Modularity, the Littoral Combat Ship and the Future of The United States Navy

Executive Summary

The U.S. Navy is engaged in a far-reaching transformation based on the exploitation of information technologies. At the heart of this transformation is the concept of networking the force. This involves, first, connecting all the platforms and major systems deployed by the U.S. Sea Services — ships, submarines, aircraft, unmanned vehicles and Marine Corps units — as well as joint forces so they can share information, establish maritime domain awareness and create a common operating picture (COP). The establishment of a COP is critical to the operation of joint and combined forces. Once interconnected, commanders can exploit the power inherent in a large pool of distributed platforms and systems through innovative operational approaches.

One program that seeks to exploit the revolution in networking as well as new possibilities in the design of naval ships is the Littoral Combat Ship (LCS). It is designed to address critical capability gaps resulting from the rise of asymmetric threats such as quiet diesel submarines, small boats and shallow water mines. It will be a low cost, highly flexible, fully networked ship.

A key feature of the LCS is its modular design. Like a set of children's building blocks, a modular ship consists of one of two basic hulls or sea frames and common ship systems, a range of mission modules and a common information system with standard interfaces. In principle, modules are interchangeable in a "plug-and-play" format. Modularity, once demonstrated by the LCS, could be the basis for major changes in the design of warships. Modularity also will help address the possibility of rapid mission evolution from Phase I to IV and even beyond. Most important of all, the LCS will help to enable a netted, distributed warfighting architecture that, in turn, will revolutionize naval, joint and coalition operations.

The LCS reflects the ongoing revolutions in technology, systems integration, knowledge development, organizational structures and management. It is a system-of-systems at multiple levels. Most simply, each of the planned mission modules will bring a self-contained, mission-specific capability to the LCS. These modules will be integrated with the basic LCS hull and its common systems. In order to achieve mission effectiveness, LCS platforms will be connected with one another, other fleet units and joint assets through a robust network.

The LCS program has made tremendous progress in a few short years. It has demonstrated innovation in the design and construction of two very different sea frames. It is completing the construction of the first three mission modules. When successfully completed, the LCS program will prove the value of standard interfaces, open architectures and an open business process. It is beginning already to change how the Navy mans its ships, trains its personnel and sustains its forces.

Representative Ander Crenshaw
Member, House Appropriations Committee

Modularity, The Littoral Combat Ship and the Future of the United States Navy

The concept of a transformed military, one based on the exploitation of advances in information technologies, has been a driving force behind U.S. force planning and weapons acquisition for nearly two decades. The power of information technologies to transform has been evident for some time now in the commercial and civil spheres. These same technologies are beginning to have a transformative impact on military affairs. Increases in computing power, provision of ever greater communications bandwidth, near ubiquitous access, miniaturization of electronics and advances in software engineering have radically altered the ways products are designed and produced, business is conducted, knowledge is acquired and exploited, and people communicate and collaborate. Increasingly, developments in information technologies will center on improving the ability to be networked. Entire sectors of the American and global economies have been completely altered under the impact of these new technologies. It is access to information and, perhaps even more importantly, to the network that is vital in the success of modern corporations.

Historically, transformations begin by applying new technologies to existing military organizations and platforms. This results in an improvement in force effectiveness even with relatively little change in organization and operations. The second stage of a transformation involves altering organizations to take greater advantage of the opportunities technology provides at the tactical level. The third stage sees the creation of new weapons systems designed around emerging technologies. Finally, the impact of transformation transcends the battlefield, changing the way military operations are planned and directed, and how strategies are developed. As the process of transformation progresses, changes in organizations and operations create demands for even more advanced capabilities and systems that are fed back into the development of technologies. A parallel transformation often occurs in the production capabilities required to support transformational technologies and systems.

Early applications of information technologies and networking in military capabilities have clearly demonstrated the power of this revolution. In

Operations Enduring Freedom and Iraqi Freedom, the combination of the GPS-guided Joint Direct Attack Munition and networking based on Link-16 enabled air platforms to exploit precision targeting in support of ground operations in heretofore unimaginable ways. Similarly, operations in Iraq demonstrated the value of real-time networking of ground forces by means of systems such as the Blue Force Tracker. The U.S. Navy is seeking to capitalize on the power of information and networks in its Naval Integrated Fire Control-Counter Air (NIFC-CA) concept. Exploiting improvements in sensors, computer processing, networking and data fusion, NIFC-CA will enable a distributed force of mature aerial and seagoing platforms such the E2-C, F/A-18, Aegis cruiser and destroyer and CVN, as well as joint assets (Patriot, the Theater High-Altitude Area Defense and F-15/F-22) to undertake cooperative and coordinated operations.

It is only in the past few years that military programs have been initiated that are transformational from their inception. These new programs seek not merely to apply information technology to established systems and processes, but to take greater advantage of the power of information technologies and of networking in systems design, integration and operation. Such programs exploit the demonstrated revolutionary potential inherent in the information revolution at all levels, from design and production to organization, tactics and operational concepts. While these acquisition programs may differ significantly in form, based on Service requirements, they reflect a powerful common truth: that in the future, success in all endeavors — military, industrial, commercial or social — will be a function of the ability to be part of the network.

