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Maritime Engineering Journal

Canada's Naval Technical Forum

102
Since 1982

Fall 2022
SPECIAL EDITION

Arctic and Offshore Patrol Ship Project

An insider's look at the Royal Canadian Navy's new capability.

Canada

Three of six new Arctic and Offshore Patrol Vessels named for Royal Canadian Navy heroes have been delivered to the RCN:

VAdm Harry DeWolf, one of Canada's most decorated naval officers.

https://www.canada.ca/en/navy/corporate/fleet-units/surface/harry-dewolf-class/harry-dewolf/biography.html

RCN Nursing Sister SLt Margaret Brooke, decorated for gallantry during the Second World War.

https://www.canada.ca/en/navy/corporate/fleet-units/surface/harry-dewolf-class/margaret-brooke/biography.html

CPO Max Bernays, awarded the Conspicuous Gallantry Medal for courage during the Battle of the Atlantic.

https://www.canada.ca/en/navy/corporate/fleet-units/surface/harry-dewolf-class/max-bernays/biography.html

UNDER CONSTRUCTION

HMCS *William Hall*
HMCS *Frédérick Rolette*
HMCS *Robert Hampton Gray*

Front cover photo by Cpl David Veldman, Formation Imaging Services.

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Special Edition: Arctic and Offshore Patrol Ship Project

RCN Welcomes Arctic and Offshore Patrol Vessels to the Fleet

By Vice-Admiral Angus Topshee, OMM, MSM, CD

As Commander of the Royal Canadian Navy, I am delighted to showcase the RCN's new *Harry DeWolf*-class Arctic and offshore patrol vessels (AOPVs) in this edition of the *Maritime Engineering Journal*, the flagship publication of the RCN's Naval Technical community.

As your readers are aware, protecting Canadian sovereignty is as important today as ever. The presence of Canadian warships in our territorial waters and exclusive economic zones sends a powerful message. It protects our fisheries, our trade routes, and our security as a nation. In short: our presence is a symbol of Canada's readiness to enforce our sovereignty and assure our place in the global commons. In addition, the RCN has a proud tradition of affiliation between His Majesty's Canadian Ships (HMCS), its sailors and civilian communities that lasts throughout the service life of each ship. Each AOPV will be affiliated with a region of the Inuit Nunangat, allowing the RCN to build strong, longstanding relationships with northern communities based on respect, mutual understanding, and shared experiences. These roles are key elements of the RCN's mandate, and ones that our sailors are proud to accept.

At its core, Canada is an Arctic nation. Nearly one quarter of Canada's ocean territory – some seven million square kilometres – is in the Arctic. As the great Stan Rogers song, *Northwest Passage*, so perfectly captures, the North is an essential element of our national identity. Canadians have a sense of stewardship for this vast region which holds so much potential. As the northern climate continues to change there will be challenges, but also increased interest in the regional economic and transportation opportunities that emerge. The AOPVs have been designed with the capabilities required to operate effectively in Arctic waters, and have the flexibility to respond to changing circumstances and requirements. This adaptability will allow the RCN to play a significant role in the whole of government effort to ensure that our North thrives.

The collective efforts of the Department of National Defence (DND) and RCN team have brought us to a stage in the Arctic and Offshore Patrol Ship (AOPS) Project where, with ships now in the water, we are achieving operational capability. HMCS *Harry DeWolf* (AOPV-430), the first of class in the AOPS fleet was commissioned on June 26, 2021, and HMC ships *Margaret Brooke* (AOPV-431)

RCN photo by Mona Ghiz, Formation Imaging Services.

and *Max Bernays* (AOPV-432) were officially named on May 29, 2022. This summer, *Margaret Brooke* deployed on Op Nanook, becoming the second AOPV to successfully conduct operations in the Canadian Arctic region.

From the initial stages of the AOPS Project many elements of DND, other government departments, and industry have contributed substantially to bringing this new class of ship into service. Today I wish to recognize and commend the hard work of the Naval Technical support community in making the *Harry DeWolf*-class AOPVs a reality.

From the beginning of the project, we knew that the *Harry DeWolf* class would be very different from any previous RCN ship, and that the development and execution of the project would require innovation in how the RCN achieves its mandate over the next quarter-century. Procurement is not easy, especially when it involves delivering an entirely new capability, but the Project Management Office, in-service support teams, coastal support personnel, and contractual partners in Canadian industry have responded exceptionally to the challenges of the project, and their perseverance and dogged determination have produced Canada's first new class of ship in over 25 years.

You should be proud of your accomplishments and the technical acumen that you have displayed to get us here. The AOPS Project is a Canadian maritime success story and has been instrumental in the modernization of the RCN.

Bravo Zulu to all those involved.

Special Edition: Arctic and Offshore Patrol Ship Project

AOPS: Canada's Naval Fleet Renewal Starts Here

By Captain (Navy) Kit Hancock,
Project Manager, Arctic and Offshore Patrol Ship Project

Welcome to this special edition of the *Maritime Engineering Journal*. The thrust behind dedicating an entire issue to the Arctic and Offshore Patrol Ship (AOPS) Project is to communicate what the acceptance of the initial *Harry DeWolf*-class ships means to the wider Naval Technical community, and to take a closer look at the ships themselves, primarily from an engineering perspective. The articles that follow will provide viewpoints that illustrate the complexity of a modern shipbuilding project, the collaboration needed to solve problems and apply lessons learned to successive builds, and the dedication required by all stakeholders to navigate the challenges of delivering new capability to the RCN.

Over the past 15 years, the AOPS Project has shaped, and been shaped, by the evolution of Canada's approach to federal shipbuilding. The project itself was born of a July 2007 Government of Canada announcement to procure armed icebreakers for the Navy. Soon afterward, the AOPS Project Management Office (PMO) was established under the aegis of the new Major Project Delivery (Land & Sea) organization – stood up under the leadership of **RAdm (Ret'd) Ian Mack** – and the project was off and running. By 2008, a Definition, Engineering, Logistics and Management Support contract was in place, and the ship design soon began to take shape. In 2009, the project was bundled into the National Shipbuilding Strategy and identified as the lead project of the strategy's Combat Package of ships, the first ships to be built under an ambitious plan to recapitalize the Navy's entire fleet. In 2011, **Irving Shipbuilding Inc.**'s (ISI) Halifax Shipyard was selected to build the Combat Package ships, and the PMO's relationship with this critical industry partner began.

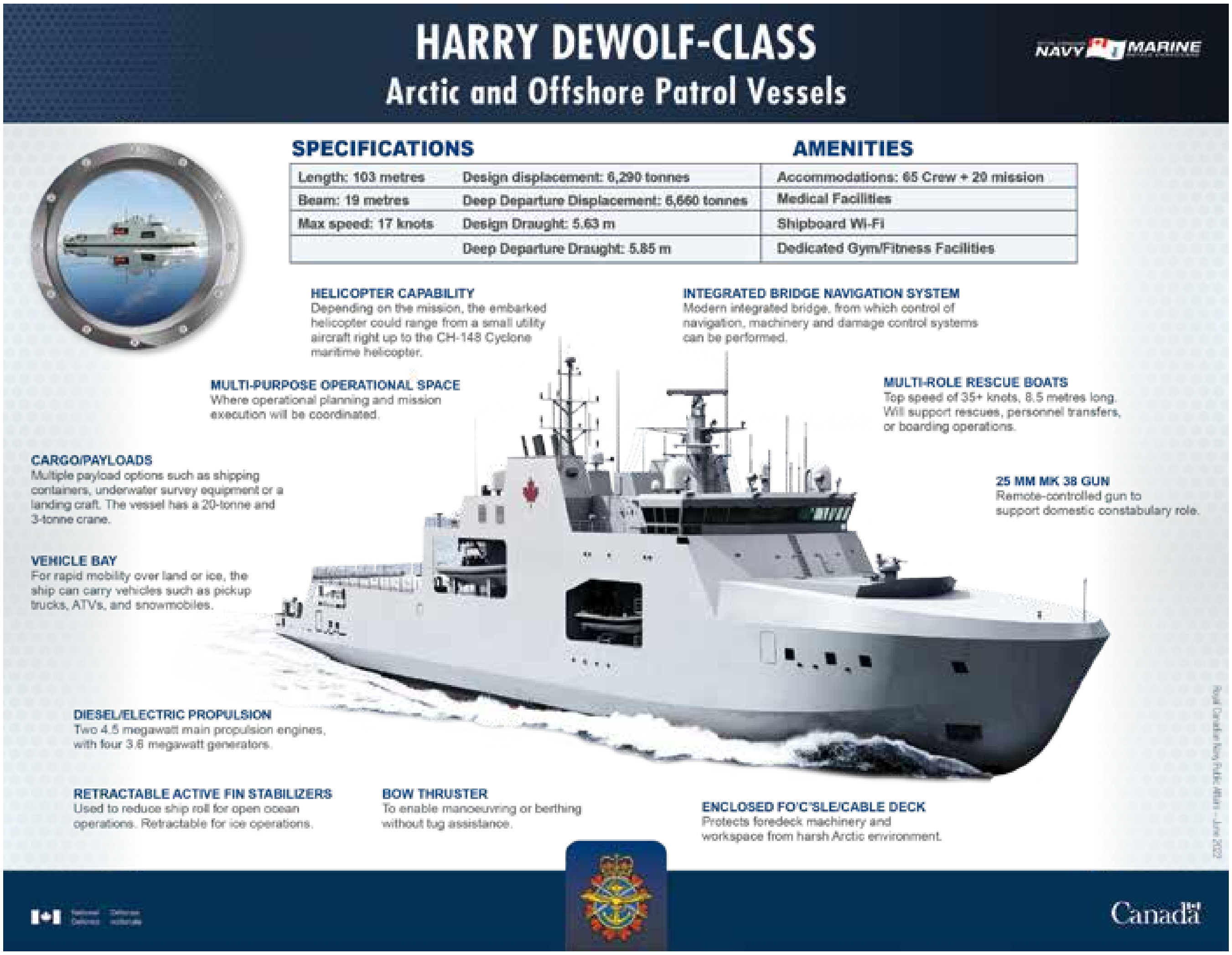
An ancillary contract with ISI to review the emerging ship design led to the project's definition phase, where detailed engineering design review activities eventually led to the commissioning of ISI's overhauled construction facility. In 2015, the project entered its implementation phase with the cutting of steel for the first of the project's Arctic and offshore patrol vessels, HMCS *Harry DeWolf*. The AOPS project team navigated this first-of-class ship through a maturing design at a greenfield shipyard, and in July 2020, just as the global Covid-19 pandemic was gaining momentum, had the satisfaction of seeing the lead ship delivered into service. The second and third vessels of the class, HMCS *Margaret Brooke* and HMCS *Max Bernays*, have since been delivered, and are to be followed by three more ships for the RCN, and an additional two variants for the Canadian Coast Guard, at a rate of one ship per year until 2027.

In addition to building ships, the AOPS project scope includes delivering an integrated logistics support (ILS) package, and funding to support new jetty infrastructure projects in Halifax, NS and Esquimalt, BC, and a berthing/refueling facility (the Nanisivik Naval Facility) in Nunavut. The importance of the ILS work cannot be understated, as it provides the equipment spares, technical data, Naval Ship Code certification evidence, and training media required to best manage the in-service phase for the ships and their crews, work that impacts many people across the Naval Technical community.

The success of AOPS to date has been underpinned by the professionalism and personal dedication of every member of the PMO teams located in the National Capital Region and our detachment in Halifax. Over the years, my predecessors have brought excellent direction and management to this historic project, beginning with **Cdr Jeff Whalen** and **Cdr John McIsaac** who led the charge through project approval, **Capt(N) Eric Bramwell** and **Nandini Srikantiah** who were at the helm during project definition, and **Geoff Simpson** and **Andrea Andrachuk** who spirited the early ships through implementation. Together, our leadership has been enabled by the unwavering support and guidance of a host of Materiel Group assistant deputy ministers and directors general, departmental and interdepartmental colleagues, and strong industry partners. The collective vision we share in delivering the best possible ships to the RCN today, is honing best practices as we prepare for our shipbuilding programs of the future.

I hope you enjoy the articles herein, and appreciate the lessons we have been learning along the way with this amazing AOPS Project. Much work remains to be done, of course, but I trust this snapshot of a work in progress will inspire those among you who will be part of our Navy's shipbuilding and project management teams going forward.

Special Edition: Arctic and Offshore Patrol Ship Project



Editor's Note

The Arctic and Offshore Patrol Ship (AOPS) Project represents a massive undertaking in the delivery of new-ship capability to the Royal Canadian Navy. With three of the six new Arctic and offshore patrol vessels now in the hands of the fleet, the *Maritime Engineering Journal* is taking the opportunity to present (and archive) a snapshot of this amazing project from a number of different perspectives.

With this special edition, we are very pleased to welcome **Cmdre Keith Coffen** as our incoming Director General Maritime Equipment Program Management. His appointment last July as "Chief Engineer" of the RCN makes him the 17th publisher of the *Maritime Engineering Journal* – Canada's Naval Technical Forum since 1982.

On behalf of Cmdre Coffen, and the regular editorial and design staff of the *Journal*, I offer my thanks to the people who helped us put this edition together, in particular: **Cdr (Ret'd) Aaron Malek** (PMO AOPS) for coordinating the AOPS special content; and **Stephanie Tran** (PMO AOPS) for stepping outside her primary role to conduct the AOPV crew interviews. It was a total team effort.

We sincerely hope you find the contents of this special AOPS edition both interesting and informative.

— Capt(N) Andrew Monteiro, Chief of Staff MEPM, Editor

Special Edition: Arctic and Offshore Patrol Ship Project

CREW PERSPECTIVE

PO1 Oleksiy Zaslavskiy
Weapons Engineering (WEng) Manager, HMCS *Harry DeWolf* (AOPV-430)

I joined the Royal Canadian Navy in 2003 while I was living in Toronto. When I was in high school, I had sailed on a tall ship with the BRIGS youth program, and wanted to be in the Maritime environment of the Canadian Armed Forces. My interest was in electronics, so I trained to become an RCN Electronics Technician.

I served aboard two frigates and an auxiliary oiler replenishment (AOR) supply ship before joining the AOPS PMO Detachment at Irving Shipbuilding in Halifax, and was working on *Harry DeWolf* for a year before it was delivered to the Navy in 2020. **PO1 Ron Fisher** was the WEng manager there ahead of me, and he did a lot of work to deliver the ship. It was thanks to his efforts that I was successful in my role once the Navy got the ship.

Harry DeWolf is quite different from my other ships, and has taken quite a bit of work to learn the new equipment and compartment configurations. I manage a team of four technicians who, because of our smaller crew size, are cross-trained on all of our equipment. In addition to managing personnel and monitoring equipment status, I take a hands-on role in familiarizing myself and the team on the new gear, and assisting with troubleshooting. The biggest challenge for us has been the operational tempo, especially keeping up with the corrective and operational maintenance when the ship is at sea.

Photo by S1 Bo Cao

Even though this is a new ship, some updated parts needed to be special ordered almost right away.

One of the best things about this new class of ship, however, is the quality-of-life improvement in terms of living and office space arrangements, and the availability of a gym. The ship is a comfortable ride.

Photo by Cpl Simon Arcand

Photo by S1 Bryan Underwood

Crew interview conducted by Stephanie Tran, PMO AOPS.

Special Edition: Arctic and Offshore Patrol Ship Project

A Primer on AOPV Construction and Launch

By Harrison Latham

The Arctic and offshore patrol vessels (AOPVs) are divided into units, blocks and mega blocks. A unit typically consists of multiple compartments. The combination of two or more units is considered a block. The blocks are then connected into one of three mega blocks, the largest individual sections of the ship, before being joined at land level prior to launch.

Stages of Construction

The first stage of construction is **Cutting**, which entails preparing the steel plate, cutting the profile of the plate, bending and shaping, grinding, beveling, edge preparation, cleaning, and priming the steel.

The next stage is **Pipe Fabrication**, which includes cutting pipe to length, bending the spools, welding sections of pipe, painting and pickling (a process to remove surface impurities like rust and scale on metal surfaces), and inspecting and testing spools and lengths of pipe.

After the pipes are fabricated, the next stage is **Minor Assembly** – joining two or more parts together to create assemblies that have length and width, of relatively shallow depth.

The next phase of construction is **Fabrication**, which includes the fabrication of heating, ventilation, and air conditioning (HVAC), and electrical supports, as well as temporary supports used in the installation. The cableways are also completed during this phase of construction.

Next up is the **Flat Panel Assembly** – assembling flat panels with stiffeners and web frames, then cutting out holes to reduce weight.

Complex Assembly is the next stage of construction, and includes assemblies with curved plates and stiffeners, transverses, and curtain plates for bulkheads. These assemblies are strictly structural and give the ship its shape. An example of a complex assembly would be the structure of a bow unit. These assemblies are often quite large and require overhead cranes to move them.

Construction then proceeds with **Main Structural Assembly**, where multiple flat or curved assemblies that have significant size and weight are joined together. At this stage, assembly sections are inverted to reduce the amount of overhead welding required.

