National Defence / Défense nationale

Maritime Engineering Journal

October 1995

Installing the TRUMP Vertical Launch System

Also:

- *More "Alternative" Posting Opportunities for MAREs*
- Protecteur's *1992 Hurricane Relief Ops*

Canada

Hurricane Andrew Disaster Relief

Looking back at HMCS *Protecteur*'s 1992 relief operations in Florida and the Bahamas

...see page 19

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OUR COVER
A foc'sl view of the TRUMP vertical launching system, looking forward to the breakwater. (*Photo courtesy of PMO TRUMP*)

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Guest Editorial

Training: Our ace in the hole, or a "black hole?"

By Captain(N) I.D. Mack
MARCOMHQ Deputy Chief of Staff Training

Providing training to the officer and NCM technical personnel in the Canadian naval community is an extremely expensive element of our training infrastructure. It is also a founding element of our professionalism, and as such one which deserves attention in the *Maritime Engineering Journal*. Since it has been addressed only rarely in this publication, I have chosen to use this opportunity of writing an editorial for the *Journal* to touch on the "potpourri" of challenges we face as a community in the *Defence 2000* environment.

Two of the timeless training "commandments" dictate that training should be both "just in time" and "just enough." Yet, MARE officer training is still almost entirely "front-end loaded," and we still hear newly qualified members of the MARE occupational group questioning the validity of their training, both with regard to timing and to the level of detail. As well, a cursory review of a selection of NCM career training plans indicates that we are spending far too much time teaching material that is unlikely to be used immediately after coursing. How much is retained until needed? Note also that, regardless of how much officers and technicians know when joining a course, all have to go through the entire program -- the "sausage mill" approach. Apart from being wasteful, it is a disincentive. As for the requirement for instruction in academics and theory (or should I say "education?"), it remains a controversial area. Doubtless we have some work to do before we can satisfy ourselves that such training is essential.

Once we have tackled the content and timing of training, and learned to tailor it to individual candidates' requirements, we must face the question of delivery. In its simplest form, training attempts to impart knowledge and then develop the skills to apply it. Today, much of the required knowledge and skill is learned in the traditional classroom setting, although we are starting to employ simulators to a greater extent. But why use expensive classrooms for small class sizes when we could be using significantly more effective computer-based media to satisfy this requirement? When employed in a distributed manner that allows candidates to learn in their own workspaces, at their own convenience and pace, computer-based learning can achieve benefits heretofore unheard of in terms of maintaining common standards and achieving high retention rates.

"Why use expensive classrooms for small class sizes when we could be using significantly more effective computer-based media?"

With respect to skills development, why are we focusing so much effort on shore-based simulators in our own schools? Why not put more of our skills training on board ship, as is being done with the Tribal-class onboard IMCS trainer? Onboard embedded trainers are fine for operator training for the MAR ENG MOCs, but maintenance training is not well suited to the operational shipboard environment. Here, too, there are questions. Why should we continue to provide maintenance skills training for marine systems officers and technicians in our own schools when a goodly portion of the kit and skills are common to the non-naval community? Clearly, we require an in-depth analysis of the potential benefits of alternative service delivery in this area.

Beyond the MOC-specific training, there has been an explosion in general-purpose training requirements. Environmental protection, harassment, management, ethics awareness, mentoring and coaching training — all of these demand a cost-effective and comprehensive delivery system. Looking at our own recent occupational analyses, we see a demand for more short coursing for officers and chief petty officers. The requirement for continuous learning is upon us, but we shall never cope without a network of learning centres across the CF.

On top of all this, we need responsiveness from our trainers and schools ashore -- two years from training requirement definition to delivery just isn't acceptable. Delivered training must be both current and high quality, the latter suggesting that the training system must adopt an ISO 9000 approach to the greatest practicable extent. As well, the use of modern technology will demand that we integrate more of our technically skilled personnel (e.g. engineers and technicians) into all of the training establishments ashore, and that we dedicate more of our scarce LCMM PYs toward the support of training technology.

A tall order? Indeed. But that is the task at hand for the coming years. As with the other aspects of our naval support job, training will demand its share of resources, including a tremendous amount of "smart-think." Unlike traditional engineering and maintenance disciplines, there is no formula to invoke the "right" training solution. Hence, open-mindedness will be required from all of us, for *everyone* has inherent responsibility for training and learning.

