LCS Sustainment Support Ashore

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Contents

Executive summary

The Littoral combat ship is minimally manned with a crew of approximately 70 personnel. This is not sufficient to manage many of the daily sustainment tasks typically done on traditional ships. Many of these tasks have been pushed to various shore commands like the logistic support team (LST) and the LCSRON.

In many respects, the personnel in these commands doing sustainment tasks and functions for LCS can be thought of as a virtual extension of the ship. A virtual teaming arrangement is defined as a group of people working with a shared purpose across space, time, and organizational boundaries. Virtual teams are common in the private sector especially in areas like software development where companies can take advantage of a full 24 hour day to create a product.

Virtual teams do come with their own challenge however. Communication across different time zones, lack of face to face contact, and leadership and trust issues work against the virtual teams.

COMNAVSURFPAC tasked CNA with looking at the Sustainment Support Ashore (SSA) in order to recommend changes to how the various stakeholders ought to be organized given this new sustainment paradigm. We found that the SSA has up to 541 tasks and functions, many of which are traditionally done onboard a ship. These include logistics, maintenance, legal and administrative tasks and functions. The major players in charge of these tasks are LCSRON, the logistic support team (LST), the mission package support facility in Port Hueneme, and the Southwest Regional Maintenance Center (SWRMC).

Time spent on at the LCSRON and on board a DDG collecting notes on sustainment operations highlighted some problems that virtual teams typically have such as lack of trust and communication problems. We examined two maintenance processes in depth to see how these problems play out in these specific circumstances. We found some potential problems. For example, in some cases there is no explicit mechanism for cost control.

More importantly, the reviews of these business processes pointed toward a system of organization that is crew/hull centric. We recommend that the LCSRON, which is the focal point for SSA work, should be organized around specific hulls/crews. Furthermore, the LCSRON currently has both SSA and ISIC duties. These duties are often done by the same personnel which may create conflicts of interest. Thus, we also recommend that the SSA staff be separated from the ISIC staff and at least some of the SSA staff be labeled as sea duty given the high optempo and lengthy travel arrangements.

Introduction

The Littoral Combat Ship (LCS) is the Navy's newest class of ships and differs greatly from older Navy ships in its ability to sustain itself at sea with little or no support from the shore. Older classes of ships are designed to operate for long periods of time with little or no support from shore commands. These ships have large crews with a variety of skill sets, which can manage ship functions like maintenance, logistics, and administrative functions such as drug tests, training, and administering certain levels of military justice. This is not to say that older classes of ships receive no support from shore commands. Reach-back services like technical assistance and logistic support is available and utilized in many cases. However, ship capabilities are robust and allow the ship to operate without utilizing this reach-back very often.

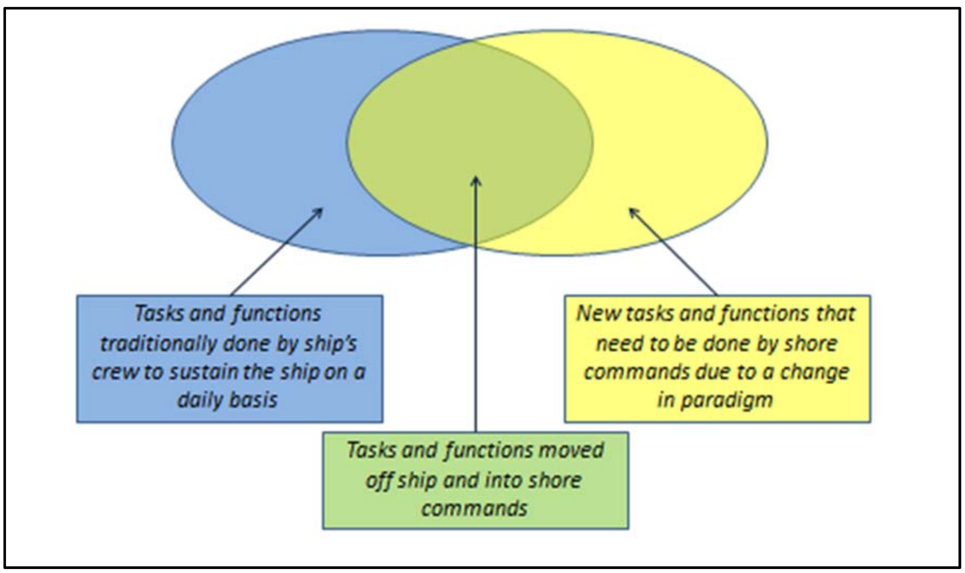
The LCS, on the other hand was designed to have a minimal crew of only 53 core personnel plus a contingent of up to 20 sailors for the mission packages. All of these sailors' major function is to operate the ship. As a result of the minimally manned crew, a large fraction of shipboard duties have been moved to shore-based commands. These include supply and logistics, administrative, operational planning, and maintenance functions. For the purpose of this study we refer to this body of work as Sustainment Support Ashore (SSA).

Another way to imagine the LCS crew setting is to compare it to a FFG. Both LCS hull types have a full load displacement of about 3000 tons while their lengths vary from 380 to 416 feet. The FFG class is somewhat heavier at 4100 tons with a length of about 450 feet. However, the FFGs are manned at about 162 crew members. A rough estimate of LCS manpower requirement based on displacement under a legacy approach to ship operations would be about 119 personnel on board. Thus, the work of roughly 46 full time personnel has been moved to various shore commands.

This presents a series of questions for the Navy. First, what tasks and functions were actually moved ashore and which shore-based commands should be responsible for them? How should these various entities be organized? Should there be one central authority figure to coordinate all the tasks being done by the various entities? Should the organizations be structured around hulls, geographic areas, or deployment status? What should be the adcon versus opcon responsibilities while on deployment? Are new systems and business processes required to efficiently execute these tasks. And ultimately, what kind of economies of scope and scale can be achieved in the shore support commands while simultaneously supporting the LCS ships afloat, especially those on deployment.

This study attempts to address those issues. We began by identifying all those tasks that would normally be done on board a ship that were moved ashore. In addition, we identified new tasks that are now done by the SSA to directly support the ship. We also attempted to identify the command that has the major responsibility for a specific task or function and whom they reach back to for support. This exercise gives us a general understanding of what tasks are being done and by whom.

Figure 1 Venn diagram of SSA functions and tasks



We next chose several business processes that we felt were significant to ship operations. This allowed us to look for factors that complicated ship support from shore commands. For example, by examining how maintenance was planned and executed, we were able to see where key decisions were being made, by whom, and how long it took for this process to flow. In identifying where the complicating factors existed within a particular ship support process, we were able to better understand how the tasks and functions should be organized.

The analysis of the business processes is an input into the final analysis of assessing possible economies of scope and scale. Work functions and tasks related to LCS can be organized in various ways, each having their own sets of strengths and weaknesses. We use the analysis done in the first two tasks, as well as information pulled from interviews with LCS stakeholders and time spent aboard a DDG collecting data on ship tasks, to determine which organizational model would be the most efficient while also providing the strongest level of support from ashore.

This study offers a qualitative assessment of the optimal organizational structure for SSA by examining work tasks and functions and examining how the business processes work relative to a traditional Navy ship.

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Literature review on virtual teams, communications, organization, and decision-making

LCS is the first naval surface combatant to effectively be supported almost entirely from ashore.[1] By moving large portions of ship sustainment to shore commands and making the sailors on board mostly operators, the Navy has implicitly created a virtual teaming arrangement. With this arrangement comes a host of issues related to communications, decision-making, and organization. The following literature review, which draws extensively from a literature review that we published in a study titled *COMFISCS LCS Support and Analysis of Supply Operations,* [1] offers insights into these issues.

Virtual teams and communication

A virtual teaming arrangement is defined as a group of people working with a shared purpose across space, time, and organizational boundaries. This is not a new concept. Private corporations have used virtual teaming effectively for decades, especially as computing power and modern communication technologies have allowed for easier coordination. Bergiel et al. [2] describe the following advantages of virtual teaming arrangements:

- Virtual teams reduce travel costs.
- Virtual teams allow flexibility in living arrangements, as there is less need to co-locate all personnel.
- Virtual teams are more diverse in nature and allow for more creative thinking.

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[1] MCM and PC ships are also minimally manned and supported from shore commands. However, these ships are smaller than the LCS and are single missioned ships that are not expected to conduct the same breadth of missions.

- Virtual teams allow physically disadvantaged workers more opportunities as they can often work from home.
- Virtual teaming discourages race and age discrimination.
- Virtual teaming allows for around the clock support as workers can be geographically placed around the world.

However, for virtual teams to be effective, the following traits must be present:

- All the geographically dispersed groups must be able to trust each other without questioning motives, intent, or effort [2 – Bergiel et al.].
- Baker [3] found that good communication is paramount to success. Poor communication has led to poor performance in the private sector, and the Navy is not immune to this problem. While new communication technologies have been developed such as e-mail and VTC, they still suffer from asynchronous communication. In addition, much information is lost when people do not communicate face to face. Andres [4] showed even VTCs are not as effective as in-person discussions.
- Leadership is even more important than it normally is to ensure that geographically dispersed groups can work toward a single unified purpose [2 – Bergiel et al.].
- Clearly stated goals dictated by leadership reduce parochial behavior, which benefits only those with a particular group, and do not support the overall goals of the organization [2 – Bergiel et al.].

Researchers also noted the following barriers to success for virtual teams:

- Groups that are displaced across time zones have a difficult time coordinating efforts. In addition, effective productive time is reduced and friction across groups can develop [2 – Bergiel et al].
- Miscommunication across groups is a large problem. As a result, misunderstandings are common and a large amount of time is spent resolving them [4 –Andres].

- Resolution of conflicts is more complex because of the loss of information flow due to non-optimal communications. Face-to face communications are almost always better but more difficult to achieve in a virtual teaming environment due to travel costs.

