National Defence | Défense nationale

Maritime Engineering Journal

Canada's Naval Technical Forum

92
Since 1982

Spring 2020

CNTHA News Inside!

Feature Article

Is human-coded software a weak link in naval combat systems? A retired CSE speaks out.

Canada

Good to go!

Photo by LS Victoria Ioganov, MARPAC Imaging Services

These engineering technicians from HMCS *Ottawa* worked with other ship's staff and fleet maintenance subject matter experts in Esquimalt to undertake a challenging pump repair while deployed to Unalaska.

see page 11

Maritime Engineering Journal

(Established 1982)
Spring 2020

Acting Director General Maritime Equipment Program Management

Capt(N) Sebastien Richard, CD

***Maritime Engineering Journal* on Canada.ca:**
https://www.canada.ca/en/department-national-defence/corporate/reports-publications/maritime-engineering-journal.html

Our complete back catalogue continues to be maintained by the Canadian Naval Technical History Association at:
http://www.cntha.ca/publications/m-e-j/

Commodore's Corner

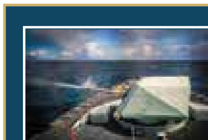
Forum

Feature Articles

Book Review

News Briefs

CNTHA News



Should computers be programming naval combat systems software? Retired CSE Roger Cyr makes a case – page 8.

(Photo by Cpl Tony Chand, Formation Imaging Services.)

The *Maritime Engineering Journal* (ISSN 0713-0058) is an unofficial publication of the Canadian Armed Forces published by the Director General Maritime Equipment Program Management. Views expressed are those of the writers and do not necessarily reflect official opinion or policy. Mail and requests for free subscriptions may be sent to: **The Editor, Maritime Engineering Journal, DGMEPM, NDHQ, 101 Colonel By Drive, Ottawa, Ontario, Canada, K1A 0K2. Unless otherwise stated, *Journal* articles may be reprinted with proper credit. A courtesy copy of the reprinted article would be appreciated.**

COMMODORE'S CORNER

Embracing Change

By Captain (Navy) Sebastien Richard, CD

Never in a thousand years did I expect to be writing this column for the *Maritime Engineering Journal*. Less than a year ago, I was a commander in charge of above-water weapons, electronic warfare effectors, and trainers within DMEPM(MSC) – the Directorate of Maritime Equipment Program Management (Major Surface Combatant). Then, in the span of nine months, a series of retirements and promotions at the top led to my being promoted Captain (Navy) as Chief of Staff MEPM, and now appointed as Acting/DGMEPM for an extended period of time. It has been a whirlwind of change to say the least.

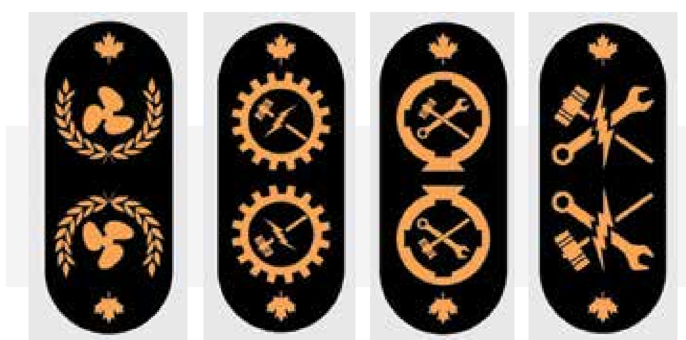
The challenges at this level are varied and many, so there is never a boring day in the office. And while I thrive on this, I am in a constant learning environment. Ensuring that the Royal Canadian Navy (RCN) has the necessary ships available to conduct its business is a huge undertaking, but having the support of a great divisional team and an engaged naval technical community in surmounting the day-to-day challenges makes all the difference.

Embracing change is a big part of what we do. Whether that change is driven by ourselves to meet the evolving technical and personnel challenges of the Navy, or in response to outside influences, we all have a role to play in adapting to changing circumstances through innovation and employment of best practices. How well we succeed at this depends on each person's willingness to participate.

Much has already happened on the naval personnel side, and more change is on the horizon. The establishment of the Weapons Engineering Technician trade more than 10 years ago, and the stand-up of the new Marine Technician trade more recently, paved the way for a pan-Navy analysis of the NCM operator trades, and the Naval Technical Officer and Naval Warfare Officer occupations, now underway. The changes from this might not be immediately welcomed by everyone, but it is worth bearing in mind that the process is being conducted in full consultation with affected members so that the naval occupations are in the best possible position to serve the RCN's needs going forward.

The RCN's Maritime Innovation Program is also making great strides in investigating the way we do business across a broad range of activities. If successful, some of the ideas currently being evaluated could greatly improve how we approach our work through such initiatives as real-time project management, digital remote assistance for deployed ships, and immersive workstation technology. Innovation involves every one of us, and it is up to each of us to share new ideas for improvement, no matter how daring or seemingly insignificant.

All things considered, the RCN's new Digital Navy strategy is the domain where Personnel and Innovation really come together to drive meaningful change for the future. What our future will look like is being shaped by what we do today. If we are to continue to have a successful Navy, and enjoy rewarding careers for ourselves, we all have a role to play in embracing a culture that sometimes breaks with tradition, but which empowers us to greater achievements.



Marine Technician Manager [MOSID 379-1]	Marine Technician Mechanical Specialist [MOSID 379-2]	Marine Technician Electrical Specialist [MOSID 379-3]	Marine Technician Basic Maintainer [MOSID 379-4]

The distinctive new Mar Tech trade badges made their first appearance last December (see page 22).

Thank you for your support

It is with a heavy heart that I would like to inform you that I am leaving the Maritime Equipment Program Management Division to assume the position of Chief of Staff within the Materiel Group. Since returning to the Division in September 2017, I have thoroughly enjoyed working with you all and can only compliment the incredible work that each of you do each and every day. Your support has been outstanding and I would like to thank all of you for your effort, dedication, and the extremely impressive support that you provide to the RCN.

My replacement will be announced in due course. Until my relief is available and a formal Change of Appointment occurs, our Chief of Staff, Capt(N) Sebastien Richard, will assume the day-to-day duties of DGMEPM until further notice but I will retain the corporate responsibilities of the RCN's Chief Engineer. I have absolute confidence that you will provide him the same level of support that you afforded me.

Fair winds and following seas / Dolphin 26a
(Thank you for your valuable assistance)

Rear Admiral Christopher Earl, December 2019

Materiel Group – Movement at the Top

As **Capt(N) Sebastien Richard** alludes to in the Commodore's Corner, the retirement last December of Assistant Deputy Minister (Materiel) **Pat Finn** (see next page) created some exciting movement among senior personnel in the upper echelons of the Materiel Group just before the holidays.

As **Troy Crosby** moved up in the Group organization to fill Mr. Finn's vacancy, **RAdm Simon Page** retired from the Royal Canadian Navy (RCN) with 35 years of service to take up a new civilian appointment as Mr. Crosby's replacement as the new Associate Assistant Deputy Minister of the Materiel Group.

At the same time, **RAdm Christopher Earl** (see above) was promoted to his present rank, and appointed to Mr. Page's former position as the new Materiel Group Chief of Staff. Capt(N) Richard filled in behind him as the interim Acting/Director General for Maritime Equipment Program Management.

Congratulations to everyone!

Troy Crosby

Photo by Brian McCullough

Pat Finn (left) with Simon Page

Farewell to Mr. Finn

A number of distinguished guests came together before the holidays to celebrate the retirement of Patrick Finn, Assistant Deputy Minister (Materiel) from 2015 until 2019.

