some sustained conventional conflicts. There have been roughly 30 major conflicts during the past decade, and only four actually occurred between nations (Jogerst, 2009). History shows that IW is a regular occurrence, and our Armed Services are adapting to irregular challenges faced in this more common form of warfare.

An increasingly stressed budget environment requires the Navy and the other Services to examine their portfolio of current and planned weapon systems with ever greater scrutiny. Large and expensive vessel platforms continue to be the planned solution to prosecute contemporary and future conflicts (US DoD, 2012; O'Rourke, 2012). The tendency to focus resources on relatively few, large, and costly platforms that complement combat units organized to wage major wars has proven difficult to adapt to effectively confront smaller asymmetric and irregular threats.

Selecting and acquiring vessels necessary to prosecute maritime IW is a complex strategic process that requires considerations of the operational environment, vessel capability, and costs to deploy the vessel. Unlike the private commercial economic sector, the Department of Defense (DoD) does not plan operations for *financial outcomes*. On the contrary, defense planning focuses on *operational outcomes* with resources that are budgeted to achieve those outcomes in support of the National Security Strategy, Defense Planning Guidance, and National Military Strategy. As budgets are reduced, and strategic as well as operational goals remain unchanged or broaden in their scope, the resources necessary to meet those strategic and operational objectives must be reevaluated and alternatives examined. Selecting the right mix of vessels to accomplish maritime IW missions will be important both in terms of operational effectiveness (capability) and efficiency (cost).

A critical part of the examination process should be an analysis of alternative resources that might be used to achieve desired strategic and operational goals. For this study, we focus on resources that already exist within the Department of Defense or those that exist in the commercial domain and may be easily and quickly adapted to defense applications without going through a formal acquisition process. The analysis of alternatives (AoA) should not only examine the capabilities of competing resource types and issue recommendations based upon the perceived superiority of one resource's inherent capabilities versus that of another, but it should also examine the relative economic investment of each resource so that decision makers may consider alternative force structures with differing *quantities* of each candidate resource. For example, acquiring multiple quantities of resource *A* that on a one-to-one basis may be inferior to a competitor resource *B*, but when deployed in a group, *A* may actually provide capabilities superior to one unit of *B* that were not previously considered.

Utilizing wargaming and cost analysis, we propose a methodological process for evaluating alternative resources that are currently in the DoD inventory, or available

APPLICATION AREAS: Analysis of Alternatives, Cost Analysis, Decision Analysis

OR METHODS: Cost Analysis, Decision Analysis, Wargaming

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OR METHODS: Cost Analysis, Decision Analysis, Wargaming from the commercial sector, based on their capabilities in an operational scenario and then comparing the relative cost of employing those resources (see Figure 1). Our methodology allows decision makers to not only strategically evaluate alternative resources on their inherent capabilities but also provides an immediate, *operational cost metric* that may be used to consider alternative force structures: the cost of employing each resource on a daily basis. The first step in the process is the definition of the resource needs in terms of operational missions and scenarios. This requires operationally defining a strategy and identifying operational goals or "mission sets" that, taken together, would result in the execution of the strategy. The second step is to identify several candidate resources that will likely satisfy the operational need and be capable of contributing to meeting the operational objective. The third step is to evaluate the alternative resource capabilities in a simulated environment that is meant to emulate the operational missions and scenarios for which the resource will be used. The fourth step is to determine a cost metric whereby each resource may be compared on a time-use basis such as cost per hour, cost per day, or cost per quarter. The fifth step in the process is to analyze the cost for capabilities of each resource by comparing the time-use costs to the capabilities that may be brought to bear by each resource during the time it is employed. This step provides decision makers a foundation upon which they may evaluate different mixes of each resource to achieve operational outcomes. The final step is to combine the capabilities and cost analysis to make a decision about how to use existing resources and how to allocate the budget for alternative resources that can achieve operational outcomes to support the overall organizational strategy. Should the needs or costs change, then the appropriate step(s) should be revisited. The entire process can be repeated as needs, capabilities, and/or cost information becomes more refined.

This research provides an example of a cost and capabilities trade-off analysis for considering alternative resources to meet an emerging mission requirement. Using maritime IW as a mission context, we explore the capabilities and operational costs of three candidate vessels and discuss the relative merits of each maritime platform. This work extends the AoA approach beyond the materiel solution analysis phase of the DoD acquisition process by introducing a method for evaluating vessels currently residing in the DoD inventory, or widely available in the commercial sector, that is easy to implement and understand by upper-level decision makers to evaluate resources to be utilized in emerging scenarios or mission environments. The addition of wargaming to an AoA approach allows decision makers to see how specific vessel capabilities may broaden or constrict the operational decision space of commanding officers, which necessarily has implications for operational outcomes.