Once this is complete, the production workers begin **High-Velocity Outfitting**. This is one of the last phases

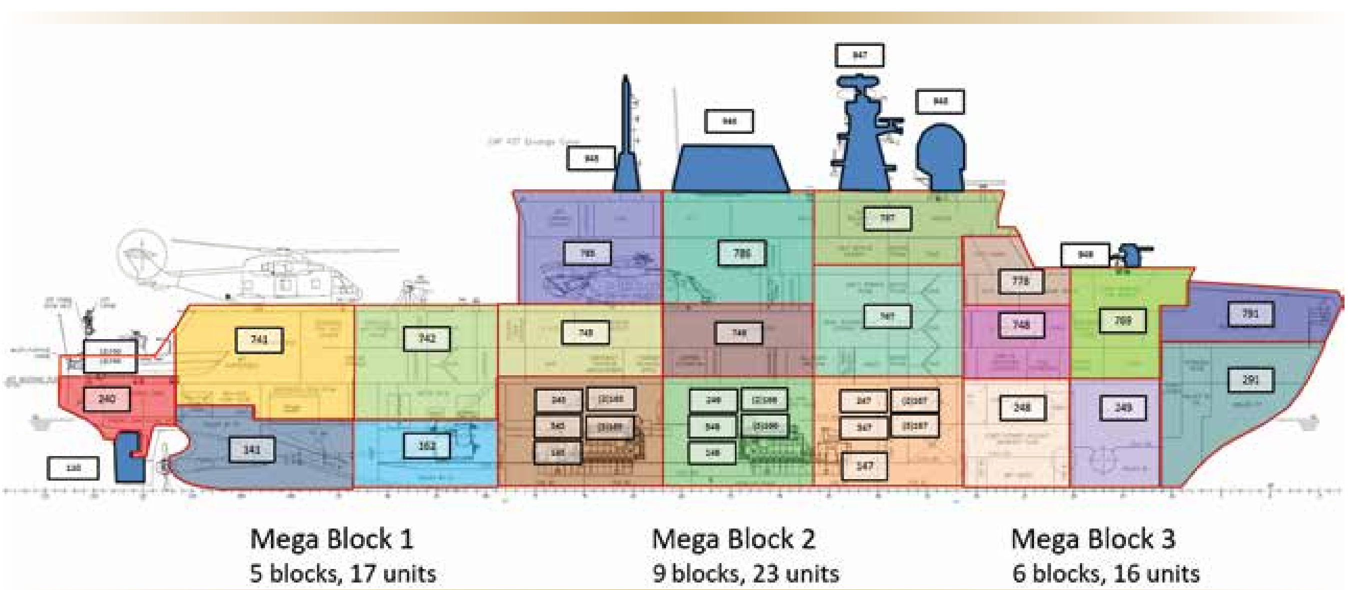


Image © Irving Shipbuilding Inc. (2022)

Unit breakdown of an AOPV.

before painting begins, so all hot work for the deckhead is completed at this time. The unit remains inverted as pipework and HVAC are fitted to the deckhead.

The unit is then flipped **Right-Side-Up**, and scaffolding is placed around the unit to access work on different levels. With the unit now ready for **Painting**, it is cleaned mechanically, and any impurities or dirt on the steel surface are removed. The unit is painted up to, but not including the final coat of paint.

Image © Irving Shipbuilding Inc. (2022)

Flat Panel Assembly being welded.

Image © Irving Shipbuilding Inc. (2022)

Main Structural Assembly.

Image © Irving Shipbuilding Inc. (2022)

A unit being flipped in Right-Side-Up.

The next stage is **Module Assembly**, which involves the construction of equipment and foundations off-ship to allow them to be installed as one large assembly. Building components in this manner provides production workers and fabricators more space to complete the assembly, rather than having to work within the ship's confines. These modules can include piping, mechanical components, HVAC, electrical, or any combination of these.

After Module Assembly is complete, **Block Assembly and Outfitting** commences. During this stage, two or more units are combined to form single- or multi-level blocks. Main equipment and machinery are installed along with all major piping and HVAC spools. Steel outfitting is undertaken, including the installation of steel ladders, stairs, and tank covers.

Once the blocks are constructed, **Mega Block Assembly and Outfitting** can begin. This involves combining multiple blocks into full-height transportable structures (keel to weather deck or above). At this stage, all pipe and HVAC work is completed, and partial testing of systems has begun.

When all three mega blocks are complete, the next phase is to undertake the **Mega Block Join**, the process of joining the three mega blocks into a fully developed hull structure. All three mega blocks are fully integrated at **Ship Land Level**. All pipework and HVAC connections are completed, and systems are activated and tested. The shafts are installed/aligned, and the rudders and propellers are installed. The final paint coat is applied to the underwater hull, and the ship is ready for launch.

The Launch: Transporting Ship to Barge

The 6,600-ton AOPVs are launched using a **Float Off** method, which is a safe, highly controlled procedure used by modern shipbuilders. To achieve this, Irving Shipbuilding leases the Boa Barge 37, a heavy-lift, semi-submersible barge capable of accommodating cargo up to 30,000 tons, with deck strength of up to 35 tons per square metre. After thoroughly cleaning the deck surface of the barge to ensure no contaminants will be discharged into the ocean, the AOPV is loaded onto 236 remote-controlled axles to transport it from land level onto the barge.

The barge needs to be ballasted to a maximum draft of 6.5 m before the ship can be loaded onto its deck. Towing lines are connected from the barge to three tugboats that will pull it away from pier side. The ship is moved onto the barge, and all axles are lashed down to the deck before being towed. Mooring lines are fixed from the AOPV to the barge, and all temporary supports are placed.

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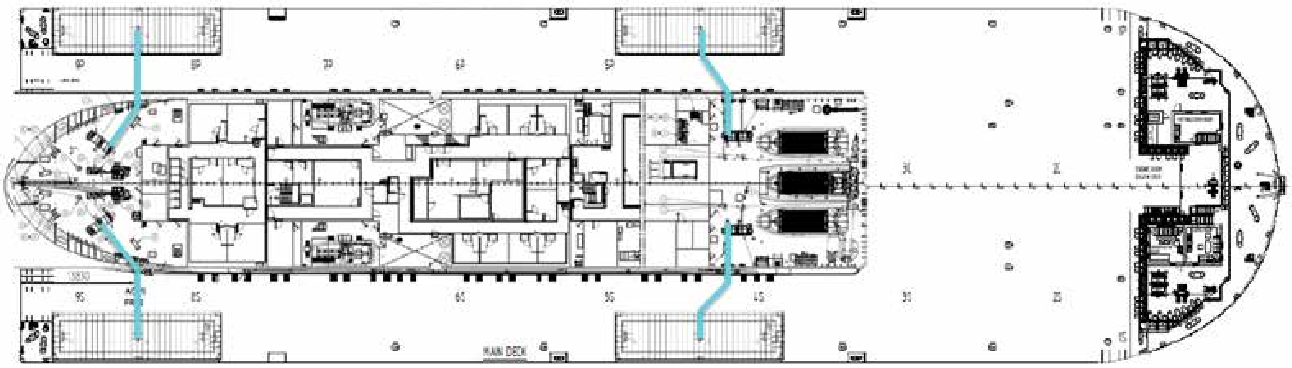


Image © Irving Shipbuilding Inc. (2022)

Depiction of AOPV mooring arrangement to Boa Barge 37.

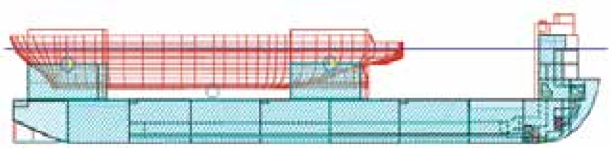


Image © Irving Shipbuilding Inc. (2022)

Depiction of Boa Barge 37 at maximum submersion.

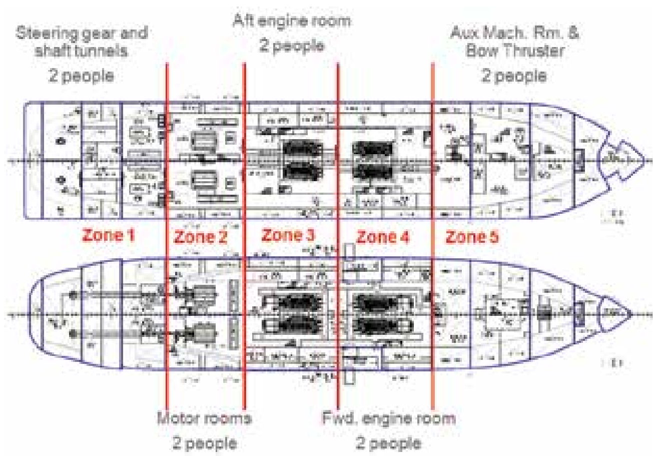


Image © Irving Shipbuilding Inc. (2022)

Zones checked during the roaming leak checks.

Requirements for the Launch Site

Certain environmental conditions need to be met to launch the ships. The wind speed must be very low to prevent any list or drift from the barge, and the water surface must be calm. The launch site also needs to be greater than 21 m deep, but less than 29 m deep. This depth range is put in place because at maximum depth the Boa Barge 37 is submerged just over 20 m, and requires 1 m clearance from the ocean floor. If the barge capsized and sank to a depth lower than 29 m, it would be nearly unrecoverable.

Launching AOPVs from the Heavy Lift Barge

After the ship is secured to the barge, the tugs tow the barge to the float-off location where they assist in anchoring it. One tugboat remains on standby, while the other tugs are released from duty until the ship is launched.

As the barge and ship are slowly submerged, roaming leak checks are performed at predetermined draft points. Since hydrostatic pressure on the hull increases with the draft, it is essential to catch any weak points early on. At drafts of 1.5 m, 3 m, 4 m, and immediately after float-off, the barge stops to allow the roaming leak checks to be performed. The compartments checked are the steering gear and shaft tunnel compartments, motor rooms, forward and aft engine rooms, and the auxiliary machinery and bow thruster compartments.

When the AOPV is in a free-float condition, the three tugs manoeuvre the ship off the barge and return it to pier side. One main tug tows the ship forward off the barge, while the other two tugs control lines from the port and starboard sides to ensure the vessel maintains a straight path.

After the ship is launched, it is moved to **Ship Pier Level**, which is the final phase of construction. This stage includes harbour trials, final integration of all systems, compartment inspections, and sealing all remaining access cuts. All systems are given a final test in preparation for sea trials and delivery to the Royal Canadian Navy.

Harrison Latham is an Engineer in Training with PMO AOPS.

Special Edition: Arctic and Offshore Patrol Ship Project

Overview of the Arctic and Offshore Patrol Ship Project

By Cdr Aaron Malek (RCN Ret'd)

In July 2007, the Government of Canada announced the stand-up of a new Arctic and Offshore Patrol Ship (AOPS) Project whose intent, primarily, was to assert sovereignty, and ensure domestic security in Canada's Arctic waters. With growing international interest over access to the Arctic's rich resources and increasingly navigable waterways due to global warming, a stronger and more capable presence in the region by the Royal Canadian Navy (RCN) was deemed a priority. In addition to having an ice-breaking capability, the project also called for the new Arctic and offshore patrol vessels (AOPVs) to be able to operate on the open ocean, thus making them versatile enough to be deployable on Canada's Atlantic and Pacific coasts, or any maritime non-combat zone in the world.

Two options were initially considered for developing the required operational capability: (A) build a mission-specific icebreaker with effective ice-breaking capabilities as its primary design feature, or (B) build a ship capable of operating effectively in both ice and the open ocean. Given that icebreakers generally have poor seakeeping qualities on the open sea, and considering that the RCN's requirement for this ship was to have it *operate* in ice conditions, not act as an icebreaker per se, it was determined that the best option would be to specify a design that allowed for safe, effective operation in both environments, something few existing ship designs could meet at the time.

Courtesy the author

Cdr Malek at the Irving Shipyard in Halifax.

With support from the Definition, Engineering, Logistics, and Management Support contractor, the AOPS project team duly produced a feasible design, capturing the requirements within a contract design specification. In early 2009, a series of industry and project working groups were held to open up dialogue in regard to potential risk and cost issues associated with shipbuilding. The consensus from industry was a preference to build the design rather than respond to a set of technical requirements, and a revised Statement of Operational Requirement was subsequently endorsed by the RCN in May 2009.

National Shipbuilding Strategy

In June 2010, the Government of Canada announced the National Shipbuilding Strategy (NSS), with the objective of establishing a strategic, long-term relationship with two Canadian shipyards to construct large combatant and non-combatant vessels for the Royal Canadian Navy and Canadian Coast Guard. In October 2011, the NSS selected Irving Shipbuilding Inc. (ISI) to build the combat vessel package, which would include the AOPVs under the AOPS project. In February 2012, Canada and ISI signed an umbrella agreement as a framework to capture the general intent and principles of the NSS, along with the parameters for the negotiation of specific project contracts, and describe the specific terms to be included in subsequent contracts.

With the signing of the umbrella agreement, the Project Management Office (PMO) had approval to begin initial planning discussions with ISI, which resulted in the

(Continues next page...)

establishment of a new and innovative "design then build" approach. Formally approved in the December 2012 Treasury Board submission, the benefits of this approach were expected to be seen in more effective risk mitigation gained through improved, collaborative understanding of project requirements that would allow for cost and capability trade-offs ahead of the build. These initial consultations also allowed the PMO and ISI to collectively appraise the project schedule, and agree on a timeline that aligned with NSS milestones.

Ancillary Contract

In June 2012, ISI was awarded an ancillary contract to allow them to review the existing AOPS design, identify potential design issues that could affect ship construction, and enable the shipyard to hire management and technical teams. The primary goal of the ancillary contract was to define the scope of work required to mature the existing design to build-ready status. To help avoid a cessation of design work between the ancillary contract and a definition contract, the PMO decided to simultaneously progress the design and production engineering activities. This would keep the project on schedule, and prepare for vessel construction immediately following completion of the ancillary contract.

With project momentum maintained, the government aim of commencing ship construction in 2015 could be achieved. However, because this plan was based on using *indicative* cost estimates, additional levels of government review were required. The full workload of the upcoming definition contract was therefore partitioned into several smaller tasks, which were subject to a rigorous review and approval process – including a full cost validation by the Department of National Defence (DND) Chief Financial Officer, and an independent third-party assessment – prior to award, and regular reporting to Treasury Board on task progress and expenditures would also be required. The smaller tasks included project management, three engineering design phases, long-lead item procurement, a production test module to validate production processes, and development of the project implementation proposal. This repackaging allowed the AOPS project to seek Treasury Board approval in December 2012.

Preliminary & Critical Design Review

The preliminary design review began in March 2013 with the goal of identifying all of the systems required to meet the contract design specification, advise the PMO where requirements had been satisfied and where there were challenges, and to develop appropriate recommendations or solutions to resolve any noted deficiencies. While most issues that arose during the preliminary design review were technical compliancy questions not seen as potential obstacles to success, one significant issue was that the specifications for accommodations, equipment, and machinery would be extremely difficult to place into the space and weight allocated in the ship's general arrangement plans. The solution selected by CRCN was to lengthen the ship in order to provide more space. Although there were design and construction cost impacts associated with this solution, it significantly reduced the technical risk of attempting to meet all of the requirements within too small a space, which could have also had negative cost effects. Providing more space and weight allocation also mitigated the need to compromise on capability, as all requirements could be included in the larger hull with minimal concessions.

Photo by Brian McCullough

With the successful confirmation that there were no outstanding major technical issues with respect to meeting the requirements of the contract design specification during the preliminary design review, Engineering Design Phase Two commenced. This phase continued until August 2014 with several interim design reviews. The interim design reviews allowed DND to submit comments as soon as deliverables were received rather than waiting until the critical design review at the end of the phase. Many elements of the ship's design were finalized and reviewed by the Classification Society (Lloyd's Registry) during this phase which culminated in the critical design review in Aug 2014. At this point, ISI accepted responsibility for the delivery of the design's key performance requirements as defined by the definition contract.

Project Implementation

As a part of the definition contract, ISI delivered a cost estimate in June 2014 that indicated the overall program budget shortfall for six ships would be larger than originally estimated. In the time it took to reach implementation after the original budget requests had been established, a period taken up mostly by the redesign work and development of the NSS, the costs for raw materials and subcontractor systems increased at a faster rate than expected. There were also unanticipated additional expenses associated with the NSS, the Directorate Major Project Services, and the AOPS PMO. An RCN investment plan change proposal for additional funding was approved in October 2014, increasing the project's overall budget to maintain the project scope. The AOPS Project was granted approval (implementation) in December 2014, with the build contract awarded to ISI in December 2014. Ship construction could begin in September 2015 in accordance with project targets.

From the outset, progress of the construction was a challenge. The shipyard was operating with a very steep learning curve, adapting to new production processes within a new facility on a first-of-class ship. Though these considerations had been anticipated in the original schedule, the challenges had been underestimated. The shipbuilder also identified issues with design reference material, which created production errors and caused significant rework. Attempts were made through a "recovery plan" to regain the original production and ship delivery schedule, but despite best efforts by ISI and the PMO, it became apparent that the schedule would need to be adjusted. Between 2016 and 2019, the delivery schedule for the first of class, *Harry DeWolf,* was amended three times to account for ongoing challenges. As the shipbuilder gained knowledge and experience, however, the PMO observed significant improvements in production efficiency and processes with the second and third ships of the class, which began building in August 2016 and December 2017, respectively. During this time the performance levels of project staff also went up, which contributed to the achievement of project milestones.

In 2018, the future HMCS *Harry DeWolf* was launched to water, and the Government of Canada committed to the construction of a sixth AOPV to meet RCN capability requirements. Part of this expansion in scope was to reduce the potential for a production gap between the construction of the AOPVs and the future Canadian Surface Combatant (CSC) frigate replacements, which would be detrimental to the overall objectives of the NSS, and result in significant cost increases to the CSC project. As such, an amended project implementation funding request, including an extension to the AOPS project production schedule by 18 months, was approved by Treasury Board in November 2018. Construction of the fourth, fifth and sixth ships continued at pace despite the onset of the Covid-19 pandemic, beginning in July 2019, May 2021 and August 2022.

Following the completion of their contractor sea trials, the first two ships were accepted by the RCN – HMCS *Harry DeWolf* (AOPV-430) on July 30, 2020; and HMCS *Margaret Brooke* (AOPV-431) on July 15, 2021. After completing post-delivery work periods, basic ship safety readiness training, and post-delivery sea trials, both ships have achieved operational status transfer to the RCN.