Instead of leaving everything to the trainers, we must shift our focus toward ensuring continuous learning in every workplace. Those in the training establishments must provide timely and adequate learning opportunities in a distributed manner to all who need it. Implemented properly, distributed and continuous learning could become the strong force multiplier we need to face the challenge of continuous change in the years ahead.

From my vantage point as the senior trainer in the navy, all of the technology and many of the resources are there for the taking. In some sectors we have already started the journey of change. Finishing it is only a question of focus, priority and willpower.

Maritime Engineering Journal Objectives

- To promote professionalism among maritime engineers and technicians.
- To provide an open forum where topics of interest to the maritime engineering community can be presented and discussed, even if they might be controversial.
- To present practical maritime engineering articles.
- To present historical perspectives on current programs, situations and events.
- To provide announcements of programs concerning maritime engineering personnel.
- To provide personnel news not covered by official publications.

Writer's Guide

The *Journal* welcomes **unclassified** submissions, in English or French, on subjects that meet any of the stated objectives. To avoid duplication of effort and to ensure suitability of subject matter, prospective contributors are strongly advised to contact **the Editor, Maritime Engineering Journal, DMEE, National Defence Headquarters, Ottawa, Ontario, K1A 0K2, Tel.(819) 997-9355**, before submitting material. Final selection of articles for publication is made by the *Journal*'s editorial committee.

As a general rule, article submissions should not exceed 12 double-spaced pages of text. The preferred format is WordPerfect on 3.5" diskette, accompanied by one copy of the typescript. The author's name, title, address and telephone number should appear on the first page. The last page should contain complete figure captions for all photographs and illustrations accompanying the article. Photos and other artwork should not be incorporated with the typescript, but should be protected and inserted loose in the mailing envelope. A photograph of the author would be appreciated.

Letters of any length are always welcome, but only signed correspondence will be considered for publication.

Editorial Note

As we promised you in the June issue, we have responded to the readership survey by making major changes to the way we distribute the *Maritime Engineering Journal*. Starting with this issue we are shipping all copies directly from DGMEPM to, in most cases, a designated contact in your unit who will take care of local distribution. In effect, we have stopped distributing the *Journal* as a publication supply item.

We are also making a concerted effort to reach all 4,245 officers and NCMs of the navy's engineering branch, and all DND civilians involved with the naval engineering and maintenance effort. This is four times the size of our previous distribution. Unfortunately, fiscal restraints keep us from quadrupling the press run, so we are asking you to accept (without too much grumbling) the idea of shared copies. The success of this new distribution initiative is going to depend as much on the integrity of your unit's internal distribution system as on the effort you make to "share the wealth."

Something we hope you *won't* notice is that we have begun doing most of the desktop publishing ourselves. This cost-saving initiative has been in the works for several years and we are pleased now to be bringing you more of a "home-grown" product.

Our aim (as ever) is to produce an informative, attractive branch publication, and to put it in your hands as soon as possible after printing. If you have any cost-effective or labour-saving ideas for improving the service, please pass them along to us. In the meanwhile, if you can see your way clear to cutting us a bit of slack as we fine-tune the system over the next couple of issues, we would be grateful.

Capt(N) Sherm Embree

Commodore's Corner

A Retrospective on 35 Years

When Rear-Admiral Saker retired as the ADM for Engineering and Maintenance in June, he was at the pinnacle of an engineering career that spanned 35 years. Well educated in the arts of marine engineering and Canadian Forces staff work, he was instrumental in rebuilding the navy as we see it today. Before his appointment as the senior Forces engineer in the last three years of his career, RAdm Saker served two years as DGMEM — the navy's senior engineer, and seven years on the CPF Project (the last three as project manager). In earlier years he had served as the EO of HMCS *Algonquin* (DDH-283) and the hydrofoil HMCS *Bras d'Or*. RAdm Saker leaves us with this final thought based on his unique career experience.

By Rear-Admiral Mike Saker (ret.)