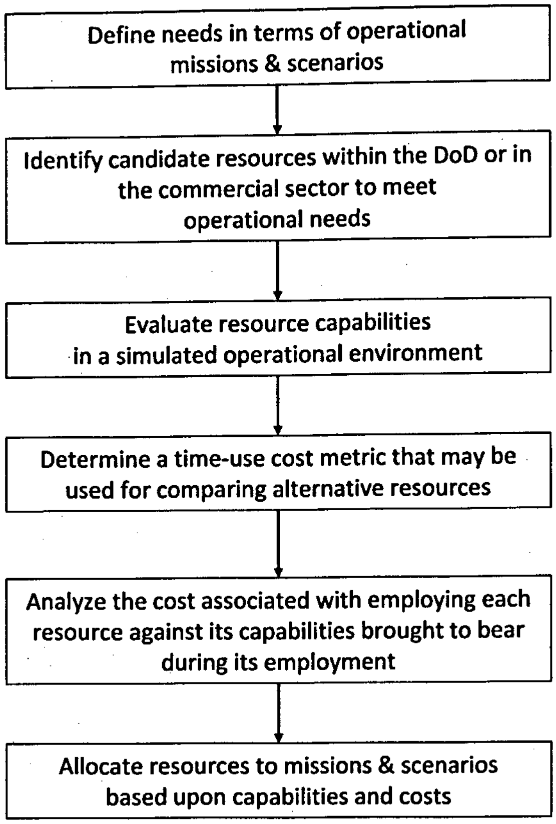

Figure 1. A method for evaluating alternative resources.

SELECTING VESSELS TO SUPPORT MARITIME IRREGULAR WARFARE

We explore the capabilities and costs of three different vessels to meet the mission requirements of potential maritime IW scenarios and then show how such a capability and cost analysis might be used by decision makers to assign specific vessel types to particular operational areas based upon the mission requirement. Although maritime IW is not specifically defined by the Navy or in joint doctrine, it has been in existence in some form since the dawn of sea power. In simple terms, it is the maritime component of IW, or IW conducted from or on a body of water. In order to select vessels appropriate for conducting maritime IW, it is necessary to define the concept in operational terms. Generally speaking, the types of maritime IW operational missions conducted over the last 50 years in oceans, seas, and inland waters have remained relatively consistent with the exception of technological advances. Naval guerrillas relying on individual combat swimmers, high-speed boats, or unconventional submarine platforms for amphibious raids, clandestine reconnaissance, infiltrating forces ashore, or attacks on military and shipping vessels typify maritime IW operational scenarios in the littoral (Sutton, 2000). Researchers at the RAND Corporation recently defined maritime IW as "operations involving at least one irregular actor or tactic that aim to shape the maritime environment in at least one of three ways: (1) to prevent supplies or personnel support from reaching an adversary, (2) to increase the capacity of partner naval and maritime forces, or (3) to project tailored US power ashore to directly confront adversary forces, when necessary" (Dunigan et al., 2012). The Congressional Research Service recently identified a broad range of IW activities conducted by the Navy to include operations in Iraq and Afghanistan (O'Rourke, 2011). The types of IW activities in which the Navy has been engaged in the last five years may be reduced to five broad categories or *mission sets* (Table 1).

Table 1. Maritime irregular warfare (IW) mission sets.

Maritime IW Mission Sets
Security force operations and assistance
Civil-military operations
Counterterrorism/piracy/narcotics
Building maritime partner capability and capacity
Intelligence, surveillance, and reconnaissance

Security force operations and assistance refer to exercises, patrols, and missions with foreign navies, coast guards, and maritime police forces to improve their ability to conduct maritime security operations, as well as operations to guard infrastructure, facilities, and supply lines that are of strategic interest to the United States (O'Rourke, 2011). Civil-military operations refer to the use of Navy hospital ships, expeditionary medical and fleet surgical teams, and naval construction units to provide medical and construction services (to include humanitarian and disaster response and relief) in foreign countries as a complement to other US diplomatic and development activities in those countries (O'Rourke, 2011). Counterterrorism, counterpiracy and counternarcotics activities include the interdiction, destruction, and discouragement of illegal trafficking, piracy, or terroristic acts in the maritime environment. The building of maritime partner capacity and capability refers to the investment of time and resources in developing partner nation navies to function effectively in order to deny sanctuaries to pirates, illegal traffickers, violent extremists, and other nefarious parties (O'Rourke, 2011). Intelligence, surveillance, and reconnaissance (ISR) activities refer to those actions undertaken to gain an understanding, as well as specific situational dispositions, of active or potential threats to US or partner nation interests through the use of human and electronic means.

