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Littoral Combat Ship and Expeditionary Fast Transport: Their Utility as Support Platforms during Humanitarian Aid / Disaster Relief Operations

December 2020

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Prepared for the Naval Postgraduate School, Monterey, CA 93943.

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ABSTRACT

Over the last several decades, there has been an increase in U.S. naval involvement in supporting humanitarian assistance, disaster relief (HA/DR) operations. Cruiser and destroyer (CRUDES) platforms, two of the most heavily employed platforms in the United States Navy, are frequently tasked outside of their primary mission sets as a result of HA/DR events, both natural and man-made. This has placed enormous pressure upon these units, their crews, and fleet commanders, specifically in how to best prioritize their use for maximum mission accomplishment. Our analysis provides side-by-side comparisons of the cost and capabilities of the LCS and T-EPF platforms to CRUDES assets and describes their ability to effectively support HA/DR operations. This analysis gives senior leadership and mission planners objective information regarding viable alternatives that could allow CRUDES assets to maintain focus on their primary mission objectives while maintaining the necessary flexibility to support HA/DR operations.

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ABOUT THE AUTHORS

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LIST OF ACRONYMS AND ABBREVIATIONS

ASW	anti-submarine warfare
C2	command and control
CG	guided missile cruiser
CJCS	Chairman of the Joint Chiefs of Staff
CRUDES	cruiser and destroyer
CSG	Carrier Strike Group
DDG	guided missile destroyer
DoD	Department of Defense
ESG	Expeditionary Strike Group
FFG	guided missile frigate
FON	freedom of navigation
HA/DR	humanitarian assistance and disaster relief
IW	irregular warfare
JTF	Joint Task Force
LCC	amphibious command ship
LCS	littoral combat ship
LEO	law enforcement operations
LSD	dock landing ship
LHD	amphibious assault ship (multipurpose)
MCM	mine countermeasure
MEU	Marine Expeditionary Unit
MP	mission package
NEO	noncombatant evacuation operations
RORO	roll-on/roll-off
SAR	search and rescue
SOF	special operations forces
SOUTHCOM	U.S. Southern Command
SUW	surface warfare
T-EPF	expeditionary fast transport
USAID	U.S. Agency for International Development

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I. INTRODUCTION

The U.S. Navy's current motto of "a global force for good" is consistent with its existing role in world events and conflicts. From acting as a protector of maritime law through presence operations, to supporting allies in armed conflict, and in more recent history, responding to countries experiencing catastrophic weather events, the U.S. Navy's resources constantly flex to meet the ever-evolving demands placed upon it. This lives up to the Department of Defense (DoD) mandate that the U.S. Armed Forces should be proficient in their abilities to "conduct, support, and lead stability operations with a level of proficiency equivalent to combat operations" (Chairman of the Joint Chiefs of Staff [CJCS], 2016). With its cruiser and destroyer (CRUDES) ship platforms, the Navy can execute multiple mission sets effectively as evidenced by their ability to quickly transition from integrated strike group operations to independent operations as the orders are given.

However, the strain on these platforms is beginning to show, and CRUDES are becoming so task-saturated that they are often called away from their primary mission areas to support emergent events such as humanitarian assistance/disaster relief (HA/DR; Apte & Yoho, 2018). The concept of the optimal HA/DR platform has been widely researched, and data has shown that CRUDES assets bring little utility to HA/DR operations (Apte & Yoho, 2018).

The presence of a U.S. asset sent quickly to provide HA/DR support provides positive, intangible effects that cannot be overstated. Maritime platforms such as the Littoral Combat Ship (LCS) and Expeditionary Fast Transport (T-EPF) can be considered viable platforms that would not only reduce the strain on CRUDES assets by undertaking missions such as HA/DR, but also provide that intangible relief that affected countries experience knowing a swift U.S. response team will be on the way to provide support as well.

The goal of our research is to examine the capabilities of the LCS and T-EPF as "first-responder" platforms during initial relief efforts. Our secondary goals are to examine the cost effectiveness of the LCS and T-EPF as compared to CRUDES assets, as well as their ability to be as effective in supporting HA/DR missions as their CRUDES counterparts. While it is widely recognized that the CRUDES platforms are severely limited in their ability to respond when diverted to a crisis, we propose that perhaps a more direct approach of outfitting the LCS and T-EPF platforms' modular mission bays with a critical aid package and potentially utilizing the two platforms in tandem during the initial onset of a disaster may provide the support that is lacking from the separate CRUDES assets.

A. BACKGROUND

The United States has refined its HA/DR response over the last 15 years, taking lessons learned from each operation and using the data to determine the optimal mix of ships and relief supplies and services necessary to meet each HA/DR mission. Everything from Carrier Strike Groups (CSG), Amphibious Readiness Groups (ARG), and independent deployers have been used to respond, and these units often have taken the lead in relief efforts. The common thread seems to be that a swift U.S. response is generally what initiates relief efforts until outside support is able to arrive on scene. CRUDES response to these disasters has been mixed, with several units at a time responding initially until the Strike/Readiness Group is able to arrive, at which point all ships work in concert to support the relief effort. To better illustrate this point, we mention a few key disasters in which the United States was a key player in providing HA/DR assistance with naval assets.

1. 2004 Indian Ocean Tsunami: Operation Unified Assistance

On December 26, 2004, an enormous earthquake struck the western coast of Indonesia. The magnitude 9.0 quake triggered a massive tsunami, with the wave heights reaching up to 100 feet high. Thousands of people were reported missing throughout the region, and approximately 175,000 total deaths were recorded across Indonesia, Sri Lanka, India, and Thailand (Reid, 2019). Six months following the event, United Nations Secretary General called the earthquake the "largest natural disaster the organization has had to respond to on behalf of the world community, in the 60 years of our existence" (Sida & Wiles, 2006).

