CANADIAN NAVAL REVIEW

VOLUME 9, NUMBER 1 (2013)

Maritime Technology Theme Issue

Realistic Timeframes for Designing and Building Ships

They Told Us It Couldn't be Done, But We Didn't Believe Them

Today's Science for Tomorrow's Navy

A Preliminary Analysis of the AOPS Design

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The editorial offices of *CNR* are located at the Centre for Foreign Policy Studies, Hicks Building, Dalhousie University. The mailing address is 1699 South Street, PO Box 15000, Halifax, NS, B3H 4R2.

Phone: (902) 494-3769
Fax: (902) 494-3825
Email: naval.review@dal.ca
Website: www.navalreview.ca

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- provide a source for the public examination of Canadian naval and maritime history and for the development of lessons learned.

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*US Navy sailors assist with the onload of the X-47B Unmanned Combat Air System (UCAS) demonstrator aboard the aircraft carrier USS **Harry S. Truman** (CVN-75). **Truman** is the first modern aircraft carrier to host test operations for an unmanned aircraft.*

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We live in the age of rapid technological change. We carry smart devices that allow us to process information at a rate that was unheard of just a few years ago. In the maritime world the situation is similar but with distinct differences.

What drives changes in maritime technology? There are many influences but in my view there are two basic drivers: the absolute necessity to reduce costs; and the exponential growth in environmental regulations. These events affect both commercial ships and naval vessels.

If a carrier is able to reduce the cost of transporting a unit of cargo, that saving applied many times over will reduce overall shipping costs. One way to do this is to build bigger and more highly technical ships that require reduced numbers of crew. The CMA-CGM *Marco Polo*, which entered into service in late 2012, is the world's largest container ship. She has a capacity of 16,000 TEU[1] and measures 396 metres in length, 53.6 metres in breadth with a draft of 16 metres. With this capacity this ship will generate significant cost savings over smaller container vessels.

The 16,000 TEU container ship, CGM ***Marco Polo***.

Marco Polo has a service speed of 24 knots. Reducing transit speed to 14 will allow a saving in fuel expenditure and associated costs. Slow steaming is becoming the norm with container ship operators because of the lower fuel consumption at lower speeds. Slow steaming has been practiced by many container ships for about four years. The requirement to reduce fuel consumption is driving ship design regardless of the type or size.

Modern offshore oil and gas support vessels have space-age designs compared to their predecessors. For example, *Seven Viking* is a newly minted offshore vessel designed to provide sub-sea repair and inspection services to the oil industry. It incorporates diesel electric propulsion with electrical-driven cranes. But the most prominent of its features is the design of its bow ('X-bow' design) that helps provide an exceptionally stable working platform for the crew.

A second example is a fireboat for New York City designed by Robert Allan of Vancouver, BC. This unique fireboat is named *Three Forty Three* in honour of the 343 firefighters lost in the 9/11 attack. With a length of 140 feet, this vessel of 500 tons can provide firewater at a rate of 50,000 gallons per minute. It also incorporates a pressurized nuclear, biological and chemical citadel that allows the crew to operate the ship in these hostile environments.

The volatility of fuel prices and increasingly stringent environmental regulations are making ship operators look at cheaper alternatives that deliver fewer harmful emissions. Many consider the fuel of the future to be liquid natural gas (LNG). It has several advantages. It is plentiful, cleaner burning and cheaper than the petroleum products now in use. Shale gas is plentiful across the Canadian and American west and promises to make North America self-sufficient in fuel. Its clean burning qualities mean less harmful emissions being pumped into the atmosphere and the ability to meet greener emission targets. On the negative side, it requires much more space to store onboard ship, LNG terminals are not abundant and there are questions about the method of extracting the gas from the shale. As well, there have been concerns about the safety of LNG but from what I can determine it is no less safe than many of the petroleum products we burn or transport on ships today.

Many new ships and retrofits are looking at dual-fuel alternatives with LNG being one of the choices. LNG has significant potential to power fuel cells. Hybrid technology is also gaining popularity. Aspin Kemp and Associates (AKA) of Dartmouth, Nova Scotia, has developed a hybrid propulsion and energy management system that reduces emissions, fuel consumption and maintenance costs. USS *Makin*, the US Navy's newest amphibious assault ship, is fitted with hybrid electric gas-turbine propulsion. *Makin* just returned from a seven-month deployment during which, it is estimated, the ship saved more than four million gallons of fuel.

There is considerable interest in the use of biofuels for military ships, aircraft and vehicles. During RIMPAC 2012 the USN carried out an extensive trial using biofuels to power an aircraft carrier, two guided-missile destroyers, a guided-missile cruiser and an oiler – as well as several aircraft and an Australian helicopter. Biofuels are clean burning but their systems can be more complicated and expensive than regular fuel systems.

Credit: Ulstein Group

Seven Viking *provides sub-sea repair and inspection services for the oil industry.*

The Canadian Coast Guard is investigating whether hydrogen fuel cells can be used to provide propulsive and auxiliary power in the offshore science vessel that is to be built as part of the National Shipbuilding Procurement Strategy. It is an interesting idea but attempting to inject this requirement into the building plan for the vessel would seem to be a recipe for delay and cost escalation.

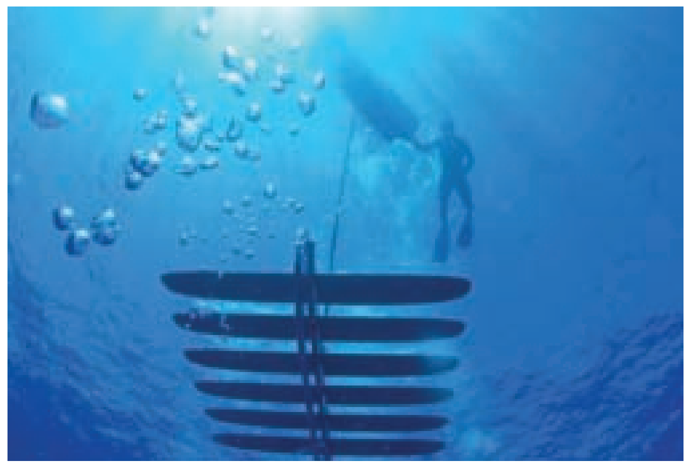
Engine exhaust gas emissions are subject to strict control from the International Maritime Organization and coastal states. Where it is uneconomical to retrofit new engines or change to cleaner burning fuels, exhaust gas scrubbers help to reduce the pollutants. There is a world-class company in this field on Prince Edward Island. Marine Exhaust Systems produces a seawater scrubber called 'the ecosilencer' which reduces sulphur dioxide emissions to a level equal to that of a low sulphur fuel.

Other companies continue to make great strides in environmental technology. Nonox Ltd, a Florida-based company, makes an emulsion combustion system which is novel because its electronic control unit can be switched back and forth between emulsion and straight fuel at the flick of a switch. Its technology apparently provides lower emissions, better performance and fuel savings of 5-15%.

Other technology has been developed to try and stem the incursion of foreign invasive species into a coastal state's rivers and streams. Ballast water treatment is now a strict requirement before a ship enters port, and this presents a monumental problem. A tanker has thousands of gallons of water to treat. The most common way to treat ballast water is to exchange it in mid-ocean, although this is a somewhat risky evolution. Ultraviolet radiation is another method of treating ballast water. Removing oxygen from the ballast water can also destroy organisms. It is estimated that 65,000 ships need retrofitting of ballast water systems. Suffice to say, treatment of ballast water is a work in progress.

Safe disposal of garbage is a problem for every ship at sea. Terragon Environmental Technologies of Montreal has developed a system that has the ability to convert waste such as plastic, paper, food, wood, used oil, etc. into an inert ash. This system has been trialed on HMCS *Protecteur* and by the US Marine Corps, and has shown great promise.

Sensors designed to measure all aspects of ocean structures are appearing almost daily. One of the most unique is a system called Wave Glider produced by the US firm Liquid Robotics. It consists of a surface float connected to a submerged glider. The company claims the key innovation is its ability to harvest energy in ocean waves to provide essentially limitless propulsion. It has recently spent more than 365 days at sea and completed a journey around the Pacific taking ocean science measurements. Those with a military background will immediately recognize its surveillance potential.



Credit: Liquid Robotics

Wave Glider is able to transform ocean wave energy into near limitless propulsion, and can travel great distances taking ocean science measurements.

Another technology that should interest the navy is a technology known as Tethered Air. This technology combines cabled robotics with tethered balloons to move objects over any type of terrain – imagine the camera that buzzes back and forth over a football game carrying a full shipping container. Cargo can be moved at speeds up to 75 miles per hour over a 25 square mile area. The system can be carried in a frigate-sized ship and has potential in disaster relief or situations where cargo or berthing facilities are not available.

There are more technologies than I can discuss in this short editorial. Remotely operated vehicles, unmanned underwater vehicles, electronic navigation systems, icebreakers and integrated platform management systems are but a few. Even paint has gone hi-tech!

Peter Cairns
President, Canadian Shipbuilding Association

Notes

1. Twenty foot equivalent unit container.

Realistic Timeframes for Designing and Building Ships

Commander David Peer

One of the most misunderstood issues surrounding any consideration of fleet renewal is how long it takes to design and build warships. Many Canadians complain that it takes too long. And from a public perspective, this seems to be the case but unfortunately these complaints reveal a lack of understanding of how challenging it can be to forecast fleet requirements and how complex the engineering task actually is. Moreover, the service life of a warship is typically 35 to 40 years in Canada. With a destroyer or frigate now costing in the range of $1 billion, we should expect the government to insist on a comprehensive consideration of the mission requirements and a full investigation of the range of technical solutions. Warships are a huge investment.

Now that Canada has adopted a national strategy for renewal of the navy and the coast guard, it is important to have realistic expectations on the time it takes to design and build ships. Why does it take so long? I will attempt to answer this question.

Credit: Jim Henderson

*HMCS **Iroquois** (DDH-280), launched 28 November 1970, moored at New York Cruise Terminal in 2009.*

Building modern warships is a major national technological achievement. A warship is a complex entity, it is a system of systems, self-contained like a spaceship. In addition to their complexity, warships are designed and built in such small numbers that even the first ship must work right the first time. There is no room for error. The financial consequence of failure is very high, not to mention the risk to national security and reputation.

Canada has renewed its fleet three times since the end of World War II: the *St. Laurent*-class of ships which were destroyers built in the 1950s; the *Iroquois*-class of destroyers commissioned in the 1970s; and the Canadian Patrol Frigates built in the late 1980s/early 1990s. Other than these three occasions, national support for the defence shipbuilding sector enjoyed brief periods of high rhetoric, but little long-term government commitment. Canada's experience is that major warship projects take longer and cost more than originally conceived, but in the end the navy receives highly capable ships. Canada developed a good reputation with the Canadian Patrol Frigate (CFP) project, and the ships have received positive international recognition.

A Chief of Review Services Report on the CPF project in 1999 noted that the cost of the frigates was 10% above a notional free-market price but the class exceeded many of the performance characteristics of similar multi-purpose frigates. What is *not* made clear in the report is that it took 20 years to get the first CPF into the fleet, and the requirements and strategic context for the ship had changed by the end of the project. For example, the government originally envisioned a 24-ship project but it ended with 12 ships.[1] As well, the frigates were designed for the Cold War, but between the commissioning of the first ship in 1988 and the last ship in 1996, the Cold War had ended and the exact role of the ships was evolving.

As noted, the government has announced plans for the next renewal of the navy and coast guards fleets – the National Shipbuilding Procurement Strategy (NSPS). Nova Scotians celebrated in August 2011 when it was announced that Irving Shipbuilding in Halifax would be the supplier for combat vessels for the navy. The mood is more sombre today. When Prime Minister Stephen Harper announced the government's intention to build a fleet of vessels to patrol Canada's Arctic waters – the Arctic and Offshore Patrol Ship (AOPS) – in July 2007, a contract was supposed to be awarded in May 2009, with delivery of the first vessel set for 2013. An announcement was made in March 2013 that the design contract for the AOPS has been signed. The delivery of the first vessel is now planned for 2018 and it will be a while before any ship construction starts.

The AOPS project is following the pattern of history whereby political considerations set the direction and pace of progress in large defence projects. The magnitude of the investment weighs heavily on political decision-makers who introduce requirements for distribution of work and Canadian-content in the attempt to ensure that taxpayers receive the best value.

Ship design and build activities take long enough, so when delays occur the reaction is usually negative. But the discussion suffers from a lack of knowledge about the ship acquisition process. Ship acquisition is like a complicated dance among the politicians who set policy objectives, naval staff who determine the operational requirements, and the project team that develops the solution. Observers see delay but often do not appreciate the risk and the consequence of failure. The risk factor creates caution in the decision-making process.

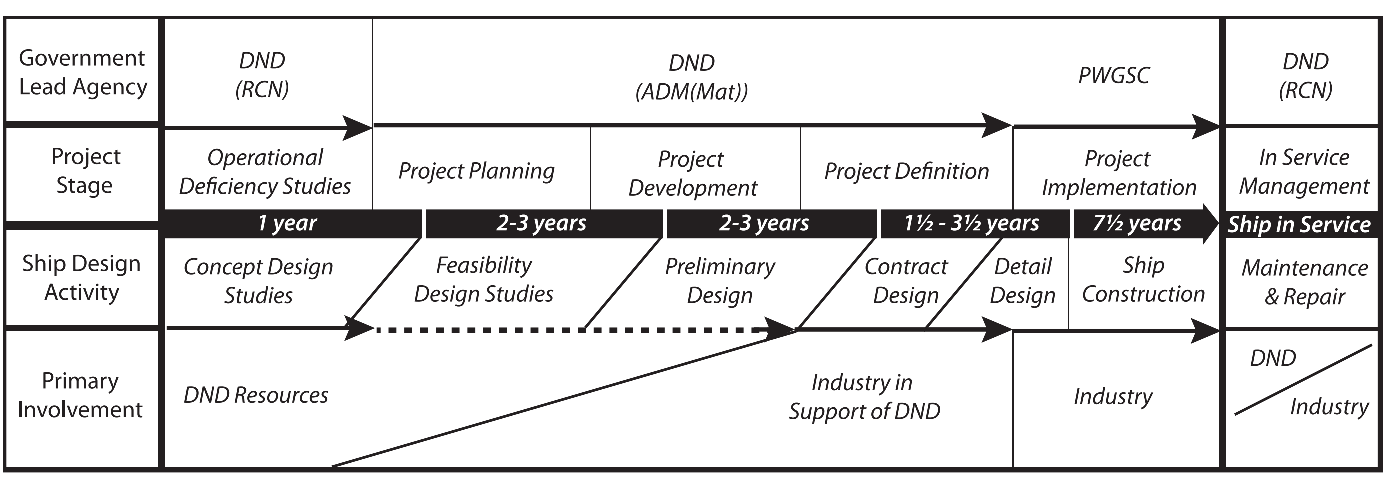
Part of the risk is the unique nature of the shipbuilding market in Canada. Acquiring ships is not like visiting a dealer and buying a car; there is no free market with ready-made solutions. Naval vessels have unique requirements and are built in such low numbers that every ship class is like a concept car. While military off-the-shelf designs are available for warships, they offer limited flexibility to respond to the particular requirements of a navy. For example, no existing design worldwide will meet the requirements of the AOPS, even if some latitude is introduced into the requirement. No country has Canada's unique mix of geography, climate and policy concerns. The desire for an optimal political solution is most often the source of delay. At least three government departments are involved in procurement: National Defence; Public Works and Government Services Canada; and Industry Canada. The dynamic that occurs between departments and in Cabinet makes comparison with other states' shipbuilding projects difficult. We can estimate the time to build a ship, but the political decision-making process is a bit more difficult to predict.

Unlike buying a car, the time it takes to buy a warship must include all design activities and well as construction. If you had to wait for your car to be designed and then built, car buying would also be a long process. It should be noted that it is not just Canada that experiences delays in shipbuilding – buying a warship never occurs quickly, no matter what state is doing it.

An appreciation of the ship design process is necessary to establish the minimum time required for warship acquisition. Figure 1 shows a generic timeline for warship acquisition based on ship design and build activity. The figure shows the entire process from the initial concept to a completed ship. Below each design activity is the organization, or organizations, that typically conduct them. It also shows project activity above the timeline and the corresponding Canadian government lead agency. This figure does not describe the actual procurement process, it just links a generic procurement process with ship design activities.

Ideas for new ships in Canada germinate within the navy when internal studies recognize a discrepancy between the navy's capability and what government policy says the navy is supposed to accomplish. Ideas are formed well in advance of any shipbuilding activity, so they always have an element of risk in terms of future threats and national priorities. Official recognition that Canada needs to consider building new ships kicks off the first set of studies for a project; these explore a future capability deficiency. For the CPF, this took two years. During these studies, the naval staff investigates the range of possible operational solutions. A small DND concept design team, which conducts design studies, works in close

Figure 1. Ship Acquisition Timeline



Credit: Maritime Engineering Journal

Canadian Patrol Frigate megamodule being lowered into place.

communication with the naval staff. In some cases, the naval staff may investigate one solution for more than one capability deficiency. A case in point is the Arctic and Offshore Patrol Ship which combines Arctic sovereignty support and offshore patrol in one ship.

Once the range of solutions that are possible to satisfy a capability is thoroughly investigated, the naval staff will have a concept design with rough costing information for more investigation. They will also have eliminated options due to cost, performance or other issues. Usually, insufficient resources are allocated to explore more than one design at once, so the concept design studies could take years. One year would be an absolute minimum and this would happen only in circumstances where there was considerable pressure to speed up the approval process and tolerance for higher cost risk.

The results of the concept design activity will lead to a submission at the departmental level to set up a capital project and transfer responsibility from a Project Director in the RCN to a Project Manager in the procurement organization under the Assistant Deputy Minister (Materiel) (ADM (Mat)). The transfer also marks the point at which financial resources shift from operations and maintenance to capital funds. The next steps are to confirm the options for further investigation, conduct planning studies, and begin to develop a Statement of Requirement and a System Requirements Document. These project documents are key building blocks for any acquisition.

Depending on the project, the ship design activity may either remain at the concept level as an extended options analysis is conducted or the design may proceed to feasibility designs investigating one or more preferred options in ever increasing detail. At this stage, designers might conduct design trade-off studies to explore the cost and capability relationship of possible solutions or confirm the technical feasibility of a solution. Studies may involve a detailed examination of a high-risk area of design, such as novel propulsion systems or new hull forms. Ship design is evolutionary, so often not all aspects of a design pose similar levels of risk.

The time spent in this stage depends on the number and depth of the studies. Simple modifications to an existing design may need relatively little exploration; novel or complicated designs may need considerable study. The purpose of feasibility design activities is not to design a ship but to ensure that technical and cost risks are acceptable and that the design concept is feasible. Designers could take two to three *years* to understand the range of feasible solutions. This period would be particularly long if a design incorporates new technology to meet the challenges of the future.

The Project Manager decides when the time is right to start a preliminary design. Now that the project team has a good idea of cost and a range of feasible design options, it should have defined the range of designs that offer a solution to the requirement. The purpose of a preliminary design is to improve the cost estimate and ship design details for one or two designs. Designers confirm all critical aspects of the design and all areas of higher technical risk in more detail. The goal is not only more design fidelity, but a more accurate estimate of the cost of the technical solution. The CPF project engaged industry for ship design activities at this point. If the requirement is clear and the design team is experienced, two to three years should be sufficient for this activity. The CPF project team took two years to complete this stage – the 'source qualification' stage.