Shortly before taking retirement leave from the Canadian Forces, I was fortunate to visit both the East and West Coasts, and to see for one last time the progress that has been made over my 35 years of service. As you wrestle with the competing pressures of heavy operations and defence reductions, I thought it might be constructive and perhaps even comforting to give you a retrospective from my particular vantage point.

When I joined the service in 1960, the Royal Canadian Navy was undergoing reductions. While the fleet was being renewed with the new Canadian-designed "Cadillacs," the overall number of ships was being reduced — virtually cut in half. (Sound familiar?) The capabilities of the new ships generally outstripped those of the old, although the navy was dealt a significant blow with the demise of the aircraft carrier *Bonaventure* in the late sixties.

Perhaps even more significant was that the navy, because of its reduced size, was now forced to specialize and focus its efforts on what it knew best — ASW. That we had lost our general-purpose nature was brought home to me vividly. I was serving as a junior officer on board one of our newest ships, HMCS *Mackenzie*, when I visited the new USN cruiser USS *Chicago* and witnessed a $1.2 million (US) ten-missile shoot. The Canadian navy didn't even have any missiles at the time, although we were in the process of addressing the situation with the design of our new DDH-280 tribal-class destroyers. Nevertheless, it was quite clear to me at the time that our newest warships were incapable of surviving on their own in anything but an ASW environment.

The 280s were our first attempt to "change gears" and produce a more general-purpose warship. While, in my view, they were only moderately successful as a total fighting platform, they kept our design capability alive and provided the vision and incentive to reach for higher plateaus in our development of the next ship design.

"Most of our allies politely chided us for trying to push the boundaries [of technology] too far."

The 1970s saw the evolution of a number of significant Canadian developments, most notably the SHINPADS, SHINMACS and SHINCOM digitally integrated systems for processing and display, machinery control and communications. With these we strove to adapt futuristic data transfer technologies and automation to the modern naval environment. For those of us who lived through this period, it was both exciting and intimidating. As Canada espoused these new concepts, most of our allies politely chided us for trying to push the boundaries too far. One step at a time (one risk at a time) seemed to be the accepted practice. Indeed, for some of us who reflected on the mixed success of the DDH-280s, these cautions carried some credence. Unperturbed, our naval visionaries pressed on and the requirement for the Canadian Patrol Frigate, as it was to become known, evolved. Most importantly, the CPF and TRUMP requirements both aimed at providing credible multithreat capability in our navy.

Much has been written about these ships, and many of you now have had first-hand experience in operating them. They represent bold innovations in a number of areas, for which we are now receiving recognition internationally. They are ships of which we can be mightily proud and confident.

As I leave the Forces I have to conclude that, on an international scale, the navy of today is far more capable and relevant than that which I joined in 1960. That's progress! I am pleased to have played a part in getting there. With continued determination and foresight, the future can look equally promising. Keep your sights on the long view while you struggle with today's problems. Goodbye and good luck.

Forum

Relief Operations — A Non-traditional Role for the Fleet*

Article by LCdr N. Leak, LCdr R. Mack *and* Lt(N) F.T. Tait

(*Condensed from the authors' 1993 report on HMCS *Protecteur*'s hurricane relief operations.)

Current global political and economic climates have demonstrated the need for a flexible and innovative military response capability. Demands placed on society and its military infrastructures have resulted in precedent-setting taskings of military forces that have shattered conventional thinking with respect to traditional military operations.

Historically, the navy has concentrated almost exclusively on ASW operations. In recent years, however, this overall tasking has undergone a state of metamorphosis — the task force concept of operations entered the naval vocabulary and the "Total Force" evolved from concept to reality. Together with Canada's response to global developments, these conspired to push the navy into a period of transition which has directly affected fleet operations. Exactly what impact this will have in the long term depends on how the navy manages its taskings and opportunities. For the navy to continue to survive as a viable service, planners and commanders will have to ensure they take full advantage of each and every deployment.

A prime example of this was demonstrated during one operational cycle of the supply ship HMCS *Protecteur* under the command of Captain(N) D.J. McClean, OMM, CD. From Operation Friction in the Gulf through to hurricane relief operations in the Bahamas and Florida (*see the Looking Back section in this issue*) *Protecteur* was tasked with missions that pushed the envelope of conventional naval thought, particularly with respect to the concept of traditional AOR operations. (This would be demonstrated on a substantially greater scale later by HMCS *Preserver* in Somalia.)