LCS sustainment issues are a reflection of the decision to move ship functions ashore—to a virtual teaming arrangement. As with all arrangements of this sort, the decision-making and coordination processes have become more complex relative to how they are done with traditional ships; ship personnel have less influence on sustainment activities. This does not mean that ship personnel have no authority over sustainment decisions, but, clearly, managing emergent issues has become more difficult, requiring more coordination among more stakeholders. And this problem is exacerbated by a lack of face-to-face communication.

Decision-making and organizational design

Organization of any type comes at a cost. When individuals are not entirely self-employed, their interests and objectives may not perfectly align with the organization they serve. They may be assigned to make decisions without the best information or without qualifications to make those decisions. However, organizations are necessary in order to coordinate effort under changing circumstances.

We begin our discussion of organizations by first considering the contexts for decision-making. That is, we formalize from previous research a set of rules by which effective decisions can be made. We then discuss the fundamental problem of centralization versus decentralization within an organization, the types of coordination problems and methods that exist, and alternative organizational structures that have been studied.

Leadership and decision-making within an organization

On board a ship, various decisions are made on a daily basis. Obviously combat critical decisions are more likely to be made in an autocratic fashion while routine decisions are delegated down to the appropriate department heads. But many decisions, especially those regarding ship readiness, are made through a consultative or joint decision-making process.

A great deal of research exists on how optimal decisions are made. Vroom and Jago (1988) [5] describe the following taxonomy of decisions:

- Autocratic I—The leader makes the decision using information available to him or her at the moment.
- Autocratic II—The leader obtains more information from subordinates but still makes a decision without consulting them.
- Consultative I—The leader shares a problem with subordinates and gets their ideas and suggestions independently (i.e., not in a group setting). The leader then makes the decision.
- Consultative II—The leader shares the problem with the subordinates in a group setting and obtains their collective information and ideas. The leader then makes the decision, which may or may not be the consensus of the group.
- Joint—The leader shares the problem with a group of subordinates and attempts to form a consensus on the decision.

Vroom and Jago's taxonomy created a set of decision rules, which leaders should use in deciding which of the above processes to use. These rules are as follows:

- Autocratic decisions are not appropriate when subordinates possess relevant information lacked by the leader.
- When the subordinates do not share the same task goals as the leader, joint decision-making is not appropriate as it gives too much influence to groups that are uninterested or even hostile to the leader's goals.
- If the decision quality is important and the problem is vague or unstructured, group interaction (CI, CII, or GII) is the most appropriate decision process.
- If the leader is interested in maximum acceptance across subordinates, then consultation is the most appropriate decision process.
- If there is significant disagreement across subordinates about the decision, then autocratic and individual consultations are not appropriate, as they do not offer a forum for differences to be resolved.

Vroom and Jago's taxonomy is based on a review of several previous studies, which strongly suggest that if the above rules are followed, the likelihood of a successful outcome (as a result of the decision made) increases significantly. For example, they computed the mean success rate across five studies and found that when the rules were followed, 62 percent of the decisions yield a positive outcome, while only 37 percent of the outcomes were positive when the decisions were made outside of their taxonomy.

Centralization versus decentralization

An organization must decide how much to rely on central planning and centralized decision authority versus empowering decision-makers lower in the hierarchy. Lazear and Gibbs (2009) [6] list some advantages of centralization. If there is a large shared asset, such as a physical facility, an accounting system, or an established relationship with an outside partner, it makes sense to have a central authority managing that shared asset. Centralized authority can make better use of knowledge, such as patterns that emerge from the experiences of smaller units. And if coordination is required among units, a central decision-maker can improve this coordination.

However, there are also several advantages to decentralizing authority. It saves management time and reduces bottlenecks. Decentralization helps to develop leadership and managerial skills among less senior personnel by giving them more responsibility. And people may feel more motivated and satisfied in their jobs when they have the greater challenges and freedoms that come with decentralization. The largest advantage of decentralization in almost all cases, however, is information. Jensen and Meckling (1990) [7] highlight that communicating information to a centralized decision-maker can be costly, so there is an advantage to moving the decision as close as possible to the original source of the information. For example, there is a clear advantage in a traditional ship's ability to coordinate decisions through the CO, who is aboard the ship.

The importance of this advantage varies because not all information is equally costly to communicate. Jensen and Meckling differentiate between "general" knowledge and "specific" knowledge. "General" knowledge, such as the number of nautical miles that a ship can travel before refueling, is easy to communicate throughout the organization.

Knowledge is “specific” and more costly to communicate to the extent that it is:

- Perishable—Taking advantage of the information requires quick action.
- Complex—Understanding the information requires factoring in several interdependent pieces of information.
- Technical—Understanding requires a background in specific technical training.
- Idiosyncratic—The situation frequently changes in unforeseeable ways, so that any communication must be frequently updated.
- Subjective—The information cannot be quantified and is only fully understood when it is directly experienced.

If a decision requires general knowledge, it is usually efficient to centralize it so that the decision-makers have a high position in the organization and have objectives closely aligned with the organization as a whole. The more specific knowledge is required, the more decisions should be decentralized to people closer to the problem.

One way to combine some of the benefits of both centralization and decentralization is by separating decision management from decision control. Fama and Jensen (1983) [8] point out that most decisions can be thought of as having four stages:

1. Initiatives—proposing alternatives for consideration
2. Ratification—choosing one of the proposed options
3. Implementation—choosing the tactics or methods by which the ratified decision is carried out
4. Monitoring—confirming that the implementation is carried out properly and in accordance with the ratified decision

The initiatives and implementation phases—decision management—require creativity and knowledge of the situation. It often makes sense to decentralize decision management to lower levels of the hierarchy while retaining decision control—the ratification and monitoring phases—at a more centralized level.

In the case of SSA for the LCS, there is a limit to how much centralization can be achieved because there is no one person who can have authority over all SSA functions. The LCSRON reports to the TYCOM, the RMCs report to Naval Sea Systems Command (NAVSEA), and currently the Logistics Support Team reports to Naval Supply Systems Command (NAVSUP) for administrative requirements (though to the LCSRON for operational requirements). Operational orders for the LCS come from a numbered fleet through a CTF. This increases the complexity and importance of coordination.

Coordination

Coordination within and across units is essential for almost all organizations because it is the fundamental reason why an organization is needed in the first place. Coordination problems fall into two general categories: synchronization and integration.

Synchronization problems are essentially one-offs: once the synchronization has been accomplished, it does not require constant communication to maintain. For example, the Bureau of Naval Personnel (BUPERS) and the LCSRON need to agree on the pay grade and rating structure of an LCS core crew and may occasionally revise this in future years. However, BUPERS will assign sailors to LCS crews as others rotate out, or as new ships are launched and new crews are stood up, without conferring with the LCSRON every time.

Integration problems, however, require specific knowledge that resides in different people and can only be resolved through costly communication. One person may know the material condition of a ship and how severely it is affected by a particular part malfunctioning. Another may know exactly what is required to repair or replace that part. A third person may have the best knowledge of the shore resources available and how much they will be able to accomplish in a particular timeframe, given the projected schedule. This information will change constantly, so that no one person can collect, process, and act on it.

There is no easy solution to integration problems, though some organizational structures are more suited for integration. Lazear and Gibbs [6] list several techniques to facilitate synchronization, including the following:

- Central budgeting and planning
- Training and standard operating procedures
- Corporate culture
- Liaisons
- Job rotation
- Informal networks

The Navy makes extensive use of these coordination techniques, and they will be important to the LCS community as they are throughout the Navy.

We note that there are limits on job rotation: sailors rotate between ship and shore assignments and often transition to civilian or contractor jobs, but they do not rotate between ratings, between supply and unrestricted line officer positions, between surface and aviation communities, or back into uniform from civilian and contractor positions.

Aldrich and Herker (1977) [9] highlight the role of boundary workers, who facilitate interaction between organizations. In the Navy, we can think of boundary workers as interacting between separate commands. A consequence of standard operating procedures is that they make boundary workers' jobs less demanding while also aligning their priorities with the command that sets the procedures. For example, RMC employees who routinely work with the LCSRON may naturally begin to identify with the LCS community more than with the RMC. However, if the RMC formally standardizes procedures for their interaction with the LCSRON, personnel will be more aligned with RMC priorities. Therefore, standardization may work for or against coordination. Ideally, standardized procedures affecting multiple commands should be approved at the highest levels in order to ensure that they support the priorities of the Navy overall.

Functional, divisional, matrix, and network structures

Lazear and Gibbs describe advantages and disadvantages of four different organizational structures. The most traditional for a corporation is the functional hierarchy: "silos," in which each person reports to a supervisor with a background and expertise similar to his or her own and has a clear career track within that function. For example, supply, maintenance, and personnel functions could each be organized separately and overseen by different commands, or by different deputy commanders within one command.

Caves (1980) [10] points out that this structure has two potentially large cost advantages. First, it is designed to exploit economies of scale. If a large number of people performing the same function are organized together, they can easily share physical resources, systems, and knowledge. This can reduce redundancy, increase efficiency, and lower costs. Second, it exploits the advantages of specialization. Working with and for other people who do the same task will ensure that personnel are highly specialized in that task, which is often more efficient than multitasking.

However, functional hierarchies can be slow to adapt to changing problems, especially those that require coordination. Also, because there is a limit to a manager's effective span of control, functional hierarchies require more hierarchical layers, as they grow larger, increasing the distance between the top decision-makers and those implementing the decisions.

An alternative is a divisional structure, where people with different functional expertise are organized together into divisions based on geography, product line, or customer type. In the context of the LCS, supply and maintenance staff could be organized together to support a set of hulls and crews, or to support a particular phase of the fleet response plan (FRP) or operating area. Cremer (1980) [11] argues that an organization should be divided in order to minimize the uncertainty involved in collaboration across divisions: if two people or units need to work together in a way that is not well defined and requires frequent communication, then they should work in the same division.