At the end of the preliminary design stage, the ship project moves into the 'definition' stage, when specifications and requirements for a contract to design and build are assembled. Depending on the contracting strategy and the best avenue for technical and financial risk reduction, the design effort in this stage may proceed to a contract design or detail design level. Which option is selected here will depend on the contracting strategy and whether the contract is performance-based or prescriptive. Prescriptive contracts for building a ship require more design detail; either a contract design for specific aspects of the ship or a fully completed detail design. Performance-based contracts leave the solution to the prime contractor, although the government must be confident that a satisfactory detail design is achievable. In any case, detailed design must be done.

For the CPF project 'definition' took 15 months and involved two separate design teams completing implementation proposals and offers for six ships. At the end of the 15-month period the government paid for two contract designs. Once the implementation contract with Saint John Shipbuilding was signed, an extensive effort was required to validate the design and develop the detail drawings and specification for construction. This effort took an additional two years. Depending on the complexity of the design, the contract and detail design activities could take up to four years.

Project implementation is the easiest stage to estimate because the details on ship build times and operational transfer to the navy are readily available. Figures 2 and 3 show the construction time for each ship in the CPF series – Figure 2 gives the exact dates, and Figure 3 compares the construction times. The CPF project used two shipyards: Saint John Shipbuilding (SJSL), the lead yard in Saint John, NB; and Marine Industries Limited (MIL) in Lauzon, Quebec. The time given in Figure 3 represents the duration from first cutting steel until the ship joins the fleet as an operational unit. The ships built at both yards experienced similar build times. It is clear that

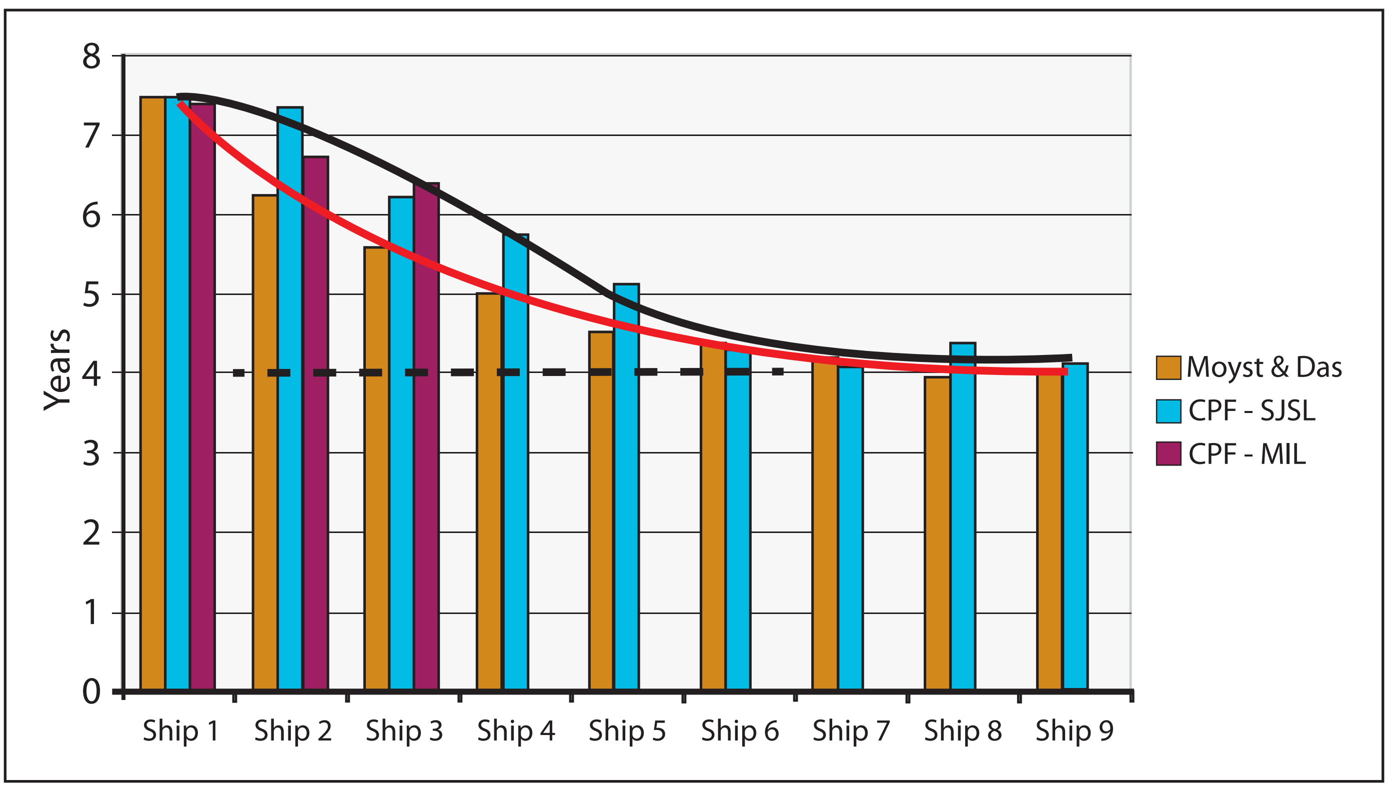
Figure 2. Canadian Patrol Frigate Schedule

		START FAB	KEEL LAYING	FLOAT-UP OR LAUNCH (L)	START SEA TRIALS	DELIVERY
CPF-01 HALIFAX	S.	31-May-86	14-Mar-87	09-Jan-88	20-May-89	25-Oct-89
	A.	08-Jun-86	19-Mar-87	30-Apr-88	06-Aug-90	28-Jun-91
CPF-02 VANCOUVER	S.	14-Feb-87	06-Feb-88	10-Dec-88	12-May-90	24-Sep-90
	A.	06-Dec-86	19-May-88	03-Jul-89	10-Feb-92	11-Sep-92
CPF-03 VILLE DE QUÉBEC	S.	02-May-87	17-Oct-88	27-May-89	16-Jun-90	29-Jan-91
	A.	25-May-87	17-Jan-89	16-May-91(L)	10-Feb-92	11-Sep-92
CPF-04 TORONTO	S.	26-Sep-87	17-Dec-88	21-Oct-89	15-Dec-90	29-Apr-91
	A.	16-Jan-88	24-Apr-89	18-Dec-90	21-Sep-92	23-Dec-92
CPF-05 REGINA	S.	07-Nov-87	18-Jun-88	19-May-90	15-Jun-91	15-Oct-91
	A.	11-Aug-88	06-Oct-89	25-Oct-91 (91)	27-Nov-93	02-Mar-94
CPF-06 CALGARY	S.	06-Feb-88	18-Jun-88	24-Feb-90	11-Jan-92	29-Apr-92
	A.	21-Feb-89	15-Jun-91	26-Aug-92 (L)	19-Jun-94	30-Aug-94
CPF-07 MONTRÉAL	S.	06-Feb-88	18-Jun-88	24-Feb-90	11-Jan-92	29-Apr-92
	A.	14-Jan-89	08-Feb-91	26-Feb-92	20-Jun-93	27-Jul-93
CPF-08 FREDERICTON	S.	17-Mar-90	10-Nov-90	21-Mar-92	12-Jun-93	29-Sep-93
	A.	03-Jul-90	25-Apr-92	13-Mar-93	23-Jan-94	24-Feb-94
CPF-09 WINNIPEG	S.	15-Dec-90	24-Aug-91	19-Sep-92	12-Mar-94	29-Jun-94
	A.	02-Jul-91	19-Mar-93	11-Dec-93	06-Sep-94	11-Oct-94
CPF-10 CHARLOTTETOWN	S.	07-Dec-91	11-Jul-92	18-Sep-93	17-Dec-94	29-Mar-95
	A.	25-May-87	17-Jan-89	16-May-91	(27-Mar-95)	(28-Apr-95)
CPF-11 ST.JOHN'S	S.	26-Sep-92	22-Jul-93	11-Jun-94	16-Sep-95	29-Dec-95
	A.	26-Jul-92	24-Aug-94	(04-Jul-95)	(13-Nov-95)	(10-Dec-90)
CPF-12 OTTAWA	S.	05-Jun-93	29-Jul-94	18-Mar-95	15-Jun-96	29-Sep-96
	A.	31-May-93	(27-Apr-95)	(24-Dec-95)	(27-May-96)	(30-Jun-96)

Credit: Maritime Engineering Journal, No. 35 (June 1995), p.8.

NOTES:
S = CONTRACT SCHEDULED DATE (preOAA)
A = ACTUAL DATE
() = CURRENT TARGET DATES
*28 JUNE 91 was Provisional acceptance For CPF-01. Final Acceptance was 23 Dec 92.

Figure 3. Warship Construction Times



first of class ships take longer to build than the seventh and eighth ships in a series. Once a workforce is familiar with a design, construction times decrease significantly. Figure 3 compares these times against a hypothetical ship series that reduces the first of class construction time by a learning factor identified by Howard Moyst and Biman Das in their study of the cost and time factors involved in building ships.[2] The effect of learning is very important for predicting the time it will take to complete each ship in a series of ships, but it is the delivery of the first ship that really sets the public perception of the time it takes to build a ship, and that's more difficult to predict.

For the CPF project, both yards took 7½ years to deliver their first ship. If you investigate recent international projects you will find that six to seven years is typical for the first of class ships of destroyer or frigate projects of medium power navies.[3] There is no reason to anticipate a significantly faster time for the first ship in a future Canadian project. We know from past shipbuilding efforts that once production is established and the workforce understands a design, build times will decrease. Significant relearning is necessary each time a shipbuilding project starts after a long delay, unless some form of continuous shipbuilding exists.

When similar sized, but less complex, offshore patrol vessels are built to civilian standards construction times can be reduced appreciably. The first ship of the French *Floréal*-class, built around the same time as the CPF in the 1990s, took only two years to build. *Floréal* has no ice protection or cold weather capability, it is a lightly armed constabulary vessel with a simple command and control capability like the Arctic Offshore Patrol Ship (AOPS). In comparison, the FREMM, a cooperative French-Italian designed frigate comparable to the CPF, took seven years. This illustrates that the time of construction can vary significantly depending on the standards and sophistication of the ship. There is a huge difference between building a naval warship and a significantly less complex naval constabulary vessel. This provides an indicator that we should expect the shipyard to build the first AOPS in much less time than a CPF. However, while the time to build an AOPS should be less than a comparable warship, it will no doubt be longer than for the *Floréal*, which was built in a French yard with a full order book and up-to-date design and build experience. In theory, if construction of the AOPS starts in 2015, Irving Shipbuilding should be able to deliver the first ship by spring 2018.

If we add up the time estimates for the different activities in the ship design and build process, the minimum time to buy a ship – from official recognition of a capability deficiency to having a new ship in the fleet – will be at least 14 years for a warship and perhaps three to four years less for a commercial constabulary vessel like AOPS.

But even that number can be disputed because the biggest challenge is knowing when to start the clock. This is not a trivial question, nor is it as simple as it sounds. The naval staff is constantly considering and evaluating capability, so determining the point when a project begins is not always clear. Take the Joint Support Ship (JSS) as an example. The naval staff published an article on preliminary studies and concept investigations in 1994 on the Advanced Logistic Support Concept, a capability that eventually became the Joint Support Ship project.[4] In this case, concept studies were prolonged as the capability requirement was debated before the activity moved forward as a capital project. If we count the years from 1994 when the concept was first discussed, we already have almost 19 years, and the JSS is still far from joining the fleet. But is it accurate to start the clock in 1994, or should it have been started later when the concept had more chance of acceptance? This real life example exposes the complexity of even something as simple as when to start the clock on a project. It also illustrates the difference between an idealized project and reality, where political concerns affect the priorities of government.

Credit: Wikimedia Commons

Carlo Bergamini, *the first Italian FREMM-class multi-purpose variant.*


Credit: Maritime Engineering Journal, (June 1995), p.8

*A **Kingston**-class Maritime Coastal Defence Vessel (MCDV) under construction in the mid-1990s at Irving Shipbuilding.*

The ship design timeline could be significantly shortened by a decision to buy an existing ship or build to a foreign design. However, such a decision would have significant implications for Canadian industry and for the navy. The advantage of saving time in acquisition must be compared against potential consequences both for the navy in terms of suitability and capability and for the government in terms of political considerations. The navy might have to compromise on Canadian requirements that a foreign design could not be affordably adapted to accommodate. As well, Canadian technical experts may not have the same level of design access for maintenance and repair activity, and service support from foreign suppliers may become impossible. And for the government, foreign design or construction means the loss of industrial benefits and employment. These consequences can be completely avoided by prudent planning for the real time scales involved in ship design.

Warship design takes time, no matter which country conducts it. A major challenge to an informed debate on naval fleet renewal is the lack of awareness about the time-frames involved in ship design and build. Moving from an idea to a material ship takes more than a decade, and once built ships can be in service for 40 years. It's no wonder the navy spends time trying to get the requirement right. A significant part of the challenge and the risk is projecting requirements half a century into the future. With so few warships built, there is no room to get the design wrong.

Up until now our discussion of the time to build ships has focused on ship design activity. But there are factors that may extend that time. A good example is the time required to obtain departmental project approvals, which must consider the wider context of expensive capital projects on the total defence budget. Another consideration is the political sensitivity of projects that are national in scope and affect regional employment and industry. The size of these projects generates considerable interest and the timelines involved offer a large window for political involvement in decision-making. And we must not forget that a change of government with different priorities, or a change in economic or strategic conditions, might take the project back a few steps. The maritime helicopter is a good example of government redefining a project even after contracts were signed.

An understanding of the time it takes to design and build warships helps to shape expectations. Ships are not designed and built in a day, and Canadians must understand that. However, Canada is capable of designing and building a warship in a reasonable time once the decision to proceed is taken. We did it with the Canadian Patrol Frigate and we can do it with future warships.

Notes

1. Department of National Defence, Chief of Review Services (CRS), "Canadian Patrol Frigate Cost and Capability Comparison," 26 March 1999, 7050-11-11, available at http://publications.gc.ca/collections/Collection/D2-127-1999E.pdf.
2. Howard Moyst and Biman Das. "Factors Affecting Ship Design and Construction Lead Time and Cost," *Journal of Ship Production*, Vol. 21, No. 3 (August 2005), pp. 186-194.
3. See Royal Institution of Naval Architect, Warship Technology and Naval-Technology website, available at www.naval-technology.com/projects/category/destroyers-and-frigates.
4. Commander S.E. King and Lieutenant-Commander P.J. Brinkhurst, "Afloat Logistic Support: The Future is *Now* for Multirole Support Vessels," *Maritime Engineering Journal*, June 1994, available at www.cntha.ca/images/Otherdocs/mej/mej-32.pdf.

Commander David Peer is the Defence Fellow at the Centre for Foreign Policy Studies at Dalhousie University. His previous position was the navy's senior naval architect at NDHQ.

They Told Us It Couldn't Be Done But We Didn't Believe Them

Major Dwight Bazinet and Captain Kel Jeffries

Even as the Sea King enters its twilight years of service, its capability and relevance are at the highest levels since the Cold War. This comes as a result of efforts to optimize the helicopter from anti-submarine warfare (ASW) to its current main operational role: surface surveillance of non-military vessels in a low threat environment.

The increase in relevance is the result of recent efforts to use the Sea King as a tool to facilitate the transition to the Cyclone. It became apparent that the delays to the Cyclone, the reluctance to modify the Sea King and the inability to provide other training tools for the crews was resulting in an untenable situation. Crews were not being given the ability to 'train as you fight' and their ability to move through the training process was reduced. In short, they were not being given the skills and experience that would be needed to optimize the use of the Sea Kings and the Cyclones which would replace them.

Traditionally, Sea King crews would train with ASW as their primary focus in order to fill their role as part of the Cold War mission of ASW convoy escort. Although dated, their equipment served them well and they gained experience in a staggered training approach. The crews learned basic ASW during their initial training, and then during their first tour were repeatedly exposed to advanced ASW. In garrison they continued to hone their skills in the Operational Flight and Tactics Trainer (OFTT) but, again, the emphasis was on open ocean ASW.

With the end of the Cold War, this focus on ASW at sea changed and as early as 1991 the mission switched to surface surveillance. Crews returning from these deployments found themselves thrust back into the OFTT and forced to re-certify using ASW tactics and procedures. The disparity between how 12 Wing trained and how they 'fought' grew greater as the deployed role of surface surveillance became the de facto role of the Sea King.

Although their crews could adapt to new missions, the Sea Kings were not able to quite as easily since they lacked the tools of modern surveillance. It was integrated radar, Automatic Identification System (AIS) for surface vessels, and user accessible imagery that were most needed to prepare crews for the Cyclone, and a system that fused this data together would be ideal. It was clear that something needed to be done to ensure that training could continue that would bridge the gap before the arrival of the Cyclones.

Credit: Internet

Medal commemorating CH-124 Sea King 50^{th} anniversary.

The idea of using the Sea King as a transitional tool isn't new. In preparation for the introduction of the EH-101, six Helicopter Towed Array Support (HELTAS) Sea King aircraft were converted from the normal dipping configuration. Until the mid-1990s, these aircraft gave valuable insight into the world of sonobuoy ASW and passive acoustics, and HELTAS crews were very successful in their use of this technology. However, with decreased ASW opportunities, the challenges of maintaining readiness with a split fleet, and the eventual cancellation of the EH-101, the capability degraded to the point that it was abandoned. For the arrival of the Cyclone helicopter, the Sea King would once again serve as the platform for transition but it would take the form of a role change away from ASW to a much-needed shift into surface surveillance.

The enabling factors were there – in particular, the emergence of cost-effective technologies combined with specialized expertise in 12 Wing at Shearwater, Nova Scotia – combined with a need to make the change to a surface surveillance role, and this led the development of what is now known as Augmented Surface Picture (ASP).

In order to challenge the crews, continue their training and provide as much capability as possible, the following elements needed to be integrated in the Sea King:

* the capability to track and display a high volume of contacts;
* the ability to display tactical maps, in conjunction with the contacts, in order to give awareness of the operational environment;
* a digitized radar, integrated with the above tactical plot, to facilitate radar tracking;
* the Automatic Identification System (AIS) to provide initial identification of contacts;
* a method to display near real-time imagery of contacts of interest; and
* the ability to import data before flights from external systems and to export it after completion of the mission.

Credit: Maj. R. Loewen and LtCdr M. Cripps, 2012

Early photo of two Sea Kings in formation over Halifax Harbour.

A prototype was rapidly built, using a laptop, to ensure the system goals could be met. This was then used to demonstrate to the weapon system managers and procurement authorities what was possible and what would be needed. The initial demonstration was basic – it showed the ability to develop the surface picture and ingest AIS data on a single laptop – and it was hoped that this would then become the basis for an acquisition of the capabilities.

Although the demonstration was able to define the operational need, it wasn't able to eliminate the technical risk. However, it was able to mitigate the risk enough to initiate a project to progress to a flight trial. The highest technical risk that had to be overcome was the integration of the analogue radar that had been installed in the 1970s with very little improvement since. Other goals were to determine how to integrate the required hardware into the aircraft and confirm that the AIS receiver could utilize an existing antenna.

The first step in creating the system was to develop a means of creating the main signals that the Sea King radar provides, as this would form the basic framework for ASP. As in the legacy OFTT, the ASP system needed to be provided with all the inputs it would receive in flight, so a PC-based system, ingeniously called Stimulator, was developed. In addition to generating appropriate radar returns for land mass it was also capable of creating over 600 concurrent radar contacts, in real time, for ASP to track. In comparison, the radar generator in the OFTT can only create eight.

