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Maritime Engineering Journal

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Canada's Naval Technical Forum

Featured Content

Submarine materials support:
The History and Development of Explosion Bulge Trials – the Canadian Experience

CNTHA News Inside!

Canada

Canada's Naval Reserve — A Century of Service

See page 12

Director General Maritime Equipment Program Management

Commodore Keith Coffen, CD

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Commodore's Corner

Forum

Feature Articles

News Briefs

CNTHA NEWS

Explosion bulge trials of pressure hull test panels are a key element of the *Victoria*-class submarine support program.

(HMCS *Victoria* entering harbour (2015) photo by LS Zachariah Stopa, MARPAC Imaging Services)

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COMMODORE'S CORNER

The RCN's Naval Technical Support Community — As Capable as Ever

By Commodore Keith Coffen, CD

As I approach the end of my first year as DGMEPM, I would like to commend you, the current members of the Naval Engineering and Maintenance enterprise, for the work you are doing to prepare for the arrival of the Canadian Surface Combatant (CSC) and Joint Support Ship (JSS), and to integrate the Arctic and Offshore Patrol Ship (AOPS) into service. That you are simultaneously supporting the fleet-in-being across a wide variety of domains, so that the Navy of today remains strong and effective while we look to the future, deserves high praise as well.

I strongly believe that the experience of the past can usefully inform the perspectives of today, and nowhere is this more germane than when discussing the management of the Navy' most precious resource — its people. In the third edition of the *Maritime Engineering Journal* from the summer of 1983[1], **RAdm Brian Hotsenpiller** offered his high-level take, as Chief of Personnel Services, on the challenges and developments relating to the Naval Technical branch occupational structure pending the introduction of the *Halifax*-class Canadian Patrol Frigates. Apart from observing that the evolution of our occupation structures has historically been more fluid than some of us might think, it is interesting to note how much overlap there is between what RAdm Hotsenpiller was describing, and our own situation today in terms of recruitment, and preparing the RCN's officer and NCM technical branch occupations for the current and future fleets.

As we look back, informed by our knowledge of how things turned out over the past four decades, what is remarkable is how the enduring strengths of the Naval Technical community — our resilience, adaptability, fortitude, and initiative — have been applied to set the technical foundation upon which RCN operational excellence is built, even in times of significant uncertainty and change.

Today, with delivery of the first CSC on the not-too-distant horizon, we face some uncertainty over the best occupation structure to support the future fleet, and

Photo by Brian McCullough

2023 East Coast Town Hall with Cmdre Keith Coffen and Cmdre Michel Thibault.

challenges both with personnel numbers and training backlogs. You may be tracking that as of early May 2023, the RCN called a temporary halt to all formal occupation analyses, with the exception of the Marine Technician (Mar Tech) and Information Warfare Specialist occupations, to examine the impact that CSC will have on the RCN occupation structure. You may also be tracking the release of a recent NAVGEN aiming to implement some further changes to the occupation structure of the Marine Technican community. In short, these changes seek to respond to feedback received from Mar Tech sailors, while continuing to best position this vital community to support the future fleet. In the 40 years since Admiral Hotsenpiller's update, the Naval Technical branch has continued to adapt as necessary to best enable the RCN, and we will continue to do so in the future.

Continuing on with my theme around the importance of our people, I wanted to highlight just a few of my interactions with the Naval Technical community over the past few months.

First off, I met directly with this year's Mar Tech RQPO1 (Petty Officer 1st Class qualifying course) cadre to kick off their visit here in Ottawa. We spoke about the need for every member of the Naval Technical community, from the

1. MEJ 3: https://publications.gc.ca/collections/collection_2015/mdn-dnd/D12-21-1983-2-eng.pdf

most junior S3 sailors to the most senior executives, to identify and address challenges head on. We discussed the training and experiential challenges we are facing, and the importance of individual and collective action in improving the path forward, particularly in the context of recent challenges with the *Harry DeWolf* and *Victoria* classes. We spoke, too, about the general condition of the fleet, both aging and new ships, and the need to prioritize efforts to ensure that in an environment where we cannot do everything, we do that which is vital.

Our discussion was refreshingly wide-ranging. We talked also about taking a practical approach to risk management — i.e. ensuring that risks are managed to as low as is reasonably practicable (ALARP), while appreciating that naval operations are inherently risky. We spoke about culture, and the importance of paying as much attention to how we treat one another as we pay to addressing technical challenges. And finally, we spoke about the critical importance of technical leadership at the PO1 level to the safety of our sailors at sea, and to the success of RCN operations. Overall, I came away thoroughly impressed by the passion, pragmatism, commitment, and dedication of these deck plate technical leaders, and am excited to see them taking up greater leadership roles in our community.

After my meeting with the RQPO1 course, I attended a session of the Marine Industry Advisory Committee (MIAC)

Photo by LCdr Chen Song, JSS Detachment Vancouver

JSS Detachment's PO1 Brandon Lawrence (centre left) receives his Canadian Forces Decoration clasp for 22 years of service from Cmdre Keith Coffen, with CPO2 Mischa Lowe at left, and Cdr Robert D'Eon at right.

in Vancouver, sponsored by Public Services and Procurement Canada. You may recall that I mentioned this forum in my last Commodore's Corner as a key initiative toward breaking down some of the organizational stove pipes in the NEM enterprise. MIAC links marine industry representatives, both directly and through industry associations, to several different federal government departments with roles to play in setting the demand for services, contracting for services, and ensuring effective stewardship over public investment in marine goods and services delivered to government.

Some of the themes we discussed at the April MIAC meeting were: attraction campaigns aimed at bringing people into the marine industry, and providing for their training (e.g., the Naval Experience Program, as one example in this domain); the development of tools to predict the demand for services by the federal fleet in the coming decades; initiatives to make the Canadian marine industry more environmentally friendly; and, initiatives to engage indigenous-owned businesses in opportunities in the marine sector.

Immediately following MIAC, I attended the opening ceremony for this year's Mari-Tech Conference, a long-running event hosted by the Canadian Institute of Marine Engineering (CIMarE, est. 1976). I was glad to have the opportunity to meet up with some former colleagues, and fellow members of the Society of Naval Architects and Marine Engineers (SNAME), including former U.S. shipbuilding executive and current SNAME president, **Rick Spaulding** to discuss SNAME's initiatives to promote careers in shipbuilding and ship repair.

I was able to leverage my couple of days in Vancouver to visit the Joint Support Ship Detachment in Seaspan's Vancouver Shipyard, and take a tour of both the shipyard and JSS1. Under the leadership of Project Manager **Blaine Duffley**, and Detachment Commander **Cdr Robert (Bear) D'Eon**, JSS1 is rapidly taking shape, and is now in the outfitting process, while construction of the blocks for JSS2 is well underway. As much as I was impressed by the size and scale of JSS (the longest ship ever constructed in Canada), and the extent to which Seaspan has improved, modernized, and automated much of its fabrication facilities, I was even more impressed by the obvious enthusiasm and dedication of the Detachment team. It was my pleasure to recognize one of the Detachment members, **PO1 Brandon Lawrence**, for 22 years of loyal service to Canada, the CAF, and the RCN.

(Continues next page...)

Photo courtesy Mari-Tech

The Marine Industry Advisory Committee (MIAC) and guest attendees in Vancouver last April.

Finally, in May, I travelled to the East Coast to participate in the MARLANT Naval Technical Seminar, and meetings of the Naval Engineering Council. I was very impressed by the quality of the presentations in the seminar — everything from technical issues in the fleet, to extending our understanding of ship stability and structure, to updates on maintenance trends, firefighting technology, research and development, artificial intelligence applications, and much more.

The best part of my East Coast visit, I have to say, was the opportunity to join **Cmdre Michel Thibault**, Project Manager Canadian Surface Combatant, in hosting a Town Hall to field questions from members of the Naval Technical community. For more than two hours we listened, and responded to a wide range of excellent questions. What I took away from this productive engagement was that while there may be no shortage of challenges, there is no shortage of willingness to proactively address them.

As we look ahead to the future, the same enduring strengths of the Naval Technical branch – resilience, adaptability, fortitude, and initiative – apply now as we approach the transition to the Canadian Surface Combatant just as much as they applied during our transition to the *Halifax* class.

As a final point in keeping with our spotlight on people, you will note that much of this issue focuses on the people of the Naval Reserve who celebrate a century of outstanding service to Canada this year. Like the Naval Technical branch, the Naval Reserve has been, and continues to be, vital to the future of the Navy.

I hope you enjoy this edition, and wish you all a safe and enjoyable summer.

FORUM

Letter to the Editor

I just finished reading the article, *Marine Systems Overview: How the Arctic and Offshore Patrol Vessels differ from the Canadian Patrol Frigates*, in the Fall 2022 edition of the *Maritime Engineering Journal* (MEJ 102).

First off, I want to say thanks for writing this article, and providing a thorough comparison of the marine systems capabilities. It is great to get some of the technical specs of our newest class of ships.

I did, however, wish to provide an observation from a naval architecture perspective. When discussing ship stability, it is more appropriate to limit the discussion to the intact and damaged stability performance of the ship. While the reference to the initial fit of ballast was pertinent, the discussion relating to the capabilities of the active-fin roll stabilization and the heeling system — correctly discussed in relation to seakeeping and ice manoeuvring, respectively — would not normally be part of any assessment of the stability characteristics of a ship.

Again, I enjoyed the article, and enjoyed reading about the “new to the RCN” active-fin stabilization and heeling systems.

— LCdr Mark Bartek
Platform ANEP77/NSR Engineering Manager
Canadian Surface Combatant Project — Ottawa

FORUM

In Their Own Words

Continuing from our spring edition (MEJ 103), we present more career perspectives from participants at the 2022 MARLANT Naval Technical Seminar in Halifax:

Completing NEI and HOD duties

The most satisfying technical challenge of my career so far was completing Naval Engineering Indoctrination, which is focused on *Halifax*-class systems, and then fulfilling Head of Department duties on board a *Victoria*-class submarine and a *Kingston*-class coastal defence vessel. Serving as an engineering officer aboard multiple platforms taught me how to work with the subject matter experts and other team members on board. The HOD cannot and will not have all the answers, and so teamwork is key.