In many ways the AOR is the ideal choice for relief operations. It has immense potential that goes well beyond simply passing fuel, ammunition and stores. Along with a significant sealift capability, the AOR's command and control and self-defence capabilities vastly extend its effectiveness. Its ability to operate three helicopters offers a great advantage over a destroyer for personnel transport, medical evacuation and security operations. The AOR's additional manning also provides a pool of manpower and expertise difficult to match in a destroyer or frigate. Senior officers should understand this and be prepared to utilize the tremendous skill resources our personnel possess, often outside their MOC.

Although hurricane relief was outside *Protecteur*'s usual line of work, the ship participated effectively within a Canadian joint task force to assist people in serious need. Apart from the extremely positive PR, goodwill and morale this engendered, the navy made substantial other gains from its relatively small investment. The apparently non-traditional missions provided useful experience for command and control teams through the JTF, and for supervisory and technical personnel engaged in small-party tasks. The dynamically changing conditions and mission goals gave wide opportunity to supervisors at all levels to exercise practical leadership, think on their feet, react and adapt to new conditions.

Canadian crews prefabricate frames and trusses for the 1992 Hurricane Andrew relief effort in the Bahamas.

There seems little doubt the navy can expect similar missions in the future. While it is not proposed that the navy expend great effort in preparing to meet disaster relief requirements specifically, we should continue developing contingency plans and resources. The relatively small expenditure involved in establishing some measure of emergency relief pack-up would greatly increase our effectiveness in this role and defray the cost of future operations. If it is not feasible to purchase complete pack-ups, we should at least compile comprehensive lists of pack-up items and establish mechanisms for their supply.

As far as personnel preparedness is concerned, officers and senior NCOs should be briefed on the special needs and opportunities presented by relief-type operations. Considering the importance these missions carry both in terms of humanitarian relief and operational professional development, MARCOM should maintain rosters of personnel experienced in joint-force relief operations. Such core personnel would be invaluable as members of a reconnaissance party. Already familiar with the capabilities of the "main force" of ships and crews that would follow, they could advise on the most effective employment of a naval relief effort.

The authors served on board HMCS Protecteur during the 1992 hurricane relief operations in the Bahamas and Florida.

The DDH-280 Vertical Launching System Installation: *An Engineering Feat*

Article by Lt(N) Brig Henry

In the late 1970s it was decided to augment the role of the DDH-280 Tribal-class destroyers from ASW to that of ASW with an enhanced anti-air-warfare (AAW) capability. The work to outfit the 280s for their new AAW role, along with some stand-alone projects and mid-life update requirements became the Tribal Class Update and Modernization Project (TRUMP).

Central to the new AAW capability is the SM-2 Block III Standard missile and its vertical-launching system — the Mk 41 T VLS[1] from Martin Marietta Naval & Aero Systems of Baltimore, Maryland. In the summer of 1992 the TRUMP detachment at the MIL Davie shipyard in Lauzon, Quebec was faced with the challenging installation of the VLS in HMCS *Athabaskan* (DDH-282). At the time, I was the detachment Hull Systems Engineering Officer (HSEO), and it is from this point of view that I will attempt to relate an appreciation of the complexity of this engineering feat.