Once Stimulator was available, the next task was to create the ability to capture these radar signals in ASP. Although dedicated hardware existed, an off-the-shelf USB oscilloscope coupled with an existing piece of test hardware was used at a fraction of the cost of purpose-built hardware. This, however, only captured the signal, and software was then required to accept these millions of radar samples per second and display them on screen in a format that could be used by the crew. Commercial software was available to do this but, again, to reduce cost custom software was written at 12 Wing. The final sensor component of the demonstration model was an AIS/GPS receiver, interfaced to existing aircraft antennas.

Two laptops were carried for the demonstration; the first placed in the rear cabin solely to capture the sensor data. The second was set on the Tactical Coordinator's (TACCO) work tray, as a representative workstation, and the aircraft flew for a single flight in October 2009. The results of this flight demonstrated that there was very little technical risk left in developing ASP and as long as normal design considerations were taken into account, the risk to achieving an airworthiness clearance was also low.

The real risks were operational. First, there was the risk that the operational need would not be met and therefore the capability of the Sea King would actually further decrease. Second, there was the risk that the acceptance of a lower ASW readiness state would not be offset by a higher surface capability. And finally there was the risk that not all normal technical clearance processes could be carried out due to the rapid and in-house nature of the system development. The Chief of the Air Staff (CAS) and Chief of Military Staff (CMS) were briefed about these risks and accepted them, thereby giving authority to proceed, and provided funding for six mission kits.

As the development proceeded, initial design work was completed at 12 Wing on integrating two displays into the tactical console. Two military-specification (MILSPEC) tablet computers were procured and a place to put them was studied, but it was found that they would not be acceptable for flight. As well, dedicated radar hardware and software was obtained and tested but this also required a computer capable of hosting it which made the overall system more complicated and expensive. And finally, a rugged keyboard was tested to replace the existing console work tray.

Throughout the development of the prototype system, the intention was to obtain a solution from industry but it became apparent that the price would be beyond available funds. Therefore, it was decided to develop the system in-house, implementing the software deployed in the demonstrator, developing a more robust radar interface, acquiring a less expensive AIS/GPS receiver, adding an integrated hand-held camera and mounting two laptops to the tactical console in order to provide a two workstation environment. The camera would be interfaced into ASP so that images were immediately available at each workstation and could become part of the surface picture. Additionally, a miniature heading sensor was placed on the camera so that a bearing line would appear on the plot to help identify specific contacts.

Two shortcomings were quickly apparent from flight testing of the new system. The TACCO laptop vibrated too much to be useable and the less expensive AIS/GPS receiver did not perform nearly as well as the demonstrator. Design modifications were rapidly implemented that had the TACCO laptop replaced by a tablet-style notebook directly mounted on the console and a return to the demonstrator AIS/GPS receiver. This was, once again, test flown to ensure suitability and became the final prototype at a hardware cost of approximately $45,000 per aircraft install, for both workstations.

Credit: Warrant Officer Randolph Rice, (Public Affairs), Ottawa

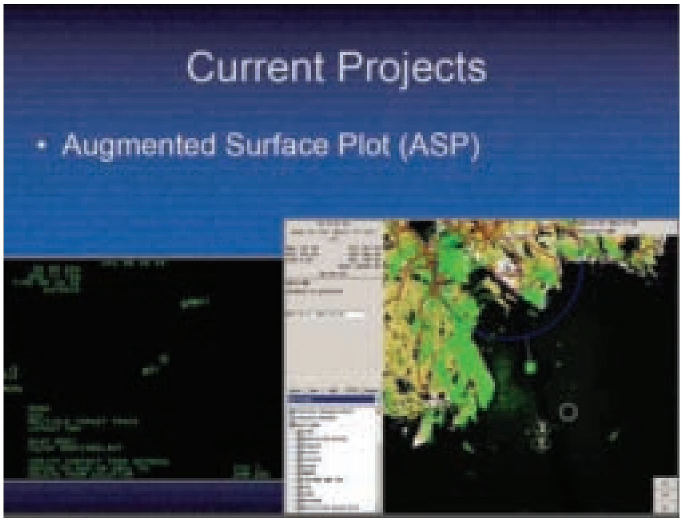
*Members of the Royal 22e Regiment are helped aboard a Canadian troop-carrying CH124B by a crew member from the flight deck of USS **Gunston Hall** during the Integrated Tactical Effects Experiment (ITEE) taking place on the eastern seaboard November 2006.*

Given the low total cost of the system, it was now possible to fit all Alpha model Sea Kings (all but six aircraft in the fleet) with the TACCO workstation while maintaining the original concept of six Sensor Operator (SENSO) workstations as mission kits to be installed when surface surveillance is the primary role.

Following testing and evaluation, a Sea King with this configuration was deployed with HMCS *Toronto* for Joint Interagency Task Force South in fall 2010 with highly encouraging results. ASP provided an immediate increase to the situational awareness of the crew, and the ability for the crew to pass significantly enhanced information to the ship both during and after flight. The AIS that is now included on the Sea King provides a level of information about merchant vessels never before available to the crew, as well as extending the AIS horizon of the ship. In addition, the increased performance of the camera, coupled with integration into the main tactical display simplified the process of conducting long-range visual identification.

But it was the fusion of this data on to an overlaid radar plot that has restored the relevance of the Sea King as an extension of a ship's sensors. No longer are they simply a platform tasked with visual identification of ship-held contacts. Now crews are able to analyse multiple fused data sources to help identify targets of interest. And overall, the system has been successful enough that all ships proceeding on major deployments since the initial installation on HMCS *Toronto* have requested, and been provided with, ASP-fitted aircraft. Of course, success results in its own set of problems. As a result of immediate demand for the capability, 12 Wing and the Aerospace and Telecommunications Engineering Support Squadron (ATESS) needed to create seven production prototypes until the final modification kits were available. The increase in operational effectiveness was, however, undeniable.

In order to maximize the benefits of ASP, it was decided to run the project as a series of spiral developments. This would allow the team not only to make the transition rapidly from one effort to another while the approval system ran its course, but would also allow risks to be minimized by compartmentalizing each phase. The



Credit: Maj. R. Loewen and LtCdr M. Cripps, 2012

A Sea King Augmented Surface Plot (ASP) visual.

failure of one spiral would not affect the core. As the spiral continued, the advance in capability would drive the discussion towards what could be accomplished in the next phase and so on. Adoption of this plan helped to enable rapid development and, while still high risk, allowed sights to be set on high reward items.

At a briefing of the capabilities of ASP to the Commander of 1 Canadian Air Division in November 2010, the potential for the Sea King to provide full motion video to a facility on the ground was raised. This had been proposed as one avenue for development, and the potential for developing this capability shifted attention to Tactical Common Data Link (TCDL). TCDL is a high bandwidth link that moves network packets and is normally associated with full motion video. It requires modern computers to interact with the network and control the link. Prior to ASP, TCDL could not be used in the Sea King. However, not only could ASP enable video via TCDL from the aircraft's forward-looking infrared turret, but the ASP information could also be extended to the ship via TCDL. In fact, virtually any form of network traffic could be moved over this link.

Since an ASP-modified Sea King now had the requisite computers and network, the question was now where the antennas and radios could be mounted on the helicopter, especially since the connection between the antenna and radio must be short in order to obtain optimal range. The team held a brainstorming session and realized that the antennas could be mounted through the internal armament chutes and the radios mounted around these chutes. This would not only provide a simple means to mount the TCDL, it would also allow for rapid installation of what could prove to be a highly effective mission kit in an aircraft that had been modified for, but not with, the system.

A proof of concept system was quickly assembled and demonstrated in January 2011 in order to illustrate that, if funding were to be available, the system could rapidly be developed into a prototype system. By April 2011 an initial design had been manufactured, installed and tested, on the ground, in a Sea King, as a means of transferring full motion video, an ASP tactical plot, still imagery and a basic chat system.

The benefits go beyond simply providing an operational capability. TCDL has given the Sea King community abilities in intelligence, surveillance and reconnaissance that have never been available before. Sea Kings can now provide vast amounts of information in real time, to agencies at sea, in the air, or on the ground. This is both good and bad. The amount of data can be overwhelming at both ends of the link and this means that much thought is

Credit: Private Malcolm Byers, MARPAC Imaging Services

*HMCS **Algonquin** (DDG 283) accompanied by Sea King helicopters, returns to Esquimalt Harbour after a mission with Joint Interagency Task Force South, 23 October 2010.*

Credit: Corporal Rick Ayer, Formation Imaging Services, Halifax

*A CH-124 Sea King helicopter from HMCS **Regina** fires flares during an exercise while on **Operation Artemis** in the Arabian Sea on 20 January 2013.*

now required about the most effective way to employ the aircraft. Certain types of missions require the aircraft to be tightly bound to the ship, passing data back for further analysis, whereas in other missions the aircraft needs freer rein, allowing the crew to determine the best course of action. Striking a balance between the two will be a challenge in the future.

The current spiral of ASP was driven by both an equipment and training need. The systems in the Sea Kings were becoming harder to maintain, and crews qualified on both ASP and legacy configurations are difficult to generate and keep proficient. In order to realize the full potential of ASP while reducing personnel requirements, training for the existing tactical computer must be minimized. The new version of ASP software now includes support for ASW and search and rescue, has just finished operational test and evaluation (OT&E) and is about to become part of training. This means new training tools must be developed for both training units and operational squadrons.

ASP has succeeded for various reasons, not least of which is that it uses new technology smartly. An important lesson is that it is important to balance what is available

Credit: Corporal (Cpl) Brandon O'Connell, MARPAC Imaging Services, Esquimalt

*HMCS **Vancouver**'s Sea King helicopter with the ASP system and a new self-defence suite, conducts air surveillance operations off the coast of Libya during **Operation Mobile**, 13 September 2011.*

against what is really needed, not just what can be done. As well, ASP has succeeded because it was able to chop changes up into smaller pieces and be flexible and focused about what came next. It has balanced curtailing the wish list in the short term in order to avoid being pulled in different directions with supporting flexibility in the medium term. To do that you must have understanding and support from Command in order to provide the top-cover and direction required to meet the aim. ASP had all of these.

Remember that the effectiveness of a system is not enabled by a concise and all-encompassing set of functional requirements. This may provide the basis for the system but it is the implementation that makes or breaks a system in the operational environment. Translating the requirements of operators into easy to use and functional software has been one of the great successes of the project. Finally, working as a team to bring all the pieces together was crucial. The requirements team, implementation team, OT&E team, procurement and funding agencies, all have to be marching in step to accomplish this type of endeavour.

The transitional Sea King, and the Cyclone following it, will usher in a different era for maritime helicopters, one centred around connectivity. The full implications of this are just starting to be realized, but the Sea King is now capable of passing full motion video, imagery, two-way plot information and two-way chat, while in flight, something that has never before been possible. It is now imperative that the Cyclone not be seen as an ASW dipping helicopter like the Sea King was for most of its life, but rather as a joint force multiplier that can contribute to the new roles that are expected of it.

Major Dwight Bazinet is a Sea King Air Combat Systems Officer, and was the primary developer for ASP, while at 12 Wing Shearwater, 2006-2011. He is currently posted to Supreme Headquarters Allied Powers Europe at Mons, Belgium.

Captain Kel Jeffries is a Sea King Air Combat Systems Officer, and has been the prime manager of ASP overall requirements since inception.

Today's Science for Tomorrow's Navy

Mark Tunnicliffe

The Royal Canadian Navy was born at the end of a fundamental technology-driven 'revolution in naval affairs.' Fifty years before the proclamation of the act creating the Naval Service of Canada, the Royal Navy launched HMS *Warrior*, a revolutionary iron-hulled, steam-powered frigate equipped with rifled shell guns. These technologies were not new at the time but their integration into a single vessel created the most powerful warship in the world and essentially made every other ship obsolete.

The use of iron and steel for hull construction removed one of the fundamental limitations imposed by the millennia-old practice of wooden ship construction. Ironically, for large vessels, iron is a much lighter construction material than wood, allowing a greater proportion of a ship's displacement to be used for the 'move' and 'fight' elements of a warship rather than the 'float' element. Revolutionizing ships' propulsion brought basic changes at all levels of decision-making. Tactically, ships were no longer constrained by the wind for course and speed, but fuel supply and consumption rates placed constraints on operational decision-making and created a need for a network of bases for fuel and engineering support. Replacing black-powder iron guns that fired solid shot with long-barreled steel ones that used a cordite propellant to fire armour-piercing high-explosive-filled shells changed naval combat from point-blank to horizon-range engagements.

Credit: Wikipedia

The Royal Navy's HMS ***Warrior*** *integrated many existing technologies in a single vessel.*

In the late 19th century in Britain, the ideas for fundamental technology change largely came from individuals: Isambard Brunel for the application of iron in shipbuilding; William Armstrong in breech-loading rifled guns; and Alfred Nobel for high explosives. The

Credit: Maritime Engineering Journal

The mating of a large, anti-submarine warfare helicopter with a small flight deck on a destroyer was a Canadian first.

Admiralty had to find a means of working with innovators and industry to manage the impact of rapidly evolving technology on British supremacy at sea. The approaches ran the gamut of competing with industry-led solutions to participating directly on the Board of Directors of major industrial concerns. This was the technology environment into which the Canadian navy was born. The challenge for the RCN would lie in where to find answers to the opportunities and challenges presented by science and technology.

The Evolving Experience

The Naval Service of Canada, as conceived in 1910, comprised a number of branches, including hydrography, tidal and current survey, wireless telegraphy, fisheries protection and military services. Ironically, while many of the Hydrographic Service vessels were state-of-the-art, the two naval vessels (HMCS *Rainbow* and HMCS *Niobe*) acquired from Britain were anything but. These ships were intended as training vessels rather than as first-line combatants, but an initial Canadian survey of *Rainbow* noted that her weapons equipment was inadequate even for training.

Fortunately, for the role that the RCN was tasked to play in the world war that broke out four years later, technology was not significant. It was just as well. At the time, most of Canada's formal scientific expertise was to be found in universities and the private sector.

Having little in-house design expertise, the RCN looked to London for advice which, in turn, expected to be able to access all the assets of the Empire in finding solutions to technology challenges. Consequently, when submarine warfare emerged as a serious threat, the British turned to technology for solutions, enlisting Canadians in the effort as well. Recognizing that acoustics would provide the most practical means of detecting a submerged submarine, they exploited some pre-war concepts already demonstrated successfully by a Canadian inventor[1] for detecting icebergs by bouncing sounds off the submerged part and listening for the echo. A McGill University professor, Dr. L.V. King pursued the concept conducting trials with underwater transmissions from HMCS *Cartier* in the Gulf of St. Lawrence in 1916, while Professor R. Boyle of the University of Alberta was recruited by the Admiralty Board of Inventions to lead the work in ultrasonic systems. A practical active sonar system was eventually demonstrated in Toulon in 1918 under a French program, too late to influence the war at sea, but Boyle was credited by the British as a co-inventor of the concept.

Credit: Author

Defence research and development on the ***Halifax****-class frigate.*

Although Canadian technological ingenuity was exploited in a number of areas during the Great War, there was no national structure for identifying scientific assets and applying them to defence challenges in a crisis. Therefore, in response to a British recommendation, Canada established the National Research Council (NRC) in 1916. NRC did not commence a research program until 1925, but after that it emerged as the focal point for technological advice to the navy when Canada went to war again in 1939. While NRC provided good support to a navy that found itself in the frontlines of a war which featured technological measure and countermeasure developments, heading into the war the Canadian science and technology organization remained quite ad hoc. In Halifax, the Naval Research Establishment (NRE) emerged from a request by the navy to Dalhousie University to investigate approaches to protecting ships from magnetic mines. In Ottawa, NRC (the Physics Division was now headed by Dr. Boyle) took the lead for many of the navy's projects with varying results. Notable NRC and NRE successes included the Canadian Anti-acoustic Torpedo decoy in response to the development of an acoustic torpedo by Germany and the production, in six weeks, of the Canadian Naval Jammer as a countermeasure to the He-293 radio-controlled anti-ship bomb.

A major challenge remained however – that of converting a lab concept through industrial production to operational reality. One of the major technological advances in World War II that led to the defeat of the U-boat was 10 cm radar. As British and American supplies of these sets were limited, Canada was largely left to develop and produce its own version – an achievement which came late at considerable cost to operational effectiveness. Canada ran out of time to develop the integrated naval staff, research and industrial production structure needed to respond quickly to a major technological demand in a wartime crisis.[2]

Realizing that the Department of National Defence (DND) needed greater control of its own science and technology program and capability, the government established the Defence Research Board (DRB) in 1947 to integrate the operations of the labs established during the war. DRB, working with Canadian industry, developed technologies or adapted allied equipment to develop capabilities appropriate to the missions of the post-war navy. A practical variable depth sonar (VDS), new sonar transducer technology and the integration of a large anti-submarine warfare (ASW) helicopter on a small ship flight deck supported the RCN's emphasis on ASW in the north Atlantic. The result was the *St. Laurent*-class destroyer, the workhorse of the Cold War RCN.

Not all developments saw the light of day. The Digital Automated Tracking and Resolving (DATAR) system, a data link and ship position management prototype, and the Bras d'Or hydrofoil projects were not integrated into RCN capability directly but they did illustrate the high degree of successful cooperation with industry critical in an era in which Canada was developing its own concepts for war at sea and designing its own warships in-house.

After integration of the three military services in 1968, DRB was dissolved and defence research and development (R&D) became a function within the Assistant Deputy Minister (Materiel Group) (ADM (Mat)). Work continued on ASW and platform concepts and this resulted in the Canadian Towed Array Sonar System (CANTASS) and acoustic and infrared signature management technology used in the *Halifax*-class frigates. However, at this time, DND had ceased designing its own warships, preferring to exploit concepts developed by industry and allies. The 1980s-era *Halifax*-class frigate was largely designed by industry and the *Kingston*-class Maritime Coastal Defence Vessels (MCDVs) were built to commercial rather than military standards. Canadian input from departmental and industry sources came in areas and technologies where it was cost-effective to insert unique systems. In 2001, the R&D function was removed from ADM (Mat) and is now conducted by the DND agency Defence Research and Development Canada (DRDC).

Today's Naval R&D Program

Today's navy is looking forward to a major recapitalization. The *Halifax*-class frigates are being modernized and the navy is planning a new fleet of surface combatants, logistics ships and patrol vessels. In a cost-constrained environment such as we face in 2013, the relationship between departmental R&D and industry must continue to evolve to propose designs that include innovation where necessary and new technology inserted as required to meet Canadian requirements. The research program therefore is designed to anticipate those requirements and to attempt to fill niches that industry is not well positioned to address. The process of anticipating requirements often involves not only pushing the boundaries of technology but trying to forecast the future operating environment of the navy, and demonstrating the art of the possible.

DND's Maritime Science and Technology Program is structured within four domains: above water warfare; underwater warfare; maritime information warfare; and naval platforms. Work spans a spectrum of 'technology readiness' or the degree to which new concepts are ready for deployment in an operational context. Today's program, therefore, identifies emerging technological concepts potentially of interest to tomorrow's fleet, develops selected capabilities that are unlikely to be available from commercial or allied sources, and demonstrates prototype capabilities to

Credit: Author

A depiction of the Command and Control Concepts for Maritime Area Air Defence (C3MAAD) system.

naval force developers in an operational environment. These demonstrations are usually conducted as part of a 'technology demonstration' project which typically consolidates four or five years of precursor work.

One such project is the Joint Fires Support project. This very successful initiative modified allied technologies and integrated them to develop a Joint Fires demonstration system (a 'test bed') that demonstrated a greatly reduced response time to a call for fire-support from artillery, naval or aircraft assets by troops on the ground. Initially conceived with a naval focus, the project became a joint one that was rapidly exploited by the army and is being followed up by a more comprehensive project. Its greatest impact for the RCN will be to suggest requirement specifications to the Canadian Surface Combatant (CSC) project for the coordination of a fire support capability with land forces.