— LCdr Kevin Hunt

Chief Engineer

As chief engineer of HMCS St. John's in 2015-2016: Taking the ship out of FELEX refit, with a six-month compressed schedule, to deployment that included an unscheduled docking and propeller replacement. Then, returning from deployment without the need for a technical assistance visit (TAV), or tiered readiness program (TRP) support from Fleet Maintenance Facility, and with all planned maintenance (PM) completed. Concurrently generated six new Cert 3E, eight Cert 2E, and 11 A/MOC (acting military occupation) certifications!

— CPO1 E. Burns

Failed propeller pitch

I arrived on board HMCS *St. John's* as the engineering officer, and during our first entrance to St. John's Harbour, the pitch failed on the starboard shaft. Here I was one week into the job, and had to figure out what was wrong and how to fix it. The chief and I spent all night taking things apart that had never been disassembled, and after hours of digging into the system, we finally figured out that the forward and after oil were married. After returning to Halifax on one shaft, we conducted a never-before-seen repair to the controllable reversible pitch propeller (CRPP) actuator, and headed back to sea. What a great experience.

— Cdr Adrian Mascarenhas

Balancing school and family

The most technical challenge during my career has been returning to university as a mature student to obtain a Bachelor of Electrical Engineering degree. I have three young children, and found it incredibly challenging/stressful to balance my home life with the academic demands of the engineering program. I often was in the classroom for 35-40 hours per week and would spend an additional 35-40 hours per week studying at home.

— SLt Nathan Sherwood

Importance of helping others

The most satisfying technical challenge of my career was helping a member of my platoon during the field portion of their training. They had a lot of difficulties, but it also made me understand how important the success of others is. Helping them made me more satisfied, even though it had an impact on my own performance.

— SLT (unsigned)

First senior electrical propulsion manager

Becoming the first senior electrical propulsion manager, and being the CAF's subject matter expert on high voltage, which includes the development of HV coursing for the RCN.

— (unsigned)

CMS

Maintaining the Combat Management System on HMCS *Winnipeg* (2015) as the first West Coast ship to deploy post-FELEX (frigate life-extension). Lasting new challenges and concepts.

— SLt Brandon McLeod

FEATURE ARTICLE

Submarine materials support: The History and Development of Explosion Bulge Trials – the Canadian Experience

By Dr. James Huang and John Porter

Preface

In the distance, across the rolling prairie grasslands of southeastern Alberta, a bright light flashes for a fraction of a second, followed by a rapidly expanding black cloud. A dark square panel can be seen flying upward, end over end through the cloud, reaching the height of a typical two-storey home before falling back to earth. Moments later, a loud boom is heard by the observer team as the explosive shock wave washes past them. The landing of the square panel marks the successful completion of yet another explosion bulge (EB) trial evaluation on a representative steel panel from a *Victoria*-class submarine (Figure 1) pressure hull. Getting to this point required considerable perseverance and originality, and is an interesting story of Canadian technical capability.

Introduction

Explosion bulge trials originated in the 1950s at the Washington D.C. Naval Research Laboratory. An effective means of qualifying new submarine pressure-hull steels and welding procedures was required to ensure that only the best materials were used in the new United States Navy (USN) nuclear submarine build programs. The resultant EB procedure became the means of ensuring the highest possible survivability of the new pressure hulls.

DND photo by Mona Ghiz, Formation Imaging Services

Figure 1. *Victoria*-class (ex-*Upholder*) submarine pressure hulls were built to UK MoD engineering standards, based on UK Defence Science and Engineering knowledge and experience.

Figure 2. The explosive energy imparted through bulge testing deforms the submarine pressure-hull test panels in a controlled, reproduceable manner.

Since those early trials, the EB procedure has been adopted by various submarine-fielding countries, including Canada, that all strive to ensure that only the best materials and procedures are employed in their submarine construction and maintenance.

The EB procedure involves subjecting full-scale panels of candidate submarine pressure-hull material to explosive shock loading. The explosive energy deforms the test panels in a controlled, reproduceable manner (Figure 2), inducing a high degree of plastic set strain in the material (preferably without inducing significant tearing or fracture). Specifically, the test panel sits atop a large steel anvil with a circular central doughnut-like opening. The explosive charge is suspended over the test panel and anvil opening, as illustrated in Figure 3. Detonation of the charge (Figures 4a, b) causes the test panel to deform into the anvil opening, stretching it into a wash-basin-like shape (Figure 5). The apex of this basin has thinned to a percentage of its original thickness. If the panel reached the desired thinning without failure (i.e., significant tearing or fracture), the candidate material system is deemed suitable for use in submarine pressure hulls. Two other EB specimens are shown in Figure 6, in which Pass and Fail are easily distinguished.

The introduction of explosion bulge trials to Canada followed a curious route, involving a variety of locations and procedural evolutions, before settling on a stable site and methodology. As such, this article is comprised of three parts:

1. The Past;
2. The Present and;
3. The Potential of Canadian EB evaluations.

The Past

Round 1: Canadian Forces Base (CFB) Valcartier, Québec

EB trials were introduced and first employed in Canada in the early 1980s by the Dockyard Lab (Atlantic) of Defence Research and Development Canada (DRDC) to evaluate the HY80 steel welding procedures used to maintain the Royal Canadian Navy (RCN) *Oberon*-class submarine pressure hulls. The *Oberon*-class boats of the 1960s were built originally with QT28 steel. HY80 steel was, in that era, a "modern" steel with a higher yield strength and better toughness; therefore, whenever possible, the *Oberon*-class QT28 pressure-hull material was replaced with the superior HY80 steel. The challenge for the RCN was to qualify new Canadian welding procedures for this modern material.

The first series of EB trials involved three candidate HY80 welding procedures, and was carried out mid-winter on the frigid ranges of CFB Valcartier. Access to the range was not a problem as nobody was competing to be on those ranges, facing midday highs of -30 degrees Celsius. The first weld procedure that was evaluated used a weld consumable with a relatively low strength level compared with the HY80 steel (an under-matched procedure). The second weld procedure used a weld consumable with a strength level equivalent to the HY80 steel (a matching procedure). The final weld procedure applied a weld consumable with a strength higher than the HY80 steel (an over-matched procedure). The question of weld-strength matching levels was one of considerable international interest among our allies, and it was agreed that Canada's contribution to the debate would be to experimentally determine which configuration would withstand the highest degree of dynamic plastic deformation.

Excellent support for these trials was provided by Defence Research Establishment Valcartier (DREV). The staff viewed the trials as an opportunity to demonstrate various novel explosive event sensors. Unfortunately, while

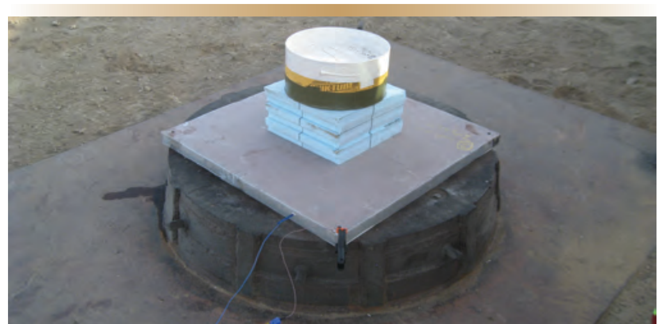
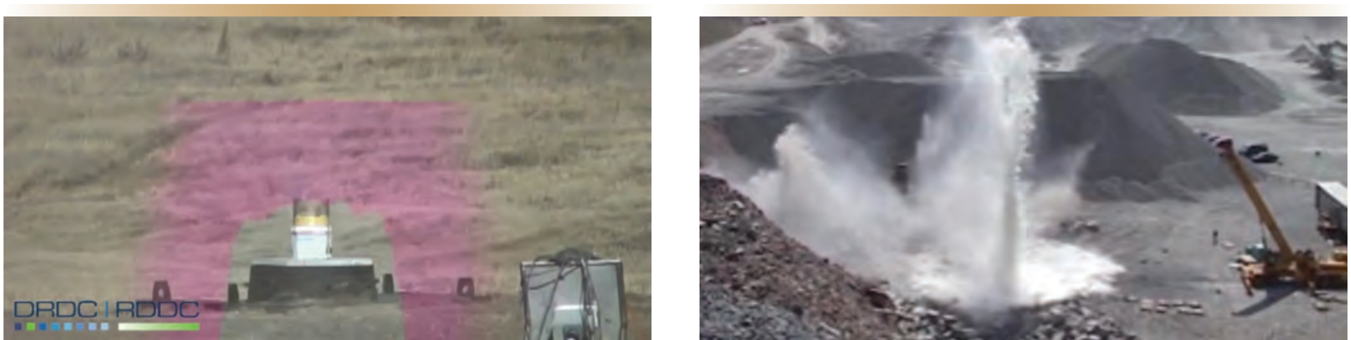


Figure 3. A 10-kg explosive charge, with Styrofoam "stand-off" and test panel atop the EB anvil prior to charge detonation.



Figures 4a and 4b. The moments of detonation. The pink area is a video capture of the beginning of the shock wave.

(Continues next page...)

the first shot deformed the test panel as expected, it also destroyed all the DREV experimental sensor hardware. The DREV team graciously decided that, despite the rather embarrassing setback, the shots on the remaining welded panels would continue. The results were surprising: the under-matched panels failed dramatically; the matched panels deformed well beyond the required plastic strain without issue; and the over-matched panels experienced severe surface cracking, but held together.

As an aside, test panel temperature is an important trial parameter. The panel temperatures had to be -20 degrees Fahrenheit at the time of firing, meaning this was the first time in the history of these trials that test panels had to be *warmed up* prior to testing in the -30 C° temperatures.

Much was learned at DREV during Canada's first foray into EB trials regarding the high deformation mechanics of explosively loaded submarine pressure hull weldments. It was politely suggested, however, that an alternate EB test site be considered for future trials.