Although the most frequently discussed accomplishment is HMCS *Harry DeWolf*'s transit of the Northwest Passage and circumnavigation of North America, the ships have been actively participating in other taskings such as Op Caribbe, Canada's contribution to the elimination of illegal drug trafficking in the Caribbean Sea and Eastern Pacific, and Op Nanook, the Canadian Armed Forces' signature northern operation. ISI continues to improve production processes for AOPVs four through six, and we are nearing completion of the definition phase for ships seven and eight, the AOPS Project's Canadian Coast Guard variants.

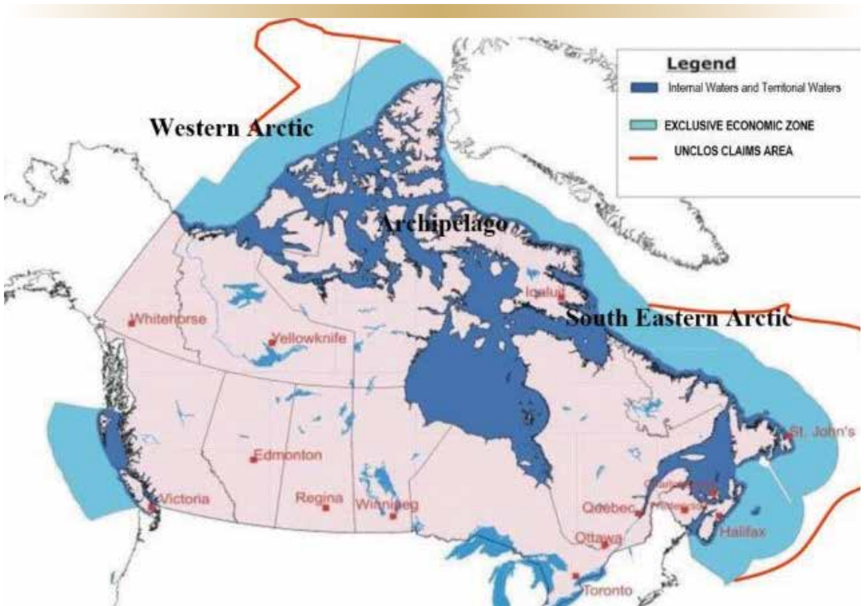
Cdr Aaron Malek, RCN Ret'd, was Deputy Project Manager and Chief of Staff for the Arctic and Offshore Patrol Ship project from May 2021 to August 2022.

Special Edition: Arctic and Offshore Patrol Ship Project

AOPS Concept of Operations

By Cdr Aaron Malek (Ret'd), and LCdr Morgan Francis
[With files from RCN Public Affairs]

In both the current and anticipated future security environment, the Government of Canada must have effective tools for exercising control of Canada's Exclusive Economic Zone (EEZ) in all three oceans that border our territory, and for protecting Canadian interests in waters beyond. The Arctic and Offshore Patrol Ship (AOPS) Project, anchored in the National Shipbuilding Strategy (NSS) and Canada's Defence Policy, *Strong, Secure, Engaged*, is one such tool.



Courtesy PMO AOPS

Prior to 2021, the Royal Canadian Navy (RCN) had limited capability to conduct constabulary or other operations in the ice-covered waters of Canada's High Arctic region, which includes the Canadian Arctic Archipelago that represents about two-thirds of Canada's coastline. The RCN's existing fleet of maritime coastal defence vessels (MCDVs) have no ice breaking capability, and are limited in their ability to operate outside of coastal waters in higher sea states. With their limited speed, and lack of ability to operate a helicopter, the MCDVs have a reduced capability to support ocean boarding operations, thus requiring the Navy to draw upon its major combatant vessels to execute many of the missions required for operations in Canada's EEZ.

To fill this capability gap, Canada sought a more economical and mission-focused vessel capable of operating in the Arctic during the navigable season, and in certain other offshore waters year-round. The Arctic and Offshore Patrol Ship Project, stood up in 2007, was the result. Initiative 30 of *Strong, Secure, Engaged* cited Arctic security as a critical emerging area requiring an increased presence in the Arctic over the long term, and identified AOPS as the means for meeting the key defence objectives of providing the Government of Canada with "awareness of activities in Canada's waters," and cooperating with partners at home and abroad.

In 2020 the AOPS project delivered the first of six *Harry DeWolf*-class Arctic and offshore patrol vessels (AOPVs) to the RCN, and within a year, the first of class was operational. A new era of capability in conducting armed sovereignty and other seaborne operations in all Canadian waters, and beyond, had begun.

Vessel Capabilities

The main capabilities of the AOPVs include:

- Flexibility to operate independently and effectively in Canada's EEZ, including such diverse environments as the Canadian Arctic, the Grand Banks of Newfoundland, the northwest coast of Haida Gwaii (Queen Charlotte Islands), and the St. Lawrence River during the navigable season;
- Capability to operate worldwide, in any non-combat zone;
- Year-round operation in medium first-year ice, which may include old ice inclusions, as well as the open ocean areas in the Atlantic and Pacific Canadian EEZ;
- Ice-breaking capability, exclusively for their own mobility, and not to provide ice breaking services to others;
- Sufficient fuel and rations to sustain operations for up to four months;

- Operational range of at least 6,800 nm at 14 knots;
- Sufficient situational awareness to ensure safety of navigation and helicopter flight operations;
- Sufficient command, control, and communication capability to participate within the Canadian Armed Forces' common operating picture;
- Cruising speed of at least 14 knots; maximum speed of at least 17 knots;
- Gun armament;
- Service life of 25 years per ship; and
- Capability to embark and operate a helicopter, up to and including the CH-148 Cyclone, with one flight crew and one maintenance team.

Mission Focus

The inherent flexibility of maritime platforms to conduct a multitude of tasks with minimum adaptation has always been of great benefit to the Government of Canada, and the *Harry DeWolf* class is no exception. The class is optimized for the harsh, unforgiving environment of the Arctic, and will be the RCN's primary platform to exercise Canada's sovereignty, and to contribute to the wider objectives of the Canadian Armed Forces and other government departments in the North. In doing so, these platforms will often be the only military asset able to meet these specific objectives. The North should be considered the AOPVs' main operating environment, but they can be tasked to other regions as required.

Given the nature of the AOPVs' construction, operating range, and flexible payload capability, the Commander RCN will be able to free up the *Halifax*-class frigates for deployment on expeditionary and coalition missions outside of Canadian waters. The large patrol vessels are built to commercial standards, with ice-breaking characteristics, an organic aviation facility, and other equipment that make them well-suited for their planned mission profile of conducting presence and surveillance operations in Canada's Arctic and other territorial waters. The ships carry a number of small boats, including LCVP landing craft for ferrying vehicles and personnel ashore in support of northern maritime communities, and faster boats for conducting boardings and search & rescue operations. They also carry a large crane that can load a mix of 20-foot (6.1 m) sea containers for general cargo, or for mission-specific operations such as scientific research, humanitarian aid, and disaster relief. The ships have accommodation space on board to embark mission specialists.

RCN Photo

Elder Jim Tuttauk, from Hopedale, Labrador, presented a Nunatsiavut flag to Cdr Nicole Robichaud, commanding officer of HMCS *Margaret Brooke*, on September 20, 2022.

Working with Communities

Recognizing the importance of working closely with Indigenous and Northern peoples as these ships transit their territories, the RCN will affiliate each of its six new AOPVs to a region in the Inuit Nunangat, and contribute to supporting and building strong ties with these remote Canadian communities. HMCS *Harry DeWolf* formalized its affiliation with the Qikiqtani region of Nunavut in May 2019, and the remaining AOPVs will be affiliated with the following regions in the Inuit Nunangat: Kitikmeot, Kivalliq, Inuvialuit, Nunavik and Nunatsiavut. Each ship's company will work with local community leaders and members, and engage with youth groups to build relationships based on respect, mutual understanding, and shared experiences. Such affiliations are a long-standing naval tradition, and are deeply valued by the sailors and the civilian communities.

Effective Platforms

By virtue of their ability to operate in ice, the AOPVs are fully capable of providing an enhanced, armed presence and seaborne surveillance capability in Canada's North. Their design also makes them effective platforms for patrolling Canada's other territorial waters, and for cooperating with partners at home and abroad. These ships have already demonstrated their unique capabilities during Op Nanook in the Canadian Arctic, and while deployed south on Op Caribbe to interdict illicit drug trafficking.

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Going forward, these impressive vessels will no doubt prove themselves equally capable of meeting whatever is required of them. In short, the capability inherent in the AOPVs will provide the Royal Canadian Navy with modern, fit-for-purpose options when fulfilling Canada's continental and global non-combat missions for decades to come.

Cdr Aaron Malek, RCN Ret'd, was Deputy Project Manager and Chief of Staff for the Arctic and Offshore Patrol Ship project from May 2021 to August 2022. LCdr Morgan Francis is the former AOPS Test & Trials Manager.

CREW PERSPECTIVE

SLt Emily Gjos
Naval Warfare Officer, HMCS *Margaret Brooke* (AOPV-431)

I joined the Navy in 2019 when I was living in Ottawa. I had originally planned to join as a Reservist, but was convinced to join the Regular Force, and haven't looked back. I have one of the most fun jobs in the Navy.

As a bridge watchkeeper under training, I am learning to "drive the ship" on behalf of the captain in support of the ship's operational program. My training includes basic navigation, responding to emergencies and executing various evolutions, both on my own ship and as part of a task group.

The *Harry DeWolf*-class Arctic and offshore patrol vessels are fairly large compared to other ships in the Canadian fleet, with a relatively small complement. They are a bit shorter and heavier than a frigate, but have only about one-third the number of crew. While we do a lot with less, one of our challenges is that we do not have a lot of junior crew members. Despite our small crew size, we have an incredibly impressive cadre of talented women sailors on board, including our captain, operations officer, and assistant chief bosun's mate. The first officer of the watch to take the ship on her maiden voyage was a woman, and during trials, I had the unique experience of being the first weapons directing officer to fire the ship's BAE Mk-25-mm gun.

Photo by by Lt(N) Jennifer Grant

As the newest ship in the fleet, HMCS *Margaret Brooke* does a lot of public relations, and is the platform for many ceremonies and events. Once deployed on Operation Nanook, we will be supporting sovereignty operations in Canada's north, relationship-building with small communities, and assisting in scientific research with other government departments. Our ship is mission-capable for operations from the Caribbean, all the way to Arctic waters, carrying the equipment we need to deliver on a number of different roles. We are learning new things about the ship every day, which has made us more versatile and resilient, and I am sure there are many capabilities and opportunities yet to be discovered.

Crew interview conducted by Stephanie Tran, PMO AOPS.

Special Edition: Arctic and Offshore Patrol Ship Project

Effects of the Covid-19 Pandemic on the AOPS Shipbuilding Project

By LCdr Anthony Morash

In early 2020, the world was hit by the first wave of the Covid-19 pandemic that changed the way we conducted our personal lives and approached our jobs. Not surprisingly, it affected the ability of Irving Shipbuilding Inc. (ISI) and the AOPS project staff to progress the building of the Royal Canadian Navy's future fleet of multi-role patrol vessels. Even today, more than two years later, the project continues to feel the impact of Covid-related workforce shortages and logistical issues, but how little we knew of all this in the early days of the pandemic.

At the beginning of March 2020, rumours began making the rounds of a potential two-to-three-week pause in operations by the Government of Canada (GOC) to help limit the spread of the virus. In the early stages there was no indication this would seriously affect the operations of the AOPS Detachment in Halifax, but we soon discovered it was about to interfere with all aspects of our lives. At midday on Friday, March 13, we were informed that military personnel were no longer permitted to report to the office, and were to remain at home in isolation. Because the detachment is made up of about half military personnel, this decision would greatly affect our ability to attend build inspections, and perform our shipyard oversight responsibilities.

There were rapid changes to follow as Canada adjusted its response to the growing pandemic. In a matter of days, we went from having no detachment military personnel on site, to instituting prioritized inspections by the detachment's Department of National Defence civilian personnel, to having a complete shutdown of the detachment. The GOC posture was being adjusted by the hour, it seemed, and the impact was also being felt by the shipbuilder. ISI had to dismiss its skilled workforce for a time, thus halting production work, while office staff and other planners continued preparing Ships 1 and 2 (i.e., *Harry DeWolf* and *Margaret Brooke*) for system inspections and trials, with a good success rate and minimal defects. This push was vital in ensuring *Harry DeWolf* was ready for sea trials and delivery to the RCN in the summer of 2020.

The AOPS detachment workforce was out less than two weeks before we were permitted back on site, yet the return to operations looked vastly different with the new Covid protocols in place. With the virus already working its way through members of the detachment, we adapted our work procedures to accomplish as much as we could, while minimizing the risk of further transmission and illness. The use of online meeting platforms such as MS Teams, and other mitigations proved to be invaluable.

Irving Shipbuilding's production line slowed drastically during the successive Covid waves, and at times their production workforce was as low as 30 percent. This resulted in the shipbuilder redirecting resources, and finding other creative ways to progress the work and salvage some level of efficiency so as to minimize the schedule slippage. Shown in Figure 1 are inspections conducted since the beginning of Covid, illustrating production low points as Covid swept through the community at various times during the pandemic. ISI's workforce was affected, but so also were subcontractor availability, field service representative (FSR) travel, and global supply of materials, with some of these problems still affecting production.

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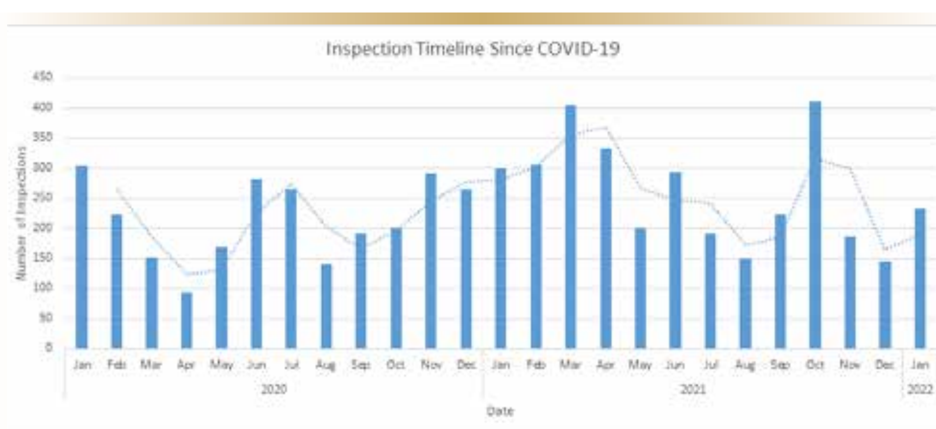


Figure 1. Production ups and downs as waves of Covid swept through the community.

The Covid disruption affected the materiel condition of the first two ships at delivery. Reduced production levels leading up to the delivery of HMCS *Harry DeWolf* in the summer of 2020 impacted ISI's ability to resolve all of the defects discovered during inspections and trials. And, because a number of resources had been reallocated to support Ship 1, HMCS *Margaret Brooke* was accepted with an even larger number of unresolved defects than *Harry DeWolf*.

The influence of Covid on the Arctic and Offshore Patrol Ship Project will certainly change the way RCN shipbuilding projects and DND project support are conducted in the future. Planners will have to expand their consideration of factors such as the security of the global supply chain, mitigation for potential loss of productivity through mass workforce illness and/or isolation, creative recruiting and deployment of personnel, and the more regular use of employees working remotely. The lasting impact of a "once in a lifetime" event such as the ongoing Covid pandemic should not be a story of what has been disrupted, but more one of how prepared we are to quickly adapt to a rapidly changing global environment that can affect the builds of Canada's future fleets.

LCdr Anthony Morash, P.Eng., is Technical Lead for the Arctic and Offshore Patrol Ship Project Detachment in Halifax, NS.

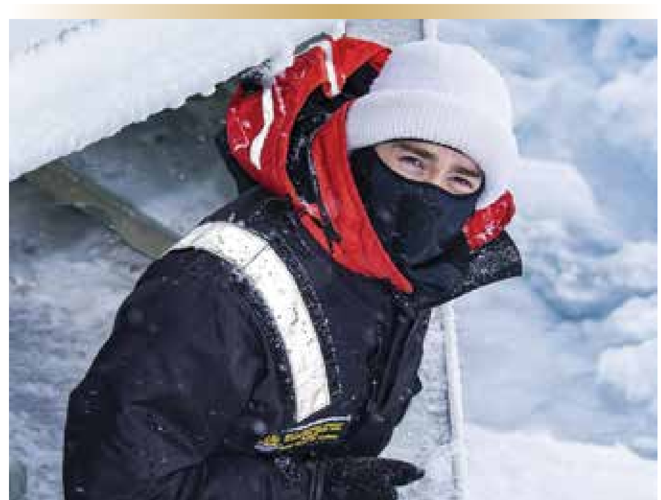
CREW PERSPECTIVE

S1 Vincent Hébert
Weapons Engineering Technician, HMCS *Margaret Brooke* (AOPV-431)

After listening to my brother's many interesting stories about his travels and opportunities while serving in the Canadian Armed Forces, along with the secure income offered, I wanted to follow in his footsteps. I joined the RCN in October 2012 while living in Sherbrooke, Québec, where I was born and raised.

Although I am trained as a Weapons Engineering Technician, my role on board *Margaret Brooke* is as a communications maintainer — making me responsible for maintaining all of the ship's radios, antennas, and network infrastructure within the ship. While we faced some difficulties when we first took possession of the ship due to a lack of tools required for maintenance, the team was able to procure them quickly enough, allowing us to continue our work. I am thoroughly enjoying serving in a brand-new ship, and working with the cutting-edge communication systems.

Compared to other ships I've served in, I have found that the quality of life aboard the AOPV is much improved due to the lower occupancy in our sleeping quarters. My cabin on board *Margaret Brooke* sleeps only six, which makes keeping everything clean and tidy much more manageable. This is so much better than the 18 to 50 people we had living together in the same messdeck in my previous ships, HMCS *Athabaskan* (DDH-282) and HMCS *Ville de Québec* (FFH-332).