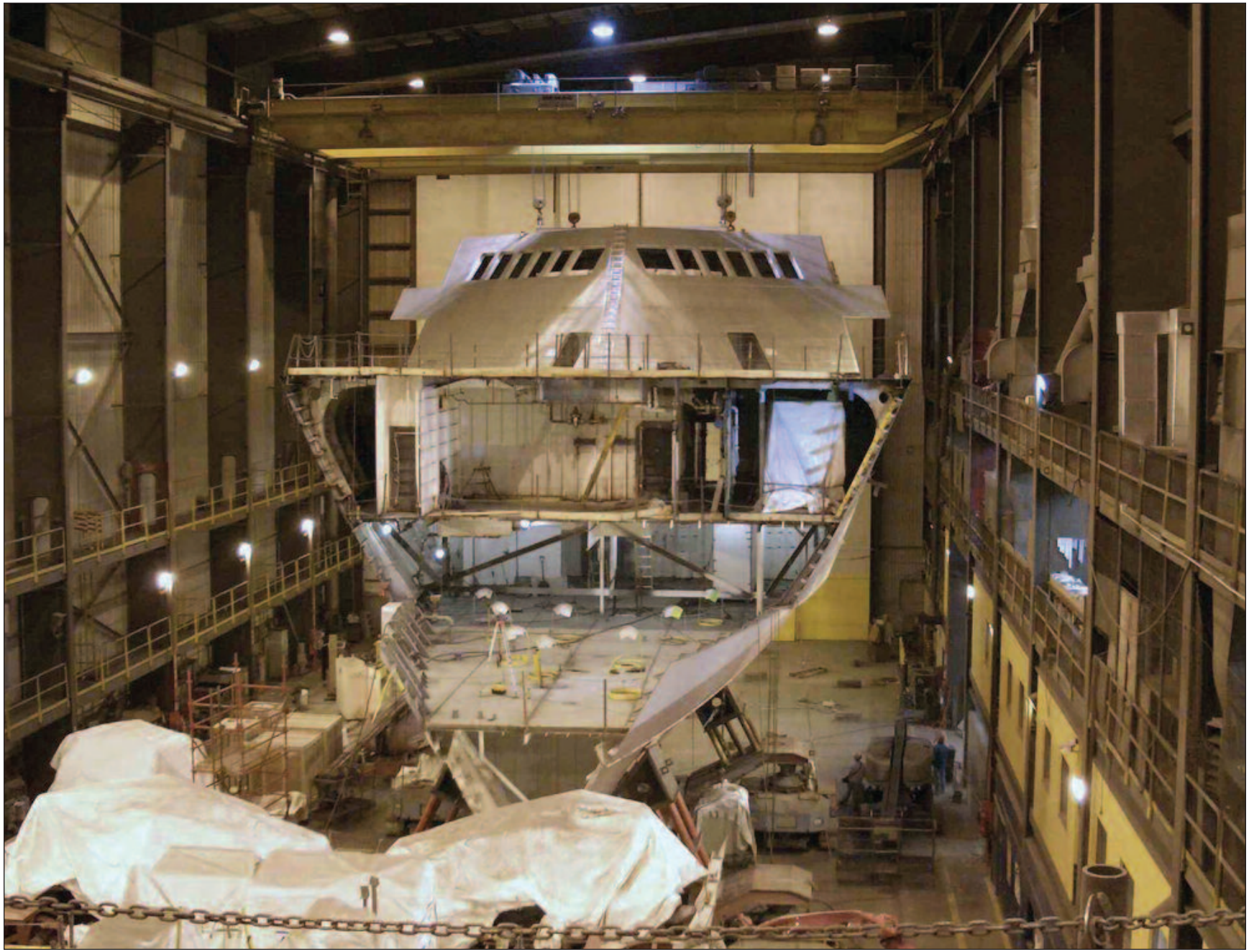
One such program is the Littoral Combat Ship (LCS). At virtually all levels, the LCS reflects the ongoing revolutions in technology, systems integration, knowledge development, organizational structures and management. The LCS is truly a system-of-systems at multiple levels. Most simply, each of the planned mission modules will bring a self-contained, mission-specific capability to the LCS. At another level, these modules will be integrated with the basic LCS hull and its common systems. Because the operational concept for LCS involves swapping mission payloads to meet tactical needs, a system-of-systems approach is necessary for both technical support and logistics.

Designed to address critical capability gaps resulting from new, globally present and often asymmetric threats, the LCS holds out the potential for a major step forward in the transformation of the U.S. Navy. The LCS program may also result in a redefinition of systems integration as both an engineering discipline and an operational concept. Modularity, once demonstrated by the LCS, could be the basis for the design of entirely new classes of warships. Modularity also will help to address the challenges posed by rapid mission evolution from Phase I through Phase IV. Most important of all, the LCS will be part of a netted, distributed warfighting architecture that could revolutionize naval and joint operations.

The Changing Security Environment

The LCS is not merely the product of a revolution in technology. It also responds to the dominant trends in a rapidly changing security environment, as well as to budgetary realities. One such trend is uncertainty about future threats. The threat spectrum is becoming broader, more complex and less predictable. At one end of this spectrum is the potential of nation states to develop robust asymmetric capabilities designed specifically to challenge areas of U.S. military advantage. Increasingly, such threats involve the use of advanced technologies, many of which are commercially available. Many asymmetric threats are the result of efforts by adversaries to exploit what few options they possess in attempting to counter U.S. military advantages. These include force proliferation — particularly of relatively cheap weapons such as sea mines, cruise missiles and small boats — the use of complex environments, tactics based on rapid mobility and mass (swarming) and operations in sanctuaries.

At the other end of the spectrum are the many disasters — some natural, and others caused by the hand of Man — which require emergency response, consequence management, and stabilization activities. Once considered to be a lesser-included case of the capability to conduct major combat operations, the 2005 Quadrennial Defense Review has elevated these missions to a level equal to those involving major combat.



Between these two poles exists a range of both traditional and new challenges and problems. Although large scale conventional conflict is considered less likely in the near future than it was in decades past, confrontations with hostile nations cannot be totally excluded. Perhaps the most stressing new challenge is that posed by international terrorist organizations that strive to use the opportunities created by globalization and the information revolution to conduct their violent and illegal activities. These groups could, on occasion, pose a serious asymmetric challenge to U.S. forces. The recent conflict between Israel and Hezbollah foreshadows such a possibility. Another growing problem is the activities of international criminal cartels. A third is the ongoing migration of millions seeking to escape danger or in search of improved opportunities. Yet another new challenge is the need to assist in preventing threats to the homeland and, in the event prevention fails, to assist in managing the consequences of a successful terrorist attack.

Recent events have demonstrated how widespread, complex and varied are the challenges confronting the U.S. military. Within a given operation, forces are finding themselves required to switch rapidly from forced entry and major combat operations to stability operations and humanitarian assistance missions. Repeatedly in recent years, deployed forces have experienced the need to transition from operations in support of the Global War on Terror in order to respond to an urgent humanitarian crisis. Rapid and unpredictable mission evolution is likely to become a normal part of future contingency operations.

The growth in the demand for military forces has been evident for more than a decade. As threats have evolved and missions have expanded, and the size of the U.S. Navy has shrunk by half, the necessity to spread scarce military resources further has also grown. U.S. forces are spread around the world, doing many things. In order to remain effective — and to counter potential asymmetric threats — distributed operations must be the centerpiece of any future concept of operations.