A "Request the Pleasure of your Company" was held at the HMCS Bytown Officers Mess on December 13. Among those who attended were The Honourable Harjit Sajjan, Minister of National Defence, Deputy Minister Jody Thomas, Gen Jonathan Vance, Chief of the Defence Staff, and Public Services and Procurement Canada Deputy Minister Bill Matthews.

Mr. Finn's keen attention to detail, and his unwavering commitment to materiel availability were remembered by his colleagues as they spoke about his precedent-setting accomplishments and remarkable professionalism.

During his 40-year career in the Canadian Armed Forces and Public Service, Mr. Finn developed expertise in leadership and management in the domain of materiel readiness and assurance for operations, and in complex project management. After serving aboard ships and submarines, he worked in various acquisition and modernization projects for the Royal Canadian Navy, and subsequently provided oversight for projects in all branches of Canada's military. He retired from the RCN as a rear admiral.

During Mr. Finn's tenure as ADM(Mat), the Materiel Group's reputation galvanized as an organization known for excellence in project leadership, and for being fully committed to supporting the men and women of the Canadian Armed Forces.

The naval technical community wishes all the best to Pat and Anne in retirement.

(Courtesy of Simon Page and Adam Watt from the Materiel Group)

Photos by Brian McCullough

Defence Minister Harjit Sajjan had many kind words of praise for Pat Finn and his wife Anne.

Distinguished guests included (left to right): André Fillion, Assistant Deputy Minister (Defence and Marine Procurement) for PSPC, Troy Crosby, Assistant Deputy Minister (Materiel), Gen Jonathan Vance, Chief of the Defence Staff, Anne Finn, Patrick Finn, The Honourable Harjit Sajjan, Minister of National Defence, Jody Thomas, Deputy Minister of National Defence, and Bill Matthews, Deputy Minister PSPC.

FORUM

Profile: Chief Petty Officer 1st Class Monika Quillan

The RCN's first female Regular Force CPO1 Marine Technician reflects on her 30-year journey to the top of her chosen occupation.

By Brian McCullough

In the fall of 1982, around the time the Solidarity trade union movement was being outlawed in Poland, 12-year-old Monika Dwornikiewicz (Quillan) and her family left their village outside Lublin on what they had told everyone was a short holiday trip to Austria. What Quillan soon discovered was that the family's life under Soviet-dominated communist rule was over, and that democratic freedom was about to become the new normal.

Her parents had used a difficult-to-obtain travel visa to facilitate their escape to the West, leaving most everything they owned behind. Apart from what was packed in their "holiday" suitcases, the family of four – political refugees, now – was starting over with little more than the clothes on their backs.

"Communism in Eastern Europe was really bad at that time," Quillan recalls. "We had no food, and you couldn't buy anything in a store – you had to buy everything on the black market. My parents' vision was for us to have a better life in Canada."

After a year in Austria, the family resettled in Brantford, Ontario as new immigrants. It would be the first major step along Quillan's path to a technical education after high school, and a groundbreaking career with the Royal Canadian Navy.

"In my family there couldn't be any lull," she says. "You were either going to school or working, and school was very important to my parents."

In 1989, Quillan was accepted into the civilian Mechanical Technician program at St. Lawrence College in Cornwall, Ontario. The Navy's English-language Marine Engineering Technician Training Plan (METTP) program happened to be embedded at the same campus (see MEJ No. 62), and it didn't take Quillan long to realize that the naval students studying alongside her were being paid for their studies. With her strong aptitude for math and physics she had no trouble transferring to the METTP the following year, becoming the program's first female candidate.

Photo by Brian McCullough

Throughout her 30-year career, CPO1 Monika Quillan says she has always looked to her supervisors for qualities of leadership and professionalism she could adopt for herself.

"I was shocked there were no other girls, but the people I went to school with welcomed me as part of the team," she says.

Over the next 30 years Quillan would quietly chart a career path for herself that included significant sea time on both coasts, as well as senior administrative, teaching, and technical responsibilities ashore. Along the way, she became the first female Cert 4-qualified marine engineering technician in the RCN, the first female chief engineer of a major warship (HMCS *Athabaskan* in 2010) and, in 2018, the first female Regular Force member in her trade to achieve the rank of chief petty officer 1st class.

All the "female firsts" are not something she says she thinks about much, but she does participate in International Women's Day panels and other working groups on women's issues. Last year, Quillan completed Carleton University's week-long Advancing Women in Leadership program for women in senior leadership roles to further her own personal and professional development.

"A formal mentorship program does not really exist for non-commissioned members," she says, "but throughout my career I have looked to my supervisors, and whatever leadership and professional qualities I liked, these were the ones I would keep in mind."

Today, Quillan is employed in the Directorate of Naval Platform Systems at National Defence Headquarters in Ottawa where she conducts materiel regulation/certification oversight for the Navy's combatants. The job is busy, but she says the reduced operational tempo gives her time to reflect on her position as a role model and senior leader in the RCN.

"My job now is to be a leader in supporting this institution, to set a good example," she says. "What I like about the military is the number of unique people who are talented in different ways, and as a leader you can utilize those talents if you can recognize them. People should

DND Photo by MCpl Stuart MacNeil

During Women's History Month in October 2018, Cmdre Chris Earl and RCN commander VAdm Ron Lloyd helped Monika Quillan celebrate her achievement at becoming the first female Regular Force Mar Tech to be promoted Chief Petty Officer 1st Class.

Aboard HMCS *Athabaskan* in 2012 as the RCN's first female Cert 4-qualified marine engineering artificer.

never feel like it is up to them alone to solve a problem. There is always someone there to guide you and help you out. There is always some kind of path you can follow that will get you to an acceptable solution."

Retirement is still about five years off, but it is definitely on Quillan's radar. She and her husband Chris, a serving captain in the Canadian Army, did a lot of single parenting while their two sons were growing up, and she says she is looking forward to having time to travel on her own terms after they retire.

Quillan's journey to the top of her chosen occupation has been both remarkable and, at the same time, a fairly straightforward occupational path for a hard-working Mar Tech. She has never looked to be in the limelight in any way, and is grateful for what the Navy has given her in terms of a rewarding career, and opportunities for personal growth.

"I've learned patience," she says. "Supervising junior ranks came in handy when my own children were growing up – helping them to handle problems without blowing up – and doing all those engineering drills aboard ship taught me to look for solutions on the spot. That's a skill I like having. Who I am now is definitely not who I was when I joined in 1990."

FORUM

Readership Survey Update:

Walking the Walk: Taking Action on Your Suggestions

Readers of the *Journal* who "talked the talk" by responding enthusiastically to our readership survey can rest assured that the editorial board has not only taken note of your input, but is acting expeditiously to implement recommended changes.

We are pleased to announce that, effective immediately, the *Journal* will be published four times a year so that your branch technical forum comes to you more frequently. This means shorter wait times to see your contributions in print, and gives us a better opportunity to include more of the newsy, easy-to-read technical items of interest you have asked for. We are particularly looking forward to receiving updates of your project activities, as well as news of your local technical achievements. Don't forget to include good quality photo jpegs of about 1 MB or larger so that they reproduce well on our printed page.

Quarterly publication also means we will be able to offer additional themed issues that document significant technical achievements made by the Royal Canadian Navy (RCN) in close collaboration with our important industry partners. These well-received special editions allow us to highlight and celebrate the expertise of those who are charged with keeping the Canadian naval fleet on the cutting edge of developments in a rapidly changing technical environment.