Canadian Armed Forces photo by S1 Taylor Congdon

One of my most memorable experiences aboard HMCS *Margaret Brooke* was during an ice trial, witnessing how the AOPV broke ice so effortlessly — what a sight that was! I look forward to my continued service on board this ship over the next year, and hope for the opportunity to experience another posting aboard an AOPV.

Crew interview conducted by Stephanie Tran, PMO AOPS.

Initial Cadre Training for the AOPVs – Computer-based Training via the Defence Learning Network

By Simon Paré

Naval personnel are introduced to the operation and maintenance of new equipment, systems, or ships through what is known as initial cadre training (ICT). The ICT package for the *Harry DeWolf*-class Arctic and offshore patrol vessels (AOPVs) consists of computer-based training (CBT) through the Defence Learning Network (DLN), augmented by physical trainers, the majority of which are themselves computer-based in the form of the maintenance procedural trainers installed at the Naval Fleet Schools on both coasts. It is important to note that ICT does not make use of on-the-job training (OJT) packages; rather, performance-oriented training elements have been established using CBT and trainers to align with the Royal Canadian Navy's Future Naval Training Strategy.

ICT Courses

The ICT courses for the AOPVs were developed as class-specific packages for the RCN's shipboard Military Occupational Structure Identification (MOSID) occupations, an approach that assumes personnel already have the minimum MOSID qualification for their respective trade, and experience with the *Halifax*-class frigate platform. In addition to the MOSID courses, the ICT includes an AOPV ship familiarization course for all crew, and specialized operator and maintainer courses for the Integrated Platform Management System (IPMS). ICT courses are usually scheduled to start within six months of the respective new ship delivery to ensure maximum knowledge retention.

Although the courses are designed to be self-paced through the DLN, every course for ICT has a scheduled start and end date, with an assigned location, to facilitate synergy between crew members of the same MOSID, and to take into consideration that not all junior members of a ship's company are assigned a personal work computer. As such, all crew members do their ICT at the ship's shore office, with the exception of the Weapons Engineering (WEng) Technicians who attend ICT at the Maintenance Procedural Trainer classroom to simplify the integration between the CBT aspect of the course on DLN, and the trainer. The command team of first-of-class HMCS *Harry DeWolf* did an excellent job of setting up the AOPV shore office to facilitate this training.

Because most of the crew members attend ICT simultaneously at the same location, the contractor provided a number of e-learning facilitators to support the crew in navigating their way through the courses. Looking ahead to the future, it has not yet been determined how the RCN will manage the AOPV class packages for crew regeneration in terms of start and end dates, and assigned locations.

Use of Technology

Given the nature of the computer-based approach to ICT, there is a fair amount of interactivity built into the courses to ensure the learning experience matches the skillsets and knowledge that need to be conveyed to the crew. To that end, the elements that make up the courses range from general knowledge and

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RCN images

Interactive 3D modelling is a strong component of the computer-based training packages designed for AOPV initial cadre training over the Defence Learning Network. Highlighted here (L to R) are the bow-thruster motor, an electrical braking resistor in one of the motor rooms, and a Purple-K cannister in the twin-agent unit (TAU) for flight-deck firefighting.

self-paced learning, to procedural training such as replacing an oil filter, or flashing (i.e. starting) a piece of equipment. To achieve this, the contractor has embedded several realistic, interactive 3D models and scenarios to act as learning materials and performance checks.

Although the interactive learning experiences were appreciated by the crew, they did pose some challenges to the program. To begin with, all embedded software contained in the courses had to be added to the Defence Wide Area Network (DWAN) baseline through the Request for Change process. Secondly, embedding 3D models in the courses increased the digital size of the courses, creating some load-out time issues on the DLN, and slower than desired response times to the interactions. Finally, some of the software unfortunately either became obsolete, or was no longer supported by the original software company during the conduct of the ICT, which made its use on the DWAN problematic. For example, all ICT courses used Adobe Flash Player to facilitate the

Initial Cadre Training – A Naval Technical Officer's Experience

By Lt(N) Amiraslan (Aslan) Eskandari

When the shore office for the future HMCS *Max Bernays* (AOPV-432) was stood up in late 2021, the majority of the people in the Naval Technical department had no prior sailing experience aboard an Arctic and offshore patrol vessel platform. In fact, our first introduction to the *Harry DeWolf* class was through our initial cadre training (ICT).

It was in February 2022 that the crew began training on the ship familiarization portion of the ICT. This included a virtual ship model which, in the absence of an actual training platform due to Covid-19 restrictions, proved to be a useful tool in helping members visualize the various compartments within the ship. Following this, members of the ship's company began their specific occupation-related courses – known as Military Occupational Structure Identification (MOSID) training – on the Defence Learning Network (DLN). Depending on the trade, the training ran from five to seven weeks. Course content for the Naval Technical (NT) department was separated into specialty blocks for Marine Technician (MarTech) Electrical, MarTech Mechanical, Weapons Engineering Technician, Integrated Platform Management System operator-maintainer, NT Chief, and NT Officer.

Some portions of the course required members to use the synthetic maintenance procedural trainers at Naval Fleet School Atlantic with the aid of an instructor, while the DLN portion of the course included both PowerPoint presentations and interactive activities and evaluations, with an appropriate number of details to keep trainees engaged. Additionally, members of all ranks from the *Max Bernays* Naval Technical department were able to augment their ICT through short and long sails aboard HMC ships *Harry DeWolf* (AOPV-430) and *Margaret Brooke* (AOPV-431). Members who did not have the

opportunity to sail on the first two AOPVs, attended the *Max Bernays* tests and trials at Irving Shipyard. In my case I had the opportunity to sail for 25 days on *Margaret Brooke* down south for warm weather trials.

Initial cadre training was my first experience with learning an RCN-operated platform using primarily computer-based training. The training – especially the 3D models and virtual ship model – was a good preamble for gaining a decent understanding of the AOPV platforms, their general characteristics, engineering plant, and combat systems equipment. While I would not consider using ICT alone as a sufficient tool to fully train and prepare NTOs for the platform, the combination of ICT and on-board training was definitely an effective way to go. The knowledge I gained helped me learn the platform in an efficient manner ahead of sea trials, and better prepare for the eventual delivery and acceptance of HMCS *Max Bernays.*

Lt(N) Amiraslan (Aslan) Eskandari is the Naval Technical Officer aboard HMCS Max Bernays.

interactive environment, but in January 2021 Flash Player became unsupported, and all ICT courses had to be republished using HTML 5 to ensure the courses could continue to run on the DLN. While we were doing this, we also replaced other software to avoid impending obsolescence.

As work to republish the software was getting underway, the DLN management team also decided to update the Learning Management System baseline software by moving it to its new DLN 3.0 platform. This upgrade necessitated that all ICT courses be recertified in the new DLN environment at the same time as the republished courses were being received for testing, and as ICT preparations for Ship 3 (*Max Bernays*) were in progress. Through strong cooperation between the DLN, Naval Personnel & Training Group, contractors and project staff, the courses were tested and ready in time for the Ship 3 ICT. On a positive note, the republished courses being launched on DLN 3.0 seem to have a better load-out time, and the 3D model interaction appears to be more responsive. All of these obstacles were overcome in the middle of the Covid-19 crisis, and it is thanks to the hard work and dedication of the organizations just mentioned that the AOPV ICT program was not delayed.

First-of-class and Follow-on Crew Training

The concept of using computer-based training during ICT brought with it many advantages in terms of flexibility in the delivery of the content, and in the introduction of technology. Overall, CBT has been well-received by the crews of HMC ships *Harry DeWolf* and *Margaret Brooke*, and provided an efficient means of conveying the knowledge and skillsets required to operate and maintain the equipment on board the Navy's newest ships. However, using CBT (augmented by physical trainers) as the sole means of providing initial cadre training has presented some challenges. Since the ICT program does not include an OJT package, the first time the crew of *Harry DeWolf* operated real equipment was when they went aboard their ship. This approach will work well once the RCN has a pool of qualified and experienced crew capable of supporting the newly trained personnel, but it is challenging when introducing a new class of ship.

To help alleviate this challenge, the commanding officers of the AOPVs have made every effort to have their crews attend tests and trials, or have access to the ships already delivered or in production to expose them to the various equipment and systems in operation (See companion article by Lt(N) Eskandari). For the crew of *Harry DeWolf*, practical training sessions alongside and at sea were also added to the ICT to increase the efficiency of the crew while maintaining and operating the first ship of the class. For *Margaret Brooke,* contractor support was made available to the crew after ship delivery to help transfer knowledge as the ship embarked on its first few operations. This contractor support will likely continue to be made available for the remaining ships.

Without necessarily adding an OJT package to ICT for new equipment, systems or ship delivery, future projects should consider either having more physical trainers to replicate the equipment, systems to provide practical training, or include a practical training session using the first of class, assisted by the contractor. This practical training session should be scheduled after the delivery of the first ship to avoid interfering with the production teams. The addition of physical trainers would have to be coordinated with the RCN, as these would require space inside the already crowded East and West Coast training campuses.

Conclusion

The initial cadre training for the *Harry DeWolf* class has been underway for a few years, and has provided a proficient level of knowledge to the crew ahead of joining their ships. The use of computer-based training through the Defence Learning Network has also proven to be a good method of delivering training to a large audience, while allowing flexibility in terms of the location and timing of the training. The level of interactivity within each course that includes the functions of real systems and intersystem dependencies should continue to be investigated to improve the transition to real systems on board ship. While this has been achieved, and will continue to be attained through the use of trainers, the inclusion of this practice in the CBT would provide a more seamless experience for crews, and for the staffs who are managing their training in the future.

Simon Paré is the Supportability Manager in the Arctic and Offshore Patrol Ship (AOPS) Project Management Office.

Special Edition: Arctic and Offshore Patrol Ship Project

Contract Design Specifications: Quality Assurance for AOPS and Beyond

By LCdr Morgan Francis, and LCdr Jeremiah Foley

Canadian Armed Forces Photo by Cpl David Veldman

HMCS *Harry DeWolf* passes under the Confederation Bridge linking Price Edward Island and New Brunswick.

There is an old saying in project management: "A good plan can help with risk analysis, but it will never guarantee the smooth running of a project." This, combined with a healthy creed of "Trust but verify," forms the basis of the ethos of the Project Management Office (PMO) for the Arctic and Offshore and Patrol Ship (AOPS) Project.

As the first major RCN shipbuilding project since the maritime coastal defence vessels (MCDVs) were built in the 1990s, the AOPS program kicked off Canada's National Shipbuilding Strategy (NSS) – the largest and most comprehensive federal shipbuilding program since the Second World War. PMO AOPS had both the opportunity and responsibility to lead things off properly.

The overall objective of the PMO is to ensure that the contractor, in this case Irving Shipbuilding Inc. (ISI), delivers on the ship as agreed upon by the Government of Canada. The document that spells everything out in terms of what the as-built technical requirements will be is the Contract Design Specification (CDS), and it is this contractual framework that ISI followed when designing the new *Harry DeWolf*-class Arctic and offshore patrol vessels (AOPVs). As the ships are being constructed, the PMO verifies that these CDS requirements are being met.

The CDS requirements form the backbone of the AOPS technical program, from design through inspections, harbour acceptance trials (HATs), sea acceptance trials (SATs), and post-delivery acceptance trials (PATS). The verification of these requirements falls largely to the Halifax Detachment of the PMO, or "the Det" as it is more generally known. The Det consists of PMO staff, both military and civilian, who witness and verify that the inspections, tests & trials (IT&T) are being performed correctly, and that the interface between Canada and ISI "at the coalface" remains open and cooperative. This practice was first employed during the Canadian Patrol Frigate (CPF) Project of the 1980s and 1990s. Cdr Darryl Hansen, the CPF Detachment Commander in Halifax, told the *Maritime Engineering Journal* in 1989 of the verification process of the time:

> *Quality Assurance was a vital part of the contract. In a perfect world, the Crown could have signed the contract, turned its corporate back and returned years later to pick up the keys as the vessel rolled off the production line. The QA system put in place by the contractor would have guaranteed that the frigates were designed and built entirely in accordance with the contracted requirements. But we're not there yet, nor are we ever likely to be.*

This is as true now as it was then. As much as there is good will and respect between client and customer, the onus remains with the PMO to ensure that the contract is being adhered to while respecting the need of both organizations to facilitate a timely delivery. That said, and flexibility being the key to sea power, the PMO has had to be open to compromise as far as the methods of verification are concerned.

While previous staff in PMO AOPS accomplished a tremendous achievement in developing the CDS (which has so far led to the launch of three new ships, it is worth looking back on the CDS requirements as written, and see how some of them have played out over the course of designing, building, inspecting, trialling and finally delivering new ships, and determine whether they could have been improved.

Enter SMART requirements. SMART is a mnemonic used to develop requirements, something most engineers have heard of by now in one variation or another. Originally coined in the November 1981 issue of *Management Review* by George T. Doran, the mnemonic has been adapted to numerous disciplines. In this instance, each requirement in the CDS should be:

- *Specific* – requirements should be specific enough to avoid unintended interpretation, but not so specific as to define a solution;
- *Measurable* – requirements should be written with future verification in mind;
- *Attainable* – requirements should be possible, and not conflict with each other;
- *Relevant* – requirements should be applicable to the problem; and
- *Time-based* – requirements should consider the production and delivery schedule.

Starting with **Specific**, consider the following requirement:

> CDS-4003 – The AOPS portable submersible bilge pump overboard discharges shall be located above the waterline, one to port, and one to starboard in each main vertical zone.

A similar capability exists on other RCN ships, and so the expectation from the PMO was that both the connection points and discharges would be above the waterline. However, because this was not specified, the connection points are currently below the waterline.

Another example of a requirement that lacks specificity is:

> CDS-3852 – The AOPS motor room, low-voltage equipment room, steering gear, and bow thruster compartments shall have adequate supply ventilation to suit the heat generated and to remove dampness.

Without defining "adequate supply ventilation" and "remove dampness," measuring the delivered ship against this requirement is left up to interpretation.

For an example of *too* specific a requirement, consider the following:

> CDS-4140 – The AOPS LP service air system shall deliver sufficient air to serve 50 percent of the total demand of all installed equipment and service air outlets simultaneously but in any event not less than 600 litres per minute of LP air at a pressure of 800 kPa plus or minus 50 kPa.

While the requirement starts off well, the specification of the air pressure at 800 kPa plus or minus 50 kPa was added to ensure the system would meet demand. However, LP air systems are not tied to a specific pressure. The system could meet demands at 700 kPa (most commercial systems operate at this pressure) or 900 kPa. This limited the designer's freedom in equipment choices, and there was no real need to have the system operate at 800 kPa. The best equipment found for the system happened to operate between 700 and 800 kPa, and so the requirement had to be changed to read 750 kPa instead of 800 kPa.

An example of a better way to write a similar requirement is this:

> CDS-3971 – The AOPS chilled water plants shall each be sized on 100 percent of the total cooling requirements of the AOPS.

Moving to **Measurable**, consider the following:

> CDS-5100 – The AOPS shall comply with the World Health Organization (WHO), Guide to Ship Sanitation.

While it makes sense to reference standards and regulations, the problem arises when the requirement later has to be verified. The WHO guide cited here has numerous chapters, only six of which apply to AOPS, and verification of this requirement requires the completion of 10 different trials. Having to track all of the individual

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elements needed to meet this requirement is administratively challenging, and is a burden of the PMO's own creation. A better solution would have been to break the requirement up into several requirements, and base them on the individual chapters.

Another example of a requirement that is difficult to measure:

> CDS-3755 – The AOPS piping systems shall have all pipes led (sic) as directly as possible with a minimum of bends.

Whereas it is certainly desirable to have piping runs with as few bends as possible, this requirement could have been made a recommendation (using the word "should" instead of "shall") rather than an imperative. In its current form, the verification of this requirement would take significant analysis to determine if indeed all piping systems were designed with minimal bends.

For **Attainable**, the following two requirements alone seem reasonable:

> *CDS-168 – The AOPS shall operate without restriction in ambient* ***air*** *temperatures over the full range from a maximum of +35 degrees Celsius to a minimum of -29 degrees Celsius.*

> *CDS-169 – The AOPS shall operate without restriction in ambient* ***sea*** *temperatures over the full range from a maximum of +29 degrees Celsius to a minimum of -2 degrees Celsius.*

The issue arises when taking the requirements together. While the ship's systems can certainly be designed to meet the stated requirements for air and sea temperatures, *verifying* that they do would entail conducting trials in an appropriate environment. This is where we run into problems. With the warm weather requirements, for example, open-ocean air temperatures are typically 2-3°C higher than the sea temperature on a clear day. So, if the air temperature is +35°C, the sea temperature is probably around +32°C, which exceeds the design maximum; conversely, if the sea temperature is +29°C and the air temperature is only +32°C, the ship's systems can't be trialled to the stated maximum air temperature.

For **Relevant**, consider this simple requirement for the inclusion of dynamic killcards (i.e. interactive checklists) in the ship's damage control system (DCS):

> CDS-4972 – The AOPS DCS shall have Dynamic Killcards.

When the AOPS CDS was written, the Integrated Platform Management System (IPMS) on other RCN ships was just being deployed, and the intention there was for the damage control system (DCS) to use dynamic killcards. However, as their use in these ships has yet to be fully figured out, it becomes a difficult requirement to meet on AOPS, much less verify.

Finally, **Time-based** requirements are not typically an issue with the AOPS CDS, but then consider the following:

> CDS-5028 – The AOPS DCS Stability Calculation Display shall interact with a stability calculator engine so that internal IPMS sensor information (e.g. tank content/volume) and current plotted damage are passed to this calculator engine with the results being shown on a dedicated stability DCS view.

This capability requires that the AOPS Manual of Trim and Stability be completed in order to inform the stability calculations used in IPMS. However, the delivery of the manual came much later than the tests and trials for IPMS. This has led to an iterative testing process, which was outside of the initial trials schedule.