The evolving security environment accentuates the need to operate with friends and allies. The current Chief of Naval Operations, Admiral Michael Mullen, has spoken about the 1,000-ship navy. "It's a thousand ships of like-minded nations working together to get at the emerging challenges of weapons of mass destruction, terrorists, drugs, weapons, pirates, human trafficking and immigration."[1] Working with the fleets of dozens of partner nations will require an unprecedented degree of cooperation and flexibility for forces that will be inherently distributed. Such a capability can only be achieved with the networking of both U.S. and foreign forces.

Uncertainty about future threats and the proliferation of mission requirements has created an increased demand for timely and accurate situational awareness. For naval forces this means a need for comprehensive Maritime Domain Awareness (MDA), including Global Maritime Intelligence Integration and the translation of situational awareness into a common operating picture for distributed and joint forces. Without comprehensive MDA, distributed forces cannot be employed effectively. Nor will U.S. forces be able to operate easily or safely with the many friendly forces that will make up the 1,000-ship navy. Moreover, MDA is central to the ability of naval forces to respond rapidly to changing mission requirements.

If a solution exists to the challenge of addressing an uncertain threat and expanding mission requirements with a numerically constrained force it will be found in the space created by the intersection of three critical capabilities: exquisite situational awareness, highly distributed capabilities and extremely flexible forces and platforms.

What is Modularity and Why is It Important?

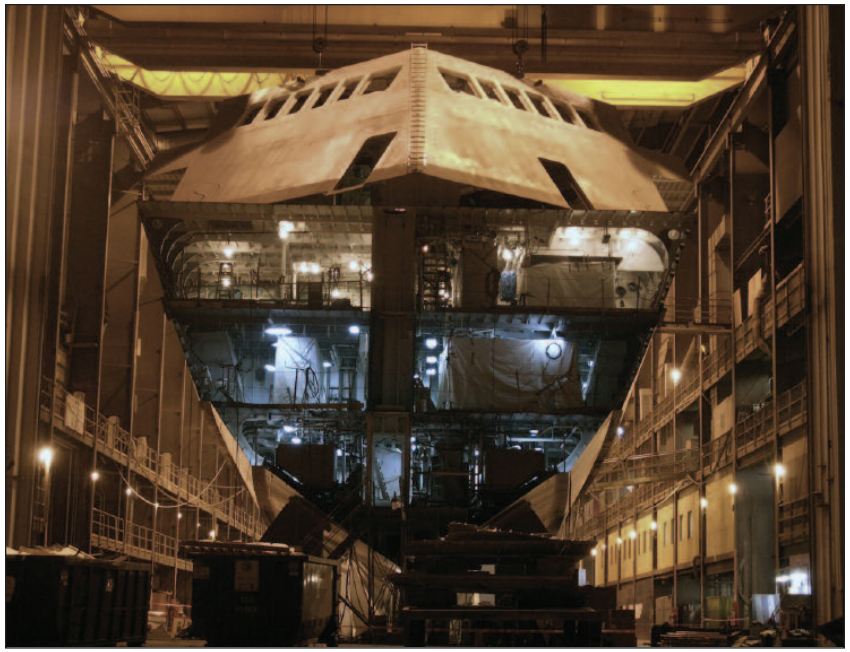
Simply put, modularity means the creation of interchangeable components or parts of a complex system linked together to perform desired tasks or missions through a set of common standards and interfaces. The popular image is of the children's toy known as Legos, a set of blocks and components of different shapes and sizes that the builder can link together by means of a common interface to make complex objects. The Naval Research Advisory Committee has defined four classes of modularity: capability swapping modularity (mission-package modularity), component sharing modularity, bus modularity, and construction/design modularity.[2]

Modularity also involves new business models reflecting the revolutionary impacts of this approach on the commercial world. An example of modularity that has transformed global business is the standard 20-foot cargo container. A wide variety of semi-tractors with standard interfaces can haul virtually any container. These containers can be carried by rail, ships and even aircraft. Another example of modularity is Toyota's flexible production line. Based on a set of common major components and computer based tools, it is possible for an individual to design a personalized variant of a wide range of Toyota models.

The commercial world is also marked by the rapid introduction of advanced capabilities. The Defense Department, by comparison, is often years behind the commercial world in its deployment of new technologies. Modularity holds forth the potential to dramatically shrink the gap between the military and commercial worlds. An inherent part of the concept of modularity is pre-planned technology spirals intended to introduce advanced technologies into existing modules on a regular (probably two year) cycle.

Modularity is not a new concept. It is especially not new to the U.S. military's design, development and acquisition of platforms or weapons systems. Capability-swapping or mission-package modularity allows for a specific module to be replaced with one of a different type. It is a common form of modularity that is present throughout the Armed Forces. The most successful example of capability swapping modularity is the Danish STANFLEX concept, now over 20 years old and present in four classes of ships. The STANFLEX system deploys a set of rapidly exchangeable, mission-oriented containers deployed into common spaces. These containers are integrated through a data bus. Among the mission-oriented containers available for Danish warships are those for counter-air, surface warfare, mine countermeasures, Anti-Submarine Warfare (ASW), sigint/elint, oceanographic research and pollution abatement. With some 90 containers deployable on more than 20 ships, the Danish system creates a multiplier effect that increases the effective size of the Danish fleet several fold.[3]

There are examples of container swapping in the U.S. military. Successes include the Black Hawk helicopter which on base can be refitted with wings



and external fuel tanks to perform a forward refueling mission (known as a Wet Hawk) or it can be fitted with packages to act as a command and control hub. The employment of ISR and targeting pods allows large numbers of U.S. aircraft of all Services to be rapidly reconfigured between air-to-air, intelligence and strike missions.

Common frame/hull modularity uses the same basic design chassis or hull which is then refitted with different mission packages through weapons systems, software or command and control suites. The most beneficial aspect of this modularity is to leverage economies of scale when developing the frame. One example of this type of modularity is the E-2D Hawkeye, a planned upgrade of the venerable E-2 family that includes the introduction of a large number of new mission systems including powerful commercial-off-the-shelf (COTS)-based computer workstations. A non-naval example of modularity is the HMMWV (popularly known as the Humvee) which can be fitted out to be a TOW missile carrier, an ambulance, or an electronic warfare suite. The Stryker armored vehicle program provides ten different mission packages on essentially two basic hull forms. The Army is presently looking to leverage commonality in development of the Family of Medium Tactical Vehicles. U.S. strategic bombers have been reconfigured to accept a wide variety of conventional ordnance.

