

**The Littoral Combat Ship:  
How We Got Here, and Why**

Robert O. Work

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Robert O. Work  
Undersecretary of the Navy

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Of course, any inaccuracies or shortcomings in this paper are mine alone.

## FOREWORD

Robert C. (Barney) Rubel  
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The Littoral Combat Ship (LCS) has been a controversial program from its inception, experiencing delays and cost overruns, not to mention severe criticism from elements of the national security community. Despite all this, every Chief of Naval Operations since Admiral Vern Clark has supported the program. To date, Navy attempts to defend the program have not succeeded in quieting the criticism, and the various technical and operational difficulties experienced by the first two examples have not helped matters. Perhaps the most serious objection to LCS is that the Navy charged into series production without having a clear idea of how the ship would be used.

Undersecretary of the Navy Robert Work is known in Defense circles as a meticulous researcher who has a comprehensive grasp of Navy force structure and fleet architecture issues, stemming from his years as an analyst at the Center for Strategic and Budgetary Assessments. Secretary Work brings those same traits to bear in the preparation of this Newport Paper. In it he forthrightly chronicles the development of the LCS; not attempting to shy away from reporting on the program's vicissitudes nor trying to put a positive spin on Navy decisions along the way. Instead, he offers an informed view of how the logic behind LCS developed and evolved as the program progressed. As he so lucidly points out, LCS does not fit easily into the existing framework of Navy thought, and thus it is vulnerable to criticism by those who attempt to judge it by existing criteria. Secretary Work provides us with a better understanding of how LCS is to function in a networked battle force. While this explanation may not quiet all criticism, it at least brings much needed clarity to the story of how and why the LCS came to be.

More than simply a history of the LCS program, this Newport Paper provides important insights into the dynamics of Navy programmatics and is therefore highly useful reading for anyone interested in understanding the Navy's acquisition process. In addition, and perhaps more importantly, if the reader pays attention to Secretary Work's discussion of how LCS might be used in "associated support" of a battle group, and thinks about it for a while, he or she will be rewarded with a glimpse of something that has been missing from the Navy's intellectual structure for a long time: naval operational art.

Since at least the end of the Cold War, the Navy has organized its fighting capability into autonomous battle groups centered around aircraft carriers or amphibious ships. These "bubbles" of combat capability could be aggregated as they were in the three Middle East wars since 1990, but their aggregate capability was cumulative and did not propel the Navy into a qualitatively different mindset. Thus, as has been the case for most of its history, save World War II, the Navy has focused on tactics and on strategy, both of which it does rather well. The operational level, something

that has been integral to Army doctrine since the 1980s, has been largely missing despite the efforts of the Naval War College to advocate its adoption. Introduction of the LCS, assuming the surface warfare community opens its mind to the full range of potential roles for smaller combatants, provides a practical basis for the development of a new naval operational art, oriented on combined arms.

It is hoped that this Newport Paper will stimulate more informed debate on the LCS and act as a catalyst for a renaissance in Navy combined arms thinking.

## **The Littoral Combat Ship: How We Got Here, and Why**

LCS will contribute to Sea Shield through its unique capability to respond quickly, to operate in the littoral environment, and to conduct focused missions with a variety of networked off-board systems. The antisubmarine warfare, mine countermeasures, and surface warfare missions associated with Sea Shield will be enhanced through the employment of a distributed LCS force. Conduct of these missions, along with persistent surveillance and reconnaissance, will be the LCS contribution toward assuring access for the Joint Force.<sup>1</sup>

Perhaps no ship in recent memory has been subject to more criticism than the Littoral Combat Ship (LCS). Many think LCS is the “wrong ship at the wrong time.”<sup>2</sup> Some compare the ship to a guided missile frigate, and find it wanting. Some complain there are better, longer-legged ships for forward presence and maritime security missions. Others think the Navy would be better served with fast-attack craft or small corvettes festooned with antiship missiles. Still others believe a purpose-built, single-mission vessel is the best choice for the mine-warfare mission. All of these alternatives would be potentially attractive choices—provided the Navy’s future fleet had a need for such ships. Instead, the U.S. Navy needs a different component for its battle force: an affordable, self-deployable and reconfigurable multirole warship designed for naval battle network operations in contested littorals.

The premise of this paper is that much of the current discourse on LCS tends to ignore the critical point that the ship was conceived as an integral part of a new battle force architecture that continues to evolve. Discussions instead focus too narrowly on the ship’s design features, characteristics, and concept of employment without considering its intended supporting role in this new fleet architecture or the design choices that sprung from it. Compounding the problem, the Navy’s LCS narrative over the last decade has been marked by constant change, and in some instances strayed away from the original principles that guided the ship’s development. This helped obscure what the Navy wanted the new warship to do, opening the entire concept to question and criticism.

Accordingly, rather than attempt a tit-for-tat response to every contemporary complaint about LCS itself, this paper will instead explain the genesis of the current fleet’s operational construct and architecture, the role LCS was originally expected to play in it, and the initial design choices stemming from its planned role. It will then explore subsequent modifications to the LCS program and to the ship’s design and planned concept of operations—some made to accommodate changes in initial assumptions and plans and others to respond to thoughtful critiques of the ship and its intended mission. After doing so, it becomes clear the Navy is getting very nearly the exact ship it asked for—and in some key aspects a better ship than expected. Assuming its planned battle force architecture has not radically changed and there

remains a valid need for a small battle network combatant like LCS, it is past time for the Navy to focus on the ship's transition to fleet service, which has been too long ignored.

### ***An Idea is Born***

On November 1, 2001, the Navy announced it would build a small, fast, and stealthy Littoral Combat Ship as part of its new DD(X) surface combatant family of ships (SCFOS).<sup>3</sup> Some assert LCS was forced on the Navy. There is some truth to this view. U.S. Navy support for small warships declined steadily after World War II. By the time of the 1997 Quadrennial Defense Review (QDR), the Navy finally decided to get out of the small combatant business entirely. It planned to retire all of its remaining guided missile frigates (FFGs) and patrol coastal ships (PCs) without replacement, leaving only twenty-six dedicated mine warfare vessels (with up to ten or eleven of them maintained in low Mobilization Category B readiness) to operate alongside a force of 116 cruisers and destroyers (CGs, DDGs, and DDs), the smallest having a full load displacement (FLD) greater than 8,900 tons.<sup>4</sup> This force of large, multimission warships was consistent with a fleet design optimized for high volume theater air and missile defense (TAMD) and littoral strike in support of Joint campaigns ashore.

The decision to exclude small combatants from future fleet plans was not universally applauded. War games, fleet experiments, and analyses conducted throughout the 1990s suggested the need for a new generation of small combatants able to penetrate a contested littoral and scout for and eliminate threats hidden in coastal clutter.<sup>5</sup> Two distinct concepts emerged from this work. The first was a heavily armed 2,200 to 2,600-ton "multi-warfare capable ship" with a composite superstructure, medium caliber gun, medium-range air defense and antiship missiles, armed helicopters (preferably two), armed unmanned aerial systems, and land attack missiles to strike shore based missile batteries.<sup>6</sup> The second, more widely publicized concept was a family of small, fast, and stealthy littoral combatants known as Streetfighters, championed by the Naval War College.<sup>7</sup> Between 1999 and 2001, proponents for small combatants used these concepts to openly question the wisdom of building a surface fleet composed entirely of large, multimission warships.<sup>8</sup>

Throughout this public debate, senior Navy leaders remained resolute in their defense of large combatants. Neither of the small warships mentioned above was included in the Cost and Operational Evaluation and Analysis (COEA) for the Navy's path finding twenty-first century Surface Combatant (SC-21) Study, completed in the late 1990s.<sup>9</sup> Indeed, the affordable "littoral combatant" ultimately considered in the COEA was the 17,500-ton DD-21 land attack destroyer, which was to be followed by an even more capable CG-21 multimission cruiser.<sup>10</sup> Using the SC-21 COEA as their guide, Navy officials reflexively denigrated any analysis or argument that suggested small warships should be included in the future battle force.<sup>11</sup>

Despite its seemingly determined resistance to small combatants, however, the Navy suddenly reversed course. During the 2001 QDR, the Office of the Secretary of Defense (OSD) directed the Joint Force to improve its ability to defeat antiaccess/area-denial (A2/AD) threats in order to maintain America's ability to project and sustain power in contested theaters.<sup>12</sup> At the same time, OSD quietly told Navy leaders it would not support their prized DD-21 program unless they included a small combatant in their future plans. Galvanized by these developments, less than four months after assuming his post as the 27<sup>th</sup> Chief of Naval Operations (CNO), Admiral Vern Clark announced a new surface combatant family of ships that would replace the SC-21 model. This new SCFOS included a large, multimission DD(X) destroyer optimized for land attack (an updated DD-21), a large, multimission CG(X) cruiser optimized for TAMC (an updated CG-21), and a small, "focused-mission" Littoral Combat Ship.<sup>13</sup> At first blush, then, CNO Clark's decision to pursue LCS appears less like an enthusiastic reembrace of small combatants and more like a ransom payment to OSD.

If truth be told, however, for Admiral Clark OSD's direction was pushing on an open door. He came to the job with a comprehensive vision for twenty-first century naval power called Sea Power 21. This vision was built around three key concepts: Sea Shield, Sea Strike, and Sea Base.<sup>14</sup> And the glue that held these three concepts together was FORCEnet—"the operational construct and architectural framework for naval warfare in the information age, integrating warriors, sensors, command and control, platforms, and weapons into a networked, distributed combat force." When fully implemented, the FORCEnet fleet architecture was expected to "transform situational awareness, accelerate speed of decision... greatly distribute combat power...and increase force survivability."<sup>15</sup>

Admiral Clark's initial FORCEnet fleet design included a 375-ship battle force, sized to execute a new Global Concept of Operations (ConOps) developed to support of the 2001 QDR's "1-4-2-1 strategy."<sup>16</sup> The DD(X) SCFOS would be the surface combatant component of the new battle force. And, to get both a new DD(X) and CG(X) and grow the fleet to 375 ships, Admiral Clark knew the Global ConOps Navy would need an affordable, "relatively small" warship "capable of performing focused or special missions in inshore waters where it would be impractical or unwise to commit larger, more high-value forces."<sup>17</sup> That's where the new Littoral Combat Ship fit in.

When announcing the DD(X) SCFOS, Admiral Clark had only a strong inkling of what an LCS would look like and how it would ultimately contribute to fleet operations. Indeed, his seemingly abrupt adoption of the ship only four months after taking the reins of the Navy came without any of the supporting material typically associated with a new shipbuilding program, such as a formal, rigorous analysis of alternatives or analysis of alternative concepts. As a result, LCS's sudden inclusion in the DD(X) SCFOS caught many inside and outside the department of the Navy (DoN) by surprise, causing some to question the justification for such a ship.



However, Admiral Clark felt there was plenty of rationale and analysis to support the development of a new small warship. In the first place, on September 30, 2001, the Navy's battle force numbered 316 ships.<sup>18</sup> Around 2005, the Navy would begin retiring the twenty-four *Spruance*-class DDs and thirty long-hulled *Perry*-class FFGs remaining in fleet service.<sup>19</sup> The planned thirty-two-ship class of DD-21s had already been cut to twenty-four new DD(X)s, and rising costs made even this number suspect. Admiral Clark didn't need any analysis to tell him the Navy desperately needed an affordable ship it could build in numbers in order to *maintain* the size of the surface combatant fleet—and he was intent on *growing* it. LCS would be his answer.

Second, although it did not represent a formal analysis of multiple concepts, the aforementioned work on littoral combatants sponsored by the Navy throughout the 1990s, and especially the Naval War College work on Streetfighter conducted between 1999 and 2001, established a strong analytical basis for small, multirole littoral combatants. Moreover, the 2001 QDR's emphasis on a Joint Force prepared to operate in antiaccess and area-denial environments ultimately spurred OSD to issue specific guidance to the Navy to improve its performance in some specific warfare areas. In this regard, the supporting *Defense Planning Guidance for Fiscal Years 2003-2007* directed the Navy to develop the "capability to maintain an Aircraft Carrier Operating Area clear of submarine-delivered and floating mines;" "improve the capability to destroy or evade large numbers of submarines operating in littoral areas;" and develop "the capability to destroy large numbers of small antiship cruise missile-armed combatants, or armed merchant vessels in littoral areas, without relying on carrier-based air."<sup>20</sup> The fleet's stable of large, multimission warships was ill-suited to such tasks, which had long been the province of small combatants and mine warfare vessels. Admiral Clark hoped LCS could do the job of both types of warships.

Third, Admiral Clark believed LCS answered the loud calls for defense "transformation" then being made by Secretary of Defense Donald Rumsfeld. In a speech given in January 2002, Secretary Rumsfeld said, "Preparing for the future will require us to think differently and develop the kind of forces that can adapt quickly to new challenges and to unexpected circumstances."<sup>21</sup> Moreover, in his view, thinking differently included a willingness to skirt or bend long-established rules when pursuing "transformational" systems. As he explained:

...we must transform not only our armed forces, but also the department that serves them by encouraging a culture of creativity and intelligent risk taking. We must promote a more entrepreneurial approach to developing military capabilities, one that encourages people, all people, to be proactive and not reactive, to behave somewhat less like bureaucrats and more like venture capitalists; one that does not wait for threats to emerge and be "validated," but rather anticipates them before they emerge and develops new capabilities that can dissuade and deter those nascent threats.<sup>22</sup>

Based on these three considerations, CNO Clark confidently declared LCS his number one transformational program and budget priority, and requested authority for a new program start in the Navy's Fiscal Year (FY) 2003 President's Budget submission. Secretary Rumsfeld approved, including the request in the Defense Department's FY 2003 President's Budget submission, delivered to Congress in February 2002.<sup>23</sup> By so doing, and consistent with his announced approach to defense transformation, the Secretary signaled he was not disturbed by the LCS's lack of analytical pedigree.

Congress was less sanguine with the idea authorizing a new warship without first validating the vessel's mission through analysis. Although it ultimately gave the Navy new start authority for LCS in the FY 2003 National Defense Authorization Act, it expressed concern that "[t]here is no definition of the [LCS] requirement and no 'road map' of how the Navy will achieve the system required."<sup>24</sup> Accordingly, it directed the Secretary of the Navy to submit a report that addressed "in detail the analytical process to examine alternatives [to the LCS], and establish relative priorities to meet valid requirements."<sup>25</sup> Then, the following year, after being presented only a brief, summary explanation of the Navy's pre-start analysis for LCS (or lack thereof), an irate Congress pointedly demanded the Secretary of the Navy to "more completely address" its concerns.<sup>26</sup>

In response, the Navy admitted the LCS program represented "a departure from traditional analysis processes *by conducting targeted analysis to support concurrent development of the capability documents, mission module definitions and integration requirements.*"<sup>27</sup> This targeted approach included a three-phase "tailored analysis of alternatives" that would "fill in analysis gaps that previous studies had not covered"—a clear reference to the conceptual work and studies conducted in the 1990s.<sup>28</sup> Regardless of whether Congress fully agreed with this approach, by allowing a concept and development process that would follow rather than precede program start to continue, it implicitly endorsed Admiral Clark's decision to pursue a small Littoral Combat Ship in a way distinctly different from normal programs.

To this day, critics continue to complain about the LCS's "analytical virgin birth," arguing that Admiral Clark first decided he needed a ship and only then turned to figuring out what the ship would do.<sup>29</sup> Even if true, this is a moot argument. The Navy was clear in its thinking. There was a compelling programmatic need for an affordable warship that could be built in numbers, and a pressing battle force requirement to defeat mines, fast attack craft and boats, and diesel submarines in A2/AD environments—missions that had long been performed by small combat vessels. Moreover, OSD had already ordered the Service to include a small warship in its future fleet architecture or risk its DD-21/DD(X) destroyer. When taken together, it is hard to fault Admiral Clark's decision to move the LCS forward. In any event, and with the explicit blessing of OSD and the implicit endorsement from Congress, CNO Clark jump-started the work necessary to transition his idea to a viable concept and program.<sup>30</sup>

## ***From Idea to Concept***

Between November 2001 and February 2003, Admiral Clark and senior Navy leaders developed the key conceptual principles and characteristics that would guide the subsequent development of the LCS program. The clearest picture of these principles and characteristics and how the LCS might fit within the FORCEnet architecture and operate as a part of the Global ConOps Navy comes from four documents or collections. The first is a series of articles explaining the overarching concepts of Sea Power 21, started off by “Sea Power 21: Projecting Decisive Joint Capabilities,” which appeared in the October 2002 edition of the U.S. Naval Institute *Proceedings* under Admiral Clark’s own name.<sup>31</sup> The second is the *Draft Littoral Combat Ship Interim Requirements Document (IRD)*, also dated October 2002, outlining the initial thinking behind the ship’s concept of employment and design criteria.<sup>32</sup> The third is the initial *LCS Concept of Operations*, developed by the Naval Warfare Development Command (NWDC) throughout 2002 and approved in February 2003.<sup>33</sup> And the fourth is a Memorandum for the Record detailing a February 2003 meeting of Admiral Clark and top Navy leadership “to resolve programmatic issues concerning LCS and to help refine and direct ship characteristics and operational concepts that will affect the LCS design.”<sup>34</sup>

After the February 2003 LCS offsite, the program passed from the concept development to the formal requirements determination phase. One cannot understand, much less judge, these requirements without knowing their conceptual underpinning. The present segment of this report therefore focuses on the thinking reflected in these early documents. After reading them, six key elements of the LCS concept stand out: the overriding emphasis placed on platform affordability; the degree to which LCS would rely on the broader FORCEnet architecture for its effectiveness and survivability; the vessel’s relatively mature concept of operations; the rationale behind a modular, reconfigurable, multirole platform; the ship’s envisioned contributions to the FORCEnet modernization strategy; and the high priority placed on getting the LCS into fleet service as fast as possible. Each of these elements will be discussed in turn.

### **Program Affordability**

The thing that stands out over all others when reading early LCS program documents is the great emphasis placed on program affordability. Recall that in 2001-2002, the Navy faced the impending block retirement of over fifty destroyers and frigates. Due to rising costs, the Navy would be lucky to replace half of these ships with new DD(X) multimission destroyers, the successor to the DD-21 land attack destroyer. The Navy literally could not afford a second costly warship program if it had any hope of maintaining a 300-ship battle force, much less expanding to a 375-ship fleet.

Accordingly, both OSD and Navy leaders wanted LCS to be a low cost ship that could be built in the high numbers to “maintain desired surface combatant force levels.”<sup>35</sup> OSD expected the DoN to buy no fewer than three missionized LCSs for the price of one *Arleigh Burke* DDG, equating to a threshold (minimally acceptable) target cost of

\$400 million per ship.<sup>36</sup> However, in February 2003, with the program still in its infancy, Admiral Clark hoped to do much better. He wanted the threshold cost for an “entire” (i.e., missionized) LCS to be no more than \$250 million (all costs in FY 2005 dollars).<sup>37</sup> This would allow the Navy to buy five LCSs per *Burke*.

As Congressional Budget Office analyst Eric Labs often observes, the cost to build a ship in U.S. shipyards is most closely correlated with its light-ship displacement (that is, without crew, fuel, ordnance stores, etc.).<sup>38</sup> However, not all ships are created equal. As shown in Table 1, a Joint High Speed Vessel (JHSV)—a commercial design with some military features but no combat system to speak of—costs \$174 million in FY 2005 dollars, equating to \$115,000/ton. The U.S. Coast Guard’s National Security Cutter (NSC), a 3,206-ton ship with a commercial design, a modest combat system and a good core self-defense capability, costs approximately \$529 million, or \$165,003/ton. And an *Oliver Hazard Perry*-class FFG, a 3,150-ton ship with greater survivability standards and equipped with a much more capable combat system and local air defense capability, would have cost at least \$617 million to build in FY 2005, or \$196,000/ton.

**Table 1. Comparative Shipbuilding Costs**

Ship Type	Light-ship displacement	Cost to Build (FY2005\$)	Cost per Ton
JHSV	1,515 tons	\$174M	\$115,000/ton
NSC	3,206 tons	\$529M	\$165,003/ton
FFG 7	3,140 tons	\$617M	\$196,000/ton

Based on this data, one might thus expect an LCS of 2,700 tons (the light-ship displacement of USS *Freedom* (LCS 1)) built to commercial standards to come in around \$310.5 million; one to NSC standards to cost around \$445.5 million; and one with FFG standards to cost \$529 million.<sup>39</sup> Conversely, achieving the \$250 million objective target for a missionized LCS would infer a 2,174-ton warship built to commercial standards, a 1,515-ton warship built to NSC standards, and a 1,275-ton warship built to frigate standards (again, all prices in FY 2005 dollars). Such small vessels might not have the space and payload to handle the manned or unmanned off-board systems expected to provide the ship’s “Sunday punch.” As these simple calculations suggest, building a missionized LCS for \$400 million would be challenging enough; nailing the desired target of \$250 million would be an amazing achievement. Needless to say, and as will soon be evident, hitting either of these aggressive cost targets would force extremely difficult trade-offs during the ship’s design process.

### **Reliance on FORCEnet**

Next to program affordability, the next most striking element of the LCS concept was the degree to which its ultimate success would rely on the broader forcewide transition to the new FORCEnet architecture. This transition would occur in stages. The first would see the more thorough integration of existing networks, sensors, and command and control systems, while subsequent stages would gradually allow the Navy to operate as a “fully netted force, engage with distributed combat power, and command with increased awareness and speed.”<sup>40</sup> Accordingly, while the legacy Aegis ships that made up the bulk of the surface force would be modified to operate as part of a “dispersed, netted, and operationally agile fleet,” the LCS would be the very first combatant designed from the keel up as a FORCEnet platform.<sup>41</sup> And, as FORCEnet’s first *small battle network combatant*, the ship’s effectiveness and survivability would depend on “reach back” to “networked force capability” to a degree unseen on any previous U.S. Navy warship.<sup>42</sup>

Having LCS rely and depend so much on FORCEnet battle networks also contributed toward the key imperative to contain program costs. By conceptualizing LCS as an integral component of broader naval battle networks—and one more reliant on the network for its own effectiveness than previous U.S. Navy combat vessels—Admiral Clark hoped to avoid the high costs associated with the complex organic combat systems found on large, multimission warships.<sup>43</sup>

Interestingly, Admiral Clark also appears to have had another incentive to link LCS into powerful fleet battle networks. For the transition to FORCEnet and the 375-ship Global ConOps Navy to succeed, the Navy’s surface warfare community would necessarily have to accept the need for an affordable small combatant. As one who had served on small *Asheville*-class patrol gunboats and keenly appreciated the community’s general antipathy toward small warships, Admiral Clark believed linking LCS into FORCEnet battle networks would be key “to enhancing the value of LCS beyond those of past small Navy vessels.”<sup>44</sup> In other words, he hoped LCS’s ability to call upon the supporting combat power of advanced naval battle networks would help overcome the prevalent fleet resistance against small warships of any type.