One potential disadvantage of a divisional structure is that divisions can compete with each other for resources and may fail to collaborate in ways that would increase effectiveness. They may also lose some of the advantages of specialization in one function. However, as organizations become larger or more complex, they almost always find that they need to move away from the traditional functional hierarchy.

When there is a need for workers to specialize in—and collaborate with peers in—both their function *and* their product area, one solution is a matrix structure that involves reporting to two different supervisors simultaneously. Matrix structures are often used to help address large integration problems, such as those involved in the launch of a new product. Use of overlapping command chains is not an unfamiliar concept in the Navy: many units report to an administrative commander and an operational commander. Reporting to both a TYCOM and a numbered fleet, or to both the Chief of Naval Operations (CNO) and a unified combatant commander, is an example of a matrix structure.

Finally, an organization can have a network structure. Informal networks often exist in parallel with the formal hierarchy: managers at various levels throughout the organization often have informal connections with each other that allow them to resolve issues. Loose networks can also be created on an ad hoc basis, as people from different parts of the organization are temporarily assigned to a team or working group. A key feature of networks is the importance of acquiring social capital. Also, some people can increase their value and influence within the network by identifying and filling "structural holes," or gaps in the communication between other parts of the network. Networks are highly political and therefore do not always arrive at the efficient solution.

The concept of network structure is particularly interesting for LCS SSA because the absence of one centralized authority is inescapable. Different commands must collaborate with each other despite the fact that they do not share a formal hierarchy except at the CNO level. Therefore, social capital will inevitably play a role in SSA.

Summary of literature review

The system that the Navy set up to support the LCS can be considered a virtual team. That is, various geographically displaced groups are responsible for much of the sustainment operation. While virtual teams do have their advantages, they also have problems. Namely, for a virtual teaming arrangement to work, the Navy must create an organization that coordinates efforts across all stakeholders and enables proper decisions to be made in the most appropriate manner.

Our basic choices of possible organizational structure are functional, divisional, matrix, or social network. As mentioned above, each has its own set of advantages and disadvantages. While the Navy must choose one as an overarching organizational structure, there is room within each choice to adopt some traits from the other structures.

The rest of this report is devoted to searching for evidence that would support the adoption of one particular structure for the SSA. We do this by first looking at the functions and tasks that SSA does and who does them. This helps us define the workload and the players. We then turn to how LCS operates versus how traditional ships operate and looking for areas where it is clear that some improvement is called for which would lead us to recommend a particular organizational structure. Finally, we examine possible organizational structures and offer recommendations on which structures would yield the greatest efficiencies while enabling timely and well-made decisions.

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Functions and tasks of the SSA

For the purposes of this report, we define SSA as follows:

> Sustainment Support Ashore is a set of requirements to provide daily support services to LCS ships both deployed and otherwise in use. These services include but are not limited to logistics, readiness, and personnel areas integral to the daily function of the ship that would, in legacy ships, be done by the ship's crew solely or in part. The commodore of the LCSRON is accountable for the fulfillment of SSA requirements, which involve resources both within and beyond the LCSRON staff.

Step one in evaluating the proper organizational structure for the SSA is to understand what it does. So in this section, we attempt to define the total work tasks and functions that have been moved off the ship to a shore command. As LCS is new, the SSA also has a series of new tasks that are unique to LCS and are directly related to supporting the ship. We examined a series of Mission Task Function (MTF) statements and Required Operational Capability/Projected Operational Environment (ROC/POE) documents. These documents outline the functions and tasks for a particular command. The main document that we examined was the MTF for LCSRON. But, because we were unsure whether there were other functions and tasks, we examined other MFTs and ROC/POES for other commands. We then asked personnel at the LCSRON and Logistics Support Team (LST) for other tasks and functions that should be included.

Once we had a complete list of tasks and functions, we asked the various stakeholders to confirm that the list contained all tasks and functions that directly support the ship as outlined in the formal definition. For example, some of the tasks on our list were more closely aligned with ISIC duty versus direct ship support. Those tasks should not be included in the SSA task and function list. Unfortunately, the validation of these tasks was problematic for various reasons, and we were unable to ensure that the task and function list include only those tasks and functions associated with SSA.

Therefore, our final list likely contains tasks and functions that are not part of the SSA.

General look at where crew reductions took place

We first look at manning for FFGs and compare it with the latest LCS ship-manning construct given to CNA by COMNAVSURFPAC. As a useful comparison, we use the actual billets authorized for a typical FFG versus the FFG ship manpower document. According to the Total Force Manpower Management System, the billets authorized in 2001 for the USS George Philip was 162 crew members. Table 1 shows the comparison between a typical FFG such as the USS George Philip and LCS not including the mission package crew.

Table 1. FFG versus LCS

	FFG		LCS		Total difference
Department	Officer	Enlisted	Officer	Enlisted	
Executive	2	4	2	2	2
Operations	4	54	3	9	46
Combat systems	3	38	3	13	25
Engineering	3	33	3	12	21
Supply	2	19	1	5	15

The comparison between FFG and LCS is not exact. First, the FFGs are larger than the LCSs. Second, the comparison above does not include the mission package crew for the LCS. Even so, the comparison gives us an idea of the types of functions that have been moved ashore.

Turning first to the executive department, there are no yeomen, master-at-arms, or personnelmen on board an LCS. Therefore, many administrative functions ranging from legal support to personnel and training rely on the SSA.

Using FFGs as a raw baseline, it appears that the operations department saw the largest reduction. Notably missing from LCS are operations specialists (20 on an FFG versus four on an LCS not including the mission package crew) and boatswain's mates (17 for FFGs versus four for LCSs).

Combat systems took a smaller relative reduction than the other departments especially when we consider the extra 20 personnel from the mission packages that would fold into this department. This is in keeping with the operational concept of the crew being operators versus sustaining the ship.

Engineering took a large reduction in manpower. Among the largest reductions are gas turbine system technicians (11 on the FFG versus one on LCS) and enginemen (8 on FFGs versus five on LCSs). This is in line with the maintenance CONOPs for LCS, which states that most repairs will be made in port as part of a periodic system of preventive and continuous maintenance.

Finally, we note a large reduction in the supply department. The USS George Philip sailed with 9 culinary specialists. The LCS sails with only five.

It is important to note that no sailor is single hatted. Almost all sailors have ancillary duties ranging from watch standing to corrosion control.

Examination of ROC/POEs and MFTs

Table 2 shows the count of tasks and functions pulled from an examination of the respective MTF or ROC/POE. Our starting point for this analysis was the LCSRON MTF. However, to be certain that there were no other tasks or functions germane to LCS ship sustainment operations, we examined six other documents. We chose these documents as they represented a reasonably wide array of operational and shore commands that we felt might have tasks or functions that were done from ashore that sustained an operational force.

In total we pulled 541 tasks and functions from seven documents. As mentioned above, once we had an initial list, we asked stakeholders to validate it in order to ensure that the tasks included were indeed related to the daily support of the ship. This task turned out to be problematic, and we were only able to validate a small portion of them. For example, after examining the ROC/POE for a certain DESRON, we pulled three tasks that we felt were not in the LCSRON MTF and that, in theory, could be something the SSA would do in support of LCS. Of those three, various stakeholders were able to validate only one of them as part of the SSA workload. In some cases, a stakeholder validated a task and decided that it was not part of the SSA workload. Those tasks were removed from the final list and are not shown.

This does not mean that those tasks that were not validated are not part of the SSA workload. It means, rather, that the stakeholders didn't have an opinion about them. Those tasks that were not validated were kept in. Thus, our list likely overcounts the tasks and functions.

Table 2. Tasks and function count by MFT or ROC/POE

Document	Total
DESRON ROC/POE	3
Validated	1
Not validated	2
JMAST ROC/POE	2
Not validated	2
LCSRON MFT	212
Validated	67
Not validated	145
NAVSUP-GLS LST guidance	284
Validated	18
Not validated	266
RMC guidance	8
Not validated	8
SUBRON ROC/POE	31
Validated	4
Not validated	27
VP squadron ROC/POE	1
Not validated	1
Grand total	***541***

The two largest contributors to our list come from the two commands that most directly support the LCS. They are NAVSUP-GLS in San Diego, which is responsible for the LST, and LCSRON. However, there are quite a few other tasks and functions found in other documents that we felt could be considered part of the SSA workload.

Table 3 shows the breakdown of the tasks and functions by major category and responsible command. Note that the majority of the tasks that we found are related to logistics and maintenance. This is logical given that almost all supply functions and most maintenance functions have been moved off the ship.

Table 3. Major tasks and functions

Command responsible for task or function	Major task or function category: Career Counseling	Combat Systems and C4I	Contractor tasks	Logistic support	Maint Analysis	Manpower, Manning, Admin	Require ments and Analysis	Training and Readiness	*Grand Total*
COMNAVSURFOR				2					*2*
LCSRON				55					*55*
LCSRON 3MC				1					*1*
LCSRON N1	21			1		68			*90*
LCSRON N3								31	*31*
LCSRON N41				38					*35*
LCSRON N43					72				*72*
LCSRON N6		9							*9*
LCSRON N8							8		*8*
LSR				1					*1*
LST				216					*216*
MPSF				1					*1*
SWRMC			8	9					*11*
Grand Total	*21*	*9*	*8*	*324*	*72*	*68*	*8*	*31*	*541*

As expected, the LST and various sections of the LCSRON are primarily responsible for most of the tasking. It is important to understand that the LCSRON is somewhat different from a typical DESRON. Normally, a DESRON has an ISIC role and does not get involved in most day-to-day activities on a DDG. The LCSRON, on the other hand, has an ISIC role similar to a DESRON, but it is also responsible for a large portion of sustainment tasks that occur daily on a traditional ship. Note that LCSRON N1 is one of the most tasked groups. They have adopted much of the administrative work, which includes tasks such as legal issues and career mentoring. The other important player in the SSA is the Southwest Regional Maintenance Center (SWRMC). SWRMC personnel work with LCSRON staff to plan and organize maintenance packages for the LCS when it is in port. In interviews with various stakeholders, we learned that the commands listed in table 3 received support from the LCS program office.