The use of specific sub-systems, components and power plants for different systems or different platforms represents the class of component-sharing modularity. The Active Electronically Scanned Array (AESA) APG-79 Radar program for both the F-22 and F-35 fighters is an example of component sharing. Other successful applications of component modularity include the Vertical Launch System, which can accommodate a variety of weapons, and the Navy's LM 2500 gas turbine engine.

To be successful, modularity relies on three things: standard interfaces, configuration management and an open business model. Standard interfaces are critical in order to ensure that models and shipboard systems can operate seamlessly once inserted into a ship. Configuration management is extremely important not only to ensure connectivity among systems and components but also to support rapid technology refresh. Many discussions of modularity focus on open architectures; what is more important is the role of standard interfaces in creating an open business model. Such a model rejects proprietary systems in favor of best value products and the extensive use of COTS, and the opportunity to exploit the capabilities of U.S. industry and technology. The effort to convert the Aegis air defense system from a closed to an open architecture has created the opportunity to increase technology insertions and lower costs through such an open business model. The LCS program has been based on both an open architecture and on an open business model from its inception.

Modularity is a valuable new way of designing and acquiring weapons systems and platforms. The benefits of "going modular" range from ease of technology refresh to decreased total ownership cost and increased readiness on the battlefield. A modular approach to systems engineering requires open architectures which, in turn, necessitate an open business model. This new business model rejects proprietary software and interfaces. As a result, module and ship designers can leverage COTS technologies and the industrial base thereby increasing competition, promoting standardization of components, mission-packages and common frames. Lastly, modularity allows the

warfighter to be prepared for however the battlefield unfolds and to rapidly reconfigure forces to ensure the optimum combination of assets with which to pursue high priority missions.

Modularity and the Littoral Combat Ship

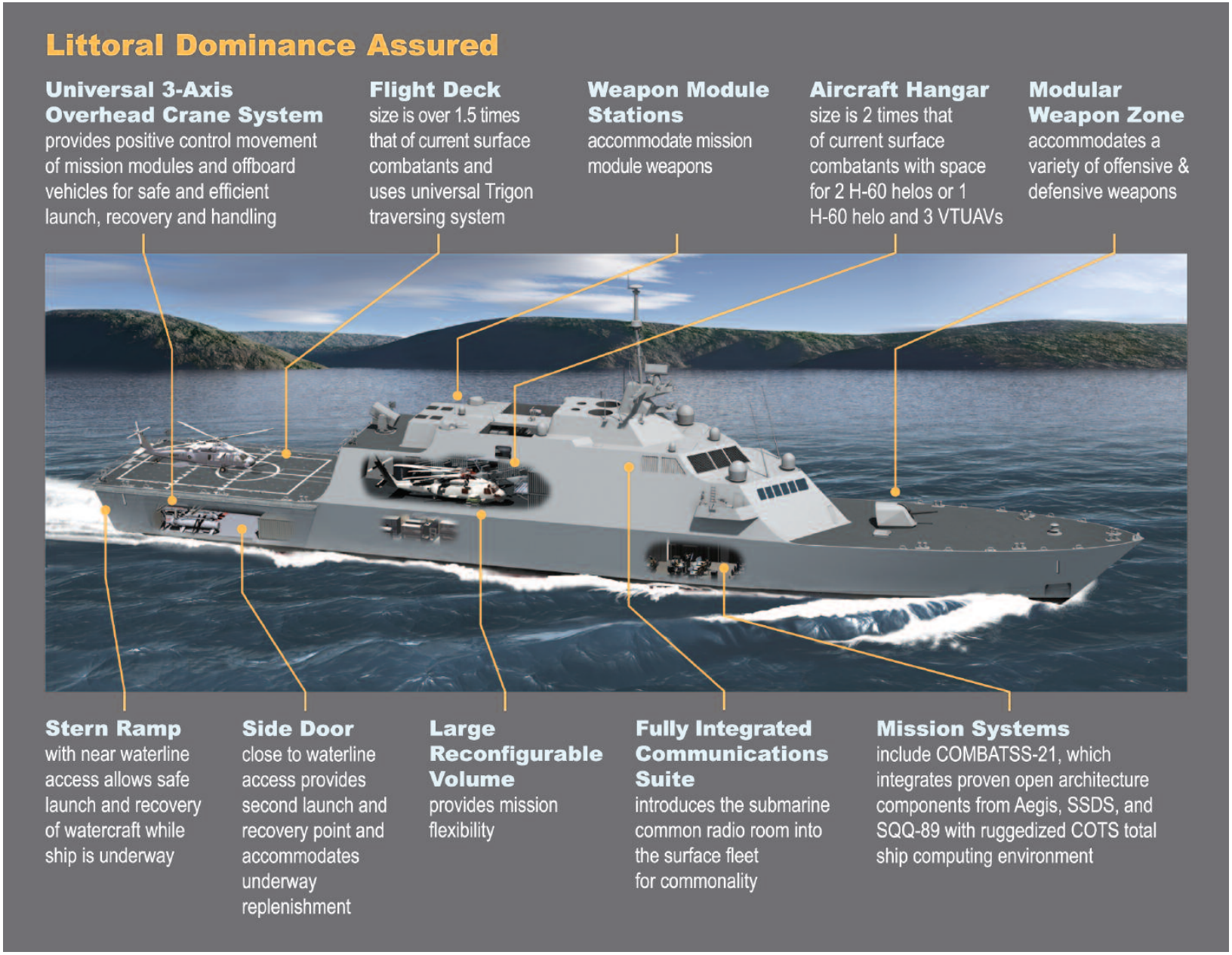
The LCS is intended to address a number of critical national needs and Navy requirements. Foremost among these is that of warfighting in the littorals. That is why the LCS is designed to be fast, maneuverable and able to operate in shallow waters. It is intended to be part of a distributed set of networked platforms, employing organic and distributed sensor and communications nodes to create a fully networked battle force.