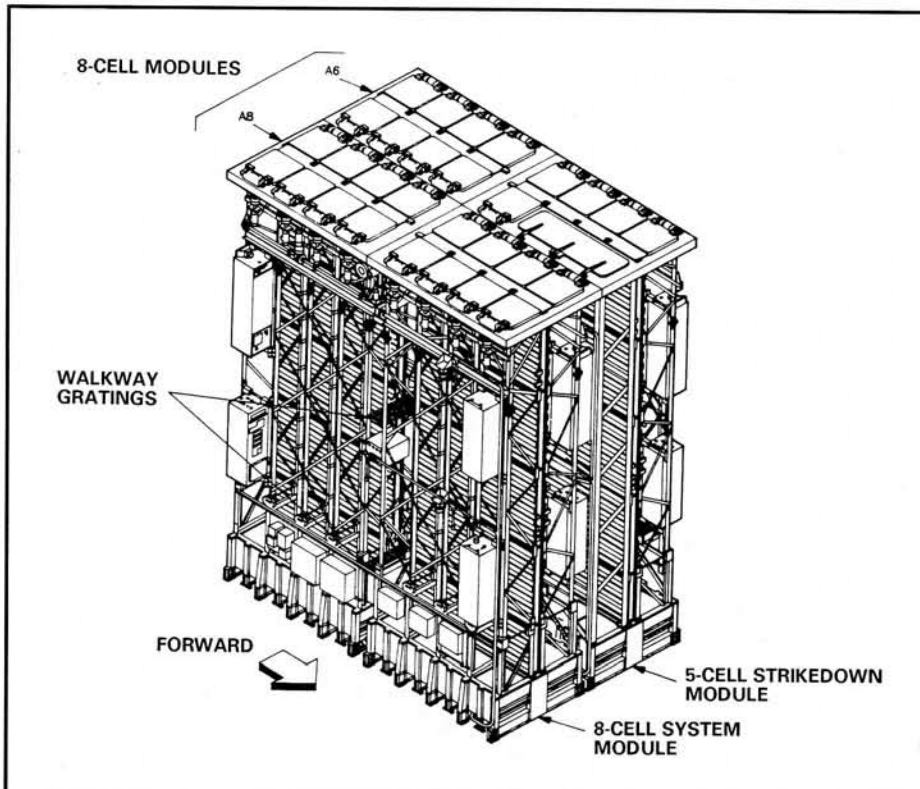

Fig. 1. DDH-280 Mk 41-T Vertical Launching System

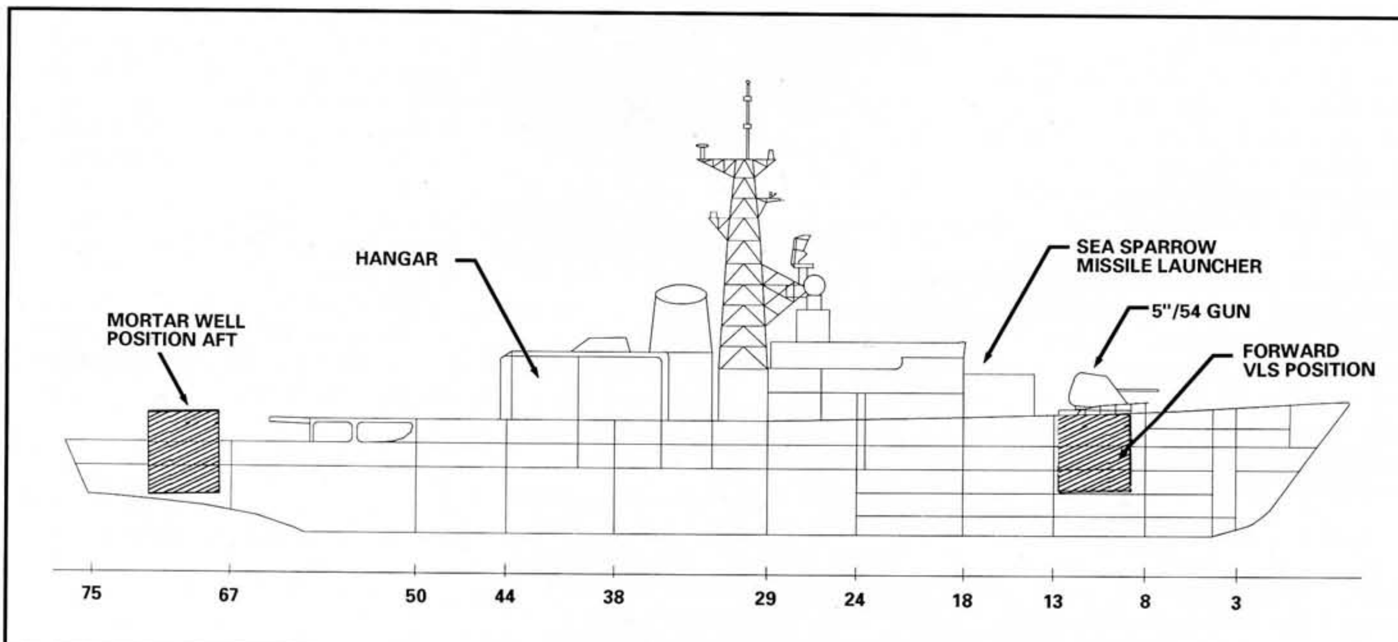