### **A Mature ConOps**

A third striking element of the LCS program was its relatively mature concept of operations. The Navy may not have concluded any formal analysis of multiple concepts before program start, but it is very clear it drew upon a decade of rich work when conceiving and defining its intended role. In the broadest terms, this work suggested LCS could “fill a niche in the near-land battlespace dominance arena” by “deny[ing] the enemy cheap asymmetrical antiaccess kills against U.S. ships operating in that environment.”<sup>45</sup>

This role was subtly but still significantly different from that first envisioned for littoral combat vessels in the decade after the Cold War ended. As mentioned previously, analysis suggested the need for a ship able to penetrate a contested

littoral in advance of high value units to scout for and eliminate threats hidden in coastal clutter. Two concepts emerged to perform this role. One was a very heavily armed 2,200 to 2,600-ton “multi-warfare capable ship” capable of fighting its way into defended near-shore waters and sustaining combat operations once there. The second was a family of fast, stealthy, 400 to 1,200-ton littoral combatants called Streetfighters which would operate in distributed groups. While the Streetfighters themselves would be inexpensively built and considered expendable, by operating in large numbers the fleet could accept individual Streetfighter losses without losing significant aggregate combat power.<sup>46</sup>

Navy leaders knew there was no way to build a “multi-warfare capable ship” with the unconstrained capabilities desired by war game players for \$400 million, much less \$250 million.<sup>47</sup> Moreover, they were not comfortable with the idea of an expendable warship, knowing it would be a very hard sell in the surface warfare community (more on both these points later in the report). Consequently, the Naval Warfare Development Command, which had the lead for LCS ConOps development, shifted away from the idea of an offensive littoral penetrator and started thinking of LCS as a Sea Base *screening platform*.<sup>48</sup>

In Sea Power 21 terms, NWDC envisioned LCS as a critical component of FORCENet’s Sea Shield, operating under the protective wing of *large battle network combatants* (e.g., multimission CGs, DDGs, and DDs) during major combat operations.<sup>49</sup> Instead of venturing forth into a contested littoral looking for trouble, LCS would take care of threats coming out to attack the high value units operating in the Sea Base, such as amphibious landing ships, combat logistics force vessels, and aircraft carriers.<sup>50</sup> In this regard, war games and campaign analysis suggested three asymmetrical threats would pose persistent problems to Sea Bases, particularly in future A2/AD environments: swarming boats armed with missiles, rockets, guns, torpedoes, and shaped charges (the latter the surface equivalent of kamikazes); diesel submarines; and mines. Accordingly, and as directed in *Defense Planning Guidance*, LCS would be designed and built first and foremost to counter these three threats. By doing so, LCS would “enable multimission platforms to perform higher order missions like missile defense and [naval surface fire support].”<sup>51</sup>

Although viewed primarily as a Sea Shield platform, by screening amphibious landing, combat logistics, and sealift ships from littoral threats and attacks, LCS would contribute to Sea Strike by enabling amphibious operations, Marine ship-to-objective maneuver, and coastal naval special warfare operations. And, as a Sea Base screening platform, LCS would underwrite the entire concept of Sea Basing, which served “as the foundation from which offensive and defensive fires are projected—making Sea Strike and Sea Shield realities.”<sup>52</sup> All in all, the important wartime role envisioned for LCS belied its small size and low desired price tag.

Of course, Navy leaders knew LCS would spend most of its service life conducting a variety of other surface force missions, particularly “long term situational awareness” and intelligence, surveillance, and reconnaissance (ISR) systems

deployment and employment. Indeed, beyond simply operating in a designated littoral area over a long period of time to observe local activities and monitor changes to them, they believed LCSs could provide a “bonanza for Fleet Commanders” in peacetime. Properly equipped, LCSs could conduct undersea warfare bottom surveys and route mapping, plant unattended sensors to monitor littoral activity, and perform covert, clandestine, unmanned remote or autonomous reconnaissance. Such information would be especially valuable should a crisis erupt, as it would enable prompt planning based on reliable, up-to-date information.<sup>53</sup> While performing this vital information-gathering role, the ship would also perform customary naval diplomacy/presence missions and routinely operate with both the U.S. Coast Guard and allied navies.<sup>54</sup>

In addition to performing their FORCEnet and Global ConOps theater situational awareness role, LCSs would also be expected to conduct special operations forces (SOF) support; maritime interception operations (MIO); antiterrorism and force protection (AT/FP) missions such as escorting high value units through maritime chokepoints; humanitarian assistance and disaster relief (HA/DR) missions; logistics or medical support missions; and non-combatant evacuation operations (NEO). Navy planners calculated that between 1970 and 1999, almost sixty percent of all tasks assigned to U.S. Navy surface combatants involved one of these “long burn...mobility related missions.” Assigning relatively low cost LCSs to conduct these missions would “free up multimission platforms to continue robust preparations for potential power projection missions.”<sup>55</sup>

However, to paraphrase the words of Steve McQueen in the great movie, *The Magnificent Seven*, the U.S. Navy deals in lead, friend. Therefore, although its ships spend the bulk of their service lives operating forward to preserve the peace, they are first designed to perform specific wartime roles as part of coherent fleet warfighting architectures. Consistent with this view, and to avoid any mission creep, Admiral Clark wanted his top officers to continually highlight the ship’s focused mission capabilities that made it an affordable swarm killer, submarine hunter, and mine warfare ship, and only then tout its “other inherent and support capabilities” applicable to the Joint Force.<sup>56</sup> As this demonstrates, then, the top Navy leadership always thought of LCS first as a *warship*, and would willingly accept LCS design limitations when it was performing its secondary or inherent missions.

### **A Reconfigurable, Multirole Platform**

The LCS’s envisioned concept of operations called for ship to perform littoral anti-surface warfare (ASuW) against small boats and craft, antisubmarine warfare (ASW) against diesel submarines lurking in shallow littoral waters, mine warfare (MIW), and a range of inherent “mobility related” missions in peacetime. Given the fundamentally different demands of these tasks, one plausible path forward would be to build three completely different purpose-built hulls, each optimized for a single wartime mission and with inherent capabilities for specific secondary missions. Another would be to build permanent mission variants using a common hull. However, Admiral Clark had another idea, one explored and developed by the

Naval War College in the late 1990s. That was to exploit the “comparative advantage” provided by modular, *reconfigurable ships* each capable of performing mobility and littoral ASuW, ASW, and mine warfare missions, *but not at the same time*:

To develop access when needed (from peacetime through combat operations), to perform frequent non-combat related missions and to integrate in Joint planning and execution will require...an optimally balanced battery of modular on and off-board systems....War games and field experimentation have demonstrated the value of distributing combat power among modular-mission platforms—small surface craft with reconfigurable on and off-board systems...networked to warfighters.<sup>57</sup>

Unlike previous Navy surface combatants, then, LCS was “envisioned to be a ‘seaframe’ serving much the same purpose as an airframe for a reconfigurable aircraft or helicopter (or as an aircraft carrier with its reconfigurable air wing ‘module’). It [would] serve as a platform for ‘plug and play’ mission packages that [could] be changed, modified, or removed in a short period of time.”<sup>58</sup>

### **FORCEnet Modernization Strategy**

In addition to facilitating its envisioned battle network role(s), LCS’s modular, reconfigurable design would contribute to another of Admiral Clark’s overarching FORCEnet design objectives: a force architecture that was rapidly and affordably upgradable over time. Many commentators note that after the end of the Cold War, the Navy retired many ships with years of useful service life left. Aside from early retirements associated with the post-war fleet demobilization, the prime reason this was so can be attributed to the expensive midlife combat system upgrades necessary to pace evolving threats, as well as the need to keep new construction going to preserve a shrinking industrial base. When forced to make a choice between upgrading an older ship with an aging combat system and building a new ship with a modern combat system, fleet planners often opted to build the newer vessel and retire the older one—sometimes long before the end of their planned service lives. To reverse this trend, the FORCEnet SCFOS would consist of a high/low force mix of large *multimission* battle network combatants and small *multirole* battle network combatants, both conducive to affordable improvement over time.

With regard to the Global ConOps Navy’s planned force of high-end, multimission CGs and DDGs, the eighty-eight Aegis combatants would all gradually receive open architecture, computer-off-the-shelf (COTS)-based combat systems and modular open architecture VLS main batteries, and the twenty-four DD(X)s would be built with these features from the outset. Consequently, all 112 ships could accept a variety of new combat system software upgrades and weapons without redesign or modification. The upgrades would help keep the ships combat relevant over their full thirty-five to forty-year expected service lives (ESLs).<sup>59</sup> Meanwhile, the open architecture combat systems and modular design found on the fifty-six planned LCSs would enable affordable “future technology refresh, technology insertion and mission capability changes,” thus keeping the ships combat capable over the course



of shorter twenty to thirty-year ESLs.<sup>60</sup> This overall modernization strategy was designed to give the U.S. Navy an important leg up in any future long-term naval competition.

### **Rapid “Speed-to-Fleet” Strategy**

The final feature central to the LCS concept was its rapid design, build, and in-service development strategy. Admiral Clark stressed the LCS program “must not be ‘business as usual.’” He wanted to dramatically reduce the long development and build times typically associated with a new ship program, and he was more than willing to accept the risks inherent by accelerated it in order to “quickly fill a capability gap” in FORCENet’s Global ConOps Navy.<sup>61</sup>

However, in an effort to bound the risk associated with a rapid speed-to-fleet strategy, Admiral Clark endorsed a plan to award three concept and preliminary design contracts, followed by a down-select to two detailed versions. After a thorough review, the Navy had the option to build only one of the two designs, or build both to better assess their strengths and weaknesses. Early thinking called for the Navy to build one Flight 0 prototype of each design—the first in FY 2005 and the second in FY 2006—for delivery in FY 2007 and FY 2008. Fleet experience with the two Flight 0 seaframes would inform the design of the first two FY 2008 Flight I production ships, planned for delivery in FY 2010.<sup>62</sup> Although never explicitly addressed in early program documents, Navy leaders expected a down-select to only one LCS Flight I production version, informed by the results of fleet tests with the initial ships.<sup>63</sup>

### ***From Concept to Requirements***

While the foregoing section explains the key elements of the LCS concept, it only suggests the thinking behind the ship’s method of employment or the design choices made for its seaframes and mission packages. These were indelibly shaped by several key judgments and principles highlighted in the aforementioned *Draft LCS IRD* and *LCS Concept of Operations*, as discussed and modified by CNO Clark and the top leaders of the Navy staff and surface warfare community in their February 2003 offsite. Their judgments were later affirmed and memorialized in the *Preliminary Design IRD for the Flight 0 Littoral Combat Ship*, signed on 13 February 2003, soon after the offsite, and validated in the *Capabilities Development Document (CDD) for the Littoral Combat Ship*, approved in April 2004.<sup>64</sup> The following section highlights the most important of them.

### **A Self-Deployable, Theater-based Platform**

As called for in the 1-4-2-1 strategy, the Global ConOps Navy would concentrate on the away game, providing global homeland defense in depth, while the Coast Guard would concentrate on the home game, manning the close-in defensive perimeter. As such, U.S. Navy warships would most often deploy and operate persistently in four forward theaters, either from the Continental United States (CONUS) or from forward operating bases and stations, supported by the Military Sealift Command’s global logistics network. The Navy would augment the Coast Guard for homeland

defense missions, if required; conversely, the Coast Guard would bolster the Navy in forward theaters, when necessary.

Guided missile frigates, which would be replaced by LCS in the new FORCEnet fleet architecture, were built for transoceanic escort missions and could execute this general employment plan. However, they were too costly to buy and build in the numbers required for a 375-ship battle force and couldn't perform all of the littoral counter-A2/AD missions envisioned for LCS. Meanwhile, less costly PCs and mine warfare ships—all to be ultimately replaced by LCSs—were *single-purpose* ships with useful littoral counter-A2/AD capabilities but very slow transit speeds; they usually got to theaters on the decks of plodding heavy lift ships. Their deployment model thus did not fit well with the Global ConOps, which demanded the ability to swing rapidly between theaters.

The FORCEnet LCS would therefore represent a cost-conscious compromise: it would necessarily be smaller, less capable, and less expensive than an FFG, but larger, more capable, and more expensive than PCs, MCMs, and MHCs. As envisioned, it would be an affordable, self-deployable, and reconfigurable multirole warship optimized for operations in littoral waters, with onboard stores for fourteen (threshold) to twenty-one-day (objective) patrols.<sup>65</sup> As explained in the *LCS Concept of Operations*, "Self-deployability (blue water endurance) is needed to allow the platforms to get to the contested area without the need for scarce open ocean transport or the support of an ever-present mothership."<sup>66</sup> Once in theater, LCS would routinely operate from forward bases, stations, and friendly ports or as an integral part of FORCEnet Sea Bases with integrated combat logistics force ships.

In other words, LCS was conceived of primarily as a *self-deployable, theater-based platform*.<sup>67</sup> Consistent with this thinking, while senior Navy leaders anticipated LCS might conduct routine deployments from CONUS up to six months in length, they expected the ships to more often be forward based or forward stationed, using multiple crews in rotation.<sup>68</sup>

### **Methods of Tactical Employment**

When in forward theaters, the specific method by which LCSs would be employed would depend on "the number of LCSs available, the specific scenarios in different theaters, the requirements of the Global Concept of Operations and other issues...."<sup>69</sup> Nevertheless, senior Navy leaders envisioned the ship would be used in three basic ways:

- As an integrated part of a Carrier Strike Group (CSG) or Expeditionary Strike Group (ESG),<sup>70</sup> several LCSs with tailored mission configurations would perform "vanguard scouting, pouncing support, and other tasks."
- As part of an LCS Division or a Littoral Action Group (LAG) with up to six ships, LCSs would be forward deployed in order to maintain a continuous presence in forward theaters in order to build FORCEnet situation awareness. In wartime the divisions/LAGs would integrate into FORCEnet

battle networks “to complement power projecting multimission ships.”

- Finally, LCSs could conduct limited independent (mobility) missions in low threat areas, such as SOF support, AT/FP, MIO, NEO, HA/DR, or logistics support.<sup>71</sup>

Despite these plans, given its cost-constrained design, Navy leaders were clearly uncertain if LCSs could *deploy* as an *integral* part of a strike group. For example, the 2002 *Draft LCS IRD* stated that, to the maximum extent possible, “LCS operations should not slow the speed of advance (SOA) of either CSGs or ESGs.” It went on to say, “Operations with a CSG or ESG must be conducted with the Flight 0 ships and its benefit to CSG or ESG operations evaluated.”<sup>72</sup> Perhaps these tests would show the better approach would be to attach LCSs already present in forward theaters to deployed CSGs and ESGs for enhanced protection when operating in constricted waters or near shore.

As this suggests, then, Navy leaders knew the final method of employment for independent LCS patrollers, squadrons or LAGs, and LCS strike group escorts would not be fully settled until after the surface warfare community had time to conduct experiments with Flight 0 prototypes. The LCS was so different from any ship the Navy had ever operated that past practices, war games, and analyses could only suggest its most effective operation. It would take actual fleet experience with the Flight 0 ships to show the best way forward.<sup>73</sup> As will be seen, using the Flight 0 LCSs to validate initial assumptions and explore alternative concepts of employment was an important recurring theme early in the program.

Regardless of the ultimate method of employment, however, Navy planners expected LCS to be a “complementary force multiplier” as “one element of a balanced force.” Its “distributed nature and integration with existing and planned multimission forces [would] help shift the fulcrum point to reduce risk and favor U.S. strategic, operational, and tactical combat power.”<sup>74</sup>

### **Sprint Speed**

As called for in the 1-4-2-1 strategy, the Global ConOps Navy would spend most of its time providing situation awareness and maintaining the peace in four critical theaters. However, it would remain postured and ready to concentrate quickly across intra/inter-theater ranges wherever a crisis was brewing. And, since the LCSs would screen large battle network combatants and high value units from littoral threats once a theater battle network was assembled, both independent deployers and forward deployed divisions or LAGs had to get to the scene of a crisis in a hurry.

Consequently, Navy leadership always wanted LCS to have very high sprint speeds, and early thinking called for it to make between fifty and sixty knots.<sup>75</sup> Many commentators believe the value of high sprint speed was oversold. Indeed, the Navy’s Analysis of Multiple Concepts conducted at the behest of Congress concluded that while speeds over thirty-five knots were useful for maritime interdiction operations and inter-theater transits, they were not needed in most tactical

scenarios.<sup>76</sup> Nevertheless, at the February 2003 LCS offsite, Admiral Clark and his staff came to a consensus that while achieving fifty knots “was not an issue,” a sprint speed of between forty and fifty knots in sea state 3 was highly desirable.<sup>77</sup> As later explained in the later 2004 *CDD for LCS*, the desire for high sprint speed was motivated by three primary reasons: “responsive mobility” (to concentrate rapidly in forward theaters from a globally dispersed posture); “increased volume of search” (consistent with the LCS’s expected FORCEnet ISR function); and “threat evasion” (particularly against torpedoes).<sup>78</sup>

Without question, such high sprint speeds would add cost to the seaframe and force trade-offs in other ship characteristics, such as endurance (see below). However, within the context of the broader FORCEnet fleet architecture and LCS’s envisioned theater-based operating model, these reasons were quite sensible.<sup>79</sup>

### **Endurance**

Navy officers knew and accepted that any ship designed for high sprint speed would necessarily sacrifice unrefueled endurance. So, while they hoped an LCS with payload might ultimately boast a range of 4,300 nautical miles at 20 knots (the original design specification for a *Perry*-class FFG), they would accept an unrefueled range of 3,500 nautical miles at eighteen knots.<sup>80</sup> This thinking was entirely consistent with the idea that the LCS was first and foremost a self-deployable theater platform operating most often over intra-theater ranges from forward bases and stations. And, as outlined in the *LCS Concept of Operations*, when combined with the LCS’s high sprint speeds, “A self-deployment range of at least 3,500 nautical miles would ensure a quick transfer to another theater.”<sup>81</sup> On the other hand, Navy planners recognized the lower 3,500 nautical mile threshold unrefueled range might require the development of a “fuel bladder mission module” to support transoceanic crossings.<sup>82</sup>

Navy leaders also knew well that LCS would be a gas hog when operating at sprint speeds. However, during an unexpected or escalating crisis, even unrefueled sprint ranges of 1,000 (threshold) to 1,500 (objective) nautical miles would often be good enough to allow the rapid concentration of LCSs from adjacent theaters.<sup>83</sup> However, the officers expected the LCS would most often operate at much more economical patrol speeds and utilize its speed only when necessary. Consequently, they thought of LCS endurance as a function of both time and speed. As stated in the 2002 *Draft LCS IRD*, the ship would “operate at low speed for mission operations, transit at economical speeds, and be capable of high speed sprints...”<sup>84</sup> And, while the officers considered unrefueled range an important characteristic, they considered time between underway replenishments, or UNREPs, to be the more critical factor for mission endurance. They decided that a “time between UNREPs” of three to five days would support either peacetime or wartime LCS operations.<sup>85</sup>

As explained by Vice Admiral Rick Hunt, a former Commander, Naval Surface Forces and currently Director of the Navy Staff, while such frequent underway replenishments is unusual today, they were quite common in the 1980s, when CSG escorts often “topped off” every two or three days from strike group station ships.

As a result, senior Navy leaders with experience from that era did not consider a three to five day UNREP rhythm to be a serious operational limitation. Indeed, it might provide an unexpected benefit: as Vice Admiral Hunt observed, frequent UNREP operations would help improve the basic seamanship of the LCS force and, by extension, the entire surface warfare community.<sup>86</sup>

### **Navigational Draft**

As called for by its envisioned role and missions, LCS would routinely operate in waters close to a coast. As a result, in addition to high sprint speeds, planners wanted the ship to have a shallow navigational draft. Accordingly, they wanted LCS's maximum navigational draft to fall between ten (objective) to twenty (threshold) feet when operating at full load displacement.<sup>87</sup> In comparison, the maximum navigation draft for a *Cyclone*-class PC is eight feet; an *Avenger*-class MCM, fifteen feet; and a *Perry*-class frigate, twenty-six feet.<sup>88</sup>

### **Manned Helicopter Capability**

Navy leaders considered MH-60 helicopters absolutely critical to LCS's combat capability in all three envisioned mission areas.<sup>89</sup> However, their focus on affordability made the ship's organic aviation capability part of the design trade space. While rejecting a simple lily pad capability offered by Flight I/II *Burke* DDGs, they weren't sure they could hit their affordability targets if the LCS possessed the organic capability for a permanently embarked aviation detachment (det). The group thus decided the minimum acceptable aviation capability was a "hybrid concept" where the LCS could host an aviation det for days at a time. They also considered designating a single ship in each LCS division or LAG as a "primary helicopter carrier." The leaders acknowledged these approaches might require both a "core manned aviation capability" for the LCS seaframe and a plug-in "aviation support module" for added personnel when a helicopter was actually embarked.<sup>90</sup> This thinking demonstrates the difficult design trade-offs forced by the driving requirement for platform affordability.