The second critical national need is for capabilities that address a range of asymmetric threats. Few, if any, prospective adversaries or threats are expected to challenge the blue water capabilities of the U.S. Navy. However, in littoral waters, close to their homelands and to sanctuary basing, potential opponents can hope to negate U.S. advantages and deny U.S. forces access to close-in waters. Hence, the first LCS mission modules are intended to address the challenges posed by mines, diesel submarines and small, fast surface craft.

Third is the need for a modular open architecture that will allow different modules to be employed on a single hull in a "plug-and-play" format. This approach will also allow for a process of continual technology refresh without the costly teardown and rebuilding necessary for current war craft. The modular open architecture will take advantage of the strengths of the U.S. and global high technology sectors in the design, production and integration of system-of-system capabilities. The value of this approach to the Navy is tremendous:

> Because technology has changed so quickly in the course of the past 10-12 years, the combat system on many surface ships is outdated and no longer able to meet threats or projected threats. Now you are stuck with a hardwired combat system that you now have to upgrade at tremendous expense and, oh by the way, you've now taken that ship out

LCS Variant built by Lockheed Martin Team



> of the fleet for up to a year while you are ripping stuff out and putting it back in. The beauty of LCS is that you are not linked to that tyranny anymore.[4]

Fourth, the LCS program is one element in the U.S. Navy's effort to create a distributed and networked force. The LCS is designed around the idea of distributed operations at multiple levels. The most basic level involves the deployment of unmanned air, surface and underwater vehicles with each LCS. Another level is that of a squadron of LCSs employing a mix of unmanned platforms. The next level is the contribution of LCS to operations by the U.S. Navy's full array of platforms. The ultimate level is that in which the entire joint force operates in an integrated fashion, relying on the full power of networks. The LCS can act as a naval and joint force multiplier, supporting highly flexible and responsive operations at sea, extending the range, reach and vision of U.S. forces. In addition, once fully tested and integrated in the Fleet, the LCS could serve as a model for the design of other fleet components.

Finally, the LCS program is the first step in a Navy-wide effort to change the ways in which it thinks about aggregating capabilities in order to ensure the ability to perform a given mission. In a world of purpose-built platforms, naval planners must make educated guesses about the relative importance of and difficulty in performing various missions many decades in the future. Any misstep will be extremely costly in terms of both resource expenditures and, potentially, mission success. Modularity and networking provide a basis for mitigating both cost and risk. Modularity will reduce the need for purpose-built platforms. The Danish STANFLEX program has already demonstrated the real world value of modularity. It also could reduce the problem of exploding critical performance parameters experienced by many acquisition programs.

The basic design concept for the LCS is now well documented. The LCS consists of a basic hull or "sea frame" which will house essential ship functions, basic sensor and communications packages and the space for the mission modules. The design of a common hull and basic systems will allow economies of scale in production, thereby helping to hold down unit costs. Standard interfaces and connectors will allow any module to be mated with each of the sea frames.

Each LCS will carry transferable modules designed to perform a specific mission. The three initial types of mission modules are Mine Warfare, Antisubmarine Warfare and Antisurface Warfare. Mission modules will contain a command and control suite, the necessary sensors, manned and unmanned air, surface and underwater vehicles, and weapons to prosecute the specific mission. The mission modules will enable each LCS to connect to off-board sensors and platforms, including other fleet elements and joint and combined forces.

A unique feature of the LCS program is the decision to construct a number of each type of two competing sea frame designs (one by a Lockheed Martin team and the other by a General Dynamics team). The current plans are to build up to 15 so-called Flight 0 LCSs between FY06 and FY09. This approach will provide a sufficient number of ships of both types to conduct extensive experimentation within the Fleet. It will also allow both developers to exploit learning curve improvements in their production of follow-on ships. The Navy has said that it will make a decision regarding the next phase of the LCS program, the acquisition of so-called Flight 1 ships, in FY09. The Navy proposes to build some 55 LCSs in all with a variety of mission modules that can be employed on any of the vessels.

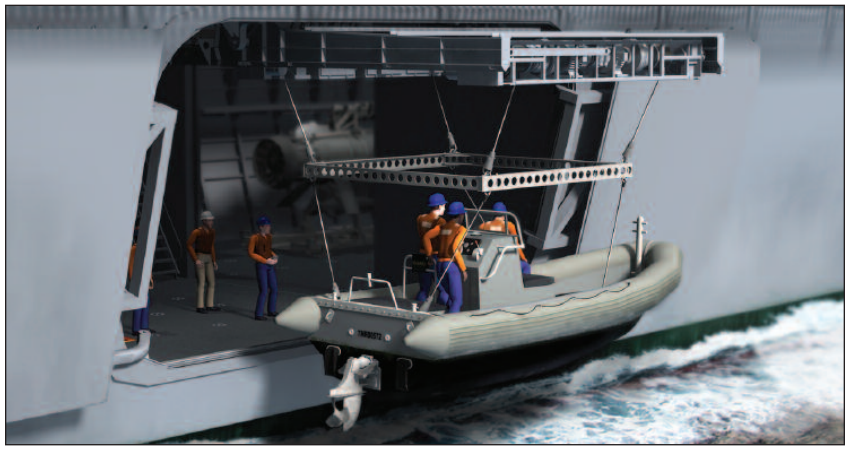
The systems integration challenge for the first modules is enormous. Many of the planned component systems were originally developed for other purposes or for deployment on different platforms. As the LCS program progresses, future spirals will make use of systems designed with modularity as a basic feature. Modularity allows for the rapid insertion of new technology at the mission module level, without tying up valuable hulls in the process.

However, in order to realize the true value of modularity, the Navy must fund future spirals even as it is deploying the first ships and modules based on current designs and technology. There are a number of areas that could be the foci of future spirals. One could be reduction in the complexity of module components and subsystems. Another focus of future spirals could be the development of standard unmanned air, sea and subsurface vehicles. Standard vehicles would be deployed as a distinct module on each LCS; different mission modules would contain, inter alia, unique mission-oriented sensors, weapons and other subsystems to be connected to the unmanned platform. A third possible

focus for future spirals could be the development of new modules to support additional missions such as emergency rescue and stability operations or environmental monitoring and support.