The AOPS Project will serve as the baseline for the RCN nexus within the NSS. It is imperative that the lessons learned at all phases of AOPS be not just recorded and filed, but analyzed and integrated into our follow-on projects. The Contract Design Specifications form the DNA of the project, and as any good technical writer will tell you, language matters. Both Canada and ISI will surely look to AOPS to see what worked and what didn't, and if one thing is certain, it's that the one constant will be change.

LCdr Morgan Francis is the former AOPS Test & Trials Manager. LCdr Jeremiah Foley is the PMO AOPS Marine Systems Engineering Manager.

The Balancing Act between Ice Breaking and Open Ocean Seakeeping in the Design of the *Harry DeWolf* Class

By Daniel Lougheed

Photo by Cpl David Veldman, CAF Combat Camera

Canadian Armed Forces photo by S1 Taylor Congdon

All ship designs involve compromise, as each element of the design impacts others. This reality created interesting challenges during the design of the *Harry DeWolf*-class Arctic and offshore patrol vessels (AOPVs). I am fortunate to have been involved with this project for 10 years now, from preliminary design review through to post-acceptance trials, and have witnessed the full range of "teething problems" anyone could expect with a complex new ship construction project. In the end, I feel we are delivering very capable ships to the Royal Canadian Navy, and in this article I would like to discuss some of the background on the AOPVs in relation to ice breaking and seakeeping.

My Introduction to Naval Architecture and the AOPS Project

In 2011, following my head of department tour in HMCS *Winnipeg* (FFH-338) and a couple of shore postings on the West Coast, I was accepted into the Naval Architecture master's program at University College London (UCL) in England. One of the program requirements was for student teams to design a ship, and at the request of naval authorities back in Canada, my group comprising one Royal Navy and two RCN officers was tasked with designing an ice capable patrol ship. Clearly, it was expected that the Canadians would carry some of this experience over to the AOPS project in the not-too-distant future. As we worked through our design, we quickly came up against the challenges of combining ice breaking capability with open ocean seakeeping, requirements that demand very different hull forms for optimal performance. This experience indeed proved to be very helpful when I returned to Canada as a newly minted naval architect, and subsection head in the Directorate of Naval Platform Systems (DNPS) in Ottawa.

I soon became involved in the review of deliverables that formed part of the preliminary design review for the AOPS project. By 2014, the design was very mature as the project had been in place for several years. STX Marine and BMT Canada had worked with the AOPS Project Management Office (PMO) to develop the concept design, which was used to form the basis of the contract with Irving Shipbuilding Inc., (ISI). Irving then worked with their design agent at the time, OMT of Denmark, to further refine and flesh out the design in preparation for production. With the exception of adding a hull extension, the original hull form and main elements of the concept design remained unchanged. My subsection and others within DNPS reviewed the design packages that were submitted to the PMO by ISI, and we provided our input on potential improvements.

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Design History

In 2016, I joined PMO AOPS, where I remain to this day. Many of the engineers who had worked with the project from the early days were still with the PMO, and I was fortunate to be able to speak to them, and learn about the design trade-offs that took place. So, let's consider some of the primary requirements they were working with. To begin with, since the ship had to be able to operate in the Arctic, it needed to be ice capable. After considering the annual ice conditions in the Northwest Passage, an overall ice-strengthened hull standard of Polar Class 5 was selected for the design (Figure 1 below). The bow area was strengthened to a more robust standard of Polar Class 4, while the shoulder areas of the stern were upgraded to a level between PC 5 and PC 4.

Initially, a top speed of 20 knots was also specified, along with good seakeeping to allow operation in the North Atlantic year-round. As a starting point for the design, the Norwegian Coast Guard Vessel *Svalbard* (W-303) — classified as an icebreaker and offshore patrol vessel — had been selected as a parent design to give the team an idea of the potential size and displacement of the future *Harry DeWolf*-class AOPVs.

Ice breaking was clearly the main design driver. To operate efficiently in ice, the hull must have a form to allow it to break ice in bending (Figure 2), which is a very different geometry than that of a frigate or destroyer. External appendages such as the bilge keels found on many ships can easily be damaged when operating in ice, but not having them affects seakeeping, as they help to reduce roll motion. *Svalbard* was originally fitted with anti-roll tanks, but these proved unsuccessful and were replaced with active fin stabilizers. Learning from the Norwegian experience, active fin stabilizers were included in the AOPV design. The advantage with them is that they can be retracted when

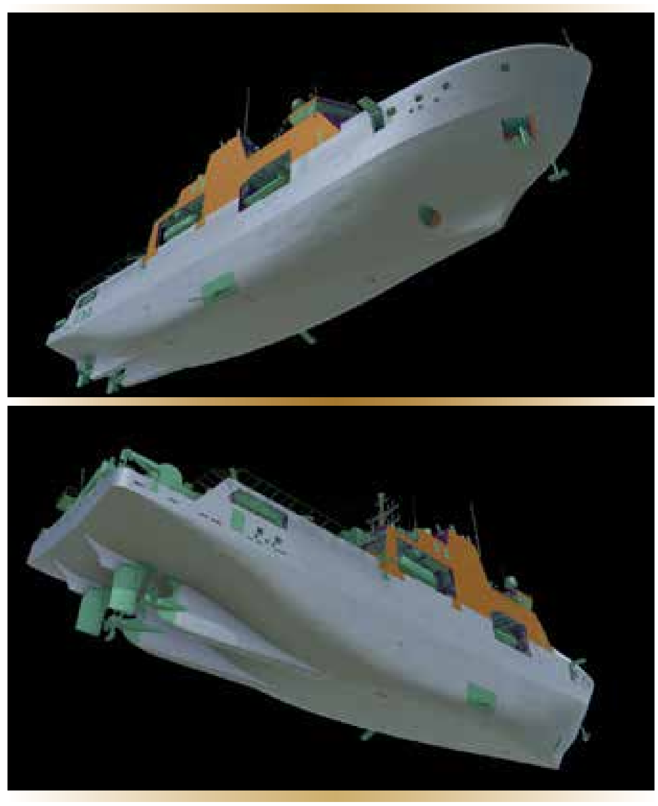

Figure 2. These computer modelling images from Irving Shipbuilding Inc. show how the geometry of the AOPV hull design has been optimized for ice breaking, as well as for seakeeping in support of helicopter operations and crew comfort. Crews have been reporting their satisfaction with the operation of these ships in all conditions.

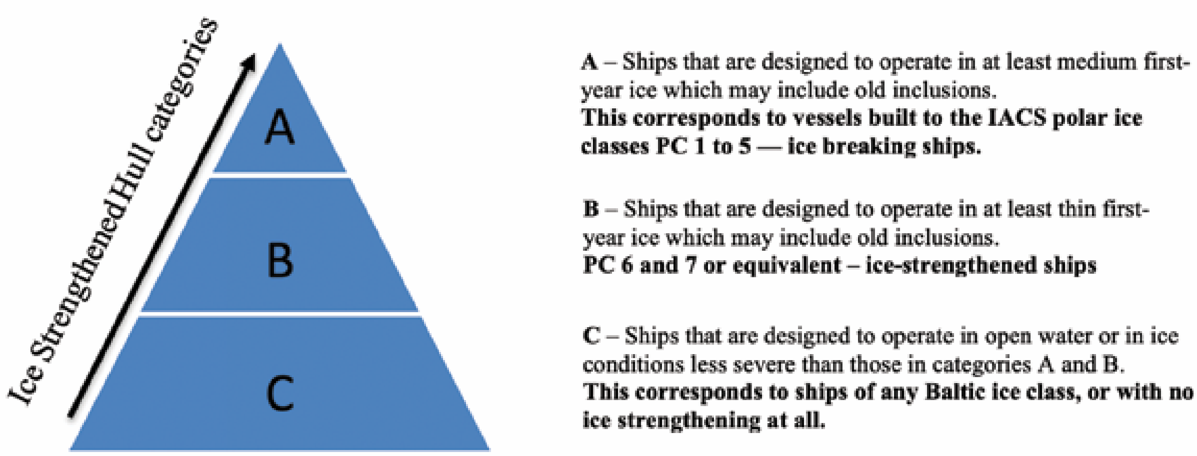

Figure 1. International Association of Classification Societies (IACS) Polar Class Ice Strengthened Hull categories.

operating in ice, or when coming alongside a jetty, but their disadvantage is that they are less effective at lower speeds, as they generate less lift in lower fluid velocities.

Apart from considering crew comfort, the need to have good seakeeping was driven by helicopter requirements. Computational seakeeping analyses were completed at several stages throughout the project to confirm that the ship would meet the needs of the Royal Canadian Air Force, and these were borne out during the helicopter/ship evaluations with HMCS *Harry DeWolf*. As initial computational models of the ship design were developed, it was found that the specified top speed would be a challenge. The relationship between speed and power is a cubed one for ships, and the power required to approach 20 knots was immense. Based on the initial work, 17 knots was therefore selected as an achievable and reasonable top speed for an AOPV.

The hull form was designed by Aker Arctic of Finland which, at the time, was part of STX Marine (now VARD). This is important, as Aker is one of the world's leading designers of ice capable vessels. The first iterations of the AOPV design included pod propulsion units, as this is what was installed on *Svalbard*. Pods offer great performance in ice, and fantastic manoeuvring in general, but are more expensive and potentially less reliable than shafts and propellers. The design was changed to traditional shaft lines based largely on input from the Canadian Coast Guard. The increased cost simply outweighed the potential benefits for the AOPVs, and having had a chance to sail in both *Harry DeWolf* and *Margaret Brooke*, I believe the project made the correct decision on this element. Given how the Navy is likely to employ these vessels, the current configuration is more than adequate. Over the years, assumptions have been made that the hull form was optimized for pods, but fitted with shafts. This is most certainly not the case. When the decision was made to go with shafts, the hull form was completely changed, and thus optimized for the current propulsion system.

In 2017, I was invited to attend a NATO working group on polar ship design at Aker Arctic. The timing was perfect, as I had been with the project management office for a year, and had many questions I wanted to put to the designers of the hull form. The Aker team set time aside to go over the drawings of *Svalbard* and the *Harry DeWolf* class to help me understand how they arrived at their design. One thing I found very interesting was the difference between the two hulls. It turns out that *Svalbard* was designed for first-year ice, just like the AOPV, but there was no speed requirement. Our ship, on the other hand, was required to break medium first-year ice at a speed of at least three knots. In addition, *Svalbard* had a more powerful propulsion plant than the AOPV, which forced our designers to optimize more for ice breaking than for open ocean performance. *Svalbard* actually has a finer stem that is more optimized for open water operations, much like what we see on a frigate. The AOPV bow, by comparison, has more of a rounded spoon shape, similar to what we find on icebreakers. A sharp narrow bow will be more efficient cutting through waves, but will break ice in shear rather than in bending. The bow of *Harry DeWolf* changes shape just above the water line to allow it to push down on the ice.

Figure 3. AOPV tank testing in ice at the National Research Council's facility in St. John's, NL.

Sea Trials in the North

Of all the various responsibilities of my position as a naval architect with the AOPS project, it is participating in trials that I find the most rewarding. There have certainly been some setbacks, but these trials give us a better understanding of the ships, and we have been able to address many issues along the way. I am most interested in the ice breaking trials, which have been years in the making across several organizations: i.e., the Canadian Coast Guard (CCG), National Research Council (NRC), Defence Research and Development Canada (DRDC), Oceanic Consulting (a Canadian company providing services related to naval architecture, now owned by Irving), ISI, and the Department of National Defence. Due to our limited experience and knowledge with ice breaking, we reached out to other organizations to learn more on the subject. Our Coast Guard was very helpful, and provided us with reports from ice breaking acceptance trials for their ships.

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The NRC conducted early towing tank tests for us (Figure 3), and also studied potential locations for the trials, based on the contractual ice breaking requirements for the AOPVs and historical ice development data for the Arctic.

While I had been looking forward to attending the first-of-class ice-breaking trials with *Harry DeWolf* in person, pandemic travel restrictions made this impossible. I asked fellow Nav Arch **Lt(N) Shane Kavanagh** in Halifax to represent the PMO during the trials, and even though the required ice conditions were not found during that trial window, we still learned a great deal. Lt(N) Kavanagh (now a lieutenant-commander) was able to let us know that in the conditions that were found, the ship appeared more than capable in first-year ice. Last winter, I was able to lead the PMO team during the ice-breaking trials for HMCS *Margaret Brooke*. We had better ice formation in the Arctic, and with help from CCG and Canadian Ice Services we were able to find what we had not found with *Harry DeWolf*.

Our primary area of operations was off the southern coast of Baffin Island in Davis Strait. Our representative from Canadian Ice Services was able to use fresh satellite imagery each day to select ice floes that would likely meet our contractual needs. We had no issue finding medium first-year ice, but finding level, consistent ice was a different story. The ice in Davis Straight is constantly on the move throughout the winter, and the floes collide with each other, causing rafting and creating rubbled ice. At one spot we could have 0.8 m of thickness, while just a few metres away the ice would be 2.5 m thick. Our goal was to determine if the ship could break one metre-thick ice at three knots or better. After several days of exploration, we located a suitable ice floe and conducted the trial (Figure 4), demonstrating that the ship's design met the contractual requirements.

On the transit north from Halifax, the weather was typical for February in the North Atlantic, which provided ample opportunity to observe the seakeeping properties of the ship. The active fin stabilizers manufactured by Rolls-Royce performed well, and dramatically reduced the roll motion of the ship in sea state five. The motion is somewhat different than what we experience in the *Halifax*-class frigates, but not any more severe in most cases.

Photo courtesy Lt(N) Joe Cheng, RCN

Figure 4. HMCS *Margaret Brooke* in Davis Strait.

Conclusion

As engineers, we necessarily tend to focus on the technical issues that need to be dealt with to improve the performance of whatever equipment it is that requires our attention. It is no different with the AOPVs. We are working through technical issues in this new class of ship, it's true, but when we look at the larger picture we can see that the fundamental elements are operating as we hoped they would. As I said at the beginning, the RCN is taking delivery of some very capable ships.

Working on this shipbuilding project continues to be immensely satisfying for me, and I am grateful for the door that opened up for me through my post-graduate program in naval architecture at UCL.

Daniel Lougheed is a retired Marine Systems Engineering Officer, and is currently the Acting Systems Engineering Manager with PMO AOPS.

Special Edition: Arctic and Offshore Patrol Ship Project

Breaking the Ice: The RCN's Triumphant Return to the Arctic

By Cdr Corey L.E. Gleason, MMM, CD

When Vice-Admiral Harry DeWolf, CBE, DSO, DSC, CD ordered HMCS *Labrador* (AW-50), the Royal Canadian Navy's first "Arctic and offshore patrol vessel" to be paid off in 1958, he likely would never have guessed that the RCN would return to the Arctic more than half a century later with a ship — and a design class — named after him.

The "future" *Harry DeWolf* (AOPV-430) was delivered by Irving Shipyard Inc. (ISI) in 2020, with a great deal of work having been conducted by the ship's staff in the preceding 18 months as we prepared to take over the care and custody of the newest addition to the RCN fleet. Our main focus during this pre-delivery period was to complete our individual and collective training, including harbour readiness training and practical original equipment manufacturer (OEM) training (supplied through ISI), attend materiel state disclosure conferences, conduct equipment verification and load-out, and participate in a week of sea trials with ISI staff.

At the commencement of the post-delivery work period, a robust training plan was implemented, aimed at increasing crew proficiency and confidence in the areas of emergency response, force protection, seamanship, ceremonial, security, shipboard safety, engineering (including high-voltage systems), and electromagnetic radiation hazards. At the same time, we also executed a basic single-ship readiness training (BSSRT) program designed to prepare the crew with respect to safety at sea, and to support the upcoming post-acceptance and in-service tests and trials. Our first-of-class BSSRT program was longer than traditional programs of its type, as we had to formalize standing operating procedures for endorsement, through Naval Force Readiness, by the Assistant Chief of Naval Staff Afloat Training & Readiness. This would become the cornerstone for follow-on ships as they conducted their own BSSRTs, with the hope of reducing future programs to five days or less at sea.

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Image courtesy Lt(N) Joe Cheng

Cdr Gleason (right) navigates HMCS *Harry DeWolf* through an Arctic ice field.

There was also a series of post-acceptance trials (PATs) governed by the ISI contract that precluded *Harry DeWolf* crew from performing tasks such as towing, replenishment at sea, and ice breaking until the PATs were completed, but ship's staff formulated an operations schedule to complete these trials alongside and at sea. For myself, the cold weather trials were a highlight, as they gave me the opportunity to put to the test my years of training with allies and the Canadian Coast Guard in Arctic ice. It was not lost on me that the success of these trials would signal to the maritime community that the RCN was back in business in the Canadian Arctic. We needed to get this right.

The *Harry DeWolf* class has ice-breaking capabilities made possible by an icebreaker stem, ice-strengthened propellers, ice knives, and the ice-breaking form of the hull itself. These features, together with the propulsion plant, are what enable the ship to proceed through ice. The AOPV hulls were designed and assessed by Lloyd's Registry against the new International Association of Classification Societies (IACS) Polar Class Rules regarding ice strengthening, particularly in the areas of the bow and stern to mitigate the risk of damage for the envisaged AOPV operating scenarios.

I am often asked what thickness of ice an AOPV can operate in. Ice thickness is certainly a factor to consider before proceeding into a floe, but we also have to be concerned with other things such as extreme cold temperatures, inconsistent ice density, and pressures at play in the ice. A ship might operate freely in quite thick ice in warm temperatures, but be stopped cold, as it were, by the same floe once temperatures drop and the ice has had a chance to increase its fractal strength. Equal contributors to the ice risk index assessment are wind speed and direction, which can cause ice ridges to interact, thereby increasing pressure between floes and hampering a ship in any ice regime.