### **Unmanned Sensors, Systems and Vehicles**

Next to helicopters, unmanned sensors, systems, and vehicles were considered most critical to LCS concept success. Since it was envisioned as a discrete "node" within a "dispersed, netted, and operationally agile fleet," Navy leaders wanted LCS to be able to maintain "broad area situational awareness" during peacetime, and exert control over wide littoral areas during combat operations.<sup>91</sup> Together, these requirements called for a ship capable of deploying and monitoring off-board sensors and employing second-stage "organic off-board vehicles (OOVs)"—like the planes in an air wing embarked aboard a fleet aircraft carrier.<sup>92</sup> Small manned craft like rigid-hull inflatable boats (RHIBs) would continue to be valuable for a variety of missions, such as maritime interdiction operations and special operations support.<sup>93</sup> But, with a growing appreciation for the untapped potential of unmanned systems, Navy leaders expected all LCS mission packages to include—if not emphasize—deployable, multi-phenomenology sensors, tactical unmanned aerial vehicles

(TUAVs), unmanned surface vehicles (USVs) and unmanned underwater vehicles (UUVs).

Navy leaders recognized a ship able to “support the full spectrum of making off-board systems effective”<sup>94</sup> was “incompatible with the design and employment concept of multimission ships.”<sup>95</sup> To perform its envisioned role, LCS would therefore be specifically designed to deploy, manage, exploit, refuel, reposition, recover, replace, and redeploy off-board sensors, systems and vehicles, a mission requirement dubbed DMER5. As stated in the *LCS Concept of Operations*, “This full service DMER5 of off-board systems requires LCS to have launch, recovery, servicing, [command control, communications, and computers], crew, and seakeeping abilities” appropriate for performing these mission related tasks.”<sup>96</sup> The picture that emerges is of Navy leadership viewing LCS as a pathfinder for a new type of combatant—a mothership for second-stage manned and unmanned OOVs, themselves expected to evolve and improve in capability over time.

Once again, however, there was great uncertainty over exactly how far a first step the LCS would be able to take. For example, the stated, “There is limited experience in the use of modular mission packages including unmanned vehicles and systems as primary elements in the mission capability of surface ships, especially multiple systems being simultaneously deployed and controlled from a single ship.” Navy leaders therefore expected the Flight 0 LCSs to investigate the utility of OOVs in each mission area, as well as the ability of the LCS’s command and control suite to support them.<sup>97</sup>

### **Persistent Presence and Operations**

Navy leaders thought LCSs operating from forward bases and stations, with onboard stores to support fourteen to twenty-one-day patrols augmented by the ability to replenish at sea every three to five days, would be able to maintain the persistent theater *presence* called for in the Global ConOps. However, to be operationally effective, patrolling LCSs would often need to deploy helicopters, boats, sensors, TUAVs, USVs, and UUVs in rough weather. The officers therefore viewed platform stability as the most important characteristic for providing persistent FORCEnet *operations* in all weather conditions. Consequently, despite its relatively small size, Navy leadership expected LCS designs to launch manned and unmanned OOVs in at least sea state 4 (sea state 5 preferred), and manned and unmanned boats and craft in at least sea state 3 (sea state 4 preferred).<sup>98</sup>

Of course, this inherent level of stability would also help make LCS a very steady littoral weapons platform at both low and high speeds in all weather conditions.<sup>99</sup> This would be a particularly useful trait in a swarm fight against small boats and craft, which would be much more prone to suffer from the effects of rough weather.

### **Reduced/Optimal Crewing**

To reduce life cycle costs, Navy leaders always wanted LCS, “to the maximum extent possible, [to] employ reduced/optimal manning concepts.”<sup>100</sup> However, achieving

small crew sizes soon became another key driving design goal—so much so that CNO Clark expected LCS builders and designers “to justify each person” in the core and mission package crews and “push for the minimum manning possible.”<sup>101</sup> This thinking mirrored that of the then long-running DD-21/DD(X) program, which aimed for a crew of no more than 175 officers and Sailors on a ship four to six times the size of LCS<sup>102</sup>.

Admiral Clark endorsed an initial “core crew” manning target (those who operated the LCS seaframe) of thirty to fifty crew members, based on his expectation that LCS would set new standards in automation.<sup>103</sup> Members of his staff pushed even harder, recommending a core crew in the range of fifteen to thirty officers and Sailors. In the end, Admiral Clark and his staff split the difference, agreeing to objective and threshold manning core crew targets of fifteen and fifty crew members, respectively.<sup>104</sup> Importantly, however, they agreed that ship accommodations for the entire crew (core crew plus “mission package” crew) should not exceed seventy-five racks (i.e., installed bunks).<sup>105</sup> They felt this aggressive target would be a forcing function both to push industry design teams towards the greatest use of automation and increase chances the Navy would minimize crew size and manpower overhead—and overall LCS lifecycle costs.

The emphasis placed on limiting the total number of racks—and therefore total crew size—was also partly influenced by the Navy’s desire to pursue a “multi-crewing, forward stationed” deployment model for LCS. By adopting a rotational crewing model along lines long practiced by the ballistic missile submarine force, Navy leaders hoped to achieve employment efficiencies of 75 percent (e.g., ships deployed for thirty-six months followed by a twelve months interdeployment maintenance and training cycle). While such high efficiencies would minimize LCS’s peacetime turn-around ratio, maximize the number of ships forward deployed and ready, and lead to “fewer transoceanic transits,” rotating very large core crews would create a substantial manpower overhead bill.<sup>106</sup> Therefore, the leaders sought to keep the total crew size from exceeding seventy-five personnel.

Of course, with such a small crew, the supporting off-board logistics, maintenance, and training construct would be absolutely critical to LCS’s ultimate success. However, in 2003 there was no substantive discussion about how this construct might work. The officers were content to let LCS Flight 0 ships “investigate alternative ...support concepts that...satisfy these requirements.”<sup>107</sup>

### **Mission Reconfigurability Timelines**

As discussed, the LCS’s envisioned FORCEnet combat mission called for the basic seaframe to at times perform the roles of a twenty-first century torpedo boat destroyer (T.B.D.), submarine chaser (SC or PC), or fast destroyer minesweeper (DMS), whose missions could be “considered from a defensive or offensive viewpoint.”<sup>108</sup> To perform all these disparate roles, the seaframe was designed to accept three distinct modular mission packages. Initial plans called for the mission packages to be installed and uninstalled on LCS seaframes depending on the needs of a campaign. For example, an LCS might first be configured to conduct battle

network ISR or support SOF insertions, then shift to littoral ASuW, ASW, or MIW, and then shift to mobility missions in support of the Sea Base. Accordingly, the initial LCS operational concept called for a “rapid modular reconfiguration capability.”<sup>109</sup>

However, when senior Navy leaders discussed mission reconfiguration timelines in February 2003, they were far less interested in changing LCS mission packages during ongoing naval campaigns. While they assumed packages would often be flown to and from distant theaters in support of the forward-deployed LCS force, they did not want battle network combat capability to rely on the airlift of mission packages during a brewing crisis or major combat operations. Instead, their envisioned LCS concept of employment emphasized “come-as-you-are” ships from a globally distributed force posture, since they believed CONUS deployers “would most likely be configured and crewed with a single mission package for the duration of a deployment.”<sup>110</sup> Consequently, they considered mission package swap-out times of “‘days’ vice ‘hours’” to be more than sufficient.

At first glance, this thinking seems incongruous with subsequent requirements documents, which stipulated that changing out one mission package for another and achieving full operational capability for the new mission should take between one (objective) and four (threshold) days, including system operational testing.<sup>111</sup> However, as explained in the *LCS Concept of Operations*, “With modularity and open architecture, LCS has an *inherent* capability to *remove* the MIW, [surface warfare], and ASW mission modules, freeing up space and weight capacity to support a host of other non-access missions.”<sup>112</sup> In other words, planners thought an LCS operating in theater might temporarily remove its mission package to conduct “inherent, mobility-related missions,” and reinstall the same package upon mission completion—thinking once again consistent with the idea of LCSs operating most frequently from forward bases or stations.<sup>113</sup>

Reinstalling a familiar mission package in one-to-four days would be far less stressing than changing out one mission package for a completely different one. The latter evolution would inevitably require the core crew to undergo refresher training and work-up time with the new mission package crew to achieve peak proficiency in the new mission, which would inevitably add time to the swap-out process. Once again, Admiral Clark and his staff expected the Flight 0 LCSs to point the best way forward. As stated in the 2002 *Draft LCS IRD*, “Modularity in support of focused missions *and possibly sequential mission support* will be explored by the Flight 0 ships...”<sup>114</sup> As this wording clearly suggests, while the ability to swap-out one mission package for a different one in the midst of a naval campaign might perhaps prove useful, rapid swaps-outs of focused mission packages to allow LCSs to conduct emergent mobility missions was considered far more important.

### **Combat Survivability**

During the 2001-2003 timeframe, when the Navy was first deciding what it expected LCS to be, retired Vice Admiral Art Cebrowski became Director of the OSD’s new Office of Force Transformation. A naval aviator by trade, Vice Admiral



Cebrowski had championed small, modular Streetfighter combatants while serving as President of the Naval War College. And, as mentioned previously, he believed Streetfighters “must be designed to lose [that is, to be lost in combat]. If no risk or loss is contemplated, they are a poor design concept because they forego... economies of scale that are a prominent advantage...”<sup>115</sup> Consistent with his experience as a combat aviator, he therefore envisioned LCS crews would simply abandon their ship after taking a serious hit.

While Admiral Clark agreed with Admiral Cebrowski that the Navy needed small combatants in its future fleet design, he personally disagreed with the idea of an expendable warship and knew such a concept would never sell in the surface warfare community. The CNO therefore sought the most survivable ship possible within the program’s aggressive cost targets.<sup>116</sup> In practical terms, this necessarily meant LCS seaframes could be built to no more than Level I survivability standards, the lowest of three levels then assigned to U.S. Navy warships.<sup>117</sup>

As explained in OPNAV (Office of the Chief of Naval Operations) instruction 9070.1, “Survivability Policy for Surface Ships of the U.S. Navy,” the governing U.S. Navy instruction on survivability in 2002-2003:

Level I represents the least severe environment anticipated and excludes the need for enhanced survivability for designated ship classes *to sustain operations* in the immediate area of an engaged Battle Group or in the general war-at-sea region.<sup>118</sup>

In other words, LCS would not be expected to *continue fighting* after taking a hit. This design approach was consistent with mine warfare and PCs, which were both built to Level I standards. However, it was not as robust as the *Perry*-class FFG, with its Level II standards, designed to allow the ship to “conduct sustained combat operations following weapons impact,” much less the Level III standards used for large multimission ships to give them “the ability to deal with the broad degrading effects of damage from antiship cruise missiles, torpedoes, and mines.”<sup>119</sup>

Although requirements documents stipulated LCS would be built to Level I standards, the Navy initially asked for ship designs using American Bureau of Shipping (ABS) High Speed Naval Craft Rules, which were essentially commercial standards.<sup>120</sup> Designers simply did not believe they could hit the LCS cost targets with more stringent standards. Consequently, early program documents established “crew survivability” as the minimal design standard.<sup>121</sup> These moves seemed more consistent with a ship “designed to lose” than a warship able to take a hit and survive. Therefore, the Navy began to address LCS survivability in a more proactive manner, talking less about Level I design standards and more in terms of a “a total ship approach to survivability that addresses susceptibility, vulnerability, and recoverability.”<sup>122</sup> In the case of LCS, the ship would forego armor and extensive compartmentation in favor of “speed, agility, stealth and maneuver with organic sensors and weapons plus networked force capability.”<sup>123</sup> These elements would unfold as follows:

- High speed and agility—defined as maintaining high speed in a variety of sea states—was viewed primarily in terms of skirting enemy aircraft search windows, improving antiship cruise missile (ASCM) countermeasures, and evading torpedo attacks.<sup>124</sup>
- Because LCSs would operate as the forward naval battle network screen, reduced magnetic, infrared, and radar ship signatures, together with good signature management, were highly desirable, as they would help disrupt every link in an enemy’s detect-identify-localize-target-engage kill chain. Nevertheless, as with both organic aviation capability and crew size, senior Navy officers well understood that the degree of stealthiness would be determined “within the Cost as an Independent Variable (CAIV) domain.” Therefore, while the officers hoped for better performance, LCS radar cross section levels “within the range of [an *Arleigh Burke*] DDG” was acceptable.”<sup>125</sup>
- The LCS’s organic sensors and core self-defense suite were expected “to enhance its capability to operate forward and in threat waters.” The key requirement here was a terminal missile defense system able to defeat a small surprise salvo of ASCMs when the ship was operating independently, or small numbers of ASCMs penetrating through both outer and inner FORCEnet defenses when LCS worked with large battle network combatants. An affordable radar “that would provide a surface search capability and a limited air picture” was considered a top priority, and the Phalanx Close-in Weapon System, Rolling Airframe Missile (RAM) anti-missile system, and Nulka decoy were all on the list of candidate core defensive systems.<sup>126</sup> Navy leadership also wanted the LCS to have a good anti-surface capability, including an over-the-horizon weapon “of some sort.” While adding the Harpoon antiship missile to the Flight 0 ships was never posed, a longer range, next generation cruise missile capability was considered “a highly desirable feature” for future LCSs.<sup>127</sup>
- In addition to its own organic sensors and weapons, LCS could also count on “powerful networking to power projection assets for increased awareness,” which would afford the ship air, missile, and undersea defense in depth. As stated in the *LCS ConOps*, “reach back assets provide an important component of LCS survivability.”<sup>128</sup>

As implied from the preceding discussion, then, LCS’s survivability would focus primarily on susceptibility—that is, its ability to avoid a hit altogether. LCS’s vulnerability to an actual weapon’s hit would be “commensurate with the ship’s size and hull displacement.” The ship would also be given an appropriate level of collective protection against chemical, biological, and radiological threats. Finally, given its small crew, recoverability would rely heavily upon automated damage control and firefighting equipment and applications.<sup>129</sup> Consistent with its expected commercial design, less attention would be given to the ship’s recoverability, which remained a sore point for the surface warfare community.

### **The Importance of Flight 0 Prototypes**

If not already evident, the two planned Flight 0 prototypes were absolutely instrumental to the LCS's rapid development, design, and build strategy as well as its ultimate success in fleet service. As the 2002 *Draft LCS IRD* stated, "surface combatants have historically been designed to operate principally with organic mission capability, and to rely on remotely generated information to enhance their organic capability."<sup>130</sup> In contrast, the LCS would rely on the power of FORCEnet for both situational awareness and survivability to a degree never seen before. This represented a big leap in battle force and ship design, as well as a major culture shift for a surface warfare community whose experiences were shaped predominately by operating large, expensive, multimission combatants.

Therefore, although the two Flight 0 seaframes would ultimately become operational fleet units, their "initial contribution" would focus on "refining the design and employment architecture... of follow-on ships to best achieve the full operational capability of the LCS force." Or, as stated later, "While intended to be a fully deployable and combat-ready asset, the Flight 0 also has a principal *raison d'être* of refining concept development, modularity, employment of off-board vehicles and affecting risk mitigation in follow-on flights of the ship class."<sup>131</sup> And, as previously stated, they would also develop the best logistics, maintenance, and training support structure. Admiral Clark anticipated Flight 0 prototype testing would help overcome any skepticism of the LCS concept within the surface warfare community, as well as small warships in general.<sup>132</sup>

### ***From Requirements to Program***

The foregoing decisions and judgments reflect what the senior leadership of the Navy wanted the LCS to be and do. The next step was to translate these decisions and judgments into a concrete ship design and stable shipbuilding program. However, as in any program that stretches over a decade or more, circumstances and planning factors change, unforeseen problems arise, and original assumptions prove false or only partially correct. Consequently, the translation from desired requirements to a final ship design is always imperfect, requiring the Navy to adjust its expectations and plans. The following section details the most important subsequent changes to the LCS program and ship designs, in rough chronological order.

### **Function to Form: A Design for Employing OOVs**

Navy leaders had a clear idea of the LCS's FORCEnet function—a self-deployable, reconfigurable, multirole battle network node designed to employ a variety of organic off-board vehicles, including both manned helicopters and a variety of unmanned systems. However, they were content to let what ultimately turned out to be six competing design teams choose the best hull form to perform this function.<sup>133</sup> To guide their choices, Navy planners established a threshold for mission package payload at 180 metric tons, with an objective of 210 tons.<sup>134</sup> Importantly, however, they stipulated the total payload had to be apportioned among twenty different modular mission stations.<sup>135</sup>

Two of these mission stations would be devoted to aviation systems. Recall that early in the program, the minimum required LCS aviation capacity was to hangar and operate at least one MH-60 helicopter for days at a time. During the subsequent Analysis of Multiple Concepts, however, a manned helo was deemed so central to every LCS combat mission that it drove the minimum requirement toward hosting a permanent helicopter detachment.<sup>136</sup> At the same time, however, Navy planners knew unmanned aerial systems would play an increasing role in naval warfare. Consequently, although the required aviation mix was ultimately set at one MH-60 helicopter and one unmanned aerial vehicle, both of the two aviation stations had to be large enough to hangar either one MH-60 or three Fire Scout TUAVs.<sup>137</sup>

The eighteen remaining mission stations were to be devoted to carrying manned and unmanned boats or craft, unmanned underwater vehicles, deployable sensors, weapons, and supplies. Four of the stations supported RHIBs, UUVs, USVs, and other surface craft; two large sea stations had to be sized for an eleven-meter long system, while two small sea stations had to be sized for seven-meter long systems. An additional station would carry deployable off-board sensors, another would carry adjunct systems for off-board vehicles (e.g., a towed mine hunting sonar), and three more would support extra guns or missile systems. Finally, the nine remaining “support stations” had to be large enough to carry 8x8x20 foot containers stuffed with the parts, supplies, and maintenance equipment to service embarked OOVs, systems, and equipment.<sup>138</sup>

By asking the six design teams to build a fast, multirole combatant around these space and payload parameters, Navy leadership hoped to see innovative LCS hull shapes and systems. They got what they wished for. In the end, the two LCS hull forms surviving the competitive design process differed radically both from each other and any other ship in the fleet. The Lockheed Martin (LM)-led team offered a steel, semiplaning monohull, while the General Dynamics (GD)-led team opted for an aluminum trimaran.<sup>139</sup> Both had full load displacements of approximately 3,100 tons. At this displacement, with their twenty modular mission stations the two ships would be the smallest in the world with such large aviation and unmanned OOV capacities.

### **Function to Form: Improving Combat Survivability**

As previously discussed, there was absolutely no way to build LCS seaframes to Level II or Level III survivability standards if they had to possess a top speed exceeding forty knots, the capacity to support MH-60s and manned and unmanned off-board systems, and cost between \$250 and \$400 million. Therefore, although the approach entailed some risks, top Navy leaders accepted that the LCS’s combat survivability would rely less on extensive armor and compartmentation and more on FORCEnet/TFBN defenses and the ship’s own speed, agility, passive stealth, and core defensive systems. As originally envisioned, its seaframe would be built to Level I standards with crew survivability being the primary design requirement.

However, as the design progressed, LCS survivability started to rely less on avoiding a hit (e.g., susceptibility) and more on reducing ship vulnerability and improving

recovery after taking a hit.<sup>140</sup> This move was made partly in response to grumblings from the surface warfare community, which was highly skeptical of warship based on commercially derived designs. Accordingly, during the design and construction of the two Flight 0 prototypes, the Navy directed the two LCS design teams (LM and GD) to shift to ABS Naval Vessel Rules (NVR), which were more stringent than the earlier commercially-based ABS High Speed Naval Craft Rules. Naval Vessel Rules define a set of combatant standards applicable only to hull, machinery, and electrical passive survivability requirements (e.g., structural strength, redundancy and separation), and not to ship combat systems.<sup>141</sup> Consequently, the move to NVR meant an LCS's main propulsion plant and associated auxiliaries, electrical generation and distribution systems, navigation, internal communication and announcement systems, fire mains, and navigation and external communications systems all had to be shock hardened. A second result was the addition of extra watertight compartmentation to allow the ship to remain afloat even with three compartments and 15 percent of its overall length flooded—the same damage stability requirement for Level II and Level III combatants. Finally, the LCS was provided no less than three redundant firefighting systems.<sup>142</sup>

The ships' core defensive systems were also locked in, and both were consistent with the original desires of Navy leadership. In terms of air self-defense, the Lockheed Martin-led team adopted an integrated Aegis-based combat management system called COMBATSS-21, with a German TRS 3D air and surface search radar and a twenty-one-cell RAM launcher to defeat low-density ASCM attacks.<sup>143</sup> Meanwhile, the General Dynamics-led team chose the Dutch TACTICOS combat management system, coupled with a Sea Giraffe 3D air and surface search radar and an eleven-cell SeaRAM anti-missile system.<sup>144</sup> Both variants also received electronic warfare systems and Super Blooming Rapid Off-board Chaff launchers to spoof and decoy incoming antiship cruise missiles.<sup>145</sup> With these systems, Navy leaders expected LCSs to be able to protect themselves from small salvos of ASCMs when operating independently, and against any "leakers" having made their way through battle network defenses.

For their basic anti-surface warfare weapon, both ships received the same medium caliber automatic cannon. Two candidates were considered: the 76 mm Oto Melara found on the Navy's FFGs, and a 57 mm cannon produced by Bofors. The 76 mm cannon offered range and punch, and could fire existing rounds in the Navy's inventory, but came at the expense of magazine capacity, rate of fire, reliability, and added weight and cost to the seaframe.<sup>146</sup> Given expectations that ASuW-equipped LCSs would have an armed helo and the non-line of sight (N-LOS) Precision Attack Missile to attack small boats operating over the horizon, the Navy opted for the Mark 110 57 mm cannon. With a rate of fire of 220 rounds per minute, and the ability to fire programmable, pre-fragmented, proximity-fuzed (3P) ammunition, the 57 mm was considered the better choice to counter any swarming boats able to penetrate the ship's longer range defenses. As an added bonus, its selection ensured system commonality with the U.S. Coast Guard's new National Security Cutter, which was also armed with the Mark 110.<sup>147</sup>

As has been widely reported, despite these design improvements and features, DoD's Director of Operational Test and Evaluation (DOT&E) still concluded, "LCS is not expected to be survivable" in littoral naval combat. While there were several technical reasons behind this conclusion, such as "knowledge gaps related to the vulnerability of an aluminum ship structure to weapon-induced ballast and fire damage," key to DOT&E's judgment was that the ship was "not expected to maintain mission capability after taking a significant hit in a hostile combat environment."<sup>148</sup> In other words, DOT&E found fault with the Navy's decision not to build LCS to at least Level II survivability standards—including "features necessary to conduct *sustained* operations."<sup>149</sup> However, this choice was fully in keeping with LCS's ConOps, and was approved by the Joint Requirements Oversight Council. Moreover, DOT&E's opinion is out of step with advances in both naval warfare and weaponry. A single under keel explosion from a heavyweight torpedo would likely sink a 10,000-ton Level III *Ticonderoga*-class cruiser as easily as it would a "Level I+" LCS. Similarly, it would be hard for any U.S. combatant to *sustain* combat operations long after being hit by a single heavy, supersonic cruise missile with a terminal impact speed of Mach 2 to 3. Accordingly, the Navy recently revised its survivability policy and standards for U.S. Navy surface ships and craft states, opting to jettison the prescriptive trilevel Cold War survivability standards adopted in 1988. As stated in the updated instruction, dated 13 September 2012:

This revision recognizes the changing nature of naval ship design and system threats and eliminates the prescriptive survivability characteristics while establishing the new requirement to derive a minimum survivability baseline that is based on the programs' ICD and defined concept of operations (CONOPS)... Survivability shall be addressed on all new surface ship, combat systems and equipment designs, overhauls, conversions, and modernizations in order that the design is provided a balance of survivability performance, risk, and cost within program objectives.<sup>150</sup>

In other words, the approach taken on survivability for the LCS is now standard Navy policy for all its battle force ships.