One of our main thrusts resulting from last year's survey is the inclusion of more material focusing on – and written by – the non-commissioned members (NCMs) of the RCN's naval technical community. It is very refreshing to see how NCM and naval technical officer (NTO) teams have been working together to bring us news of what's happening aboard ship and along the waterfront. It doesn't get much better than this.

Collaboration has brought other good things to the table for us. Over the past few months the *Journal*'s management team has been working diligently with the people at RCN Public Affairs to offer the *Maritime Engineering Journal* as a **fully accessible** PDF on an external facing web page. We are thrilled to announce that we are now up and running on the Canada.ca website. The links are below.

Watch for other initiatives as we move forward, but please take an active role by giving us your thoughts on how we are fulfilling our mandate, and with suggestions for future content. As ever, we look forward to receiving your own wonderful contributions of articles and other timely and informative content that makes the *Journal* recognized as "Canada's Naval Technical Forum."

Comments, enquiries and offers to write for the *Maritime Engineering Journal* can be sent to **MEJ.Submissions @gmail.com**

Look for the "accessible" *Maritime Engineering Journal* on Canada.ca:

https://www.canada.ca/en/department-national-defence/corporate/reports-publications/maritime-engineering-journal.html

Our complete back catalogue continues to be maintained by the Canadian Naval Technical History Association at:

http://www.cntha.ca/publications/m-e-j/

Submissions to the *Journal*

The *Journal* welcomes unclassified submissions in English or French. To avoid duplication of effort and ensure suitability of subject matter, contributors are asked to first contact the production editor Brian McCullough. Contact information may be found on page 1. Letters are always welcome, but only signed correspondence will be considered for publication.

FEATURE ARTICLE

The Weak Link in Naval Combat Systems

By Cdr Roger Cyr, OMM, CD, P.Eng, RCN (Ret'd)

Cpl Tony Chand, Formation Imaging Services.

The Royal Canadian Navy has experienced quantum leaps in combat systems technology over the past decades, an evolution that has increased weapon and sensor performance, and their integration. There has also been tremendous improvement with respect to the human/machine boundary in weapon systems, where there are now smart systems based on artificial intelligence that are capable of instant decision-making, thereby reducing human intervention. However, with all these innovations in system capability and automation, there remains a weak link — the dependence on humans for software programming, and the ensuing unreliability this introduces to naval combat systems. This is a real concern that warrants greater discussion within the naval technical community.

Software is an integral part of shipboard systems, and yet it is the most fragile and potentially dangerous component, and a leading cause of system unreliability. One need only look at the software updates that are routinely issued for simple home computers. Some manufacturers actually encourage and reward hackers who can find bugs in their software, but can human-coded software ever be as reliable as any of the hardware components in a system? When it comes to higher-level systems, the consequences of software error can be high.

In October 2018, and May 2019, two Boeing 737 Max 8 aircraft crashed, the first in Indonesia, and the other in Ethiopia. In both crashes, an automated Maneuvering

Characteristics Augmentation System (MCAS) mistakenly turned the noses of the planes down in response to faulty readings from a single sensor. Pilots were unable to regain control, and 346 people died. After these disastrous incidents all Max 8s in service were grounded. Boeing frantically updated its flight-control software so that this would not occur again, but why did it happen in the first place? Was the flight-control software not thoroughly controlled, tested, and certified as being totally safe?

It certainly brings to light a simple fact that any software, be it embedded into any vehicle, electronic device or combat system — is an intangible, both unpredictable and dangerous. Thankfully, there have been no recorded software-related failures associated with a modern Canadian naval combat system resulting in serious injury or worse, but the risk is always present.

The software dilemma

The evolution of the human/machine boundary in the operation of combat systems, and leaps in weapon and sensor technology, have resulted in increased automation and computer control. Machines are taking over most of the routine functions that were once performed by humans, and expert systems are now even able to duplicate the kind of results achieved by human intelligence in solving problems, predicting outcomes, and making decisions. Command and control systems no longer require human intervention for decision-making. Smart systems can function as the integrating and decision-making elements in controlling warfare functions during an engagement, ensuring optimum response to a threat through accurate modelling of the environment based on procedures, doctrine, tactics and rules of engagement, and by using elaborate deductive processes. When it comes to decision-making, machines are much faster, more accurate, not affected by sentiment or bias, and much less likely to err than humans.

The issue now, of course, is that smart systems are totally dependent on human-coded software for their performance. Humans write code according to various models, such as iterative or evolutionary development, and while doing so introduce a multitude of errors. The software is developed through repeated cycles, in small portions, taking advantage of what was learned during the development of earlier versions. At each iteration, modifications are made, and new functional capabilities are added. After each iteration, the code is then tested according to documented scenarios. Since the test scenarios themselves are based on human perception of what should be tested and under what circumstances, they are subject to human bias and behaviour that can hardly reveal all coding errors. The potential for missing a coding error is huge. Test scenarios developed by humans cannot possibly consider all situations or unusual circumstances, so systems are deployed with software errors that remain hidden until there is a catastrophic failure.

Looking ahead

One look at how software is produced and maintained is enough to see that these processes have hardly kept up with the state of technology. The human/machine boundary in software production needs to evolve to the point where computers can program themselves, or at least make the entire process much less human-dependent. The future rests with tilting the human/machine boundary in computer programming toward the machine — to computers that have the ability to write their own code, something that current artificial intelligence (AI) technology can now achieve to some extent. Machines are already doing some of the things that thinking human entities do naturally.

Programming trends suggest that software development will undergo a radical change in the near future: the combination of machine learning, AI, natural language processing, and code generation technologies will improve in such a way that machines, instead of humans, will write most of their own code by 2040. Many initiatives to have machines write their own software are using a technique called program synthesis, which creates new programs by

LS Ogle Henry, Formation Imaging Services.

combining existing lines of code taken from other software. Self-coding AI is now seen to be a reachable objective in the not-too-distant future, which means that there will not be much need for humans to write code at all. The machines will be trained to do it for us.

Instead of laboriously writing code for how a computer should solve a problem, all that would be needed is to tell the computer what needs to be done, and an algorithm would be created by the computer to do what is needed. Engineers will provide the data that defines a successful or unsuccessful outcome, and feed it into machine learning systems that will use trial and error, and mathematics, to determine the path to success. Such evolutionary computation, through which a computer can evolve its own solutions to problems, will save humans from having to go through a series of possibly complex steps to write the computer program, and allow the use of automated systems more efficiently and accurately for software development.

Conclusion

Technological advances in combat systems have brought incredible innovation to the way in which naval ships are operated, particularly with respect to the human/machine boundary and machine-based decision-making. However, reliability remains the Achilles heel of naval systems that depend on human-coded software. While computer-created software is undoubtedly the instrument that will create the next evolution of combat systems, its evolution must keep pace with technological advances so that software does not continue to be the unstable element — the weak link — of naval combat systems.

Roger Cyr retired from a 36-year career with the RCN as a commander CSE in 1993. He went on to employment by NATO as Chief of Quality Assurance at the NATO Support and Procurement Agency in Luxembourg, and as Chief of the Theatre Contracting Team in the former Yugoslavia. After his retirement from NATO, Roger worked for the Canadian Air Transport Security Authority as Compliance Advisor for Screening Technologies. He is now fully retired and lives in Victoria, BC.