The LCS will be the first deployed ship designed for reduced manning. The basic crew is expected to consist of approximately 40 personnel with additional specialists associated with the different modules. The Navy has incorporated design ideas from a number of sources, including the DDX/DDG 1000 program in the effort to reduce manpower requirements on the LCS. The LCS program will provide important information to the Navy as it seeks to design reduced manning into future classes of warships.

The LCS program is at the leading edge of the revolution in naval systems engineering. Currently, the Navy is moving from closed to open architectures that allow for the introduction of COTS technologies and for some reduction in technology refresh rates. The LCS takes this another step forward. This revolution involves moving away from tightly coupled systems to tightly controlled interfaces. Open architectures allow for the creation of open business models. An open business model offers the potential of harnessing the power of competition as new suppliers, particularly those in the commercial sector, are brought into the program. The decision to employ smaller, largely commercial yards in the construction of both variants of the LCS is but the first step in the Navy's effort to reach out to commercial industry.



In addition to an open business model, the LCS program can achieve economies of scale on multiple levels. First, there is the common sea frame. Then there are exchangeable modules all sized to a standard 20-foot container. Support modules will also be built in the same way. Access to COTS technologies will allow the development of common C4 components and even subsystems. Finally, elements of the LCS program, mission modules and some ship systems could also be deployed more widely on other naval platforms.

The LCS program is focusing a great deal of effort on configuration control and managing the integration of ship systems and modules. This is absolutely critical if the operational goal for the LCS, rapid exchange of common mission modules, is to be achieved. Integration is equally important to guarantee that modules can be deployed with "plug-and-play" ease. In order to ensure the proper management of integration issues, the Navy has created the LCS Mission Systems and Ship Integration Team (MSSIT). The MSSIT includes the offices responsible for oversight of both module and ship systems development.

A modular open architecture may also advance the Navy's and the Nation's interest in building relationships on the way to the 1,000-ship navy. The systems integration philosophy that underpins LCS modularity will not only permit other nations to design their own modules but could encourage greater standardization of subsystems and components among friendly navies and defense industrial bases. "Plug-and-play" could become an anthem for international naval cooperation.

The LCS is intended to operate as a mission specific node in a distributed and networked force. While it is designed to successfully perform a variety of critical missions on its own, LCS's ultimate utility will be in the context of highly distributed operations. Such operations, in turn, will be dependent on distributed forces being networked and exploiting the potential of those networks to create a common operating environment.

LCS modularity also embraces new approaches to unit support and logistics. To most effectively exploit a flexible configuration, LCSs must be capable of rapid exchange of mission modules. Such an exchange must be conducted forward, requiring in turn, the forward positioning both of additional modules

and module specialists. Arrangements will have to be made to allow for forward deployment and storage of mission modules. It is possible that sea basing of support services and additional modules will prove an effective means of supporting rapid mission evolution. Consideration is being given also to underway exchange of mission modules. Because of the reduced manning, additional capabilities to conduct forward maintenance probably will be required.

Manning and training presents another challenge for the LCS program. Because of the reduced crew size, each individual member of the crew will be filling an essential billet. The loss of even a few crew people could significantly degrade ship operations. In addition, the LCS goal of being able to rapidly swap out modules in response to changes in missions will require rapid change out of mission personnel and the equally swift recertification of both ship and crew for the new mission.

The LCS program embodies a fresh approach to systems design. LCS will allow technology insertion at the mission module level without the costly modification and extensive time lines common to ships and systems of an earlier era. At the same time, by holding in common the basic hull, mechanicals and electrical elements, economies of scale can be achieved, allowing a larger unit buy of 50+ ships. Through the integration of standard and open architecture interfaces, the Navy is both enabling innovation and reduced costs. It is also potentially liberating the information that was previously locked up in the closed architectures of the legacy platforms.

Modularity, Networking and the U.S. Navy

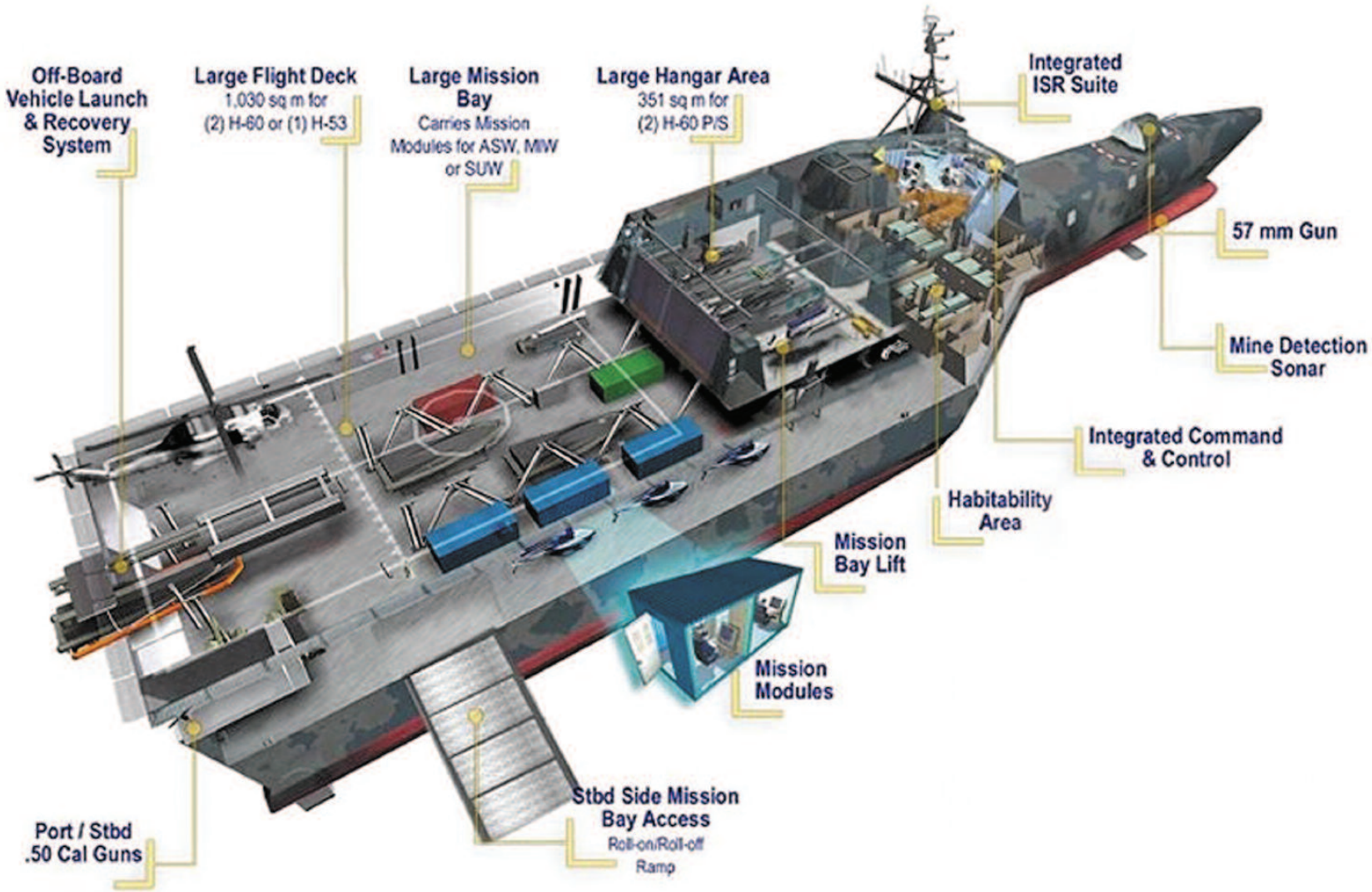
The future of transformation for the U.S. Navy is ultimately about building and exploiting networks. Meeting the challenges of the new security environment will require that the Navy conduct distributed and networked operations. Networked operations requires, first, connecting all the platforms and major systems deployed by the U.S. Sea Services — ships, submarines, aircraft, unmanned vehicles and Marine Corps units — and even joint forces so they can share information, establish domain awareness and create a common operating picture (COP). The establishment of a COP is critical to the operation of joint and combined forces. Once interconnected, commanders can exploit the power inherent in a large pool of distributed platforms and systems through innovative operational approaches.