Round 2: Militia Training Centre, Aldershot, Nova Scotia

The next round of EB trials occurred at the Militia Training Centre (MTC) Aldershot, located in Nova Scotia's Annapolis Valley. Various novel HY80 welding procedures were evaluated during Round 2, and another question of international interest was addressed: the depositing of weld metal on the surface of corroded QT28 pressure-hull plate (i.e., weld cladding) as a means of returning the steel to its required thickness. Royal Navy (RN) standards of the day restricted cladding to areas of less than 100 square inches, but RCN *Oberon*-class submarines experienced corroded plate over much larger areas. A series of EB samples with various areas of weld cladding were fabricated and evaluated. It was experimentally demonstrated that because of the superior properties of the Canadian welding procedures (compared to the base QT28 parent plate), that the greater the amount of weld cladding, the better the panel's performance from a dynamic and high deformation perspective. Distortion due to surface cladding however remained problematic.

EB trials continued successfully at the MTC until the Centre's commanding officer drove out to the ranges and insisted that the trials cease immediately. It turns out that an elderly lady had visited the CO that morning, claiming that the trials had caused considerable damage to her property. Her complaint was unique in that she had brought a printout from a seismograph as evidence. A lawn-mounted seismograph in rural Nova Scotia might be unusual, but it certainly had the desired effect in terms of compensation. It was time to find another location.

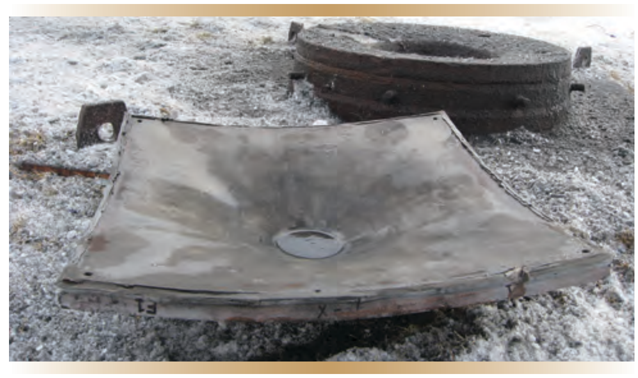


Figure 5. The blast result: A "wash-basin-like" bulged test panel.

Round 3: A Rock Quarry, Dartmouth, Nova Scotia – Late 1980s

The late 1980s witnessed USN and RN submarine materials authorities experimenting with alternative test procedures to ensure material suitability. Some procedures involved testing smaller defect-containing samples under water, but defining a meaningful weld defect configuration and associated acceptance criteria proved problematic and challenging to relate to an actual submarine structure. Canada therefore maintained its practice of evaluating full-size defect-free panels, as per the original EB procedures. However, the idea of conducting the blasts under water was seen as possibly more effective in deforming the test panels to the required plastic strain.

The ever-helpful Halifax Fleet Maintenance Facility Cape Scott (FMFCS) constructed a massive eight-foot high, eight-foot diameter, half-inch-thick steel tank, and delivered it to a rock quarry located on the northeastern outskirts of Dartmouth, NS. The tank was filled with water. An anvil with a test plate and a one-pound explosive charge mounted above it was carefully lowered into the tank. Upon detonation, the charge launched the entire assembly (tank included) about six feet vertically. Interestingly, the blast caused considerable damage to all the test equipment (tank, anvil, hoist, scaffolding, etc.) while the steel test panel remained undeformed. Subsequent experimental iterations failed to achieve the desired efficiencies with the tank arrangement. Perhaps a larger body of water might work.

Round 4: Underwater off a Jetty in Port Hawkesbury, Nova Scotia – Mid 1990s

Continuing with the underwater theme, the next iterations of Canadian EB trials were conducted off an old jetty in

Port Hawkesbury, NS. The test assemblies (anvil, test piece and explosive charge) were lifted by an old crane on the jetty and submerged into the ocean, then recovered following the detonation of the test charge. This approach worked exceedingly well, and a significant number of weld procedures were evaluated at the Port Hawkesbury site. Unfortunately, the firm providing technical support decided to issue a press release extolling the virtues of this unique new Canadian capability. Around that time, the firm had submitted a proposal to the Turkish Navy regarding possible mini-submarine support work, and released a second press statement on this separate activity. Somehow, the two press releases were combined in an American Navy news article that reported that Canada was supporting the development of Turkish submarines. Upon reading the erroneous article, senior RCN leadership was somewhat displeased. It was time again to find another location for Canadian EB trials.

Round 5: The Return to the Dartmouth Rock Quarry – late 1990s

Following the success of submerged testing in Port Hawkesbury, it was decided to use an artificial lake created at the Dartmouth rock quarry (see Round 3). Numerous efficiencies were made to the EB procedure, and thicker plates with larger charges were used to qualify a range of candidate materials. One highlight involved qualifying a novel Canadian steel that was superior to the American HY80 pressure-hull steel. A Canadian steel mill had developed a high-yield strength, weldable, quenched and tempered steel with a yield strength of 700 mPa (designated HYW700QT) for use in possible built-in-Canada submarines. The parent metal steel far exceeded the EB deformation requirements. Two-inch-thick welds in this material were, however, unable to attain the degree of required plastic strain prior to failing. Post-blast examinations revealed that the parent metal strength levels were considerably higher than the designed 700 mPa, and therefore the weld procedures were unintentionally undermatched. The welds were subject to plastic strain concentration and premature tearing during plastic deformation in an EB evaluation. While the Canadian submarine steel project was cancelled, it is worthwhile noting that had either a slightly lower strength parent metal plate or a higher strength weld consumable been used, the welded panels would likely have passed the EB evaluations and Canada would have had access to a superior Canadian submarine pressure-hull steel and associated weld procedures.

In 2002, a series of two-inch-thick Canadian welded panels were evaluated using a single-shot underwater EB procedure at the Dartmouth quarry site. These results compared favourably with identical welded panels evaluated using the RN Flawed Bulge Explosion for Category 1 weld procedure qualification. Based on the successful comparison, in September 2003, the Canadian EB procedure was formally adopted as a required evaluation procedure for Canadian pressure-hull steels and weldments.

The acquisition and delivery of the *Victoria*-class submarines (VCS) in the early 2000s resulted in a reduced requirement to qualify new pressure-hull materials. The VCS Q1N pressure-hull steel (the British equivalent to the American HY80) and its weldments were regarded as well-established, with all of the maintenance repair welding deemed to be up-to-date when the boats were delivered to the RCN. As the requirement to qualify new materials for pressure-hull usage seemed at an end, the quarry lake was filled in, and the support equipment moved into storage.

The Present

As it happened, the introduction of the new-to-Canada *Victoria*-class submarines to the RCN did result in the odd maintenance challenge, requiring some of the expertise and capabilities acquired during the *Oberon*-class era. For example, considerable under-tile surface corrosion of VCS pressure hulls demanded immediate consideration. Was pressure-hull weld cladding as performed earlier on *Oberon*-class QT28 hulls an option, or was plate replacement the only way forward? Could newer weld procedures reduce pressure-hull distortion during cladding of the newer Q1N pressure-hull steel, thereby allowing larger surface areas to be reclaimed rather than replaced? Would these newer

Figure 6. *Oberon*-class submarine explosion bulge test panels.

(Continues next page...)

cladding procedures improve or degrade the survivability of the hulls during dynamic loading events?

Definitive answers to these questions would only be available through experimental evaluation, including the recently retired EB trials. Once again, a new location was required.

Round 6: CFB Suffield, Alberta

To investigate the pressure-hull corrosion repair options, a series of legacy flux-cored arc welding (FCAW) and novel pulsed-gas metal arc welding (P-GMAW) overlay samples were fabricated for evaluation and comparison. Earlier, DRDC Suffield had assisted the Dockyard Lab (Atlantic) in the underwater shock evaluation of nickel aluminum bronze (NAB) hull valves containing selective phase corrosion. The successful conduct of these trials at CFB Suffield led to the observation that the expertise and facilities to conduct submarine pressure-hull EB trials did not require resurrection; they were already resident on the prairies of Alberta.

Drawing upon its expertise in explosive shock dynamics, DRDC Suffield proposed a new single-shot in-air explosion bulge procedure, replacing the previous single-shot underwater procedure. The new procedure adhered to all the requirements of the previous EB procedures, and the expansive ranges of CFB Suffield allowed for the use of large in-air explosive charges. The first Suffield EB trials validated the legacy FCAW weld-repair procedures, and qualified the new Canadian P-GMAW overlay procedure to address large-area pressure-hull corrosion. Supplemental EB trials qualified P-GMAW procedures for pressure-hull butt welds. Figure 7 summarizes the explosion bulge testing programs conducted by DRDC Suffield to qualify various submarine pressure-hull weld and advanced joining procedures. These trials were overseen by the technical authority in the Ship Systems Engineering section of the Maritime Equipment Program Management Division at National Defence headquarters in Ottawa.