EVALUATING VESSEL CAPABILITIES THROUGH WARGAME SIMULATION

Wargaming has long been recognized by the military as the best peacetime test of a war plan (Mood, 1954). The earliest formal wargames may be traced back to the introduction of the rules to *kriegsspiel* by Von Reisswitz (McHugh, 1966; Perla, 1990). Andlinger (1958) was one of the first to point out the usefulness of wargames for business, and by 1963 the US Army's Strategy and Analysis Group (STAG) had estimated that more than 200 major corporations were using wargames for developing and testing strategies (Paxson, 1963). Wargaming continues to play an important role in the development and testing of military strategy (Brennan, 2002; Perla, 2008), and the contemporary business teaching case used in master of business administration (MBA) programs across the United States may be regarded as an outgrowth of the type of scenario-based decision making that takes place in wargaming.

The purpose of wargaming is exploratory in nature and is used "to investigate the processes of combat, [and] not to assist... in calculating the outcomes of those processes" (Perla, 1990). The intent of the wargame and analysis of this study was to compare and contrast the capabilities of three candidate ships as well as their ability to successfully complete anticipated missions in support of maritime IW. The wargame allowed us to explore the decision process of vessel commanders and how the relative strengths and weaknesses—the capabilities—of each vessel either constrained or expanded the commander's decision space as well as their ability to complete specific missions.

The candidate ships were a chartered commercial support vessel similar to an ocean-going tug (hereafter referred to as a CSV), the High Speed Vessel (HSV)-X1 *Joint Venture,* and the Littoral Combat Ship *USS Freedom* (LCS-1). These candidate ships were selected based upon past success with vessels in their class and future availability for the maritime IW mission.

The Chartered Commercial Support Vessel (CSV)

The chartered CSV considered in the wargame was a 220-foot long, 56-foot wide ocean-going tugboat with a 16-foot beam and a working deck of 3,640 square feet; this type of craft is currently in the inventory of vessels operated by US Special Operations Command (USSOCOM). The vessel was assumed to meet the standards set by the International Convention for Safety of Life at Sea (SOLAS) and be modified so that it can accomplish its primary mission which is to support, launch, recover, refuel, rearm, and provide limited maintenance to various-sized craft, to include the Naval Special Warfare (NSW) 11-meter Rigid Hull Inflatable Boat (RHIB) and a vessel similar in configuration and capability to the MK V Special Operations Craft (SOC), which was retired in late 2012. The cost of all modifications to the CSV to accomplish its missions during the wargame analysis is captured in a later section, "Cost Versus Capabilities Trade-offs." For the purposes of the wargame, we assumed the CSV was armed with two .50 caliber machine guns and had four RHIBs.

The High-Speed Vessel X-1 *Joint Venture*

After the terrorist attacks on the World Trade Center in New York on September 11, 2001, USSOCOM negotiated to take the last two years of a five-year split lease of the HSV X1 *Joint Venture* that was managed jointly by the Army and Navy. The purpose of taking over the lease was to evaluate the vessel's ability to perform specific missions and to conduct limited operational experiments in order to assess the vessel's usefulness in maritime IW applications. Essentially a high-speed catamaran originally designed as a ferry, the HSV was modified for military purposes. The HSV was used by USSOCOM in many areas of the world, including the Philippines, over this two-year span and even used as part of the invasion force for Operation Iraqi Freedom by speeding it into the shallow regions of the Persian Gulf. Use of the vessel was discontinued when its lease expired after two years. There were no other high-speed catamarans commercially available to replace the vessel when its lease expired, and all other catamarans with suitable configurations or capabilities were either already under charter or not available in a timely manner (MSC, 2010). The HSV has a length of 331 feet, a beam of 87 feet, and a helicopter pad capable of accommodating a MH-60R helicopter. For the purposes of the wargame, we assumed the vessel was armed with one 25-mm gun, two .50 caliber machine guns, two MK-19 40-mm belt-fed automatic grenade launchers, and had two 11-meter RHIBs.

The LCS-1 *USS Freedom*

The *USS Freedom* is part of a new class of ship designed specifically to support "A Cooperative Strategy for 21st Century Seapower," which outlines how Navy, Coast Guard, and Marine Corps maritime power will be used to protect vital US interests over the next several decades. The *USS Freedom* is designed to conduct shallow water missions in the littoral to include engagement of small boats, antisubmarine operations, mine-sweeping, and humanitarian operations. With a speed of 45 knots, one 57-mm gun, two 30 mm cannons, four .50-caliber machine guns, and a helicopter detachment consisting of a single MH-60R with a helicopter pad and a plan to add a vertical take-off unmanned aerial vehicle, the LCS is fast, lethal, and can react to a wide range of contingencies.

