Subject: Small, speedy, shallow LCS signals major shift
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Small, speedy, shallow LCS signals major shift

Bill Sweetman

The US Navy's Littoral Combat Ship programme is showing how the concept of'transformational' weapons can mean wholesale changes to platform design. By Bill Sweetman

·Radical designs challenge traditional notions of naval operations.

·Fast warships made possible by technology developed from modern catamaran ferries.

There is much talk about 'transformational' weapons in the Pentagon, but there are few major programmes that represent such a dramatic change in platform design and performance and in operational concepts as the Littoral Combat Ship (LCS). Developed to meet a need that was first identified in the 2001 Quadrennial Defense Review, the LCS is well on the way to operational reality. The keel of the first ship, Lockheed Martin's USS Freedom (LCS-1), was laid by Marinette Marine in Marinette, Wisconsin, in June this year (2005), while the competing General Dynamics (GD) LCS team was due to receive a contract for its first ship in mid-October. Meanwhile, an experimental ship - the USS Sea Fighter, or Fast Sea Frame-1 (FSF-1) - is cruising the Pacific off San Diego at speeds up to 50 kt, demonstrating some of the key technologies for LCS.

The first unique feature of the LCS is implied by the fact that the first-of-class has been laid down in Wisconsin - which, barring a major tectonic event, is more famous for its cheese than for its ocean vistas. At less than 3,000 tons, the LCS is substantially smaller than the US Navy's (USN's) smallest current combatants, the FFG-7 Perry-class frigates, and fits easily through the locks that bypass Niagara Falls between the Great Lakes and the Atlantic.

The second unique feature of the LCS is its speed. Although the Lockheed Martin and GD LCS designs and the Sea Fighter differ from one another, none has a hullform or propulsion system that is recognisable from earlier USN warships. Instead, they draw on commercial technology which has, over the past two decades, made it possible to build fast ships that have good stability and sea-keeping properties and can achieve high speeds with respectable efficiency and range.

The LCS also differs from any combatant since the 1400s in its built-in offensive weapons: it has none. Its permanent armament is entirely defensive and its offensive firepower will be delivered by helicopters and unmanned airborne, surface and submarine vehicles.

Unique classification

Finally, the LCS will not have a permanent suite of mission equipment. The Sea Fighter's unique 'sea frame' classification is analogous to the airframe of a combat aircraft. Along with their hullforms, the Sea Fighter and the LCS designs borrow a common feature from their fast-ferry ancestors: a cavernous dry, covered deck compartment with wide openings. Instead of cars and trucks, this space will accommodate unmanned vehicles and containerised modules of mission equipment. Initially, the USN plans to have interchangeable sets of equipment for mine warfare (MIW), anti-submarine warfare (ASW) and anti-surface warfare (ASuW). The only permanent equipment on the ship will be the core communications, navigation and surveillance systems and air-defence weapons.

This approach allows for effective suites of equipment to fit in a small ship - because not all equipment need be carried at all times. It has also helped to speed development, because the platforms and their core systems are relatively simple, and the USN's vision is that the mission modules can and will be upgraded separately from the platforms.

The LCS is complementary to existing and future USN ship classes, such as Aegis air-defence destroyers and the advanced-technology DD(X) destroyer. It is designed to operate in shallow water - with depths as low as 6 m - where larger warships cannot manoeuvre but where some threats, such as small surface attack craft, can operate freely. Its main targets will be mines, diesel-electric and air-independent submarines, and small fast surface craft.

The need for the LCS emerged in the late 1990s as the USN acknowledged that it had capability gaps in shallow-water mine warfare and ASW. The suicide attack on the USS Cole in 2000 demonstrated the threat from small boats, particularly those operating in swarms. The 1999 Global War Game at the Naval War College in Rhode Island incorporated, for the first time, a small, agile craft called Streetfighter, and the 2001 game additionally incorporated the use of modular systems and unmanned vehicles. The requirement that emerged was for a fast, agile ship larger than Streetfighter, with the ability to support manned helicopters and unmanned aerial vehicles (UAVs). Key missions include protecting the fleet against mines and submarines - in areas where the USN's nuclear submarines are too large to operate effectively - and to protect ships against small-craft attacks, particularly in choke points. The LCS programme office was formed in early 2002.