Altogether, then, LCS is a tougher ship than expected and far better able to defend itself than the patrol combatants and mine countermeasure ships it replaces. Indeed, its defensive armament stacks up well against the legacy *Perry*-class frigates now operating with the fleet, with their single 76 mm cannon and one Phalanx Close-in Weapon System for missile defense.<sup>151</sup> Although LCS does not have the more extensive internal subdivision necessary to allow the ship to continue fighting after taking a hit, because of its greatly improved structural strength, component hardening, and advanced damage control features, it is far tougher and more resilient than originally envisioned. Program managers now consider the LCS a "Level I+" design, with the ability to take a hit, recover, and return home under its own power (think the Israeli corvette *Hanit*).<sup>152</sup>

### Increased Cost Projections

The shift to Naval Vessel Rules and other changes made in the middle of the detailed design and early production phase disrupted the LCS program schedule and contributed to spiraling costs for the first two Flight 0 ships. They also had an impact on the projected average cost of a missionized Flight I LCS. Recall that in early 2003, Admiral Clark wanted the *threshold* (minimally acceptable) cost for “an entire” (i.e., missionized) LCS to be \$250 million. By mid-2004, however, the *LCS Capabilities Development Document* stipulated an *objective* (desired) cost of \$225 million, divided between \$150 million for the seaframe and \$75 million for the mission packages, and a threshold cost target of \$370 million, of which \$220 million was dedicated to the seaframe and \$150 million to the mission packages.<sup>153</sup> This adjusted threshold target, which established the new minimally acceptable cost for a missionized LCS, was very close to the \$400 million threshold target established by OSD in 2002-2003, and subsequently endorsed by the House Armed Services Committee in 2006.<sup>154</sup> It was also the first harbinger of continual “cost creep” which was ultimately to cause significant program disruption down the line (more on this point shortly).

### Changes to IRD Requirements

During any ship’s development, design requirements are often modified to constrain costs. The LCS program was no different in this regard, particularly once it became clear the basic seaframe would come in well above even the modified \$220 million threshold target. Of the cost avoidance decisions to the LCS seaframe made in the 2005-2005 timeframe, three stand out:

- The Navy relaxed the threshold for unrefueled endurance to 3,500 nautical miles at fourteen knots, with an objective of 3,500 nautical miles at sixteen knots.<sup>155</sup> While this decision represented a further concession to the LCS’s emphasis on high sprint speed, it was consistent with the idea that the ship was first and foremost a self-deployable theater asset. Without question, however, since the *average* SOA of a strike group is about sixteen knots, this move will make it more difficult for an LCS to operate as an *integral part* of a deploying CSG, and perhaps for an ESG or amphibious ready group. Said differently, slower economical transit speeds make it more likely that LCSs will be attached to strike groups once they arrive in theater and are operating in littoral waters, rather than deploying with them. Of course, exact LCS operating procedures with strike groups will ultimately be worked out through fleet testing, as planned in 2003.
- The Navy eliminated the requirement for a collective protective system (CPS) for airborne contaminants (nuclear, biological, or chemical), which originally had to be “of sufficient size and capacity to allow the operation of all core systems inside the CPS boundary.” The LCS will instead be equipped with less costly ship decontamination stations and carry sufficient individual protective suits and equipment for the entire ship’s company.<sup>156</sup> This could be a regrettable loss in capability for a ship designed to operate inside

contested littorals.

- Finally, the original LCS design called for a vertical replenishment (VERTREP) spot, a fueling at sea (FAS) station, and a connected replenishment (CONREP) station used to transfer bulk stores on pallets. To constrain costs, the Navy dropped the requirement for a CONREP station.<sup>157</sup> Given the small size of the crew, the thinking was VERTREP replenishment would be sufficient, and losing bulk store transfer capability would have little to no impact on the LCS's three-to-five-day UNREP frequency.

### **Manning and Crewing Developments**

Recall that the Preliminary Design IRD set the objective and threshold manning for the core crew to be fifteen and fifty crew members, respectively. In addition, maximum shipboard accommodations for a missionized LCS—that is, one operating with a combined core and mission package crew—were set at seventy-five racks. This requirement was based on the expectation that the core crew would contain forty crew members, the embarked aviation detachment would number twenty personnel, and a mission package team would consist of no more than fifteen people. However, Navy planners knew this manning target was quite aggressive, and past experience suggested additional Sailors and officers might be needed once the Flight 0 ships were in fleet service.<sup>158</sup> Therefore, the April 2004 *CDD for LCS* added a new seaframe attribute for “total platform manning,” with objective and threshold targets of seventy-five and 110 crew members, respectively.<sup>159</sup> In other words, Navy planners recognized that final ship manning might easily exceed seventy-five personnel.

Subsequent events proved them right. Follow-on functional workload analyses suggested a core crew size of forty would be difficult, but possible, to achieve. However, in August 2007, in light of the requirement to carry and operate one MH-60 and one to three UAVs at all times, the LCS Flag Oversight Council approved an increase in the planned size of the aviation detachment to twenty-three pilots and maintainers, three above the originally approved number. In turn, this decision prompted the LCS program's Configuration Change Board to add three additional racks to LCS 1 and 2 in post-delivery availabilities.<sup>160</sup> Seventy-eight bunks thus became the new “total platform manning” objective.

As a hedge against further crew growth, the Navy wanted both builders to account for the possibility that total platform manning might exceed seventy-eight personnel. One hedge involved providing the capability to accept 8x8x20 foot habitability modules with bunks and showers that could be temporarily installed in one or more of the LCS's nine support stations. A second hedge involved designing in the capability to increase the number of installed shipboard racks if manning requirements grew beyond seventy-eight crew members. Thus, while the Flight 0 LCSs would start with a total of seventy-eight racks in a *two-high* bunk configuration, both designs could accommodate up to ninety-eight personnel in a *three-high* rack configuration without compromising Navy habitability standards.



Assuming the combined aviation detachment and mission crew remained at the planned target of thirty-eight spaces (twenty-three plus fifteen), if subsequent experience showed the core crew to be too small, this second design hedge would allow the Navy to increase the planned forty-person core crew by up to 50 percent without significant problems. Alternatively, if the core and mission crews did not exceed seventy-eight personnel, the ship could easily be modified to carry up to twenty additional personnel without having to install habitability modules. Above that number of people, more substantive and costly changes to seaframe potable water, sewage and solid waste disposal systems and food/dry provision storage would have to be made.<sup>161</sup>

This forward thinking proved to be prescient. Early data from LCS operations, particularly from USS *Freedom*'s early operational deployment and performance during major fleet exercises, suggests the core crews will likely have to be increased modestly in numbers to accommodate more maintainers and watch standers. Additionally, the surface warfare mission package now includes a maritime security module, which includes two eleven-meter RHIBs and two Visit, Board, Search, and Seizure (VBSS) teams. As a result, the mission package crew now numbers nineteen personnel, four more than originally planned.<sup>162</sup> The mine warfare mission package crew is also projected to grow to nineteen people. Moreover, fleet experience with embarked habitability modules has not been encouraging; the modules are cramped and have poor ventilation, and sound sleeping in the open mission bays is difficult due to high noise levels. Consequently, in preparation for her planned 2013 deployment to Singapore, LCS 1 was provided the additional twenty "hedge bunks." This move will accommodate the observed growth in the aviation detachment and mission package crews, and allow for further experimentation with larger core crews. The extra bunks will also be added to USS *Independence* (LCS 2) and all future ships of both classes.<sup>163</sup> At the same time, the LCS Program Office is examining any changes to seaframe "hotel" services (e.g., fresh water and stores) needed to support ninety-eight personnel for twenty-one day patrols. The costs for these modifications are expected to be modest.

As for the desired "multi-crewing, forward stationed" deployment model, analysis suggests the most efficient manning approach is to assign three core crews to every two LCS seaframes. Moreover, experience gained from USS *Freedom*'s first deployment indicates the seaframe's relatively small core crew can operate effectively for up to four months. At that point, the crew would need a break from the demanding tempo of operations, even if augmented. Consequently, current plans have a thirty-two-month deployment cycle for each seaframe pairing, with both hulls alternating between one sixteen-month period deployed or ready for tasking and a second sixteen-month period devoted to maintenance and local operations from home port. At the same time, the three assigned core crews would operate on a twelve-month rotational cycle, spending four months in training, four months in workup, and four months on deployment. In this way, over the course of the thirty-two-month cycle, there will be—for every two crews and three seaframes—eight four-month crew deployments, four per hull, with no single crew spending more

than twelve months deployed.

As LCS program managers put it, three core crews and two seaframes will keep one ship deployed at all times. In other words, the “3-2-1” crewing scheme is expected to yield a forcewide availability rate of 50 percent. This means a force of 55 LCSs will be able to keep 27 or 28 ships continuously forward deployed. It would take a force of 103 to 124 single-crewed, CONUS-based FFGs to provide the same level of forward presence.<sup>164</sup> Further fleet experimentation will identify the optimum LCS manning and settle whether the 3-2-1 rotational crewing model is the best and most sustainable approach.

### **Changes to Mission Packages and Systems**

Early thinking called for each seaframe to have three dedicated mission packages—one of each type (e.g., ASuW, ASW, and MIW), resulting in a requirement for 168 total packages for the fifty-six seaframes called for in the 375-ship Global ConOps Navy. This was always a notional planning factor to establish estimated program costs, and was based on an assumption of frequent mission package swap-outs over the course of a naval campaign.

However, with the deemphasis on serial change-outs during campaigns in favor of a globally distributed mix of deployed seaframes and mission packages that could be concentrated in a wartime theater, thinking on the number of required packages per seaframe began to change. For example, after a detailed review of war plans during the Analysis of Multiple Concepts, planners concluded eighty-eight mission packages were needed to support fifty-six LCSs, for a mission package-to-seaframe ratio of 1.6:1.<sup>165</sup> A later study conducted for the Navy by the RAND Corporation called for a long term mission inventory of 126 packages for fifty-five LCSs, including twenty-eight ASW, thirty-eight mine warfare, and sixty surface warfare packages—or about 2.3 mission packages per seaframe.<sup>166</sup>

Ultimately, as the 3-2-1 crewing scheme was solidified and idea of basing more LCSs forward became more prominent, the Navy’s plans for mission packages ratcheted downward. With twenty-seven of fifty-five planned LCSs forward stationed, forward deployed, or ready for tasking, fleet planners concluded that an apt allocation of ready mission packages, coupled with LCS’s high operational transit speed (that, is, ability to reach the scene of action), would allow the quick concentration of sufficient mission packages to respond to almost any campaign. As a result, current plans now call for just sixty-four mission packages for fifty-five LCSs, including sixteen ASW, twenty-four MIW, and twenty-four ASuW versions—for a mission package-to-seaframe ratio of 1.2:1. This ratio is consistent with the idea that forward deployed LCSs might temporarily remove their mission packages to conduct a mobility mission, but would not often change their primary mission focus packages over the course of a deployment. Needless to say, if the number of planned LCS seaframes drops and campaign requirements stay constant, serial mission package changes might become more important and the ratio of packages to seaframes might need to rise. In any event, if fleet experience proves the seaframe-mission package balance to be incorrect, the Navy can always consider procuring

more packages as needed.

There have been similar changes to planned mission package systems, as testing revealed some systems to be less effective or reliable than expected. For example, the Navy decided to completely skip the planned first ASW package, which relied on deployable off-board sensors, in favor of a hull-mounted mission package allowing for littoral and open ocean ASW escort of high value units. Similarly, some planned systems did not move to production, such as the aforementioned N-LOS surface-to-surface missile, developed jointly with the Army. None of these changes have caused major design changes to the LCS, demonstrating the wisdom of designing the LCS seaframe as a modular, reconfigurable, multirole system able to support a wide array of deployable sensors and second-stage OOVs and systems. This design approach takes the idea of “fitted for, not with” to a whole new level. Indeed, the LCS’s open architecture and modular design allows it to adapt to changes in its mission systems better and faster than any other ship in the fleet, if not the world.

### **The Demise of the Global ConOps Navy**

Changes since the LCS was first conceived have not been limited to modifications to its seaframe, mission systems, or operational requirements. As implied above, one of the more obvious changes is the 375-ship Global ConOps Navy is no more. By late 2004, the Bush Administration had jettisoned the 1-4-2-1 strategy/force sizing construct upon which it was based. In truth, however, the 375-ship battle force with its fifty-six Littoral Combat Ships (representing 15 percent of total battle force ships) was never endorsed by OSD. It instead represented Admiral Clark’s aspirational goal for a larger fleet. However, by early 2005, fiscal realities prompted him to start talking more realistically about a future Navy battle force ranging from 260 to 325 ships, with the variation in number dependent upon assumptions about the degree of technological insertion, rotational crewing, and the number of ships forward stationed or based. Despite the dramatic drop in planned fleet size, however, the prominence of LCS in the projected future battle force only increased, with sixty-three ships included in the 260-ship fleet (or 24 percent of the force) and eighty-two in the 325-ship fleet (25 percent).<sup>167</sup>

The 2005-2006 Quadrennial Defense Review called for a battle force able to respond to irregular, traditional, catastrophic, and disruptive challenges. It had to be large enough to win two nearly simultaneous conventional campaigns (or just one if the Joint Force was already engaged in a long duration irregular conflict), and have the residual ability to deter the hostile actions of an opportunistic aggressor.<sup>168</sup> The supporting Navy Force Structure Assessments (FSA) for this new strategy, published in February 2006, called for a battle force of some 313 ships, fifty-five of them Littoral Combat Ships (18 percent).<sup>169</sup> While the subsequent 2009-2010 QDR retained its predecessor’s basic strategy, the Navy decided to update its Force Structure Assessment. To account for changes in assumptions and plans since 2006, this new FSA outlined a battle force of 313 to 323 ships, including fifty-five LCSs (17 to 18 percent).<sup>170</sup>

Before the 2010 FSA was formally approved by OSD, however, the dramatically

reduced defense budgets associated with the Budget Control Act of 2012 triggered a thorough reappraisal of the 2009-2010 QDR strategy. This review concluded that the QDR strategy could not be executed on the reduced defense resources presaged by the Act, meaning a new strategy and force-sizing construct were required. After the end of an intense, two-month long strategic review, the Defense Department's updated strategy called for a Joint force large enough to provide for homeland defense, robust combat credible forward presence in two primary theaters (PACOM and CENTCOM), and innovative and lower cost presence in other regions (EUCOM, AFRICOM, and SOUTHCOM). From this global posture, the force had to be able to decisively defeat an aggressor in one theater while denying an opportunistic aggressor from achieving its objectives in another.<sup>171</sup> The newest draft FSA for this strategy calls for a battle force of around 300 ships with around fifty-five LCSs (18 percent).<sup>172</sup>

As these numbers suggest, then, demand for LCS has remained strong—between 15 and 25 percent of planned battle force inventories—despite several adjustments to our national defense strategy. The reason is simple. The Navy's twenty-first century operational construct and architectural framework is defined more by Admiral Clark's vision of FORCEnet—a “globally distributed, fully netted force”—than the precise number of ships in commission. Consequently, the department of the Navy continues to link its vertically layered fleet sensor grids, command, control, communications, computers, cyber warfare, and intelligence (C5I) grids, and effects grids to form ever more powerful fleet battle networks. In these battle networks, every fleet platform is a potential sensor, payloads are as important, if not more so, than platforms, and network enabled weapons are the desired standard. As it implements this construct, the Navy is well on its way to transforming itself from a legacy Total Ship Battle Force to a true *Total Force Battle Network* (TFBN).

In other words, if the term “FORCEnet” has fallen out of vogue, its key tenets very much live on in the form of the TFBN. Moreover, while the numbers of ships necessary to implement national military strategy may change, TFBN architectural principles are relatively independent of such changes. They remain in the background regardless of the battle force's exact mix of ships. Therefore, even though current ship counts are smaller than those first envisioned for the FORCEnet 375-ship Global ConOps Navy, the fundamental rationale for a small battle network combatant like LCS remains valid.

### **The Demise of the DD(X) Surface Combatant Family of Ships**

The requirement for LCS is also relatively insensitive to the numbers and types of large battle network combatants in the FORCEnet/TFBN fleet architecture—plans for which have changed repeatedly since the announcement of the DD(X) SCFOS. These changes can be attributed mainly to a big mismatch between the DD(X) SCFOS's aspirational goals and fiscal reality. Its assumed legacy baseline structure included eighty-eight Aegis combatants, (twenty-seven *Ticonderoga*-class CGs and sixty-one *Arleigh Burke*-class DDGs) and twenty-four modernized *Spruance*-class DDs.<sup>173</sup> However, by the end of FY 2001, just before the DD(X) program was

announced, only thirty-two *Burkes* were in commission. Plans for the DD(X) SCFOS therefore envisioned the Navy building twenty-nine more *Burke*-class ships before replacing the “Spru-cans” with twenty-four new DD(X) land attack destroyers (later DDG 1000s), resulting in a steady state force of 112 large battle network combatants. At this point, production would then shift over to CG(X), which would replace the twenty-seven “Ticos” in the theater air and missile defense role. Once done, the Navy would then begin replacing the sixty-one *Burkes* with a new multimission warship. While all this was happening, the baseline small combatant force of thirty long-hulled *Oliver Hazard Perry*-class FFGs, fourteen *Avenger*-class MCMs, twelve *Osprey*-class MHCs, and thirteen *Cyclone*-class PCs would gradually be replaced by fifty-six LCSs.

In other words, these plans assumed the Navy would replace all its multimission destroyers and guided missile cruisers on a one-for-one basis with vastly more capable (and expensive) ships—while at the same time replacing legacy escort, patrol, and mine warfare craft with new LCSs. This could only work if the department of the Navy received a substantial increase in its budget topline and maintained ruthless cost control on all of its new combatants. Neither happened. First, the long ground wars in Iraq and Afghanistan and then the 2012 Budget Control Act consumed any additional discretionary spending. And then, both the DD(X)/DDG 1000 and CG(X) programs foundered on the rocks of the uncontrolled requirements and cost growth. The former program ended after just three ships were authorized and the latter was canceled altogether. Making matters worse, to help balance its books the Navy chose to retire five *Ticonderoga*-class CGs and all twenty-four VLS-equipped *Spruance*-class destroyers long before the end of their expected service lives, resulting in a much smaller starting baseline of cruisers and destroyers.

These changes inevitably meant the large battle network combatant force would shrink regardless of strategy. As fate would have it, however, the SCFOS needed for the new “win-hold strategy” numbers only about ninety large multimission battle network combatants, about twenty-two fewer than called for in the Global ConOps Navy. Given lower projected future budgets, however, meeting and sustaining even this lower requirement will be no easy task. The Navy in 2011 therefore opted to double down on its proven *Arleigh Burke* DDG design. It first restarted the production line of the most up-to-date Flight IIA *Burke*, which had halted after sixty-two ships. Then, after ten or eleven additional Flight IIAs are built, the Navy plans to shift production to a new Flight III version of the ship. With a powerful new Air and Missile Defense Radar and long-range SM-6 surface-to-air missiles, the Flight IIIs will replace all remaining *Ticonderoga* CGs and an undetermined number of older *Burke* DDGs.<sup>174</sup> The benefits of an all-*Burke* surface battle line in terms of training, logistics, maintenance, and easy fleetwide upgrades should be obvious.

Meanwhile, the department continues plans to replace the entire force of legacy FFGs, PCs, and mine warfare ships with approximately fifty-five Littoral Combat Ships. That LCS numbers remain relatively static despite major changes to plans for large combatants and the ships’ own well-publicized problems can be attributed to

three interrelated things:

- Now more than ever, the Navy's future SCFOS requires a multirole small battle network combatant to complement its ninety or so large multimission battle network warships and to maintain its overall numbers. The battle force missions now performed by the retiring or aging FFGs, mine warfare ships, and PCs are not going away; the original warfighting role envisioned for the LCS remains both valid and vital.
- Second, the new defense strategy requires the Navy-Marine Corps Team to deploy its most combat capable forces in two forward theaters—PACOM and CENTCOM—and provide less capable and more affordable forces in EUROM, AFRICOM, and SOUTHCOM. Low cost LCSs can provide affordable, tailored forward presence in such economy of force theaters, freeing up the large battle network combatants to concentrate on higher priority missions in higher priority theaters—just as envisioned a decade ago.
- Finally, the basic idea of a “high/low mix” of battle network combatants, all featuring rapid FORCEnet/TFBN upgrades and improvements, remains sound, especially given the emerging strategic environment. While there is a budding naval arms race in the Western Pacific, U.S. discretionary defense spending is coming down, putting pressure on the Navy's new ship construction budget.<sup>175</sup> Under these circumstances, being able to affordably and quickly upgrade legacy platforms provides U.S. naval planners with a great competitive advantage.

In short, despite the demise of the Global ConOps Navy and its DD(X) family of ships, demand for an affordable small battle network combatant like the Littoral Combat Ship has remained remarkably and steadily high.