Wargame Description

The wargame simulation conducted to evaluate the capabilities of each vessel in a maritime IW scenario was set in the Republic of the Philippines (see Figure 2).

Figure 2. Republic of the Philippines: Setting for the wargame exercise.

The wargame was an open-seminar exercise adjudicated and run by a moderator and assisted by several monitors and "red team" members whose role was to act as adversaries during specific scenarios. The game board was a computer-generated map display that included custom game piece icons with a separate fuel gauge and fuel use manager that calculated and monitored fuel burn rate.

Each vessel was evaluated across all vignettes in a single session across a three-day period and was commanded by a single captain who acted as a subject matter expert (SME) and responded to events in each vignette. The captains of the HSV-X1 *Joint Venture* and the CSV were retired US Navy commanding officers and the captain of the LCS-1 *USS Freedom* was that ship's former navigator who had recently finished a tour.

Each of the three vessels was run through four vignettes that required the vessel captain to conduct one or more maritime IW missions identified in Table 1. The vignettes, as well as the maritime IW mission sets corresponding to them, are described in Table 2.

These vignettes were designed to evaluate each ship's ability to accomplish designated missions, the logistics requirements and limitations (fuel usage and duration at sea) of each vessel, and the time each vessel required to arrive on scene for each mission, as well as the total time required to complete all missions. Vessels were required to return to base whenever their respective fuel level was near or below 20 percent of the total fuel capacity. There was only one possible logistics services port (Cebu), and follow-on vignettes could not be executed until all civilians (other than the civilian mariners that were a part of the crew of the CSV and HSV) had been delivered to a safe port.

Vignette 1: Humanitarian response. In the first vignette, a ferry capsized 50 nautical miles (nm) away, and support was needed by the candidate ship (CSV, HSV, or LCS) as soon as possible to quickly recover 400 civilians. The candidate ship's captain needed to utilize available assets (e.g., RHIBs, MH-60R, and MK Vs) to recover personnel as quickly as possible. Each captain was presented with medical casualties from the capsized vessel and needed to both provide medical support and transport casualties to proper facilities.

Table 2. Vignettes used in the wargame simulation exercise.

Vignette	Description	Maritime IW Mission Set
1. Humanitarian response	Support rescue operations of 400 victims of a capsized ferry and evacuate three medically urgent cases for surgical care	Civil-military operations; building maritime partner capability and capacity
2. Insert Special Operations Forces (SOF)	Transit to support insertion of SOF assets in response to a terrorist bombing and provide support for a medical emergency	Security force operations and assistance; counterterrorism/piracy/narcotics; building maritime partner capability and capacity
3. Conduct Noncombatant Evacuation Operations (NEO)	Conduct NEO of 12 American citizens	Security force operations and assistance; counterterrorism/piracy/narcotics
4. Defend against fast boats	Defend against a coordinated speedboat attack	Counterterrorism/piracy/narcotic ISR

Vignette 2: Insert special operations forces and conduct security operations. In the second vignette, an improvised explosive device (IED) was used in an attack on a government building on Negros Island. The vessel was 125 nm away, and SOF support was needed as soon as possible to extract casualties and secure the area. At least one medical casualty needed to be evacuated and the responding vessel had to provide medical support by utilizing its available assets.

Vignette 3: Conduct evacuation operations. In this vignette, increased hostility on the island of Negros resulted in the need to evacuate American citizens from the embassy. The mission for the SOF was to evacuate 12 American citizens, who were 100 nm from the vessel's location.

Vignette 4: Defend against small boats. During the final vignette, vessels were attacked within 20 nm from the port of Cebu as they were heading inbound to refuel. Three small boats harassed the inbound vessel and the ship's captain had to utilize available assets and the ship's native capabilities to defend the ship against the small-boat attack.

Wargame Results

The metrics of merit that were used to judge the most capable platform were mission completion time, scenario completion time (time to complete all four mission vignettes), average vessel speed, and fuel consumption. The LCS was considered the most capable ship for the vignettes encountered due to its embarked helicopter detachment, its defensive capabilities, and its ability to deal with unforeseen emergencies. The HSV was also considered to be very capable due to its speed and flight deck. However, utilization of the flight deck depended upon external assets; during the wargame simulation, the needed helicopter assets were available but were two hours away and, unlike the LCS, not organic to the HSV itself. Furthermore, the HSV's high rate of fuel consumption and its limited defensive measures were considered to be capability gaps for this platform. Finally, the CSV was seen as being severely limited in its ability to deal with unforeseen emergencies due to its slow speed and dependency on external assets. However, the CSV had the lowest fuel consumption—6,713 total gallons compared to 245,609 total gallons and 41,919 total gallons by the HSV and LCS, respectively.

