Making Waves

Learning Curves
Commander David Peer

The intent of this piece is to examine the extent to which shipyard competitiveness can be improved. It does so by probing whether the National Shipbuilding Procurement Strategy (NSPS) allows the shipyards involved in the large ship contracts the time to learn and thus build more efficiently.

The NSPS is a long-term ship procurement strategy for the Royal Canadian Navy (RCN) and the Canadian Coast Guard. While some may argue that long-term arrangements may impede getting the best value for the taxpayer, NSPS is supposed to allow the two shipyards involved in the large ship contracts the time to learn and maintain skills and build ships more efficiently.

At first glance, the NSPS seems to run counter to government policy for competition in procurement. That policy is built on the premise that competition frees human creativity to solve virtually any problem at the lowest cost. The problem in the Canadian shipbuilding context is that not enough demand exists to have a free market in ideas and solutions, not to mention the market is constrained to one buyer and only a few suppliers. Shipyards that can build efficiently in a controlled market may be more advantageous for Canada than a reliance on competition.

If every shipyard that competes only wins ship contracts sporadically then expect poor core productivity especially for first-of-class ships in yards that have long rested idle. Ideally, Canada’s defence shipbuilding sector should have a better balance between supply and demand. With a better balance, government could renegotiate the NSPS arrangement to ensure competition for the work and in turn value for money. It rests with the government to plan strategically and ensure enough work will exist to support more than one major shipyard. After all, the goal of the NSPS is to obtain value for taxpayers while keeping the work in Canada.

Part of the obligation of the two shipyards selected for the NSPS – Irving Shipbuilding in Halifax and Seaspan in Vancouver – was a commitment to improve their competitiveness and contribute to the long-term health of the Canadian marine industry with a surtax of 0.5% of the value of any contract. The commitment to the long-term health of the Canadian marine industry is easily tracked and measured; improving competitiveness will be more difficult. The government plans to measure competitiveness with periodic assessments to see if benchmarks have been attained.1

Under the NSPS, the government is using a three-step process to get the best value for money for the renewal of the RCN and Canadian Coast Guard fleets. The government has selected two preferred shipyards and established framework agreements within which contracts will be negotiated to build ships. The process is intended to provide more stable work demand for the two shipyards, which should promote strategic decisions to improve productivity.

A long-term relationship is the only way to ensure the competitiveness of the defence shipbuilding sector. NSPS is structured to encourage the sector to harness human creativity through learning and continuous improvement. The government’s commitment to regular work is a key element to the shipyard’s ability to make a commitment to improve productivity.

Figure 1 illustrates how this should work. It shows a generic cost and time relationship for the order book of a hypothetical shipyard over time – a shipyard with a full order book committed to continuous improvement of productivity. There are four lines on the graph. The three solid lines represent the cost reduction experienced during the building of three different series of ships. Each solid curve represents the cost reduction over the build of a series of similar vessels. The cost reduction comes from productivity improvements from a mix of ship learning and organizational learning. The time it takes for a shipyard to approach its core productivity in a series of ships is reflected in the length (in time) of the solid curves. The bottom dotted line in Figure 1 is the measure of core productivity over a progression of ship projects.

**Figure 1. The Effects of Learning on Ship Cost**

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Estimating learning effects is easier for a shipyard that has a continuous stream of work than it is for one that receives unpredictable occasional ship orders. Learning curves cannot be constructed when build activity is sporadic, or in very small quantities. It should be noted that learning affects the productivity of the human workforce; the concept does not apply where work is highly automated. Also, estimating learning becomes more complex if a shipyard makes major changes to its processes and practices or has little or no work for periods of time.

Learning achieved over the construction of a series of vessels occurs at two levels: at the organization level; and at the ship-specific project level. Organizational learning that has a direct effect on core productivity usually comes from incremental improvements – and, rarely, major improvements based perhaps on technological breakthroughs. Organizational learning is transferable between projects. Ship-specific learning occurs as a workforce learns how to build a particular ship efficiently. This learning is completely experience based, context specific and not transferable to other ship projects.

Minimizing the first-of-class productivity penalty (X in Figure 1) for each new series of ships represents the path to improve productivity for the NSPS shipyards. A steep curve (large X) can be attributed to many causes. Late production information, an ineffective build strategy and poor standards are causes within the control of the shipyard. The complexity of the vessel, badly defined contract specifications or immature design detail that results in changes during first-of-class construction are causes that are not.2

As I discussed in my article in this issue, the construction of the Canadian Patrol Frigate (CPF) provides an example of a learning curve (see Figure 3 in my article). The CPF case confirms that ship learning is most significant over the first few ships in a series. The tail end of the production line is when the shipyard is most efficient. Productivity may never approach a shipyard’s potential core productivity if the number of ships being built is too small. The CPF curve example also contains an element of organizational learning as well. After the first two ships, Saint John Shipbuilding (SJSL) took the decision to make a radical change in production methods to maximize the work conducted in a controlled environment. This was one of those rare situations in which a technological breakthrough contributed to a major productivity improvement. Changing the building process so radically after two ships was a major risk, but without breaking from the initial construction methodology the shipyard would never have reached the productivity necessary to recoup schedule delays and to meet the cost targets.