Fig. 2. VLS Installation Position Options

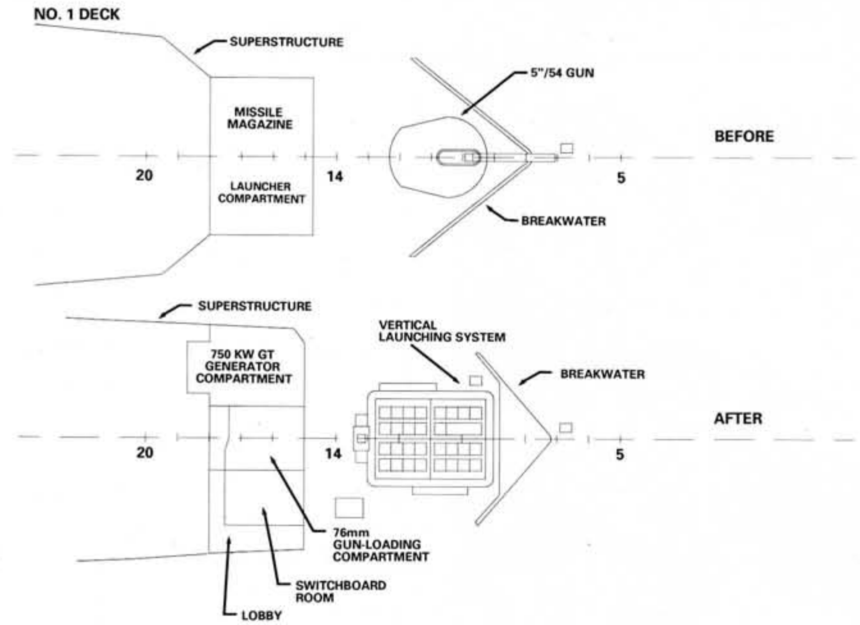

Fig. 3. HMCS *Athabaskan* No. 1 Deck: Before and After the TRUMP VLS Installation