### **Shifting Program Plans**

Recall that in 2002-2003, the Navy planned to award each of two winning LCS design teams a contract for one Flight 0 prototype. The first was to be built in FY 2005 and the second in FY 2006. After a period of fleet testing, the Navy would down-select to a single Flight I variant, with the first two production ships being requested in FY 2008 and delivered in FY 2010.<sup>176</sup>

This plan proved unworkable for two reasons. First, the winning teams of the design competition—led by Lockheed Martin and General Dynamics—indicated that stick-building a single Flight 0 prototype and then keeping their design teams and production lines idle until the Navy decided on the eventual Flight I winner would be prohibitively expensive. Accordingly, the 2004 *CDD for LCS* indicated four Flight 0 ships would be built between FYs 2005 and 2007. However, the *CDD* also made clear that the first Flight I LCS would still be delivered in FY 2010.<sup>177</sup>

While adding two more Flight 0 ships helped solve the idle production line problem, it did little to solve a second, more pressing issue. Based on the planned transition to Flight I production, the second builder would just be finishing its first Flight 0

seaframe as the down-select decision was being made. In other words, the Navy's plan allowed for little if any time for comparative testing between the two prototypes. The lack of testing was particularly troublesome for Admiral Clark. He was well aware that LCS concepts of employment and support would need testing and validation once the ships were in active service. He therefore wanted to keep both Flight 0 seaframes in production longer both to thoroughly understand their strengths and weaknesses and to refine LCS operations and support plans before committing to a single production design—or to keeping both versions in service. Indeed, CNO Clark believed no decision could responsibly be made until at least ten ships were in service, a number large enough to test them as individual deployers, with Carrier and Expeditionary Strike Groups, and as part of a Littoral Action Group or LCS division. The downside to this approach was that should the Navy ultimately down-select to a single Flight I production variant as expected, it would have to contend with at least five “orphans” of the losing design. However, given the need to fully explore assumptions and judgments about LCS, Admiral Clark felt the challenge of dealing with a small class of orphans was manageable.<sup>178</sup>

This new approach was reflected in the final FY 2005 National Defense Authorization Act, which called for LM to construct its first Flight 0 seaframes in FY 2005 and FY 2006, and GD to build its first two Flight 0 ships in FY 2006 and FY 2007. Nine more Flight 0 seaframes (for a total of thirteen ships, seven of one version, six of the other) would then be built in FY 2008 and FY 2009 before a down-select decision occurred in FY 2010.<sup>179</sup> These plans changed slightly in subsequent budget submissions. For example, the final FY 2006 defense bill called for a total of fourteen Flight 0 ships (presumably seven of each variant) to be built between FY 2005 and FY 2009 before the Navy decided whether to move to one Flight I production version or to keep both variants in design. Despite these minor variations, all the plans were consistent with Admiral Clark's desire to delay the final Flight I decision until the two designs could be thoroughly evaluated in fleet service.

These plans came apart in early 2007, just as the Navy's FY 2008 budget was being delivered to Congress. The problem was long in the making. Lured by the siren song of “transformation,” the department had forsaken long established defense acquisition rules and processes in favor of Secretary Rumsfeld's “entrepreneurial approach to developing military capabilities”—an approach that encouraged all military departments to “be proactive,” “behave...less like bureaucrats and more like venture capitalists,” and not wait to validate threats or programs before developing the capabilities to respond to them.<sup>180</sup> One consequence was the Navy tried to control program costs by establishing utterly unrealistic “transformative” budget targets for the LCS seaframe.<sup>181</sup> Another was that in the midst of seaframe detailed design, the Navy dictated a change from commercial standards to Naval Vessel Rules, causing a major program disruption and increase in ship costs. And, in keeping with a rapid speed-to-fleet plan, the lead ships were placed into production well before their designs were stable. As a result, change orders became the program standard rather than the exception, further complicating and disrupting

production and driving costs up. Worse, the overriding desire to get the LCS into fleet service as fast as possible inculcated an idea that schedule drove the program rather than letting measurable progress—or program budgets—set the pace, which incurred even more cost growth.



Predictably, all of these missteps caused a breakdown in internal controls in both the government and industry sides of the house, and by early 2007 the DoN lost any semblance of seaframe cost control. As suggested above, the original seaframe cost projections trumpeted by Navy officers and used in department of the Navy program budget documents reflected more of a hopeful forcing function than a realistic appraisal of likely costs. Sticking to such low, unrealistic estimates, even as the evidence mounted that they were faulty, simply made the subsequent surprise and furor over seaframe cost growth much worse than it should have been. In any event, with a cloud over the entire program, and with the Navy's credibility severely damaged, the department and Congress moved to completely restructure the program.<sup>182</sup>

Ultimately, the Navy canceled or Congress rescinded funding for all seaframes authorized or appropriated from FY 2005 through FY 2008 except for USS *Freedom* and USS *Independence*, the two first ships of each new version (authorized and appropriated in FY 2005 and FY 2006, respectively). Moreover, the two surviving ships suffered from successive delays, and their costs continued to rise, with each breaking the \$750 million mark (in FY 2010 dollars).<sup>183</sup> In an effort to get costs under control and stabilize the program, Sean Stackley, Assistant Secretary of the Navy for Research, Development, and Acquisition, bundled together two FY 2009 LCSs with three FY 2010 LCSs into a single, five-ship, fixed price solicitation. Each builder (that is, LM and GD) would be awarded a contract for one "Flight 0+" ship in FY 2009, while the overall winner would get to build two of the three FY 2010 ships.<sup>184</sup> The hope was that competitive pressure would induce both builders to reduce their costs dramatically.

Unfortunately, when the department received the builders' bids in the summer of 2009, its leaders were dismayed to find the average ship costs for the five ships remained well above a Congressionally mandated cost cap of \$480 million (FY 2010 dollars).<sup>185</sup> The bids therefore failed to meet the most basic and important requirement of the LCS program—affordability. Secretary Stackley therefore recommended a more radical step: moving to a single Flight 0+ variant through a winner-take-all, fixed price competition. This plan represented a final roll of the dice for LCS. If the DoN could not get ship costs down to somewhere between the threshold and objective target, it would be forced to sharply curtail the program or cancel it outright. A winner-take-all competition seemed the only plausible way to prod the builders to meet the department's cost goals and keep the program alive.

Secretary of the Navy Ray Mabus and Chief of Naval Operations Admiral Gary Roughead agreed to this new approach. Accordingly, in September 2009, Secretary Stackley canceled the earlier FY 2009/FY 2010 five-ship solicitation and entered into formal negotiations with LM and GD for each to build one of the two FY 2009 ships. This would help keep their production lines hot while the department was pursuing its new acquisition strategy. At the same time, he directed each builder to resubmit a fixed-price bid for ten ships over FYs 2010 through 2014, at a rate of two ships per year, as well as for their technical data packages. To cut down overhead, he also stipulated the bids must assume the ships would be built in one shipyard.<sup>186</sup>

The building team with the best bid would be awarded a fixed price contract for ten ships. Armed with the winning team's technical data package, the department would then compete the right to build five ships *of the same design* in another yard. Importantly, the losing bidder would *not* be the presumptive builder of the five ships; the competition would be open to any shipbuilding company. Upon completion of both production runs (fifteen total ships), the two building teams and yards would compete for the right to build additional ships.<sup>187</sup>

The downside of this plan was the fleet would never have the ships or time to conduct a thorough comparison of the strengths and weaknesses of each design, or the ability to work out many of the remaining LCS unknowns before committing to serial production. The final decision over which variant would ultimately serve in the fleet would be made solely on cost. However, given the need to maintain battle force numbers and for a ship able to address the LCS's important missions, DoN leadership believed a competitive down-select based on affordability was the best way forward, even if it entailed some risk.

### **Keeping Two Variants in Service**

In the end, however, the Navy was able to have its cake, and eat it, too. The threat of losing the opportunity to build *any* ships, combined with the program stability offered by a guaranteed ten-ship production run prompted both LM and Austal America—which replaced General Dynamics as the prime contractor for the aluminum trimaran—to submit extremely attractive fixed price bids. Indeed, because their bids were so competitive, Secretary Stackley judged the likelihood that the loser would protest an unfavorable award to be very high, stalling all progress on the program—a circumstance both civilian and uniformed leaders of the department wanted to avoid. Given these circumstances, DoN leadership reconsidered the merits of awarding two contracts—that is, for ten Flight 0 ships of each design.

The advantages of keeping a small number of both designs in service before down-selecting to a single design had not changed. As Admiral Clark had long argued, having a chance to compare the strengths and weaknesses of the two seaframes and using both to validate LCS concepts of employment and support was the most prudent way forward. The only reason the DoN moved away from this approach was to get costs under control. The downside of choosing a single variant—resulting in orphan ships—also remained the same, but now there would be twelve to contend with. Alternatively, should the department keep both variants in service, it would pay a price in terms of life-cycle costs, due to the resulting lack of commonality in the LCS fleet.

After thorough review and debate, Secretary Mabus and the senior civilian and uniformed leaders in the DoN unanimously decided the potential problems of LCS orphans or increased lifecycle costs were manageable. Indeed, the higher number of potential orphans could actually prove a blessing, should there be a future down-select to one version—a twelve-ship class would be easier to manage than one of only three to seven ships.<sup>188</sup> Moreover, analysis showed that the life cycle savings

associated with down-selecting to a single ship class would never exceed the \$2.9 billion in procurement savings gained by awarding both builders a ten-ship, fixed price production run. That money could help finance dual ten-ship awards to each builder (five more than originally expected), and fund an additional *Burke* DDG as well as the first Mobile Landing Platform. Finally, this approach would build up the LCS force more quickly, which was important because of the steady retirement from FY 2010 through FY 2019 of the thirty remaining legacy FFGs (the MCMs and PCs would begin retiring after FY2018). Based on these arguments, the department was able to convince Congress to approve the dual ten-ship block buys.<sup>189</sup>

### ***Getting What We Asked For***

The department of the Navy is well aware of the mistakes it made in the early stages of the LCS program. While getting the LCS into service quickly may have been a worthy goal, the mistakes made and problems encountered in building the ships, and the department's resulting inability to restrain program costs, tell a cautionary tale to all current and future DoN leaders. Simply put, the department should never again repeat the short cuts or questionable shipbuilding approaches taken in the LCS program. Objective cost targets and imposed cost caps are simply no substitute for reasonable performance requirements, detailed planning, a stable design at the start of production, a well-thought out production schedule, a ruthless attention to change orders and the impacts they have on costs, and good internal controls with strict monitoring of performance.<sup>190</sup>

But that was then. This is now: in essence, the decision to award two, 10-ship production contracts made LCS 1 (all odd numbered ships are built by Lockheed Martin) and LCS 2 (even numbered ships are Austal America-built) the Flight 0 prototypes. LCS 3 and LCS 4, both authorized in FY 2009—three to four years after the first two ships of class—are now considered transitional production ships incorporating initial changes to the basic prototype designs.<sup>191</sup> That makes LCS 5 and LCS 6, the initial ships of each 10-ship buy, the first full "Flight 0+" production versions.

Accordingly, there have been over 270 design changes from LCS 1 to LCS 3 and as many design changes from LCS 2 to LCS 4. For example, LCS 3 was lengthened by 2.8 meters above the waterline and 4.5 meters below the waterline to improve stability margins for both service life and damage. As an added bonus, this modification increased the ship's fuel capacity by over fifty tons (a 12.6 percent increase) and increased its constant speed on diesel alone to sixteen knots.<sup>192</sup> Over sixty more design changes for the first Flight 0+ versions are anticipated. While both designs are now considered stable, and as is the case for all Navy ships, further changes will be made as necessary based on fleet experience and input. Given these improvements, the Navy's Board of Inspection and Survey (INSURV) now judges both LCS seaframes to be "yellow trending green."<sup>193</sup> At this point, there is little reason to believe the seaframes won't perform as expected.

Moreover, because of the changes made to the program, the Navy is confident it will hit its originally established LCS cost targets, if in a different way than expected. The projected average seaframe cost over both ten-ship production runs, including the basic construction cost, all government furnished equipment, and change orders (the costs included in the FY 2010 Congressional cost cap), is \$383.2 million. Moreover, benefiting from learning curve efficiencies, the average cost for the tenth seaframe of each variant is expected to come in at \$358.1 million—which will become the starting price point for future LCS production flights (all cost figures in this and the following two paragraphs are in FY 2010 dollars).<sup>194</sup> While there still remains some cost and schedule risk, because these projected costs are derived from fixed price contracts and observed performance at both building yards is consistent with projections, there is every expectation the building teams will hit these goals. As a Bloomberg Government Study concluded:

After a rocky start, the Littoral Combat Ship program is meeting its cost and schedule goals. The service could get the prices it wanted only by halting failing cost-plus contracts and holding a true head-to-head competition between capable contractors with everything at stake.”<sup>195</sup>

Critics will likely point out that while the average cost for the seaframes are 20 percent below the FY 2010 Congressional seaframe cost cap of \$480 million, they are well above even the minimally acceptable threshold target of \$270 million established in the 2004 *CDD for LCS* (\$220 million in FY 2005 dollars inflated to FY 2010 dollars). While true, this observation misses an important point. Even after factoring in costs for class design, program management, and engineering support costs, and adding in the average cost for all three LCS mission packages, the average projected cost of a “missionized” LCS over the current ten-ship production run is \$500.8 million.<sup>196</sup> This is just 2 percent over the \$490.4 million threshold target for a missionized LCS established by OSD a decade ago (\$400 million in FY 2005 dollars, adjusted for inflation).<sup>197</sup> Moreover, the lower price for the tenth ship in the production run for each class means the baseline for future missioned LCSs will be \$469.3 million—about 3.5 percent above the Navy’s 2004 threshold target of \$453.5 (\$370 million in FY 2005 dollars, adjusted for inflation).<sup>198</sup>

*In other words, while the Navy underestimated the costs for the LCS seaframe, it overestimated the costs for mission modules and associated program costs. These two estimates thus offset each other, allowing the Navy to very nearly hit its threshold cost targets for a missionized LCS.* As a result, the Navy will achieve its key programmatic goal to buy three missionized LCSs for the price of one Burke-class DDG—currently \$1.49 billion. This will allow the department to keep up the numbers of battle force combatants without breaking its budget.<sup>199</sup> As Eric Labs has observed, there is simply no more affordable TFBN warship option than the Littoral Combat Ship—including off-cited alternatives such as the National Security Cutter, which already costs nearly \$600 million to build and cannot perform any of the LCS’s wartime missions without substantial upgrades.<sup>200</sup>

And, most importantly, at this price the Navy is getting very nearly the exact ship it envisioned a decade ago. Both seaframes have full load displacements around 3,100 tons—larger than PCs and mine warfare ships they replace in the battle fleet’s architecture, but smaller than the FFGs. They are built to operate independently in low threat environments and as part of a naval battle network in mid to high-threat environments. To make them less susceptible to being hit, they have relatively low radar, infrared, and magnetic signatures. And, although never intended or designed to continue fighting after taking a hit, the move to NVR construction standards makes LCS tougher and more resilient than originally envisioned. The ships now include additional shock hardening, selected fragmentation protection, extensive automated firefighting systems, and additional watertight compartmentation. These features allow them to remain afloat with 15 percent of their length and three compartments flooded—the same damage stability requirement as Level II and Level III combatants. These features are consistent with a “Level I+” survivability requirement for the ship to take a hit and to return to port under its own power.

Given its sturdier design and the nature of expected fleet ConOps, the Navy remains confident that both LCS variants will be fully capable of operating at the forward edge of a “globally distributed, fully netted force.” When doing so, LCS will perform low-cost ISR and forward presence influence operations and a variety of mobility missions in peacetime, and screen TFBN Sea Bases and high value fleet units from littoral threats in wartime. The ships will have a capable core defensive system allowing them to perform both roles. Based on their prescribed mission, they will also host and employ a variety of deployable sensors and organic off-board vehicles, including MH-60 helicopters, TUAVs, RHIBs, USVs or UUVs. Indeed, in terms of aviation and unmanned systems, the ships have more aviation and OOV capability and capacity than any surface combatant of comparable size in the world.

The LCS’s Increment I surface warfare package, with an armed helicopter, Fire Scout VUAV, two 30 mm cannon supplementing its core 57 mm gun, and two eleven-meter RHIBs carrying VBSS teams, will have an initial operational capability in FY 2014. The Increment I mine warfare package will also be ready to go in FY 2014. With two UUVs towing mine hunting sonars and MH-60 helicopters employing mine neutralization weapons, this package is expected to provide greater sweep capability than legacy MCMs now in the fleet. The Increment I ASW package, following in FY 2016, will include variable depth sonar, a multifunction towed array, torpedo alertment and decoy systems, and MH-60R ASW helicopters. These systems will transform the LCS into an able ASW corvette, with capability equaling or exceeding the FFGs they will replace.

All of these initial mission packages will be updated by increasingly capable increments over time. For example, in response to an urgent operational need for the U.S. Special Operations Command, the Navy decided to shift production to a larger, more capable MQ-8C Fire-X TUAV, with greater range and payload than the MQ-8B Fire Scout.<sup>201</sup> The Navy is also working to develop and add a longer range, fire-and-forget missile to the surface warfare package for use against small boats and craft. Moreover, the Navy continues to study the best mix of mission packages,

where they should be staged and maintained, and how often and in what circumstances packages should be changed. And, as has been discussed, the LCS's modular design allows for continual evolutionary upgrades to capability over the life of the ship, making it far more likely they will serve to the very end of their expected service lives.

Both LCS 1 and LCS 2 will achieve the modified unrefueled endurance of 3,500 nautical miles at 14-16 knots (LCS 2 gets 4,200 nautical miles 14 knots, while LCS 1 is closer to the threshold range)—adequate for both transoceanic transits and expected intra-theater range operations from forward bases or stations. In other words, LCS's endurance is well matched to their envisioned role as a self-deployable, theater-based platform. Indeed, analysis shows the Navy's planned globally distributed force of 17 oilers (T-AOs) and 12 new dry cargo/ammunition ships (T-AKEs, which also carry useful amounts of transferrable fuel) will be sufficient to support all forward deployed forces, including LCSs and new Joint High Speed Vessels.<sup>202</sup> Forward-deployed and stationed LCSs will therefore have the fuel they need, when they need it—and inside the desired three to five-day UNREP window. If this proves not to be the case, the department can choose to buy more oilers or make necessary adjustments to LCS employment plans.

Even at about 3,100 tons full load displacement, both LCSs can exceed forty knots, and meet or exceed the threshold requirement for unrefueled endurance when operating at these speeds.<sup>203</sup> Fleet experience will reveal how best to exploit such high speeds in tactical situations. Planners expect it to show that high tactical speed will be a very good thing to have for maritime interdiction operations and in a fight against swarming boats, but less important for ASW or mine warfare operations. With a good torpedo alertment system, planners also think high sprint speed will also be useful for torpedo evasion. However, they expect the highest payoff will come from the ship's high *operational* speed, which will facilitate the rapid concentration of naval power across inter/intra-theater ranges during times of crisis.

Despite their relatively large size, both ships have navigational drafts less than fourteen feet.<sup>204</sup> The only U.S. Navy vessels currently in active service with shallower drafts are the diminutive *Cyclone*-class PCs. This characteristic will allow fleet LCSs to operate close to shore, where they can use their impressive maneuverability to best advantage. As a result, they will be able to interdict even small coast vessels hugging a coastline, escort ship-to-shore connectors very close to shore, and provide deadly close-in suppressive fires in support of special operations forces and Marine Corps units operating ashore. The ships are also extremely stable when operating at speed, even in relatively rough weather. The combination of shallow draft and platform stability will make LCSs formidable all-weather counter-boat platforms in close-in coastal waters.

Indeed, with its unique combination of reconfigurable modular payload space, tailored endurance, high operational speed and shallow draft, LCS will provide the TFBN with great operational flexibility—just as foreseen a decade ago. With a 3-2-1

crewing scheme and both ships on a sixteen-month deployment cycle, 50 percent of the LCS fleet will always be forward stationed or deployed and ready for operational tasking. Plans now call for up to eight LCSs to be forward stationed within the CENTCOM area or responsibility in Bahrain, and eight in PACOM using rotational crews operating from Singapore and Sasebo. Up to eleven more will be deployed in SOUTHCOM, EUCOM, and AFRICOM, perhaps from new forward bases or stations. These deployed ships will have a mix of ASuW, MIW, and ASW modules. If a crisis erupts in any theater, high sprint speed will allow this globally distributed, ready force to concentrate quickly the exact mix of properly configured LCSs necessary to the job. Add to that the flexibility to rapidly swap-out mission packages to conduct emergent mobility missions, if needed, and you have a very agile operational and tactical employment construct. Fleet experimentation and experience will tweak and perfect it.

Regardless of what one might hear, then, the department is not revisiting the need for the Littoral Combat Ship, which fits nicely within the FORCEnet or TFBN's "operational construct and architectural framework for naval warfare in the information age." Nor is the department planning to truncate the program before it builds twenty-four ships, or to buy substantially fewer than fifty-five seaframes. What it is doing is discussing ways to make the seaframe designs better, by making required modifications to crew accommodations and hotel services as well as improving design features. The Program Office is also exploring moving to common combat and command, control, and communications systems as quickly as possible, and to improve all mission packages.

Just as importantly, fleet operators are now looking beyond the first twenty-four ships and contemplating further changes and improvements to the basic designs—made possible by the ever-shrinking price for the seaframes over their ten-ship production runs. Perhaps a shipboard fire control radar might be added to make the 57 mm cannon more effective in adverse weather (although improvements to the radar-combat system interface is making substantial improvements to 57 mm gun performance).<sup>205</sup> Perhaps the ship might receive longer-range antiship cruise missiles. Perhaps the ship will be given a more capable electronic warfare system. Even more significantly, perhaps the ship might evolve into a more capable ocean escort with a small VLS battery capable of firing short-range surface-to-air missiles.<sup>206</sup> All one has to do is compare the early *Spruance*-class DDs with their two 5-inch guns, one antisubmarine rocket launcher, and NATO Sea Sparrow Missile (NSSM) system with later versions of the ship armed with two 5-inch guns, a 61-cell VLS battery, eight Harpoon ASCMs, two Phalanx CIWSs, and NSSM system to get a sense for the future possibilities of the LCS design.<sup>207</sup> Like the "Spru-can," LCS is designed with an abundance of open payload space, which can be used in a number of ways to continually upgrade its combat capability.