The first request for proposals for the LCS was issued in mid-Fiscal Year 2003 (FY03). Teams led by Lockheed Martin, GD and Raytheon responded. Raytheon was eliminated in May 2004, when the other two contenders were awarded contracts for system design of the LCS. Lockheed Martin was awarded a contract for the first Flight 0 LCS in December 2004. The GD ship is running about a year behind the Lockheed Martin LCS, as part of the USN's basic programme plan. The project is fast-paced: USS Freedom is due to be delivered at the end of 2006, 31 months after the award of a system design contract. The first GD ship will deliver in late 2007 and each contractor will deliver two Flight 0 ships.

USN goals for the LCS include a speed in Sea State 3 of at least 40 kt, with a desired speed of 50 kt; the ability to carry a payload of at least 180 tonnes, including up to 105 tonnes of equipment, with 210 tonnes desired; and a range of at least 3,500 n miles at an 18 kt transit speed. The LCS should be able to carry and support at least one Sikorsky MH-60R ASW helicopter or MH-60S multirole helicopter, together with three Northrop Grumman RQ-8B Fire Scout UAVs, and launch and recover them in conditions up to Sea State 4, with Sea State 5 as a desired performance level. The LCS should be able to launch an 11 m rigid hull inflatable boat (RHIB) in Sea States 3 to 4 and should have a core crew - that is, minus any crew required for the mission module - of fewer than 50 persons. The cost target for the 'seaframe' is USD220 million in FY05 dollars, with a desired target of USD150 million.

The USN plans a spiral development process for the LCS. The first ships are identified as Flight 0 and make use of largely proven, off-the-shelf equipment in their mission systems - although there are major exceptions, such as the Fire Scout and unmanned surface vehicles (USVs). They will be used to develop tactics and test mission packages. They will be followed by a group of Flight 1 ships, incorporating new technologies and lessons from the first ships, which will be the basis for full-scale production of 50-60 LCS-class warships.

Navy programme manager Captain Don Bab says that the service has deliberately left open the question of whether the USN will pick one team's design for the Flight 1 ships, continue with both designs, or even re-open the competition entirely. "Both designs meet our requirements and have unique attributes," he says.

Monohull form

Lockheed Martin is working together with Marinette Marine, Bollinger Shipyards of Louisiana and naval architects Gibbs & Cox. The team's design is based on the semi- planing monohull form adopted by Italy's Fincantieri for the prototype Destriero - a 1,000 tonne ship, funded by the Aga Khan, that set a transatlantic speed record of 55 kt in 1992 - and for the later 3,000-tonne Jupiter-class fast ferry, with a 42 kt maximum speed. The semi-planing steel hull, with a shallow-V bottom and moderately canted sides, achieves low drag with a lower length-to-beam ratio than a traditional non-planing hull, which translates into better roll stability and more

useful space. (The LCS is 115 m long with a maximum beam of 13 m.) The ship has a draft of less than 4 m at rest, and much less than that at speed, reducing the effect of coupling between the ship's hull and the sea floor at high speed in shallow water. According to Lockheed Martin, tank tests in simulated Sea State 8 conditions and 320 km/h winds have failed to capsize the ship.

The ship design is dominated by the hangar, twice the size of that of any current USN combatant (discounting carriers and amphibious ships), and the flight deck, which is 50 per cent bigger than that of any cruiser or destroyer in the USN. The hangar can accommodate two MH-60s. The flight deck and hangar are equipped with the UK-developed McTaggart Scott Trigon cable-based helicopter traversing and recovery system.

Below the hangar and flight deck is a large reconfigurable area, fitted with an overhead crane that can move longitudinally and laterally throughout the bay. At the stern, this area is fitted with an articulated ramp for launching and recovering large watercraft, and there is also a sliding side door for underway and dockside access. The overhead crane extends through this door, allowing smaller craft to be picked up directly from the water and carried into their storage positions.