In response to this calamity, the United States dispatched Carrier Strike Group Nine, led by USS *Abraham Lincoln* (CVN 72) and its complement of support ships USS

Shiloh (CG 67), USS *Shoup* (DDG 86), USS *Benfold* (DDG 65), and USNS *Rainier* (T-AOE 7), to provide support to Indonesia. An Expeditionary Strike Group (ESG) led by USS *Bonhomme Richard* (LHD 6) and its accompanying ships which included USS *Milius* (DDG 69), USS *Thach* (FFG 43), and USS *Bunker Hill* (CG 52) were also diverted to provide support (Elleman, 2007). These assets along with a contingent of DoD civilian support units and first responders made up Operation Unified Assistance. As an aside, a general poll conducted after the disaster regarding the Indonesian population's views towards America's response indicated a 23% increase in positive public opinion (Wike, 2012).

2. 2007 Cyclone Sidr: Operation Sea Angel II

On November 15, 2007, Cyclone Sidr made landfall in Bangladesh and India, causing extremely high winds and massive flooding across the area. The Category 4 storm produced surges as high as 10 feet off the coastal areas, breaching its coastal and river embankments. The corresponding wind and flood damage decimated local fishing agricultural centers, destroyed schools and houses, and severely damaged many heritage sites. The flooding contaminated the drinking water supply with refuse and debris and left many areas without power. Approximately 3,400 people were killed, with thousands more missing or otherwise unaccounted for and close to 55,000 injured. The estimated damage to the region was approximately $1.7 billion, and to make matters even worse, this was the second natural disaster to hit the area in a 12-month span, the first being the monsoon season that caused almost $1.1 billion in agricultural losses and physical damage.

In response to this event, the Navy dispatched its closest asset, USS *Hopper* (DDG 70), a Flight II Guided Missile Destroyer, to the region. Due to the bottom topography of the region and the draft of the warship, *Hopper* was unable to provide any measurable response to support relief efforts (Apte & Yoho, 2018). The amphibious assault ship USS *Kearsarge* (LHD 3), along with elements of Amphibious Squadron 8 and the 22nd Marine Expeditionary Unit (MEU), were diverted from their Western Pacific deployment and arrived in the region on November 22, 2007, delivering over 12,000 gallons of fresh water and over 73,000 pounds of relief aid to the storm-ravaged region. *Kearsarge* was relieved by USS *Tarawa* (CV 40) and the 11th MEU on December 3, 2007, which provided additional assistance in the region until the situation had stabilized enough for their departure (Kingsley & Vernon, 2011). A poll conducted after the relief efforts trended in favor of the U.S. response, though there were some negative press articles regarding the initial coordinating efforts (Kingsley & Vernon, 2011).

3. 2010 Haiti Earthquake: Operation Unified Response

On January 12, 2010, a 7.0-magnitude earthquake struck Haiti, one of the most impoverished countries in the world. The epicenter of the earthquake was the capital city of Port-au-Prince, home to more than two million people. Aftershocks continued throughout that same day, and over 50 more were recorded over the following two weeks. It was the most devastating natural disaster to ever strike the country, claiming over 230,000 lives and injuring or displacing several hundred thousand more (History, 2010).

The catastrophic effects extended to the country's infrastructure and government as well. The quake decimated the presidential palace and many of the government ministry buildings, seriously damaged all the hospitals in Port-au-Prince, and made its airport and seaport completely inoperable. Major roadways were made impassible due to debris and physical damage, power losses greatly reduced available communications services, and over 300,000 buildings and residences sustained either significant damage or had completely collapsed. As a result, the Haitian government made an immediate request for assistance from the United States (History, 2010).

In response, the United States pledged its full support, directing a response led by the U.S. Agency for International Development (USAID) and the U.S. military. The Navy's response was led by the aircraft carrier USS *Carl Vinson* (CVN-70) and included the cruisers USS *Normandy* (CG-60) and USS *Bunker Hill* (CG-52), the destroyer USS *Higgins* (DDG-76), the frigate USS *Underwood* (FFG-36), as well as a host of other platforms. The collective DoD effort was titled Operation Unified Response and continued to provide vital relief supplies and support to the stricken nation until June 1, 2010 (Margesson & Taft-Morales, 2010).

4. 2011 Japan Tsunami: Operation Tomodachi

On March 11, 2011, northeastern Japan sustained a 9.0-magnitude earthquake (Carafano, 2011). Considered the largest earthquake in this region, it caused a tsunami with waves over 24 meters in height that swept across the region, causing destruction of infrastructure that comprised the road network, ports, railroads, and 190,000 buildings (Kajitani et al., 2011). Over 28,000 people were recorded as either dead or missing, and damage to the country's infrastructure led to the complete loss or shortages of drinking water, shelter, electricity, and food. Over 15 million people in total were affected, and the destruction cost was estimated between $122 and 305 billion.

A significant consequence brought on by the disaster was the damage to the Fukushima Daiichi nuclear plant. The power loss and subsequent flooding caused by the earthquake rendered the generators unusable, resulting in the inability to cool the reactors and the pool for fuel rod storage. This caused overheating, which led to the release of radiation into the air, ground, and water. This was considered the highest level for a nuclear event on the International Nuclear and Radiological Event Scale recorded to date (Norio et al., 2011).

Though officials ordered the evacuation of the area, some survivors stayed due to lack of transportation or fear of further exposure to radiation. While Japan has an earthquake warning system run by the country's meteorological agency, the system was not entirely effective in this instance because some locations were not alerted due to lack of power and other areas did not respond because they had grown complacent from past false positives. It is difficult to evaluate the benefits of the system given these factors, but with a culture that educates about tsunamis coming after an earthquake and the need for preparedness, the early warning system did save lives (Percher, 2014).

In support of the HA/DR operation, 15 U.S. Navy ships provided search and rescue (SAR), delivery of supplies ashore, troop movement, and aircraft refueling operations. Platforms included an aircraft carrier, an amphibious assault ship, three guided missile cruisers (CGs; USS *Cowpens* [CG 63], USS *Chancellorsville* [CT 62] and USS *Shiloh*), six guided missile destroyers (DDGs; USS *Mustin* [DDG 89], USS *McCamble*, [DDG 85], USS *Preble* [DDG 46], USS *John McCain* [DDG 56], USS *Fitzgerald* [DDG 62], and

USS *Curtis Wilbur* [DDG 54]), three dock landing ships, and one amphibious command ship. Support was also provided by eight Military Sealift Command (MSC) ships through the transfer of supplies needed for the relief efforts to responding U.S. Navy ships. Included in the eight MSC ships was one high-speed catamaran, MV *Westpac Express* (Aurelio et al., 2012).