The Joint Fires Support project illustrates that much of the developmental work being done today is not so much in the physical realm but rather improving software, concepts and implementation to improve performance of existing hardware – sometimes dramatically so. The Command and Control Concepts for Maritime Area Air Defence (C3MAAD) project addresses the air defence challenge of detecting, evaluating and tracking a threat in sufficient time to engage it successfully. In an era of supersonic and sea skimming anti-ship missiles fired in salvoes, that time is very short but it can be increased by extending the distance at which sensors and weapons are effective or by improving response times. Since Canada is unlikely to develop new long-range sensors or air defence weapons, the most cost-effective opportunity to buy back some of this engagement time lies in the command and control function. The C3MAAD project proposes to demonstrate a test bed with new air defence coordination algorithms to share sensor information and response tactics amongst a task group to improve response times. An early demonstration of this was recently conducted in a major coalition exercise with very satisfactory results.

The same approach to force warfare coordination is being explored in the underwater realm as well. The Advancing Multistatic Active Sonar Employment (AMASE) technology demonstration will illustrate the potential of networking Canadian sonar technology to exploit multistatic operations. In multistatic operations, an active sonar in a ship, helicopter or sonobuoy emits a ping to generate an echo from a target submarine. If its position and ping time is shared with a distributed network of units operating their sonars in receive-only mode, the echo may be received by any of the receivers to localize the target, potentially increasing the area of coverage provided by the network and allowing the receiving units to remain covert.

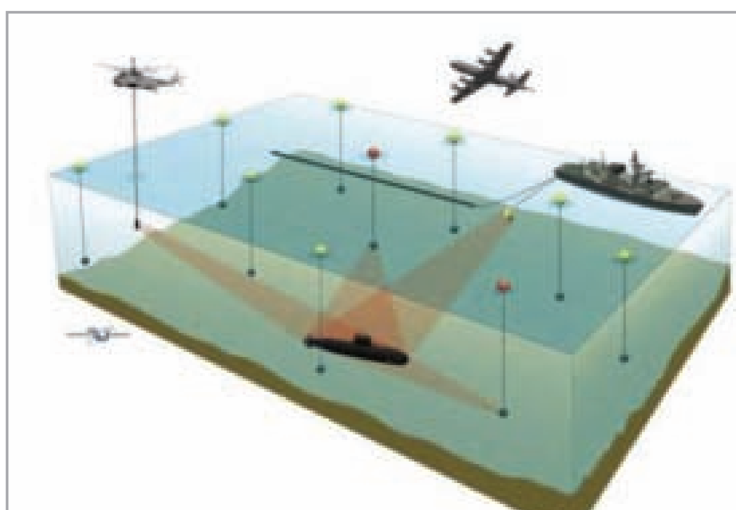
DRDC sensor development currently includes a prototype over-the-horizon radar system for maritime surveillance in Canada's Exclusive Economic Zone and DRDC is exploiting its expertise in lasers for maritime application. Ships operating in the littoral regions are exposed to attacks by land-based weapons, often guided by optical systems, including lasers. DRDC's Laser Optical Countermeasures Against Threat Scenarios (LOCATES) project capitalizes on previous work done in support of the army to integrate laser detection and countermeasures innovations developed for the army to create a shipboard system that can detect laser signals (from range finders, designators or missile guidance systems) and, if necessary, direct a countermeasure laser back at the missile firing post. The technology also allows detection of optical systems pointed at a ship – a capability which led to a serendipitous application of the technique in the Arctic. During the deployment of DRDC's research vessel CFAV *Quest* to the Arctic, components of the LOCATES system were used to exploit optical differences between ice and water to detect growlers. These large blocks of ice are often invisible to radar and represent a danger to ships in northern waters. Initial results are promising, illustrating that in science, what you find is often not what you initially go looking for.

At a more fundamental level, DRDC's R&D work includes: ship signature management technologies to reduce detection ranges against Canadian ships; development of missile decoys or jammers (soft-kill technologies and techniques); force command and control and maritime domain awareness tool development; and maritime employment of unmanned vehicles for decoy, communications, mine countermeasures and surveillance operations. Underwater research is investigating high-bandwidth underwater communications, torpedo defence, diving and engagement modeling. While significant effort in the naval platforms program is given to responding to support requests on warship hull, structures and materials requirements from the major Crown projects, other research addresses maintenance and support technologies not widely available from industry.

What's Next

All this work is intended to support the 'next navy' as announced in the Canada First Defence Strategy, but DRDC also has a responsibility to look beyond that, to the 'navy after next.' This not only involves projecting what technologies might emerge in a world some 50 years from now, but more importantly, how they might be implemented (both by Canada and by opponents) and their impact. The DRDC Maritime Science and Technology Program informs, and is informed by, DND's appreciation of the future world,[3] which provides the context for the development of future capabilities of the Canadian Forces.

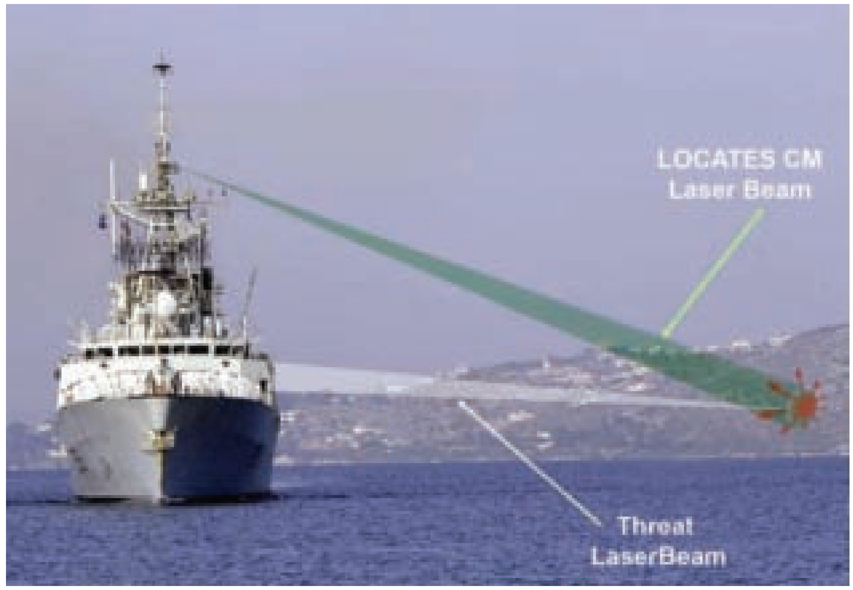
Is the RCN facing a new paradigm shift in the way warfare at sea will be conducted? We won't know until we can examine the situation in retrospect, but we can be sure that just like the mid-19th century, that paradigm shift will not be affected by the introduction of one key technology but by a combination of them.



Credit: Author

The Advancing Multistatic Active Sonar Employment (AMASE) technology demonstrator concept.

Some technologies appear to be evolving in an evolutionary manner while new ones may introduce a step change in naval warfare. What are these and where will they have an impact?



Credit: DRDC

The Laser Optical Countermeasures Against Threat Scenarios (LOCATES) technology demonstrator concept.

Advances in materials (some aided by nanotechnology) may lead to improvements in signature management or composite superstructures, integrated antennae, or perhaps provide a realistic option for armour protection to warships at a limited cost in money and weight. However, iron will still probably remain the fundamental construction material for large ship hulls. Improvements in propulsion and energy will continue to be made, perhaps involving a shift to all electric drive with podded propulsors in which the propellors are driven by electric motors suspended below the ship's hull. But despite the early promise of nuclear power, propulsion systems will likely still be supported by fuel-constrained systems in all but the largest ships and submarines.

There may be a step change in weapons technology if a practical directed energy weapon can be demonstrated at sea. While 'phasers' may seem to be the answer to the anti-ship missile defence conundrum (and lasers have been demonstrated on land to be capable of destroying missiles and bombs), they still face limitations in a high-humidity sea environment and are limited to line of sight. What would a counter to a laser-based air defence look like: a solid shot projectile travelling at hypersonic speeds with internal guidance updated by satellite? The United States is looking at that – another example of the inevitable innovation and counter-development that marks the evolution of military technology.

Perhaps the next major revolution in naval affairs will centre on the technology available to ships' crews. We are already seeing the advances in computer technology, power sources and communications that have led to the development of autonomous vehicles in sub-surface, surface and aerial domains. Autonomous underwater vehicles capable of doing mine countermeasures surveys, long-range reconnaissance and underwater intervention are already operational, while surface platforms conduct patrol and interrogation, target and decoy functions. Given the extensive operational experience already demonstrated by autonomous aerial platforms in many of the roles traditionally conducted by manned aircraft (most notably selective strike operations), how long will it be before we see a fully autonomous major surface or submarine combatant?

While such a capability will pose a wide range of technical challenges – bandwidth, redundancy, autonomy and encryption – the most significant issues are likely to lie in the legal, political, diplomatic and social domains. Unmanned vehicle technology will undoubtedly spread to all major state players and no doubt to non-state actors as well. When this happens, will the technology have pulled sailors out of the frontline of battle only to expose civilians to it instead?

Clearly, the government and Canadians will be interested in the answer to questions like this. So will the RCN. Although it has an internal source of advice on emerging concepts, the broader technological development of the navy will rely on a variety of sources – industry, universities and allies – just as it has always done.

Notes

1. His name was Reginald Fessenden, and he did this work in Massachusetts. He was recommended to the Admiralty by the Canadian Minister of Militia and Defence, Sam Hughes.
2. This is documented in detail in David Zimmerman, *The Great Naval Battle of Ottawa* (Toronto: University of Toronto Press, 1989).
3. Chief of Force Development, "Future Security Environment 2008-2030, Part One: Current and Emerging Trends," Department of National Defence, available at www.cfd-cdf.forces.gc.ca/documents/CFD%20FSE/Signed_Eng_FSE_10Jul09_eng.pdf.

Mark Tunnicliffe recently retired after 35 years in the Canadian Navy and is now working at DRDC Corporate Headquarters on the formulation of the next generation Maritime Research Programme.

A Preliminary Analysis of the AOPS Design

Ken Hansen

The Arctic and Offshore Patrol Ship (AOPS) will be a major new addition to the Canadian naval fleet. The construction of such a ship illustrates a strategic pivot to the north first expressed by the government of Prime Minister Stephen Harper in 2006 when it announced plans to build three heavy armed icebreakers for the navy. That plan was subsequently modified into building between six and eight AOPSs for the navy for $3.1 billion, and one 'polar-class' icebreaker for the coast guard, to cost $720 million.

Criticism of the AOPS concept was immediate and pointed. Most vocal amongst the critics of the AOPS idea is Senator Colin Kenny. Kenny famously classed the new ships as suitable only for breaking the kind of ice one would find in a cocktail glass and too slow to catch a fishing vessel. Citing Michael Turner, a former deputy commissioner of the Canadian Coast Guard from his testimony before the Senate Committee on Fisheries and Oceans, Kenny wrote, "the new patrol vessels would be of hybrid design, they would be only semi-useful in their intended roles … (with only) limited capacity in open water."[1] The criticism didn't stop there.

A naval staff check determined that the first version from the contracted designer was unaffordable. The navy was satisfied with the re-design and accepted the resultant operational capability. Despite this, criticism of the AOPS program mounted when the first call for proposals resulted in costs that were beyond the means of the project. As well, there is great uncertainty about when construction will commence, how many ships will be built and what characteristics they will finally embody. As a result of the criticism and the uncertainty, the entire project is now officially 'delayed.'

To gain a better insight into the AOPS project, in October 2011 the Centre for Foreign Policy Studies invited Commander C. David Soule, Project Director for the AOPS, to make a presentation at Dalhousie University.[2] The presentation was a candid and detailed treatment of the history and design theory of the project to that point.

The data provided by Commander Soule was sufficient to begin a preliminary analysis of the AOPS concept as a means of examining the criticisms made by Senator Kenny and others. In this article I will provide an overview and preliminary assessment of the findings, which I have also presented at a conference and workshop.[3]

Credit: Internet

Left to right: Ross Langley, Vice Chairman of Irving Shipbuilding, The Honourable Rona Ambrose, Minister of Public Works and Government Services Canada, and The Honourable Peter MacKay, Minister of National Defence.

The first task of my analysis was to determine where the AOPS 'fits' as an 'ice-capable' ship. I selected three representative ships from the Canadian Coast Guard (CCG) fleet – CCGSs *Louis St. Laurent*, *Amundsen* and *Sir William Alexander*. These ships portray three broad categories of icebreaker: T1300 'Heavy' or Arctic-class; T1200 'Medium' or River-class; and T1100 'Light' or High Endurance/Multi-Tasked-class. Table 1 compares the AOPS with these three classes of icebreaker in the CCG fleet.

Table 1 shows that the AOPS is comparable with the T1200-class icebreakers for length and beam. It most closely resembles the T1100-class icebreakers for displacement, draught, engine power, range, endurance and bunkers (fuel capacity). The T1200-class, T1100-class and AOPS are all very close with respect to maximum speed. The AOPS appears to be an intermediate step between the medium and light icebreaker types when it comes to motor power (all four types of ships use diesel engines to run electric motors for propulsion). Commander Soule stated in his presentation that the range of the AOPS, 6,800 nautical miles at a speed of 14 knots, was considered inadequate by CCG experts. He suggested that reducing speed to 10 knots could increase range to between 9,500 and 10,000 nautical miles. These numbers are for endurance during transit and not for operations in ice, where a wide variety of factors affect fuel economy.

Table 1. Comparison of Coast Guard Ice-Capable Ships with AOPS

Class	T1300-class	T1200-class	T1100-class	AOPS Design
Displacement	15,342 tonnes	8,090 tonnes	5,029 tonnes	5,730 tonnes
Length	119.6 metres	98.2 metres	83.0 metres	97.5 metres
Beam	24.4 metres	19.5 metres	16.2 metres	19.0 metres
Draught	9.9 metres	7.2 metres	5.8 metres	5.7 metres
Engine Power	40,000 kilowatts	17,700 kilowatts	13,204 kilowatts	13,200 kilowatts
Motor Power	20,142 kilowatts	10,142 kilowatts	5,250 kilowatts	9,000 kilowatts
Maximum Speed	20 knots	16 knots	16.5 knots	17 knots
Range	23,000 n. miles	15,000 n. miles	6,500 n. miles	6,800 n. miles
Endurance	205 days	192 days	120 days	120 days
Bunkers	3,500 cubic metres	2,450 cubic metres	800 cubic metres	690 cubic metres

The AOPS design is as fast as two of the other classes of ships, one of which, the T1200-class, is regularly used in the Arctic. Therefore, the head-to-head comparison on the basis of speed indicates that criticism on this basis is unfounded. Further, all four classes of ship are capable of operating a helicopter, making any relative speed disadvantage to other ships largely irrelevant.

What about the capability of the AOPS to operate in ice? The Statement of Requirement called for an International Association of Classification Societies rating of Polar Class Five, capable of operating in medium first-year ice with inclusions of older 'multi-year' ice. First-year ice is defined as sea ice that is 70 to 120 centimetres thick and which can be present in wind or current-driven concentrations amounting to 100% of the sea surface. Subsequent discussions with the CCG and other operators experienced in Arctic conditions resulted in upgrading the classification of the AOPS bow to a Polar Class Four standard as an additional precaution against the ship inadvertently hitting much harder old ice. This satisfied both the navy and the coast guard that a reasonable minimum standard had been set for the mission and task profiles envisioned for the ship.

Ice operations are not solely an issue of a vessel's hull strength. Power is required to drive the ship forward into the ice, and fuel consumption increases significantly as the power demanded rises. Based on this, there are four critical characteristics that have significant bearing on how the ship will perform in ice – displacement, range, motor power and bunkers. Displacement and range are related to the volumetric capacity of the ship to contain all the resources needed to satisfy both the human and mechanical requirements to continue operating. This is particularly true in the Canadian Arctic as there are currently no facilities for logistical support that either naval or coast guard vessels can use. Logistical planning for the CCG is conducted a year in advance, with fuel being prepositioned in either shore storage or on barges at a selected site.

Displacement and range are connected due to the increase in volumetric capacity allowed by greater displacement. While this analysis focuses on greater bunkerage, larger vessels are capable of carrying all manner of other stores items each of which can extend endurance based on the circumstances. Motor power and bunkers are connected due to the direct relationship between power output and fuel consumption. Typically in naval ships, fuel consumption in open water can be 300% higher at full power than at the most economical speed, which is dictated by hull form and length. Rates of fuel consumption in ice can be even higher. The more fuel the ship can hold, the longer high power settings can be applied, assuming that the ice conditions are not more challenging than those for which the ship is designed. If the ice is thicker or older, the choice to use power and burn large amounts of fuel becomes a question of risk assessment and management.

Credit: Tatiana Pichugina

*The icebreaker and Arctic Ocean research vessel CCGS **Amundsen**, 3 June 2008.*

The four characteristics are compared graphically in Figure 1. Displacement, expressed in thousands of tons (kt), and range, expressed in thousand of nautical miles (KNM), are shown in black. Bunkers, expressed in thousands of cubic metres (Kcum) and electrical propulsion motor power, expressed in thousands of kilowatts (KW) are shown in black. The resulting black points (displacement vs. range) for coast guard icebreakers are connected by a black line. Likewise, the red points (bunkers vs. power) are connected by a red line. The same characteristic comparisons are plotted for AOPS in red and black points. Standard deviation circles for AOPS and T1100 data sets are also shown. The graph shows more clearly than the table that the AOPS design is most like the T1100-class coast guard ship, despite the fact that some of its physical characteristics are more comparable to the T1200-class ship. The graph also shows that the design criteria used by the coast guard for its fleet of ships have been roughly linear, with a clear requirement for increased size and capability for more challenging ice operations.

The graph also shows that there is validity to the criticism made by coast guard experts about the low range and fuel capacity of the AOPS. Operations in the far north, even in summer, are typified by bad weather, low visibility and unpredictable ice conditions. While DND's three yearly northern operations (Nunalivut, Nunakput and Nanook) have shown that it is possible to operate in favourable 'windows' during the late summer months, a credible northern operating capability demands more robust characteristics for the ships that will support those operations.

The AOPS design has been reduced from an earlier version. How would the characteristics of the first version compare both to the CCG ships and to the second version of the design? The data are presented in Table 2.

The comparison in Table 2 shows that a significant reduction (10 to 20%) for displacement, length and draught resulted, likely as a de-emphasis on open-water performance in rough seas where these characteristics produce a more seakindly vessel (one which reduces rolling and pitching motions and provides a reasonable working environment for the crew and fitted equipment). As well, a major reduction (21 to 40%) in engine power and motor power resulted, almost certainly as the consequence of a modest reduction (10 to 20%) in maximum speed. Reducing the requirement by three knots of speed produced a 40% reduction in the power output of the engineering plant, which will substantially reduce cost.

The high priority the navy places on speed and power needs to be matched by an understanding of the importance of volumetric space and fuel capacity for northern operations. The first version of the AOPS design was close in physical character to the CCG's T1200-class ships, which are regularly used in the far north. This was changed in the second version of the ship. The hybridisation of the AOPS between its Arctic and offshore uses has caused the navy to err on the side of speed, rather than endurance. On a comparable displacement it is estimated that the first version of the AOPS managed barely more than half the range and carried less than half the fuel of a very credible CCG Arctic ship.