What should be obvious from the CPF example is that adding an additional ship to a small series provides better productivity gain than adding one to a large series. Thus, Marine Industries Limited (MIL) should have shown greater productivity improvement with a fourth ship than SJSL on a tenth. Another factor to note is that interruptions in construction for whatever reason have a detrimental effect on ship learning and, hence, productivity.

The CPF productivity penalty (the X factor from Figure 1) was approximately 44% higher than the core productivity level, and core productivity was reached at the sixth vessel. This large and long-lasting penalty is typical for a warship. In a comparable yard with similar productivity building less complex merchant ships, the typical penalty is lower (10%) and core productivity is reached earlier, at the fourth vessel. Some leading European commercial yards have reduced the performance penalty to 2-3% on a new class of vessels that is similar to a previous class, and about 10% for a complete change in design.

Large first-of-class performance productivity penalties and steeper learning curves are a characteristic of warship construction because of the complexity of the work. The rapid decrease in the production penalty for the CPF is a credit to the shipyard considering it had not built any
warships at all in the previous decade. Shipyards that commit to use best industry practices will approach core productivity faster and after fewer ships.

In the coming years, Irving Shipbuilding will have the greatest opportunity to take advantage of the ship-specific learning effect. The NSPS combatant ship package will have the longest production runs with six to eight Arctic Offshore Patrol Ships and a fleet of Canadian Surface Combatants scheduled to be built. The NSPS guarantees the steady stream of work with smaller ship classes and single ships that provide learning opportunities at the organizational level even when the advantages of ship-specific learning are not available. It is rare for shipyards to have regular and long production runs for ships, either commercial or military, so how will yards without long production runs achieve peak efficiency?

Ship construction is not entirely unique. Modern shipbuilding techniques use manufacturing processes that subdivide fabrication and assembly into different types of modular products. Experience-based learning and improvement can occur at the modular level as well as at the full final product level. What is important for learning is a regular stream of work, no matter what ship is being built.\(^3\) Constant demand and regular work are crucial to the shipbuilding sector and provide the catalyst that allows organizational learning to occur. The NSPS provides a long-term strategic supply of work that should allow Canadian shipyards to build large vessels competitively and contribute to growth of an effective shipbuilding sector.\(^3\)

Notes

Surveillance of Canada’s Ocean Approaches: Possible and Important?
Calvin Mofford

Immediately following the attacks on 11 September 2001, there was a flurry of activity focused on obtaining a better understanding of who and what was in the vessels approaching North America. The Canadian government announced its intention to build a network of high-frequency surface wave radars as well as extend its network of shore-based Automatic Identification System (AIS) interrogators. Regulations were introduced to require ships to make reports to the Canadian Coast Guard well in advance of their arrival (96 hour rule) in Canadian ports. One of the missions for Radar Satellite 2

![Image of Radar Satellite 2](Credit: Canadian Space Agency)

Canada is currently building the Maritime Monitoring and Messaging Micro-Satellite (M3MSat), a technology demonstration satellite, that will be used to read signals from vessels to manage marine transport in Canadian waters.
(Radar Sat 2) is support of maritime surveillance. Many of these activities were focused on dealing with a potential terrorist threat that never materialized or which was mitigated through regulations and procedures such as the International Ship and Port Security (ISPS) Code and the Container Security Initiative (CSI). Given this reduced threat, is the status quo satisfactory?

The ocean waters surrounding Canada are a simply enormous area. Under the United Nations Conference on the Law of the Sea (UNCLOS), Canada can regulate activities out to 200 nautical miles (nm) from its shores. Economic activities that are in Canadian national interest include fisheries, resource exploitation and ocean-borne trade. But along with these beneficial activities come vulnerabilities which include illegal fishing, pollution from ocean-going vessels or ocean-based activities, smuggling of drugs and other goods, and the transportation of illegal migrants. As well, access to the vast maritime reaches of the Canadian Arctic is controversial, and some countries contest Canada’s claim that the waters of the Northwest Passage are internal.