B. MOTIVATION

The Navy, in particular CRUDES assets, has been in an enduring state of doing more with less. The collective strain to fill the mission gap was felt by the DDG and CG platforms with the retirement of the last guided missile frigate (FFG) in 2015. This gap, combined with the increased demand for supporting HA/DR missions, resulted in U.S. Navy ships being diverted over 366 times for humanitarian aid relief operations from 1979 to 2000, as opposed to 22 times for combat operations in the same time period (Apte, Greenfield, Ingram & Yoho, 2013). There is no direct data available to suggest this number has gone up since 2000, but there are indicators that would support this idea. By the DoD's own account, it responds to about 70–80 global disaster events each year alongside other governmental and non-governmental agencies. Due to the overtasking of ships to meet mission requirements, the general wear and tear on these ships increased; extensions on deployments led to longer, more extensive maintenance availabilities that only continued to grow worse over time. The stress on these crews grew at a comparable rate to their ships. The LCS was designed to fill the gap left by the retirement of the FFG platform and was built with modularity in mind to support those missions. As it stands now, the LCS can begin to explore its capabilities in taking HA/DR missions from its CG and DDG counterparts.

II. LITERATURE REVIEW

Before anyone can begin to understand the role the LCS and T-EPF can provide in supporting HA/DR operations, it must first be understood what exactly it is that those operations entail. HA and DR are nuanced in their definitions, so it is important that each is properly differentiated so that the core capabilities and competencies that are required to effectively perform HA/DR can be drawn out. The Navy has spent a considerable amount of effort in establishing baseline requirements for supporting natural disasters, and a wealth of information and research exists to support its claims. While it is widely established that there already exists a “right type” of ship class to support these operations, it is important to note that less capable classes of ships are still an important part of the equation. CRUDES ships, normally part of short-fused HA/DR responses, are spread so thin by the number of missions they undertake that other classes of ships are needed to fill the gaps. Finally, we can begin to address what capabilities the LCS and T-EPF have to provide support when the time is needed.

A. HUMANITARIAN ASSISTANCE

According to Lange and Quinn (2003), humanitarian assistance a collective effort to manage the distress endured by a population as a result of man-made or natural disasters. Supporting efforts include providing shelter to the displaced population and distributing essential supplies like food, water and other necessities to mitigate the consequences of the disaster. Once assistance has been rendered, the affected area is rebuilt and its population rehabilitated to an acceptable, pre-disaster condition. Jakovljecic (1987) states that humanitarian assistance should be a call to action necessitated by extraordinary circumstances in which the basic essential needs of a population are unable to be provided. Jackovljecic later expresses the criticality of organization, a systematic approach, and the inclusion of proactive measures to reduce improvisation, as well as ensuring adequate preparation for unique situations that may occur.

International humanitarian assistance is executed by various international organizations, whether governmental or non-governmental; it is because of the involvement of these organizations that humanitarian assistance efforts are practicable. Jackovljecic goes on to say that these organizations may be humanitarian in nature, meaning they render this kind of assistance as a primary mission, or they may be non-humanitarian, meaning they perform this type of assistance for some other reason. Examples of non-humanitarian organizations providing humanitarian assistance are the United Nations and the U.S. Navy.

B. DISASTER RELIEF

As mentioned earlier, it is important to understand what disaster relief is. The DoD defines a *disaster* in Joint Publication 3-29 as

> a calamitous situation or event that occurs naturally or through human activities, which threatens or inflicts human suffering on a scale that may warrant emergency relief assistance from the United States Government or foreign partners. (CJCS, 2019, p. I-4)

It goes on to define *foreign disaster relief* as

> assistance that can be used immediately to alleviate the suffering of foreign disaster victims that normally includes services and commodities as well as the rescue and evacuation of victims; the provision and transportation of food, water, clothing, medicines, beds, bedding, and temporary shelter; the furnishing of medical equipment, medical and technical personnel; and making repairs to essential services. (CJCS, 2019, p. GL-7)

Non-DoD literature, such as that contained in the New World Encyclopedia (n.d.), also provides valuable information on this topic. Disaster relief, also known as emergency management, can be described as the necessary resources provided to those coping with losses caused by disasters. Effective disaster relief mitigation relies on thoroughly developed and integrated emergency plans involving both governmental and non-governmental agencies. Most countries have specific laws or mandates that outline the procedures for declaring emergencies, and often designate specific agencies to coordinate these relief efforts. While disasters are tragic and result in injuries, losses of life, material goods and property, disaster relief is “a truly human response” (New World Encyclopedia, n.d.).

C. HA/DR CORE CAPABILITIES AND COMPETENCIES

Moffat (2014) identified HA/DR as one of the core capabilities of the National Military Strategy (NMS). The presence of the U.S. Navy at sea projects sea power in maintaining freedom of the sea while deterring terrorism. HA/DR capabilities are valuable in projecting soft power and building positive foreign relationships and foreign perception of the United States. The concept of smart power can be used to explain the relationship between hard and soft power, and how it is essential in achieving strategic U.S. interest through HA/DR operations, which create new alliances while justifying regional presence for deterrence operations (Capie, 2015).

Conducting HA/DR requires a very specific set of competencies that must be performed effectively, and there is an abundant amount of research that outlines the core competencies involved in supporting HA/DR operations. Kovacs and Spens (2007) described the distinct characteristics of humanitarian logistics during disaster relief operations. They explained the gaps or challenges faced during the preparatory, immediate response, and reconstruction phases in executing logistics operations given the complex environment surrounding most disaster relief efforts. They also created a framework that explains the integration of the diverse pool of actors and the logistical processes during disaster relief (Kovacs & Spens, 2007). Additionally, Idris and Soh (2014) identified human resources, logistics, and coordination as the three constructs important for success in HA/DR missions.

By observing the various disaster traits, we can draw connections to the specific relief requirements that can mitigate those traits. Some of the key traits and relief elements are displayed in Figure 1.