Figure 1. Comparison of three CCGS class parameters with AOPS

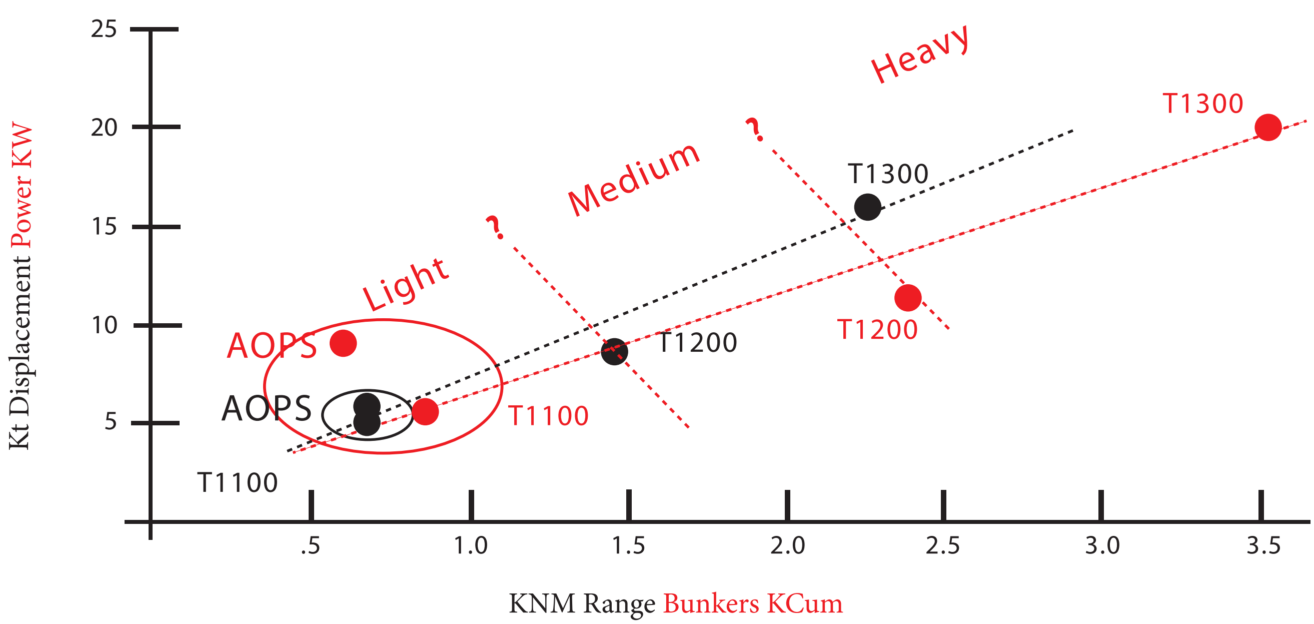


Table 2. Comparison of First and Second AOPS designs with T1200-class CCG Ship.

Class	T1200-class	AOPS V1	AOPS V2	Change
Displacement	8,090 tonnes	6,940 tonnes	5,730 tonnes	-17.4%
Length	98.2 metres	109.6 metres	97.5 metres	-11.0%
Beam	19.5 metres	18.2 metres	19.0 metres	+4.4%
Draught	7.2 metres	7.0 metres	5.7 metres	-18.6%
Engine Power	17,700 kilowatts	18,000 kilowatts	13,200 kilowatts	-27%
Motor Power	10,142 kilowatts	15,000 kilowatts	9,000 kilowatts	-40%
Maximum Speed	16 knots	20 knots	17 knots	-15%
Range	23,000 n. miles	8,000 n. miles est.	6,800 n. miles	-17.4%
Endurance	192 days	120 days	120 days	NC
Bunkers	2,450 cubic metres	810 cubic metres est.	690 cubic metres	-17.4% est.

Note: Estimated data are calculated using a linear relationship for displacement.

It is understandable that naval force planners would seek to maximize the number of AOPSs derived from the fixed funding envelope by reducing capabilities in the design. Numbers provide the most flexibility for scheduling operations and reduce the risk of not having an asset available when unexpected tasks arise. However, the austerity and severity of the northern maritime environment places a premium on size, capacity and self-contained support capabilities unlike anything the navy has experienced since HMCS *Laborador* left the fleet on 22 November 1957. It is evident that the lessons of that era have not been translated and internalized into doctrine by the current generation of naval leaders.

The size and capabilities of the AOPS have been reduced from the first iteration, mainly as a cost-cutting measure. The reduction in the complexity of the ship could make it a more suitable vessel for service with the naval reserve. Despite the reduction in size, however, the AOPS would still be a significant step up from the 970-ton *Kingston*-class ships normally used by the naval reserve. Moreover, the probable length of deployments to the north will mean that very few reservists will be available for such tasks. The new Arctic missions mean it is likely that the organization structure of both the regular and reserve branches of the RCN will become more diversified along functional lines with the development of new classes of specialists in northern operations.

The Canadian Forces generally, and the navy specifically, need to increase logistical capacity to ensure their own viability in the north as well as to provide support services to other government departments and agencies. Based on the almost complete lack of logistical facilities in the high Arctic, the reduction in size of the AOPS seems an odd change and one that will reduce the value of the AOPS for other purely military operations. This does not mean that military capabilities will be absent from the naval Arctic inventory, only that it is unlikely they will be put to their primary purpose in the Arctic. However, a new emphasis on volumetrics and interoperability could lessen the overall relative importance of weaponry.

If the Canadian government is really sincere about its strategic pivot to the north, then all future naval platforms should have the characteristics essential to operate reliably in cold weather combined with good internal reserve space and proper data-processing capabilities. These characteristics would also be useful in a wide number of missions and tasks beyond support operations in the Arctic. The navy's potential to accommodate joint forces, defence and civil scientists plus non-government organizations of all types could be critically important to success in a wide array of military, constabulary and diplomatic missions. It seems obvious, however, that the navy views its role in the Arctic as a sideshow that threatens to drain away resources from traditional capabilities. The revision of the AOPS design indicates that these basic principles are still not part of the theory that guides naval force development.

Notes

1. Colin Kenny, "Canada Needs an Armed Coast Guard," *National Post*, 18 April 2011.
2. Commander C.D. Soule, "AOPS: Evolution of the Operational Requirement and the Associated Design Challenges," CFPS Seminar Series, 5 October 2011.
3. "The Second Sino-Canadian Exchange on the Arctic," held on 26 June 2012; and Atlantic Council of Canada Roundtable event "The Future of the Navy-Coast Guard Relationship in Canada," 13 September 2012. Both events took place at Dalhousie University. Presentation materials used by the author for the most recent event are available on the CFPS website at www.dal.ca/dept/cfps/news-events/news/2012/12/05/the_future_of_the_navy_coast_guard_relationship_in_canada.html.

Ken Hansen is a Resident Research Fellow with the Centre for Foreign Policy Studies and a member of the Science Advisory Committee for the Halifax Marine Research Institute.

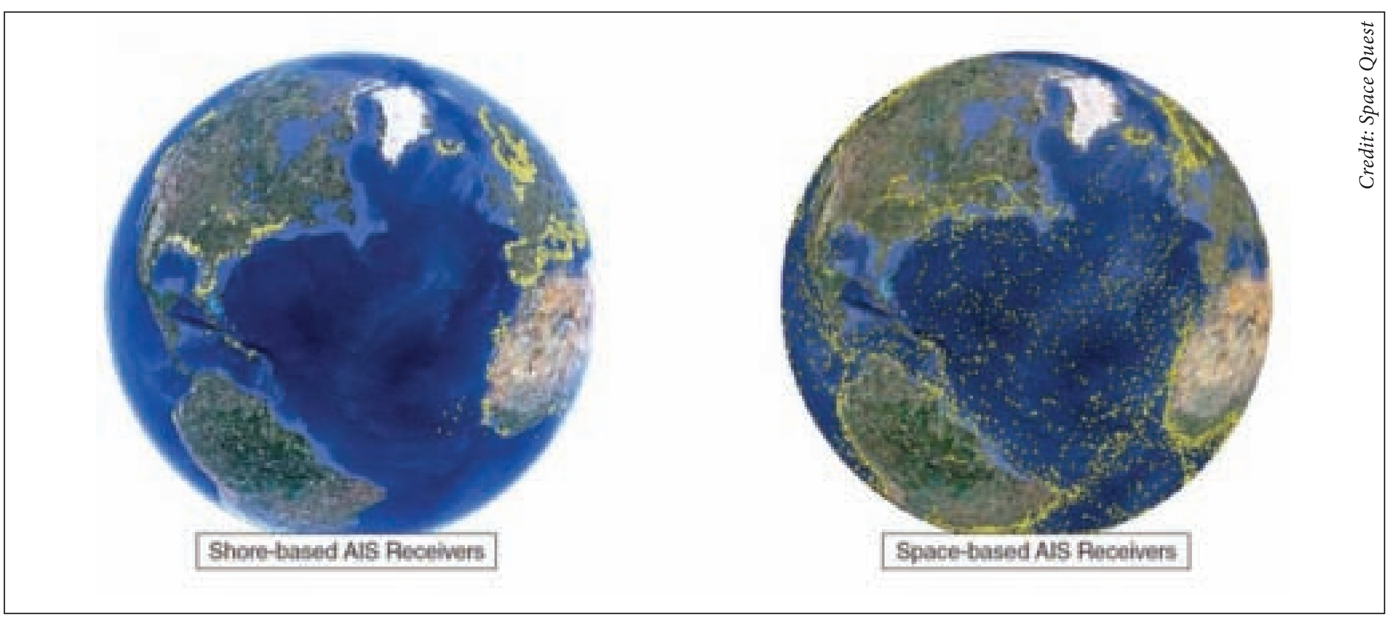
Space-Based AIS: The Game Changer

George Guy Thomas

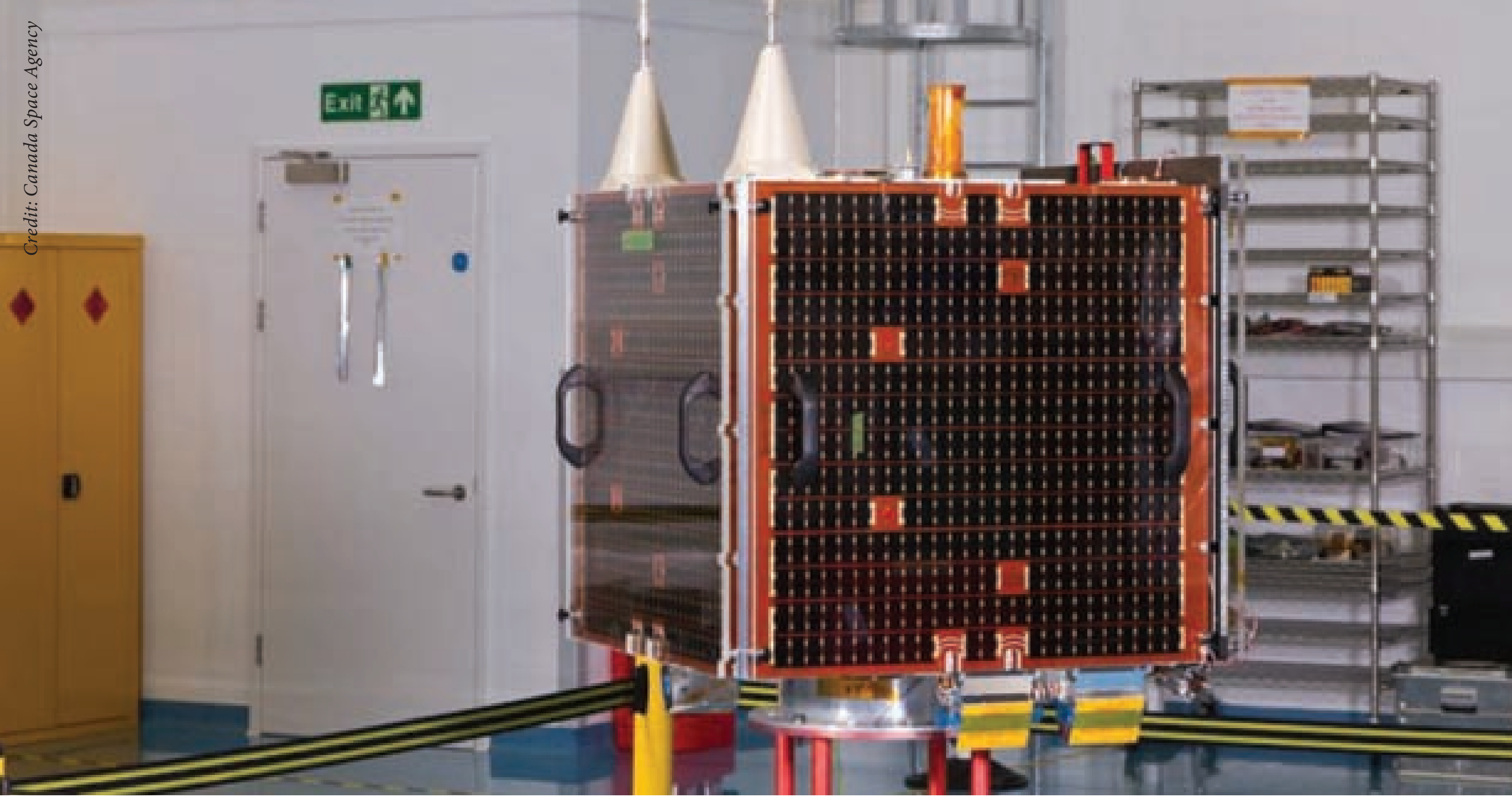
The Automatic Identification System (AIS) was created by a committee of the International Maritime Organization (IMO), an agency of the United Nations, in the 1990s as a collision avoidance and shipping control system. It uses a VHF beacon to identify and provide pertinent information to all similarly equipped ships within line of sight. Some of the information is static, including for example, length, beam, draft, owner, name, IMO registration number and captain. Some of the information is dynamic, including position, speed, heading, rudder angle, next port of call and immediate past port of call. Ships need to broadcast only a limited set of details every few seconds, with the interval dependent on the vessel's speed. Every five minutes ships broadcast all 29 data fields of the system. These are the two basic types of messages, but base stations can request a situation-tailored set of data from a specific ship or from all ships in range. All ships engaged in commercial traffic over 300 tons, all ships carrying six or more passengers, and all tugs over 600 shaft horsepower are now required to carry AIS.

Space-based collection of AIS signals (S-AIS) was conceived less than a month after 9/11. It was designed as a means to increase the security of the maritime assets of the United States from terrorism and, secondly, as a counter-smuggling device. In the ensuing years, the employment of S-AIS has morphed into very wide-ranging usage, not the least of which is the marrying of the output of this system to the other earth observation space systems. Current space-based systems, and ones planned for the immediate future, will conduct a wide range of missions, including security and safety but also provide information to assist in the response to humanitarian emergencies and disasters, safeguard the maritime environment and protect the resources of the sea. Commercial maritime enterprises are also using S-AIS to optimize the use of their assets by timing their operations to a broad range of conditions, including port and berthing availability, actions of competitors, commodities price variations, and traffic loading in a specific area. All of these conditions, plus many more, can be ascertained by studying S-AIS reporting over a period of time. It seems as if smart people are devising new ways to use S-AIS every week. The limits are one's imagination.

One of the major payoffs for the space industry is the fact that the use of Earth observation systems such as synthetic aperture radar satellites (SARsats) and elector-optical imaging space systems (EO sats), which are digital cameras onboard satellites, are now being much more widely used over the world's oceans. The effectiveness of monitoring systems has been increased dramatically because S-AIS can give highly useful indications about where to point these systems for maximum effectiveness, in strategic, operational and, as more terminals come into existence to upload commands to these satellites and download their collected data, in a tactically useful time-frame as well. Indeed, the spread of the terminals is due



Added information provided by satellite-based AIS data collection system.



ExactView-1 satellite by exactEarth prior to launch in 2012.

in part to the realization of the unique usefulness of S-AIS when coupled to SARsats. Thus, as the tactical usefulness of S-AIS has come into sharper focus, the importance of the latency of the S-AIS data has also come into focus. As anyone who has been in combat knows, the more timely and accurate the information, the more useful it will be from both tactical and operational views.

There is a growing realization that what was originally envisioned as an anti-terrorist device has huge applications for other issues at sea as well. It can be used for environmental protection and monitoring, resource safeguarding, and in times of distress, for humanitarian assistance and disaster relief, all while still protecting against unlawful activity at sea such as smuggling, piracy and acts of terrorism. Indeed, S-AIS may have come into existence as a security system, but it is in environmental safeguarding, resource protection and disaster response, as well as to counter smuggling of all sorts (human, contraband, drugs, weapons) that the real value of the system has evolved. All states either on, or dependent on the use of, the seas have these problems in more or lesser degrees. However, no one state has sufficient resources to patrol or even monitor the vast oceans from which these challenges arise.

The recognition of this fact has given rise to the concept now called Collaboration in Space for International Global Maritime Awareness (C-SIGMA). The concept calls for the banding together of all states of good will to share their space resources and unclassified data on maritime operations and conditions. This would create a system not unlike the way weather and civil aviation international flight data is shared globally. A collaborative system would have the purpose of making the world safer, more secure and able to respond more rapidly and effectively to disasters and human needs of all sorts. An effective response would not be possible if it were not for S-AIS and its proliferation on a global scale.

At this time, early in 2013, there are approximately 12 S-AIS receivers in space. Two companies, exactEarth from Canada and ORBCOMM from the USA, are making a business of collecting the S-AIS data and reselling it. Both companies, after launching test/research and development satellites, have turned to the very best satellite builders to push the state-of-the-art in receiver technology. Additionally, several countries, Japan, Norway and India at a minimum, have experimental S-AIS receivers in space. In all cases, more and better follow-on systems are planned. Indeed, the European Space Agency (ESA) and at least one private company are seriously considering putting up a significant number of AIS receivers in space.

Now that S-AIS is well on its way to being a complete system, the other satellite systems with significant input to building a global system – the radar and optical satellite companies – are also rapidly expanding their fleets. Canada has just announced that it will be launching three more SARsats, calling them the Radar Constellation Mission (RCM). The ESA plans to launch at least two Sentinel SARsats; e-Geos, a Telespazio/Finmeccanica subsidiary, has four satellites in a complementary trail formation and is planning to launch four even more advanced satellites in a second constellation. India has just launched two and Japan is planning to launch one SAR and one optical imaging satellite.

This illustrates that S-AIS is evolving rapidly. States are increasingly looking at using these systems for ocean surveillance, as well as over terra firma. But questions remain. There are three relevant questions we should ask before we move forward.

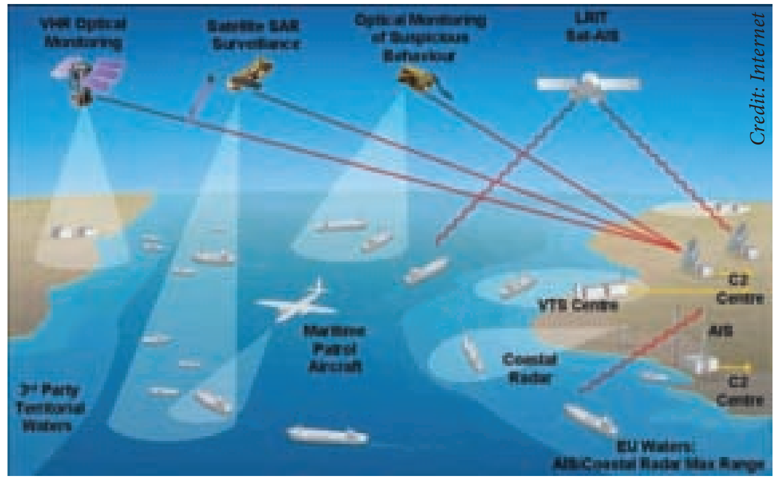
1. What is the actual cost of using these systems in this way?
2. What are the real benefits?
3. What are the costs of *not* using S-AIS/C-SIGMA?