Networks allow the exploitation of information from a variety of sensors distributed throughout the battle space to be gathered and fused so as to achieve MDA. Maritime Domain Awareness is about more than just threat detection; it is comprehensive, high confidence situational awareness to enable effective decision making. This awareness tremendously enhances the capability to identify threats, track them and coordinate responses.

Future naval operations will center on the command and control of distributed forces that more likely than not will be engaged in simultaneous offensive and defensive operations. This will be an extremely challenging task requiring tracking hundreds of friendly, hostile and even neutral objects in the battle space and selecting optimum weapons firing strategies among hundreds of potential solutions. To do this job successfully means establishing MDA and the creation of a common operating environment. The Navy has begun this process with programs such as ForceNet and Naval Integrated Fire Control-Counter Air.

Distributed operations and the employment of modular mission platforms can exercise a powerful influence on future naval operations. Distributed operations will complicate an adversary's ability to hide from U.S. C4ISR capabilities while simultaneously complicating his ISR and targeting problems. A distributed, networked force will be less vulnerable, require less force protection and have reduced risk of catastrophic mission degradation as the result of the loss of any particular platform. A modular and networked force can switch among missions more rapidly than the current force. Such a force, particularly involving the extensive employment of off-board sensor and weapons systems should be able to achieve extremely high levels of effectiveness, particularly relative to the number of platforms deployed. The new Navy/Marine Corps Naval Operations concept embraces these concepts. According to recent reports, its goal is "more widely distributed forces providing greater forward presence, as well as decentralized decision-making and execution based on broad centralized guidance."[5]

LCS Variant built by General Dynamics Team



The LCS program is an important step forward in the process of transforming the U.S. Navy. The key to the success of LCS at the platform level, mission level and battle group level is in the network. As stated by Robert Work:

> …the LCS is less a ship and more a battle network component system, consisting of a sea frame, a core crew, assorted mission modules, assembled mission packages, mission package crews and a reconfiguration support structure. The total system aims for a level of battle modularity that will allow for a LCS's complete mission reconfiguration — including operational testing of its combat systems and crew readiness for follow-on mission tasking — in less than four days. If successfully demonstrated, the LCS's high degree of modularity would be without precedent in naval history and would afford the 21st century Total Force Battle Network a unique ability to adapt itself to confront any existing or evolving access challenge.[6]

The LCS will serve two important functions. First it will fill a critical space in the spectrum of capabilities deployed by the U.S. Navy. Second, it will be the first step on a path towards a redesigned fleet, one that operates in a distributed fashion, takes maximum advantage of networks, is designed around modular capabilities and standard interfaces and employs its manpower in different and, one would expect, more efficient ways.

The LCS program is part of a revolution in the way naval forces are designed, acquired and operated. Modularity requires standard interfaces which, in turn, necessitate open architectures. It is a small step from an open architecture to an open business model. Such a model creates the potential for future shipbuilding programs to access a larger slice of U.S. industry. Inherent in the LCS program is the idea of commoditizing the various aspects of engagement. Sensors, weapons systems and even platforms are being proliferated. Each of these is intended to be relatively low cost and simple, relying in part on networking as a mission multiplier. In addition, the knowledge gained in the systems integration effort on LCS could change the way industry thinks about interfaces, creating a new level of standardization at the subsystem and even component level that may further reduce costs while creating economies of scale.

It is important also to recognize that the traditional approach to acquiring ships and sizing the Fleet is no longer sustainable. The results have been skyrocketing costs, a declining force structure, inadequate recapitalization and lengthy technology refresh rates. New approaches are required. Lessons learned from the LCS program, together with those acquired on the DDG 1000 should be applied widely in the Fleet. Indeed, if the LCS program proves itself, modularity should become the template for the design of future classes of warships. There is no reason why larger vessels cannot be constructed employing the basic principles of modularity demonstrated in LCS.

The path forward towards a truly transformed military that can respond to the changes in the security environment is clear. It involves distributed forces based on the exploitations of networking technologies to create a connected capability able to perform multiple missions simultaneously. In a recent speech, the former Chief of Naval Operations, Admiral Vernon Clark, described how transformation was impacting the U.S. military, in general, and the Navy, in particular. The key to meeting the challenge of new and asymmetric threats is to exploit networks, termed "ForceNet" by the Navy.