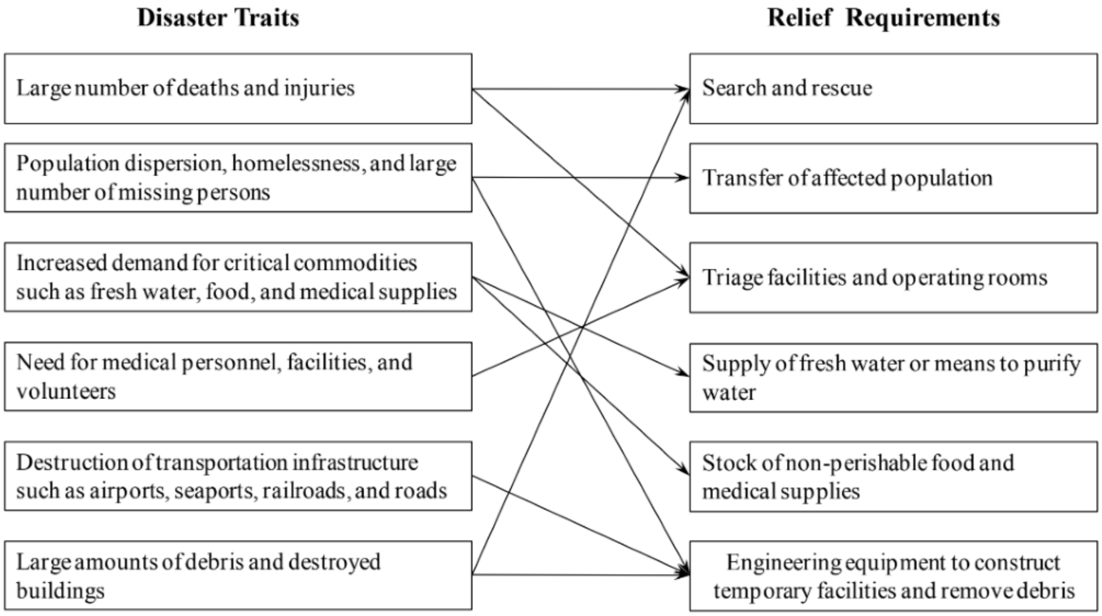

Figure 1. Disaster Traits by Relief Requirements

Demand created by a natural disaster or humanitarian event drives the need for supplies in terms of the resources and support vessels that provide them. It is hard to gauge what sort of emergency resources are going to be needed for any one given disaster, as those will differ from event to event. However, the U.S. Navy has done well to glean data from its years supporting HA/DR events to use in selecting assets capable of rendering the assistance necessary. Kovacs and Spens (2007) explained that the efforts of HA/DR are focused on transporting needed supplies, food, first aid, and equipment to desired locations while rescuing and evacuating affected persons in the disaster area. Humanitarian logistics is absolutely vital to the success of all disaster relief phases. They summarized the characteristics of humanitarian logistics as:

- an aim to alleviate the suffering of survivors
- a general lack of clear focus by the various stakeholders
- variability in supplies
- irregularities in demand
- transportation constraints leading to delays in the supply chain or evacuation
- lack of infrastructure or communication assets

After a catastrophe, the lack of information technology assets creates a gap in communication between stakeholders and in gathering and tracking data. Another challenge is access throughout the disaster area due to lack of infrastructure or road networks (Kovacs & Spens, 2007).

Greenfield and Ingram (2011) took a qualitative approach at addressing some of those critical elements, such as aircraft/landing craft support, search and rescue (SAR), dry/refrigerated goods storage, fuel/water storage capacity or production, medical and personnel support, berthing space, roll-on/roll-off (RORO) capability, and transit speed. These capabilities were ranked among all the maritime platforms available to support HA/DR operations on a scale from 0 to 2, with a 0 indicating the asset has no ability to support a competency, a 1 for having a limited capacity to support a competency, and a 2 indicating the highest level of ability to support a competency (Greenfield & Ingram, 2011).

Based on disaster traits and relief requirements, it is obvious that a CRUDES asset would be ill-suited to support an HA/DR mission on its own; the platforms are simply too small to effectively carry out the mission for an extended period of time based on their general lack of storage, berthing, medical services, water production, and minimal capacity for RORO capabilities (Apte & Yoho, 2018).

D. A FLEET STRETCHED TOO THIN

As previously mentioned, the CRUDES platforms are considered the backbone of the U.S. Navy. They are multimission–capable ships that help the Navy and the United States provide a swift, global response to any threat. Thomas Callender (2017), a former senior research fellow for defense programs, stated

> The U.S. Navy provides a continuous global presence that enables our nation to respond quickly to crises around the world. These operations can range from humanitarian and disaster relief assistance—such as the current post-Hurricane Maria operations in the Caribbean—to support of counterterrorism combat operations in Libya and Syria.

Callender (2017) posited that given the current world climate and the United States' commitments to its allies abroad, the Navy is stretching itself thin to the point of breaking. Global threats posed by the United States' adversaries are typically deterred utilizing

CRUDES assets, whether working in concert with an ESG or a CSG or even acting as independent deployers in line with U.S. international policies. However, with Navy ship numbers being at their lowest point since World War I, a less than 300-ship fleet is going to be hard-pressed to support even its primary missions, let alone a “surge in response to a major regional conflict or crisis” (Callender, 2017). He went on to mention an instance of surge response to an HA/DR mission involving the USS *Wasp*, an amphibious assault ship that was diverted from its primary deployment in Japan to support relief efforts in Puerto Rico, which caused cascading effects on the maintenance cycle of another amphibious assault ship desperately in need of repair. These sorts of cascading effects affect every aspect of the readiness of a ship, from training and deployment length to maintenance availability and crew proficiency. Similarly, the age of the Navy’s assets also does not help in this regard. Callender (2017) continued that all of these issues and reductions in assets “further inhibit the Navy’s ability to surge forces when needed. The Navy’s readiness score of ‘marginal’ in the 2018 Index thus seems well-deserved” (Callender, 2017). Therefore, in terms of meeting the task of power projection and primary mission support, there is a need for assets to assume duties in soft power engagements.