References

1. "Artificial Intelligence in Business: Balancing Risk and Reward," A Pega Whitepaper by Dr. Rob F. Walker. [www.pega.com]
2. "The Superhuman Future of Software Development," Posted on September 17, 2018, by Sandy Sharma. [www.daskeyboard.com/blog]
3. "Evolutionary Computation has been promising self-programming machines for 60 years, so where are they?" Graham Kendall, The Conversation. [www.phys.org]

[**Editor's Note:** It was a wonderful surprise to receive a new article from Roger Cyr. His last publication in the *Journal* was, *NATO Defense College – Higher education with an Italian flavour*, that appeared in MEJ 27, released in June 1992. A year before that, however, we published his article, *Danger – software ahead*, MEJ 25, October 1991, that now makes for an interesting forerunner companion piece to the present article. You can find all of the *Journal*'s back issues online at: http://www.cntha.ca/publications/m-e-j/]

FEATURE ARTICLE

Forward Fire Control System Repair – HMCS *Ottawa* prevails against one stubborn pump

By Lt(N) Dusan Brestovansky and Lt(N) Karl Pijanka

While en route to Unalaska in the Aleutian Islands as a part of her greater journey in support of Operation Projection and Operation Neon, HMCS *Ottawa* (FFH-341) suffered a fault in the forward fire-control system (FCS). The initial symptoms included an inability to move the fire-control director. The FCS console indicated that the oil pressure for the hydraulic pump unit (HPU) was low, and that the pump itself was off. The HPU, located in Fire Control Equipment Room No. 1, powers the director's hydraulic system that actuates the director. Without it, our forward fire-control director was stuck in place, rendering it mission incapable. This was a devastating system casualty as *Ottawa* was now down to only a single fire-control radar unit, thus severely limiting the ship's anti-air warfare (AAW) capability.

A technical crew quickly confirmed that the HPU was off, and that the 230-V_{AC} breaker had tripped. Once the breaker and HPU were reset it became apparent that the HPU was running at the wrong pitch, with no sound indicating that the pump was engaging. The hum of the electric motor was audible, but the pressure filter indicator was halfway released, which meant that the oil pressure was too low, and the oil filters might be clogged. This malfunction was quickly confirmed when the FCS cabinet indicated a pressure filter fault, and the pressure-relief valve cartridge LED indicator was no longer illuminated. Lastly, the pressure gauges indicated the HPU was only able to supply 10 bar pressure instead of the normal 50 bar. The job seemed simple.

The techs quickly took action and replaced both the supply and return filters, but to no avail. It turned out that the filters and the pressure filter indicator were just a symptom of a greater problem. By remotely collaborating with Fleet Maintenance Facility Cape Breton (FMFCB), subject matter experts helped our techs narrow the cause to either the vane pump or the shaft coupling. The HPU is designed with a series of successive pumps that turn on and off depending on the demand on the system. This action ensures the system is responsive and able to track a quickly closing missile, but it also ensures parts are not wearing out unnecessarily when the system is standing by for input.

The vane pump is designed to provide the initial oil pressure, and the shaft coupling links one pump to another. But there were further complications. First of all, *Ottawa* doesn't carry a spare vane pump, and, furthermore, no one on board had ever performed this repair. On top of all of that, the HPU access from above was obstructed by an HVAC unit with no apparent hard-point to lift the HPU cover plate. All of this, coupled with rough seas ahead, meant that this was going to be a challenge, and it was decided that the safest repair plan was to request a technical assistance visit (TAV) by FMFCB staff to help with replacement of the pump.

The ship therefore raised a high-priority requisition (HPR) for a replacement part, and liaised with Canadian Fleet Pacific staff and Maritime Component Command (MCC) to arrange a TAV. It was still a few days until *Ottawa* was scheduled to arrive at Dutch Harbor in Unalaska, so the techs continued researching, planning, and investigating until finally it was decided to attempt the repair organically, while keeping the TAV as a back-up plan.

The planning involved collaboration between the ship's Combat Systems Engineering (CSE), Marine Systems Engineering (MSE) and Deck departments to coordinate a plan for accessing the inside of the HPU. On receipt of a replacement pump a few days later in Dutch Harbor, the repair was a go, and it was all-hands-on-deck for this one. The MSE department removed the HVAC unit, and uncovered a hard-point so that the Deck department could rig a lifting block around the HPU cover plate to safely hoist it high enough to expose the vane pump within. This was a slow and deliberate operation as the HPU is filled with 90 litres of oil – which added a very real possibility of a major hazmat spill into the mix of things that could possibly go wrong.

Photo by LS Victoria Ioganov, Image Technician

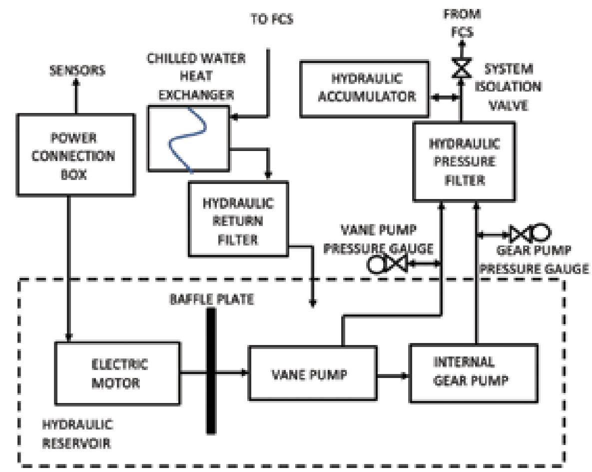
Weapons Engineering fire-control technician MS Aaron Blaney with the forward fire-control system hydraulic pump unit lifted for trouble-shooting and repair.

The cover plate of the HPU acts as a lid to the tank, and supports the pumps, motors, pressure gauges, and hydraulic valves. The pumps and motors are inside the tank and suspended by the cover plate above. The pressure gauges, hydraulic valves, and electronic components are mounted above the cover plate. The techs hoisted the plate to clear the top of the oil tank, which appeared to be free of contamination, then placed a ¼-inch steel plate, wrapped in a hazmat bag, over the tank to prevent possible contamination of the oil from outside the tank. The team examined the condition of the motor, vane pump, and gear pump, and all components looked perfect.

The entire pump assembly was taken apart for further examination. The vane pump was rotated by hand, and when it would not turn as easily as the replacement unit, the team knew they were on the right track. The techs installed the new vane pump, and reassembled the HPU assembly, and thought they were almost finished. Ship's staff lowered the HPU cover plate, reconnected all external connections, and flashed up the HPU only to find the internal system pressure was still reaching only 10 bar maximum even though the vane pump was running as indicated by a change in pitch. The techs tried adjusting the pump flow rate, but this action had no effect on the system pressure. They suspected that the pressure-relief valve cartridge might be stuck in its open position, preventing the system pressure from building up.

The techs started digging deeper. They investigated the pressure-relief valve connection and discovered that the S2 plug was partially melted, with smoke residue visible in the clear housing. Although the precise moment when this damage occurred could not be ascertained, the most likely explanation was that condensation from the system's chilled water lines had dripped onto the S2 plug, causing a short and damaging the plug. Voltage measurements showed 0 V_{DC} on some pins, and an unbalanced voltage on two others. It was now clear that the pressure relief valve cartridge was receiving only one correct source of AC voltage, and that the motor controller was providing unequal power, thus creating an imbalance. Comparative measurements on the functional after system HPU confirmed the voltage irregularities. The team now faced not only a hydraulic problem, but an electronic one as well.