The Lockheed Martin ship has combined diesel and gas turbine (CODAG) propulsion. High-speed power comes from two commercially proven Rolls-Royce MT30 gas turbines, based on the Trent aircraft engine and delivering 36 MW each. For long-range cruise, the LCS has two Fairbanks Morse PA6B V-16 turbocharged diesel engines, each providing 6.4 MW of power. The four engines will be geared to a set of four Rolls-Royce KaMeWa 153SII waterjets, two installed as boosters and two as steering-reversible units.

Unmanned engine spaces are an example of automation on the ship. The LCS will also have a network of sensors to detect damage or fire, and automated and remotely operated systems to respond to damage.

Lockheed Martin claims that its LCS design will perform at the high end of the USN's requirements, reaching 45 kt at full load and 50 kt at light load, recovering aircraft in Sea State 5 and launching and recovering small watercraft in Sea State 4. The LCS is also expected to be highly manoeuvrable, thanks to its hullform and waterjet propulsion: Lockheed Martin says that it will perform a full 360° turn in a radius less than eight ship lengths at full speed; make a 180° turn in a radius of three ship lengths at 30 kt; and accelerate to full speed in less than two minutes.

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AMTP10E **Small, speedy, shallow LCS signals major shift pt 2** 10/20/2005 7:10:01 AM

Trimaran design GD's LCS is a trimaran design. The basic advantage of a trimaran is that the main hull can be made long and slender - for pitch stability and low drag - while the slender outriggers provide roll stability. The principle dates back to Hawaiian outrigger boats, but the modern technology used in the GD LCS comes from its Australian partner, Austal, which will build the LCS in its US shipyard in Mobile, Alabama. GD's Bath Iron Works unit is the prime contractor; GD Advanced Information Systems will integrate the core systems; and L3 Communications and BAE Systems are also providing electronic components and subsystems. The team had not announced its choice of a propulsion system and partner at the time of writing, but like the Lockheed Martin ship it will be powered by two gas turbines and two diesels driving steerable waterjets. The precursor to the GD LCS is the fast ferry Benchijigua Express, which was built by Austal in September 2004 and went into service with Fred Olsen SA earlier this year, carrying passengers and vehicles on routes in the Canary Islands. The 127 m ferry is the largest high-speed trimaran yet built. One advantage of the trimaran, according to GD, is the large beam available across the rear of the main hull and the amahs, or outriggers - a massive 30.4 m in all. The company says that this feature gives its LCS design an equivalent usable volume to a monohull ship of one-third greater size. It also makes the flight deck large enough, at 1,030 m2, to land a CH-53 helicopter - not an LCS requirement but a useful advantage, particularly for special operations. The flight deck is also higher above the