It is the third question that really stands out as you survey what is happening in the early 21st century in the maritime domain. But before we examine that question, let's lay some foundation of C-SIGMA first.

As noted, C-SIGMA uses unclassified systems, including the number of highly capable space systems now on orbit or planned for in the near future, to build a truly global maritime awareness system. This is only possible because of S-AIS. The need for global cooperation is increasingly being recognized. For example, one of the main points of the US Navy/Marine/Coast Guard publication "Cooperative Strategy for 21st Century Seapower" (MS21) is the need for information sharing among all of the world's navies and coast guards. That has been reiterated as a core goal at several International Seapower Symposiums, an annual gathering of Chief Naval Officers of the world's navies and coast guards. To date most of the action moving MS21 forward has been a long list of bilateral meetings. C-SIGMA could change this by providing a specific goal to which everyone can work.

Besides the obvious strategic, operational and tactical advantages of having a much better picture of what is happening off of one's coasts, there are other less obvious reasons to move toward implementing something like C-SIGMA. Most navies in the world are multi-mission organizations. They all have a security mission, but increasingly they spend a large part of their time in resource protection, and many are deeply involved in environmental protection as well. Implementing C-SIGMA offers an opportunity to build the global commons data exchange called for in MS21. As well, it gives all maritime authorities globally a means by which to focus all data-sharing efforts, and can provide a common framework for discussions on information sharing.

Collaborating to share space-based information can result in a synergistic melding of diverse capabilities held by diverse states for common good. C-SIGMA offers



Credit: Internet

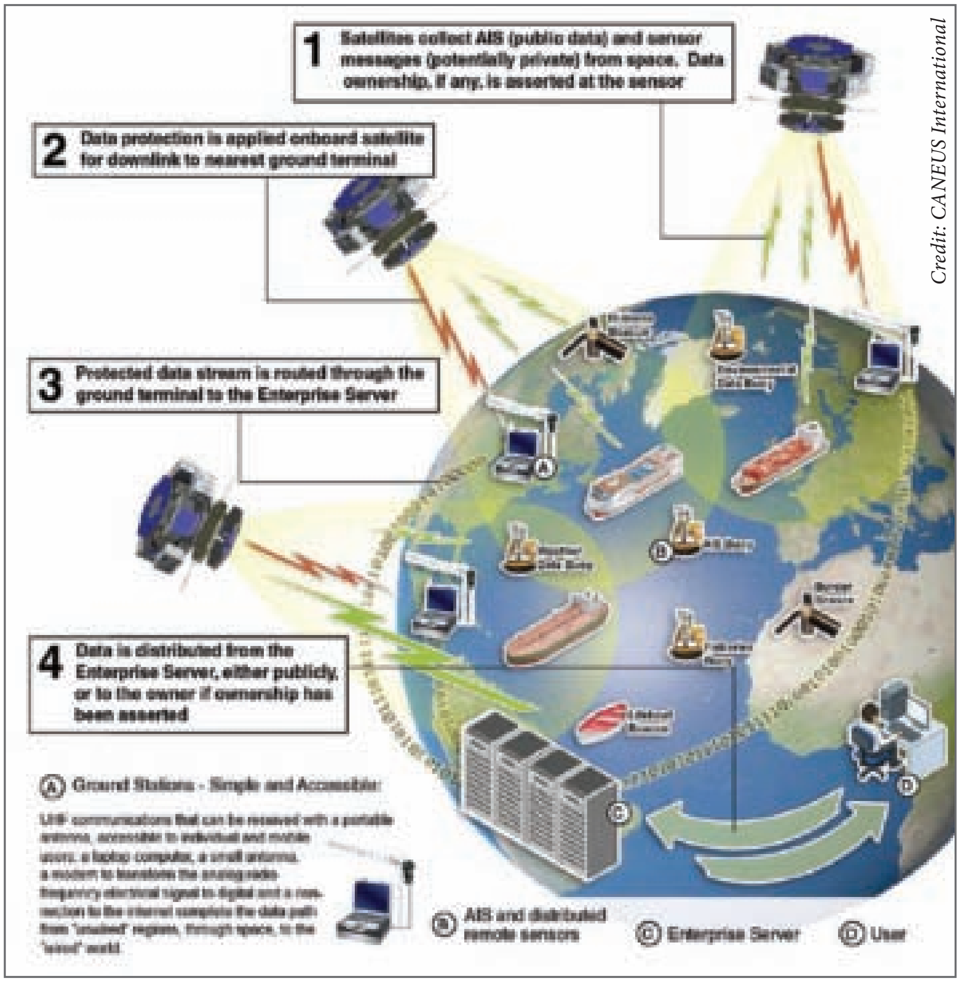
A depiction of an integrated European Satellite Automatic Identification System.

opportunities for better off states to help those which are not so fortunate, while helping themselves address known maritime problems such as smuggling (goods/drugs/people), environmental pollution, resource theft (fish/oil/minerals), safety and security. It's win-win for the global maritime community.

What is needed is someone to take the lead in adopting the system. But whatever agency takes the lead, it should not be an intelligence agency. Across the world, intelligence organizations are just not trusted by the global maritime community, and if the organizing agency is not trusted this will limit the effectiveness of the system. As well, and perhaps more importantly, it would be counter-productive for an intelligence organization to try to lead this effort because in order to be effective across the maritime domain the data gathered by this system must remain unclassified. The vast majority of people and agencies that utilize the maritime domain for lawful purposes do not hold clearance for access to classified information at any level. This is not to say that the products from this system cannot be used by the various intelligence services, but rather that there is a need to make sure the information is available to all legitimate users of the maritime domain. Undoubtedly, there will be one level of separation, that of "for official use only," for use by just the governments which are participating, but otherwise the information must still be basically unclassified.

Building collaboration of space-based information collection efforts provides a huge opportunity for trust building across the maritime domain – if done correctly. This why the agency that hosts the system will be so important. Indeed, the Irish National Space Centre, in coordination with both the government of Ireland and the ESA, is working diligently to establish the C-SIGMA Global

Coordination Centre at Cork, Ireland. Hosting it at an intelligence facility would be a large mistake. If the US National Maritime Intelligence-Integration Office (NMIO) formerly the National Maritime Intelligence Center (NMIC) created a subset or sub-element without the word Intelligence in its name it might be a logical place to host the US Global Maritime Awareness Space Coordination Office, or whatever you want to call it. Other locations to host the US portion of this organization include the Department of Transportation, North-eastern University's Homeland Security Center, or at a university-affiliated re-search centre such as Johns Hopkins University's Applied Physics Lab, or Penn State's Applied Research Lab. The same options would apply in Canada – it could be hosted with the Canadian Coast Guard, or Department of Transportation, or with a university-affiliated maritime organization like those at Dalhousie University. The choices are vast.



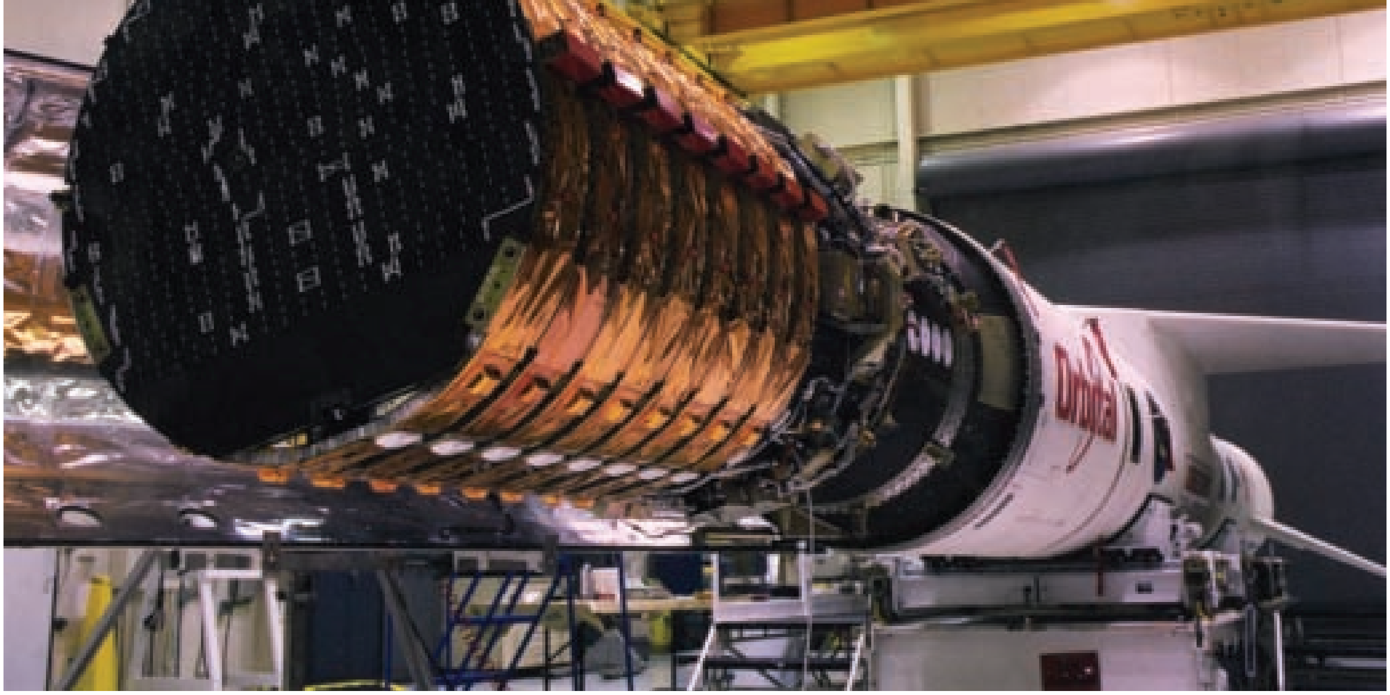
The Space-Based AIS and Data Extraction Backbone.

Credit: CANEUS International

I don't have the resources to undertake the in-depth research needed to define the real benefits and costs of collaborating on the collection of space-based maritime information but the costs of not doing it are self-evident. Billions of dollars are being stolen from the countries bordering the Gulf of Guinea alone – particularly from the offshore oil industry and from fishing areas. Additionally, the countries on the Gulf of Guinea also report significant pollution in their fishing waters. How are these crimes being enacted? By illegal fishing and by the theft from minimally manned offshore oil well pumping stations, or theft from/hijacking of oil tankers by increasingly common and increasingly bold pirates. Nigeria reports the cost is approximately $14 *billion* (US) a year to Nigeria alone. And illegal dumping of oil waste in the waters is also causing significant concern. Ghana, the Ivory Coast, and the other countries on the coast of the gulf report crimes of similar magnitude, but they have not been able to get a firm handle on the numbers because it is difficult to estimate the cost of these illegal activities. This one case, the Gulf of Guinea maritime problems, makes the case for C-SIGMA by itself.

There have been various exercises and tests of this concept over the past six years that also need to be considered. The first test took place in 2006 and used both optical and SAR space craft, coupled with terrestrial AIS, to detect and track target ships. The ships were tracked from the time they left port in Greece until they entered port in the east coast of the United States. Other tests since then, from places as diverse as the waters off Chile, the Seychelles, most of the approaches to Europe, the Gulf of Aden and the Indian Ocean, have clearly shown that we have the technology to collect information from around the world. We also have the ability to fuse the products of the various space systems and introduce information from a wide range of databases to give us a very good idea of which vessels we are looking at and what their history is. We can use this information in order to make wise decisions on who to take a closer look at by sending out the expensive maritime patrol aircraft and interdiction vessels.

Commercial vessels and naval ships are costly systems, and they are being made dramatically more effective with the use of space systems to provide informed cuing and vectoring. Exactly how big the cost savings are from using unclassified space systems is unknown, and should be the focus of a substantial study. However, the people who have conducted the tests – now numbering nearly a dozen – have almost unanimously come to believe that space systems could make the terrestrial systems significantly more effective.



Credit: Wikipedia

A stack of ORBCOMM micro-satellites are mated to their launch vehicle in its final assembly stage.

The costs described in general terms by the commercial providers of these systems seem to be quite reasonable, and could be made more so if all of the users of such systems banded into a common bargaining unit, perhaps under a future C-SIGMA Coordination Centre, and were able to provide a stable order for the space data. Many of us believe that the system could be very cost-effective if all states worked together to create a main centre, coordinating with regional centres all over the world, and it would not be all that expensive to create and operate if resources are pooled together. The main cost would be for the purchase of the data from the commercial earth observation space systems and manning and running a small headquarters. The regional centres would, most probably, be co-located with existing maritime law enforcement and security organizations, such as the coast guards of the world.

There are many advantages to having a central coordinating centre, serving as an 'honest broker' for the entire world. The centre could negotiate for the best prices for data from the several difference commercial providers, it could also be the authoritative source for the capability and status of all space systems with maritime observation capabilities. This is already being done in several regions, such as the European Maritime Safety Agency (EMSA) in Portugal, and the new Japanese Coast Guard watch centre in Japan. Canada and the United States also use commercial systems to help maintain watch on their maritime domain. Why not share the information for the betterment of all mankind?

The other major task of the centre would be as an honest broker for standardization. Standards are a keystone for cooperation – but of course just the keystone, not the whole building. In many instances there is still a lack of standardization. For example, each SAR satellite has a different image and metadata format, and when we asked the commercial providers last year for VDS (ship detections) from SAR images (KSAT, eGeos, DLR), each gave the simple data in a different format.

There are other aspects of standardization besides data standards that need to be addressed. A global centre could be a very useful tool in addressing them. For example, the centre could assist in the access to space-based data, the ordering, the billing, the requests for value added, and the analysis of data. All this could and should be based on standardized machine-to-machine web functionality. Ordering space-based data should be as simple as ordering on Amazon or eBay, and even further automated.

With such standardization, not only are the end-users reached more easily, but also the various providers and value adders can better work together. Standardization might lead to good information, and good analysis of the information, and that would benefit all users of the maritime commons. Having a much better picture of what is happening off one's coasts is a need of all maritime states. Most see this requirement as one that is impossible to be fulfilled, and it was until technology developed over the past few years. All of this started when it became feasible to identify and track ships from space, which only became possible with the advent of space-based AIS and commercial high-resolution synthetic radar satellites, which were not even created with that thought as a primary driver back in 2001. Funny how these things work.

George Guy Thomas retired from the US Navy, US Coast Guard and John Hopkins University Applied Physics Lab. He is now at the Global Maritime Institute for Safety, Security and Stewardship, Taksha University, and Co-Founder/Advisor, C-SIGMA Coordination Centre.

Reality of the Virtual World

Janet Thorsteinson

As the 1985 science fiction novel *Ender's Game* opens, Earth has barely survived successive attacks by an insect-like race of aliens. The only hope of survival in the next war is the military skill of a little boy named Andrew 'Ender' Wiggin. From physical close combat instruction at Battle School, the prodigy soon graduates to the 'reality' of an advanced simulation at Command School. By the time he had been at Command School for a year, he was adept at running the simulator at any of 15 levels, from controlling an individual fighter to commanding a fleet.[1]

In the real world, military simulations have assumed an increasing role in training since the Second World War. Virtual instruction can be safer, less expensive and, in its infinite patience and persistence, more effective in teaching essential skills. The February 2013 report of the Special Adviser to the Minister of Public Works and Government Services, "Canada First: Leveraging Defence Procurement through Key Industrial Capabilities," singles out training systems as one of a half dozen key industrial capabilities the government should consider supporting.

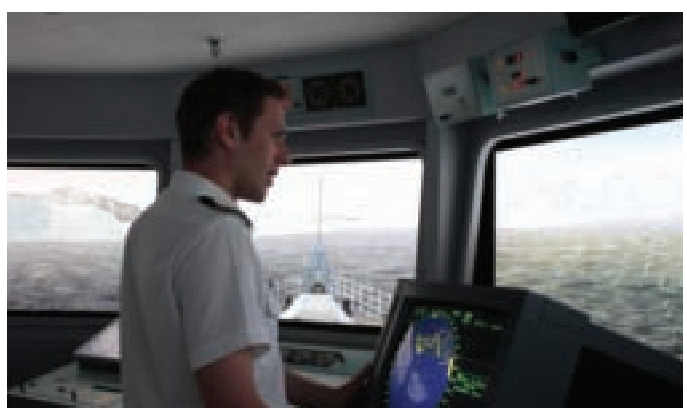
According to the report, advances in digital technology have had both positive and negative effects. They have made the world in which militaries operate more complex, but they have also helped make training more effective. The report notes that the technologies have "enabled a revolution in training based upon simulation, modelling, visualization technologies and, more recently, gaming technologies." As the report says, the components of these training systems include, "digital media; modelling and simulation; ultra-large geographic information systems; massively multi-user environments; and human factors."[2]

The Royal Canadian Navy (RCN) has long used simulators in training. At the Naval Officers Training Centre (NOTC) in Esquimalt, British Columbia, simulations have replaced ships for many instructional requirements. "It's extremely cost-effective," says Captain (N) (Ret) Ken Scotten, the simulator manager at NOTC Venture. According to Scotten, "[t]he cost to run this facility – all the bridges – for a year, is about the equivalent of the cost to run an old destroyer for a week."[3]

The Canadian Patrol Frigate program of the late 1980s/early 1990s was an incubator for many naval innovations, simulations among them. The rising cost of maintaining ship equipment for shore training and the falling cost of computing led to the Canadian development of three simulation-based training systems. First there was the Maintenance Procedures Trainer developed by Lockheed Martin Canada, which cut training time by up to 60% and claims to improve work performance. Norway, Japan, the United Kingdom and the United States all purchased the system. Second, Lockheed Martin Canada also developed the Operations Room Team Trainer, which the navy uses to train and evaluate *Halifax*-class Command Teams. This system uses a synthetic environment and commercial off-the-shelf equipment to duplicate the frigate's operations room equipment. And, finally, MacDonald Dettwiler and Associates (MDA) developed the Naval Combat Operator Trainer (NCOT), a reconfigurable, PC-based trainer that emulates combat systems and equipment. NCOT led to the development of the Reconfigurable Maritime Training System (RMTS), a modular naval training solution that adapts to meet specific requirements for naval training systems around the world.[4] This system is not just used in Canada – the Royal Navy also acquired the RMTS for Type 42 and Type 45 destroyer combat training.