COST VERSUS CAPABILITIES TRADE-OFFS

Having evaluated each vessel's capability to perform a variety of maritime IW missions, we now calculate the cost per day of putting those capabilities on station at any given time. Evaluating each vessel on a cost-per-day basis provides decision makers with an assessment of the costs of deploying a specific capability for a given mission over a discrete time period, and further simplifies the determination of anticipated costs for the duration of a mission.

For each vessel, we collected data on the capital costs (such as acquisition and procurement), or lease costs, as well as the operating and support (O&S) costs. We do not discount the costs because the purpose of the cost analysis is not to arrive at a precise cost for each vessel but instead to illustrate the relative costs between each vessel to facilitate decision making with respect to which vessel type would be best to employ in support of different scenarios. Discounting costs would be simple to implement and would provide numerical values different from the ones presented here but would not change the analysis itself or the conclusions.

The cost data collected for the LCS was gathered from reports by the Congressional Research Service (O'Rourke, 2011) the Government Accountability Office (GAO, 2010), and a Congressional Budget Office report (CBO, 2010), which are based upon US Navy cost estimates. We used the lowest estimate we could find at $480M per vessel for the purpose of our analysis.

Costs for the CSV were collected from actual budget-and-spending documents at Navy Special Warfare Command (NAVSPECWARCOM). Costs for the HSV were obtained through conversations and correspondence with the Military Sealift Command (MSC) and are based upon actual costs in a previous lease contract for the HSV-2 *Swift*, which is an identical hull form and a vessel very similar to the HSV-X1 *Joint Venture.*

Table 3 shows the cost breakdown for the LCS in dollars based upon estimates by the US Navy and analyzed by either the CRS or the GAO. Estimated costs for the LCS have increased significantly over time. The original LCS cost cap of $220 million per vessel that was established in the FY2006 *Defense Authorization Act* has since grown to a conservative estimate of $480 million per vessel for those that are procured beyond 2010 (O'Rourke, 2011).

The US Navy's estimate of $480 million per unit for the LCS-1 assumes a 25-year service life for the sea-frame and a 30-year service life for each of the four planned mission modules (the mine-warfare module, the antisubmarine warfare module, the surface-warfare module, and the maritime-security module). The $61.7 million per year in operating costs per vessel is an estimate that includes the cost to operate and support a mix of the two sea-frames plus one year of mission-module cost (GAO, 2010); because there are two sea-frames in competition, and the Navy has yet to select one of them, the estimated costs for the LCS are a mix of the two. The sea-frame portion of the O&S costs includes unit-level manpower; unit operations; maintenance; sustainment and support; system improvement; disposal; and command, control, communications, computers, and intelligence (C4I). The mission-module portion of the O&S costs includes food and berthing, maintenance and repair, personnel, training, fuel, supplies, expendables, hardware, and engineering and technical support. Although the $61.7 million estimate for O&S costs may seem high for the LCS-1, it should be noted that these are estimates and that estimates for the LCS have tended to increase (rather than decrease) greatly over time. To calculate the cost per day to deploy the LCS-1 for a maritime IW mission, we take the estimated cost per vessel of $480 million and divide it over the 25-year planned lifecycle, which gives a cost of $19.2 million per year. Next, we add the $61.7 million per year O&S costs and divide the sum by 365 days, which results in ($19.2M + $61.7M) $\div$ 365 $\approx$ $222,000 per day.

Table 3. LCS unit and O&S costs.

LCS-1	Cost
Unit cost	$480,000,000
O&S costs	$61,700,000
Cost per day	$221,644

The HSV-2 *Swift* is a leased vessel that is currently operating as a Global Fleet Station Ship. The lease was for one year with three one-year options. The daily rate for the HSV-2 *Swift* was $50,000 (which included the cost of maintenance, repair, and a civilian-contracted crew) and we have estimated the annual lease cost based upon this daily rate to be $18.25 million ($50,000 $\times$ 365 days = $18,250,000). The food and berthing costs for the HSV-2 *Swift* were $30 per day for the 20-person military detachment (MilDet). We therefore have the estimated total annual food and berthing costs (excluding the food and berthing costs for the civilian crew, which are already captured in the daily rate) to be $219,000 ($30 × 20 (person MilDet) × 365 days = $219,000). The fuel costs associated with both the LCS-1 and the HSV-2 can vary widely depending upon the number of days the vessel is at a particular speed. To estimate the fuel costs, we used fuel cost curves provided by the MSC that give the estimated fuel usage for various vessels, and developed an operating-speed profile that assumes the number of days the vessel will have its engines running and the speed at which the vessel will be operating.