Summary of work tasks and functions

The three major commands responsible for SSA workload are LCSRON, which plays an ISIC and sustainment role; LST, which reports to both LCSRON and NAVSUP GLS; and SWRMC. The majority of the SSA workload falls under logistics and maintenance categories, but administrative tasks and functions are also drivers of SSA workload.

Examination of certain SSA business processes

In the previous section, we described what SSA does. The scope of the tasking and functions, as well as who is responsible for doing them, is relatively well understood. But, to better understand how to organize the tasks and functions, we have to examine the business processes.

In this section, then, we examine a sampling of broad SSA functions. We consider how lessons learned aboard a traditional ship could apply to streamlining SSA processes, and how the issues associated with these processes inform our broader analysis of organizational issues. This is central to our purpose of identifying economies of scope and scale. An organization can benefit from broader scope and scale only if it is organized in a way that enables it to do so, and the strengths and weakness of its organization become apparent in the context of the functions it must accomplish.

Readiness, logistics, and personnel processes are inherently different when they are moved from ship to shore. Staff must make decisions without firsthand knowledge of the ship's situation. They must collaborate across different commands, physical locations, and perhaps time zones. And they do not report directly to the ship's commanding officer (CO). These conditions may lead to misunderstandings and tensions between competing command priorities (e.g., short-term priorities of operational commands and longer-term priorities of administrative commands.)

Our choice of processes is based on several considerations. Ideally, they should

- relate to lessons learned aboard the USS *Mahan*, from observations of the January 2012 LCS sustainment/logistics wargame and from interviews with DESRON staff;
- highlight cross-functional issues that require collaboration between commands;
- depend on the organizational structure of the SSA; and

- directly relate to mission capability.

We chose two readiness processes: prioritizing and scheduling maintenance for availability, and flying out a team for emergent maintenance. As a basis for understanding the issues, we compare LCS business practices with those of a traditional ship. To better understand how traditional ships work, we spent five days aboard the USS *Mahan* interviewing crewmembers in all the departments and observing maintenance, logistics, and administrative functions. We do not believe that the LCS should function like a traditional ship or adopt its business practices. Rather, because processes on traditional ships are well understood and have improved after years of lessons learned, they are a reasonable point of comparison.

Prioritizing and scheduling maintenance for an availability

The ship's crew is composed mainly of operators, not maintainers, and has very limited ability to perform even O-level maintenance outside of an availability. The CONOPS calls for two types of routine availabilities: planned maintenance availabilities (PMAVs), which notionally occur after every 25 days of operation and last five days, and continuous availabilities (CMAVs), which notionally occur every 117 days (accompanying a crew swap) and last two weeks. Because time in port is limited, the highest priority work must be identified and planned, and the service provider must be ready before the ship arrives.

Lessons from a traditional ship

Aboard a traditional ship, readiness is overseen by a chain of command from the work center supervisor (typically a petty officer second class), to division officer (typically an ensign or lieutenant junior grade), to the Chief of Engineering (CHENG), to the CO. Each node in the chain of command has standing orders defining which issues require his or her direct attention. In some cases of corrective maintenance, a problem may be identified and addressed using the ship's supplies and personnel without the CHENG ever being aware. Preventative maintenance is automatically scheduled by the program SKED, and the work center supervisors assign personnel to carry it out.

If the ship and crew do not have the knowledge, parts, or equipment to diagnose and repair a problem, or if time is a priority and outside help will accelerate repair, the CHENG calls the port engineer (PE), who works for the type command (TYCOM) and the regional maintenance center (RMC) or ship support activity to coordinate resources. Much of the labor provided by civilians and contractors comes at no direct cost to the ship, but overtime, weekends, and other special charges may apply.

Our observations of the USS *Mahan* and interviews with the crew indicate that this typically occurs in accordance with a general understanding of the CO's priorities and intent, even if the CO is not immediately informed of the decision. For example, on the day that the *Mahan* was preparing to depart with us aboard, the CHENG reported two problems to the PE: a failure to transition from shore power to ship power (which required an immediate solution), and a faulty tank-level indicator for one of the four potable water tanks (which was not urgent but required a calibration to be performed ashore).

If the costs of parts and of civilian or contractor labor exceed the ship's original allocation, the CO and department heads agree on a prioritization of maintenance needs and ask the TYCOM for additional funding. The PE coordinates the ship support activity's spending of the TYCOM's funds, according to the CO's priorities.

Adaptation to the LCS

The process of scheduling maintenance for the LCS is necessarily different. Much of the preventative and corrective maintenance traditionally performed by the ship's force, some of it without the CHENG's awareness, must be performed by civilians and contractors in port. The CO and CHENG have less control over readiness, partly because less of the work is performed by their own sailors and partly because of limited communication between the ship while underway and the shore establishment where the work will be performed.

The Littoral Combat Ship Platform Wholeness Concept of Operations, Revision D (CONOPS) partially specifies a process for scheduling maintenance.

1. The ship's force generates automated work notifications (AWNs).

2. The LCSRON's ship maintenance management officer (a staff member reporting to the maintenance officer assigned to this hull) reviews the AWNs.

3. The LCSRON staff member compiles a list of AWNs and emails it to the maintenance support team (MST) for this hull.

4. The MST meets. It is headed by the PE and includes the LCSRON material readiness officer (who oversees all hulls in the squadron), the RMC project manager, the reliability engineer, the maintenance officer (MO) for this hull, the mission package support facility officer in charge (MPSF OIC), and representatives from the maintenance provider and the off-hull crew. This team is charged with validating and adjudicating AWNs, prioritizing jobs, and planning availabilities.

5. The LCSRON staff member generates the work request in the organizational-maintenance management system–next generation (OMMS-NG) and emails the meeting minutes to the rest of the MST.

6. The PE brokers work in the regional maintenance automated information system (RMAIS) for assignment.

7. The MST screens the PE's list to the proper availability, and the work is completed.

In interviews with LCSRON personnel, we learned that the MST is co-chaired by the PE and the material readiness officer, and that it formally convenes weekly for each hull, but informally it meets daily. Having co-chairs, one representing the demand side (LCSRON) and one the supply side (the TYCOM and RMC) could potentially lead to unresolvable conflicts, but these are referred to the LCSRON commodore to resolve at the O-6 level.

There are some gaps in the future applicability of this process map. Everyone in this team currently deals with one region and one hull (or two hulls of two different classes). There is no explicit mechanism for cost control. Also, there is no operational commander involved; at the time the CONOPS was written, the LCSRON was intended to have both administrative and operational control. Decisions about the timing of availabilities cannot be made without operational orders, and prioritization should include consideration of the operational commander's immediate priorities.

When a squadron contains multiple ships of one class, deploying to 5th, 7th, and possibly 4th Fleet, as well as operating in 2nd the 3rd Fleet, the process will involve more distance communication and will depend heavily on structure. An MO can be tied to geography, and co-located with the relevant PE, project manager, contractor representative, and mission module readiness center (MMRC), as well as be in or close to the time zone of the operational commander (CTF). Alternatively, an MO can be tied to one or more hulls, and co-located with the LCSRON commodore, the Mission Package Support Facility (MPSF), the off-hull crew, and the reliability engineer. In either case, planning maintenance for deployed ships involves stakeholders in different time zones.

We propose the following process:

1. The ship's force generates AWNs.
2. A deputy to the MO reviews and compiles AWNs and circulates them to the LCSRON material readiness officer, the MPSF OIC, and all those listed in step 3.
3. The MO convenes a meeting with his or her deputy, an MPSF representative, the MMRC OIC, the off-hull CHENG or CO, the PE, the project manager, and representatives from the CTF and the contractor, and the reliability engineer if available. If possible, this meeting should include a phone conversation with the on-hull CHENG, executive officer (XO), or CO.
4. The PE, project manager, and contractor agree on a not-to-exceed for any overtime costs or special charges.
5. The MO and the off-hull CO approve the not-to-exceed. If the initial funding allocation is exhausted, they apply first to the LCSRON material readiness officer (and, by extension, the commodore) and then, if necessary, to the TYCOM for more funds.
6. The RMC or ship support activity and the contractor execute the maintenance.

This process raises multiple difficulties. Regardless of organizational structure, there is limited communication with the on-hull crew, who has the best information about the current situation. There will be distance communication and virtual teaming, trying to resolve tensions across different commands, but the exact nature of this will depend on the structure.

Emergent maintenance requiring a fly-out team

Some emergent issues will inevitably have to be addressed outside a port availability, either because the ship cannot safely return to port or because the ship must remain on station but the repair is mission-critical. In that situation, someone must determine that the situation is emergent, and then the appropriate support team must be chosen and the logistics for their travel and parts must be arranged.

Lessons from a traditional ship

The crew of the USS *Mahan* told us of two different cases of emergent maintenance that had occurred prior to our visit. In one case, the ship was off the coast of Africa when the CO recommended a mid-deployment, two-week stop for maintenance. There were several open casualty reports (CASREPs), some of which were already open at the beginning of the deployment. Technicians from ashore attempted to provide distance support via email, but this was not sufficient to resolve the large number of problems.

The CTF approved the stop. Contractors overseen by a senior chief petty officer were flown in to support, mostly from Naples, and local labor was contracted to help complete small jobs. The support was mostly supply driven; rather than the ship requesting specific resources from specific commands or locations, support facilities coordinated to spread the load while providing the needed support.