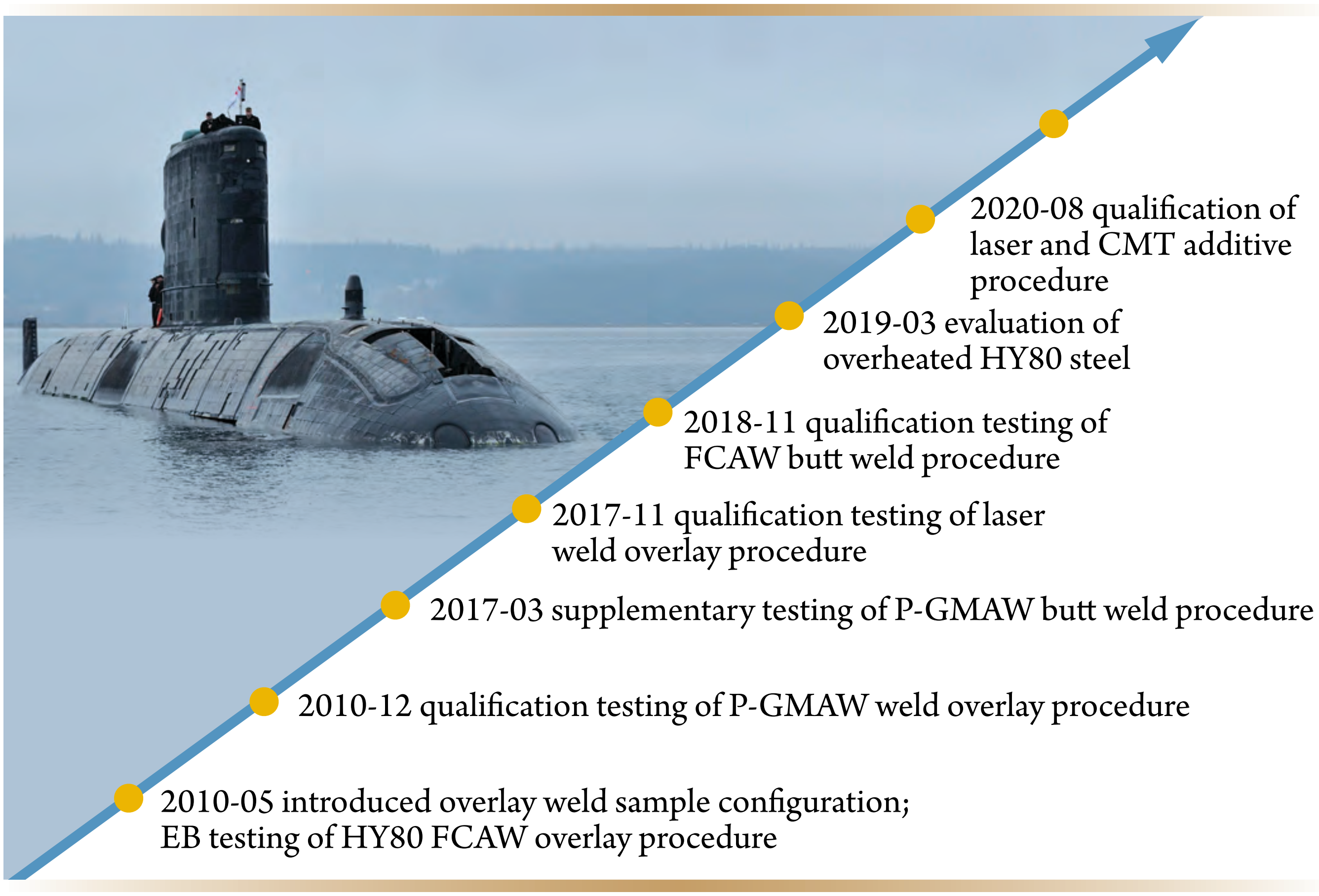


Figure 7. EB testing conducted by DRDC Suffield

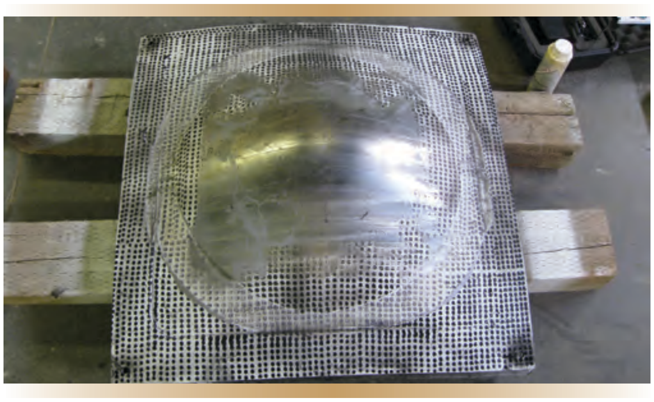


Figure 8. A laser additive manufactured specimen after EB loading. It passed.

One recent highlight was the EB testing and qualification of a laser additive manufacturing (LAM) procedure for pressure-hull repair. This innovation removed the onerous requirement of pressure-hull base metal pre-heating, thereby significantly reducing time, cost and risk for some pressure-hull maintenance activities. An EB LAM test panel is shown in Figure 8. These efforts paved the way for a joint DND-CanmetMATERIALS patent application for this laser additive manufacturing technology.

The Potential

Dynamic robustness is desirable for most military platforms. The simplicity of the EB philosophy is expandable to other military platform applications (surface vessels, armoured vehicles, etc.) to ensure the best possible dynamic performance of these platforms.

Despite the simplicity of the EB evaluations, a great deal of metallurgical knowledge has been learned through the post-trial examination of the EB specimens. Fractography and microstructural analysis have provided significant insights into the behaviour of the materials under high-strain-rate dynamic explosive loading. Feedback on microstructures and weldment features that best resist dynamic tearing and fracture has helped, and will continue to help, improve weld procedure developments, resulting in better, more shock-resistant structures.

The behaviour of defect-containing structures subjected to explosive shock or other dynamic loading conditions remains an unpredictable challenge. This has very significant ramifications in distinguishing between damaged structures that require urgent repair versus damaged structures that can safely defer repair. Availability of platforms often depends upon the ability to know the difference. EB type testing and the lessons learned from these evaluations improve that essential capability.

The future of EB testing is potentially far-reaching. It may include evaluation of all critical materials used in land, sea and air platforms. Metallurgical insights gained through these evaluations will contribute to the development of better materials and joining procedures. EB testing provides data to enhance and validate numerical modelling tools for dynamic predictions. The behaviour of defects in critical structures can be experimentally explored, resulting in better fabrication, inspection, and maintenance standards.

Summary

From 1980 to the present, explosion bulge trials have accompanied the RCN's submarine capability sustainment program in various stages. The EB testing has served as an important control gate for the evaluation of submarine materials, and the qualification of conventional and advanced material joining technologies, to ensure that only the best-performing materials and joints are allowed on our submarine platforms. The scientific and technical authorities in the Canadian EB technical field have, through numerous trials (and the occasional tribulation), refined the EB capability as a key element for the submarine program support. The high level of enthusiasm in this field will sustain continued improvement in this capability, and its application for the RCN submarine program and potentially many other platforms.

Dr. James Huang leads the Naval Material & Petroleum Engineering subsection of the Directorate of Naval Platform Systems (2-4) in Ottawa.

John Porter retired in 2014 as a Defence Scientist after 34 years with Defence Research and Development Canada, working in naval materials science, primarily doing failure investigations and some research and development. In the second half of 2010, he was Science Advisor to General Vance and General Milner in Kandahar, Afghanistan. Since 2016, he very much enjoys being a part-time senior engineering consultant with NETE, working primarily on submarine materials challenges.

FEATURE ARTICLE

Canada's Naval Reserve Centennial: Part 1 – A Century of Service

By LCdr Paul Pendergast

For 100 years, the Naval Reserve has played a critical role in Canada's safety and security as a vital element of the Royal Canadian Navy (RCN) and Canadian Armed Forces (CAF).

Canada's 24 Naval Reserve Divisions, located in most major cities across Canada are holding their own commemorative events to mark the special occasion, with 12 Reserve divisions also celebrating their own centennials. Canadians across the country on September 23 will be able to watch some of the largest centennial events — Freedom of the City Parades, involving sailors in 24 cities across the nation.

Beginnings of a Naval Reserve force in Canada was due largely to the effort of one man, **RAdm Walter Hose**, a Royal Navy officer who transferred to the RCN. He had served with Royal Navy reservists from Newfoundland during the First World War and was so impressed with their seamanship skills that he wanted to establish a Naval Reserve force in Canada to augment the RCN, but met resistance at all levels.

On January 31, 1923, after years of lobbying by RAdm Hose, the Government of Canada authorized the organization of a force to be called the Royal Canadian Naval Volunteer Reserve (RCNVR).

The formation of a Reserve force was initially seen as a great way for the fledgling RCN to build support across the country. It envisioned the establishment of Naval Reserve Divisions in every major Canadian city, effectively bringing the Navy to Canadians living far from our coastlines.

The RCNVR became the backbone of the RCN, recruiting sailors from across the country. During the Second World War, the RCN needed to expand rapidly. From its modest beginnings of six ocean-going ships and a total of 3,500 sailors and officers at the outbreak of the war, it grew into a large and capable fighting force. By the end of the Second World War, Canada had the third largest navy in the world, with 95,000 men and women in uniform, and 434 commissioned vessels including cruisers, destroyers, frigates, corvettes and auxiliary vessels.

Approximately 77,000 of this serving force were members of the RCNVR, or the Women's Royal Canadian Naval Service (WRCNS). The WRCNS was established by the RCN to support women's recruiting for shore positions that would allow men to be freed for service at sea. (See MEJ 101; https://www.cntha.ca/static/documents/mej/mej-101.pdf)

Centennial planning has been under way for two years, with a project team directed by **Capt(N) Beth Vallis**, along with **LCdr David Arsenault** as project manager, and centennial project coordinator **CPO1 Patty Bouthat**.

"It has been an honour to work on this project to commemorate the contributions of our sailors to Canada over the last 100 years," said CPO1 Bouthat. "From helping to win the Battle of the Atlantic in the Second World War to coming to the aid of Canadians during natural disasters to deploying with the Royal Canadian Navy across the full spectrum of its operations, naval reservists continue to have a lasting impact on our nation."

In addition to commemorating the past 100 years, the centennial will also recognize the contributions of our current sailors, while looking towards the future.

Today, the Naval Reserve has a strength of 4,100 sailors across 24 divisions from Victoria, British Columbia to St. John's, Newfoundland and Labrador. Their mission is to generate trained sailors for CAF operations both domestically and abroad, while simultaneously supporting the Navy's efforts in connecting with Canadians through positive interactions in the community.

Naval reservists are members of the RCN who typically serve on a part-time basis. They are employees, co-workers and students from your community who embody the courage, loyalty and integrity to keep one foot firmly planted in a civilian career and the other training and preparing to protect Canadians at home and abroad.

Naval reservists have deployed on operations at sea and on land around the world, from counter-narcotics missions in the Caribbean and Pacific Oceans to sovereignty patrols in the Arctic. They have also responded when called upon to support provincial and local authorities in domestic operations including support to flooding in Manitoba, Alberta, Ontario and Quebec; forest fires in British Columbia; and hurricanes in Nova Scotia and Newfoundland; as well as helping to care for seniors in Ontario and Quebec during the early days of the Covid-19 pandemic.

Later this year, the Naval Reserve 50th Anniversary Monument in Ottawa will be restored and re-dedicated, and the annual Navy Bike Ride and Nova Scotia International Tattoo will both have a Naval Reserve Centennial theme. Ottawa's Canadian Tulip Festival also highlighted the sacrifice of naval reservists, known as citizen-sailors, from the RCNVR who served in the Second World War.

LCdr Paul Pendergast is the Atlantic Region Public Affairs Officer at Naval Reserve Headquarters.