Given the importance of the oceans to Canada, and the vulnerabilities that go with this, it may be time to put a bit more attention on this matter. Regardless of the lack of a demonstrated terrorist threat, there is still a need to have an understanding of the activities on the oceans that surround Canada. The loss of a fishing boat off Nova Scotia in February 2013, with five lives lost, underscores the need to have a detailed and timely understanding of vessel locations in order to direct resources to save lives.

The challenge is considerable and there is no single technology that can provide a solution. The best solution would appear to be space-based. The Radar Sat Constellation Mission satellites scheduled for launch in 2018 will provide a partial solution. However, with only three satellites in the constellation there will only be several passes a day over any of Canada’s oceans. In addition, like all synthetic aperture satellites, these satellites have variable but finite swaths to their picture, and resolution is lost as the swath gets larger.

The Maritime Monitoring and Messaging Micro-Satellite technology will potentially provide another complementary sensor when it is ready. These satellites can be fitted with an AIS receiver that would cover a relatively wide swath. This increased swath plus the small size of the satellites, and therefore lower cost, means more of them can be launched – and this makes them a significant asset.

Another possible step forward is the fact that the Radar Sat Constellation Mission satellites also have the potential to carry AIS receivers. The problem with AIS-based satellite sensors, like shore-based sensors, is that they are dependent upon vessels actively utilizing their onboard AIS system. Frequency of satellite passes is important because vessels move. The faster they move the harder it is to make definitive vessel correlations unless the vessel has a distinctive signature such as appearance, AIS identity or some other electromagnetic signature exploitable by the satellite payload. The problem becomes even more challenging when the density of vessels increases making it difficult to correlate a given signature to a specific hull. Therefore a persistent look, where there is no break in the tracking of a vessel, is also important. This sort of tracking can be
High Frequency Surface Wave Radar (HFSWR) provided real promise to deal with a large area of coverage and persistence of coverage. The HFSWR coverage could potentially be measured in the low hundreds of miles and it could operate continuously. These attributes would make the number of stations manageable and affordable. Unfortunately the Canadian-developed HFSWR, launched in the early 2000s, had a problem – it was unable to receive regulatory approval to use the frequencies in which it operated. So the plans to establish a network along the East and West Coasts of Canada were shelved. However, Defence Research and Development Canada (DRDC) has continued with a project aimed to improve the functioning of HFSWR technology including using a novel approach for frequency management. The project is now called Persistent Active Surveillance of the Exclusive Economic Zone. So there is real potential that another sensor could be available to add to Canada's sensor toolbox for monitoring its oceans.

Both the micro-satellite and the persistent activity surveillance projects are Technology Demonstration Projects (TDPs) with DRDC. TDPs are meant to develop and showcase potential technologies that would be of practical use to the Department of National Defence (DND). They do not form part of DND’s capital acquisition program until such time as the technology is sufficiently developed, can be made available to industry and meets a need that is of sufficiently high priority to be funded as a project to deliver that capability to the department.

So is the status quo satisfactory? I would say no. There may not be a terrorist threat in the ocean approaches to Canada, but national interests in the activities that occur in Canada’s ocean approaches are immutable. They run the gamut from being able to control and regulate resource exploitation, illegal activities and pollution, to ensuring the free flow of trade. Even more basically, being able to monitor and control these activities allows Canada to establish that its ocean approaches are Canadian and an essential part of its heritage.

There are several promising technologies that will allow Canada to do a better job of keeping an eye on its oceans at a reasonable cost. Whether or not we as Canadians make these investments is a matter of national will. The future will tell.
Sea Kings can be employed for sea surveillance, anti-submarine warfare, troop transport, and search and rescue. The helicopter has an old surface search radar, an aging but effective forward-looking infrared camera, good communications equipment, and a rescue winch. The crews are well trained. No other helicopter in the RCAF has all these capabilities. There are definitely positive factors, but the reliability of the Sea King is uncertain. For example, hydraulic problems have led to several emergency landings around Nova Scotia in recent years. This probably explains why the aircraft is kept close to base in stormy weather.

There was no mention of a Sea King participating in the search for the fishing vessel Miss Ally and her five-man crew in February 2013. During the search, there were CH 149 Cormorant helicopters, CC130H Hercules transports, a CP 140 Aurora maritime patrol aircraft, a Fisheries and Oceans Canada King Air maritime patrol aircraft, a Transport Canada aircraft, and a US Coast Guard Guardian aircraft employed at various times. These additional resources provided sophisticated surveillance technology that was not available on the Cormorant or Hercules primary search aircraft.

Despite the fact that SAR is one of their secondary roles, the Sea Kings were not used during the week-long search for Miss Ally. Both the primary search helicopter, the Cormorant, and the fixed-wing search aircraft, the Hercules, based at 14 Wing, Greenwood, NS, lack an electro-optical/infrared camera and dedicated surface search radar, although both have weather radar with limited surface search capability. While other resources were called upon to fill this gap, the fact remains that Canada’s primary search and rescue aircraft do not have modern surface search equipment and calling on secondary resources, no matter how responsive, consumes time.