The motor controller in the forward HPU was replaced with an onboard spare, and tests verified the electrical system. When power was applied, the voltages returned to normal. All



Hydraulic system schematic for the CEROS 200 fire-control system hydraulic pump unit.

external connections were reattached, and the system was fully tested. The HPU reached a correct system pressure of 50 bar. Further system tests confirmed that the director was able to operate normally, and so capability was restored.

At the end of the day, the repairs took approximately 90 hours of combined effort, drawing on expertise from personnel throughout the ship. This fault was unique because it appeared to be outside of the ship's ability to repair, but due to operational necessity we decided to venture out into unfamiliar waters. That we were ultimately successful is a testament to the technicians' training and abilities. Through teamwork, perseverance and good old elbow grease, *Ottawa* solved the problem and restored the ship's AAW capability to its former operational state.

Lt(N) Brestovansky is the Combat Systems Engineering Officer aboard HMCS Ottawa. *Lt(N) Pijanka is the ship's A/CSEO.*

FEATURE ARTICLE

Update — Frigate Mid-life Refit Diesel Generator Replacement

By Michel Meunier

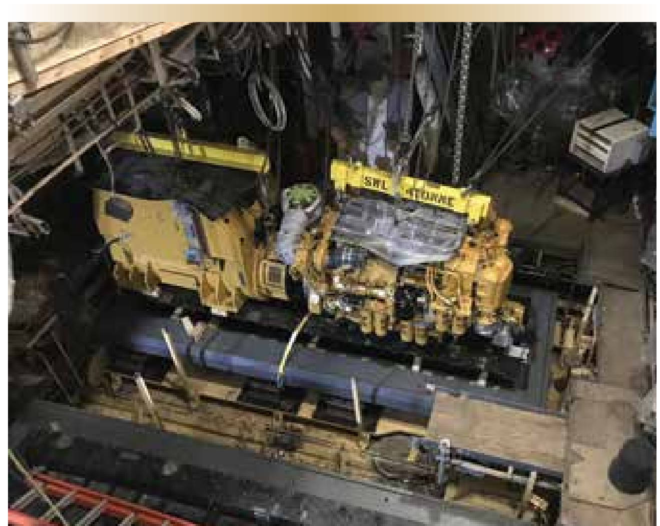
Photos courtesy of the author.

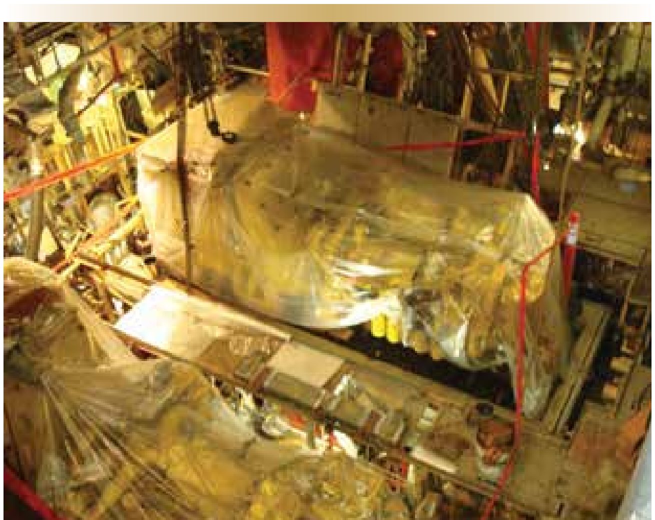
The C32 ACERT Caterpillar diesel engine and Hitzinger 830-kW generator make a powerful combination when it comes to delivering onboard electrical power for the RCN's *Halifax*-class frigates.

As with all major engineering systems discussed more than a decade ago for the *Halifax*-class mid-life refits (MLRs), the situation with the MWM602 diesel engines used to power generators for shipboard electrical service became a hot topic of debate: Could the Navy carry on using these units until the anticipated end of the frigate fleet's service life, or would they need to undergo a complete revamp? At that time, a study was conducted within DGMEPM's marine diesels section to evaluate the situation, and while many different aspects were considered, the two major points of discussion centred on maintenance costs and parts obsolescence.

The MWMs had suffered a number of catastrophic engineering failures early in their service (see MEJ No. 65), but these issues were addressed such that, over the years, the engines became more and more reliable. A cost comparison demonstrated that keeping the existing MWM units was the only logical solution, but as the Navy moved on with the MLRs, the maintenance costs for the MWM engines began creeping up. In normal operation, when an MWM reached 15,000 hours of operation, the engine would go through what is known as a complete bottom-up rebuild at the original equipment manufacturer (OEM) facility. In the span of a few years, however, the maintenance costs had almost doubled, so it became obvious that it was time to make a change to a new generation of engines.

A Letter of Intent was sent out to industry in October 2012, followed by an industry day conference on January 16, 2013. The prequalifying companies were selected in September 2013, and four OEMs were retained. During the industry day sessions that followed, it was found that





there was reluctance on the part of these companies to assume an in-service support contract if the original generator were to be kept in place. It was suggested to us that providing any sort of guarantee on a 20-year old generator would be next to impossible, so it was decided by DND to have the complete diesel generator (DG) set replaced at the same time. In 2014, following two years of iterations and subsequent industry conferences, a Request for Proposal (RFP) for this work was promulgated.

The four potential bidders looked at the package requirements, but in the end only three submitted bids. In June 2015 a contract was awarded to Hewitt Equipment, since taken over by Toromont Industries, to acquire and provide in-service support for 48 DG sets for the frigates, one fully operational dynamic trainer for the East Coast fleet school, one static engine for each of the East and West Coast fleet schools, four spare engines, and four spare generators. The contract includes initial cadre training for the Navy, whereby the main contractor provides 1^{st}-level training for each of the frigates being fitted with the DG sets. The fleet maintenance facilities on both coasts will also receive initial 2^{nd}- and 3^{rd}-level training.

The second portion of the contract is for in-service support related to the maintenance of the DG sets until end of life of the *Halifax*-class frigates. In summary, DND is responsible for all 1^{st}-line maintenance, Toromont and the fleet maintenance facilities will split the yearly 2^{nd}-line maintenance, and Toromont is responsible for all 3^{rd}-line maintenance through the life of the contract. Corrective maintenance is also included in the contract, and all of it is the responsibility of the main contractor. All required material needed for maintenance will be supplied by the contractor on an as-required basis. Ships will carry enough contractor-owned material to complete six months of maintenance while deployed, paying for the materials as they are consumed.

The new diesel-generator system is fully automated with an engine control module that allows the engine to operate efficiently at low loads, which was a problem for the MWM engines they replaced. Since the new sets had to fit within the existing footprint, Toromont chose the C32 ACERT Caterpillar engine along with a Hitzinger generator capable of generating up to 920 kW of electricity. The one fitted in the *Halifax* class generates 830 kW per set, for a total of 3.32 MW of power.

Some of the subsystems that make up the new DG sets are:

- a **Novec fire-suppression system**, which is the newest generation of firefighting capability, and is both human and environmentally friendly.
- a **dead ship battery backup** to ensure that the electronically fuel-injected engines can be started during a complete ship blackout.
- a **marine genset control panel** — a more modern control system for the engine, generator, and enclosure equipment, which will monitor operation on a continuous basis. It has set limits that will shut the engine down automatically if these conditions are not maintained, and has local start/stop capability, a local emergency stop, local generator parameters, and diagnostics.
- **dual automatic voltage regulators** — an easy-to-operate and easy-to-maintain digital excitation control system located outside the enclosure for easy access in a more habitable environment.