> …all the forces in the future are going to be much more distributed. There are articles written now about the various generations of warfare and we are in generation four. Generation two was fundamentally attrition warfare. Generation three was the beginning of precision like we saw in Desert Storm. Generation four is a war landscape dominated by asymmetries, which is what we are seeing today and what I think a lot of the future will be about. In generation four warfare, it is going to be absolutely essential for us to distribute our force. And distributing the force is not remotely possible without ForceNet solutions.[7]

The Navy's approach to modularity in the LCS reflects its evolving views on distributed forces. The goal of modularity is the ability to accomplish the mission by integrating the capabilities available in a host of systems and platforms. By deploying distributed and netted systems, both onboard the LCS and throughout the Fleet, the Navy has the ability to leverage all its assets to achieve the mission. LCS integrates both manned and unmanned platforms in both the horizontal and vertical domains (air, surface and subsurface) to enhance situational awareness and operate in a distributed manner. In its way, LCS is emblematic of the broader approach the Navy is taking to operations in the information age.

Critical Issues

As the LCS program moves forward, it must address a number of critical issues. The LCS program must meet established targets for cost, producibility and basic capabilities. One goal of the LCS program was to build affordable ships on a time line much shorter than those traditionally associated with warship construction. The time from concept definition to the first ship in the water will be less than half of that generally seen in the first ship of a new class. However, the estimated cost for the first LCS has grown. If the program is to be successful it must control costs. While some cost growth is to be expected in any new program, much less one as innovative as this one, the program must demonstrate a fairly steep production learning curve.

In addition, the program will need to tackle the following issues:

- The Naval Research Advisory Committee report on science and technology for modular systems concluded that the process of implementing modular systems required that a taxonomy of modularity be defined and that, in particular, the Navy needs to develop a systems analysis capability for complex, interactive capabilities. It is not clear whether sufficient capability is resident in both the Navy and the private sector.

- A singular benchmark for LCS success is the design and integration of mission modules. The program must be able to demonstrate that a modular open architecture can be created. It must establish the standard interfaces that will create a baseline for development of follow-on systems to be deployed in subsequent spirals.

- Second only to modularity is connectivity. Not only must the modules perform as intended — once integrated with the sea frame — but they must also connect with other ships of the LCS squadron, with off-board sensors, with the rest of the Fleet and with joint and combined forces.

- In the medium and long term, the LCS program will only be successful operationally and in terms of impact on acquisition and sustainment, if exacting configuration control is maintained.

- In addition to demonstrating the feasibility of modularity, the utility of both sea frame designs and the operational value of LCS, the Navy also needs to adapt its manning and training procedures and systems to reflect the LCS's many unique features.

- The Navy will have to reorganize or modify its support activities to meet the unique characteristics of the LCS. The traditional approach to fleet sustainment will not be adequate for an LCS squadron. First, there will be the need to forward base sets of different mission modules and associated mission crews. Because of the small size of the LCS crew, additional maintenance requirements will fall on intermediate facilities.

- Finally, how the LCS will be employed is subject to some uncertainty. Advocates expect that once it is deployed, the LCS will help to promote the development by the Navy of a CONOPS for distributed, networked forces. The program is intended to allow the Flight 0 LCS to be deployed with the Fleet, in part, as a learning exercise.

Conclusions

The LCS program has already achieved noteworthy results. It has demonstrated innovation in the design and construction of two very different and unique sea frames. It has successfully designed and is building three distinct mission modules. It has proven the value of standard interfaces, open architectures and an open business process. It is changing the way the Navy mans its ships, trains its personnel and sustains its forces.

It is imperative that the Navy and the Department of Defense provide full support to the LCS program. There is a growing need for the capabilities the LCS will provide to deal with asymmetric threats. Equally important, the LCS is an important part of the Navy's overall effort to transform itself into a distributed and networked force.

It is difficult to identify a more transformational program than the LCS in all of the Department of Defense. In an era of tightening budgets, it is imperative that the Navy move to an approach that reduces shipbuilding costs, lessens the time required to introduce new classes of ships, increases the pace at which new technologies — particularly from the commercial sector — are introduced and shrinks personnel rolls. The LCS program holds forth the potential to further all these goals.

Cost is an important issue with respect to acquisition of the LCS. However, cost is not the only factor, perhaps not even the most important consideration. The Navy is attempting to simultaneously deploy two new types of hulls, modular mission packages and a new manning and training system for the LCS's crew. Some cost growth is inevitable.

It is important that the Navy acquire a sufficient number of LCSs to fully test its capabilities and understand the implications of modularity and networking for the future of distributed operations. The Navy has made the decision to acquire 15 LCSs, divided between two variants, between now and FY09. The additional costs to sustain two types of LCS is not negligible. They could well be minimized by changes to the Navy's approach to sustainment and the potential for the lessons learned on the LCS program to reduce the costs of future class-

The LCS program is reaffirming the value of open architectures and an open business model. The Navy must require that all future ship classes be designed with these two concepts uppermost. Where possible, as is being done with the Aegis combat system, formerly a closed system, the architectures of other major systems need to be opened up.

The Navy should be encouraged to aggressively experiment with its fleet of LCSs. The interaction between designers and operators is critical both to refinement of the LCS design and to the development of new operational concepts. In an era of tightening budgets, there is often a tendency to reduce resources for training and experimentation. These tendencies must be resisted. A robust experimentation program is essential to the future of both the LCS program and the Navy's effort to network the Fleet.

The LCS program is part of the Navy's broader efforts to transform itself into a distributed, networked force. Efforts under the mantle of ForceNet such as NIFC-CA must continue and receive the highest priority in the Navy. The revolutionary potential of the LCS program will not be realized without a fully networked Navy. At the same time, the LCS program can contribute to distributed networked operations and provide important insights into the way ahead.

The LCS program creates the potential for new ways to achieve desired mission capabilities. The traditional way has been to provide robust redundant capabilities in the form of multi-mission ships across the force for many important missions (e.g., ASW, power projection, surface warfare). This approach is extremely expensive. A distributed, networked and modular force may be able to achieve the same level of mission capability through selected investments in mission modules or simply by networking. The Navy needs to consider ways that networking and modularity can replace investments in stand-alone systems.

Finally, a basic element of the LCS program is rapid technology refresh through a program of measured spirals. However, the Navy has not funded future spirals. This is a mistake. Funding needs to be provided to ensure that improvements can be made to mission modules and more advanced technology inserted.

Endnotes

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