Another incident, not long before our visit, began while underway in shallow water not far from homeport. Power went out, and the crew restored it within 40 minutes but they did not know the underlying cause. The CHENG called the PE as soon as the immediate problem was addressed. Technicians from Yorktown arrived at the ship within hours, but it took six weeks to diagnose and correct the problem.

Adaptation to the LCS

Because this process, by definition, involves resources beyond the ship, it is largely similar for traditional ships and the LCS. However, because the CHENG has limited time and communication constraints, the MO has a logical role in coordinating the right support.

We propose the following process:

1. The ship's force generates an AWN.
2. If the ship is capable of safely returning to port for an availability, the CO consults with the CTF about whether to remain on station.
3. If the ship is unable to operate or ordered to remain on station, the CHENG calls the PE and notifies him or her that the task is emergent.
4. The MO, PE, and contractor agree on a team overseen by a senior enlisted sailor or Navy civilian.
5. The PE, project manager, and contractor agree on a not-to-exceed.
6. The CTF—and numbered fleet if necessary—approves the fly-out team.
7. The CTF coordinates transport and resolves diplomatic clearance issues.
8. The Naval Operational Logistics Support Center (NOLSC) works needed parts and equipment through customs.
9. The fly-out team completes the repair.
10. The CTF coordinates the return trip.
11. If the MO is tied to the hull and the ship is forward deployed, the MO and PE are located in different time zones, hindering communication.

Other observations from the USS *Mahan* and LCSRON interviews

Loss of crew members

While on board the USS *Mahan*, we learned that the ship's crew had recently had a problem with drug use, which led to the investigation of 18 sailors (almost 6 percent of the ship's crew). During the investigation, the ship had to operate without these sailors, which put considerable stress on the ship's crew despite the fact that DDG manning has some redundancy. In the case of an LCS, a loss of 6 percent of the crew (just three or four crew members) would create terrible problems for the ship, as there is little redundancy.

Even more important, as we mentioned, the LCS must be viewed as a virtual team consisting of not just the ship's crew, but also those personnel within the SSA that are critical to the daily sustainment of the ship. Any loss of personnel in those critical areas, while not as catastrophic as losing an actual crewmember, will create a great amount of stress.

Cannibalization

Right now, there are not enough ships in the LCS fleet for cannibalization to be an issue. But many ships in the fleet take advantage of cannibalization to expedite ship repairs, especially during their workup cycle when they are in CONUS and near other ships of their own class. On the USS *Mahan*, we saw an example of cannibalization. The ship's Bridge Control Unit (BCU) failed. The Electrical Material Officer knew to look at the Navy's inventory of BCUs via One-Touch (an inventory system that allows personnel to locate a certain part). He realized that a ship parked near his had one that they would lend. He made a few calls to the neighboring ship and the TYCOM and arranged a swap. The necessary paperwork for the swap was created and within a few hours the parts were swapped. Only afterward did the crew put in an AWN and generate the normal CASREP.

We did not see any examples of LCS cannibalizing another ship for parts. But any future maintenance plan needs to consider this as a viable part of the ship's ability to maintain itself. Thus, there is a strong argument for this type of repair to be done without the SSA having too large a role. Any impediments to this kind of action by the crew should be reviewed.

Training

The LCS uses a different training model from traditional ships. LCS crews perform multiple functions on a ship and must operate on a crew rotation basis. In addition, there is little time on board the ship for on the job training or other proficiency training. According to the LCSRON Wholeness CONOPS, the new training program incorporates Train-to-Qualify (T2Q), individual training, and Train to Certify (T2C), individual and unit training, in such a way to meet the following requirements:

- Individual training must cross trained sailors ready to stand watch.
- Personnel must rotate onto a ship fully qualified.
- Training must be shore centric.

The crews try to accomplish as much training as possible through simulation during the off-hull phase, but some scenarios such as damage control (DC) cannot be simulated. Therefore, DC training is usually done at the beginning of the on-hull, non-deployed phase. The non-deployed hull is supposed to be ready for 3rd Fleet tasking. In practice, the first three or four weeks are spent completing training, and for the remaining three months the ship is fully ready for tasking.

One complication that arose from discussions with LCSRON staff concerned the actual training instructions. Each DDG has its own standardized set of training instructions. This is because each ship has some unique systems. In our interviews with LCSRON staff, we heard that COs and crews were having difficulties adjusting to the LCS model, in which the squadron is responsible for the standardized set of instructions.

The integrated training team (ITT) is part of a DDG crew. For LCS, the ITT is external to the crew and is augmented to include some ATG roles. Constant training drills are also part of a DDG's routine, but they are not for the LCS. One reason for this is that complex drills require some people to observe while others run through the drill. The LCS crew doesn't have spare observers.

Aboard a DDG, oversight of training is not a collateral duty; a second-tour officer is assigned as the Training Officer (TRAINO).The job includes scheduling training, verifying completion, and creating scenarios. All this work has been moved to the SSA. Organizing oral boards is a gray area, as the crew must still do some of this work. The strain on the LCSRON staff has been reduced some because training specific operational scenarios (a SUBRON task) has become more standardized into classroom and ITT training.

Possible conflicts of interest

One issue we saw in different parts of the LCSRON is that the command has both ship and ISIC duties, which, at times, could create a conflict of interest. For example, ship training, which is part of the ship's TRAINO responsibilities, has been pushed into the LCSRON. But the LCSRON has also adopted some ATG roles, as well as the normal ISIC duties, which oversee training. This represents a conflict of interest as the personnel doing the certifications are sometimes the same people who train the crews, or they work closely with them. This suggests that any organizational structure for the LCSRON should have a bright line between the ISIC staff and the SSA staff.

Operations

In the LCSRON, certain staff members are responsible for ship operational planning. On board a traditional ship, the Operations Officer (OPSO) and his or her subordinates do these duties. The LCSRON has two main duties: Maintenance Officers (MOs) and Mission Liaison officers (MLOs) for operations. MLOs are involved in the scheduling of training, services, and operations at sea.

The way operations are coordinated on a DDG is much different from how they are coordinated on the LCS. For example, on a DDG, the OPSO calls the port when the ship needs to get underway. For the LCS, the squadron makes that call. The squadron also generates naval messages for the ship.

Aboard a DDG, the OPSO coordinates requirements from the other departments and builds a unified schedule. For example, the

CHENG requests gas, the SUPPO makes the financial and logistical arrangements, and the OPSO schedules it. Or the CO might request a training event requiring a live shoot, for which the OPSO schedules a "hot box." The OPSO sends schedules to the DESRON and on to the numbered fleet for approval. These schedules notionally cover a quarter at a time; they can be updated more frequently than once a quarter but should not require daily updates. LCSRON N3 has similar responsibilities but it does not always go to the level of detail that an aboard-ship OPSO would.

LCSRON staff acting in ship's crew capacity

We heard from various LCSRON personnel that this is not a typical shore duty. The current plan is for a contingent of LCSRON staff to go forward to the forward operating station (FOS) to support the ship. These staff members will certainly have a more arduous tour than most other shore tours. Not every position in the SSA should be considered sea duty. However, the Navy should review some of these positions to determine if any might have sufficient reason to be renamed as such.

In addition, several informal tasks and positions done aboard a traditional ship have now been moved to the SSA. For example, traditional ships have hundreds of informal counselors, but the LCS does not. Because the counselors are ashore, they mostly counsel before and after deployments. However, they do not have a lull in their year because, while one crew is deployed and mostly out of reach, two others are around. They spend a great deal of time in unscheduled one-on-one customer service and often accomplish their formal job at night or on the weekends.

Cultural problems and differing incentives

While conducting the interviews, we saw several instances of conflicting incentives, not just between the various commands within the SSA but also across other Navy components.

For instance, in our discussion with SWRMC personnel, they noted that OPNAV N43 is perplexed that LCS is so expensive to maintain. But they do not see the savings from the reduction in manning on the ship. That is, while realizing savings from the ship's manning, some of that work has been shifted into the maintenance portion of the SSA, which N43 must pay for.

We also saw an instance where LCSRON staff put two work orders in for the same broken part. One was listed as an O-level repair (which meant the LST was directly responsible for ordering the part and getting it to the ship), while the other was listed as an I-level repair. I-level repairs go through a slower maintenance paradigm, which includes working with many other stakeholders. We were not able to track down the exact cause, but personnel told us that the LCSRON has a habit of doing this to ensure that the part is ordered. This reflects some breakdown in trust and probably a tremendous amount of pressure on the LCSRON staff to ensure that the LCS program "works."

We believe that the root of this is a cultural and alignment problem about ownership. The crew feels that it owns the ship, and it feels the pressure to have it all fixed. But because it does not own the resources, this translates into them being somewhat didactic with the other stakeholders. As the ship and the LCSRON are most accountable for the ship, they tend to react more to ship issues, which creates a certain level of distrust for SWRMC.

Ideally, the ship should deliver its prioritization to LCSRON, and from there it should be delivered to SWRMC. SWRMC assumes that the list they get represents the CO's priorities, but then the ship CO comes to them himself and they learn this is not the case. The crew rotation doesn't help either. The MST meeting convenes on Tuesdays and Wednesdays. Tuesday is supposed to be a general planning meeting, while Wednesday is for screening and brokering new jobs. The two COs and the LCSRON use these meetings to de-conflict priorities, to the annoyance of SWRMC, and they try to add new jobs at the Tuesday meeting.

Summary

In the preceding exercise, we examined current practices on the LCS and compared them with those on a traditional ship. We also looked at issues that might surface because of the virtual teaming arrangement that the Navy has adopted for the LCS.