After discussions with the representatives at the MSC who were familiar with the HSV-2 *Swift*, and referring to observations during our wargame to evaluate vessel capabilities, we made some assumptions about the HSV's fuel consumption and operating speeds (reported in Table 4). We assumed that the crew of an HSV deployed in a maritime IW environment would operate its engines 265 days per year; during the other 100 days the crew would perform maintenance or have other engine downtime events, such as port visits. The assumed operating-speed profile is given in Table 4. The HSV-2 Swift consumes 420 gallons per day at idle, 14,906 gallons per day at 15 knots, and 36,788 gallons per day at 25 knots. After discussions with former commanders of the HSV we developed operating speed profiles to estimate the amount of fuel consumed. We have assumed that an HSV deployed in a maritime IW environment would idle 15 percent of the time and that it would operate at 15 knots 70 percent of the time and at 25 knots 15 percent of the time. Under this operating-speed profile, the annual fuel costs would be $13.156 million per year; however, it should be pointed out that operating speed and fuel consumption greatly impact total cost estimates.

Our estimate of the cost per day to bring a leased HSV on station to support maritime IW (Table 5) is $86,645, which is the sum of the lease cost ($18.250 million) + the operating costs, consisting of fuel, food, and berthing ($219,000 + $13.156 million) ÷ 365 days.

The CSV is under a one-year firm-period lease with three one-year option periods and one 11-month option period. The CSV operates approximately 265 days per year, which is the same assumption used to conduct the HSV analysis. The baseline costs of the lease include the daily rate of $18,104 (or an annualized daily rate of $6.608 million), Navy administrative costs of 5 percent on the total lease budget, and MSC administration costs, which are 5 percent of the total lease cost. Actual FY09 costs for fuel were $2.2 million, port costs were $88,000, food and berthing costs were $84,000, and travel costs were $216,000, resulting in a total lease spend of $10.157 million. The cost per day (see Table 6) to deploy CSV in the maritime IW environment is $28,000 ($7.569 million in baseline costs + $2.588 million in O&S costs, then divided by 365).

Table 7 summarizes the cost analysis of the LCS-1, the HSV-2 *Swift* and the CSV. By calculating the cost per day to bring a particular vessel into a maritime IW environment, and then combining this information with evaluations of the vessel capabilities to achieve particular mission sets, decision makers may be able to make better choices about how to deploy different assets in different scenarios. The LCS-1 brings considerable ISR, maneuverability, and firepower to any operation relative to the HSV or CSV. However,

Table 4. Fuel costs of HSV.

Speed (knots)	Fuel Consumed (per day in gallons)	Percentage of Days Assumed Operating at Speed	Estimated Gallons Consumed (in millions)	Estimated Fuel Cost (in millions)
0	420	15	16,695	$51,755
15	14,906	70	2,765,026	$8,571,580
25	36,788	15	1,462,315	$4,533,177
Total		100	4,244,036	$13,156,511

Table 5. HSV lease and O&S costs.

HSV-2 *Swift*	Annual Cost
Baseline lease costs	
Daily rate	$18,250,000
O&S costs	
Food and berthing (per year)	$219,000
Fuel	$13,156,511
Cost per day	$86,645

to do so, the LCS-1 costs approximately $222,000 per day. The HSV offers maneuverability and considerable capacity at a rate of approximately $87,000 per day. The CSV offers utility and economy at approximately $28,000 per day.

ALIGNING VESSELS WITH MARITIME IW MISSIONS

Earlier we stated that maritime IW is a multidimensional concept and that there are identifiable activities, or mission sets, associated with its conduct (see Table 1). Accordingly, there is no universal vessel appropriate for all maritime IW environments, either from a capability or cost perspective. To illustrate this point, we considered four hypothetical scenarios, similar to real-world areas of operation, with varying degrees of demand for each of the mission sets. These scenarios were intended for use as an instrument for discussing vessel applicability within certain contexts that may share characteristics of a specific geographic region or area of operations. Discussing each vessel in the context of a scenario demonstrated the type of cost and capability trade-offs that must be made when deciding what types of assets and resources should be deployed, assuming a mission duration and timeline, to achieve a desired result.

Table 6. CSV lease and O&S costs.

CSV	Annual Costs
Baseline lease costs (FY09)	
Daily rate	$6,608,000
Navy administration costs (5%)	$512,000
MSC administration costs (5%)	$449,000
O&S costs	
Fuel	$2,200,000
Port costs	$88,000
Food and berthing (per year)	$84,000
Travel costs	$216,000
Cost per day	$27,827

Having explored the relative merits and capabilities of each vessel across each of the identified maritime IW mission sets (see Table 2) during the wargame simulation, and having determined a cost-per-day to deploy each vessel, we now illustrate how our method could be used to assign vessel types to particular operational or geographic environments to accomplish specific IW objectives.