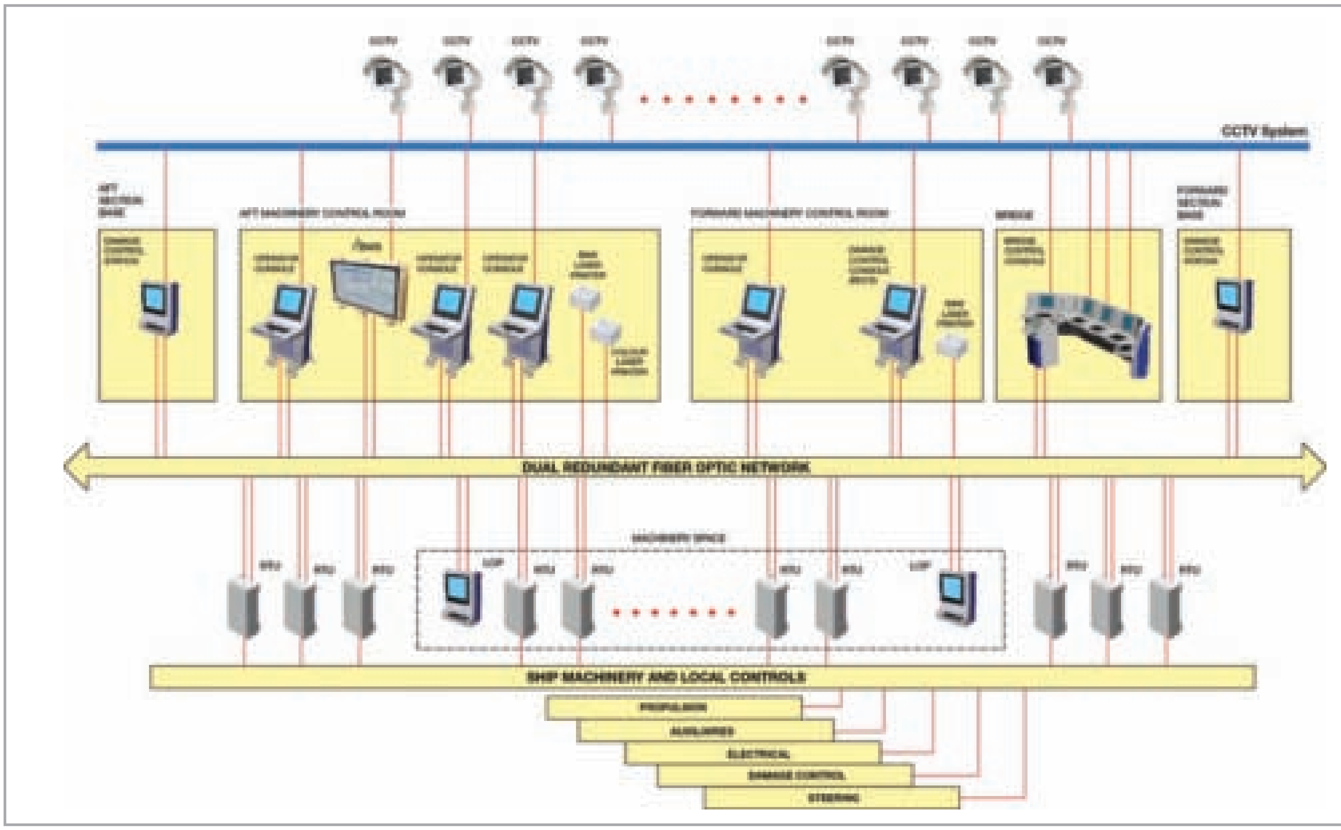
The list doesn't end there. L-3 MAPPS, a spin-off from CAE Inc., a Canadian company that has built a global aviation simulation business, developed the On-Board Team Training System as part of the Integrated Platform Management System. The system simulates controls for a ship's machinery and systems, and includes an instructional capability that allows operators to train while the ship is at sea.[5] Several navies have purchased L-3 MAPPS land-based training simulators.

The Royal Canadian Air Force (RCAF) plans to rely heavily on flight simulators for the new F-35 fighter. With only 65 aircraft in the proposed fleet, and high operational costs, virtual training makes the program more effective and affordable. Speaking last fall, before he became Commander of the RCAF, Lieutenant-General Yvan



Credit: Mr. Terry Moore

Lieutenant (RNZN) André Davies, attending the RCN Arctic Operations course, in June 2012. The simulation in the picture shows an Arctic passage being executed, and showcases the RCN as a leader in simulation technology and training.



Credit: L-3 MAPPS website

A schematic of the L-3 MAPPS Integrated Platform Management Systems (IPMS).

Blondin told Canadian Press that the RCAF was "probably" going to move to training that was 50% simulation and 50% flying. This is a big change from the training program currently in place in which about 20% of advanced jet fighter pilot training is done in simulators. According to Blondin, "[i]f I can do this I'm reducing my operational costs. I am reducing the carbon footprint. It's one way for me to approach the budget restriction we're going to see in the future, so I certainly want to go there."[6]

In the current economic climate, the navy will undoubtedly face similar challenges to its budget. New generations of simulation developed for its new warships offer the opportunity to train crews more cost-effectively, and through computer-based training, those solutions can literally sail with the fleet and enhance sailors' qualifications while at sea. Virtualization technology will support cost reductions in the construction of the new fleet, because modelling and simulation is a component of the National Shipbuilding Procurement Strategy "to attain cost fidelity."[7]

As simulations blur the distinction between the virtual and the real, they can highlight the importance of human judgement. US Airways Flight 1549 from New York's La Guardia Airport flew into a flock of Canada Geese on 15 January 2009 at about 2,500 feet and lost power in both engines. Three minutes later Captain Chesley Sullenberger safely ditched the aircraft in the Hudson River. Everyone on board survived. Sullenberger told USA Today that as the incident happened, he heard "[t]he sound of finely balanced machinery being destroyed, like a tennis shoe thrown into a dryer, only much louder. It was the worst thing that had ever happened in my entire life."[8] In the subsequent investigation, pilots in simulators repeatedly duplicated the incident to show Sullenberger could have performed a safer landing back at La Guardia.[9] Was Sullenberger wrong, or does the decision to steer away from populated areas show a higher standard of judgement? The lesson of the "Miracle on the Hudson" may be to build more Sullenberger into tomorrow's simulations.

Notes

1. Orson Scott Card, *Ender's Game* (New York: Tor Books/Tom Doherty Associates, 1994 edition), p. 259.
2. Report of the Special Adviser to the Minister of Public Works and Government Services, "Canada First: Leveraging Defence Procurement Through Key Industrial Capabilities," February 2013, pp. 31-32.
3. Leslie Craig, "Simulated Training Offers Real Benefits," *The Maple Leaf*, Vol. 14, Issue 27 (September 2011), p. 14.
4. Sovereignty, Security and Prosperity, CADSI Marine Industries Working Group, May 2009, pp. A9-A10.
5. *Ibid*., p. A-6.
6. Murray Brewster, "Pilot Training Going Virtual," *The Chronicle-Herald*, 3 February 2013, available at http://thechronicleherald.ca/canada/626066-pilot-training-going-virtual.
7. Public Works and Government Services Canada, Briefing for Nova Scotia Government Delegation, "National Shipbuilding Procurement Strategy: Benefits of Design Then Build," available at www.tpsgc-pwgsc.gc.ca/app-acq/sam-mps/nouinfor-novadel-eng.html.
8. Marco R. dela Cava, "By-the-book Pilot Sullenberger Opens Up on Life and 'Duty,'" *USA Today*, October 2009, available at http://usatoday30.usatoday.com/life/books/news/2009-10-12-sullenberger-main_N.htm.
9. Andy Pasztor, "'Hudson Miracle' Gets Closer Look," *The Wall Street Journal*, 4 May 2010.

After over 30 years in the public service, Janet Thorsteinson became Vice-President Government Relations at the Canadian Association of Defence and Security Industries (CADSI).

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.

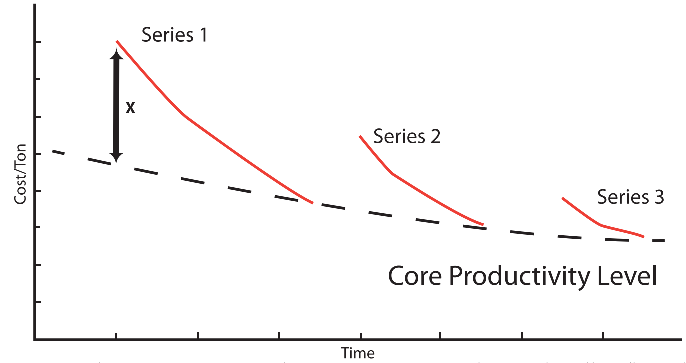
Part of the obligation of the two shipyards selected for the NSPS – Irving Shipbuilding in Halifax and Seaspan in Vancouver – was a commitment to improve their competitiveness and contribute to the long-term health of the Canadian marine industry with a surtax of 0.5% of the value of any contract. The 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



Source: John Craggs, Damien Bloor, Brian Tanner and Hamish Bullen, "Naval Compensated Gross Tonnage Coefficients and Shipyard Learning," Journal of Ship Production, Vol. 20, No. 2 (May 2004), p. 111, Figure 4.

Credit: Maritime Engineering Journal photo gallery

*A **Kingston**-class Maritime Coastal Defence Vessel under construction at Halifax Shipyards, Limited.*

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.

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]

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 ship-building 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.

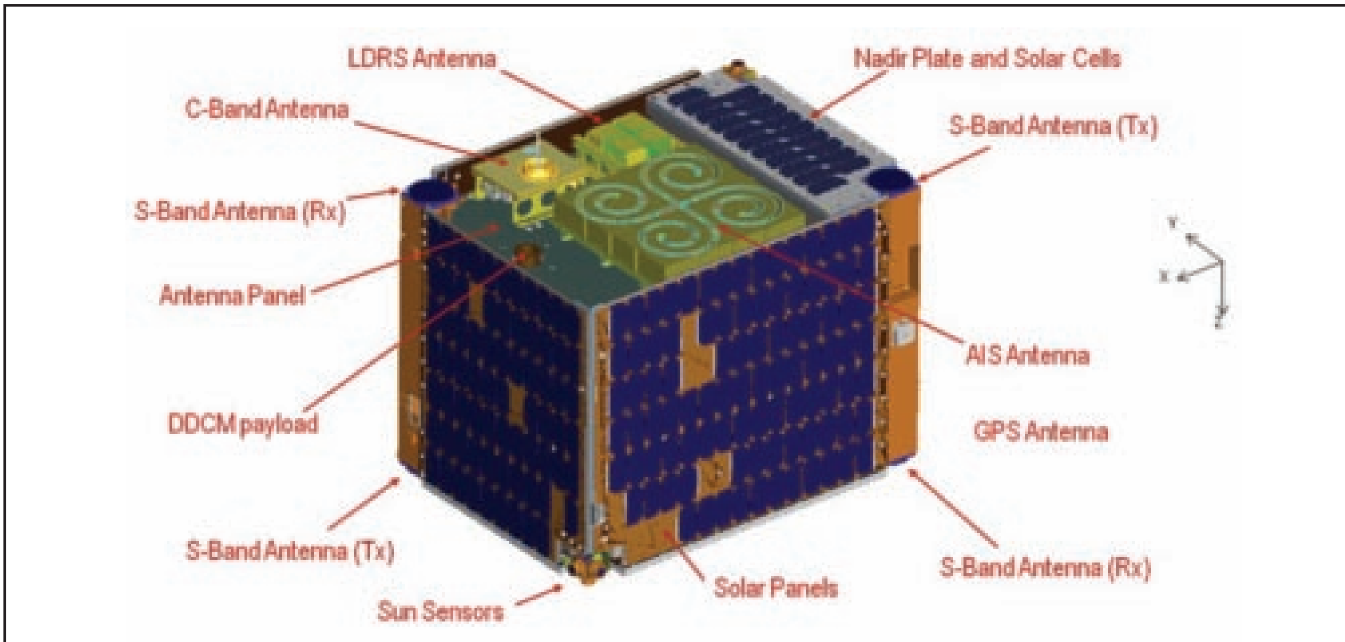
Notes

1. Canada intends to use the expertise of First Marine International to conduct periodic benchmarking of NSPS shipyards to assess whether they have met their commitments related to improving competitiveness. Public Works and Government Services Canada, "NSPS: Frequently Asked Questions," available at www.tpsgc-pwgsc.gc.ca/app-acq/sam-mps/faq-eng.html.
2. John Craggs, Damien Bloor, Brian Tanner and Hamish Bullen, "Naval Compensated Gross Tonnage Coefficients and Shipyard Learning," *Journal of Ship Production*, Vol. 20, No. 2 (May 2004), p. 111.
3. Mark H. Spicknall, "Past and Present Concepts of Learning: Implications for US Shipbuilders," Society of Naval Architects and Marine Engineers 1995 Ship Production Symposium, 25-27 January 1995, available at www.dtic.mil/cgi-bin/GetTRDoc?AD=ADA452935.

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



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.


Credit: Janice Lang, DRDC Ottawa

The High Frequency Surface Wave Radar (HFSWR) installation at Cape Bonavista, Newfoundland, 2003.

(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 provided by shore-based conventional radars but they have a very limited range measured in the small tens of miles, and it would be simply unaffordable to ring the country with a network of these types of radars.

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 is 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.

A Taxpayer's View of Maritime Search and Rescue

Brian K. Wentzell

Several incidents in the past year have raised concerns in the minds of the public with respect to the air search and rescue (SAR) capabilities of Canada, and particularly the Canadian Forces. First was the perceived tardy response by the Joint Rescue Coordination Centre in Halifax to the disappearance and death of a young Junior Canadian Ranger in coastal Labrador. Second was the death in Nunavut of the Search and Rescue Technician who parachuted into the Arctic waters to assist two Inuit hunters but could not reach their small boat. The technician died in the water before a SAR helicopter from Gander could reach him. Finally, there was the loss in February 2013 of the fishing vessel *Miss Ally* and five fishermen off the coast of Nova Scotia in stormy conditions.

The public was unhappy with the search for *Miss Ally*. This raises two issues: the structure of the Canadian government's SAR organization; and the quality of the SAR equipment of the Royal Canadian Air Force (RCAF). This commentary addresses the latter point.

As many Canadians know, this year marks the 50^{th} anniversary of the entry of the Sikorsky CH 124 Sea King helicopter into service with the Canadian Forces (CF). It has outlived several reorganizations of the CF, the Cold War for which it was designed, many of the ships that carried it and some crew members. Its replacement date remains uncertain. The RCAF has declared that it will come to the end of its life expectancy in 2015,[1] but unfortunately, ongoing issues with its intended replacement, the CH 148 Cyclone, may mean an extension.

Taxpayers might be pleased with the longevity of their investment, however, they know all too well that a vehicle can only be kept so long before it becomes impossible to maintain and unreliable to run. The RCAF and federal government could soon be asking taxpayers to shell out more money to extend even further the life of these venerable helicopters.

The Sea Kings are a maritime helicopter used on the frontline every day on the deployed frigate in the Indian Ocean-Red Sea area, and they are used frequently for operations over Canadian waters. Of the 21 Sea Kings at Shearwater in Nova Scotia, however, you rarely see more than two in the sky at any given time. One suspects the Sea King strength is an illusion, and an illusion can create false expectations.

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.[2] 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

Credit: Master Corporal David Singleton-Browne, Canadian Forces Combat Camera

*A Canadian search and rescue technician from 103 Squadron, Gander, Newfoundland is hoisted down from a CH-149 Cormorant to the deck of **Strait Explorer**. This casualty extraction exercise was one of several scenarios in which **Strait Explorer** was involved during **Operation Nanook 12**, 24 August 2012.*

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.[3] The decision has improved the serviceability 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.[4] (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.[5] 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.

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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.

A View from the West: Political Dimensions of Military Technology

Brett Witthoeft

Military technology is a key part of the idea discussed by Carl von Clausewitz, the famed military theorist of the 1800s, of states pursuing political goals by other means. In addition to providing the means to fight wars and address security issues, military technology also advances domestic political goals by providing legitimacy to a ruling regime.

In the abstract, technology is the physical representation that a country has certain qualities and capabilities, such as an educated workforce, access to key materials and an ability to craft specialized equipment. The successful development and deployment of improved technology suggests that the regime that oversaw the process has the competence to provide the means for such advancement. This competence displayed in one area creates a halo effect that is applied elsewhere: if a government is able to produce advanced weapons and systems, whatever its other faults, it must be fit to govern.

This effect is probably most evident in North Korea. North Korea has long followed a 'military first' policy (*songun*) that not only prioritizes the military in the distribution of state resources, but also places the armed forces at the centre of daily life. *Songun* was emphasized in the 1990s by former leader Kim Jong-il in part to maintain control over an increasingly brittle state that was under pressure from floods, droughts and deteriorating manufacturing capabilities related to the loss of one of its key patrons, the Soviet Union.[1] The difficulty with *songun* as the central tenet for the Kim regime is that the military, for all its size and conventional military capabilities, has been in steady decline for 15 years.[2]

This is where North Korea's advanced technology projects – namely, its nuclear and missile programs – take centre-stage. Despite the occasional failed test, the Kim regime and North Korean military have acquired significant deterrents against external enemies, which grants them the halo effect of competence. This halo is reinforced by the fact that South Korea and Japan have made significant investments in anti-missile defences, and global powers have engaged North Korea on its nuclear program via the Six Party Talks. These reactions to its weapons technology by outside powers indicate that the North Korean regime is sufficiently important to warrant such attention, and is therefore legitimate. Lacking clear political and military credentials, current North Korean leader Kim Jong-un has continued the weapons development projects to garner some of the political legitimacy of his father and indicate his continued support of *songun*.

Credit: U.S. Navy photo by Mass Communication Specialist 1st Class Bobbie G. Attaway

Helicopters fly over the Republic of Korea Aegis destroyer ***Sejong the Great*** *(KDX 991) during an international fleet review in October 2008 celebrating the 60th anniversary of the Republic of Korea.*

In the maritime realm, China's acquisition of its first aircraft carrier – carriers are highly complicated pieces of technology – marked an important step in its rise as a regional and a global power. The Mahanian idea that Great Powers should be supported by strong navies is deeply rooted in China. As the only member of the UN Security Council without an aircraft carrier, China lacked a potent naval capability and significant symbol of its Great Power status and technological prowess.

The idea of acquiring its own aircraft carrier was born soon after the foundation of the People's Republic of China in 1949, but a lack of funds meant that it was not a priority.[3] A strong push for an aircraft carrier for the People's Liberation Army Navy (PLAN) did not come until 1986, and over the course of two decades, support for a carrier grew, moving from the PLAN to government agencies and think tanks to the public. One weakness associated with a lack of aircraft carrier capability was illustrated by the 2004 Indian Ocean tsunami, when the United States dispatched the *Abraham Lincoln* carrier strike group to assist Indonesia but China could not do the same, even though the tsunami occurred in its own

*Pakistan navy frigate F-22P **Zulfiqar** on a visit to Port Klang, Malaysia, 27 August 2009.*

neighbourhood. This was highlighted in popular Chinese media, in particular by a December 2006 Chinese Central TV program entitled "The Rise of the Great Powers," which emphasized the link between Great Powers and great navies.[4] In the face of this popular movement, and in part because of its reliance on military-related nationalism for its political legitimacy, the Communist Party was almost forced to make acquiring a carrier a top priority. It was no accident that the carrier *Liaoning* was commissioned and publicly displayed just before the once-in-a-decade leadership transition in November 2012. The ship demonstrated the Communist Party's ability to produce Great Power capabilities.

On the international level, technology is an important means of strengthening relationships and alliances. Information sharing, technology transfers, joint project development and equipment transfers help bring two countries together by intertwining their military capabilities and displaying trust. One example is the Pakistan-China relationship which has become increasingly close since the 1970s. In addition to collaboration on major projects such as the JF-17 fighter, Pakistan has procured four *Zulfiqar* general-purpose frigates from China. The fourth of these frigates was built in Pakistan, is now undergoing sea trials and is expected to enter active service in 2013. The *Zulfiqar* project is mutually beneficial, as China's augmentation of Pakistan's capabilities means China has a more competent ally in the conflict with their common antagonist, India, and Pakistan has received much-needed knowledge, experience and military technology.