water than that of any cruiser or destroyer - 11.2 m above the waterline - which is a significant safety feature. Unlike Lockheed Martin's LCS, the GD design is largely made from aluminium. The interior of the ship is divided into highly protected, segregated areas to contain fire, and the ship will have state-of-the-art fire-suppression systems that will quickly contain and extinguish any fire without endangering shipboard firefighters or introducing excessive amounts of water that could have a destabilising effect on the ship. Naval architect Nigel Gee, whose company designed the Sea Fighter, notes that aluminium construction has become widely accepted both in terms of durability and survivability. Inherently, steel retains its strength better than aluminium at high temperatures, but the use of modern insulating materials, subdivision of the interior and good fire-extinguishing systems can make an aluminium ship as survivable as a steel ship of the same size. "We use insulation on this ship, rather than sailors with firehoses, to cool a bulkhead in a fire," says Capt Bab. Fixed weapons on the LCS will include a version of the Raytheon Rolling Airframe Missile (RAM) system, widely used on USN ships. Raytheon has developed a lighter, 11-round launcher for LCS and other smaller craft, and the new Block 1 version of the missile itself introduces an imaging infrared (IR) seeker similar to that of the related AIM-9X Sidewinder air-to-air missile. The Lockheed Martin team has announced its selection of the BAE Systems/United Defense Mk 110 Mod 0 57 mm gun system for the LCS, and the GD team is understood to have followed suit. Already in full-scale development for the US Coast Guard's new Maritime Security Cutter, the Mk 110 is the US version of the Mk 3 gun, developed by BAE Systems subsidiary Bofors. It is designed to use the company's 3P (Pre-fragmented Programmable Proximity fuzed) ammunition, which can be used with selectable proximity and burst settings for different targets, and with high-capacity extended range (HCER) rounds with a range of up to 17 km. The gun has a rate of fire up to 220 shots per minute and a twin-compartment magazine allows it to switch instantly between ammunition types. The USN has defined the basic equipment that will make up the Flight 0 mission modules. Mine warfare is the first mission to be addressed. The first module should be incorporated on the first Flight 0 LCS when it joins the USN in early 2007. For MIW missions, the LCS will carry the MH-60S helicopter, which in turn will carry an array of mine-hunting equipment: the Airborne Laser Mine-Detecting System (ALMDS); the AQS-20A mine-hunting sonar; and the Organic Airborne and Surface Influence Sweep (OASIS). The ship will launch the WLD-1 remote minehunting vehicle, also equipped with the AQS-20A sonar, and the Spartan Scout USV based on an 11 m RHIB. The Fire Scout, with its standard electro-optical sensor system, will scout for mines in the surf zone. ASW and ASuW modules are due to arrive in early 2008 for the second and subsequent Flight 0 ships. For ASW, the most formidable weapon is the MH-60R helicopter, dedicated to the ASW mission and equipped with the Advanced Low-Frequency Sonar and the Mk 54 torpedo. However, it will be joined by the WLD-1 minehunter, equipped with a towed array and an active noise source, and the unmanned RHIB equipped with a dipping sonar. In the ASuW mission, an important weapon will be the Fire Scout, armed with the Advanced Precision-Kill Weapon System (APKWS): a laser-guided version of the 70 mm pod-launched rocket, aimed by the UAV's laser designator. The MH-60 is armed with Hellfire missiles and the GAU-16 single-barrel 12.7 mm machine gun, while a version of the unmanned RHIB carries a 30 mm gun, the Javelin missile and the non-lethal Running Gear Entanglement System (RGES), which basically comprises a floating header line with U-shaped ropes dangling from it, intended to foul the target's propeller. The USN is also looking at adapting the US Army's Non-Line-of-Sight Launch System (NLOS-LS) missile, part of the army's Future Combat System, to the LCS. In the ASuW role, each ship would carry three NLOS launchers, firing the Raytheon Precision Attack Missile - a weapon with a 40 km range and a dual-mode (imaging IR and semi-active laser) seeker. NLOS, for example, could engage targets detected and designated by Fire Scout or by an electro-optical sensor on a USV.

Maturity issues Although the USN has plans to have these systems ready for testing on the first LCS, not all of them are mature at this point. For example, the WLD-1 unmanned minehunting vehicle and the Spartan Scout USV are still at the Advanced Concept Technology Demonstration (ACTD) stage - that is, the current vehicles are technology demonstrators, with the goal of providing a few assets at the end of the programme that can be used operationally. (The Spartan Scout ACTD started in 2002 and the first version - tailored for reconnaissance - was experimentally deployed in the Gulf in late 2003. The system is also being supplied to Singapore.) The Fire Scout is a fully funded programme with strong support from the USN and US Army, but the first engineering and manufacturing development (EMD) vehicle does not fly until August 2006 and operational evaluation is not due until 2007. Even the MH-60R and MH-60S helicopters have not emerged from development for all their contemplated missions. When they do - in FY07 - the USN will have a limited number of assets available and will have to choose whether to assign them to the experimental LCS or to the operational fleet. The NLOS missile is in the system development and demonstration (SDD) phase and is not due to reach