As we expected, the business processes for the LCS demonstrate much of the disadvantageous traits we saw in the literature on virtual teams:

- Communication problems as noted by the existence of many different stakeholders (LCSRON Readiness Management, LST, CO of the ship, SWRMC) stretched over various commands working on a maintenance action.
- Misalignment of SSA staff as noted by the possibility of various conflicts of interests.
- Coordination problems associated with many stakeholders. This is exacerbated because there are two hull types.
- Trust issues as shown by LCSRON's action of putting in the same order for a part creating some churn in de-conflicting the two orders. This is partially a function of a part supply chain that is currently thin (in some cases there is only one vendor who is foreign), and this causes consternation.

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Analysis of alternative organizational structures

The central question regarding LCS SSA is how it will be organized when there are dozens of LCS hulls and crews deploying around the world. Issues of organizational structure are not unique to LCS; they are ubiquitous, and many scholars and professionals have studied them. In this section, we outline some possible organizational constructs and discuss the advantages and disadvantages of each. The processes we discussed in the last section provide some context for these comparisons. We also discuss the achievable economies of scope and scale that could result from these organizational constructs.

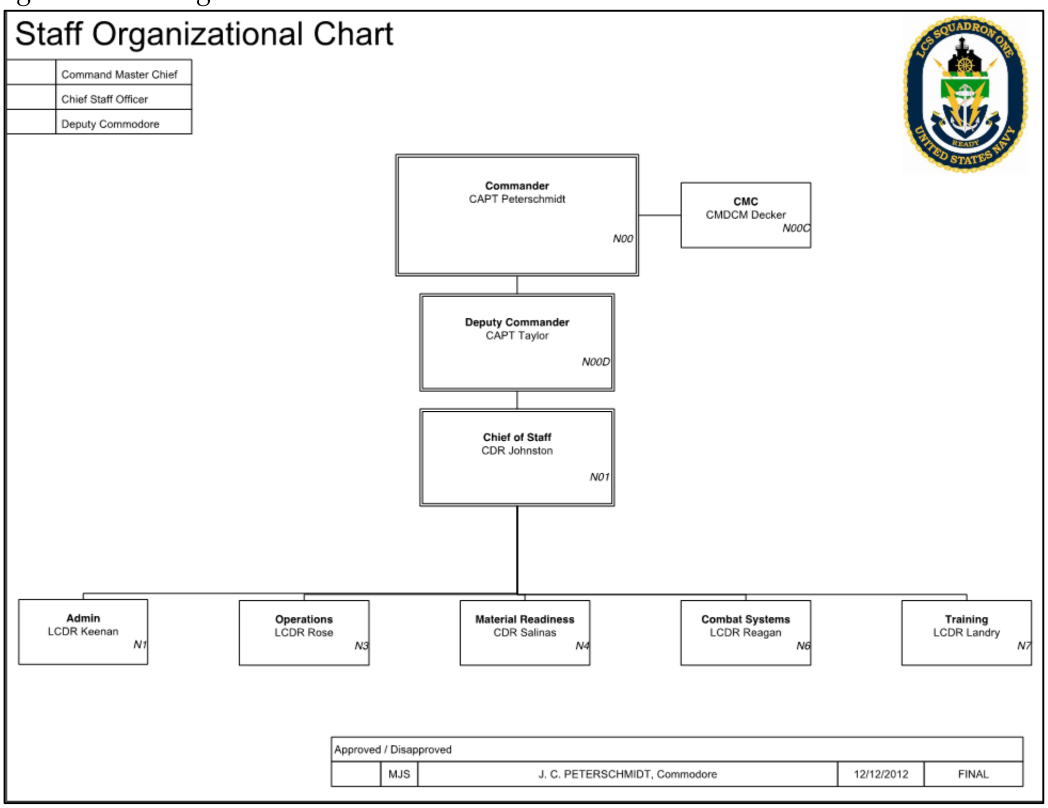
The Navy should expect to be able to sustain the LCS at less than the manning costs if it were designed as a traditional ship. Roughly speaking, the LCS would have a manning level close to three quarters of an FFG based on their relative displacements. That would yield a crew of about 160 personnel. LCS is currently manned at 73 personnel when we include the mission packages. Thus, if the Navy can support the ship with an SSA manning of less than 87 personnel (including contractors who will do some of the repairs), then the LCS will save the Navy money on manpower.

Current organization for the LCSRON

Figures 2 shows the current organizational chart for the LCSRON. We note that the LCSRON is not the only player in the SSA. But it is the biggest and plays the largest role, and the efforts of all other stakeholders will be coordinated through this command. Nevertheless, the point of this exercise is to create an organization that incorporates all players while attempting to achieve economies of scale and scope and taking into account unique SSA issues.

Note that the personnel supporting the ship directly are not separated from those responsible for ISIC duties. Also note that the command already has a functional structure similar to the rest of the Navy and that it uses the same N codes. In addition, the N code divisions are loosely aligned with how a ship is normally organized. That is, the executive department is composed of the commander, his or her deputy, the chief of staff, N1, and N7. The operations department is aligned with N3, the engineering department with N4, combat systems with N6, and supply with the LST (not shown on the LCSRON organizational chart). Under each of the N codes is another organizational structure that is functional (versus divisional or matrix) in design.

Figure 2. Staff organization chart



Possible organizational constructs for the SSA

Several questions need to be addressed in creating an overarching organization for the SSA. First, should the main stakeholders (LCSRON, MPSF, LST, and SWRMC) be co-located to avoid the issues associated with virtual teams? Second, given that the LCSRON is primarily responsible for the sustainment of LCS while simultaneously having an ISIC duty, how should it be organized? Third, how can the SSA structure be organized to create economies of scale and scope?

Co-location of LCSRON, LST, MPSF, and SWRMC

Currently, the four main stakeholders are responsible for the eight SSA functional areas described earlier. For simplicity, we bin these into the following four main groups:

1. Admin and manpower—includes career counseling, manpower, manning and administrative tasks, and training (primarily done by LCSRON N1 and N3).
2. Logistics—includes logistic support (primarily done by the LST with some support from the other three)
3. Maintenance—includes maintenance analysis and contractor tasks (primarily done by LCSRON N4, MPSF, and SWRMC)
4. Combat systems and ops—includes combat systems and C4I and requirements analysis (primarily done by LCSRON N3 and N6)

Each of the main stakeholders is located in its own office and has its own chain of command, although many personnel are dual hatted to the LCSRON commodore. The LCSRON is located at the Naval Station in San Diego as are the LST and SWRMC, which are both a 15-minute walk away. Even so, there is little ability for informal face-to-face communication. It is our understanding that efforts are coordinated via meetings with representatives.

MPSF is located about four hours away in Port Hueneme. They too have their own chain of command with some representatives in the LCSRON office spaces. Again, efforts are coordinated via meetings with the various representatives. But most of the MPSF staff is physically located in Port Hueneme and has little interaction with the rest of the stakeholders.

The question we address here is: What advantage is there to having these groups physically separate? In the case of MPSF, they require a large warehouse for the mission packages for maintenance, storage, and logistic services. There is no such structure in San Diego that could house the MPSF, and building one in San Diego would not be practical. Therefore, the current situation will have to suffice.

It is our understanding that, so far, the current situation is working fine and no major problems have occurred. However, there are very few actual mission packages and only a handful of crews and ships. So the actual workload is not near a future steady state. What the future has in store for the LCS community is an open question, and the community will have almost assuredly the same problems that every virtual team has. However, the advantage of geographic dispersion (i.e., a far cheaper warehouse facility) will likely outweigh any advantages of co-location.

SWRMC, which is its own command, supports the entire Navy fleet, not just LCS. Therefore, there is no feasible way to co-locate the entire LCSRON and SWRMC commands either, and this would not be in the best interest of the Navy. Furthermore, we understand that the current situation, while complicated and at times creating distrust, is improving.

We argue, however, that LCS is a much more complicated ship to manage than a traditional ship, and we envision at least some SWRMC personnel becoming totally dedicated to LCS support, especially as more ships come on line. Recall that, according to our interviews with SWRMC personnel, one LCS ship requires almost 2,000 jobs during an availability, including PMS and FM. A DDG, on the other hand, typically requires only 20 to 30 jobs. Coordinating this workload for upwards of 27 ships in various stages of deployment will be a tremendous task requiring careful coordination. Co-locating SWRMC personnel with the LCSRON will reduce the complications of virtual teams.

A similar situation exists with the LST, which is dual hatted to NAVSUP and LCSRON. Its offices are close to LCSRON, and the offices communicate well. But the same argument that we made for SWRMC applies. Currently things are going smoothly (although the issue of ordering parts is difficult because of the thin supply line), but as more ships become active, supporting them across all spectrums of maintenance and supply will require more coordination. Physically locating the LST with the LCSRON would facilitate this.

In sum, there is no apparent advantage to physical separation except that there is no office space in the LCSRON. The LCSRON building is fairly small and has only two stories. The cost of building a larger facility for them is unknown. Thus, we can make no clear assessment of whether the benefits of co-location outweigh the costs.

ISIC versus SSA roles

The SSA is organized principally via the LCSRON. For a variety of reasons, we believe that the line between ISIC personnel and SSA personnel should be bright and that many of the SSA billets should be considered sea duty.

First, as we mentioned, there are some cases in the current LCSRON organization where there appears to be a conflict of interest. By separating the two staffs, the line between the inspection personnel and the people working to support the ship is made much brighter and should reduce conflicts of interest.

Second, SSA personnel are extensions of the ship placed in a shore billet. Furthermore, as noted, the LCS has little manning redundancy and is very dependent on the SSA. Cutting an SSA billet will likely have a much larger effect on the day-to-day operational capability of LCS than a cut in ISIC staff. However, shore billets are more vulnerable to cuts than ship billets. If SSA personnel were clearly associated with the ships' crew, they would survive budget cuts, or, at the very least, the LCSRON and other stakeholders could clearly convey the risk of the proposed cuts.