Tokyo and Canberra have become increasingly close since the signing of the 2007 Joint Declaration on Security Cooperation, with regular ministerial dialogue and an intelligence-sharing agreement. Japan may transfer key technology from its advanced *Soryu*-class diesel-electric submarines to Australia. The naval relationship between the two countries has strengthened with increased participation in Rim of the Pacific (RIMPAC) exercises. Both countries dispatched warships and flag-rank component commanders who worked side by side for the 2012 RIMPAC. As well, the Royal Australian Navy (RAN) provided assistance to Japan following the March 2011 earthquake and tsunami, and has conducted several joint exercises with the Japanese navy. With Japan's relaxation of its arms export restrictions in December 2011, the Australia-Japan relationship looks poised to take a step further. In May 2012, a senior Australian official examined Japan's *Soryu* submarine, and in July 2012 there was another inspection of the boat by the head of the RAN's Future Submarine Program. These visits led to Australian Defence Minister Stephen Smith's confirmation in September 2012 that Canberra is strongly considering *Soryu* systems for the RAN's next submarine.[5] There are significant hurdles to be overcome in a *Soryu* transfer, such as where the boats will be built and the degree of technology transferred, but the project holds the possibility of bringing the two allies even closer together.

Credit: Military-Today.com

*The 4,2000-tonne **Soryu**-class deisel-powered attack boats are the only new conventional submarines of the size and capabilities set out in Australia's 2009 Defence White Paper.*

Technology is much more than computer chips, explosives and wiring. Weapons and equipment underpin regime legitimacy, unite a government and its populace in a common cause, and bind countries together in projects of mutual interest. In this way, technology is an important tool in the toolbox of militaries and governments, both domestically and internationally.

Notes

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Brett Witthoeft is the senior research analyst in the International Engagement section at Maritime Forces Pacific.

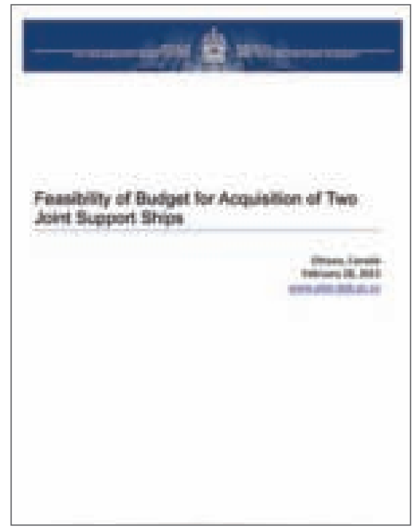
Dollars and Sense: How Much Technology Can the Navy Afford?

Dave Perry

The column "Plain Talk" by Sharon Hobson has frequently been critical (and rightly so) of the lack of clear government communication about matters related to defence. Too often, officials and politicians speak in generalities that fail to articulate government strategy or policy on critical issues. Given this state of affairs, plain talk should be applauded. In this spirit, senior officials associated with the National Shipbuilding Procurement Strategy (NSPS) should be commended for their candour in a recent technical briefing given the day before the Parliamentary Budget Officer (PBO) released a report entitled "Feasibility of Budget for Acquisition of Two Joint Support Ships." In the briefing, the senior government officials addressed the speculation that the $2.6 billion budgeted by the government to procure two to three Joint Support Ships (JSS) will not be sufficient to procure two vessels.

The officials unequivocally stated that two JSS will be affordable within the project budget, and cost-capability trade-offs will be made as necessary to ensure that this is so. The budget, they stated, includes a $300 million contingency, and the capability requirements will be adjusted (downward, although that wasn't stated explicitly) to ensure the budget envelope is not exceeded.[1] On the one hand, this clarity is heartening. On the other, its implications are troubling.

The next day, the PBO's report concluded that the $2.6 billion budget is problematic. The PBO used a sophisticated cost-estimating tool to undertake a parametric costing analysis of procuring two JSS under the NSPS framework. Without a clear understanding of the exact characteristics currently envisaged in the JSS project, since the most recent Statement of Operational Requirements is no longer available to the public and the final design has yet to be selected, the PBO estimated what it would cost to build two of the *Protecteur*-class supply ships (AORs) currently in service with the Royal Canadian Navy (RCN). Based on its analysis, the PBO estimated that simply replacing the existing naval replenishment-at-sea capability would cost $3.28 billion. Given the early stage of the program, and uncertainty surrounding its characteristics, international best practices would suggest that a budget of $4.13 billion be set aside to allow a reasonable chance of the project coming in within budget.


Feasibility of Budget for Acquisition of Two Joint Support Ships

Credit: PBO

Parliamentary Budget Officer report "Feasibility of Budget for Acquisition of Two Joint Support Ships," released 28 February 2013.

The PBO estimates that, if everything goes according to plan, a one-for-one capability replacement will cost $700 million more than has been allocated, and prudent budgeting would recommend that $1.5 billion more be set aside for the project. Incidentally, the PBO is apparently not alone in recognizing that a *Protecteur* replacement would be more costly than the government has stated. The PBO report cites an internal DND cost estimate from August 2008 that states that $2.96 billion would be required to replace the two *Protecteur*-class ships.[2]

Reconciling the PBO estimate (assuming it is accurate) with the statements of government officials, it appears that the navy's project to replace the JSS will result in the Canadian Forces *losing* capability. Given the commitment to procure vessels within budget, the new AORs will be less capable than the ones sailing now. Since some aspects of the project require capability upgrades (environmental standards now mandate that the new ships be double-hulled, for instance), the capability reduction in other areas, such as maximum speed or number of replenishment-at-sea stations, might have to be significant to ensure affordability.

How this approach to procuring within budget will apply to the more costly Arctic Offshore Patrol Ship (AOPS) and Canadian Surface Combatant (CSC) projects remains to be seen. The JSS program faces a basic constraint that the other two programs do not – minimum fleet size. For the JSS, two vessels is viewed as an absolute minimum requirement. (Incidentally, one aspect of the PBO report that has not received adequate attention is its finding that the cost to build a third JSS would only be $125 million.[3] Although the life-cycle costs associated with another vessel would be significant, the acquisition costs apparently would not. Since the JSS project originally envisioned three or four

Credit: Cpl Charles Barber, DGPA/J5PA Combat Camera

*View of HMCS **Protecteur** (left) as HMCS **St John's** sails alongside just prior to a replenishment at sea during **Operation Apollo**, 23 July 2002.*

vessels, if the difference between procuring two vessels and procuring three is really so small, this warrants further study.) For the other projects, the fleet size has not yet been fixed, so it, along with capability, can be adjusted to fit within the project budgets. For the AOPS, the top speed has already been reduced with this goal in mind – and it remains to be seen what other capabilities, and/or vessel numbers, will be reduced.[4]

With most of the costs associated with the CSC project, budgeted at $26 billion, likely to go towards the high-technology systems incorporated into the vessels, how sophisticated the vessels are will be the primary determinant of how many can be acquired. For this reason, reaching the appropriate balance between adequately capable and sufficiently numerous ships will not be easy, and will likely require a lengthy period of project definition. Given the proliferation of long-range anti-ship ballistic missiles and long-range cruise missiles, a sophisticated, and presumably costly, missile defence capability would certainly seem warranted if the RCN wants to retain the ability to access contested littoral zones. But how big can the fleet ultimately be if even a few ships with such a capability are acquired?

Finding the appropriate balance among risk, capability and cost will be challenging, particularly if domestic politics come into play. While the NSPS specifies that the RCN's new ships be built in Canada, this requires only that actual metal-bending, ship construction activities be performed here.[5] Many components of the platform and mission systems, representing the bulk of the acquisition costs, will likely be sourced offshore, as domestic manufacturers of the most sophisticated equipment do not exist.[6] As a result, if more technologically complex CSCs means fewer ships, it could also mean less work for Canadian industry, and Irving Shipyard in particular, compared to procuring more but less complex ships.

Such a state of affairs may not be politically palatable. Given the favourable reception to the February 2013 'Jenkins Report' on Canadian defence procurement, which recommends a number of measures designed to use the Canada First Defence Strategy investments more effectively to stimulate Canadian industry, and the report's endorsement in the 2013 federal budget, there may be a strong desire to keep as much of the $33 billion NSPS in Canada as possible.[7] To what extent will this influence the set of capabilities obtained in the CSC project? The answer may shape how much technology the RCN ultimately acquires.

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Dave Perry is a Doctoral Candidate in Political Science at Carleton University.

Warship Developments: Technology at Sea

Doug Thomas

The most exciting new naval technologies that I see are unmanned, remotely-controlled aircraft, surface vessels and submersibles now being employed to perform a broad range of roles more cheaply and effectively than manned platforms. A generation ago these developments would have been the stuff of science fiction, now they are proliferating – not only in numbers and acceptance around the world, but also in enhanced capability. At the same time, many of these devices are becoming smaller with the miniaturization of electronics and sensors. This is a burgeoning area of development, and I have space only to stimulate further interest and research. Let us look at this topic briefly in three dimensions: under, on and above the sea.

Credit: Wikipedia

Stingray *is a small unmanned surface vehicle which is based on a jet ski design. It can carry a 150 kilogram payload and can be equipped with day and night electro-optical cameras.*

There are now projects to develop a variety of unmanned underwater vehicles (UUVs). These include tiny electronic devices that will move like eels and jellyfish, and larger UUVs that could remain just below the surface for many months conducting acoustic surveillance, and rising to the surface periodically to signal what they have recorded. Remotely-operated armed surface craft have also been developed in various sizes, some of them based on personal water craft, such as 'Stingray,' the unmanned surface vehicle (USV) produced by Israel's Elbit Systems.

Stingray can perform autonomously or be remotely controlled by an operator, located at a shore station or in a ship, who can monitor and operate the mission payloads. Top speed is up to 40 knots, with endurance over eight hours. It is equipped with autonomous navigation and positioning capability, cruise sensors and a stabilization system which prevents capsizing. Stingray can carry a payload up to 150 kilograms in two watertight sealed compartments. It is also equipped with day and night electro-optical stabilized payload.

There has been a lot of attention recently on unmanned aerial vehicles (UAVs), or drones as they're often termed in the media. These airborne platforms vary greatly in size and capability. Because they are not manned, a great deal of weight can be saved, not only that of the pilot and crew, but the seats, safety equipment and other systems necessary to sustain life, and the additional fuel needed to do that. There is also another huge advantage: these aircraft

Credit: OS Jason McIsaac, HMCS ***Charlottetown***

The Scan Eagle unmanned aerial vehicle (UAV) is mounted and ready for take-off from HMCS ***Charlottetown*** *during a surface exercise for* ***Operation Active Endeavour*** *on 29 February 2012.*

can be employed in dangerous missions where hazarding human life is a major consideration.

The fixed-wing Scan Eagle UAV is a good example of the low end in this technology, and has been introduced in a number of navies and used widely in land operations, including by the Canadian Army in Afghanistan. It can be operated from vessels of all sizes, including fast attack and patrol craft. Scan Eagle carries a stabilized electro-optical and/or infrared camera and can broadcast what it sees to its parent vessel at ranges up to about 100 kilometres. It is tiny, with a wing-span of 3.1 metres, length of 1.4 metres and weight of 20 kilograms. This catapult-launched UAV was trialed in HMCS *Glace Bay* three years ago and is now deploying in *City*-class frigates, including those for which there is no helicopter detachment available due to the delay in delivery of the CH-148 Cyclone Maritime Helicopter to replace the Sea King.

Scan Eagle can stay airborne for up to 20 hours, is difficult for opposing forces to detect or shoot down, and is relatively inexpensive and disposable. It can be recovered by a system which uses a hook on the end of the wingtip to catch a rope hanging from a nine to 15 metre mast. It would be very complementary to a manned aircraft as it could be used to locate and identify potential targets, which would then be attacked by manned assets or missiles. Its tiny size means that a number of Scan Eagles can be easily embarked, even in small vessels.

Vertical take-off UAVs (VTUAVs) are rotorcraft of various sizes, the largest being the US Navy's Fire Scout, an adaptation of a small manned helicopter. Many flight hours have been recorded in operating from a range of ships, and successful operational deployments have been conducted in at least two frigates. Trials continue in the Littoral Combat Ship (LCS), of which there may eventually be over 50 units of two different classes, and it is probable that many of them will utilize VTUAVs.

Fire Scout is controlled from its parent ship, and can be used together with manned aircraft in a supporting role. It is intended to be an intelligence, surveillance and reconnaissance asset, forming part of the specialist mission package in the LCS for its role in mine countermeasures, anti-submarine and surface warfare. These mission packages allow an LCS to adapt rapidly by changing out equipment and operators from a shore or ship-board support facility and redeploying for a new mission. Fire Scout is fitted with radar and a data-link, can drop sonobuoys and torpedoes, be fitted with missiles, rockets and machine guns, and can be embarked in larger numbers than manned helicopters due to its small size. For example, LCS-1, USS *Freedom*, and others of that class would

Credit: Kurt M. Lengfield, USN

*A USN Fire Scout vertical take-off UAV (VTUAV) prepares for the first autonomous landing aboard USS **Nashville** during sea trials, January 2006.*

normally embark one manned Sea Hawk helicopter and three Fire Scouts. The larger Trimaran (triple-hulled) LCS-2 (first of class USS *Independence*) have a truly large flight deck and hangar and could embark a veritable swarm of manned and/or unmanned helicopters.

Finally, a truly exciting development is the Unmanned Combat Air System (UCAS). In recent years, it has become accepted wisdom that after the next generation of manned combat aircraft, future high-performance fighters will be unmanned. For the reasons previously mentioned, such an aircraft can be smaller, faster, cheaper – and its loss would not involve the loss of human life! A number of states are developing combat UAVs, but let us look at what the USN is doing.

The Northrop Grumman experimental aircraft X-47B first flew from Edwards Air Force Base in California just over two years ago, and conducted a number of test flights. It was intended that these tests would take three years, but they were so consistently successful that the program moved on to land-based arrested landings and catapult launches. The first land-based catapult launch was conducted successfully on 29 November 2012, and its first at-sea test phase in USS *Harry S. Truman* (CVN-75) was conducted in December 2012. X-47B was remarked to have performed "outstandingly," having proved that it was compatible with the flight deck, hangar bays and communication systems of an aircraft carrier. With deck testing completed, the X-47B demonstrator returned to Naval Air Station (NAS) Patuxent River for further tests, with another carrier deck test planned for mid-2013. The USN is planning to deploy a UCAS fighter aircraft operationally in 2019 – that is only six years in the future!

In conclusion, we can anticipate increasing use of unmanned and remotely-operated vehicles at sea as surveillance patrols and warfare become more and more automated. It is likely that large ships will continue to be operated by people, but increasing use of autonomous systems from them seems certain.

Book Reviews

My Naval Career: 1954-1957, by W. Grant Thompson, Toronto: Breakout Educational Network, 2010, 101 pages, $15.00 (soft cover), ISBN 978-0-9781693-7-4

Reviewed Colonel P.J. Williams

It's true what they say; you learn something new every day. For instance, did you know that the distance between San Diego, California, and Tijuana, Mexico, is 28 miles, the same distance as between the Biblical towns of Sodom and Gomorrah? Grant Thompson, a young Canadian reserve naval cadet and the author of this light-hearted account of his short stint in uniform, learned of this geographical coincidence from the chaplain of HMCS *Sussexvale*, while making a port visit to San Diego. The padre was hoping that having been warned of latter day dens of iniquity the cadets would, in his words "eschew their modern Mexican equivalent." They didn't.

Dr. W. Grant Thompson, now Professor Emeritus (Medicine) at the University of Ottawa, and a specialist in gastroenterology, is already a man of letters having written *The Irritable Gut* (1979), *The Angry Gut* (1993) and *The Irritable Bowel* (1999). Perhaps more digestible fare, *My Naval Career* is an account of his three years as a member of the now defunct University Naval Training Division (NITD, also known as UNTD) and his adventures both ashore and afloat.

NITD was a program which began in 1943 with the aim of meeting the wartime exigencies for producing Canadian naval officers. It continued until 1970 when, in the author's words, "it became a casualty of the detested Canadian Forces amalgamation, and the growing aversion to all things military after the Vietnam War." At its height, some 27 universities across Canada participated in the program. Indeed, part of the aim of this book is to restore links between universities and the military with a view to reinforcing responsibilities that come with citizenship. In compiling this account, the author relied on his own cadet log, photographs and stills from 8 mm movies he took of his three year naval career.

For such a short period in uniform Surgeon-Lieutenant Thompson (the rank he ultimately reached) certainly got around a lot, and his account reads like an advertisement for a 'Join the Navy and See the World' campaign. Indeed, it was on seeing a recruiting poster which said exactly that, right after being turned down for service in the Royal Canadian Air Force, which turned the then medical student to the navy and the NITD. Over three summers he would spend four months each in Halifax, Nova Scotia, and Esquimalt, British Columbia, at Canada's two major naval bases. He would serve aboard HMC Ships *Quebec* (a light cruiser), *Stadacona* (a shore-based 'vessel' in Halifax), *York* (a shore installation in Toronto), *Brockville* (a minesweeper), *Naden* (*Stadacona*'s West Coast twin), and finally *Sussexvale* (a frigate). His travels took him to such exotic ports as San Juan, the Virgin Islands and, of course, Tijuana, which as Thompson says, "specialized in those goods and activities which were illegal in California"! He was also able to see much of Canada and, at Her Majesty's expense, along with his comrades, was able to take a train trip from Halifax to Vancouver for his West Coast training summer. He was 21 and the event made a huge impression on him, as no doubt it would on any 21 year old even today. I wonder if our current Canadian Forces Temporary Duty or Relocation policies would allow such trips these days!

Thompson left the navy to practice medicine but still retains fond memories of his time with the NITD. In the early 2000s he, along with former NITD comrades, decided to form the 'Old Oars' to preserve those days gone by. His 8 mm films were eventually used in a documentary, "No Country for Young Men" which celebrated and advocated for a return of Canada's university officer training corps.

I found this short account a very enjoyable read. Thompson writes with humour and nostalgia for times which clearly remain very close to his heart. I particularly liked his account of "The Frenched Lieutenant's Bed," and what is perhaps the ultimate admonition for someone who has screwed up and feels worthless: "nobody is useless – you can always be a bad example!" The book is illustrated with images from the author's own collection, including many colour photos from the 1950s. There are appendices which describe the NITD history, and pleas for the restoration of such a program. This book is both highly entertaining and highly recommended.

CANADIAN NAVAL REVIEW

Announcing the 7th Bruce S. Oland Essay Competition

The *Canadian Naval Review* will be holding its annual essay competition, the Bruce S. Oland Essay Competition, again in 2013. The winning essay will receive a prize of $1,000. The first prize will be provided by Commander Richard Oland in memory of his father Commodore Bruce S. Oland. The first and second place essays will be published in *CNR*. (Other non-winning essays will also be considered for publication, subject to editorial review.)

Essays should relate to the following topics:

- Canadian maritime security;
- Canadian naval policy;
- Canadian naval issues;
- Canadian naval operations;
- Canadian oceans policy and issues;
- History/historical operations of the Canadian navy;
- Global maritime issues (such as piracy or smuggling);
- Arctic maritime issues;
- Maritime transport and shipping.

Contest Guidelines and Judging

- Submissions must be received at naval.review@dal.ca by **21 June 2013**.
- Essays are not to exceed 3,000 words. Longer submissions will be disqualified.
- Essays must not have been published elsewhere. Essays that have been published elsewhere will not be accepted.
- All submissions must be in electronic format and any accompanying photographs, images, or other graphics and tables must also be included as a separate file.

For more details, questions about subject matter, or information about the adjudication process and criteria for judging, please visit our website at **www.navalreview.ca** or email us at **naval.review@dal.ca**.

Aircraft technicians from 19 Wing Comox, British Columbia perform after flight checks on a Canadian Forces CP-140 Aurora aircraft at Marine Corps Base Hawaii, 5 July 2012. The Aurora was participating in RIMPAC 2012.

Credit: MCpl Marc-Andre Gaudreault, Canadian Forces Combat Camera