Canada's Naval Reserve Centennial: Part 2 – The Naval Reserve Centennial Identifier

The Naval Reserve Centennial official graphic identifier was launched on January 31, 2022. After a design competition, a panel of all-ranks members selected the design by **Sailor 2nd Class (S2) Joseph Dimayuga** who joined the Naval Reserve in 2018, before transferring to the Regular Force in March 2021.

DND photo

S2 Joseph Dimayuga

S2 Dimayuga was born in the Philippines and immigrated to Canada with his family in 2003. With experience in advertising, and after 12 years working as a garment manufacturer and master tailor, S2 Dimayuga was confident he could submit a winning design.

"I wanted to incorporate historical images of past sailors while highlighting the modern Naval Reserve," he said. "My plan was to represent the 100-year time line through the silhouettes and headdresses of sailors from the past and today. I kept the ship's wheel similar to the one on the present Naval Reserve badge, and made the waves a bit more emphasized as a nod to the old 'Wavy Navy' term used to refer to Reservists."

(Courtesy LCdr Paul Pendergast, RCN Navy News)

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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 at MEJ.Submissions@gmail.com.

Canada's Naval Reserve Centennial: Part 3 – Engineer Walter McGiffen Love (Citizen Sailors Virtual Cenotaph)

https://untd.org/csvc-home/

Walter McGiffen Love was one of 128 men lost on His Majesty's Canadian Ship (HMCS) *Athabaskan* (G-07) during the Second World War. He was among the first of many volunteers to enroll in the Royal Canadian Naval Volunteer Reserve and swell the ranks of the Canadian Navy to near 100,000 strong by the end of the war. Volunteers like Walter Love were essential to the RCN's wartime service and we celebrate their contributions and legacy.

Love's naval story began at the age of 20, when on May 8, 1923 he was sworn into HMCS *Star*, one of the founding Naval Reserve Divisions located in Hamilton, Ont. Hamilton had been his home since the age of two, when his family moved there from the hamlet of Natural Dam in upstate New York.

Love was sent aboard HMCS *Patriot*, an older British World War One era destroyer that was used as a training ship for those initial ranks of the Reserve, where he received training as a motor mechanic and served as an ordinary seaman. While continuing his education at Hamilton's Technical School to become an engineer, Love was mobilized for active service and assigned to the eastern fleet in 1939 as the Second World War broke out. For the first two years of conflict, he served on an assortment of minesweeping vessels that searched shallow waters along the coast looking for mines left by German U-boats. During this period Love continued his training, and obtained an Engine Room Artificer Fourth Class (ERA 4) – a specialist in marine engineering, and a long held aspiration.

In early 1942 Love was selected to sail as an ERA 3 in the recently commissioned HMCS *Athabaskan*. He would spend the rest of his service in the Atlantic aboard this ill-fated Tribal-class destroyer. The first 18 months aboard the warship were spent laying mines off German waters, patrolling the English Channel, and escorting convoys. *Athabaskan* was almost sunk by a Henschel Hs 293 glider bomb during an anti-submarine chase in the summer of 1943. Several sailors were killed, but fortunately for the rest of the crew the bomb passed through *Athabaskan* before detonating outside of the ship's hull. However, *Athabaskan*'s luck wouldn't last forever.

Engine Room Artificer Third Class Walter Love.

On the morning of April 29, 1944, *Athabaskan* was patrolling with its fellow destroyer HMCS *Haida* (G-63). With orders to intercept German warships near the English Channel, the Canadian ships engaged a number of German torpedo boats, and *Haida* successfully drove off two of the attacking vessels. As *Haida* returned to *Athabaskan*'s last known location, it discovered the destroyer had been fatally struck with a torpedo and sunk. (See MEJ 57 and 60.)

After an extraordinary 966 cumulative days at sea, Walter Love, 40 years old, was lost to the ocean. He left behind his wife and three children, ages eight, five, and two. Of those who survived, 44 were rescued by *Haida*, and six by small boats. Eighty-three sailors were taken as prisoners of war by Germany.

For his service ERA 3rd Class Walter Love was awarded the 1939-45 Star, the Atlantic Star, the Canadian Volunteer Service medal and clasp, and the Defence medal. He is remembered on panel 12 of the Halifax Memorial located in Halifax, N.S.; the HMCS *Star* memorial, and the Second World Book of Remembrance, page 368, Centre Block at the Houses of Parliament, Ottawa, Ont.

RCN photo

FEATURE ARTICLE

A Proposal to Install an Ultraviolet Ballast Water Treatment System in *Halifax*-class Frigates*

By MS C.A McFadden
(Technical Advisor: PO2 Jamie Whittle)

[*Adapted from a July 2022 Naval Fleet School (Atlantic) Mar Tech RQ-PO2 course student Technical Service Paper.]

Ships making their way from port to port require proper ballasting control throughout the voyage to maintain the vessel's safe trim and stability. As the liquid load of fuel, bilge water, and black/grey/fresh water changes while at sea, the distribution of ballast must be adjusted to compensate.

While ballast water is clearly essential for safe and efficient modern shipping operations, the International Maritime Organization (IMO) warns that untreated ballast water taken on in one body of water, and discharged en route, or in another port, carries serious risks, as "…the multitude of marine species carried in it may pose serious ecological, economic and health problems. These include bacteria, microbes, small invertebrates, algae, eggs, cysts, and larvae of various species."

In areas of the world that are highly sensitive to environmental change, such as the Arctic Ocean, ballast water contamination can have severe repercussions. Since ballast water could cause environmental harm if left untreated and discharged into a different body of water, HMC ships are therefore restricted from evacuating their ballast tanks overboard indiscriminately.

The seawater ballast system on board the *Halifax*-class frigates consists of a series of four tanks located along the keel. Originally designed to take on and discharge untreated seawater, the ships currently employ an Engineering Change (EC) that uses *fresh potable water* produced by the new Mk 4 reverse osmosis desalination system (RODS) to fill the ballast tanks. Although no further treatment of the water is required, relying on the RODS to meet this demand may be asking too much of the system. In a perfect world where all of a ship's RODS units are in operation all the time, this goal might be realistic, but in my experience, this is not always the case.

The purpose of this technical service paper, then, is to propose the addition of an ultra-violet (UV) treatment system within the ballast water system of RCN frigates. Two possible solutions to sterilize the seawater ballast were investigated for course study purposes. The preferred option uses a multi-pass, closed-loop system with the incorporation of a UV-C light unit, while the other involves the installation of multiple UV-C lamps inside the ballast tanks.

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Photo: Cpl Stuart Evans, Borden Imaging Services

HMCS *Regina* at Brisbane Port, Australia in 2019.

Using UV light to sterilize ballast water

Ultraviolet systems radiate a wavelength of light that is not visible to the human eye, but which contains enough energy to damage the DNA of organic matter. The longer the exposure to the UV light, the more permanent the damage at the cellular level. The effectiveness of the UV-C light is dictated by the power/intensity of the lamp, the length of time the organic matter is exposed to the light and its distance from the lamp.

For this study, the following criteria were imposed:

a. ballast water must be sterilized before being discharged;
b. the discharge must meet or exceed appropriate environmental standards for marine vessels;
c. the UV treatment system must fit into the ship's current configuration, and be able to use existing shipboard power; and
d. the engineering change must be cost-effective.

As noted, **two options** were considered:

Option A investigated installing a multi-pass, closed loop system that incorporates an in-line ultra-violet lamp unit (Figure 1). A suction pipe installed at the bottom of the ballast tank feeds a positive displacement pump that moves the ballast water through the unit at 25 gallons per minute (g.p.m.), where it becomes sterilized as it moves past a UV-C (200-280 nm) quartz bulb before returning to the tank.

To ensure that all water and contaminants are completely sanitized, it is recommended that the entire contents of the tank make a minimum of two passes through the UV-C unit. A 25-g.p.m. unit can effectively sanitize 0.09 m^3/min of water, meaning that a 60m^3-tank would take nearly 24-hours of sanitization before it can be dumped back into the sea. Installing two UV-C units in series, with bypass lines for each, would allow one unit to be cleaned without having to shut the system down (Figure 2). The quartz glass that surrounds the lamp will become dirty over time, and need to be cleaned to ensure the UV-C light effectively reaches all the water that passes through the unit.

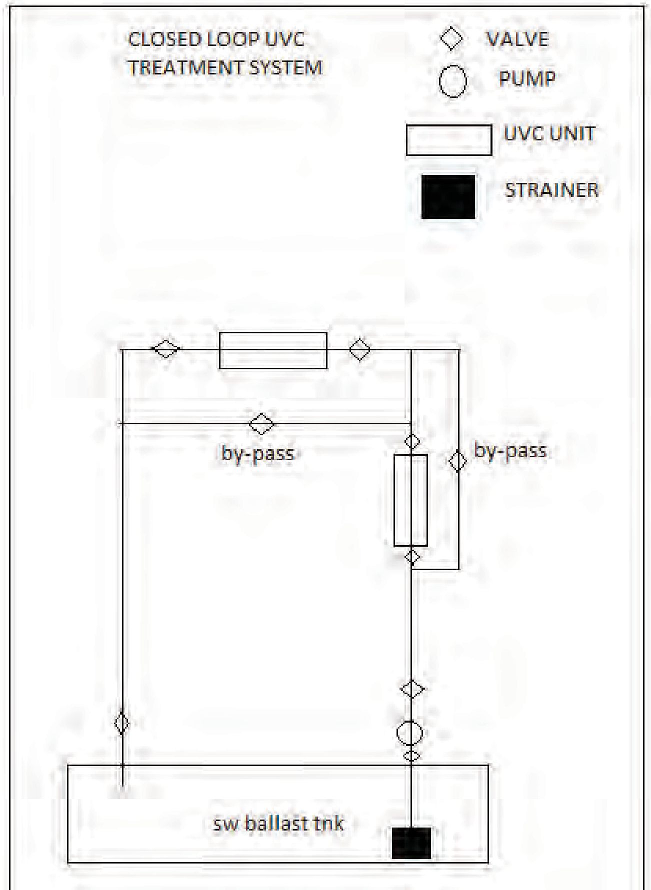
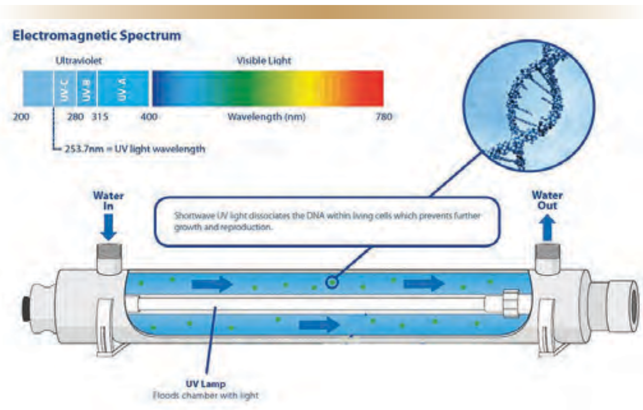


Figure 2. Basic schematic for a closed-loop seawater ballast UV-C treatment system, featuring two in-line UV-C units with fitted by-pass valves to allow for maintenance to be completed by ship's staff.