the army's evaluation brigade until 2008. These factors have caused the Government Accountability Office (GAO), in a report in March 2005, to fret that development of the LCS, although moving ahead with creditable speed, may be outrunning the maturity of the mission, and that the USN risks committing to a Flight 1 ship before it has had a chance to learn necessary lessons from the Flight 0 units. The USN, in its response to the GAO, has said that it has plans to deal with those problems and that some of the systems identified in the GAO report had already moved beyond the ACTD stage. "Everything in the first mission packages will be tested and ready to go to sea," says Capt Bab, "although it may not have full logistics support." LCS challenges many traditions in the USN and may ultimately do the same for services around the world. As such, it will inevitably be a risky venture and there will be critics charging that the small craft do not have the muscle or protection needed for the mission. But its radical design approach and the speed with which it is being developed will be important lessons for future projects. **SEA FIGHTER AND HIGH-SPEED DESIGN** USS Sea Fighter, in many respects a half-scale prototype of the Littoral Combat Ship (LCS), started its first year of at-sea trials in September this year (2005), operating out of San Diego. As well as being a technology demonstrator - initially labelled X-Craft to reflect a similarity to the US X-plane series - it also typifies the way in which commercial and military technologies and concepts have merged in these new warships. British naval architect Nigel Gee, who designed the Sea Fighter, says that in terms of ships, "platform development in the commercial world has gone ahead faster than in the military. At the same time, the nature of warfare has changed and navies are looking at smaller, faster ships". The technologies that have made fast warships possible have emerged over the past 30 years, Gee says, since the first fast catamaran ferries demonstrated speed comparable to the hovercraft or hydrofoil. These include advanced hullforms - whether catamaran, trimaran or monohull; the use of aluminium or composites in construction to reduce weight; waterjet propulsion, which is more efficient at high speeds than propellers; and compact and efficient propulsion. Gee's company, Nigel Gee & Associates, has designed trimarans, catamarans and monohulls. Monohulls provide a conveniently concentrated space for propulsion and other systems, but the higher beam required for stability may require a good deal of power at large sizes and speeds. The trimaran - like the General Dynamics LCS - has a long slender hull with sponsons for stability. For the 1,500-tonne, 50 kt Sea Fighter, the catamaran is the right solution, Gee says, because it can have very slender hulls in relationship to its length. The problem is that a small catamaran is necessarily short, which leads to issues with pitch stability and sea-keeping. To deal with this problem, Sea Fighter - like Gee's commercial designs - has active ride control, with T-foils under the bow for pitch and heave control, and pitch and yaw surfaces at the rear of the hulls. It also has a slightly different hullform from its commercial cousins. Trading some drag for high-speed stability, Sea Fighter is expected to exceed 50 kt in Sea State 3, the original specified maximum speed. Roughly the same size as a commercial vehicle ferry, Sea Fighter is powered by two 25 MW GE LM2500 turbines and two MTU 16V diesels driving four Rolls-Royce KaMeWa waterjets. The mission deck beneath the flight deck is 60 m long, 20 m wide and 5 m high, is air-conditioned and is fitted with standard interfaces for mission equipment, including power, a local area network and cooling water. The deck also features a 16-ton capacity overhead crane and a stern ramp for watercraft. L3's Titan Corporation subsidiary was the prime contractor for Sea Fighter, which was built by Nichols Brothers in Whidbey Island, Washington. Despite being the world's fastest large naval craft of its size, and the largest catamaran ever manufactured in the US, it was built in 20 months from order to launch. In early October this year, Sea Fighter's commanding officer, Lieutenant Commander Brandon Bryan, spoke to IDR from the ship as it "ran like a Cadillac" at 50 kt off San Diego during initial propulsion and sea trials. Tests planned over the next year include the installation of a prototype Non-Line-of-Sight (NLOS) launcher and the live firing of a ballistic test vehicle, due in early December. This month (November 2005), the ship will conduct its first aviation trials with manned helicopters. Early in 2006, the ship will launch and recover Spartan Scout USVs armed with machine guns. By mid-2006, Sea Fighter should be taking part in the Rimpac exercise series and will also be tested with Titan's Affordable Weapon System, a small, low-cost cruise missile. LCS programme manager Captain Don Bab says that Sea Fighter will be "very valuable from many aspects", both as a laboratory for the launch and recovery of unmanned craft and as a training craft. "We not only have to build a ship, but also a crew that is significantly different from today's crews." For instance, the LCS programme office expects to have trained its crews in paperless navigation aboard Sea Fighter before they set to sea in LCS-1. Cmdr Bryan and his crew are also studying the operation of the automated ship, which has a normal complement of 26 persons. In tests in August, the crew dealt with simulated flight deck fires at the USN's China Lake research centre, showing that small crews with multidiscipline training, using some techniques from the civilian firefighting world, could deal with a JP-8 fire on the ship. Manning and human-factors lessons

from Sea Fighter will support development of training for the LCS.

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How on earth do you name a ship Freedom without cringing....

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