Maritime IW Scenarios

In developing the hypothetical scenarios, maritime IW activities were weighted based on discussions and interviews with SMEs and practitioners of surface warfare and naval special warfare. For each scenario we have given it a regional identifier which may or may not represent the *exact* distribution of mission set activities but are meant only for illustration and discussion purposes. Figure 3 illustrates the distribution of the weighted percentages among the scenarios.

Scenario 1: Maritime partnering, capacity-building, and counterterrorism. Scenario 1 emphasizes the building of maritime partner capability and capacity as well as counterterrorism with some degree of civil-military assistance, security force operations and assistance, and ISR. The primary objective in this scenario is to "win hearts and minds" in order to train a host nation's forces to combat terrorism and insurgency, as well as provide effective humanitarian relief and rapid response in case of a disaster such as a typhoon or ferry sinking not unlike operations ongoing in the Philippines today. In this type of situation, a prolonged presence should be anticipated and sustained support for forces would be required. Although sleek and swift vessels such as LCS-1 and HSV can offer rapid response to a host of isolated situations within this scenario, their

Table 7. Summary of vessel costs per day.

	LCS-1	HSV-2 Swift	CSV
Unit cost	$480,000,000		
Baseline lease cost		$18,250,000	$7,569,000
Operating and support cost	$61,700,000	$13,375,511	$2,588,000
Cost per day	$221,644	$86,645	$27,827

fuel consumption alone makes them cost prohibitive when considering a long dwell time. Furthermore, any extended presence of a gray-hulled vessel will attract the attention of the local population.

For extended support of SOF in the region, a vessel such as the CSV might be preferred. Its commercial paint scheme allows it to blend in with commercial vessels, while its slow, lethargic pace and capacious deck and habitability spaces offer low fuel consumption and provide a sustainable floating hotel for SOF. Additionally, the civilian crew of a chartered vessel blend in with local mariners and do not draw unwanted attention when going to port for fuel or repairs.

The use of smaller, slow, mothership-type civilian vessels can be extremely effective when working in conjunction with small attack helicopters (AH-6 or similar) or combatant craft detachments (such as the MK V). This strategy was proven during the "Tanker Wars" (1987–1988) in which SOF leased two oil field support barges for $21,000 per day to respond to Iranian mine attacks on oil tankers while simultaneously keeping a low profile so as not to provoke an outright war (Zatarain, 2008).

Scenario 2: Counterpiracy. In Scenario 2, the highest level of effort was placed upon counterterrorism, counterpiracy, and counternarcotics. SOF and conventional naval operations would work together to fight against state sponsors of terrorism. From a maritime IW perspective, this would include maritime interdiction operations (MIO), which typically employ visit, board, search, and seizure (VBSS) teams. These teams may consist of SOF, conventional sailors from ships' company, or US Coast Guard law enforcement (LE) detachments. In this type of scenario, a slow, minimally armed commercial vessel would probably be less than ideal, as is little more than a floating target for even the most primitively equipped aggressors. Cost would be less of a factor, as a combatant commander would want a vessel with combative capability. Because of the incorporation of conventional naval operations, sustained SOF support would not be much of a requirement, since specific SOF boarding teams would probably be temporarily embarked on a combative vessel for limited periods of time. A LCS or frigate could perform this mission adequately, and, given an assumed heated environment in which pirates, terrorists, or narcotraffickers are operating with impunity, political sensitivity to a warship off the coast would probably be irrelevant, as is the case in the vicinity of the Horn of Africa.

Scenario 3: Maritime capacity-building and security force assistance. Scenario 3 represents a context somewhat similar to that encountered in Scenario 1. However, in this scenario, the overarching

Maritime Irregular Warfare Activities	Scenario 1 *Philippines*	Scenario 2 *Horn of Africa*	Scenario 3 *Gulf of Guinea*	Scenario 4 *South America*
Security Force Operations and Assistance	10%	20%	10%	20%
Civil-Military Operations	10%		20%	10%
Counterterrorism/piracy/narcotics	30%	70%	10%	50%
Building Maritime Partner Capability & Capacity	40%		60%	
Intelligence, Surveillance, and Reconnaissance	10%	10%		20%

Figure 3. Maritime IW scenarios.

emphasis is on building maritime partner capability and capacity as well as conducting civil-military operations. In October 2007, US Naval Forces Europe launched the African Partnership Station (APS) and the dock landing ship *USS Fort McHenry* (LSD 43) was deployed to the Gulf of Guinea to serve as a floating schoolhouse to provide "training focused on maritime domain awareness and law enforcement, port facilities management and security, seamanship/navigation, search and rescue, leadership, logistics, civil engineering, humanitarian assistance and disaster response" (Ploch, 2009). Different vessels (such as the CSV) may serve as a platform for the African Partnership Station, but an amphibious warfare ship, though costly, may be desired by combatant commanders, as it provides ample room for cooperative military training, berthing, and medical facilities. These vessels have a minimal footprint onshore, and their relatively shallow draft allows them to pull into austere ports to perform a variety of community relations projects.