Option B investigated installing multiple UV-C lamps inside the ballast tanks to create an uninterrupted flow of UV-C radiation. Since UV light only works on direct line of sight, lamp placement and power output are important for proper sanitization, and any blind spots could present a problem. The movement of water inside the tank due to the motion of the ship, and the shape of the tank itself, could



Source: www.alfaauv.com

Figure 1. UV-C Unit

result in a varying level of sanitization. One advantage of this setup is that, apart from the control unit, there is no requirement for any significant additional equipment footprint outside the tank.

While both options meet the overall criteria identified in this paper, the multi-pass closed loop system (Option A) offers the best results for more thorough sanitization of ballast water. It provides a constant flow of water through the UV-C light area, and the proximity of the contaminated water to the UV lamp increases the effectiveness of the process. This option also allows for the ability to shut down a unit to conduct inspections and maintenance, while allowing the system to continue to operate.

Conclusion

It is recommended that an Unsatisfactory Condition Report (UCR) be raised, and that a trial be conducted on one ballast tank aboard a frigate to confirm the effectiveness of the proposed inline UV-C arrangement. Following a successful completion of the trial, an engineering change (EC) could be developed to install this ballast-water treatment system in all *Halifax*-class platforms.

This would ensure that the RCN's major surface fleet could meet important environmental and operational goals by ensuring any ballast water returned to the sea has been effectively sanitized.

Master Sailor Alex McFadden is the Marine Technician Mechanical Supervisor/Auxiliary Section 2IC aboard HMCS Montréal (FFH-336).

NEWS BRIEFS

FMF Cape Scott — Additive Manufacturing Update

By Lt(N) Jonathan Baldwin and Lt(N) Oleg Lyubenko

Since 2014, Fleet Maintenance Facility Cape Scott's Additive Manufacturing (FMFCS AM) section has been utilizing 3D printing technology to support the Royal Canadian Navy (RCN). This includes designing and fabricating unique, obsolete, or costly parts and specialized tools, improving part design for use within the Canadian Armed Forces, creating 3D models to improve training experiences, and, upon request, fabricating other specialty products.

Through the use of various computer-aided design (CAD) software packages, FMFCS AM can design and print specialty products in plastic (Figure 1) or metal (Figures 2 and 3) materials consisting of: **Plastics** – Acrylonitrile butadiene styrene (ABS), polylactic acid (PLA), polycarbonate (PC), and thermoplastic polyurethane (TPU); and **Metals** – stainless steel (grades 316L and 17-4), steel alloy (1440), tool steel (H13), and copper.

Currently, significant effort is focused designing, modeling and printing parts that are either unavailable, too costly to replace, or poorly designed. Common candidates for these jobs are parts that often break or get misplaced

Photos by Lt(N) Oleg Lyubenko

Figure 1. ABS plastic AM is useful for easily broken or lost parts such as fan covers, and smoke marker arming tools.

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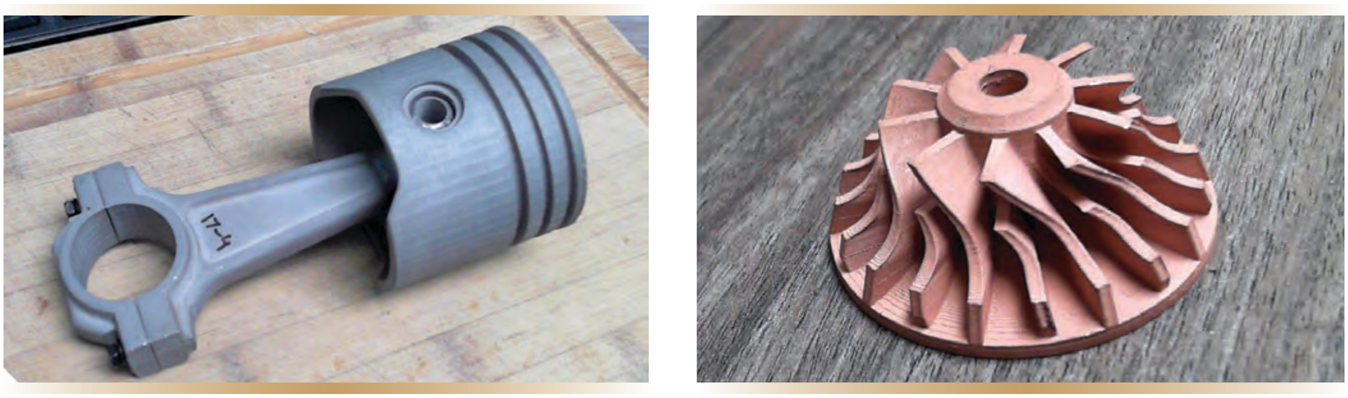


Photos by Lt(N) Oleg Lyubenko

Figure 2. Metal AM proof-of-concept items include this 17-4 stainless steel piston (left), and a compound impeller manufactured in copper.

Figure 3. Metal – 316L stainless steel worm gear.

(e.g., plastic deck penetration covers, smoke marker arming tools, and fan cover plates), making readily available, inexpensive replacements very desirable. In the realm of metal material printing, the focus has been around the development of test and certification processes to ensure material properties are acceptable for use in any intended application. As such, most metallic parts being printed are for testing and proof of concept.

The challenge with using 3D printed metal parts in the fleet is that parts intended for use in OEM supported equipment will often require material certification. Due to the sensitivity and variability in 3D printing, many of the metallic materials cannot guarantee the exact same material properties each time they are used. One possible solution is to print a standard specimen piece while printing the desired part, and then use the specimen to ensure it meets the required specifications. At present, testing has been completed for the stainless steel (17-4), with other materials ongoing.

To meet increasing demands and expand the capabilities of AM, the section hopes to acquire the equipment and training necessary for advanced 3D scanning. The AM section has been investigating the solution of a multi-functional, high-precision handheld 3D scanner that does not use a laser, thus making it completely safe in nearly any environment. This capability will significantly reduce the time required to model projects, enable portable scanning, and produce more accurate models.

Furthermore, AM is looking to acquire a resin polymer printer to address the restrictions around plastic part precision. Additional advantages of resin polymer printing are a larger material range, full colour, or even clear high-quality finishes, flexible materials, and textured surfaces to reproduce the feel of natural materials. These benefits virtually eliminate post-processing requirements such as surface finishing and painting.

The AM section provides additional support to HMC ships by loaning out 3D printers, providing instruction on their operation and uses, and providing design and modelling services. To enquire about any of our services, or to provide feedback on how to improve service delivery, please contact Lt(N) Oleg Lyubenko at oleg.lyubenko2@forces.gc.ca

Lt(N) Jonathan Baldwin is the Deputy Naval Architecture Officer at FMFCS in Halifax, NS.

Lt(N) Oleg Lyubenko is an Additive Manufacturing Engineer at FMF Cape Scott.

NEWS BRIEFS

HMCS *Vancouver* supports TAPA during RIMPAC 2022

Story and photos by Lt(N) Michelle Scott

The modern battlespace is evolving rapidly and the Royal Canadian Navy (RCN) is adapting to keep pace. As part of their participation in Rim of the Pacific (RIMPAC) 2022, His Majesty's Canadian Ship *Vancouver* spent over a week trialing various electronic warfare (EW) tactics that culminated in the ship being the first RCN vessel to tactically launch a surface off-board passive decoy (SOPD).

The SOPD is one component of the *Halifax*-class anti-ship missile (ASM) defence suite. A spherical inflatable decoy launched from the ship, it attracts radio frequency missiles toward it, and away from the ship.

Over the course of eight days, *Vancouver* was home to a number of subject-matter experts from the Canadian Forces Maritime Warfare Centre who led the team through various tactics trials as part of the Technical Cooperation Program Anti-Ship Threat Project Arrangement (TAPA). TAPA is a Five Eyes cooperative series of EW exercises to test current and future non-kinetic defensive tactics and procedures. RCN ships take theoretical tactics and test them in real time using real missiles and ammunition to prove their viability — and there's no better place to test these tactics than during RIMPAC, where TAPA trials have been a regular component since 2006.

"TAPA22 with HMCS *Vancouver* was extremely successful and a huge step forward for RCN electronic warfare tactics and procedures," said trial staff member Lt(N) Adelaide Hawco. "There were some significant milestones and successes that were achieved during the week: an effective hard-kill/soft-kill combination solution was identified and confirmed for specific current threat anti-ship missiles; and sophisticated jamming techniques were refined."

EW is different from traditional kinetic warfare and hard-kill tactics — it doesn't involve the use of munitions to destroy a target. Soft-kill tactics are used to disable an enemy without destructive force, using distraction and seduction to divert an attack.

The launching of the SOPD was just one of the many sophisticated EW tactics trialed while *Vancouver* supported TAPA22. Over the week, the ship also tested and fine-tuned its multi-ammunition soft-kill system (MASS)

The MASS launcher being loaded with SOPD passive RF decoys... and firing.

capabilities. MASS is an automated decoy system that fires a wall of chaff to confuse sensor-guided missiles and disguise a vessel. *Vancouver* was also able to fire its Dueras rocket system, which is built onto the ship's MASS launcher. The rockets fire a decoy rocket with the aim of protecting the ship from anti-ship missiles and infrared threats in an asymmetrical threat environment.

"EW is by far the most effective defensive method against anti-ship missiles," added Lt(N) Hawco.

For MS Matthew Cormier, fire-control supervisor in HMCS *Vancouver*, TAPA22 was a chance for him to see the growth of his team's skills in the EW environment.