### ***Transitioning to Fleet Service***

A recent article describing LCS asserted that, "By all accounts this is not the ship the Navy—nor the nation—initially expected."<sup>208</sup> As argued above, however, nothing

could be further from the truth. After a decade of twists and turns, the Navy is getting very nearly exactly the ship it asked for: *an affordable, self-deployable, reconfigurable multirole warship designed to counter mines, diesel submarines, and swarming boats in contested littorals when operating as part of a naval battle network*. True, the LCS's lower economical transit speeds will likely make it more difficult to deploy with Carrier Strike Groups; its lack of a collective protective system could pose problems in some scenarios; and its lack of a CONREP capability will make the ship more dependent on vertical replenishment. Moreover, although the ships hit their threshold costs target, Navy planners were hoping for even less expensive ships. In trade, however, the Navy will be getting a much tougher and resilient ship with the organic capacity to hangar and operate an MH-60 helicopter and one or two UAVs throughout a deployment. Given LCS's expected role, and the fact that the Navy can still buy three of the ships for the price of a guided missile destroyer, these trades appear well worth it.

Ironically, even though the Navy is in some respects getting a better ship than expected, it is so different in concept, mission, and design from past U.S. warships that much work remains to be done for the ship to survive as a program and thrive in fleet service. Despite the fact that twenty-four LCSs are either building, authorized, or on contract, program critics continue to outnumber supporters, and some call for the program's truncation or cancelation. Many of these critics tend to focus on problems encountered early rather than the current state of the program. Others reject the idea for the ship, either not understanding or accepting its place in a Total Force Battle Network. These critics include some in OSD, who continually view the LCS as an attractive target in annual program budget reviews. And, since the program's 2007 implosion, the department continues to respond to a steady stream of skeptical Congressional queries from both Members and staffers.

In the long run, however, these outside critics will likely be silenced if the ship's most important constituencies and potentially strongest champions—the active and retired surface warfare communities—come to fully embrace the ship after proving its value in the fleet service. Unfortunately, this is by no means a sure thing. The fact is these communities are still skeptical of small combatants of any kind. This attitude is quite striking given the U.S. Navy's history, which, up until World War II, demonstrated a widespread appreciation for the contributions of small warships in fleet operations. Indeed, the World War II Navy included a wide array of “small boys,” including diminutive but well-armed patrol torpedo boats, gunboats of various kinds, armed yachts, both wooden and steel submarine chasers, and destroyer escorts. With the massive post-war demobilization, however, these ships were all scrapped in favor of smaller numbers of larger, multimission combatants. Moreover, with the post-war appearance of jets, guided missiles, and nuclear-powered attack submarines, attempts to build a new generation of small warships failed miserably. They either could not accept the larger and heavier electronics, sensors, and weapons needed to fight and survive in guided missile combat, or had too little margin to be affordably upgraded over time. Consequently, by 1960, the “smallest” combatants deemed worthy of being part of the battle force by surface



warfare officers were ocean escorts or protection of shipping combatants (e.g., DEs, DEGs, FFs, and FFGs), and even these ships had full load displacements of 4,000 tons—making them larger than World War II general purpose destroyers.<sup>209</sup>

Unsurprisingly, then, the only operational ships built after World War II that were smaller than ocean escorts—including seventeen *Asheville*-class patrol gunboats, six *Pegasus*-class patrol hydrofoils, and thirteen *Cyclone*-class patrol coastal ships—were retired after only a few years of service (or were prepared for retirement; plans to up the *Cyclones* were reversed after 9-11). Then, during its post-Cold War downsizing, the surface warfare community rejected even guided missile frigates in favor of large, multimission guided missile cruisers and destroyers. As a result, the bar for acceptance by contemporary surface warfare officers is set exceptionally high for any combatant much smaller than 8,900 tons full-load displacement—and particularly for any ship smaller than a modern guided missile frigate with multi-warfare capabilities.

When serving as a young Lieutenant, Vern Clark commanded USS *Grand Rapids* (PG-98), an *Asheville*-class patrol gunboat. As Chief of Naval Operations, therefore, Admiral Clark well recognized and appreciated that fleet acceptance would come even harder for a ship as small and unusual in concept and design as the Littoral Combat Ship. He hoped to overcome the surface warfare community's general level of disdain for small combatants by defining LCS as a "node" in FORCENet battle networks. However, it seems evident even CNO Clark underestimated just how difficult a road the LCS would have to travel. Indeed, the road was made even bumpier as the terms "network-centric warfare" and "FORCENet" gradually fell out of favor and as senior leaders stopped emphasizing the Navy's accelerating transition to and growing dependence on battle networks—or the changes these networks were causing in both naval warfare and fleet design and architecture. After all, it was these changes that provided the very foundation for a small battle network combat like the Littoral Combat Ship.

Moreover, while senior Navy leaders since Admiral Clark have steadfastly defended LCS since its conception over a decade ago, it is one thing to fight hard for the LCS program in the halls of the Pentagon and on Capitol Hill, and quite another to fight hard for the ship within the fleet itself. While surface warfare officers might grudgingly accept a guided missile frigate's less capable multi-warfare combat capabilities if forced to do so, it would take a lot to convince them that a ship only three-quarters the size of an FFG, and one so dependent on "the network," would be wise addition to the battle force. And, in hindsight, there was never a concerted effort to sway them, one way or the other. As a result, the general lack of emphasis on socializing the LCS concept and design gradually had a pernicious influence on the fleet's view and acceptance of the ship.

The LCS's struggle for acceptance was only compounded by the constantly changing nature of the program's "narrative," or declared vision and justification. Both Ronald O'Rourke and Eric Labs, respected naval analysts at the Congressional Research Service and Congressional Budget Office, respectively, have commented on

this problem. They point out the ever-changing LCS story has helped undermine understanding of the ship's role and mission both inside and outside the Navy. What makes this all so ironic is that while the LCS story has changed frequently over the past several years, the ship now entering service remains remarkably consistent with its original concept and design principles laid out a decade ago. Indeed, much of today's confusion and misunderstanding over LCS can be explained by the fact that Navy leadership did not simply stick to these early, straightforward principles when explaining the program. Leaders instead constantly tinkered with the LCS story when selling it.

This problem is not unique among long running ship programs. But it has proven to be especially problematic for a ship that "represents [such] significant departures from the normal shipbuilding path."<sup>210</sup> Over time, senior program leaders and managers inevitably rotated out of their positions to be replaced by new ones. Naturally, these new leaders tended to explain LCS in ways and in terms closely aligned to their own past experiences, rather than referring to the Navy's different expectations for a small battle network combatant operating as part of Total Force Battle Network. And, as with all struggling programs, each also sought and tested new terms and concepts to help better sell it, often in ways inconsistent with original program intentions. For example, many emphasized LCS's rapid mission package swap-out times, despite the fact that early in the program senior leaders did not consider this characteristic essential during naval campaigns. Worse, the Navy failed to consistently make the case that LCS's three wartime missions were both important and enduring with the new ship the most affordable and effective way to accomplish them. Instead, too many touted the LCS's inherent capabilities for battlespace awareness, joint littoral mobility, special operations support, combat search and rescue, maritime interdiction/interception, homeland defense, and antiterrorism/force protection. This helped give the impression the Navy was overselling LCS's true capabilities.

The lack of a simple, consistent, and coherent program story was underlined by the curious lack of preparation for the LCS's transition to fleet service. Between 2005 and 2009, although senior Navy leaders continued to argue strongly for the ship, little work was done on fleshing out the new training, logistics, and maintenance procedures necessary to support a minimally crewed, modular warship like LCS. Similarly, there was little effort expended to further game or test the notional concepts of employment and operation developed in the 2002-2005 timeframe. Moreover, responsibility for LCS mission packages was gradually spread over numerous sponsors and program offices, a trend that threatened LCS's "death from a thousand cuts" in yearly budget drills.<sup>211</sup>

In fairness, after the program's implosion in early 2007, there was great uncertainty over whether LCS would even survive, which focused Navy efforts on saving the program and moderated demand for a thorough look at early program judgments and assumptions. However, the apparent lack of departmental preparation for a new ship with such novel crewing, training, maintenance and logistics undoubtedly helped to muddy the LCS story and contributed to the skepticism about the ship

both inside and outside the Navy.

But once again, that was then. This is now: by word and deed, Navy leadership is now squarely focused on smoothing the LCS's transition to fleet service. The first concrete step was then-CNO Admiral Gary Roughead's (a surface warfare officer) bold decision to operationally deploy USS *Freedom* in 2010—two years ahead of schedule—to “incorporate lessons that can only be learned in a deployment setting more quickly and effectively in the LCS fleet integration process.”<sup>212</sup> While some critics think this deployment was nothing more than a publicity stunt to shore up support for a failing program, it was precisely the type of thing originally envisioned for the Flight 0 prototypes. The second concrete step was creating a single Program Executive Officer for LCS, responsible for all technical aspects of the seaframe, mission modules, and the ship's transition to service.<sup>213</sup>

The next steps were triggered by Secretary of Defense Robert Gates' September 2011 announcement that the Navy would station LCSs in Singapore beginning in FY2013.<sup>214</sup> Soon thereafter, Admiral John Harvey, the Commander, US Fleet Forces Command, asked CNO Roughead's successor, Admiral Jon Greenert, for permission to conduct a sustainment war game to assess the logistics, maintenance, and support plans to support this early deployment. Admiral Greenert agreed. Not surprisingly, the game showed there was much work to do. In response, Admiral Greenert initiated a broad series of efforts to make sure the Navy would be ready for the ship's transition into fleet service as well as for Singapore deployments. He first ordered Admiral Mark Ferguson, his Vice Chief of Naval Operations, to oversee an in-depth review of the Navy's readiness to receive, employ and deploy the “LCS Class Vessel.” This resulting “OPNAV Report,” prepared by Rear Admiral Sam Perez, was designed to identify all remaining barriers to the ship's smooth introduction. He also tasked Rear Admiral Robert Wray, President of the Navy's Board of Inspection and Survey, to conduct a similarly clear-eyed review of LCS material condition and maintainability, and directed Admiral Harvey to conduct a second CFFC war game focused on LCS concepts of employment and operations.

Finally, and perhaps most significantly, CNO Greenert recently named Vice Admiral Rick Hunt, former Commander, Naval Surface Forces, as chairman of a new three-star (that is, vice admiral-level) LCS Council. As such, he will be the “primary Flag Officer responsible for coordinating all Navy administrative control responsibilities for the LCS class” and systematically addressing the findings of the above efforts. Admiral Hunt's immediate tasking is to develop and implement an LCS transition Plan of Action and Milestones by 31 January 2013. In the meantime, he was to report his progress directly to Admiral Greenert in biweekly updates and meet in person with the CNO every month.<sup>215</sup>

As is clear, then, the senior leadership of the department is now strongly and properly focused on taking the needed steps ensuring LCS's smooth and successful transition from prototype to operational fleet platform. However, they are under no illusion that their work is done. As this report has argued, LCS is so different from any ship the Navy has operated that no matter how much preparatory work is done,

senior leaders expect there to be further surprises once it is in the fleet, operating in numbers, and deployed overseas. As the draft IRD stated a decade ago:

There are substantial uncertainties as to the extent to which all of the [notional] Concepts of Employment can be achieved in a single ship design. A focus of the Flight 0 LCS is to investigate these uncertainties, resolve issues, and to determine practical and efficient design combinations...that will accommodate the [Concepts of Employment].<sup>216</sup>

In other words, ten years ago, Admiral Clark and his top leaders knew the surface warfare community's long-established and trusted rules, along with widely accepted concepts of employment and operations would not necessarily apply to the LCS. The only way to change ingrained habits and views would be to build prototypes and let the community establish new LCS tactics, techniques, and procedures based on hands-on experience. Therefore, even though they knew they didn't have all the answers, they were supremely confident that future surface warfare officers would work them out.

This kind of thinking is hardly unique for a Navy long willing to build new types of ships and explore new operational concepts. For example, just over one hundred years ago, our Navy made the choice to invest in a new and exciting naval platform known as the torpedo boat. Much effort was expended to find the proper balance between speed and lethality in these small, swift craft that were expected to operate in shallow and confined waters, executing high speed runs against capital ships—cruisers and battleships. Some of these ships experienced damage in high seas, leading critics to suggest limiting speed and adding more durability and survivability. Others suggested limiting the production of these ships until their future mission could be better defined and their designs adjusted to meet the mission. However, senior Navy leaders, including Assistant Secretary of the Navy Theodore Roosevelt, made the decision to build the ships, evolving the designs and maturing the mission as they went along.<sup>217</sup> Variants of these ships remained torpedo boats, others became torpedo boat destroyers, and later the design evolved into larger, general purpose “destroyers.” Sometimes, trusting in the innovation of Sailors just works.

As stated at the very start of this monograph, however, trust in the LCS concept and design remains low. It seems certain that this circumstance will not materially change until LCS is in the fleet and the concept and designs are proven sound. In the meantime, while endeavoring to do just that, the Navy needs to do a better job in explaining what it expects the ship to do, and how it fits within its planned fleet architecture. And critics of the ship would do better if they stopped complaining about specific ship characteristics without addressing the rationale for their selection, and tried making the case that the Navy's planned fleet architecture, and the role LCS is expected to play in it, is faulty or no longer germane. Such discussion would help ensure the Navy continues to review and analyze its assumptions and conclusions about the ship, and increase the likelihood it will ultimately improve fleet combat capability.

In sum, then, despite a rocky program start, the Littoral Combat Ship will soon be in fleet service, and in large numbers. Designed to be a flexible, multirole component in future Navy battle networks, LCS's reconfigurable modular design will be a first among Navy combatants. Indeed, because the ship is so different, much hard work and experimentation still needs to be done to unlock its full potential. But a solid foundation has been laid. The seaframes are steadily improving and the first increments of three mission packages are coming along, to be followed by ever-more-capable increments over the life of the ship. Future variants of the LCS may evolve in ways not now anticipated or foreseen., just as happened with torpedo boats. The only thing standing in the way of success for LCS would be a lack of imagination and hard work. After fleet operators get their hands on the ships and refine old operational and logistical support concepts and develop new ones, there is little reason to think the ship will not be an important contributor to twenty-first century Total Force Battle Network operations.

## Notes

<sup>1</sup> Naval Warfare Development Command, *Littoral Combat Ship Concept of Operations, V3.1* (Newport, RI, February 2003), available at [www.globalsecurity.org/](http://www.globalsecurity.org/) [hereafter as *LCS ConOps V3.1*].

<sup>2</sup> See for example Cdr. John Patch, USN (Ret.), “The Wrong Ship at the Wrong Time,” U.S. Naval Institute *Proceedings* (January 2011).

<sup>3</sup> U.S. Defense Dept., “Navy Announces DD(X) Program,” *Department of Defense News Release 559-01*, dated 1 November 2001.

<sup>4</sup> The 1997 QDR called for a future surface combatant force of 116 cruisers and destroyers, including twenty-seven *Ticonderoga*-class CGs, fifty-seven *Arleigh Burke*-class DDGs, and thirty-two DD-21 land attack destroyers. Early-flight *Burke* DDGs had a full load displacement of 8,900 tons; all other ships had even greater displacements. Indeed, the initial designs of DD-21 had FLDs of approximately 17,500 tons. The twenty-seven mine warfare ships included a Mine Countermeasures Support Ship (MCS, a converted *Iwo Jima*-class LPH), fourteen *Avenger*-class MCMs, and twelve *Osprey*-class MHCs. Descriptions of all these ships can be found in Norman Polmar, *The Naval Institute Guide to the Ships and Aircraft of the U.S. Fleet*, eighteenth edition (Annapolis, MD: Naval Institute Press, 2005).

<sup>5</sup> Among these were the Title X Global War game series conducted at the Naval War College; the Joint Multi-Warfare Analysis Game sponsored by the Chief of Naval Operations’ staff; the Capabilities for the Navy After Next (CNAN) games sponsored by the Defense Advanced Research Project Agency (DARPA); Fleet Battle Experiments conducted by active Navy units; and other field and lab experiments. See *LCS ConOps V3.1*.

<sup>6</sup> See Capt. Robert Powers, USN (Ret.), “Birth of the Littoral Combat Ship,” U.S. Naval Institute *Proceedings* (September 2012). In this excellent article, Captain Powers describes the aforementioned mid-1990s war-gaming process called the Joint Multi-Warfare Analysis Game (JMAG). The JMAG looked at all aspects of future joint military campaigns. During excursions involving the closure of the Straits of Hormuz, game players conceived of a multi-warfare capable “Littoral Combat Ship” to conduct armed reconnaissance patrols into the gulf in advance of Aegis CGs and DDGs.

<sup>7</sup> “Streetfighter” was the generic name given by Vice Chief of Naval Operations Admiral Don Pilling to the small, fast, stealthy combatants co-championed by Vice Admiral Art Cebrowski, President of the Naval War College, and retired Navy Captain. Wayne P. Hughes, Jr., USN (Ret.), who headed operational analysis at the Naval Postgraduate School, in Monterey, California. Initial concepts called for a fast, stealthy multirole, focused-mission ship with a 160-ton modular payload capable of performing littoral ASW and mine warfare, but not at the same time; second, a larger variant with a 400-ton payload capable of operating as either a logistics support vessel or a remote missile magazine for theater air- and missile-defense ships. For a thorough discussion of the Streetfighter concept, see Robert O. Work, *Naval Transformation and the Littoral Combat Ship* (Washington, D.C.: Center for Strategic and Budgetary Assessments, May 2004), pp. 45-64.

<sup>8</sup> Vice Admiral Cebrowski and Captain Hughes believed a fleet consisting of nothing but large, expensive, multimission ships would be “tactically unstable,” with combat power vastly out of proportion to its survivability. As a result, they believed fleet commanders would be averse to risking these ships in dangerous littoral waters. See Work, *Naval Transformation and the Littoral Combat Ship*, pp. 50-54.

<sup>9</sup> *Wikipedia*, s.v. “SC-21 (United States),” [en.wikipedia.org](http://en.wikipedia.org).

<sup>10</sup> The DD-21 was originally envisioned as a relatively inexpensive replacement for *Spruance*-class DDs and *Oliver Hazard Perry*-class FFGs. Its objective (desired) and threshold (minimally acceptable) cost targets were \$650 and \$750 million, respectively, in FY 1996 dollars. See Federal of Atomic Scientists, “DD-21 *Zumwalt*,” [www.fas.org/](http://www.fas.org/).

<sup>11</sup> Senior Navy officials perceived the Naval War College’s call for small combatants to be a direct threat against its DD-21 land attack destroyer program. For a synopsis of the arguments Navy officers used against small warships, see Work, *Naval Transformation and the Littoral Combat Ship*, pp. 67-69.

<sup>12</sup> U.S. Defense Department, *Quadrennial Defense Review Report* (Washington, D.C.: 30 September 2001), p. 30.

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<sup>13</sup> The term “focused mission” conveyed the fact that LCS was expected to perform one primary mission at a time, as opposed to a multimission ship capable of performing several missions simultaneously (e.g., antiair warfare *and* antisubmarine warfare). For a full discussion of the DD(X) family of ships, see Ronald O’Rourke, *Navy DD(X) Future Surface Combatant Program: Background and Issues for Congress*, CRS Report RS21059 (Washington, D.C.: Congressional Research Service, updated 27 January 27, 2003).

<sup>14</sup> Sea Strike represented the ability of future naval forces to project precise and persistent offensive power from the sea; Sea Shield the ability to extend defensive assurance throughout the world; and Sea Basing the ability to enhance operational independence and support for the Joint Force. From Adm. Vern Clark, USN, “Sea Power 21: Projecting Decisive Joint Capabilities,” U.S. Naval Institute *Proceedings* (October 2002), [www.navy.mil/](http://www.navy.mil/) [hereafter Clark, “Sea Power 21”]. For a full discussion of Admiral Clark’s vision, see Work, *Naval Transformation and the Littoral Combat Ship*.

<sup>15</sup> Clark, “Sea Power 21.” [Emphasis added.]

<sup>16</sup> Adm. Mike Mullen, USN, “Global Concept of Operations,” U.S. Naval Institute *Proceedings* (April 2002), available at [www.military.com/](http://www.military.com/). As described in this article, the new 1-4-2-1 strategy required the Joint Force to be prepared to provide for homeland defense (1); deter forward in four critical regions (4); swiftly defeat adversaries in two of the four regions (2); and, if necessary, defeat (1) of the two adversaries decisively (e.g., change the regime). Because this strategy drove the need for a 375-ship battle force, it is also sometimes referred to as the “1-4-2-1 force sizing construct.”

<sup>17</sup> Scott C. Truver, “Navy Plans to Develop LCS Fleet with ‘Lightning Speed,’” *Sea Power* (May 2003), [www.navyleague.org/sea\\_power/](http://www.navyleague.org/sea_power/).

<sup>18</sup> U.S. Naval History and Heritage Command, “U.S. Navy Active Ship Force Levels, 2000 – 2006,” [www.history.navy.mil](http://www.history.navy.mil).

<sup>19</sup> The Navy commissioned thirty-one *Spruance*-class DDs between 1975 and 1983, with expected service lives of thirty years. Of these, twenty-four were ultimately provided with the Mark 41 vertical launch system (VLS). Six ships retained two Armored Box Launchers (ABLS) for Tomahawk Land Attack Cruise Missiles, while one received neither VLS nor ABLS. The seven non-VLS ships were all decommissioned in FY 1998. The Navy commissioned a total of fifty-one *Perry*-class FFGs between 1977 and 1989, with expected service lives of thirty years. Of these, twenty-one were short-hulled versions capable of operating LAMPS I antisubmarine helicopters; thirty were long-hulled versions able to hangar and employ the SH-60R LAMPS III multipurpose helicopter. The Navy decommissioned all short-hulled versions between FY 1995 and FY 2003. See the entries for “‘Spruance’ Class” and “‘Oliver Hazard Perry’ Class,” in Polmar, *The Naval Institute Guide to the Ships and Aircraft of the U.S. Fleet*, eighteenth edition [hereafter Polmar, *Ships and Aircraft of the U.S. Fleet*].