Scenario 4: Counternarcotics and ISR. In the final scenario, we considered a context in which the counternarcotics mission was the primary focus. A fast and agile vessel would be preferred to intercept the stereotypical drug-runner speedboats that are often portrayed in the media. The US Navy commonly and successfully uses frigates with US Coast Guard LE detachments for this mission. The *USS Freedom* has been successfully employed in this role as well and has interdicted several vessels and seized several tons of cocaine in US 4th Fleet's Area of Responsibility. However, a more cost-effective method for counternarcotics operations might be the employment of the PC-1 Cyclone Class. These patrol craft do not have as sophisticated weapons systems as frigates or the LCS, but they do have the speed and firepower to satisfy the mission. The LE detachments and special warfare teams can be embarked, and the PC's shallow draft allows it to proceed close to the beach, should any shoreline maritime IW missions need to be fulfilled. RAND also conducted a study to examine the feasibility of using the PC-1 Class as a small ship for use in theater security cooperation (Button et al. 2008). The PC would be given an updated propulsion system and improved C2, as well as a stabilized 25-mm gun. Incorporating a mothership concept, RAND found that the PC-1 would be rendered fully capable in theater security cooperation missions, and this would likely be a more cost-effective way to conduct maritime IW operations, such as the one outlined in Scenario 4.

CONCLUSIONS

We have illustrated a method of combining wargaming with cost analysis to explore alternative resources or systems that may be employed to support maritime IW operations. The wargaming findings were supported by SMEs that made credible decisions that reflect appropriate utilization of the maritime vessels under study in each scenario. Though our wargaming findings are scenario dependent the scenarios used are illustrative of common maritime IW mission sets that can be expected to be supported currently and in the future. The cost analysis was conducted in such a way as to make comparisons at an operational deployment level – measuring the cost to operate each vessel on a daily basis – to illustrate the economic implications of using specific resource types for specific scenarios.

In the future, as in the past, the US military will have to respond to a wide range of scenarios, and maritime IW is becoming an increasingly significant part of the Navy's mission. Senior-level decision makers, both military and civilian, must decide on the nation's objectives and strategies—which include but are not limited to the National Security Strategy, Defense Planning Guidance, Defense Planning Strategy, Steady-State Security Posture scenarios—and then acquire the appropriate capabilities and platforms to meet those objectives and strategies. As the defense budget becomes more constrained, all viable options to pursue needed technologies or weapon platforms should be considered. Our findings are consistent with those of Hughes et al. (2009) in their description of how the Navy can develop "a more distributed combat capability for sea control and the projection of national influence from the sea" through the acquisition of smaller, single-purpose vessels. Because of the cost advantage of the CSV, two or three of these vessels could be deployed in an operational area at the same cost per day or less than the HSV or LCS, therefore ameliorating the disadvantage of being slowest to arrive at a scene of action.

Gompert and Gordon (2008) found that the average length of an insurgency is more than a decade. If the United States is to deploy maritime forces in support of counterinsurgency or irregular operations, then it is likely that assets deployed to support those forces will dwell for an extended period of time. At $222,000 per day deployed continuously over 10 years, the LCS-1 would cost roughly $800 million versus a vessel like the CSV which would cost $94 million over the same period. This is a difference of $700 million and does not include the costs of rotating the LCS-1 every six months, which is part of the current concept of operations for the vessel. Given the differentiated costs of the three vessels we studied as candidates to support maritime IW, it would be prudent to send the vessel that provides the needed capability (as dictated by the tasks necessary to achieve a mission within a given region or maritime IW scenario) at the lowest possible cost.

There are also benefits to lease-chartering vessels in support of maritime IW to include lower upfront costs (if the cost of procurement is extended over the useful life of a vessel), faster response times, and better value for taxpayers' money, particularly for those assets and platforms that do not require an extensive acquisition process and can be purchased commercial off-the-shelf (COTS) or contracted through commercial companies. Lease-charters offer far more flexibility in highly dynamic operational environments since option years can be exercised at the discretion of the lessor. The flexibility of exercising future options allows the lessor to find the best vessel to meet current end-user requirements, whereas vessel procurement incurs a likely 30-year obligation to support, maintain, and utilize a vessel and limits the capacity to adapt to changing end-user requirements. By evaluating the specific operational need for various maritime IW environments the Navy may determine the correct mix of vessels to retain or acquire for its inventory and assign those vessels to missions accordingly in order to achieve the proper mission effect which achieving economic efficiency.

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