"TAPA was extremely busy but very rewarding," he said. "It not only honed our skills as a team, but provided an excellent opportunity to contribute critical data to the teams ashore working to develop new and innovative tactics for us to employ in the future."

NEWS BRIEFS

MSC's *Halifax*-class Performance Measurement Dashboard

By Andrew Braden and Francois Costisella

The *Halifax*-class frigates are currently scheduled to remain operational well beyond their originally planned lifespan. To ensure that the fleet can continue to achieve RCN operational requirements effectively, safely and in an environmentally conscious manner, stakeholders will require reliable, near-real-time information on the materiel fitness of these ships. Particularly as the fleet transitions from mid-life to end-of-life, good quality data and associated reports will become increasingly valuable.

The Major Surface Combatant (MSC) *Halifax*-class performance measurement (PfM) dashboard (Figure 1) was designed to provide quality decision-support data to all levels of the MSC organization. It resides within the internal SharePoint environment of the Department of National Defence (DND), and is available to all network users wanting to find quick-reference information regarding the materiel condition of the *Halifax*-class ships.

The MSC directorate is responsible for maintaining the data aggregations for: equipment obsolescence; corrective and preventive maintenance; Engineering Change projects; defects, deviations and waivers; tiered readiness trials; transfer requirements (TRANREQs); high-priority requests; Unsatisfactory Condition Reports (UCRs); and all outstanding hours of second-line support.

Using the Defence Resource Management Information System (DRMIS), MSC brings together system-of-record data with other sources of offline information such as UCRs, equipment manager insights, and regularly updated foundational data (e.g. the design agent's equipment family tree), to provide accurate assessments of the systems and underlying equipment that support the float, move and fight capabilities of the *Halifax*-class fleet. This is accessible through the PfM dashboard, which also hosts the information resources for the MSC *Halifax*-class Obsolescence Management (OM) program (Figure 2). The OM program is the outcome of a collaboration between the *Halifax*-class design agent and MEPM system authorities, managed by the MSC capability management team, and is a key component of the MSC strategy to support the *Halifax*-class through to divestment.

When the Strong, Secure and Engaged strategic posture was adopted by DND, MSC moved to build and sustain an internal capability to provide decision support data on the state of the *Halifax*-class, free from any constraints that may have existed in an in-service-support contract arrangement with one of our maritime partners. This independence has

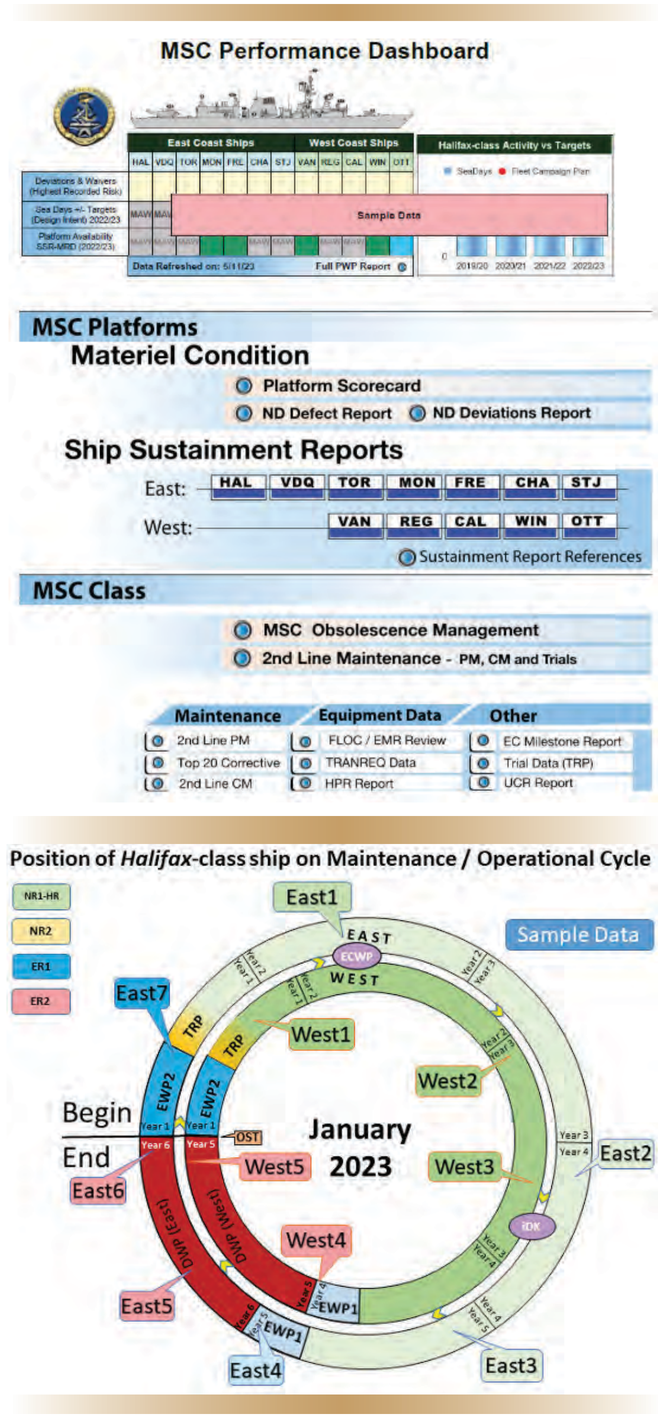


Figure 1. The MSC performance measurement (PfM) dashboard offers an easy-to-read, up-to-date assessment of the evolving materiel fitness of the *Halifax*-class frigates.

allowed the dashboard to remain flexible, and to respond quickly to the changing needs of the organization. Through the dashboard, MSC is supporting (a) engineers working with in-class materiel management and acquisition, (b) project and program managers building work schedules, and (c) support leadership at all levels who need to review consistent data points to build briefs and solutions.

MSC has worked closely with our coastal partners in Fleet Maintenance, and Fleet Technical Authorities to ensure our organizations are collecting data following consistent protocols, which in turn ensures leaders are provided with consistent data and data aggregations. The MSC performance measurement dashboard supports the MSC capability management team's work with our Maritime Equipment Program Management (MEPM) partners to help clean problematic data in the system-of-record, and improve data recording protocols. This work ensures that, as we mature our reporting processes, we are also gathering increasingly accurate data.

Every selection from the dashboard data menu quickly loads either a single page aggregation, or a launch page with a selection of aligned reports. In turn, each report links to a managed spreadsheet that presents all data points used in that aggregation, and is in a form well suited to further research.

With a "single click," the Naval Defect report, for example, comprehensively aggregates defect data from ships, systems, and system authorities, allowing users to review five years of aligned data. Equipment managers, docking work period planners, and ship project managers can request customized versions of the report, aligning data to support a specific project, system, ship, or group. Embedded links in the various materiel condition reports offer higher-level views of the *Halifax*-class support activities that correspond to the most recent operational/maintenance cycles, and the upcoming two-year forecast of materiel readiness targets.

MSC continues to build relationships with our data partners in Maritime Information Systems, MEPM, and the RCN to ensure we are well positioned to respond to the ever-increasing need for comprehensive, up-to-date information and information resources to support the fleet. The MSC Halifax-class performance measurement dashboard is an important tool that stakeholders will find increasingly useful in managing the materiel condition of the frigates through to their required end of service.

For readers with access to the Defence Wide Area Network (DWAN), more information can be found at: https://collaboration-materiel.forces.mil.ca/sites/MEPM/MSC/PMS/default.aspx

Andrew Braden is a Performance Measurement Analyst (Contractor) with the MEPM Major Surface Combatant Supportability section in Ottawa.

Francois Costisella is the MSC 9-2 Subsection Head for Supportability.

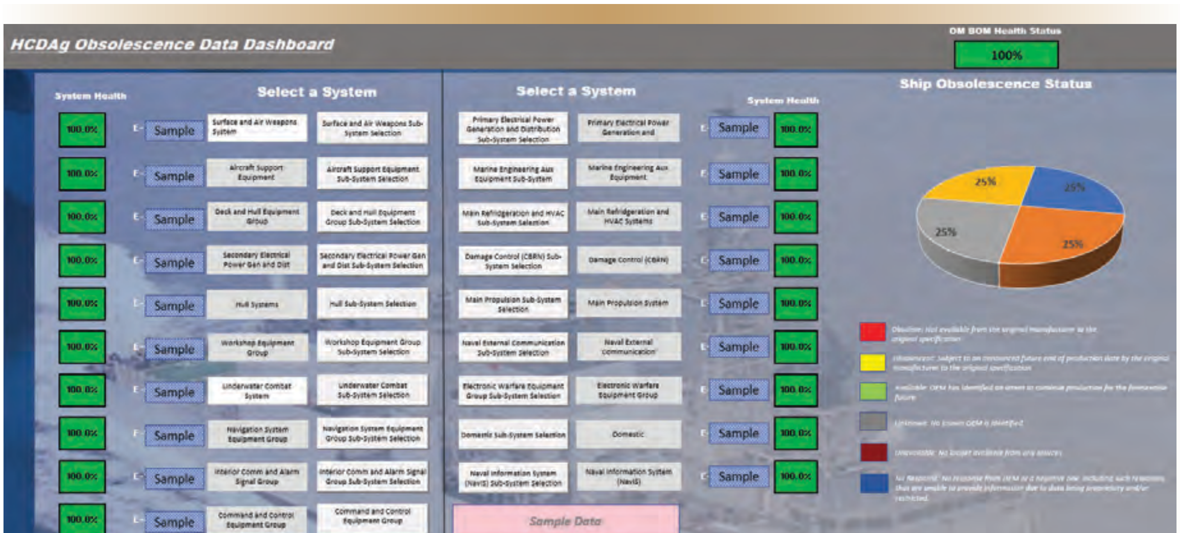
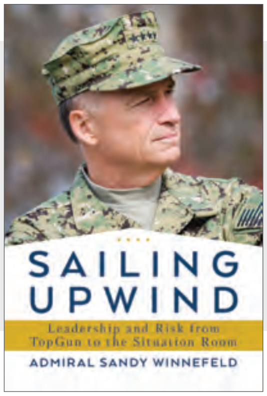


Figure 2. Information resources for the *Halifax*-class Obsolescence Management (OM) program information are accessible through the PfM dashboard. The OM program is a key component of the Navy's strategy to support the class as it transitions from mid-life to end-of-service.