E. LITTORAL COMBAT SHIP

The LCS, part of a program originally announced on November 1, 2001, was intended to be a relatively inexpensive surface combatant for the U.S. Navy that would ideally be a long-term replacement for the guided missile frigate (Work, 2014). According to the OPNAV Instruction 3501.352A which outlines the operational capabilities and environment for the platform, the LCS is expected to “be able to operate offensively in the high-density, multi-threat littoral environment independently or as a member of a CSG, ESG, or surface action group.” To that end, the ship was built with a modular design capable of being reconfigured to perform three primary missions: mine countermeasures (MCM), surface warfare (SUW), and anti-submarine warfare (ASW; Forbes et al., 2013). The one-mission capacity and focus of the LCS would be completely different than the Navy’s most comparable platforms, the CG, DDG, and FFG, which are designed to perform multiple missions at once.

The LCS is further divided into two separate ship classes: Freedom and Independence. The two classes are aesthetically very different in design but share the same key performance parameters. to the OPNAV instruction, the ship is comprised of all the necessary components included on all navy ships such as the basic mechanical, electrical, and computing systems, as well as core systems necessary to conduct operations such as navigation and self-defense. The ships possess the ability to protect themselves from most surface and subsurface threats, but should not operate in heavily opposed air defense environments unless they are "under the air defense coverage of a CSG, ESG, or an air defense asset such as an Aegis cruiser or destroyer" (Office of the Chief of Naval Operations [CNO], 2014). The ships have respective lengths of 387 feet and 421 feet, a cruising speed of 14 knots for up to 3,400 nautical miles, and sprint speed of 40 knots for up to 1,000 nautical miles (CNO, 2014).

The LCS is manned with a crew of 50 sailors, including nine officers and 41 enlisted personnel. In addition to the permanent crew, both classes of the LCS have accommodations for up to 48 additional personnel, for a total of 98 people. The endurance of the LCS is approximately 14 days at sea before requiring a replenishment of provisions. Both ships have a single fueling station, however, unlike other comparable ship classes, the ships lack the capability for connected replenishment. Replenishment of ammunition and other stores is meant to be accomplished either ashore or by vertical replenishment at sea. Each can embark a helicopter detachment with at least one MH-60 helicopter (CNO, 2014).

What allows the LCS to be reconfigured to perform its three primary mission areas is a large, reconfigurable volume for a mission package (MP), which are customizable in order to modify the ship's focused warfighting capability. For instance, in order for the LCS to conduct visit, board, search and seizure (VBSS) operations, the OPNAV instruction outlines the required assets for the LCS' SUW MP to include a maritime security module. Aside from the physical assets required to perform this mission, the MP is accompanied by personnel augmentations necessary to conduct mission-specific operations. The LCS' biggest advantages are its shallow draft, large mission bay, and speed, which allow it to conduct specialized littoral operations such as "special operations forces (SOF) support, search and rescue (SAR), freedom of navigation (FON) operations, noncombatant evacuation operations (NEO), global fleet station, maritime law enforcement operations (LEO), and irregular warfare (IW)" (CNO, 2014).

The OPNAV instruction defines the operating environment for the LCS as "forward-deployed wartime operations within the littoral coalition battle space" in support of a CSG and/or ESG as well as with joint and coalition partners. These operations would be restricted to water and air space occupied by both friendly and adversarial combatants that make timely identification and coordination challenging (CNO, 2014). Operations conducted forward during times of peace are also demanding and may require the LCS to operate in areas that make it vulnerable to potential submarine, land-based missile, mine, terrorist, and other asymmetrical threats (CNO, 2014).

Ng (2012) conducted research that examined whether or not the LCS could be utilized during HA/DR operations. His research goals were to study the viability of using an LCS to conduct these missions and propose possible Concepts of Operations (CONOPs) that would modify the existing IW MP to support HA/DR efforts. His research concluded by recommending that the Navy develop a specific IW MP for the LCS, with its aim being to support HA/DR operations.

F. EXPEDITIONARY FAST TRANSPORT

The Expeditionary Fast Transport (T-EPF), a lightweight, all-aluminum construction, is a unique combination of the attributes of a high-speed transport with a commercial ferry design. The platform, initially called the Joint High-Speed Vessel, weighs 1,646 tons, measures 338 feet long, and is considered the seafaring equivalent of a cargo aircraft. From a cost perspective, the T-EPF is considered a low-cost option to perform the mission, as the first-of-class ship was delivered at a cost of $185 million. Its mission is logistical in nature, able to rearrange and reconfigure medium payloads of supplies and operational units for transport into areas that traditional deep-draft vessels may be unable to access (Jean, 2011). The T-EPF is manned with a civilian crew totaling 41 members but has a total of 144 berths and seating for 312 passengers. Designated a non-combatant vessel, it is allowed to operate in permissive environments or in higher threat environments when escorted by combatant vessels or other joint forces. In addition to supporting combat missions, the ship is touted as being able to execute "soft power" missions, including HA/DR operations, joint training exercises with U.S. and allied forces, and diplomatic engagements (Jean, 2011).

In addition to its ability to move at high speeds, the T-EPF has a unique set of attributes, including a large cargo bay (approximately 20,000 square feet) able to accommodate 600 short tons of troops, supplies, and equipment. It also boasts RORO capability and a shallow draft that allows it to get in and out of smaller ports that ships with a deeper draft cannot traverse. The T-EPF's wide beam and massive amount of space gives it significant logistics capabilities, but its catamaran design makes it difficult to operate the vessel in higher sea states. Because of the attributes mentioned previously, the T-EPF is able to deliver/provide essential support capabilities and supplies to dispersed locations as needed (Jean, 2011).

The current iterations of the T-EPF include a flight deck capable of landing helicopters as large as a CH-53, which is the heaviest helicopter used by the Marine Corps. In addition to the landing pad, the flight deck has the capacity to park and store one additional rotary-wing aircraft up to an H-60. However, at this time, the T-EPF is not equipped with a helicopter hangar, making it incapable of embarking a helicopter detachment, though there have been talks of including it in future constructions of the platform (Lundquist, 2019).