<sup>20</sup> U.S. Defense Department, *Defense Planning Guidance (DPG) for Fiscal Years 2003-2007*, as cited in *LCS ConOps*, V3.1.

<sup>21</sup> Secretary of Defense Donald Rumsfeld, “21<sup>st</sup> Century Transformation,” transcript of remarks given at the National Defense University, Fort McNair, Washington, D.C., on 31 January 2002, [www.defense.gov/speeches/](http://www.defense.gov/speeches/).

<sup>22</sup> *Ibid.*

<sup>23</sup> Truver, “Navy Plans to Develop LCS Fleet with ‘Lightning Speed.’”

<sup>24</sup> Dan Morgan, “Proposed Ship Speeds Into Gathering Storm,” *Washington Post* (6 July 2005), p. 5.

<sup>25</sup> Section 218, National Defense Authorization Act for Fiscal Year 2003, Public Law 107-314, as cited in “Littoral Combat Ship,” Title II (RDT&E), Other Matters of Interest, Navy, Senate Armed Services Committee Report (108-046), for the Fiscal Year 2004 Defense Authorization, S 1050, pp. 179-80.

<sup>26</sup> “Littoral Combat Ship,” Title II (RDT&E), Other Matters of Interest, Navy, Senate Armed Services Committee Report (108-046), for the Fiscal Year 2004 Defense Authorization, S 1050, pp. 179-80.

<sup>27</sup> Joint Requirements Oversight Council (JROC), *Capability Development Document for Littoral Combat Ship, Flight 0, Pre-MDAP* (Washington, D.C.: May 2004), p. 2-1 [hereafter *2004 CDD for LCS*]. [Emphasis added.]

<sup>28</sup> “Tailored Analysis of Alternatives Under Way for Littoral Vessel,” *Inside the Navy* (2 September 2003).

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- <sup>29</sup> The term “analytical virgin birth” was first coined by Ronald O’Rourke, naval analyst at the Congressional Research Service, soon after the Navy announced the new ship. See Hunter Keeter, “O’Rourke: Lack of Pedigree May Haunt LCS Program,” *Defense Daily* (16 January 2003).
- <sup>30</sup> For a thorough discussion of the arguments for and against the LCS’s unusual program start, see Ronald O’Rourke, *Navy DD(X) and LCS Ship Acquisition Programs: Oversight Issues and Options for Congress* (Washington, D.C.: Congressional Research Service, Report RL32109, updated 28 October 2004), p. 35-40.
- <sup>31</sup> Clark, “Sea Power 21.”
- <sup>32</sup> U.S. Navy Dept., *Draft Littoral Combat Ship Interim Requirements Document (IRD)* (Washington, D.C.: 21 October 2002) [hereafter *2002 Draft LCS IRD*]. The draft IRD contained detailed explanations of the thinking that went into developing the LCS requirements that was missing in the later, formal IRD. It therefore provides an especially clear view of what the LCS was originally conceived to be and do.
- <sup>33</sup> *LCS ConOps V3.1*. Developed by the Naval Warfare Development Command, then hosted in Newport, RI, this early concept of operations drew heavily from the work done by Naval War College between 1999 and 2001.
- <sup>34</sup> Memorandum for the Record, Littoral Combat Ship Offsite Meeting held on 1 February 2003. This 5-page memorandum for the record (MFR), provided to the author by the LCS Program Office, recorded discussions on LCS requirements and concepts between Admiral Clark and his top leadership during a special LCS Offsite. Perhaps more than any other document, it illuminates precisely what Admiral Clark believed the LCS should be and do [hereafter February 2003 MFR].
- <sup>35</sup> *2002 Draft LCS IRD*, p. 9 and 20.
- <sup>36</sup> As will soon be discussed in detail, the LCS system included the cost of its modular reconfigurable “seaframe” (i.e., hull plus “core” mission systems) and its embarked mission package. For the purposes of this paper, a “missionized LCS” includes the cost of the seaframe plus the average cost of all three mission packages. At the time the LCS was conceived, the department of the Navy was procuring *Arleigh Burke* DDGs per year for \$1.2 billion per ship. OSD’s mandate to procure three LCSs per *Burke* was conveyed to the author in an interview in 2004 with Web Ewell, then a naval forces analyst with the Office of Program Analysis and Evaluation (PA&E), Office of the Secretary of Defense.
- <sup>37</sup> February 2003 MFR, p. 1.
- <sup>38</sup> See Eric Labs, *An Analysis of the Navy’s Fiscal Year 2013 Shipbuilding Plan* (Washington, D.C.: Congressional Budget Office, July 2012), p. 15.
- <sup>39</sup> Lightship displacements for the Joint High Speed Vessel and FFG-7 class come from U.S. Navy, “Naval Vessel Register,” available at [www.nvr.navy.mil/](http://www.nvr.navy.mil/). Lightship displacement for the National Security Cutter is taken from Polmar, *Ships and Aircraft of the U.S. Fleet*, p. 576. Ship costs were provided by Ms. Allison Stiller, Deputy Assistant Secretary of the Navy for Ships (DASN Ships).
- <sup>40</sup> Clark, “Sea Power 21.”
- <sup>41</sup> *Ibid.* Although conceived of before FORCEnet, the DD(X)/DDG-1000 design was consistent with its principles.
- <sup>42</sup> *LCS ConOps V3.1*.
- <sup>43</sup> See Jim Wilson, “Stealth Strike Force,” *Popular Mechanics* (Nov 2003), p. 90. CNO Clark’s intent to avoid high combat systems costs was emphasized in a telephone conversation between the author and Admiral Clark on 12 September 2012.
- <sup>44</sup> February 2003 MFR, p. 2. The seventeen *Asheville*-class PGs commissioned between 1966 and 1971 were built in response to lessons learned during the Cuban missile crisis. With a full load displacement of 240 tons, a draft of less than ten feet, and a top speed of thirty-five knots, they were designed for coastal patrol, blockade, and maritime interdiction operations. Many of the *Ashevilles* participated in Operation Market Time, the coastal interdiction effort mounted along the coast of Vietnam during the Vietnam War. Others operated in the Mediterranean. However, like other classes of small combatants built by the U.S. Navy after World War II, they were never considered valuable battle force assets, and were retired or transferred to allied navies long before the end of their expected service lives. See *Wikipedia*, s.v. “Asheville Class Gunboat,” [en.wikipedia.org](http://en.wikipedia.org).
- <sup>45</sup> February 2003 MFR, p. 1.



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- <sup>46</sup> Capt. Wayne. P. Hughes, Jr., USN (Ret.), "22 Questions for Streetfighter," U.S. Naval Institute *Proceedings*, (February 2000), pp. 46-50.
- <sup>47</sup> The notional, cost-unconstrained ship described by Capt. Powers in "Birth of the Littoral Combat Ship" was never endorsed by the Navy. It was not mentioned in the 21<sup>st</sup> Century Surface Combatant (SC-21) cost and operational effectiveness analysis (COEA) or the 1997 or 2001 Quadrennial Defense Reviews. Therefore, although JMAC game players wrestled with many of the same ship design issues later tackled by the designers of the DD(X) SCFOS LCS (e.g., platform speed, modularity, etc.), and some Navy officers undoubtedly were aware of the JMAC games in 2001, the JMAC LCS was not the model for the FORCEnet LCS.
- <sup>48</sup> Adm. Vern Clark, USN (Ret.), telephone conversation with author, 12 September 2012.
- <sup>49</sup> To clarify, the author coined the terms small and large battle network combatants, not NWDC.
- <sup>50</sup> See Clark, "Sea Power 21," and *LCS ConOps V3.1*.
- <sup>51</sup> February 2003 MFR, p. 1.
- <sup>52</sup> *LCS ConOps V3.1*.
- <sup>53</sup> *Ibid.*
- <sup>54</sup> *2002 Draft LCS IRD*, pp. 1-2.
- <sup>55</sup> *LCS ConOps V3.1*.
- <sup>56</sup> February 2003 MFR, pp. 1-2, and Clark, telephone conversation. During the phone discussion, Admiral Clark commented that "people started coming out of the woodwork" to hang additional missions on LCS once it was announced. To avoid requirements creep, he wanted the LCS design focused squarely on the ship's three designated wartime missions.
- <sup>57</sup> *LCS ConOps V3.1*.
- <sup>58</sup> *Ibid.*
- <sup>59</sup> The idea of pursuing open architecture combat systems (that is, avoiding proprietary specifications that would complicate future work by contractors not originally involved) to facilitate rapid fleetwide capability upgrades was first championed by the submarine community in the 1990s, with the Acoustic Rapid COTS Insertion, or A-RCI, program. Admiral Clark wanted to adopt the same model for all FORCEnet platforms. Therefore, in 2002, Admiral Clark established a new Program Executive Office for Integrated Warfare Systems (PEO IWS) "to help select common standards and products in the areas of frameworks, middleware, resource management, and operating systems, using both established and evolving industry standards to avoid proprietary solutions that might constrain rather than enhance interoperability, operational effectiveness, and future technology insertion." Capt. Thomas J. Strei, USN, "Open Architecture in Naval Combat System Computing in the 21<sup>st</sup> Century," *Command and Control Research Program*, [www.dodccrp.org/](http://www.dodccrp.org/).
- <sup>60</sup> *2002 Draft LCS IRD*, p. 3.
- <sup>61</sup> February 2003 MFR, p. 1.
- <sup>62</sup> *2002 Draft LCS IRD*, p. 20.
- <sup>63</sup> Clark, telephone conversation.
- <sup>64</sup> U.S. Navy Dept., *Preliminary Design Interim Requirements Document for Littoral Combat Ship (LCS), Flight 0, Pre-ACAT, Serial Number N763F-S03-026* (Washington, D.C.: 13 February 2003) [hereafter *2003 Preliminary Design IRD for LCS*; *2004 CDD for LCS*].
- <sup>65</sup> "Critical Design Parameters," *2003 Preliminary Design IRD for LCS*, p. 4.
- <sup>66</sup> *LCS ConOps V3.1*.
- <sup>67</sup> In the section entitled "LCS" in Mullen, "Global Concept of Operations," the Littoral Combat Ship was explicitly described as a "theater-based asset."
- <sup>68</sup> See *2002 Draft LCS IRD* throughout, especially p. 6, and February 2003 MFR.
- <sup>69</sup> *LCS ConOps V3.1*.
- <sup>70</sup> An ESG is a three-ship Amphibious Ready Group with an embarked Marine Expeditionary Unit escorted by several surface combatants.
- <sup>71</sup> *LCS ConOps V3.1*, and *2002 Draft LCS IRD*, pp. 2-3.
- <sup>72</sup> *2002 Draft LCS IRD*, pp. 2-3, and 5.
- <sup>73</sup> *Ibid.*, p. 21.
- <sup>74</sup> *LCS ConOps V3.1*.

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<sup>75</sup> Rear Adm. Sam Perez, USN, who was a requirements officer in the LCS program in 2002-2003. The *2002 Draft LCS IRD* called for a speed of fifty knots (p. 7).

<sup>76</sup> Jerry Gaston and Miguel Rivera, *Analysis of Multiple Concepts—Littoral Combat Ship Study Phase II Report* (Dahlgren, Virginia: Dahlgren Division, Naval Surface Warfare Center, May 2003), pp. 133-34.

<sup>77</sup> February 2003 MFR, p. 2.

<sup>78</sup> *2004 CDD for LCS*, p. 6-2.

<sup>79</sup> Even if sensible, given its inherent impact on both LCS designs, many continue to question whether high sprint speed was a *cost effective* program decision. However, Adm. Clark and his senior staff clearly felt any trade-offs necessitated by their demand for high speed were well worth it.

<sup>80</sup> "Critical Design Parameters" in *2003 Preliminary Design IRD for LCS*, p. 4; February 2003 MFR, p. 2.

<sup>81</sup> *LCS ConOps V3.1*.

<sup>82</sup> A 3,500-nautical mile range would theoretically allow an LCS to make an unrefueled transatlantic voyage to the Mediterranean (Gibraltar), or an unrefueled voyage from the West Coast to Hawaii. See *2004 CDD for LCS*, p. 2-2. In practice, however, commanders of Navy warships seldom want their fuel state to fall below 60 or 70 percent, in case they receive a tasking to transit to a brewing crisis or high priority mission. Navy planners thus derived several route choices that would allow LCS to top off its fuel bunkers during transits from CONUS to theater, and participants at the 2003 offsite discussed the idea of adding fuel bladders to increase LCS "transoceanic crossing ranges." February 2003 MFR, p. 2.

<sup>83</sup> "Critical Design Parameters" in *2003 Preliminary Design IRD for LCS*, p. 4.

<sup>84</sup> *2002 Draft LCS IRD*, p. 7.

<sup>85</sup> February 2003 MFR, pp. 2-3.

<sup>86</sup> Vice Adm. Rick Hunt, USN, Chairman of the LCS Council, conversation with author, 4 September 2012.

<sup>87</sup> "Critical Design Parameters" in *2003 Preliminary Design IRD for LCS*, p. 4.

<sup>88</sup> All navigational drafts are drawn from "Naval Vessel Register."

<sup>89</sup> The Sikorsky MH-60S Knighthawk and the MH-60R Seahawk are marinized derivatives of the Army's UH-60 Blackhawk helicopter and will form the backbone of the U.S. Navy helicopter fleet over the next two decades. For a description of the two helicopters, see Polmar, *Ships and Aircraft of the U.S. Fleet*, pp. 450-51.

<sup>90</sup> See February 2003 MFR, p. 3.

<sup>91</sup> *2002 Draft LCS IRD*, p. 5.

<sup>92</sup> *Ibid.*, p. 2. The idea of "second-stage" combat systems comes from George Root at the Naval Postgraduate School. He sees first-stage systems as being organic to and an integral part of a platform. Manned or unmanned second-stage systems perform their missions after being launched from a host platform. Third-stage systems are in turn launched from second-stage systems, such as autonomous sensors seeded by a second-stage system launched from the host platform.

<sup>93</sup> The RHIB is a staple on all U.S. Navy ships and craft. Standard Navy RHIBs generally come in seven and eleven-meter versions. See *Wikipedia*, s.v. "Rigid Hull Inflatable Boat," [en.wikipedia.org/](http://en.wikipedia.org/).

<sup>94</sup> *LCS ConOps V3.1*.

<sup>95</sup> *2002 Draft LCS IRD*, p. 9.

<sup>96</sup> *LCS ConOps V3.1*.

<sup>97</sup> *2002 Draft LCS IRD*, p. 7.

<sup>98</sup> *Ibid.*, p. 7; February 2003 MFR, p. 3; "Critical Design Parameters" in *2003 Preliminary Design IRD for LCS*, p. 4.

<sup>99</sup> *2002 Draft LCS IRD*, p. 7.

<sup>100</sup> *Ibid.*, p. 11. [Emphasis added.]

<sup>101</sup> February 2003 MFR, pp. 3-4.

<sup>102</sup> The key performance parameter (KPP) for DD-21 manning was 95 (objective) and 150 (threshold), for a ship with a design FLD of 17,500 long tons. The KPP for DD(X) manning was 125 (objective) and 175 (threshold), for a ship with a design FLD of 14,500 tons. Figures from the DD-21 Operational Requirements Document (ORD) dated 3 November 1997, and the DD(X) ORD of June 2004. Ms. Allison Stiller, DASN Ships, e-mail to the author, 27 November 2012.

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- <sup>103</sup> In a telephone conversation between the author on 12 September 2012, Adm. Clark emphasized his high expectations for LCS automation.
- <sup>104</sup> February 2003 MFR, p. 4.
- <sup>105</sup> "Critical Design Parameters" in *2003 Preliminary Design IRD for LCS*, p. 4.
- <sup>106</sup> From *2002 Draft LCS IRD*, pp. 4-7.
- <sup>107</sup> *Ibid.*, p. 7.
- <sup>108</sup> *Ibid.*, p. 4. As their name suggests, torpedo boat destroyers (T.B.D) were small, fast craft designed to screen capital ships from torpedo boat attack. The first American torpedo boat destroyer was *USS Farragut* (T.B.D. No. 1) commissioned on 5 June 1899. By the end of World War I, these ships later evolved into larger, general purpose "destroyers." See Global Security, "Torpedo Boat Destroyers," [www.globalsecurity.org/](http://www.globalsecurity.org/). Submarine chasers were craft first developed by the U.S. Navy in World War I to hunt and kill German submarines. The initial 110-foot versions carried the hull designations S; later 173-foot versions used a PC hull classification. Destroyer minesweepers were general purpose destroyers converted into high-speed, ocean-going minesweepers (DMS). See *Wikipedia*, s.v. "Submariner Chaser," and "Destroyer Minesweeper," [en.wikipedia.com/](http://en.wikipedia.com/).
- <sup>109</sup> *LCS ConOps V3.1*.
- <sup>110</sup> February 2003 MFR, p. 3.
- <sup>111</sup> "Critical Design Parameters" in *2003 Preliminary Design IRD for LCS*, p. 4.
- <sup>112</sup> *LCS ConOps V3.1*. [Emphasis in the original.]
- <sup>113</sup> *Ibid.*
- <sup>114</sup> *2002 Draft LCS IRD*, p. 3. [Emphasis added].
- <sup>115</sup> Hughes, Jr., "22 Questions for Streetfighter," pp. 46-50.
- <sup>116</sup> Clark, telephone conversation.
- <sup>117</sup> *2003 Preliminary Design IRD for LCS*, p. 10.
- <sup>118</sup> U.S. Navy Dept., "Survivability Policy for Surface Ships of the US Navy," OPNAV Instruction 9070.1, 23 September 1988, enclosure (2) [Emphasis added.]
- <sup>119</sup> *Ibid.*
- <sup>120</sup> The 2003 Preliminary Design Contracts awarded to Lockheed Martin and General Dynamics stated, "It is recognized that the unique nature of these vessels necessitate hull forms, material and some systems which incorporate features normally associated with 'high speed naval craft.' As a result, the applicable ABS Rules will include some parts of the ABS Guide for Building and Classing High Speed Naval Craft." David C. Robinson, Acting Chief of Staff, Program Executive Officer for LCS, email to the author, 5 December 2012.
- <sup>121</sup> *2003 Preliminary Design IRD for LCS*, p. 10.
- <sup>122</sup> *Ibid.*, p. 9.
- <sup>123</sup> *LCS ConOps V3.1*.
- <sup>124</sup> *Ibid.*
- <sup>125</sup> February 2003 MFR, p. 4.
- <sup>126</sup> The radar-guided, rapid-firing Mark 15 Phalanx Close-In Weapons System (CIWS) can fire between 3,000-4,500 20 mm cannon rounds per minute, either autonomously or under manual command, as a last-ditch defense against incoming missiles and other targets. It has been a staple on U.S. warships since its fleet introduction in 1980. The RIM-116 Rolling Airframe Missile is a lightweight, quick-reaction, fire-and-forget missile with radio frequency or infrared guidance designed to destroy anti-ship cruise missiles and asymmetric air and surface threats. It is the Navy's standard terminal defense missile, found on carriers and amphibious warships. It is a quick reaction, fire and forget missile with radio frequency or infrared guidance. See entries for "20 mm/76-Cal Close-in Weapon System Mk 16" and "RAM (Rolling Airframe Missile) RIM-116A" in Polmar, *Ships and Aircraft of the U.S. Fleet*. The Mark 53 Decoy Launching System, known as Nulka, is a rapid response active expendable decoy system capable of providing highly effective soft-kills against modern Anti-Ship Missiles. *Wikipedia*, s.v. "Nulka," [en.wikipedia.org/](http://en.wikipedia.org/).
- <sup>127</sup> February 2003 MFR, pp. 4-5. The Harpoon anti-ship cruise missile has been the standard U.S. Navy ASCM since its fleet introduction on surface ships in 1977. See "Harpoon AGM/RGM/UGM-84A," in Polmar, *Ships and Aircraft of the U.S. Fleet*, pp. 513-14.

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<sup>128</sup> *LCS ConOps V3.1*.

<sup>129</sup> *2003 Preliminary Design IRD for LCS*, p. 10.

<sup>130</sup> *Ibid.*, p. 3.

<sup>131</sup> *2004 CDD for LCS*, p. ii.

<sup>132</sup> Clark, telephone conversation.

<sup>133</sup> On 8 November 2002, after reviewing inputs from eighteen companies, the Navy awarded six companies \$500,000 contracts for ninety-day ship concept studies for LCS. The six companies were General Dynamics; Gibbs and Cox; John J. McMullen Associates, Inc.; Lockheed Martin; Northrop Grumman; and Textron. On 17 July 2003, Lockheed Martin, General Dynamics, and Raytheon received seven-month contracts to develop preliminary designs. On 27 May 2004, Lockheed and General Dynamics were awarded contracts for final system design, with options for up to two Flight 0 LCSs. solicited ideas from industry for the LCS seaframe. See Kevin Broncato, Ph.D., *'Real Competition' for the Littoral Combat Ship*, a Bloomberg Government Study, Bloomberg L.P., 2012, p. 5.

<sup>134</sup> "Critical Design Parameters," in *2003 Preliminary Design IRD for LCS*, p. 4.

<sup>135</sup> Todd Tompkins, "Clarified Seaframe and Mission Package Definition," PowerPoint presentation, Naval Sea Systems Command's Third MSSIT-Industry Working Group Meeting, 6 November 2003.

<sup>136</sup> Gaston and Rivera, *Analysis of Multiple Concepts—Littoral Combat Ship Study Phase II Report*, p. 12.

<sup>137</sup> Tompkins, "Clarified Seaframe and Mission Package Definition." The MQ-8B Fire Scout is a vertical takeoff and landing unmanned aerial vehicle based on the diminutive small Schweizer 330 helicopter. See "Fire Scout RQ-8A," in Polmar, *Ships and Aircraft of the U.S. Fleet*, p. 474.

<sup>138</sup> Tompkins, "Clarified Seaframe and Mission Package Definition."

<sup>139</sup> The original LM offering was an all-aluminum design. During detailed design, LM shifted to a steel hull and aluminum deckhouse. For a good description of the LM LCS design, see "Lockheed Martin LCS Team," *Lockheed Martin LCS Team*, [www.lmcsteam.com/](http://www.lmcsteam.com/). For a good description of the GD LCS design, see *Wikipedia*, s.v. "USS Independence (LCS 2)," [en.wikipedia.org/](http://en.wikipedia.org/).