Title of Interest



Sailing Upwind: Leadership and Risk from TopGun to the Situation Room

By Admiral Sandy Winnefeld, USN

Naval Institute Press, 2023

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ISBN 10: 1682478742

320 pages, 46 b/w photos; 4 figures

Hardcover

Admiral Sandy Winnefeld graduated from the Georgia Institute of Technology with a degree in aerospace engineering, and served 37 years in the U.S. Navy before retiring in 2015 as the ninth Vice Chairman of the Joint Chiefs of Staff.

In "Sailing Upwind," the former F-14 fighter pilot and TopGun instructor recounts how he challenged the military processes and bureaucratic systems he encountered as he progressed through his career. But rather than being just a memoir of a distinguished former naval officer's highly diverse career, this book by Adm James Alexander "Sandy" Winnefeld Jr., USN, is also intended to offer useful reflections regarding how the author accepted and managed risk along the way, as well as a concise description of the qualities one must develop to become a successful leader.

Winnefeld would go on to command an aircraft carrier, and served in a variety of flag officer billets on his way to becoming the Vice Chairman of the Joint Chiefs of Staff. This book describes in an entertaining and humble manner how that journey unfolded, and the lessons he attaches to it.

The reader learns what it is like to become a U.S. Navy fighter pilot, and to fly and fight from an aircraft carrier — including a harrowing description of ejecting from an F-14 Tomcat at night far from land. Winnefeld describes the culture of excellence at the real TopGun school and within the USN's nuclear propulsion program, and recounts how he learned to lead the men and women who operate at every level of Navy operational command, from squadron to ship to fleet. Finally, the author presents a behind-the-scenes look at how decisions are made at the highest levels of government regarding whether and how those forces will be used, and how they are acquired.

In the process, Winnefeld provides descriptions of how, by challenging existing assumptions and processes and through relentless creativity, he was able to lead change. He reflects on how the risk associated with such changes should be accepted and managed.

Sandy Winnefeld was born and raised in a naval family and, like all military families, experienced many moves. He was often the new kid in school, and it was this experience, he says, that greatly influenced and shaped his willingness to be creative, and to learn how to think for himself.

"I believe that the character trait of challenging assumptions is not something that comes naturally; rather, it has to be learned," he writes.

Adm Winnefeld emphasizes the importance of leadership as a lifelong journey, and stresses that it demands constant effort. The book focuses on five leadership "anchors," supported by quotes from well-known or influential people that illustrate his assertions:

Anchor 1: Lead Yourself

Anchor 2: Lead People

Anchor 3: Lead Organizations

Anchor 4: Lead Execution

Anchor 5: Lead Change

In addition to leadership, Adm Sandy Winnefeld highlights the importance of critical thinking, problem-solving, innovation, risk management, and making changes in an organization that is slow to accept change, or to innovate.

In the end, "Sailing Upwind" is an inspirational text that offers hard-won insight on the value of critical thinking and creative leadership in the face of risk and institutional inertia — expertise that readers from all walks of life might find beneficial in their lives and careers.

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FHE-400 Hydrofoil Combat Systems Equipment — More to the story!

By Cdr Pat Barnhouse, RCN (Ret'd)

Energy Storage

One of the more interesting pieces of kit supplied for the FHE-400 hydrofoil fighting equipment (FE) was the energy storage system for the AN/SQS-507 sonar. As I recall, there was considerable discussion over how to provide enough oomph (non-metric term for power!) to generate the required output power for the transmitted sonar pulse. The discussion drifted from flywheels to large capacitors. In the end, Westinghouse (the combat systems contractor) did settle on a form of capacitor, going for a nickel-cadmium (NiCad) based "coulometer." If memory serves, the NiCad batteries used in this device were of the vented type that would suffer from thermal runaway if not properly controlled. The whole contraption was fitted out in a coffin about 4' by 2' by 1'.

The subcontract for the energy storage system was let to Gulton, Inc., a NiCad battery manufacturer in Metuchen, NJ (USA). I really didn't know much about NiCads, except that the Royal Canadian Air Force recommended separating NiCad battery shops from lead-acid battery shops by the full width of a runway to prevent a hygrometer used on the one type from being used on, and contaminating, the other.

During our visit to Gulton, we were treated to a practical demonstration of the NiCad's power-to-size ratio, vis-a-vis that of a lead-acid battery. At the end of our meeting, the project engineer took us out to the parking lot, and lifted the hood of his great "boat" of a 1960s station wagon to show us the NiCad battery he had installed in place of the original lead-acid unit. I expected to see something of comparable size, but what was there was a tiny battery, about 3" x 6" x 1"! It was January, and the temperature was well below freezing, but this little battery provided more than enough power to crank and instantly start the big V8 engine. I was later to learn that NiCads were often used in big semi truck trailers, and that what prevented their more general use in the automobile business was cost.

Photo from 2012 by Brian McCullough

HMCS *Bras d'Or* (FHE-400) on display at the Maritime Museum of Québec, at L'Islet-sur-Mer. This wonderful museum on the south shore of the St. Lawrence River 75 km east of Québec City is well worth a visit.

Mk 32 Torpedo Bore Gauge

The Mk 32 torpedo tubes specified for the hydrofoil needed certain functions that increased the size of the on-mount control boxes, to the extent that the torpedo tubes could not be mounted in the same tri-tube configuration as was being procured for our surface ships. I believe it had something to do with air mode launch, and the functions that had to be remoted to suit hydrofoil operation.

(Continues next page...)

In any event, discussions at Naval Ordnance Station Louisville, KY (USA) led us to purchase individual tubes with the intention of designing our own tri-tube mounting arrangement. While at Louisville we were advised that, since we were buying and mounting individual tubes, it would be prudent to acquire a bore gauge to verify that the tubes had remained true after handling and mounting. We bought the gauge.

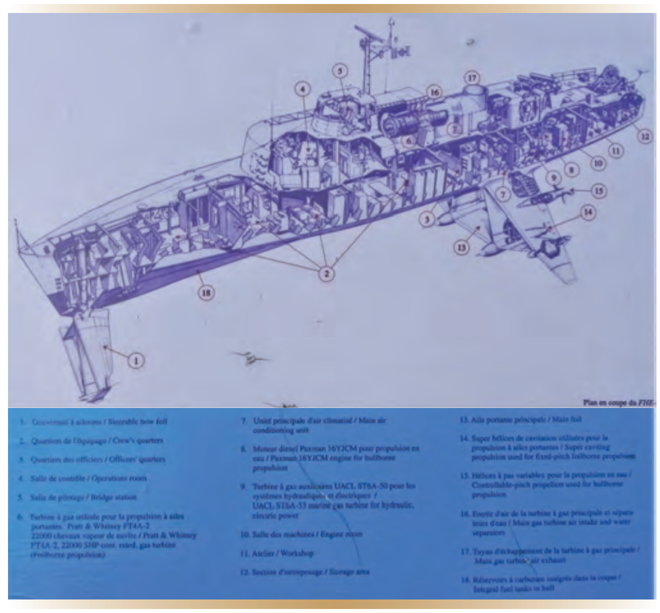
All fighting equipment items bought for the hydrofoil and not intended for first fit (i.e., not essential for going to sea) were sent to the Gladstone Stores in Halifax marked, "For FHE-400 hydrofoil." Consequently, the torpedo tubes and bore gauge ended up there, but were never fitted due to the cancellation of the FHE-400 program.

Some years later, while serving in Halifax, I received a call from George Bishop at National Defence Headquarters in Ottawa. George was an underwater weapons technician in the Combat Systems directorate, and wanted to know if, perchance, I had purchased a bore gauge for the hydrofoil, as the Navy had not seen fit to do so when buying all the Mk 32 Mod 5 triple torpedo tubes for the fleet. A problem had arisen that required checking the tubes, and they had no money to buy the requisite gauge. I was able to tell him where to find one, along with six Mk 32 tubes of somewhat different pattern to those in general use, and believe it or not the gauge was still right there in Gladstone Stores.

The Case of the Imploded Transducer

The specifications for the hydrofoil's AN/SQS 507 variable-depth sonar (VDS) transducer required it to be capable of surviving immersion to a depth of approximately 900 feet without physical damage, and without impairing its operating ability. Since there were no facilities in Canada for conducting a test to demonstrate this capability, arrangements were made to have the transducer tested at the US Navy's Underwater Sound Reference Laboratory in (pre-Disney World) Orlando, Florida.

The transducer itself, unlike the AN/SQS 505 transducer that was made up of elements with each radiating face covered by its own "rubber" boot (Rho-C rubber, I presume), was designed with one boot to fit over the whole cylindrical radiating face. Somewhere in the setting-up of the depth test in the laboratory's pressure tank, the 900-foot depth specification was misunderstood as 900 psi. Since every 30 feet of depth in water equates to a pressure of one atmosphere (approximately 15 psi), then 900-psi pressure represents a depth of 1,800 feet, twice that specified for the transducer. The transducer was duly tested with the 900-psi specification in place, and while the mistake may have been discovered before reaching the full value, the transducer was subjected to considerably more pressure than intended by us. When it was removed from the test tank, the rubber boot had clearly imploded into the spaces between the transducer elements.



The triple-banked torpedo tubes and variable depth sonar equipment are visible on the after part of this ship, once billed as the fastest warship in the world.

The transducer was duly shipped back to EDO (Canada) Ltd. in Cornwall, ON (the subcontractor for the transducer and, incidentally, the builder of the AN/SQS 505 sonar transducer) for damage assessment. Luckily, because the SQS 507 was a VDS set, Westinghouse and yours truly had decided to procure two of everything that hung in the water, so there was another transducer on the assembly line that became available about two weeks later for a repeat of the test. I am happy to report that this latter test went off with no hitches, and that the transducer passed (survived?) the test. The original transducer was not badly damaged, apart from the boot, and was subsequently repaired.

Cdr Pat Barnhouse, RCN (Ret'd), was a Combat Systems Engineer, and former Assistant Project Officer and later Project Officer (Fighting Equipment) for the FHE-400 Hydrofoil, and is currently Chairman of the CNTHA.