Third, we believe that SSA duties will require full time personnel who understand the inner workings of the ships they support. Making SSA personnel responsible for SSA duties solely would allow for greater knowledge concentration and development of subject matter experts. Both a functional and divisional organization would benefit from personnel with deeper knowledge of the intricacies of LCS sustainment.

Basic organizational designs to consider

We believe there are two logical ways to organize a team for any function: align the team with hulls and crews or align the team with an FRP phase or geographic region. The hull/crew-centric approach would exploit the fact that two hulls are shared by three rotating crews. A team could support the hulls and the people who crew them, wherever they go. This paradigm would create a support team with a sense of ownership for the hulls and people. Its workload would be smoothed because, at any time, one ship would be deployed, one would be in homeport, and one crew would be in off-hull training. Almost certainly a portion of the support team would have to move to one of the forward operating stations (FOS) that would be set up for the LCS. However, this team would have less detailed knowledge of the western Pacific and Persian Gulf regions, the suppliers and technicians who service the ships there, and the operational commanders in the 7th and 5th Fleets.

Alternatively, an FRP/geography-centric approach would exploit specialization in the various processes and operations that the ships go through during their deployment cycles. Larger teams could be assigned to more support-intensive FRP phases, and smaller teams to less support-intensive phases. Teams could be located on site at FOSs in 7th Fleet and 5th Fleet and specialize in supporting ships deployed to those regions. However, these teams would have less knowledge of the hulls and crews that they support and no sense of ownership.

In theory, each of the four major functional area groups mentioned above (admin and manpower, maintenance, logistics, and combat systems and ops) could be organized separately. That is, one team that manages admin and manpower could be hull/crew-centric while logistics could be FRP/geography-centric. The decision to organize functions separately or jointly will depend in part on whether there are greater advantages to hull/crew-centric organization or to FRP/geography-centric organization. If one function benefits more from ownership of a hull, and another benefits more from geographic specialization, then it is probably not efficient to organize them jointly. If they both benefit from the same internal structure, then creating a cross-functional team around that structural concept may eliminate some redundancies and create synergy. However, it may also create some unnecessary communication, and unnecessarily increase the span of control for the team lead.

What is the potential for economies of scope and scale?

Economies of scope and scale are driven by the difference between “fixed costs” and “marginal costs.” A cost is “fixed” if it is independent of the quantity or variety of output, at least over a certain range. That is, the fixed portion of cost does not always increase as the scope or scale of activity increases. There are significant fixed costs to launching a class of ships. Best practices for operating and maintaining the ship must be learned, and training for these best practices must be developed. As the number of ships and the scope of operations that they accomplish increase, the average cost per ship falls because the fixed costs are spread across a wider base.

Eliminating mistakes and rework can have significant second- and third-order effects. Fuller (1985) [12] argues that complexity at work resulting from errors often takes up the majority of workers' time and effort. Mistakes external to an organization complicate time management and process flows, which in turn leads to more mistakes in the internal organization, and these further complicate time management and process flows leading to yet more errors and time spent correcting them. Experiments have shown dramatic improvements in worker efficiency resulting from improved quality and more streamlined processes. One case study in Hewlett-Packard's Computer Systems Division resulted in a reduction in man-hours of approximately 50 percent and a decrease in production cycle time from an average of 16.5 days to 12 hours.

Different organizational structures have different advantages and disadvantages for realizing economies of scope and scale. A hull/crew-centric approach emphasizes economies of scope: wherever the hull deploys and whatever operations it is tasked with, the same core team supports it, leveraging the team's detailed knowledge of the hull and crew. We expect this to confer greater efficiencies for readiness tasks and personnel/admin tasks than for logistics. Readiness is closely tied to detailed knowledge of the material condition of the hull, and admin is closely tied to knowledge of the crew. Logistics, meanwhile, is more closely tied to detailed knowledge of the geographic region.

The hull/crew-centric approach appears to have less potential for economies of scale. For every two ships, there must be an additional team, and there must be staff at each FOS in addition to the core teams located at home ports in the continental United States. Even in this case, however, there are still significant economies of scale to be realized for the LCS program as a whole, through more mature cost control mechanisms and a large team of technicians and suppliers who are familiar with these ship classes.

The FRP/geography-centric approach places a greater emphasis on economies of scale. With this approach, adding additional ships and crews does not require new teams of SSA staff and may not always require additional personnel for the teams already in place. However, inefficiencies may result from the shore staff's lack of ownership of any one hull.

There is also the possibility that some diseconomies of scale could arise. In a hull/crew scenario, multiple teams would report to one group command, and as the number of hulls increased, eventually there would be multiple groups reporting to some higher-level coordinator. The span of control for managers and the number of layers of management would increase. Larger span of control can mean greater fatigue and less attention to detail from managers, and additional layers of hierarchy could increase communication problems and leave central decision-makers disconnected from the "ground truth."

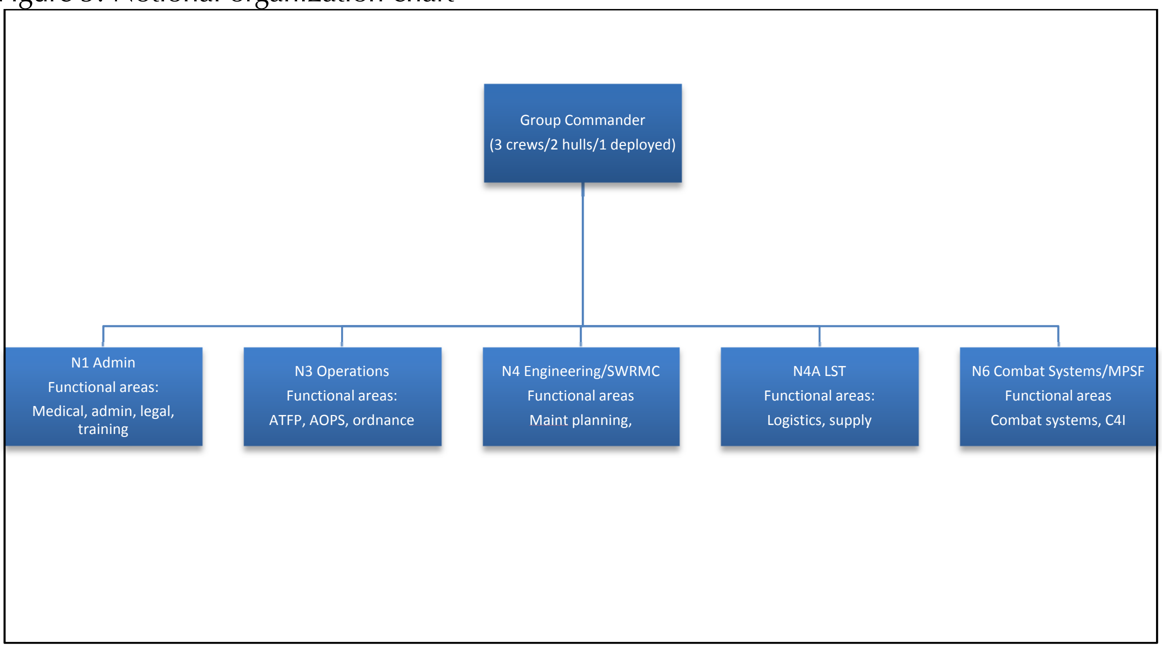
Alternatively, teams dedicated to specific FRP phases or geographic regions would either multiply (e.g., ships near Singapore are assigned to one of two teams for support) or grow large. If they were to grow large, span of control would increase significantly at the team level. If they were to multiply, span of control would increase at the squadron level (one squadron managing many teams) or an additional layer of hierarchy would be created.

Weighing the potential economies of scope and scale from alternative organizational constructs requires subject matter expertise, and even then it is to some extent a matter of conjecture. Below, we offer a notional organization chart for a hull/crew versus FRP/geographic alignment and summarize insights from stakeholders in the LCSRON, LST, program office, and TYCOM.

Hull/crew-centric

In this paradigm, one team that spans all of the main stakeholders would manage three crews, two hulls (one deployed and one in workups). Under this construct, one overarching group commander, reporting to the LCSRON commodore (not shown in figure 3) would manage all SSA personnel. He or she would be responsible for one 3/2/1 crew ship combination throughout its entire cycle from workup and training to deployment. The teams would be tailored to manage the workload associated with those crews and ships and some personnel would be part of a deployed team that would sustain the deployed ship at the FOS. The resources outside the LCSRON, such as LST, MPSF, and SWRMC personnel, would report to the group commander. Those personnel would also be dual hatted to their home command.

Figure 3. Notional organization chart



If we assume that each LCSRON command would be responsible for half the LCS fleet, then there would be 13 group commands. All would report to the LCSRON commodore and would be totally separate from the ISIC staff who would retain the organizational structure shown in figure 3. Given that the LCS CONOP is still immature and that it has been rewritten several times, we hesitate to estimate the number of personnel required for each functional area.

There are many advantages to this construct. It is somewhat flexible in that personnel in each N code would be able to manage issues related to more than one ship. It also achieves some economies of scale and allows for deep knowledge of the ship and crew as well as enabling a sense of hull/crew ownership among the SSA staff. This is important because COs want that type of knowledge onboard and would feel more comfortable with shore personnel who, in a sense, are part of the crew. We stress that many of these personnel, especially those moving to the FOS to support the ship, should be considered to be on sea duty. We also believe that having these personnel report to a central group commander would align incentives, build a stronger sense of trust, and reduce communication problems. To the greatest extent possible, these personnel should also be co-located so as to enable informal discussions, which are vital to ship operations.

The disadvantage is that the construct is not very flexible because the personnel in the construct are subject matter experts on their hulls only. Right now, this is not a problem as the hulls in inventory are the same (i.e., LCS 1 is equivalent to LCS 3). But, like all Navy surface combatants, modifications and new equipment will mean that each ship will be somewhat different from the other. Under these conditions, if SSA personnel move to another group commander, some institutional knowledge will be lost in their previous group and some must be learned for their new group. This is a manageable problem as the Navy often moves personnel across ships.