Ice found in the Canadian Arctic is a mixture of first-year and multi-year ice. Multi-year ice is extremely dense, and dangerous even for ice-breaking ships when proceeding too fast. During the summer thaw, multi-year ice breaks away and mixes in with first-year ice. When the winter begins to set in, that multi-year and first-year ice freezes together, resulting in a challenging navigable season the following year. Depending on the degree of summer melt, much of the Canadian Arctic can remain inaccessible during the normal navigable season.

The year 2021 marked the beginning of the RCN's triumphant return to the Arctic with new, extended capacity for conducting constabulary patrols, supporting research, and other operational taskings as required in Canada's northern waterways. What was once only weeks of operational time in-theatre, can now be expressed in months, thanks to the capable design and solid concept of operations for the *Harry DeWolf* class of Arctic and offshore patrol vessels.

Our ship performed admirably, both in the dead of winter during cold weather trials, and in all other climates as we circumnavigated North America via the Northwest Passage and Panama Canal. I can only offer my heartfelt appreciation to the many organizations, businesses and people — our sailors in particular — whose dedication to the tasks at hand made this endeavour possible. Whether you shared this AOPV journey in whole or in part in the years leading up, your efforts deserve to be celebrated. It was a mountain of work, and I am immensely grateful to have worked with you. Bravo Zulu.

Cdr Corey Gleason is Commander Sea Training for Patrol Vessels (Atlantic), and was Commanding Officer of HMCS Harry DeWolf, Canada's first Arctic and Offshore Patrol Vessel from 2015 to 2022.

Photo by Cpl David Veldman

Special Edition: Arctic and Offshore Patrol Ship Project

Marine Systems Overview: How the Arctic and Offshore Patrol Vessels differ from the Canadian Patrol Frigates

By Lt(N) Xuzhou Lin
Photos by Lt(N) Shannon O'Reilly

Figure 1. Two of the AOPV's four 3600-kW MAN diesel engines that provide electrical power for propulsion and ship electrical systems.

The Royal Canadian Navy's newest platforms, the *Harry DeWolf*-class Arctic and offshore patrol vessels (AOPVs), have enhanced our ability to assert Canadian sovereignty in Canada's coastal and Arctic waters, in addition to supporting international operations. With a crew size of 65 and only a single Naval Technical Officer (NTO) responsible for both the marine and combat systems, it is imperative that NTOs have a good understanding of all onboard engineering systems. Through this article, I am endeavouring to provide a general technical overview of the AOPV's major systems, by contrasting them with the systems we know so well aboard our *Halifax*-class Canadian patrol frigates (CPFs).

To begin with, the AOPVs are fitted with a diesel-electric power plant arrangement that provides electrical power for both propulsion and ship electrical systems. The CPFs, on the other hand, are fitted with a combined diesel or gas (CODOG) propulsion plant, with gearboxes and a separate electrical power generation and distribution system.

Propulsion and Steering

AOPVs are designed to have a top speed of 17 knots, and an endurance speed of 12 to 14 knots. In sea state 3 (0.5 to 1.25-metre waves), at endurance speed, the AOPV is capable of travelling well over 6,800 nautical miles, depending on the diesel-generator (DG) configuration. To achieve this, the ships are fitted with four main MAN diesel and turbo 6L 32/44CR B2 engines (Figure 1). These are medium-speed, six-cylinder four-stroke marine diesels, with a 320-mm bore and 440-mm stroke, and have a rated power of 3600 kW each. They were selected for their high efficiency, high specific power output, low emissions, low operating and life cycle costs, long maintenance intervals, long service life, and high reliability.

The cylinders have a top speed of 750 rpm at 50 Hz, and are connected to four General Electric B128U110, 6600 VAC, 321A, PF 0.9, 10-pole, synchronous AC generators

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that each have an output of 3670 kVA at 720 rpm, at 60 Hz. In addition, the AOPVs are fitted with a thermal oil system that uses exhaust-gas economizers to recover heat from the DGs to provide hot water for the HVAC system. Two DG sets are each coupled to one of two main high-voltage switchboards, which each supply power to one main propulsion motor and one ship service transformer.

The ship's two propulsion motors are General Electric N3HXC1120 1600/6C motors, with a rated shaft power of 4555 kW and a system operating voltage of 3000 VAC. They are asynchronous, squirrel-cage, induction type AC motors with a single winding maximum torque at 145 rpm, and maximum rated speed of 190 rpm. The propulsion motors receive power from the high-voltage switchboards via a propulsion transformer and frequency converter (PFC). The PFC is used to control shaft rpm, while a braking resistor is used for each shaft line to aid in normal and emergency braking. Unlike the CPF, this propulsion arrangement does not require reduction gearboxes, nor a supporting main lube oil system for lubrication and cooling. On the AOPV, each motor is directly coupled to its shaft line via a flexible coupling. However, each motor drives its shaft line independently, with no cross-connect capability.

By comparison, the CPFs are designed to have a top speed of over 30 kts on two LM2500 gas turbines for high-speed manoeuvring, and a service speed of 17 kts on an SEMT Pielstick 20 PA6 V280 type propulsion diesel engine that has an endurance speed of 13 kts for fuel-efficient, long-range transits of up to 9,500 nm.

The AOPV propulsion arrangement allows for a shorter and simpler shaft line compared to the CPF's shaft, which traverses three machinery spaces and the gland space before leaving the ship. The AOPV shaft lines begin *abaft* the main machinery spaces in the motor rooms (Figure 2), and traverse through the shaft tunnels. They are encased by a stern tube and void space, which protects them from damage when the ship is transiting through ice. Additionally, the AOPV shaft line has a disc brake and locking mechanism fitted abaft the flexible coupling.

The propellers fitted on the AOPV (Figure 3) are four-bladed, ice-strengthened, fixed-pitch propellers that meet Polar Class 5 requirements (year-round operation in medium first-year ice). They are each 3.8 m in diameter, including four skewed blades individually bolted to the propeller hub. Each propeller is designed to absorb the maximum continuous power rating of its related propulsion motor at full, open-water speed, and at the bollard condition. The blades are designed to minimize cavitation when the propeller is operating at heavy load conditions. This is in contrast to the CPF's five-blade, controllable reversible pitch propellers (CRPP), which is an entire major system on its own. With fewer mechanical and hydraulic moving parts to its propulsion system, the AOPV maintenance requirement is both lower, and easier to conduct than on a CPF.

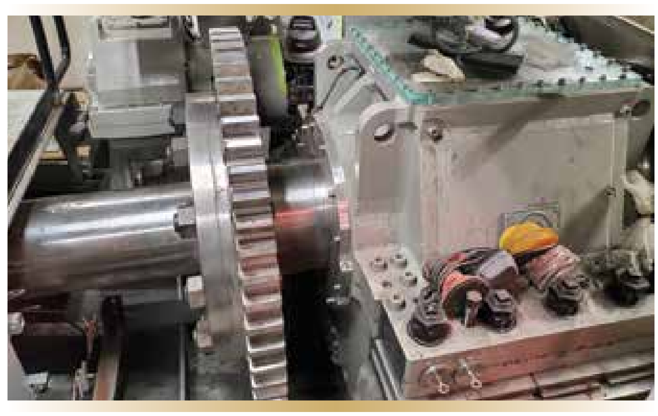

Figure 2. Thrust block and turning gear arrangement.

Figure 3. The fixed-pitch propellers fitted on the AOPV are ice-strengthened to meet Polar Class 5 requirements.

Primary manoeuvring is provided to the AOPV by two Van der Velden semi-spade, underhung, shallow horn, semi-balanced type rudders that each weigh 6.9 tonnes (Figure 4). They are positioned abaft each propeller and are

Figure 4. The AOPV rudders are well protected for operation in ice.

protected by ice knives that prevent ice from jamming between the hull and rudder, or rudder and rudder horn. The rudders are controlled by separate Rolls-Royce hydraulic steering control units, consisting of a rotary vane actuator (RVA) fitted with two reversible pumps, that are able to move the rudders 35 degrees to port/starboard, with a full travel arc of 37.5 degrees before being stopped mechanically. The pumps are started and stopped by an electric motor, and are used to pump hydraulic oil bi-directionally to move the RVA to the desired rudder angle. Once the pumps are stopped, the rudder is hydraulically locked in place.

The CPF differs in that it uses a single spade rudder positioned between the two propellers, controlled by a rotary vane actuator that has hydraulic oil sent through a proportional valve manifold assembly from an oil sump. The hydraulic pumps provide a constant flow of hydraulic oil at system pressure to the proportional valve manifold, which delivers a proportional flow to the RVA to move the rudder to the desired angle. Once the desired angle is reached, the proportional valve manifold closes and locks the rudder in place hydraulically, and relieves the oil from the pumps back to the sump.

The AOPVs are also fitted with a single, fixed-mounted, transverse tunnel bow thruster (Figure 5), something the CPF does not have. This allows for enhanced manoeuvrability during low-speed operation, and during docking and undocking operations. At full power, the bow thruster is able to provide a maximum transverse thrust of 150 kN. Power is supplied from a dedicated transformer via a main bus from one or both high-voltage switchboards through a power cross-connect to an electric motor that controls the speed and direction of the bow thruster propeller's rotation.

Electrical

As mentioned, the AOPV has four DG sets coupled to two main high-voltage 6600-VAC switchboards for primary electric power generation. Each HV switchboard supplies 6600-VAC, 3-phase, 60-Hz power to one of two ship service transformers, of which only one is required during normal operation to supply the full service electrical load. The ship service transformers convert the HV power to a low-voltage (LV) 465-VAC, 3 phase, 60-Hz power for use in ship-wide systems via one of two ship service 440-VAC switchboards. Various transformers are used throughout the ship to convert power to 440, 220, or 120 VAC to support specific ship service systems. A 440-VAC emergency switchboard is also fitted, supplied from either one of the 440-VAC service switchboards, one of two shore power panels, or the emergency diesel generator. The emergency switchboard provides power to all emergency power consumers, or to provide power to all ship service systems when under shore power.

The emergency diesel generator is fitted to provide initial starting energy to propulsion machinery within 30 seconds of a dead ship. It is able to carry its nominal full-rated load within a maximum of 45 seconds. The emergency diesel generator is a four-stroke, non-reversible, turbocharged, and inter-cooled Caterpillar 3512C diesel engine with direct fuel-injection. The engine has a 60-degree V-12 configuration, with four valves per cylinder, and a cold start capability. The engine is coupled to an OV2319 Kato AC brushless revolving field generator that is rated to produce 1360 kW of 440 VAC, 3 phase, 60 Hz at a maximum engine speed of 1800 rpm. The emergency DG can be brought online in parallel with main ship service power, or shore power, to implement a make-before-break energization strategy that allows for a transfer of power without blackout.

In contrast, the CPFs have a dedicated electrical power generation and distribution system solely used for supplying the ship with electrical power. Four DG sets are fitted, powering two main LV 440-VAC, 3-phase, 60-Hz switchboards that are used to supply 440, 220, or 120-VAC power to the ship services. In normal operation, two DG sets supplying both switchboards supply the full ship service electrical loads. The DG sets fitted on the CPF

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Figure 5. The AOPV transverse tunnel bow thruster.

are four-stroke, turbocharged, after-cooled Caterpillar CATC32 diesel engines with direct fuel injection. These are coupled to Hitzinger marine synchronous 4-pole, 3-phase, 6-lead brushless generators that each produce 830 kW of 440 VAC, 3-phase, 60-Hz power at a nominal speed of 1800 rpm.

Ship Stability

In addition to ballasting to maintain ship stability, the AOPVs are fitted with an active-fin roll stabilization system, as well as a heeling system to provide an additional degree of stability that is not available aboard the CPFs. The Rolls-Royce Aquarius 100 active-fin roll stabilization system is designed to reduce sea-induced roll motion by up to 90 percent at speeds between 5 and 17 knots. The system, fitted amidships, has low-drag, high-lift fins with flat outer end-plates, and trailing edge plates. The fins are retractable and can be locked in place within the hull mechanically, or fully extended hydro-mechanically. The fins are hydraulically controlled using a dedicated hydraulic system.

The AOPVs are also equipped with a heeling system that, when activated, continuously rolls the ship five degrees to port, then five degrees to starboard over a four-minute period to prevent the ship from getting stuck in heavy sheets of ice. Saddle heeling tanks with a volume of 98.7 m3 are filled or emptied using the ballast/bilge pumps from the seawater ballast system, and treated sea water is transferred between the two tanks using two reversible heeling pumps. The system is designed to operate continuously for long periods of time.

Damage Control

Both the *Harry DeWolf*-class AOPVs and *Halifax*-class CPFs are fitted with smoke control and evacuation systems, drencher systems to protect magazines, ammunition lockers and pyrotechnics, aqueous film forming foam (AFFF), galley fire protection, and a twin-agent unit. However, CPFs use Halon to protect against electrical equipment fires, and machinery room fires.

The AOPV does not carry Halon, but uses two different systems instead. For fire protection in areas with Class B materials (petroleum, oils, lubricants) such as in the main machinery rooms and the JP-5 pump room, the AOPV uses a water mist system – a single fluid, high-pressure dry-pipe system that uses water at high pressure (55 bar) to generate fine water droplets that are safe for both personnel and the environment. For fire protection in areas containing vital electrical equipment (Class C hazards), such as the motor rooms and low-voltage equipment rooms, the *Harry DeWolf* class uses a fixed gas system. This consists of a dry-pipe system that uses NOVEC-1230™ as the suppressing agent, and nitrogen gas as the pressurizing agent. Once activated, a mechanical 32-second delay is introduced before the NOVEC is discharged to allow sufficient time for personnel to evacuate the space, and for the compartment doors to be closed. CPFs carry NOVEC as well, but it is only used for suppressing DG fires.

Conclusion

The Arctic and offshore patrol vessel is an engineering marvel with a distinctly 21st-century look and feel to it. As the Royal Canadian Navy's newest ship of the past few decades, its design considerations have clearly incorporated the technological improvements expected for a modern ship. NTOs and other technical staff who have been trained on the CPFs can look forward to operating a ship that truly opens a new era in marine systems engineering.

Lt(N) Lin is a Marine Systems Engineer with the Arctic and Offshore Patrol Ship Project in Ottawa.

Ballast Water Treatment aboard *Harry DeWolf*-class Arctic and Offshore Patrol Vessels

By Lt(N) Anthony Kim

Canada's Arctic waters are home to one of the most pristine marine environments in the world, a delicate ecosystem teeming with aquatic plant and animal species that require protection for their survival. This complex marine biome can easily be disrupted by the introduction of invasive species, such as may be found in ships' ballast water, potentially causing irreversible damage to the delicate balance of life.

Taking on ballast water in tanks located along the keel is an integral part of managing a ship's stability, as it counteracts the rise in centre of gravity as a vessel's fuel load is consumed during a voyage. This is critical in preventing a ship from becoming top heavy and capsizing, especially during inclement weather or sea conditions. However, improper handling of untreated ballast water can be a major cause of transfer of invasive species from one area of the world to another.

The amount of ballast water carried by a single ship can be considerable. The *Harry DeWolf*-class Arctic and offshore patrol vessels (AOPVs) have 14 ballast tanks, with a total volume of 1,256 cubic metres, and when it comes to protecting Canada's Arctic ecosystems, extreme diligence is required when handling ballast water at all stages. The International Ballast Water Management Convention, and the Canadian Ballast Water Program specify that ballast-water exchange in the Arctic is to be conducted more than 200 nautical miles away from shore, in a designated ballast-water exchange area, or by using an onboard ballast water treatment system.

There are many commercially available treatment methods, and the AOPVs use a dual-stage process of particle filtration and ultraviolet treatment to remove and destroy biological organisms such as zooplankton, algae, and bacteria from ballast water during ballasting and de-ballasting operations (Figure 1). Combining two treatment methods like this ensures that the ballast water meets International Maritime Organization Regulation D2, the standard governing the treatment of ballast water at uptake to ensure that strict ballast water quality standards are met at the point of discharge.

As ballast water is taken on, it is pumped through a mechanical filter to remove any larger organisms and particles from the stream, before being passed through a

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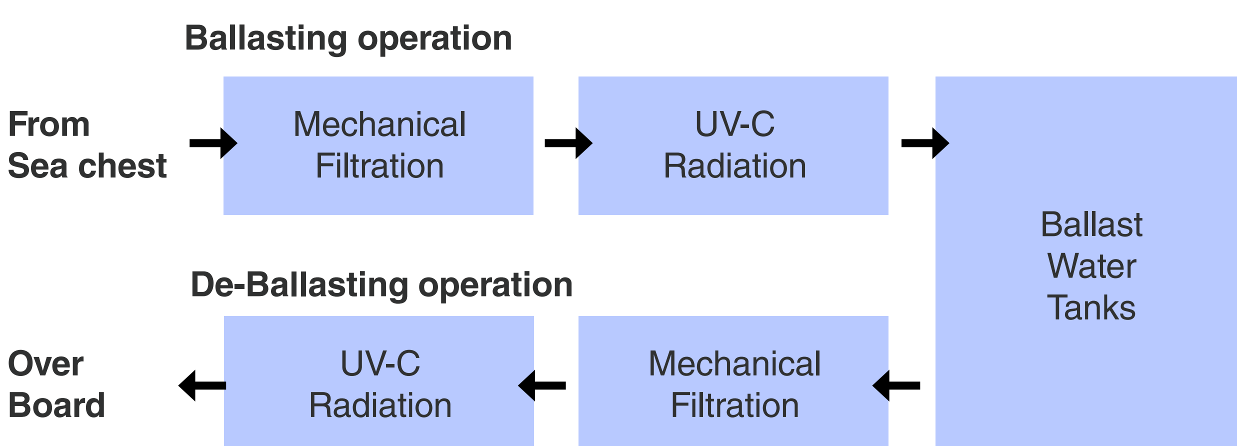

Figure 1. *Harry DeWolf*-class ballast water treatment process.