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III. DATA AND METHODOLOGY

We compiled qualitative and quantitative data for this project from several research documents on U.S. maritime response to HA/DR crises. This is particularly important for this subject as there is little to no research or practical use data on the LCS or T-EPF in HA/DR operations. Aside from modeling the existing data regarding the important characteristics of a maritime platform responding to an HA/DR crisis, we had to create our own comparisons for the LCS and T-EPF.

Utilizing a qualitative data table developed from Greenfield and Ingram's (2011) research on selecting maritime disaster response capabilities, we were able to perform comparisons among the CRUDES assets and the LCS and T-EPF. Similarly, we reviewed quantitative data from the Visibility and Management of Operating and Support Costs (VAMOSC), which Moffatt (2014) also used for his research on the cost of employing various platforms for HA/DR, to develop our own comparisons specifically between the CRUDES, LCS, and T-EPF platforms.

We needed to compile the capabilities deemed important to HA/DR operations to be able to compare the LCS and T-EPF's abilities against their CRUDES counterparts. We utilized the data table developed by Greenfield and Ingram (2011), who ranked 19 critical capabilities for each maritime platform that could be used during HA/DR operations. Those capabilities include aircraft support, the number of embarked aircraft, landing craft support, search and rescue (SAR), dry goods storage, refrigerated goods storage, freshwater production/storage, RORO, fuel storage/dispensation, self-sufficiency, personnel transfer/support, berthing capacity, medical support, transit speed, hydrographic survey, ability to conduct salvage operations, and towing. They used visual markers to indicate each ship's ability to perform a task as having little to no capability to perform the mission set, having some capability to perform the mission set, and being very capable of performing the mission set (Greenfield & Ingram, 2011). Moffatt (2014) used these mission sets/capabilities to "score" each platform and added a component that considered each platform's ability to embark its own helicopters when performing missions. Taking our collected data for each ship type, we created a scaled down version of the table to use for our ship comparisons, as shown in Table 1.

We also needed to consider the cost to deploy each asset. From a commander's standpoint, this could be a key decision data point that may decide which assets are best suited to respond in the event of a disaster; the larger a ship is or the longer it is required to respond to a crisis, the more it will cost to keep it in operation. We took specific ship type data for each class of ship from the VAMOSC database to develop an annual cost to employ each ship type. The dollar values we gathered captured crew size and composition, fuel consumption rates, maintenance and repairable costs, contracted costs, consumables purchase data, and more. We calculated the total value of these factors and divided that cost by 365 to get a rough estimate of the average daily cost to deploy each asset. The costs we calculated are provided in Table 2.

Utilizing the method employed by Moffat (2014) in his cost analysis of HA/DR operations, we were able to take the cost per day to employ each ship type and divide it by the ships' calculated capabilities scores. As described by Moffat, this gave us a quick "bang for buck" breakdown of the various CRUDES platforms against the LCS and T-EPF. This is displayed in Table 3.

IV. DATA ANALYSIS

A. CAPABILITY ANALYSIS

Putting each of the CRUDES assets against the LCS and T-EPF assets, one can see that both the LCS and T-EPF are fairly comparable to those classes of ships in Table 1.

Table 1. Capability Scores by Ship Type

Ship Type	# Helo Aboard	Helo Points Score	Aircraft Support	Landing Craft Support	Search & Rescue (SAR)	Dry Goods Storage	Refrigerated Goods Storage	Fresh Water Storage	Roll On/Off	Fuel Storage/Dispensation	Self Sufficient	Personnel Transfer	Fresh Water Production	Personnel Support	Berthing Capacity	Medical Support	Transit Speed	Hydrographic Survey	Salvage Operations	Towing	Total Capabilities Score
CG	2	40	1	0	1	0	0	0	0	0	0	1	0	1	0	0	2	0	0	1	47
DDG FLT I	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	2	0	0	1	4
DDG FLT II	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	2	0	0	1	4
DDG FLT IIA	2	40	1	0	1	0	0	0	0	0	0	1	0	1	0	0	2	0	0	1	47
FFG	2	40	1	0	1	0	0	0	0	0	0	1	0	1	0	0	2	0	0	1	47
LCS (Freedom)	2	40	1	0	1	0	0	0	0	0	0	1	0	0	0	0	2	0	0	1	46
LCS(Independence)	1	20	1	0	1	0	0	0	0	0	0	1	0	0	0	0	2	0	0	1	26
Expeditionary Fast Transport	0	0	1	1	0	0	0	0	1	0	0	1	0	1	0	0	2	0	0	0	7

The CRUDES assets, in particular the DDG FLT IIA and CG, achieve a total capability score of 47 (Moffat, 2014). Only slightly behind these are the Freedom-class and Independence-class variants of the LCS (46), and further behind is the T-EPF (6). The reasoning for the slight variance in these scores lies in the personnel support category, where they lose one point because the crews for the LCS are much smaller than their CRUDES counterparts; however, the larger gaps observed are due in large part to each platform's ability to carry a two-aircraft helicopter detachment; the T-EPF in its current iteration is not able to accommodate a helicopter detachment at all.

It is important, then, to make the distinction that these slight variations do not necessarily constitute weaknesses that make the LCS and T-EPF less capable; in fact, there are a number of nuanced advantages that the data does not capture. By addressing some of the specific capabilities listed, we are able to better understand the LCS and T-EPF in terms of their ability to support HA/DR operations.

A platform's capacity for carrying helicopters is a vitally important piece to HA/DR operations, as airlift, SAR, and personnel transport are critical during disaster relief operations; it is for this reason that there is a multiple added to this capability when calculating the overall capabilities score (Moffat, 2014). For the CRUDES platforms, utilizing their helicopter detachments in this fashion is one of the main contributions they provide when operating within a CSG or ARG responding to a disaster. The LCS variants, therefore, are just as capable in this regard, being able to support the same number and size of helicopters that their CRUDES counterparts can support, while being capable of supporting unmanned aerial systems as well (Makin, 2014). The flight decks on the LCS and T-EPF are also much larger, making them able to support landing larger aircraft than the CRUDES platforms can if the need for it should arise.