Weather conditions were appalling during the Miss Ally search and that was a complicating factor for the searchers. However, search aircraft did fly and were able to find and track the overturned vessel, although sadly, the five missing fishermen appear to have died in the wreck of their vessel. Nonetheless, taxpayers are right to ask whether the RCAF has the proper equipment to fulfill its primary SAR tasks. It is apparent that in this case the RCAF required the assistance of other government departments and the US Coast Guard. Why should this be?

Why do we maintain the Sea Kings if they cannot be employed in marine search and rescue operations – even those close to home as Miss Ally was? Canada should reduce the fleet to what is needed for the deployment of a handful of aircraft with the Royal Canadian Navy and release the crews and money for the modernization or acquisition of other maritime surveillance and SAR equipment.

It has been long recognised that the Cormorant is a very capable but high maintenance vehicle. Spare parts have been in short supply and the failure of tail rotor hubs has
been a continuing worry. The 14 surviving Cormorants are insufficient to provide the necessary SAR coverage in Canada. CH 146 Griffon helicopters are employed at 8 Wing, in Trenton, Ontario, in their place but not elsewhere in Canada. It does not have to be this way.

To reduce the spare parts problem, Canada purchased the entire VH 71 fleet (a close relative to the Cormorant), spare parts stock and testing equipment of an aborted US helicopter project in 2011 for the bargain price of $164,000,000. The decision has improved the service-ability of the Cormorant fleet, increased the number of flying hours by 20% and each of the three Cormorant squadrons now has a ready stand-by helicopter. (It might make US taxpayers unhappy to hear that the US Navy spent several billion dollars on the project before it was abandoned.) Included in the buy were nine barely used VH 71 helicopters. Unfortunately, the RCAF has decided that the helicopters will not be put into service as they are not certified for flight in Canada and would require some modifications for SAR work. The RCAF has never stated what the costs would be for certification and modifications. Taxpayers are entitled to ask how such a decision can be justified without apparent analysis when there is well-founded concern about the adequacy of SAR resources throughout Canada.

While Cormorant readiness has improved, there remains a coverage problem in the North. Canada has signed an international agreement that makes it primarily responsible for SAR response in the North. And yet there are no dedicated SAR resources there.

Taxpayers may struggle to understand the inability of the government of Canada, the Canadian Forces and RCAF to make any progress on the Fixed Wing Search and Rescue Project which was initiated in 2004. This project is supposed to replace the obsolete CC115 Buffalo and the older Hercules aircraft. Coupled with other acquisition debates, there is waning confidence in the ability of the federal government to purchase military equipment, despite the successful purchase of the CC177 Globemaster and CC130J Hercules.

This taxpayer has some suggestions for the government of Canada, the CF and the RCAF. First, leverage a good decision. The maker of the Cormorant and the VH 71, Agusta Westland, believes that seven of the nine barely used helicopters Canada acquired can be converted to meet Canadian SAR requirements. Canada should seriously study this idea and, if a reasonable capability that includes a modern surface search radar and electro-optical/infrared camera can be obtained for a fraction of the cost of new build Cormorants, the idea should be put into action with the highest priority. This will provide sufficient helicopters for all four primary SAR squadrons in the country and a secondary maritime surveillance capability to partially offset the Sea King issues.

Second, the purchase of the Globemaster and new Hercules aircraft freed up eight CC130H Hercules transports, four of which are relatively young, having been purchased in equal batches in 1985 and 1997. These four aircraft could be refitted along the same lines as US Coast Guard HC130H Hercules with a Selex Galileo or equivalent surface search radar for primary SAR duties and assigned to 435 and 413 (Transport and Rescue) Squadrons. The four 1973 vintage units could be used as secondary resources until the Fixed Wing Search and Rescue Project produces a replacement for them and the six old Buffalo aircraft.

The money for the modifications to the VH 71 and the four younger Hercules can come partly from not extending further the life of the non-deploying Sea Kings and partly from the Fixed Wing Search and Rescue Project.

The time has come for action. The Canadian government and RCAF have dithered too long and wasted too much money on studying and debating the requirements and potential solutions for search and rescue aircraft. Taxpayers deserve better results.

Notes

Editor’s Note
Unfortunately some text went missing in the article “Canada and the Arctic” by Jean-François Bélanger in the last issue of CNR (p. 7 of Vol. 8, No. 4, Winter 2013). The text should read: I would agree with Michael Byers when he said in an interview “my preference is for Canada ....”

The online version has been corrected.