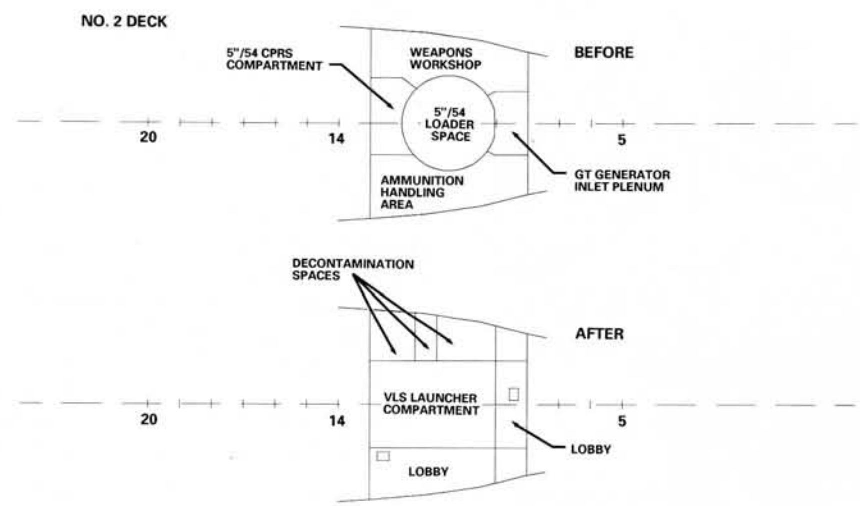

Fig. 4. No. 2 Deck: Before and After

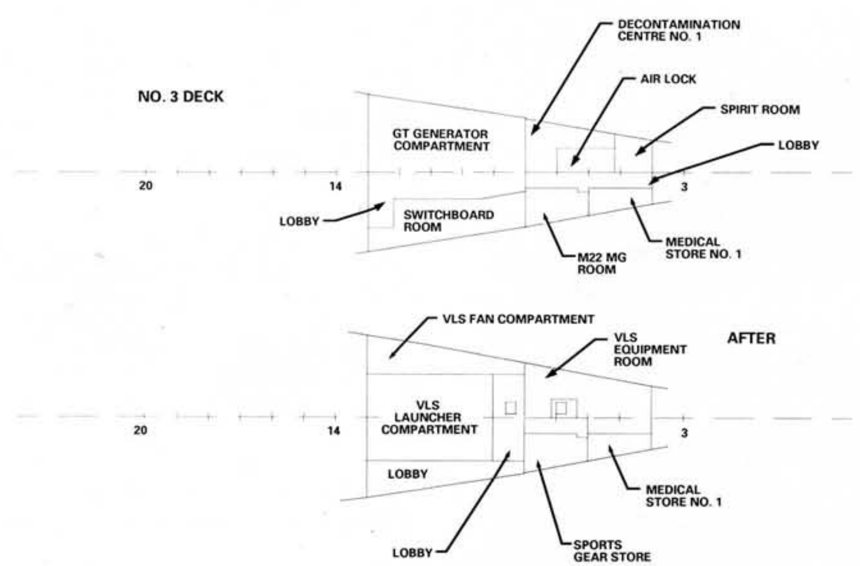

Fig. 5. No. 3 Deck: Before and After

The Tribal-class VLS launcher set (*Fig. 1*) is capable of firing a mixed load of surface-to-surface, surface-to-subsurface and surface-to-air missiles. The launcher set consists of an eight-cell system module, a five-cell strikedown module, two eight-cell standard modules, a status panel and associated module-related items. The four modules are very large structures. Joined, they weigh 96 tonnes (excluding the missiles), occupy 204 m^3 of space and extend inside the ship to a depth of nearly eight metres (three decks).

System Integration

So how was this enormous weapon launcher integrated into the DDH-280? Traditional warship concept design initially involves defining the payload volume requirements. This volume is used by the designer to calculate a first-iteration ship total volume and hence (based on an assumption of ship density) an initial estimate of ship displacement. In other words, the payload drives the design. However, in considering the integration of a new weapon system (like the VLS) into an existing ship, the designer is restricted by the already defined envelope of the ship — i.e. the volume, the superstructure layout and, to a large extent, the ship's weight distribution and pre-modification displacement.

Given the immense size of the TRUMP vertical-launching system, there were really only a few sensible places where it could be located on board the ship, such as the old mortar well aft and the 5"/54 gun position forward (*Fig. 2*). These two particular sites would each preserve the original spacing of watertight bulkheads, however placing the launcher in the mortar well would leave its upper portion proud of the deck. The 5"/54 gun position, on the other hand, would allow the weapon system to fit flush with the upper deck, thereby offering it better support during missile firing and minimizing its radar cross-section.

The forward position would eventually be selected, however there were notable drawbacks — the 5"/54 gun would disappear, and the ship would trim by the bow. (I estimate that the VLS modules and local strengthening caused a net weight increase of 17 tonnes in this part of the ship.) The inclusion of a water-displaced fuel system and some additional solid ballasting aft corrected the trim. As far as the 5"/54 gun was

Fig. 6. The VLS Sub-base in Two Halves

Fig. 7. A module is transported to the ship by crane during module load-out.

concerned, the TRUMP ship weaponry was deemed to ably compensate for its loss.

Compartment Reconfiguration

In addition to the removal of the 5"/54 gun, other radical changes were required in the ship to accommodate the VLS. Certain vital systems had to be retained, whereas other systems made redundant by the new configuration and could be stripped out. For example, on No. 1 deck (weather deck) the pre-TRUMP Sea Sparrow missile magazine launcher compartment was given over to a 750 kw emergency generator and switchboard displaced from No. 3 deck by the VLS (*Fig. 3*). The compartment in the centre of this superstructure extension in the post-TRUMP ship became the gun-loading compartment for the new 76mm gun situated on the deck above this space. The VLS, of course, displaced the 5"/54.