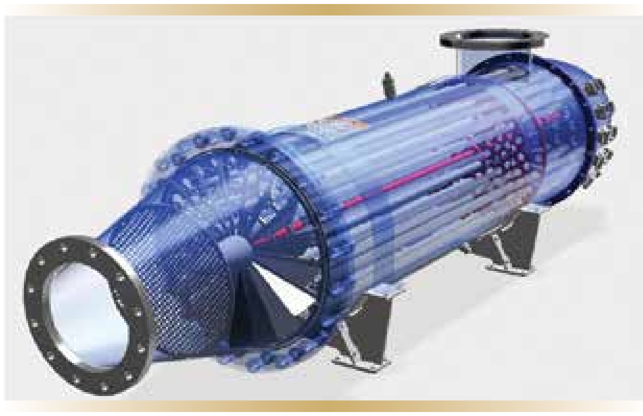

Photo courtesy DESMI

Figure 2. This DESMI ultraviolet unit is used to treat ballast water aboard the AOPVs.

second-stage ultraviolet treatment unit (Figure 2). The UV radiation destroys tiny organisms by causing a photochemical alteration of their DNA, which the organisms are unable to repair. The fully treated water is then directed into the ballast tanks. The filtration and ultraviolet radiation treatment steps are repeated during de-ballasting operations to ensure that any biological growth from the ballast water stored in the tanks is not discharged overboard.

It is the RCN's responsibility to ensure that our ships are built to proper standards for safe, responsible operation in the Arctic's fragile environment and unique climate conditions. Preventing the introduction of invasive aquatic species through a robust on-board ballast water treatment system, backed up by the diligence of the crew, is just one aspect of what makes the *Harry DeWolf*-class AOPVs great platforms for carrying out their assigned missions in Canada's beautiful Arctic region.

Lt(N) Anthony Kim is the Test and Trials Officer for the Arctic and Offshore Patrol Ship Project Management Office in Ottawa.

CREW PERSPECTIVE

PO1 Troy McDonald
Senior Mechanical Manager, HMCS *Harry DeWolf* (AOPV-430)

As a former mechanical apprentice in the private sector, I knew I wanted to continue in this trade. It felt important to me to not only have the ability to share my knowledge and experience, but to develop and grow professionally. With this in mind, I joined the RCN in 2003 while living in Sackville, Nova Scotia.

As the senior mechanical manager on board HMCS *Harry DeWolf*, I am responsible for a team of more than 10 members who maintain the ship's diverse mechanical equipment. Having arrived on board earlier this year, I continue to be intrigued by the intricacies of the new equipment, such as the dual diesel-electric, high-voltage power shafts, and am enjoying the spacious mechanical room that allows for easy access to the large equipment.

After serving on several *Halifax*-class frigates and *Kingston*-class maritime coastal defence vessels, I now find myself on the first of the Arctic and offshore patrol vessels with a phenomenal crew, and great support from the second-line maintenance team. I am most impressed by the efficiency of maintenance on the AOPV while in port. I have worked on ships that required an entire day to ensure everything was properly shut down and in good shape for our next sail, but it took my crew only 50 minutes to perform the required shutdown procedures and maintenance checks, including cleaning, and emptying fuel.

I look forward to my new role on the RCN's first AOPV, and welcome any challenges ahead.

Crew interview conducted by Stephanie Tran, PMO AOPS.

Combat Suite Overview for the Arctic and Offshore Patrol Vessels

By Lt(N) Ken Tse
(All photos by Lt(N) Ken Tse, HMCS Max Bernays, except where noted.)

The combat suite on board Canada's new *Harry DeWolf*-class Arctic and offshore patrol vessels (AOPVs) was designed to ensure these ships can support sovereignty operations of the Canadian Armed Forces, conduct surveillance operations in the Canadian Arctic, and complete all other missions assigned to the Royal Canadian Navy. Known as the Command and Surveillance System (C&SS), the combat suite comprises a number of subsystems that utilize existing commercial technology, and adhere to Lloyd's Register classification society rules. Lockheed Martin Canada acted as the overall system integrator for AOPVs, including the C&SS.

C&SS Subsystems

Combat Management System

The CMS-430 combat management system integrates various ship sensors and subsystems, and provides control capability to the operators. The system consists of three multi-function consoles, or MFCs (Figure 1), three large-screen displays that are separate from the MFC screens, and a single equipment rack for data processing. The design of the MFCs is similar to that of the CMS-330 multi-function workstations aboard the *Halifax*-class frigates, and features tactical, auxiliary and isolated display functions that are controlled using a trackball and key-board, and a tactical telephone console for internal and external communications. The large-screen displays are capable of displaying video from the MFCs, as well as CCTV video from the Integrated Platform Management System (IPMS). The equipment rack houses processors and servers that handle computing, radar distribution, video-switching, and data collection and analysis.

Integrated Bridge and Navigation System

As its name suggests, the Integrated Bridge and Navigation System (IBNS) integrates data from all of the ship's navigation sensors, displays this information throughout the ship, and feeds the data to end users. The IBNS receives inputs from sensors including the Global Positioning System (GPS), inertial navigation system, speed log, echo sounder, automatic identification system, meteorological sensors, and (Kelvin Hughes SharpEye™) X-band & S-band navigation radar systems. All received data is processed by the dual redundant Navigation and Tactical Data Distribution Unit (NavTac DDU) before being sent on to the Electronic Chart Precise Integrated Navigation System (ECPINS) navigation displays, compass bearing repeaters, and other C&SS subsystems (Figure 2).

Primary Gun System

The ship's primary gun system is the BAE Mk 38 Mod 3A 25-mm machine-gun (Figure 3), a complete fire-control and ammunition feed system capable of firing up to 180 rounds per minute with an effective range of 1.5 nm. The

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Figure 1. A multi-function console (MFC) for the AOPV combat management system.

Figure 2. The Integrated Bridge and Navigation System integrates and feeds data to multiple AOPV systems and displays.

Photo by Cpl Simon Arcand, Formation Imaging Services

Figure 3. The BAE Mk 38 25-mm Mod 3A machine gun.

Figure 4. Starboard view of an Arctic and offshore patrol vessel's mainmast, with the surveillance radar on top, and the S-band navigational radar situated lower and forward.

fire-control system, located atop the gun mount, includes an advanced electro-optical/infrared (EO/IR) sensor that is capable of all-weather operation, day and night. The movement of the EO/IR sensor is independent of the gun, allowing operators to track without pointing the gun at the target.

Surveillance Subsystems

AOPVs are equipped with various surveillance subsystems, including the Terma Scanter 6002 Surveillance & Helicopter Control and Approach Radar (HCAR), Identification Friend or Foe (IFF), a direction-finder, and a forward-looking echo sounder. The HCAR is capable of tracking up to 500 surface and air targets at a range of approximately 15 nm. Other subsystems work in conjunction with the HCAR (Figure 4) to provide surveillance of surrounding vessels and navigational hazards.

Integrated Communication System

The Integrated Communication System (ICS) provides means for internal and external communications for voice and data in both plain and secure modes. The internal ICS contains the tactical telephone system, sound-powered telephone system, public address and alarm system, and the entertainment system, which includes satellite TV and "quality of life" (QoL) Internet. The telephone system can also be used to communicate externally through a shore line, or through external ICS radios.

The external ICS provides a wide array of antennas for HF, VHF, UHF and satellite communications (SATCOM). All circuits are established and controlled automatically through the use of the MarCom® Integrated Voice Communication System switch, with a standalone Global Maritime Distress and Safety System included for emergency communications.

Naval Information System

The AOPV Naval Information System (NavIS) resembles the Navy's existing shipboard networks for both classified and unclassified (ShipLAN) traffic. NavIS provides ship-to-shore data communication through the jetty fibre connection, or via the ship's SATCOM. The system includes backbone equipment such as routers, switches and network drops, as well as "trusted thin clients" (TTCs) to allow users to access the networks.

The Naval Engineering Test Establishment (NETE) was a key stakeholder in designing the system, and providing guidance to Lockheed Martin Canada regarding the procurement and installation of NavIS to ensure all guidelines and policies of the Department of National Defence Communications Security and Emission Security were adhered to.

Challenges

As with all other engineering systems, the design, integration, and testing of the C&SS has been no easy task. With the continuous advancement of technologies, design requirements defined in the early stages of the project might need to be modified to meet the current needs of the RCN, and additional engineering changes are sometimes required to bridge capability deficiencies. The Project Management Office has been working closely with RCN stakeholders to understand the current requirements, and is in frequent communication with ships' staffs and their counterparts in the headquarters Directorate of Maritime Equipment Program Management for Non-Combatants (DMEPM(NC)) to ensure deficiencies are captured and addressed appropriately.

System integration testing has proven difficult at times, especially with the SATCOM systems. During the harbour acceptance trials (HATs), assistance was required from other organizations to ensure successful testing. Preparation for testing included having to arrange satellite leases, procure shore equipment, and request technical support from stakeholders including ship staff, Base Information Services/N6, Fleet Maintenance Facility Cape Scott, NETE, 76 Communication Regiment, and Director Project Delivery Satellite Communications. Scheduling for the SATCOM tests had to be carefully considered, as the PMO needed to coordinate events so that all stakeholders were available during the testing window. Because the trials were being conducted alongside, the ship had to be berthed away from certain structures in the Halifax naval dockyard and the Macdonald Bridge. This would sometimes interfere with other shipboard engineering work that required the ship to be at a different jetty.

Aside from the logistical challenges, there were technical issues that had to be overcome during SATCOM testing, and much effort was spent configuring the equipment so that it would connect to and track the satellites. Technical support from the system vendor and SATCOM service provider was needed to troubleshoot a timing signal issue. It took a joint effort involving many organizations to achieve a successful test in the end.

Conclusion

The Command and Surveillance System was designed and built to ensure the *Harry DeWolf* class is versatile, and able to complete a wide variety of missions in all waters. The system's open architecture easily allows for subsystem upgrades, and for growth margin as new subsystems are integrated. With flexibility like this, the AOPVs will be able to serve the RCN in its mission to affirm Canadian sovereignty for many years to come.

Ken Tse is a retired Naval Technical Officer, and is currently a Combat Systems Engineer with the Arctic and Offshore Patrol Ship Project in Ottawa.

New Sonar System Tested Aboard *Harry DeWolf*

(Navy News / December 6, 2021)

During HMCS *Harry DeWolf*'s participation on Operation Nanook 2021, a team from Defence Research and Development Canada (DRDC) launched a new underwater listening device used to find submarines.

Called the Towed Reelable Active-Passive Sonar (TRAPS), the system recorded passive data to characterize ambient noise and the *Harry DeWolf*-class acoustic signature. The collected data will be analyzed for environmental characterization and sonar performance modelling, and may have the potential to be used for marine mammal acoustic monitoring.

"The deployment of the sonar system near the hamlet of Grise Fiord, Nunavut, was the northernmost deployment of a towed array system by the Royal Canadian Navy," said Jeff Scrutton, a lead engineer for underwater warfare at DRDC and part of the TRAPS trial team aboard the ship.

The increased cargo and payload capability of the new Arctic and offshore patrol vessel provided a unique opportunity to accommodate not only three DRDC technical staff, but also a sea container which acted as storage for their equipment and a mobile laboratory.

Photo by Cpl Simon Arcand

HMCS *Harry DeWolf* crew members help launch DRDC's Towed Reelable Active-Passive Sonar (TRAPS) in the fall of 2021.

"This trial is one example of how DRDC's research is advancing acoustic sensing applications for anti-submarine warfare operations, as part of our overall mission to enhance Canada's defence and security posture through excellence in science, technology and innovation," said Michel Couillard, Section Head for Underwater Warfare with DRDC.

Special Edition: Arctic and Offshore Patrol Ship Project

The AOPVs — Fostering Capability, Teamwork, and Interoperability through Design

By Lt(N) Joseph Cheng

RCN photo by Cpl David Veldman

HMCS *Harry DeWolf* in joint operational trials with RCAF CH-149 Cormorant search and rescue helicopter "Outcast 905."

For most of us, it all started more than three-and-a-half years ago when we began showing up, one at a time, at the blue door of a nondescript brick building numbered D40-A — entrance to the shore office for the inaugural crew of HMCS *Harry DeWolf* (AOPV-430), first of class of the Royal Canadian Navy's new Arctic and offshore patrol vessels.

As the team came together, we participated in innovative online lessons, digital learning, virtual reality-styled simulations, countless tabletop discussions, and endless standard operating procedures (SOP) development. Every so often, our days were accented by a visit to the Irving shipyard to visit our ship that was under construction, and take a peek at its progress. The global pandemic of 2020 certainly added a significant level of complexity and challenge to the program with working from home, online meetings, and a significant shift in priorities. Topping it off, there were countless diagrams, specifications, drawings, and thousands upon thousands of pages of documents and manuals to review, but it wasn't really until the ship was delivered to the RCN on July 30, 2020 that the real learning began.

Harry DeWolf was designed and purpose-built with a variety of capabilities, allowing it to embark a gamut of mission-specific kit, including everything from vehicles to shipping containers needed to support humanitarian assistance/disaster relief (HA/DR) operations. However, it would take close to a year for the crew to learn, develop, and trial the procedures required to employ and maximize these capabilities. In a way, the ship needed to learn how the Navy worked as much as the crew needed to learn how the ship worked. What follows is strictly my opinion, based on observations in my role as an officer of the watch at sea, as an officer of the day in harbour, and as a crew member who has had the pleasure of sailing aboard all of the Navy's active surface fleet platforms.

A significant element in the successful development of our inaugural crew, and what I imagine would be the same for other AOPV crews, seems to be the "interoperability" inherent in the ship's design — pushing the small crew to work across departmental lines to achieve mission success. This attitude of interoperability was evident during our deployments for Op Nanook up north, and Op Caribbe down south, where we also worked closely with various other government departments, media agencies, research and development groups, local communities, and allies.

I believe a number of factors were instrumental in helping us achieve this level of teamwork, including the crew size, the watch and bunking organization, the placement of stations for work and evolutions, and just as importantly, the shared all-ranks cafeteria. I will describe each one of these points in detail, with the intent that we take them into consideration for future platform organization. There is no substitute for leadership from the top, and for solid deck-plate leadership at all levels in achieving mission success and high morale. Yet, critical infrastructure design can, and certainly does, play a role in exacerbating or ameliorating conditions aboard a ship, especially over an extended deployment where the small things begin to add up.

One key challenge faced by the *Harry DeWolf* class is the relatively small core crew size of 65 personnel, while the requirement and expectation for continuous operations over extended durations and distances remain. This has been partially mitigated by improvements in technologies such as the Integrated Bridge and Navigation System, CCTV, and increased sensors and automation throughout the ship. While electronic sentries don't replace competent, trained individuals, they certainly reduce requirements and help provide round-the-clock, all-area coverage and monitoring, which increases command confidence. Another successful approach has been to give crew members a wider range of responsibilities, and more cross-training to allow them the flexibility to adapt their roles according to each situation. In turn, they report feeling better challenged and increasingly valued, and freed from some of the more mundane rotework.

A unique design feature of the AOPVs is that the crew have the ability to see the status of, and control, the machinery plant from any of the integrated Battle Damage Control System (BDCS) boards positioned throughout the ship. The ship's engineers essentially have a full-function station at the after part of the bridge, complete with communication nets. This allows the ship's Naval Technical Officer (NTO), or a key member of their team, to be closed up for critical manoeuvring evolutions such as replenishment at sea, entering and leaving harbour, and especially during ice-transit operations. This increases situational awareness for the team below decks, and puts a subject matter expert on scene to advise command. Similarly, during damage control situations, the DC petty officer, NTO, and command personnel effectively run the response from the after part of the bridge, liaising with the section base(s) below for dispatching personnel and equipment, and monitoring progress.

A significant difference in the AOPV bridge's peacetime steaming posture, unlike that found aboard the *Kingston*-class maritime coastal defence vessels or *Halifax*-class frigates, is the inclusion of a Naval Combat Information Operator (NCI Op) stationed at the multi-function workstation (MFW) on the after part of the bridge. This 'SeaGuard' position performs the basic functions of the track supervisor and operations room during normal peacetime sailing. Because of the closer integration with the bridge team, the operator has much better situational awareness, and therefore better ability to organically support, manage, and provide intelligence. Formal reports are still made over the nets as required, but I have found that there is a significant improvement in the flow of operational information.

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Photo by Cpl David Veldman

Joint ops with members of the 5th Division Canadian Army, and 5th Canadian Ranger Patrol Group (Bonavista).

I've also noticed that the placement of the multi-purpose operational space (MPOS) that acts essentially as the AOPV operations room, communications control room, and flight-deck control room all within the same deck space, streamlines communication, making it easier for key players to walk about to share information, quickly discuss issues, and share intent. While all stations are interconnected by phones, communication nets and terminals, there is something particularly effective in being able to have a quick face-to-face chat with someone. Designing spaces that allow for this type of ergonomic have significant value, as they incorporate the human element more fully.

The MPOS was one space that, over time, took on a life of its own. When we first started sailing, we didn't really know how it would be used, but with the various terminals, secret network access, large-screen displays, printers, and a large work table, it soon proved itself invaluable for briefings, tabletop discussions, and mission planning and coordination, such as for search and rescue operations. Teams will certainly find their own ways to use this dedicated, yet flexible open-concept workspace. During Op Caribbe, for example, the MPOS was a critical element in our successful interoperability with the integrated U.S. Coast Guard Law Enforcement Detachment embarked with us.

Finally, there is another space on board, unique to the AOPV design, that facilitates teamwork and cross-departmental integration like no other — the all-ranks cafeteria. While people are free to take their meals to their respective messes, the simple act of lining up with a tray in a common meal line encourages people to sit and eat together. Whether it is a senior officer chatting with a junior non-commissioned member, or an embarked contractor talking shop with some member of the crew, the informality of the shared dining space contributes to an overall stronger sense of shared understanding and teamwork.