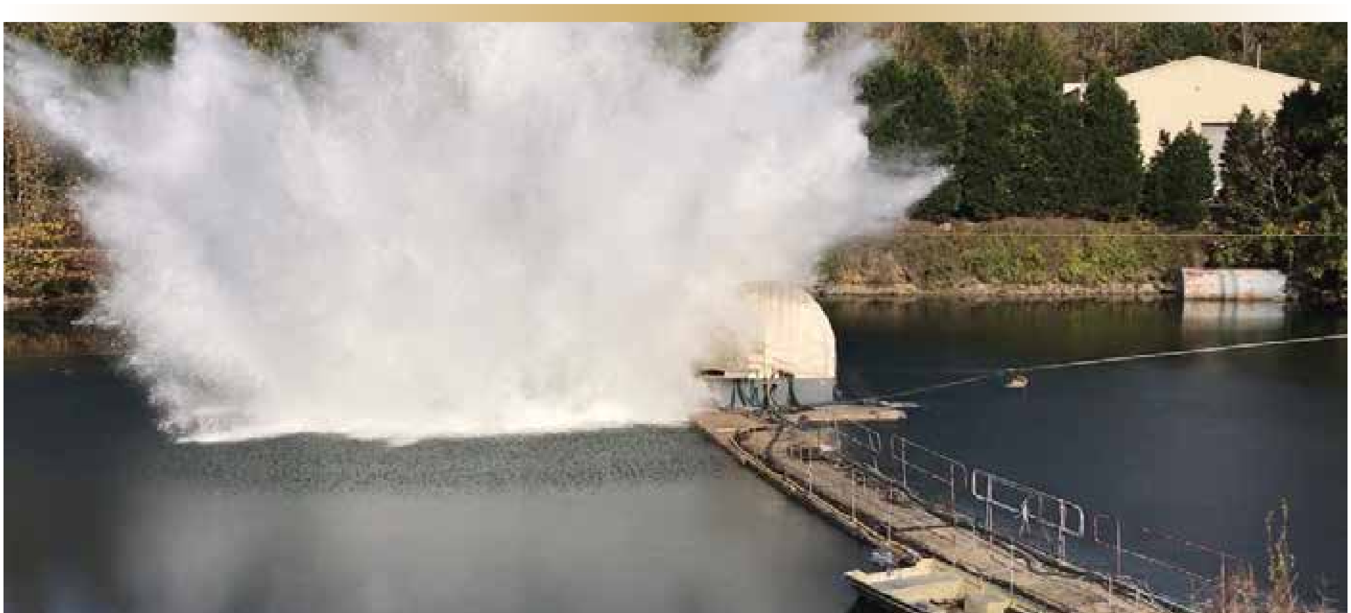
The new diesel-generator features state-of-the art fire-suppression inside the enclosure, and a modern marine genset control panel (pictured) that will shut the engine down automatically if set conditions are not maintained.

The first installation coincided with HMCS *Calgary*'s 2017 docking work period (DWP). Even though DND did not have all of the accessories in hand, the decision was taken to push on and start the installation process. Some time prior to the DWP it had been discovered that the existing lower raft mount assemblies supporting the new equipment would not meet the military shock standard. The contractor designed a new assembly, which was sent for shock testing at the Naval Engineering Test Establishment (NETE) barge facility in Shearwater, N.S., but the setup proved not to be ideal for the size of the equipment we were testing.

In 2017, everything was shipped to a facility in Arvonia, Virginia that specializes in doing shock trials for the United States Navy. After a full week of preparation by the NETE crew and the in-house team of Hi-Test Laboratories in Arvonia, a three-day trial was conducted on the DG set and raft assembly. It performed beyond expectation, and passed the military shock standard with flying colours.

Although there was a delay in delivering the necessary mounts and other components for the DG sets, the first installation was completed in *Calgary* by the time she was scheduled to return to operational status in December 2017. In January 2018 the ship sailed on a six-month deployment, with all four DG sets remaining fully operational throughout. It was the beginning of a success story that involved many dedicated stakeholders. We have since completed three more DG installations for *Winnipeg*, *Fredericton* and *Montréal*, and if all keeps going the way it has been, the entire 12-ship frigate fleet will be fully converted by the end of 2023 when HMCS *Halifax* comes out of DWP at the Irving Shipbuilding yard in Halifax.

Michel Meunier is the Marine Diesel Sub-Section Head for the Navy, and works for the Major Surface Combatant (MSC) 3 section in Gatineau, Québec.



The new lower raft mount assembly was shock tested at the Hi-Test Laboratories facility in Arvonia, Virginia, where it passed the military shock standard with flying colours.

FEATURE ARTICLE

A Shipboard Electrical Training Aid for Marine Technicians

By LS Rob MacMillan, HMCS *Halifax*
(with editorial assistance by LCdr Jason Correia, MSEO, HMCS *Halifax*)

LS Rob MacMillan uses an in-house designed training aid to introduce junior Mar Techs to the components and tools used during routine maintenance and troubleshooting of shipboard electrical equipment.

"There is nothing wrong with change, if it is in the right direction" – Winston Churchill

The creation and implementation of the Marine Technician (Mar Tech) trade has brought with it certain growing pains with respect to knowledge and training for in-service sailors adjusting from legacy trades to the new Mar Tech classification. Former marine engineers, electricians, and hull technicians are now expected to possess the skills to work with marine and platform systems, as well as electrical systems, despite not having received formal training in all of these areas during their legacy trades courses.

The Marine Systems Engineering (MSE) department of HMCS *Halifax* recognizes the realities of the evolved trade structure, and is working to overcome the challenges it brings during this transition period. In order to streamline integration and to motivate junior technicians, *Halifax*'s Electrical Section designed and built a basic electrical board as a training aid while deployed on Operation Reassurance to Central and Eastern Europe. For many, electrical troubleshooting can be a daunting task as we cannot see what is physically happening in the circuit. In the safety of a controlled environment, however, our electrical board combines several basic components to introduce Mar Techs to routine maintenance tasks that are performed on shipboard electrical equipment.

The electrical board contains a simple circuit comprised of switches, fuses, general receptacles, a terminal block, and a light. These components were chosen by the electrical manager and legacy electricians to demonstrate routine electrical work. The circuit will allow technicians to troubleshoot different pieces of equipment in a logical manner through the use of schematic and block diagrams. Basic hand skills, electrical safety, and developing a methodology toward repairing faulty equipment can all be practised. For instance, after a brief explanation of electrical theory, the terminal block will help technicians to understand that voltage is a difference in potential between two points. The single conductors will help teach how a current changes when resistive loads are increased or decreased.

This locally-built training aid represents the ingenuity and enthusiasm of marine technicians in the RCN, especially among junior sailors who are willing to seek out and share knowledge instead of waiting for it to be delivered to them. As part of its Mar Tech training initiative, the MSE department of HMCS *Halifax* continues to push legacy trade sailors outside of their comfort zone with theoretical and hands-on training of different systems throughout the ship.

Photos by Cpl Braden Trudeau, Formation Imaging Services

LS Daniel Mounsey explains the functionality of HMCS *Halifax*'s integrated platform management system (IPMS) controls to OS Jesse-James MacDonnell during on-watch training. A simple training aid designed by the ship's electrical section allows the ship's Mar Techs to enhance their familiarity with routine electrical maintenance tasks in the safety of a controlled environment.