A key weakness for the CRUDES ships identified in past HA/DR research is their inability to support carrying additional supplies outside of what is necessary for their own crews; storage onboard is minimal for any extra equipment that could be utilized for HA/DR support (Apte &Yoho, 2015). However, one of the key differences among the platforms is the fact that both LCS variants and the T-EPF enjoy large, modular mission bays that can accommodate relief supplies and equipment for HA/DR missions that the CRUDES assets cannot. The Independence-class LCS has a much larger mission bay than its Freedom-class counterpart, and T-EPF boasts a much larger mission bay than either variant of the LCS. For the LCS in particular, there has been an irregular warfare (IW) mission package that has been developed specifically for HA/DR support, including hospital beds, training facilities, and other critical care equipment that would be deemed vital to HA/DR support (GAO, 2013). For the T-EPF, "adaptive mission packages" exist that can meet the demands of the HA/DR mission, possessing the ability to outfit their over 22,000 square-foot mission bays with self-contained shipping containers that secure to the deck. These containers can contain anything from refrigeration units, medical stations, communication suites, and various other capabilities that merely plug up to the mission bay and are ready for use (Fontana, 2016). This capability slightly mitigates some of the disadvantages the T-EPF experiences in regard to its own self-sustainability for storage, as it can simply attach modules necessary to house refrigerated storage space, fresh water production equipment, or any other vital services if needed. In addition to the mission bays, the T-EPF has the unique advantages of having roll-on/roll-off capability and its own telescoping boom crane, meaning it can off-load supplies independently and has the ability to have vehicles come directly into its mission bay for on-load and off-load (MSC, 2018).

One of the major drawbacks to the LCS and T-EPF is their crew size in comparison to the CRUDES assets. CRUDES platforms have a crew size of about 270–320 personnel, while the LCS and T-EPF are at about 40–70 personnel (Ng, 2015). This creates a situation in which fatigue of the crew can become a factor as there are more personnel available on a CRUDES platform to support the tasks required to conduct HA/DR operations. The limited size of the LCS also prevents the ability to berth and transport personnel, and neither the LCS nor the T-EPF have adequate organic medical facilities onboard capable of long-term HA/DR support. The T-EPF has a unique advantage over the LCS variants and the CRUDES platforms, however, because it has 100 berthing spaces in addition to those used for the ship's crew, as well as a personnel transport bay (similar to a ferry) that can move about 300 personnel if needed.

Lastly, transit speed is an advantage shared among the CRUDES, LCS, and T-EPF platforms. Able to move at speeds in excess of 30 knots, any of these smaller platforms can move toward an area much quicker than any of the larger, more capable HA/DR platforms. However, the LCS variants and T-EPF have a much higher advantage over their CRUDES counterparts in terms of their relatively low draft. At just over 12–15 feet of draft, the LCS variants and the T-EPF are well suited for operating in littoral areas, meaning they are able to get in much closer to land and can navigate into various port sizes much easier than their CRUDES counterparts. This is an important distinction among the ship classes because this is a limiting factor for CRUDES assets that affected their ability to provide support to disasters in the past. In environments where a port is likely to be affected by a natural disaster, having a much lower draft affords the LCS variants and the T-EPF the opportunity to easily enter port to off-load supplies, pick up personnel, and otherwise move freely throughout the affected area.

B. COST ANALYSIS

The next measure considered for comparison was cost per platform. Deploying assets, whether in line with deployment schedules or specific mission objectives, bears with it an associated cost that fleet commanders must consider. By the numbers, the CG is the costliest asset to employ at approximately $200,000 per day; by contrast, the least costly asset to employ is the T-EPF at about $61,000 per day. Cost data for the DDG Flight 1 and Flight 2 were included with the intention of comparing that data to the other platforms, but will not be analyzed thoroughly due to their relatively low capability score. Similarly, the cost data for the FFG will not be analyzed thoroughly as it is no longer active and is meant to be replaced by the LCS. As shown in Table 2, the daily cost to deploy an FFG in 2014, which is the last year a ship of that class was in service, is very similar to the current cost to deploy a Freedom-class LCS, while the FFG is significantly less costly per day to deploy than the Independence-class LCS. The daily cost to deploy the DDG (Flight 2A) differs by $30,000 and $73,000, respectively, for the Independence- and Freedom-class LCS platforms. If a fleet commander was faced with a decision as to which asset to use for an HA/DR mission, and each of the platforms shown in Table 2 were available options, the Freedom-class LCS and the T-EPF would be the least costly options. Furthermore, the daily cost of the Freedom-class LCS and the T-EPF combined would be about $36,000 less than the daily cost of the CG and $13,000 less than the daily cost of the DDG (Flight 2A). Even when comparing the combined cost of the Independence-class LCS, which is much greater than the Freedom-class, and the T-EPF, it only exceeds the cost of the CG by just over $6,000, and exceeds the cost of the DDG (Flight 2A) by just over $30,000. The $30,000 difference associated with the DDG (Flight 2A) and the Independence-class LCS/T-EPF platforms seems significant but could be justified by the fact that there are two platforms available rather than one.

Table 2. Cost to Deploy per Ship Type

Ship Type	Cost to Deploy (Year)	Cost to Deploy (Day)
Cruiser	$69,914,085.00	$191,545.44
Destroyer (Flight 1)	$66,617,668.00	$182,514.16
Destroyer (Flight 2)	$64,060,665.00	$175,508.67
Destroyer (Flight 2A)	$61,108,433.00	$167,420.36
Frigate (up to 2014)	$36,068,267.00	$98,817.17
LCS (Freedom-class)	$34,237,123.00	$93,800.34
LCS(Independence-class)	$50,021,469.00	$137,045.12
Expeditionary Fast Transport	$22,246,706.19	$60,949.88

Taken together, the ship's capabilities scores combined with their cost to deploy are able to give a rough estimate of the associated cost per capability of each ship type that mission commanders can utilize to understand which platform can provide the most use for the cost and capabilities they bring to bear. A low cost per capability could indicate that the platform has many capabilities that may prove useful in the event of an HA/DR mission as its associate cost to deploy is spread among its various capabilities. Similarly, high cost per capability could indicate that the platform may have fewer capabilities to bring to bear during an HA/DR operation, driving their cost per capability higher.