As a junior officer looking to implement command's intent, and as a department head working with my peers, the critical question always remains, "How can we get the best out of our teams when executing complex tasks in challenging, unforgiving environments?" The AOPVs seem to answer this by creating an environment that fosters teamwork and

RCN photo by Cpl David Veldman

Canadian Coast Guard offshore fisheries research ship *Capt. Jacques Cartier* with HMCS *Harry DeWolf*.

interoperability throughout the ship, a positive can-do approach that naturally extends from the crew to the rest of the fleet, and to our external agency partners.

With the third AOPV (*Max Bernays*) delivered to the Royal Canadian Navy this fall, and looking ahead to the upcoming missions for HMC ships *Harry DeWolf* and *Margaret Brooke*, I can say that we have come a long way both from those early days in the shore office on the other side of that blue door, and from that "Aha!" moment when two dozen of us saw "the plan" come together at sea during Irving's first builder's trials. I can't wait until the full AOPV fleet is in operation on all three of Canada's coasts.

Lt(N) Joe Cheng spent over three years as a bridge watchkeeper with HMCS Harry DeWolf, from construction through to delivery, followed by a myriad of acceptance trials, the proficiency sail, and the ship's inaugural circumnavigation of North America. Hailing from a hospitality background and eight years' sailing on cruise ships, he continues to enjoy the unique global adventures of a seagoing career as the deck officer aboard HMCS Summerside (MM-711).

Courtesy the author

Special Edition: Arctic and Offshore Patrol Ship Project

A Naval Technical Officer's AOPV Experience

By LCdr Shane Kavanagh

[LCdr Kavanagh served as the Naval Technical Officer (NTO) on board HMCS *Margaret Brooke* (AOPV-431) through the vessel's delivery, readiness training, and post-acceptance trial in the Canadian Arctic. – Editor]

HMCS *Margaret Brooke* had the benefit of being the second vessel of class, following on from HMCS *Harry DeWolf* (AOPV-430) whose team had developed a number of standard operating procedures (SOPs), and made note of lessons learned. I worked with **LCdr James Everett**, *Margaret Brooke*'s first NTO, to review the draft SOPs, apply the lessons learned, modify them as required, and educate the team. I also worked closely with members of the Arctic and Offshore Patrol Ship (AOPS) Project Management Office (PMO) to gain an understanding of the vessel's materiel state through construction, keep the command team informed, and ensure maximum collaboration and open communication. I also sailed with *Harry DeWolf* during their ice-breaking post-acceptance trial (PAT) as the PMO's naval architecture representative, and participated in activities such as fueling and ammunitioning. When HMCS *Margaret Brooke* was delivered, I felt comfortable in assuming my role as the vessel's NTO.

In preparation for taking delivery of our ship, personnel completed a series of formal and informal training programs. Formal training included AOPV-generic and occupation-specific initial cadre training, which included virtual delivery through the Defence Learning Network (DLN), and practical training delivered by contractors. While personnel completed individual training on an opportunity basis, collective training required to ready the team was conducted at Damage Control Training Facility (DCTF) Kootenay, and on board *Harry DeWolf*. In terms of informal training, personnel maximized opportunities for employment within the AOPS detachment at Irving Shipbuilding Inc. (ISI), and through sailing opportunities aboard HMCS *Harry DeWolf* – including basic single-ship readiness training (BSSRT), and ice-breaking and tropical PATs.

Although there were a number of significant issues to overcome leading to ship delivery, the greatest challenge was personnel readiness. We completed our harbour readiness training (HRT), and our spill response and damage control (DC) team training with few issues, but ensuring there were sufficient Marine Technicians trained to operate the plant in accordance with draft Naval Order (NAVORD) 3293-2 Marine Technician Watchkeeping

Photo by Lt(N) John Baldwin

> "When HMCS *Margaret Brooke* was delivered, I felt comfortable in assuming my role as the vessel's NTO."

Operating Requirements, and NAVORD 11000-1 Qualification and Access Requirements for High Voltage Ships, proved challenging. We worked with *Harry DeWolf* to ensure our staff gained sufficient time at sea to endorse their watchkeeping qualifications in the new class, and once *Margaret Brooke* was delivered, we would be able to endorse additional watchkeepers and rounds personnel ourselves. Although packages to endorse personnel were developed by Sea Training, Naval Personnel and Training Group, and *Harry DeWolf*, we worked to develop qualification boards in *Margaret Brooke* for personnel who did not previously hold a watchkeeping qualification. As with many of the challenges we faced, open and transparent communi-

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RCN photo

> "Our crew actually completed HRT aboard HMCS *Harry DeWolf* one week prior to our ship's delivery."

cation with major stakeholders proved key to ensuring success in this phase of *Margaret Brooke*'s journey.

Prior to HRT, *Margaret Brooke* personnel completed self-directed rapid response training at DCTF Kootenay, and spent as much time as possible completing damage control tours aboard HMCS *Harry DeWolf*, and on board *Margaret Brooke* during construction. Our crew actually completed HRT aboard HMCS *Harry DeWolf* one week prior to our ship's delivery while the majority of the *Harry DeWolf* team was on leave. Completing readiness training on a new platform was challenging, as we had to consider every detail, right down to who was preparing meals and how to coordinate between *Harry DeWolf*'s qualified personnel, and *Margaret Brooke*'s trainees. We decided it would be best to train a core home-port duty watch that would stand 1-in-3 for the month following delivery, and then as personnel became qualified, we could ease the rotation. This model was successful, and gave us confidence that we could handle any issue that might arise in harbour once we had our ship.

The preparations that the Naval Technical department undertook ahead of delivery had absolutely prepared the team for the post-delivery work period (PDWP). Working closely with the PMO Detachment at Irving Shipbuilding allowed for a clear understanding of the vessel's materiel state, and the work required to meet our ordered readiness. We developed good relationships with key personnel from Thales, PMO, and ISI who were involved in the PDWP.

Post-delivery departmental training and sea readiness

The *Margaret Brooke* team faced a number of difficulties leading into and throughout BSSRT. Achieving platform experience and materiel readiness posed significant challenges, compounded by Covid-19 protocols that restricted access to the vessel immediately prior to sailing. Although the Naval Technical department was comfortable operating the vessel in harbour, our experience with operating the plant at sea was limited to a few key members who had sailed aboard *Harry DeWolf*.

Prior to departing for BSSRT, we made several fast cruises, and conducted a series of basin trials during which we brought the vessel from high-voltage (HV) "dead" to HV "live," operated the ship's main propulsion system, and conducted blackout recovery training for each engineering watchkeeper, which included recovery by emergency harbour diesel generator and main diesel generator using the air-driven fuel pumps. There were also several pressing materiel issues that proved challenging, including cleanliness of the main diesel-generator freshwater cooling system, and the port-side fully enclosed lifeboat davit. Working with Thales and other industry partners, we were able to overcome these and many other technical challenges.

As the damage control officer (DCO) in an AOPV, the NTO has significantly fewer resources available to conduct damage control as the crew compliment is only 65 personnel. Although there are two section base locations, the smaller AOPV crew can only staff one or the other at a time. The officer of the watch must therefore direct the crew to the appropriate section base when piping emergency stations, and the DCO must consider certain priorities carefully – and this is where understanding the construction of the vessel is key. Unlike the *Halifax* class, the AOPVs are fitted with fire insulation to limit heat transfer between compartments. In a multi-event scenario, knowing the various fire insulation ratings throughout the ship will influence key decisions regarding boundary priorities, attack routes, and casualty extraction routes. Fortunately, there are also far more heat/smoke sensors and cameras in the AOPVs, that allow the DCO to monitor for signs of fire progression.

When *Margaret Brooke* was delivered, the *Harry DeWolf* team had been working to improve upon the initial Emergency Response Manual, or drill manual, that the PMO had developed. The AOPVs operate at sea with an unmanned machinery control room, and as such it is possible the bridge, rather than the engineering watchkeeper, might be the first station to receive an alarm. The early version of a platform-specific drill manual offered some good direction to the team, and was a good starting point for the AOPV crews to build upon in developing a fully integrated, platform-based approach to emergency drill response.

My most significant memory of this stage would be the morning the ship was entering Boston Harbor following the first week of BSSRT at sea. No one item stands out from this particular day, just the feeling of accomplishment. The journey to BSSRT was difficult in terms of preparing the vessel and completing the required training. As we completed damage control exercises, we also conducted a number of significant maintenance routines to ensure the vessel could remain at sea. *Margaret Brooke* had introduced a number of amendments to Ship's Standing Orders (SSOs) which were being tested during BSSRTs, and we had been generally successful. Reaching Boston represented a significant milestone for *Margaret Brooke* and the Royal Canadian Navy, and a significant accomplishment in terms of what our small Naval Technical department had achieved as a team.

Arctic post-acceptance trials – success!

As with any mission, we sought to ensure the vessel was in the best materiel state possible, and that our personnel were ready to fulfill the assigned mission. In terms of personnel readiness, my priority was ensuring our staff were able to respond effectively to emergency situations, in particular, recovering from a blackout as we had rehearsed earlier. In terms of materiel readiness, we verified that all the equipment required to operate in the Arctic was operational prior to departure, and we reached out to *Harry DeWolf* to identify the key spares, equipment, and operating procedures they had noted during their Arctic PAT.

One of our significant challenges while operating in the Arctic was the operation of the seawater cooling system. We had discovered during *Harry DeWolf*'s Arctic PAT that when the vessel is parked in ice overnight, a minimum of one main diesel generator must be running in each main machinery space to provide hot seawater return to the sea bays so they do not freeze. *Margaret Brooke* spent significantly more time in ice than did *Harry DeWolf*, and the relationship between the high and low sea bays was not clear. After filling two seawater strainers with ice, we discovered that the best solution was to operate only the low sea bays, and supply only those sea bays with hot sea water. Since both the hot seawater return, and the seawater

Photo courtesy of Lt(N) Jon Hammill

> "After nearly two years of preparation for this moment, *Margaret Brooke* had reached the Canadian Arctic and was doing the most strenuous task it was designed to do – break ice."

overboard valves are manually operated, there was some adjustment required to ensure there was sufficient margin in the seawater temperature to cool the main diesel generators, and avoid condensation in the converter cabinets.

It is not uncommon for equipment aboard ship to require corrective or planned maintenance while away from home port for extended periods, and the AOPVs are no exception. HMCS *Margaret Brooke* experienced several equipment failures during the Arctic PAT that required rectification to ensure mission success. At the time, our crew did not have significant exposure to maintaining AOPV systems, but we were given additional resources to help us gain experience in maintaining these new systems, and had the benefit of leveraging the wealth of knowledge and experience that the

(Continues next page...)

trial staff assigned to the PAT program brought with them. During lengthy maintenance activities, personnel not required for watchkeeping would be brought on task, and in some cases the watch rotation was temporarily reduced to 1-in-2. One good "plus" for us was that when the ship was operating within heavy ice floes, the vessel would park at night, reducing the watchkeeping requirement and freeing personnel to conduct maintenance.

Conclusion

An interesting comment from **LCdr Anthony Morash**, the Naval Technical Officer on board HMCS *Harry DeWolf* during its first year of service, was that during their HRT and BSSRT, ship's staff were more familiar with the platform and ship's SOPs than the Sea Training staff. It made for a unique learning experience for both groups, one that furthered and enhanced the fleet's understanding of the vessel's capabilities, and the crew's challenges.

I have great memories from my time aboard HMCS *Margaret Brooke*, but the best would have to be when the ship first entered a significant ice floe. After nearly two years of preparation for this moment, *Margaret Brooke* had reached the Canadian Arctic and was doing the most strenuous task it was designed to do – break ice. The crew had worked hard to ensure *Margaret Brooke*'s machinery plant would be ready for this, and with the assistance of Fleet Maintenance Facility Cape Scott, ISI, Thales, and many industry partners we succeeded. The excitement and pride that our Naval Technical department personnel displayed that day will stay with me forever.

HMCS *Harry DeWolf* during Arctic trials.

Photo by Cpl David Veldman

HMCS *Max Bernays* (AOPV-432) joins the Fleet!

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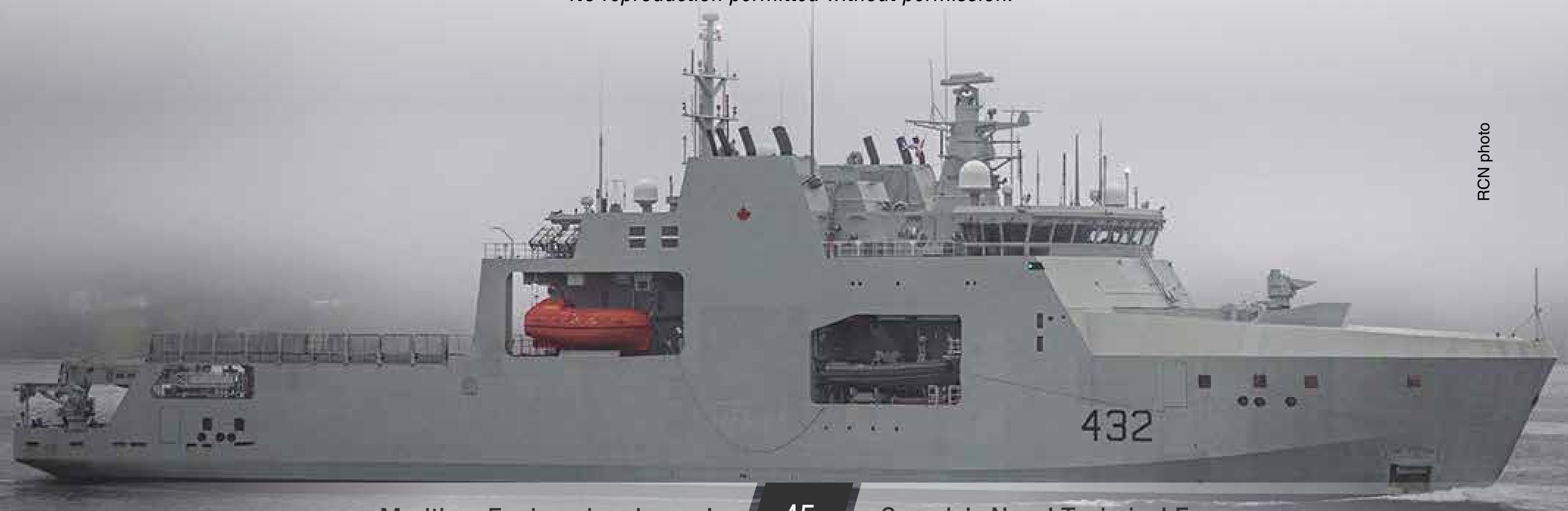


RCN photo

Special Edition: Arctic and Offshore Patrol Ship Project

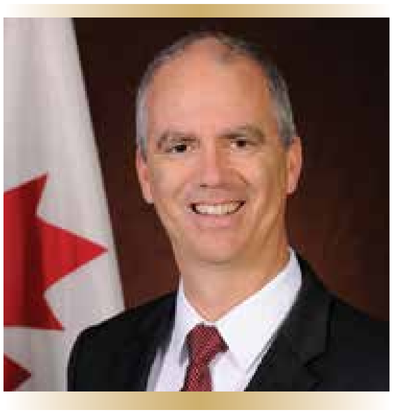
AOPS – a Government and Industry Success Story

By Wayne Rockwell,
Director General Major Project Delivery – Sea

With the delivery of HMCS *Max Bernays*, the Royal Canadian Navy's third Arctic and offshore patrol vessel (AOPV), I can't help but feel an overwhelming sense of thanks. Success certainly smooths the historic bumps along the road, but I think it is worth taking a moment to acknowledge the tremendous effort put forth by the many people who overcame countless challenges to get us to this point.

Much has been written about the National Shipbuilding Strategy (NSS) since its launch in 2010, and to be sure there remains much to be studied and evaluated through the wonderful perspective of hindsight. However, we should pay homage to the architects of the NSS, for without the perseverance and dedication of the original "plank holders" of the strategy, Canada and the RCN would not be reaping the benefits now. Patience is a virtue in shipbuilding, and as an early constituent of the ambitious NSS program, the Arctic and Offshore Patrol Ship (AOPS) Project was always expected to be challenging. While it did not disappoint in this regard, the simple truth is that Canadian industry is now delivering capable ships to the RCN, and we should offer our thanks to those who had the foresight to launch this complex national endeavour.

Few people truly appreciate the extent of the work that is done by government project management teams on something the magnitude of AOPS. I have been extremely fortunate to witness the talents and efforts applied by so many of my colleagues and friends over decades in this adventure. Individuals from across the Department of National Defence, the RCN, Public Services and Procurement Canada, Innovation, Science and Economic Development Canada, and the central agencies all have their DNA in these ships. I remember writing a staff college paper years ago on the importance of the Northwest Passage, and little did I realize then how humbled and proud I would feel today, knowing of the incredible work done by so many people to build a class of ships that could transit this historic Canadian sea route as lead-ship HMCS *Harry DeWolf* did in 2021.



These accomplishments could not have been achieved without the cooperative and capable involvement of Canadian industry. I still remember the sparkle in the eyes of **Matt Reid**, Irving Shipbuilding Inc.'s Executive Vice President of Operations from 2012 to 2014, when he showed the initial blueprints for the proposed new Irving Shipbuilding facilities in Halifax to future AOPS Project Manager **Geoff Simpson**. Industry has faced its share of challenges throughout this project, but as the shipyard operations have matured and the industry teams hit their stride, the ship-over-ship improvements have been clearly in evidence.

Now, as steel is being cut for the sixth and last of the Navy's AOPVs, it is satisfying to look in the rear-view mirror and reflect on the many significant milestones we have passed along the way in this great shipbuilding journey of ours. Our industry partners deserve our thanks for their skillsets, and for the passion and pride they have demonstrated in their work. After all, with these Canadian-built ships, crewed by Canadian sailors, we are showing the world that "We are the North." And that, I dare say, is something we can all be extremely proud of.

Royal Canadian Navy photo