BOOK REVIEW

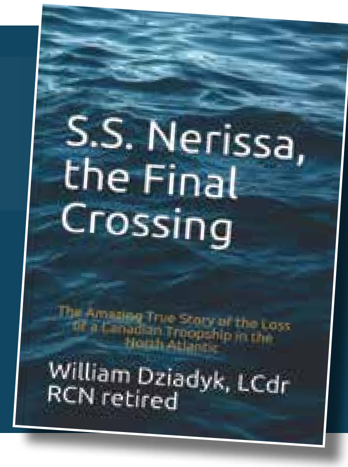
S.S. Nerissa: the Final Crossing

The Amazing True Story of the Loss of a Canadian Troopship in the North Atlantic

Reviewed by Brian McCullough

ISBN 9781704113821

151 pages; black & white photos, tables, casualty lists, footnotes



In the frontispiece of author Bill Dziadyk's new investigation into the tragic loss of the Newfoundland-based, British-registered troopship *S.S. Nerissa* on April 30, 1941, there is a photograph of the ship taken by the crew of an RAF Coastal Command patrol aircraft while *Nerissa* was still several hundred miles short of her destination of Liverpool in the U.K.

The photo shows the trim, 5600-ton passenger-cargo ship charging forward at a good rate of knots, sailing unaccompanied as was her custom, along a route that had been reported clear of enemy U-boats. It was her 40th wartime North Atlantic crossing. Launched in 1926 for Bowring's Red Cross Line passenger and freight service between St. John's, Halifax and New York, the ill-fated converted troopship was about to make a date with destiny.

Ten hours after the photo was taken, at 11:30 that night, the ship was struck a lethal blow by two torpedoes fired from U-552, a Type VIIC nicknamed the Red Devil. The officer at the submarine's periscope was none other than Kapitanleutnant Erich Topp, Germany's third most successful U-boat commander of the Second World War.

In a matter of minutes, with several lifeboats damaged or destroyed, the *Nerissa* was on her way to the bottom of the sea of the Western Approaches northwest of Ireland. Rescue ships arriving the next morning could save only 84 survivors from the freezing waters. The sinking claimed the lives of 207 crew and passengers, including 17 civilians.

Dziadyk, a retired RCN combat systems engineer, has produced a well-researched and highly detailed account of what is a largely unknown episode involving Canadians during the war at sea – not surprising since much of the information relating to the sinking remained classified for nearly 50 years. Through his diligent research into official naval and military documents, casualty lists, Allied and German wartime logs, as well as transcripts of survivor testimonies, the author has pieced together what is a remarkably human story, one that is well worth reading on the eve of the 75th anniversary of the end of the Battle of the Atlantic.

On January 4, *S.S. Nerissa, the Final Crossing* was highlighted in the eWeekly Update of Ontario Ancestors – an Ontario Genealogical Society website.

[**Editor's Note:** LCdr (Ret'd) Bill Dziadyk was the CSE technical editor for the *Journal* from 1992 to 1993. His predecessor was Cdr (Ret'd) Roger Cyr, whose latest article appears elsewhere in this issue. Welcome back, gents!]

NEWS BRIEFS

FMF Cape Scott Assists HMS *Queen Elizabeth* with Conduit Repair

By Lt(N) Rosemary Suen, Formation Technical Authority (Combat Systems)

On September 13, 2019 HMS *Queen Elizabeth*, a British aircraft carrier participating in Cutlass Fury 2019, requested Fleet Maintenance Facility Cape Scott (FMFCS) repair an exhaust cooling conduit. The part arrived in the morning and was completed by noon that same day. Here's how FMF "turned-to" on a Friday to aid a NATO ally:

First, the part arrived at the Non-Destructive Testing (NDT) shop where NDT Technician **Scott Sanford** (Fig. 1) examined the part for defects using a dye test. The defects were identified and clearly marked for repairs.

Figure 1.

Other services available from the NDT shop include magnetic testing, x-ray testing, ultrasonic testing, and material identification through optical emissions spectroscopy. One other party that relies on NDT is the additive manufacturing centre of excellence (Laser 3D Metal and Plastics Printing shop).

After the defects were identified, the part was sent to **Joey Baker**, an experienced welder at FMFCS, who performed tungsten inert gas (TIG) welding to correct the defects (Fig. 2). The material defects, if not remedied, could have compromised structural integrity of the conduit later on.

Figure 2.

The repaired part was then sent back to NDT for inspection by Scott Sanford to ensure the defects were corrected, and this was verified by his supervisor **Rodney Cole** (Fig. 3). The part was then sent back to HMS *Queen Elizabeth*.

Great job FMFCS!

Photos courtesy FMF Cape Scott

Figure 3.

(This edited reprint from *The Great Scott Times* FMFCS newsletter is used with permission, courtesy of editor Ashley Evans, strategic communications officer, FMF Cape Breton Esquimalt.)

Send us your announcements!

The *Maritime Engineering Journal* looks forward to sharing your news.
Please send us your news items that have been approved by chain of command,
along with high-resolution jpegs, to: MEJ.Submissions@gmail.com

NEWS BRIEFS

First New Marine Technician Badges Presented

As one of his final official duties as DGMEPM before being promoted to take up his new appointment as Materiel Group Chief of Staff last December, RAdm Christopher Earl presented the first of the new Marine Technician sub-occupation trade badges to all Mar Techs working in the Maritime Equipment Program Management division in Ottawa.

Photo by LS Anne-Marie Brisson, Canadian Forces Support Unit (Ottawa) Imaging Services

PO2 Amy Durrah (at left), from the Major Surface Combatant directorate, was the first RCN Regular Force member to receive the new Marine Technician badge (Electrical Specialist). Reservist **PO2 Marie Connors** (right), from the Non-Combatant directorate, was the first to receive the new Marine Technician trade badge (Basic Maintainer) for the Naval Reserves.

The Marine Technician occupation was stood up to meet the modern and future requirements of the Royal Canadian Navy.

Joint Support Ship Update: Keel Laid for Future HMCS *Protecteur*

The laying of the keel of one of two new Joint Support Ships (JSS) that took place at Seaspan Shipyards in North Vancouver January 16 was termed an important milestone in fleet renewal by Vice-Admiral Art McDonald, Commander of the Royal Canadian Navy (RCN). The ceremony included the traditional placement of a newly minted coin near the keel of the new vessel for good luck.

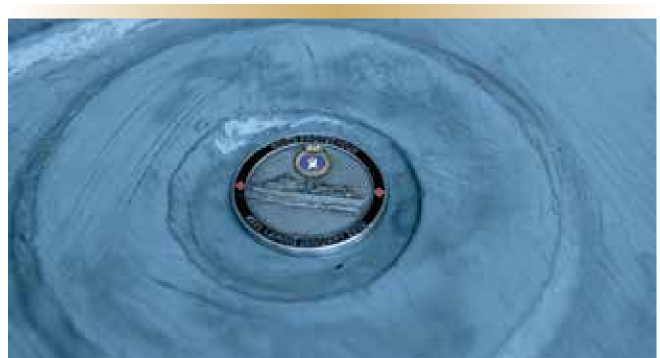


Photo courtesy of Seaspan

The design of the lucky coin features the badge of the future HMCS *Protecteur* on one side, and the crests/logos of the key members of the Government of Canada and Seaspan Shipyards JSS project teams on the back.

VAdm McDonald added that the *Protecteur*-class vessels being constructed under the JSS project will build on the RCN's proud legacy of delivering excellence at sea: "Once delivered, these warships will be strategic assets that will once again afford Canada the sovereign capacity to deliver – even in harm's way – an enduring at-sea replenishment and joint sustainment capability, as well as significant humanitarian assistance and disaster relief capacity."