Both classes of LCS, which could be considered most comparable to the cruiser and destroyer (Flight 2A) platforms in terms of capabilities scores, have significantly lower cost per capability than their counterparts. At 43% less than the cost per capability of a destroyer (Flight 2A) and about 50% less than the cost per capability of a cruiser, the Freedom-class LCS displays the lowest cost per capability of any of the platforms being compared, making it the most viable platform for use in terms of HA/DR support; the Independence-class LCS comes in next at 27% less than the cost per capability of a cruiser and 16% less than the cost per capability of a destroyer (Flight 2A). The T-EPF, with capability scores comparable to the destroyer (Flights 1 and 2), is roughly 80% less than the cost per capability of either destroyer.

Table 3. Non-Air Capable vs. Air-Capable Cost Per Capability Comparison

Non-Air-Capable Platforms	**Cost per Capability**
Destroyer (Flight 1)	**$ 45,628.54**
Destroyer (Flight 2)	**$ 43,877.17**
Expeditionary Fast Transport (T-EPF)	**$ 8,707.13**

Air-Capable Platforms	**Cost per Capability**
Cruiser (CG)	**$ 4,075.43**
Destroyer (Flight 2A)	**$ 3,562.14**
Littoral Combat Ship (Independence-class)	**$ 2,979.24**
Frigate (FFG)	**$ 2,102.49**
Littoral Combat Ship (Freedom-class)	**$ 2,039.14**

V. CONCLUSION

The purpose of our analysis was to determine the feasibility of utilizing the LCS and T-EPF for HA/DR missions and to determine how well they compare in terms of capability and cost to CRUDES platforms. Our scope was limited to observing only the capabilities that each platform is able to perform for HA/DR support, and to compare the cost associated with employing each platform; the intent was not to proclaim the LCS or T-EPF to be the primary option for HA/DR support, but rather to highlight their ability to be used in this capacity when fleet commanders consider options for supporting HA/DR missions. As previous research has suggested and our initial analysis concluded, the limitations of the LCS, T-EPF, and CRUDES platforms in terms of their size and capabilities generally makes them incapable of providing significant long-term assistance for HA/DR missions. However, utilizing the LCS and T-EPF as potential first responders for short-term mission support seems to provide the most value for the capabilities they possess as opposed to being part of the more sustained operations performed by larger platforms such as the LHD, LHA, or the LPD.

The LCS and T-EPF are able to meet the same capability expectations as the CRUDES assets, but nuanced differences such as their large mission bays, large flight decks, and low draft that allows them access to more restrictive littoral areas set them apart from their CRUDES counterparts. Specifically, for the T-EPF, its additional capacity for transporting personnel could be a key difference maker in terms of the small crew size it has in comparison to the CRUDES platforms. The T-EPF also brings the added, albeit smaller RORO capability, which can be leveraged in being able to move relief supplies independently of any pier-side support as well as movement of casualties to more suitable support areas. Drawbacks in utilizing these platforms center mainly around the crew size, which is significantly smaller than any of the platforms being used for comparison. The relatively small crew size could result in increased mission fatigue on the crew due to lack of depth in personnel rotation, limited ability to cope with large casualty numbers, and potential inability to perform multiple mission sets at once.

From a cost perspective, both the LCS and T-EPF are cheaper to operate than the CRUDES platforms. It is relevant to point out that our analysis did not account for the additional cost incurred by the Navy when the CRUDES assets are diverted from their primary missions to HA/DR missions. The cost benefits offered by both LCS platforms and the T-EPF make the option to utilize them specifically as HA/DR support platforms more viable. Given their relatively low cost to deploy, both the T-EPF and the LCS platforms could be used together to offer similar, if not more viable capabilities than any singular CRUDES platform at a similar price point.

As great power competition among the United States, Russia, and China continues to grow, it becomes increasingly important that CRUDES assets are able to remain focused on their primary mission sets in order to meet potential threats. The capacity of the LCS and T-EPF to meet the expectations for HA/DR first responder support provides mission commanders a viable option that allows them to keep CRUDES assets focused on their primary missions. It should be noted that the best advantage for utilizing the LCS and T-EPF platforms would come from employing them directly from their homeports rather than diverting them from an assigned mission. This would allow them to load, carry, and directly deliver much of the requisite support equipment in their large mission bays, thereby maximizing their ability to support HA/DR missions, which is listed as a core competency in the NMS.

There are several areas for future research that necessitate a deeper look into the utilization of the LCS and T-EPF such as the proximity of their homeports to disaster-prone areas, the effective amount of time they can remain on station to support an HA/DR mission, how the capabilities of the LCS and T-EPF can be best utilized to meet the demands of an HA/DR environment, and any additional costs associated with outfitting them for HA/DR.

The LCS and T-EPFs can be found in almost all of the Navy's high fleet concentration areas, with some forward deployed to areas such as Singapore, Souda Bay, the Middle East, and Japan. Future research could identify the associated travel time it would take to reach disaster-prone areas and how that compares with diverting assets to respond. Understanding their limitations in size and carrying capacity will ultimately affect their ability to loiter and provide support; therefore, further analysis needs to be conducted on the optimal time these platforms can remain on station and how that may affect their overall cost. To further understand how to best leverage the advantages that the LCS and T-EPF have in terms of their mission bays, analysis is necessary to determine the combinations of mission modules and equipment that would be best suited for various HA/DR mission scenarios as well as the associated costs to procure and field these technologies aboard each platform. Current configurations on both the LCS and T-EPF platforms allow for adaptive force packages to be loaded and plugged into their mission bays (Lundquist, 2019). Modular disaster relief technology continues to improve, and some of these medical packages have been designed specifically to be loaded, assembled, and utilized either within the mission bays of any adaptive platform or as "flat packs" that can be carried and off-loaded directly into an area for HA/DR support (Lye, 2019; Spitzer et al., 2020). In either case, the associated costs of employing these packages will have to be calculated as part of the ships' operating costs in supporting HA/DR missions.

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