<sup>140</sup> *2004 CDD for LCS*.

<sup>141</sup> Ms. Allison Stiller, DASN Ships, email to the author, 20 January 2012.

<sup>142</sup> Rear Adm. (lower half) James Murdock, USN, LCS Program Manager, "LCS DOTE Report Response," PowerPoint briefing, 4 March 2010. The three systems include watermist, aqueous film forming foam (AFFF), and heptafluoropropane (HFP). Watermist particles are many times smaller than water droplets from water sprinkler systems. When these particles enter a fire plume they are converted to steam, which displaces oxygen and extinguishes the fire. Securiplex, "High Pressure Water Mist Systems," [www.securiplex.com/](http://www.securiplex.com/). AFFF generates foam that smothers fuel fires. It is effective in large areas such as hangar or mission bays. See U.S. Navy, "Nimitz Tests AFFF Firefighting Systems," [www.navy.mil/](http://www.navy.mil/). The Naval Research Laboratory developed HFP to provide the same fire extinguishing characteristics of Halon without the adverse environmental effects (e.g., damaging the stratospheric ozone layer). It is generally used in combination with watermist systems. Ronald S. Sheinson et al, "Heptafluoropropane With Water Spray Cooling System As a Total Flooding Halon 1301 Replacement: System Implementation Parameters," [fire.nist.gov/](http://fire.nist.gov/).

<sup>143</sup> COMBATTS-21 is an enhanced open architecture combat system derived from the Aegis open architecture system found on Ticonderoga-class CGs and Burke-class DDGs. The COMBATTS-21 library shares 95 percent commonality with the Aegis system library. See Lockheed Martin, "Littoral Combat Ship's Combat System Validated by U.S. Navy," [www.lockheedmartin.com/](http://www.lockheedmartin.com/). The TRS-3D multimode radar uses a phased array antenna for detection and tracking of multiple surface and air targets. It is very effective in clustered littoral environments. It is also installed on U.S. Coast Guard National Security Cutters. See EADS North America, "TRS-3D Multitmode Radar," [www.eadsnorthamerica.com/](http://www.eadsnorthamerica.com/).

<sup>144</sup> TACTICOS is a combat management system comprising command and control, command support and fire-control facilities for anti-air, surface, anti-submarine and electronic warfare as well as naval gunfire support. Jane's C4I Systems, "TACTICOS Combat Management System (Netherlands), Command Information Systems (Marine)," available at [articles.janes.com/](http://articles.janes.com/). The Sea Giraffe radar uses agile multi-beam technology to detect air and surface targets. It can simultaneously handle multiple threats approaching from different directions and altitudes, including diving anti-ship missiles. Like the TRS-3D radar, the Sea Giraffe is specialized for rapidly detecting small, fast moving

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targets at all altitudes and small surface targets in severe clutter. *Wikipedia*, s.v. "GIRAFFE Radar," en.wikipedia.org/. The SeaRAM system combines the radar of the Phalanx Close-in Weapon System with an eleven round Rolling Airframe Missile launcher.

<sup>145</sup> The Mark 36 Super Rapid Blooming Off-board Chaff (SRBOC) is a short-range mortar that launches chaff or infrared decoys from naval vessels to foil anti-ship missiles. See *Wikipedia*, s.v. "Mk 36 SRBOC," en.wikipedia.org/.

<sup>146</sup> The Mark 75 76 mm automatic cannon is suitable for installation on small combatants due to its light weight, and low manpower requirements. One gun mount is installed aboard U.S. Navy *Oliver Hazard Perry*-class frigates and older U.S. Coast Guard cutters. See "76 mm/62-caliber Gun Mk 75," Polmar, *Ships and Aircraft of the U.S. Fleet*, p. 494.

<sup>147</sup> The 57 mm is considered a multi-purpose cannon effective against small boats, close in air targets, antiship missiles, and land targets. Its "3P" ammunition has six modes: proximity (air); gated proximity (air, anti-jamming); gate proximity with impact priority (air and large targets); precision time (surface); armor piercing (surface and shore); and impact (shore). It is possible to choose ammunition mode at the moment of firing, giving the gun the ability to switch rapidly between surface targets, air targets as well as ground targets. In a mode called Rapid Switchover for Maritime Intercept Operations (MIO), this all-target ammunition enables the gun to fire warning shots, step up to disabling fires, then instantly switch to lethal fires if required to slow, stop or destroy a vessel of interest. See "Mk-110 gun," *Seaforces-Online: Naval Information*, www.seaforces.org/.

<sup>148</sup> Spencer Ackerman, "Navy's \$670 Million Fighting Ship is 'Not Expected to be Survivable,'" Pentagon Says, *Wired*, 15 January 2012, wired.com/dangerroom.

<sup>149</sup> Malcolm Philips, "The U.S. Navy's Littoral Combat Ships Compared," *Naval Forces* 32, no. 5 (2012), p. 100. [Emphasis added.]

<sup>150</sup> U.S. Navy Dept., "Survivability Policy and Standards for Surface Ships and Craft of the U.S. Navy," OPNAV Instruction 9070.1A, 13 September 2012, p. 4.

<sup>151</sup> When first introduced into fleet service, the *Perry*-class FFGs were armed with a Mark-13 single arm missile launcher, sitting atop a rotary magazine capable of carrying forty SM-1 surface-to-air missiles and Harpoon ASCMs. In the early 2000s, however, the Navy retired the SM-1 missile, and in 2003 began removing the missile launcher and magazine from the ships. Since then, the *Perrys* have been armed with only a 76 mm cannon and a Phalanx Close-in Weapon System. See Polmar, *Ships and Aircraft of the U.S. Fleet*, p. 163.

<sup>152</sup> LCS Branch, OPNAV N868, "LCS Survivability," PowerPoint briefing, March 2011. During the 2006 Lebanon War, while operating off the coast of Lebanon, the Israeli Navy corvette INS *Hanit* was hit by a suspected C-802 antiship cruise missile fired by Hezbollah forces. The ship caught fire; its propulsion plant was damaged, and four crew members were killed. Nevertheless, the corvette was able to sail back to Israel under her own power. See *Wikipedia*, s.v. "INS *Hanit*," en.wikipedia.org/.

<sup>153</sup> Mission module costs represent a "per seaframe average cost," consistent with amortizing the costs of all mission packages for each seaframe in the LCS fleet. See paragraph 6.2.8 in "System Capabilities Required for the Current Increment," in 2004 *LCS CDD*.

<sup>154</sup> The \$400M target was endorsed in both the Fiscal Year 2006 House Armed Services Committee (HASC) Report (109-62) Language, Section 124-Littoral Combat Ship Program, p. 121, and the Fiscal Year 2006 HASC Defense Authorization Bill (HR 1815), Section 124, Littoral Combat Ship (LCS) Program.

<sup>155</sup> Joint Requirements Oversight Council (JROC), *Capability Development Document for Littoral Combat Ship Flight 0+*, Memorandum 126-08, Serial Number 757-86-08, dated 17 June 2008.

<sup>156</sup> *Ibid.*, (updated 19 August 2009).

<sup>157</sup> *Ibid.*

<sup>158</sup> The original threshold manning target for the *Perry*-class FFG was for 185 crew members. Once in service, however, it quickly became apparent that a crew of about 215 officers and Sailors were needed to operate the ship effectively.

<sup>159</sup> 2004 *CDD for LCS*, p. 6-3.

<sup>160</sup> Rear Adm. (lower half) James Murdoch, e-mail to the author, 12 October 2012. RDML Murdoch pointed out that the original GD design had 76 bunks, while the LM design had 75.

<sup>161</sup> *Ibid.*

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<sup>162</sup> For a description of VBSS teams, see *Wikipedia*, s.v. “Visit, Board, Search, and Seizure,” [en.wikipedia.org/](http://en.wikipedia.org/).

<sup>163</sup> Murdoch, e-mail, 12 October 2012.

<sup>164</sup> Numbers are based either on one seven-month deployment per 27-month period, or one seven-month deployment per 32-month period.

<sup>165</sup> Carol Weaver, *Analysis of Multiple Concepts—Littoral Combat Ship Study Phase III Report* (Dahlgren, Virginia: Dahlgren Division, Naval Surface Warfare Center, 30 January 2004), pp. 63-70.

<sup>166</sup> Brian Alkire et al, *Littoral Combat Ships: Relating Performance to Mission Package Inventories, Homeports, and Installation Sites* (Washington, D.C.: RAND, 2007), p. xxiv, available at [www.rand.org/](http://www.rand.org/).

<sup>167</sup> For a thorough recap of the changing numbers and types of ships in Navy plans between 2001 and 2005, see Ronald O’Rourke, *Potential Navy Force Structure and Shipbuilding Plans: Background and Issues for Congress* (Washington D.C.: Congressional Research Service, 25 October 2012).

<sup>168</sup> U.S. Defense Dept., *Quadrennial Defense Review Report* (Washington, D.C.: 6 February 2006), p. 38., available at [www.defense.gov/](http://www.defense.gov/).

<sup>169</sup> O’Rourke, *Potential Navy Force Structure and Shipbuilding Plans*.

<sup>170</sup> Ibid. Mr. O’Rourke cites all the changes announced at various times since 2006, and concludes the 2010 FSA called for 328 ships. The actual number, never publicly announced, was 323 ships.

<sup>171</sup> U.S. Defense Dept., *Sustaining US Global Leadership: Priorities for 21<sup>st</sup> Century Defense* (Washington, D.C.: January 2012), p. 4, available [www.defense.gov/](http://www.defense.gov/).

<sup>172</sup> This FSA is now in staffing at OSD; once approved, it will be published with the FY 2014 President’s Budget Submission.

<sup>173</sup> While the existing program of record for *Ticonderoga* CGs and *Burke* DDGs was for twenty-seven and fifty-seven ships, respectively, the stated requirement for the Global ConOps Navy was eighty-eight Aegis combatants. Planners assumed that the *Burke* would remain in production until the DD(X) was ready to go, which would lead to an additional four ships being built.

<sup>174</sup> As opposed to the SPY-1 passive phased array radar found on Aegis combatants, the new active phased array Air Missile Defense Radar, or AMDR, has the increased sensitivity needed to detect, react to, and engage stressing Very Low Observable/Very Low Flyer (VLO/VLF) threats in the presence of heavy land, sea, and rain clutter. See U.S. Navy, “Air and Missile Defense Radar (AMDR),” [www.navy.mil/](http://www.navy.mil/). The SM-6 Extended Range Active Missile, or ERAM, has the same active radar seeker found on the AIM-120 Advanced Medium Range Air-to-Air Missile (AMRAAM). This allows its firing platform to engage targets at long range and below the ship’s own radar horizon. See *Wikipedia*, s.v. RIM-174 Standard ERAM,” [en.wikipedia.org/](http://en.wikipedia.org/).

<sup>175</sup> For a thorough discussion of the budding naval arms race in Asia, see Geoffrey Till, *Asia’s Naval Expansion: An Arms Race in the Making?* (London, UK: The International Institute for Strategic Studies, December 2012).

<sup>176</sup> The plan outlined in the 2003 Preliminary LCS IRD was slightly modified in the Navy’s May 2003 Report to Congress on Annual Long-Range Plan for the Construction of Naval Vessels. This report indicated the Navy planned to build three Flight I LCSs in FY 2008, followed by four in FY 2009 and five per year thereafter. See Ronald O’Rourke, *Navy DD(X) and LCS Ship Acquisition Programs: Oversight Issues and Options for Congress*, CRS Report RL32109, (Washington, D.C.: Congressional Research Service, updated 28 October 2004), p. 23.

<sup>177</sup> 2004 LCS CDD, pp. 5-1 to 5-2.

<sup>178</sup> Clark, telephone conversation, 12 September 2012.

<sup>179</sup> See O’Rourke, *Navy DD(X) and LCS Ship Acquisition Programs*, p. 23.

<sup>180</sup> Rumsfeld, “21<sup>st</sup> Century Transformation.”

<sup>181</sup> In 2003, a Massachusetts Institute of Technology project team concluded that no ship with the requirements for payload, range, and speed announced for LCS could be built for \$220 million. The team concluded the cost for the seaframe would be at least \$333 million. See Brancato, ‘*Real Competition*’ for the Littoral Combat Ship, p. 6.. Internal DoN studies conducted in 2004 projected the costs for each first-of-class seaframe to be somewhere in the \$400-450 million range, which turned out to be much closer to the truth than Navy then-current budget numbers. Eric Labs, naval analyst at

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the Congressional Budget Office, email to the author, 9 November 2012. This cost projection was confirmed by Ms. Allison Stiller, DASN Ships.

<sup>182</sup> For a good synopsis of problems encountered in the early years of the LCS program, see Ronald O'Rourke, *Navy Littoral Combat Ship (LCS) Program: Background, Oversight Issues, and Options for Congress*, CRS Report RL33741 (Washington, D.C.: Congressional Research Service, updated April 7, 2008), pp. 9-17.

<sup>183</sup> The end cost for LCS 1 was \$750.9 million, while the end cost for LCS 2 was \$864.5 million (both in FY 2010 dollars). Allison Stiller, DASN Ships, email to the author dated 17 January 2013.

<sup>184</sup> For a good summary of Congressional actions and the FY2009 acquisition strategy, see O'Rourke, *Navy Littoral Combat Ship (LCS) Program* (updated 5 June 2009), p. 6.

<sup>185</sup> The cost cap for LCS has evolved over time. The FY 2006 National Defense Authorization Act established a cost cap of \$220 million for the fifth and sixth ships of the class. The FY 2008 NDAA amended the cap to \$460 million, with no adjustments for inflation, for all LCSs procured from FY 2008 on. The FY 2009 NDAA deferred the implementation of the cap by two years, to FY 2010 and beyond. Finally, the FY 2010 NDAA established a new cap of \$480 million per ship, which included the basic construction cost for the seaframe, government furnished equipment (GFE), and change orders. It excluded mission package costs, plans, the ship's technical data package, class design services, post-delivery, outfitting, and program support costs. It also allowed the Navy to adjust the \$480 million cap each year to take inflation and other events into account. See O'Rourke, *Navy Littoral Combat Ship (LCS) Program* (updated 10 August 2012), p. 6.

<sup>186</sup> The Lockheed Martin led team planned to alternate production between Marinette Marine Corporation (in Marinette, Wisconsin) and Bollinger Shipyards (in Lockport, Louisiana). The General Dynamics-led team planned to concentrate building in the Austal America shipyard in Mobile, Alabama, but reserved the right to build the ships in either Bath Ironworks or NASSCO.

<sup>187</sup> For a thorough explanation of the down-select acquisition strategy, see Appendix D in O'Rourke, *Navy Littoral Combat Ship (LCS) Program* (updated 22 October 2012).

<sup>188</sup> The Navy already operates eleven aircraft carriers (CVNs), fourteen fleet ballistic missile submarines (SSBNs), fourteen MCMs, thirteen PCs, and twelve LSDs without great difficulty, and will soon operate eleven large deck amphibious ships (LHDs and LHAs), eleven LPD-17s and fourteen T-AKEs. In contrast, the three-ship *Seawolf*-class SSN presents a unique support challenge, as will the three-ship *Zumwalt*-class DDGs. Moreover, recall that two LCS versions will ultimately replace FFGs, two different classes of mine warfare ships, and PCs. In comparison with the 2001 fleet, then, the move to LCS simplifies fleet maintenance.

<sup>189</sup> For a discussion of the down-select acquisition strategy, see Appendix E in O'Rourke, *Navy Littoral Combat Ship (LCS) Program* (updated 22 October 2012).

<sup>190</sup> Brancato, 'Real Competition' for the Littoral Combat Ship, p. 6.

<sup>191</sup> The prime contractor for LCS 2 and LCS 4 was General Dynamics. The prime for LCS 6 and all subsequent even numbered ships in the 10-ship block buy is Austal America.

<sup>192</sup> Rear Adm. (lower half) James Murdoch, e-mail to the author, 2 January 2013.

<sup>193</sup> Rear Adm. Robert Wray, USN, President of the U.S. Navy's Board of Inspection and Survey, conversation with the author, 2 August 2012.

<sup>194</sup> All costs from "Littoral Combat Ship (LCS) Information Paper for President's Budget (PB) 2014 Congressional Testimony," prepared by the Assistant Secretary of the Navy for Research, Development, and Acquisition for the author, 14 January 2013. The costs in this paper are derived from the most recent 2012 Program Life Cycle Cost Estimate, which forms the basis for the LCS Service Cost Position..

<sup>195</sup> Brancato, 'Real Competition' for the Littoral Combat Ship, p. 12

<sup>196</sup> The projected average seaframe "end cost" which includes all cost cap costs (basic construction cost, government furnished equipment, and change orders) plus class design services and program management/engineering support costs. The cost of the MCM package is projected to be \$107.5 million; the cost of the surface warfare package, including the new maritime security (VBSS) and irregular warfare modules, is \$35.9 million; and the ASW package is \$23 million. In addition, every package has an average of \$16.3 million in "common equipment costs," which includes the mission package computing environment permanently installed on each seaframe and the mission module

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containers, shipping containers, and support equipment associated with each mission package. Per Congressional direction, the cost of common equipment is broken out separately from the module-specific equipment in each mission package. The average projected cost for a mission package is thus \$76.8 million (all costs in FY 2010 dollars). . From "Littoral Combat Ship (LCS) Information Paper for President's Budget (PB) 2014 Congressional Testimony."

<sup>197</sup> Recall that OSD established the "threshold" cost target for a LCS with its associated mission modules at \$400 million in FY 2005 dollars, which equates to \$490.4 million in FY 2010 dollars.

<sup>198</sup> Average projected seaframe end cost for the tenth ship of each buy is \$392.5 million in FY 2010 dollars. With average mission package costs of \$76.8 million, the average cost for a missionized LCS is \$469.3 million. Adjusted for inflation, the FY 2005 threshold cost of \$370 million equates to \$364 million in FY 2005 dollars.

<sup>199</sup> DDG 51 end cost, average of FY 2013 Flight IIA ships, in FY 2010 dollars. Allison Stiller, DASN Ships, email to the author, 18 January 2013.

<sup>200</sup> Eric Labs, presentation on LCS at the CATO Institute, 21 May 2012.

<sup>201</sup> Bill Carey, "Northrop Grumman Gets Go-Ahead for Larger Fire Scout," *AINonline*, [www.ainonline.com/](http://www.ainonline.com/).

<sup>202</sup> See the entries for oilers and dry cargo/ammunition ships in Polmar, *Ships and Aircraft of the U.S. Fleet*, pp. 267-69.

<sup>203</sup> LCS-1 has a full load displacement of 3,292 tons, while LCS-2 's FLD is 3,104 tons. From "Naval Vessel Register."

<sup>204</sup> LCS-1 has a maximum navigational draft of thirteen feet; LCS-2's draft is fourteen feet. Ibid.

<sup>205</sup> The new QA-11 software upload on LCS 1 fixed several interface issues between its TRS 3D radar and COMBATSS-21 combat management system. This upload now allows the combat system to factor in the ship's own velocity when determining surface track velocities and corrects several discrepancies observed in earlier gun firing tests. As a result, the ship can now engage surface targets using the TRS-3D radar. Vice Adm. Thomas Copeman, email to the author, 11 January 2013.

<sup>206</sup> Both the LM and GD LCS variants have the margins necessary to accept an array of additional combat systems and weapons. For example, LM is now marketing a Multi-Mission Surface Combatant family of ships based on the LCS 1 design, with the proven Aegis combat system, SPY-1F (V) radar, and Mark 41 VLS. See Lockheed Martin, "Multi-Mission Surface Combatant," [www.lockheedmartin.com/](http://www.lockheedmartin.com/).

<sup>207</sup> "'Spruance' class," in Polmar, *Ships and Aircraft of the U.S. Fleet*, pp. 154-55.

<sup>208</sup> Michael Fabey, "Redeeming Freedom: U.S. Navy Seeks to Renew Faith in LCS Fleet," *Aviation Week* (30 November 2012).

<sup>209</sup> The *Knox*-class frigate and long-hull *Perry*-class FFGs had full load displacements of 4,163 tons and 4,100 tons, respectively. In contrast, the ultimate World War II destroyer, the *Gearing*-class DD, had a FLD of 3,460 tons. See "Naval Vessel Register," and *Wikipedia*, s.v. "*Gearing* class Destroyer," [en.wikipedia.org/](http://en.wikipedia.org/).

<sup>210</sup> Chief of Naval Operations, "Littoral Combat Ship (LCS) Council," memorandum to Director, Navy Staff, 22 August 2012, p. 1.

<sup>211</sup> The sponsors included the Deputy CNO (DCNO) and subordinates responsible for Information Dominance (N2/N6) Expeditionary Warfare (N8/95), Surface Warfare (N8/96), and Air Warfare (N8/98).

<sup>212</sup> See Andy Yee, "US deployment of Littoral Combat Ships to Singapore," *East Asia Forum*, [www.eastasiaforum.org/](http://www.eastasiaforum.org/).

<sup>213</sup> Acquisition and maintenance of the sea-frame and mission modules were previously overseen by two different program executive offices: PEO Ships and PEO Littoral and Mine Warfare (PEO LMW), respectively. With the creation of PEO LCS, PEO LMW was disestablished and resident LCS program functions were transitioned to the new PEO. The new PEO LCS subsumed the following program offices: LCS (PMS 501), Remote Minehunting System (PMS 403), Unmanned Maritime Systems (PMS 406), LCS Mission Modules (PMS 420), Mine Warfare (PMS 495), and essential fleet-introduction program and functional offices, such as test and evaluation and aviation integration.

<sup>214</sup> Adm. John Harvey, Commander, Fleet Forces Command, as cited in "LCS-1 *Freedom* to Deploy 2 Years Early," *Pentagon Brief*, [pentagonbrief.blogspot.com/](http://pentagonbrief.blogspot.com/).



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<sup>215</sup> See "Littoral Combat Ship (LCS) Council."

<sup>216</sup> *2002 Draft LCS IRD*, p. 6.

<sup>217</sup> Assistant Secretary of the Navy Theodore Roosevelt, letter to John Davis Long, 18 February 1898, National Archives, provided to the author by Capt. Jerry Hendrix, USN, director of the Naval History and Heritage Command, 1 November 2012.