HMCS *Protecteur* and sister ship HMCS *Preserver* will replace the former *Protecteur*-class Auxiliary Oiler Replenishment vessels. As a warship based on the German Type-702 *Berlin*-class design, the JSS will include sophisticated damage control and self-defence systems that will allow it to conduct a full range of military operations in high-threat environments.

Construction of the early blocks of the first JSS began in June 2018, with the delivery of the first ship – which Seaspan calls the largest naval vessel by length ever built in Canada at 173.7 metres – expected in 2023.

CNTHA

News

Canadian Naval Technical History Association

The Navy's Technical History: Should the Past Guide the Future?

(An abridged and edited short excerpt from a 2012 Mari-Tech presentation)

By Capt James G. Dean, RCN (Ret'd), with the assistance of various CNTHA members

On June 3, 2010, the Government of Canada announced the establishment of the National Shipbuilding Procurement Strategy (NSPS), a government/industry initiative designed to support Canadian marine industry, revitalize Canadian shipyards, and build ships for the Royal Canadian Navy and Canadian Coast Guard. On October 19, 2011, the government announced that large naval combat vessels would be built by Irving Shipbuilding in Halifax to naval standards, and that large non-combat vessels for both the Navy and the Coast Guard would be built by Seaspan's Vancouver Shipyards to commercial standards.

Since this new approach will not only provide much-needed new ships, but is anticipated to revive and provide a degree of stability to Canada's moribund shipbuilding industry, it is timely now (i.e. 2012 – Editor) to examine some of the historical aspects of Canadian shipbuilding underlying the NSPS approach. In this paper, the Canadian Naval Technical History Association (CNTHA) will examine the Navy's technical history associated with various naval shipbuilding programs, and ask whether the past should guide the future as the NSPS evolves.

....

Auxiliary Oiler Replenishment Ships (AOR)

HMCS *Provider* (AOR-508) was the RCN's first dedicated Auxiliary Oiler Replenishment ship. Built by Davie Shipbuilding and Repairing Company Limited of Lauzon, Québec, she was laid down in July 1961, launched in July 1962, and commissioned in September 1963.

The ship was designed by the Davie shipyard, mainly by ex-UK personnel working in close collaboration with the Department of National Defence (DND). The design was innovative and went well beyond the traditional "oiler" concept to provide for replenishment at sea (RAS) in all its forms (an RCN concept). The ship was built to commercial standards and fitted with commercial equipment. The shipyard was unfamiliar with RAS equipment, so this had to be reworked after the ship was accepted from the yard. The propulsion machinery was steam-driven, but the ship was designed to accommodate nuclear propulsion should that ever have been considered a future enhancement. At full load the ship displaced 22,700 tons, was capable of 21 knots, and could carry three helicopters.

Provider was initially assigned to operations on the East Coast, but her open deck made her vulnerable to the heavy Atlantic weather. She was reassigned to the West Coast where she served until she was paid off in 1998. Overall, *Provider* was an excellent ship that served the RCN well, providing valuable experience for the construction of other AORs.

HMC ships *Protecteur* (AOR-509) and *Preserver* (AOR-510) — the two follow-on ships to *Provider* — were commissioned in 1969 and

(Continues next page)

CNTHA News
Est. 1997

CNTHA Chairman
Pat Barnhouse

CNTHA Executive Director
Tony Thatcher

Directorate of History and Heritage Liaison
Michael Whitby

Maritime Engineering Journal Liaison
Brian McCullough

Webmaster
Peter MacGillivray

Webmaster Emeritus
Don Wilson

CNTHA News is the unofficial newsletter of the Canadian Naval Technical History Association. Please address all correspondence to the publisher, attention Michael Whitby, Chief of the Naval Team, Directorate of History and Heritage, NDHQ
101 Colonel By Dr
Ottawa, ON K1A 0K2
Tel. (613) 998-7045
Fax (613) 990-8579

www.cntha.ca

HMCS *Provider* in 1969 still with her forward goalpost.

1970, and deployed on both coasts. Displacing 24,700 tons fully loaded, their design took into account the problems experienced with *Provider*. The ships were built with larger bridges, paired funnels to permit a much wider hangar door, and were designed to accommodate the Canadian-designed and -built AN/SQS-505 sonar as well as an M22-based fire-control system and guided-missile launcher system. The missile and fire-control systems were never fitted, but for self-protection the ships were outfitted with a 3"/50-calibre gun on the bow. The gun was later replaced with a Phalanx anti-missile close-in weapon system (CIWS).

The preliminary design of the two *Protecteur*-class ships was carried out in-house by the Navy through the Naval Central Drawing Office. The contract for both ships was awarded by the Department of Defence Production to Saint John Shipbuilding in New Brunswick. The ships were built to commercial standards, with the Navy managing the technical aspects of the contract and providing oversight. Both ships were laid down in 1967, and launched in 1969. *Protecteur* commissioned August 30, 1969, and *Preserver* commissioned July 30, 1970. Both ships served for more than 40 years, but were hard to maintain and were manpower intensive.

Construction to commercial standards was reported to have caused significant problems and strain between the Navy and the contractor. Construction initially started out for commercial vessels built to Lloyd's standards, for which the ships would be inspected and approved by Lloyds, but the Navy did not want Lloyd's approval — it wanted Navy standards, which would have been more stringent and costly than the commercial ones. This disagreement created a serious problem... It is noted that the approach of the National Shipbuilding Procurement Strategy may significantly mitigate or avoid this problem. Time will tell.

....

Observations and Conclusions (abridged)

Over the years the technical sophistication of Canadian warships has increased dramatically as each new class has been procured. Many of the technical advances were led by creative young naval officers who applied their operational experience and engineering creativity to develop new system and integration concepts. In 50 short years the Navy advanced from stand-alone equipment integrated by sailors talking on sound-powered telephones, to the Canadian Patrol Frigate's fully-automated, integrated command and control and weapon systems that can detect, identify, engage and destroy a threat without a human being in the loop. In the CPF Project, the combat system integration facility proved invaluable in the design, development testing, set-to-work and integration of the combat system, saving time and money that would have been expended had it been done piecemeal in the lead ship. As we approach NSPS, in which 60% of a combatant warship's cost will be in the combat systems, the establishment of a sustained payload facility will be as important as a sustained shipyard.

HMCS *Preserver* in 1979.

For half a century, the Navy's shipbuilding projects have been completed successfully, creating good jobs and delivering excellent ships. It was evident, however, that the Navy's ship batch programs alone were insufficient to sustain the Canadian shipbuilding industry and its suppliers. Under NSPS it is anticipated that a continuing series of ship programs will sustain the industry and the supporting system and equipment manufacturers and integrators. This will depend on the government's provision of funds in its budget for both naval and other government ship projects.

The CNTHA believes that as implementation contracts begin under NSPS, the lessons of the past in system technology development and ship acquisition management must continue to guide the design, construction and project management of the new ships. If Canada is to continue as a serious maritime nation operating in three oceans, it will be important to retain a shipbuilding and ship repair capability as a national, sustainable resource.

Capt(N) James Dean, RCN Ret'd, crossed the bar on January 3, 2015 at age 77. His comprehensive and insightful 7200-word paper is well worth reading in its entirety at: http://www.cntha.ca/static/ documents/papers/mari-tech-cntha-paper.pdf

HMCS *Protecteur* conducts a replenishment at sea (RAS) in 1981.