FRP/geography-centric

LCS ships will go through a training/workup cycle just like any other surface combatant. The cycle will begin with an off-hull crew training in a classroom while another crew is on a ship training to get certification to deploy. While these two crews are in training, a third crew will be on a forward deployed ship. Each part of the cycle will last about four and a half months.

At each stage, the sustainment requirements will be different. For example, the off-hull crews will not need any maintenance or logistics support as they will be ashore in a classroom. The training crew will require more sustainment support as they will be on a ship and spending some time at sea. Their sustainment support requirements will include logistics, combat systems support, and maintenance. Compared with deployed ships, support will be somewhat easier for training ships because they will not be far from their homeport and they do not stay out to sea for lengthy periods. Sustainment will be more complex for the deployed ship as they will need similar services but in foreign countries.

Under these circumstances, we envision three types of group commanders. One type of commander would be responsible for off-hull crews. As the level of service at this stage is mostly training, manpower, and administrative, one group commander could probably manage several off-hull crews with only an N1 set of personnel. Type two and three commanders would have an N code organization such as the one shown in Figure yyy, but they would only be responsible for ships that are either in training or deployed. Thus, as a crew progresses from off-hull training to on-hull training, they would transfer from the type one commander to a type-two commander who provides them with a larger set of sustainment services. Eventually, the crew will fly out and take control of the deployed ship via sea swap or they will sail the training ship out to the deployed AOR and take over for the deployed ship. The deployed ship will sail home for maintenance availability. When this happens, that ship will be sustained by a type three commander.

This construct is very flexible and can be uniquely tailored to manage the issues related to crews and hulls in various stages of FRP. In addition, it is likely that each group commander will become a subject matter expert in a certain geographic area. For example, type two commanders will support only ships close to homeport. So they will understand the services available in that area. Type three commanders could be aligned geographically. So, for example, all LCS ships in the 7th Fleet would fall under a certain type three commander who would understand sustainment services for that area.

This structure has one important disadvantage. Namely, ship expertise will be almost non-existent. As the crew and ship move in and out of an FRP cycle, the same people will not support them.

Recommendation

Based on our understanding of ship operations and the importance and nature of communications and coordination of effort, we believe that a crew/hull-centric organization, separated from the ISIC staff at the LCSRON, would be the best choice. However, our understanding of LCS ship operations is evolving as the Navy has not had much experience with the ship yet. Nonetheless, the benefits of SSA personnel who are more connected to the ship are likely to be large, especially if each LCSRON manages only one hull type. Ship and crew expertise will move with the ship across entire FRP cycles leading to better communication, better coordination of effort, increased trust across the SSA players, and more successful deployments.

A side note on this study

We began this study with the understanding that the major portion of work in SSA is related to maintenance and logistics. This was because we had already done several studies, which focused on those two areas. However, as we progressed, we began to understand that SSA includes a much larger set of functions and tasks, such as training (done by a TRAINO aboard a traditional ship), legal, and administrative duties. Thus, this study addresses the optimal organizational structures for these work areas as well.

Even so, maintenance is still the area of biggest concern because a large amount of daily activity related to the long-term material readiness of the ship has been pushed ashore. This is a different paradigm for the Navy surface combat community.

While working on this report, we became concerned that the maintenance CONOP for LCS is sufficiently different from the traditional baseline that no matter how efficiently SSA work is organized, there is a significant probability that LCS will never experience the same level of readiness as traditional ships. This is because O-level maintenance done aboard the ship by the ship's crew is executed quickly relative to either I-level or D-level repairs, which require more planning and that the ship to be in port while the repairs are done. Thus, by pushing such a large portion of maintenance out of the O-level category and into I- and D-level, there is likely going to be longer intervals between when a maintenance request is opened and when it is closed. This will lead to degradation in material readiness.

The following simple queuing model offers some insights into what the Navy might expect for LCS given its new maintenance CONOPS.

Assume that a hypothetical ship with a certain O-level capability experiences the following arrival rates for repairs:

λ_O = the rate at which a repair request arrives that can be done at the O-level

λ_I = the rate at which a repair request arrives that must be done at the I-level

λ_D = the rate at which a repair request arrives that must be done at the D-level

Now assume that we have service rates, μ for O-, I-, and D-level repairs such that $\mu_O > \mu_I > \mu_D$. This means that it is faster to execute a repair at the O-level than it is at the I- or D-level. In reality, this is usually true since, if the repair is O-level, the ship has the parts, labor, and skills required to perform the repair. I-level repairs take longer as they require some technical assistance, usually coordinated by the Regional Maintenance Centers (RMC). D-level repairs must wait until the ship pulls into a depot facility. Thus, they take the longest.

Queues such as the one described above have certain performance metrics that are used to describe how well a process is working. For our simple exercise, we examine only the average amount of time a repair spends in the queue.

To demonstrate the effect of moving a great amount of repairs from O level to I- and D-level, we populate the simple model as follows.[2] Assume that the typical patrol time for a ship is 25 days. During those 25 days, the ship's crew will address various O-level repairs. I-level repairs will wait until the ship returns to a port on the 25th day. The window of repair opportunity for I-level repairs is five days. We further assume that the ship enters into a D-level repair facility after four, 25-day deployments. Thus, the time between D-level repair opportunities is 115 days. Each D-level window of opportunity is 15 days. Now assume that the ship experiences one failure per hour of which a certain portion are O-level, a certain portion are I-level, and a certain portion are D level.

If 75 percent of all failures are considered O-level because of the robust maintenance capability aboard the ship, then the O-level arrival rate λ_O is equal to .75 x 24 failures = 18. Assuming the other six failures are evenly split across the I- and D-level, then $\lambda_I = \lambda_D = 3$. Thus,

[2] Note that the metrics used in this section are descriptive only and are not based on real data for Navy ships.

after 25 days at sea, the I-level queue will be 25 x 3 failures = 75. After 115 days between D-level repairs, the queue for D-level repairs will be 115 x 3 failures = 345.

During the five-day, I-level repair availability, maintenance personnel must complete the 75 repairs already in the pipeline as well as three new repairs per day over the period. That equals a total of 90 repairs. To complete all repairs and leave no backlog, a service rate, μ_I, of 18 repairs per day is required. Anything less will yield a backlog that will lead to a long list of broken systems. Similarly, the required D-level service rate, μ_D equals 26.

Table 4 shows the required service rates for I- and D-level as more maintenance is moved from ship to shore. Note that the required service rates increase at the same rate that we move work into their area. For example, a doubling of the I-level arrival rate requires a doubling of the service rate to keep up.

Table 4. Required service rates

λ_O	λ_I	λ_D	Required μ_I	Required μ_D
18	**3**	**3**	**18.0**	**26.0**
16	**4**	**4**	**24.0**	**34.7**
14	**5**	**5**	**30.0**	**43.3**
12	**6**	**6**	**36.0**	**52.0**

However, discussions with SWRMC representatives suggest that the service rate for I- and D-level repairs exhibits decreasing returns to scale. That is, doubling labor resources yields an increase in the service rate of less than double. A variety of factors contribute to this, including the sequencing of repairs (i.e., problem A needs to be fixed before problem B), the necessity for the ship's crew to inspect the repair, and the time to tag out a system prior to beginning a repair.

We return to our performance metric, W, to determine how the material readiness of our imaginary ship will be affected by a change in maintenance paradigms. Table 5 shows the average time a repair in O, I-, and D-level spends in the system. The last column is a weighted average of the three. Note that as we push more repairs into the I and D level, the average time for all repairs increases significantly, even if the service rate is adjusted to compensate for the increased workload, as shown in table 4.

Table 5. Performance characteristics

λ_O	λ_I	λ_D	W_O	W_I	W_D	W_{Tot}
18	**3**	**3**	**0.114**	**12.5**	**57.5**	**8.8**
16	**4**	**4**	**0.095**	**12.5**	**57.5**	**11.8**
14	**5**	**5**	**0.080**	**12.5**	**57.5**	**14.6**
12	**6**	**6**	**0.069**	**12.5**	**57.5**	**17.5**

Table 5 demonstrates the problem of moving O-level repairs to I- and D-level. Basically, a time wedge has been incorporated into the repair system, requiring longer wait times before repair. The ship, then, will always spend more time with more broken parts. The size of this effect is a function of the arrival and service times, as well as of the variance in service times.

The bottom line is that no matter how well organized the SSA is or how good the support systems are, the paradigm itself will likely never achieve the same level of material readiness as that achieved on a traditional ship. In fact, we believe that this change in the material readiness steady state is currently taking place. According to personnel at SWRMC, a DDG undergoes 20 or 30 jobs during a two or three week CMAV. An LCS is undergoes up 2,000 jobs in a two-week CMAV, counting all the PM and FM jobs.

Glossary

AOR	Area of responsibility
ATG	Afloat training group
AWN	Automated work notification
BCU	Bridge control unit
CMAV	Continuous Maintenance availability
FM	Facility maintenance
FOS	Forward operating station
FRP	Fleet response plan
ISIC	Immediate superior in command
LCS	Littoral Combat Ship
LST	Logistic support team
MLO	Mission liaison officer
MO	Maintenance officer
MPSF	Mission package support facility
MST	Maintenance support team
MTF	Mission task function
OMMS-NG	Organizational-maintenance management system-next generation
PE	Port engineer
PM	Preventive maintenance
RMAIS	Regional maintenance automated information system
RMC	Regional maintenance center
ROC/POE	Required operational capability/Projected operational environment
SSA	Sustainment support ashore
T2C	Train to certify
T2Q	Train to qualify

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List of figures

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List of tables

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