On No. 2 deck (*Fig. 4*) the 5"/54 loader space and other gun spaces were stripped out and replaced by the VLS launcher compartment, a lobby and a personnel decontamination centre. On the pre-TRUMP No. 3 deck (*Fig. 5*) we see the 750 kw GT generator, switchboard and decontamination centre that had to be moved. In its new configuration, No. 3 deck holds the VLS launcher compartment, the VLS fan compartment, a lobby and, forward of Frame 8, the VLS equipment room. The remaining deck that was affected from an outfitting point of view was No. 4 deck, where the VLS launcher compartment replaced the 5"/54 magazine and shell room.

Shipyard Work

The sub-base of the launching system was fabricated in two halves (*Fig. 6*) which were then carefully aligned and welded together. *Figure 6* shows pads which were welded to the top of the VLS seats to serve as mounting surfaces for the VLS module feet. The next step was to drill through the mounting pads into the module seats. Martin Marietta provided a template to drill the 80 holes required in each of the four seats.

The sub-base was transported as a unit to the ship in the drydock. A transporter attachment furnished by Martin Marietta was used for the operation. The foundation was tack welded into position on No. 4 deck and checked one last time for levelness and alignment before being fully welded to the deck. All welds were subjected to magnetic particle inspection.

At this point, the load-out of the modules could begin (*Fig. 7*). The operation was very complex. Although the modules were initially moved from the quay to the ship by crane, once at the ship the final positioning was substantially accomplished by hand. Particular attention had to be paid to the vertical positioning of the first module (*Fig. 8*) as the positions of the other three modules would be governed by it. The only way to adjust module verticality during load-out was with temporary set screws located in the base of each module. Although somewhat tedious, this method of module position manipulation worked surprisingly well.

The load-out was at times a rather stressful affair because of the possibility of a descending module hitting another already in place. This, and the effort it took to make the set-screw adjustments made for a long process (nine hours, in the case of *Athabaskan*).

Immediately following load-out, the modules were temporarily bolted together to ensure their relative positions did not change during float-up. Shortly after the load-out the ship was floated-up and moved out to an outfitting pier where a final alignment check was made prior to bolting the modules to their respective seats and to each other (*Fig. 9*). A coaming was constructed around the top of the weapon system to complete the installation.

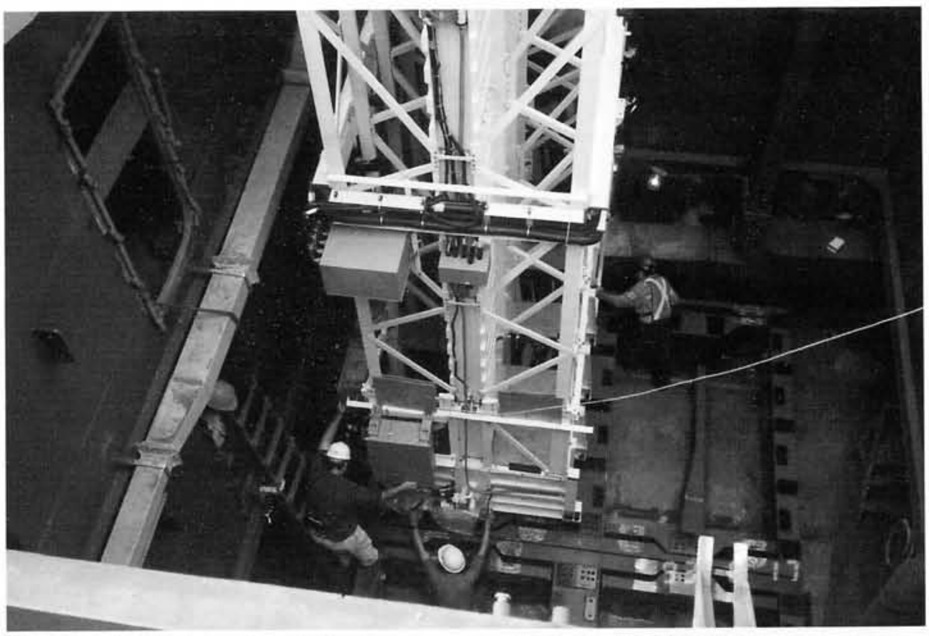

Fig. 8. The first module being manoeuvred into position by hand.

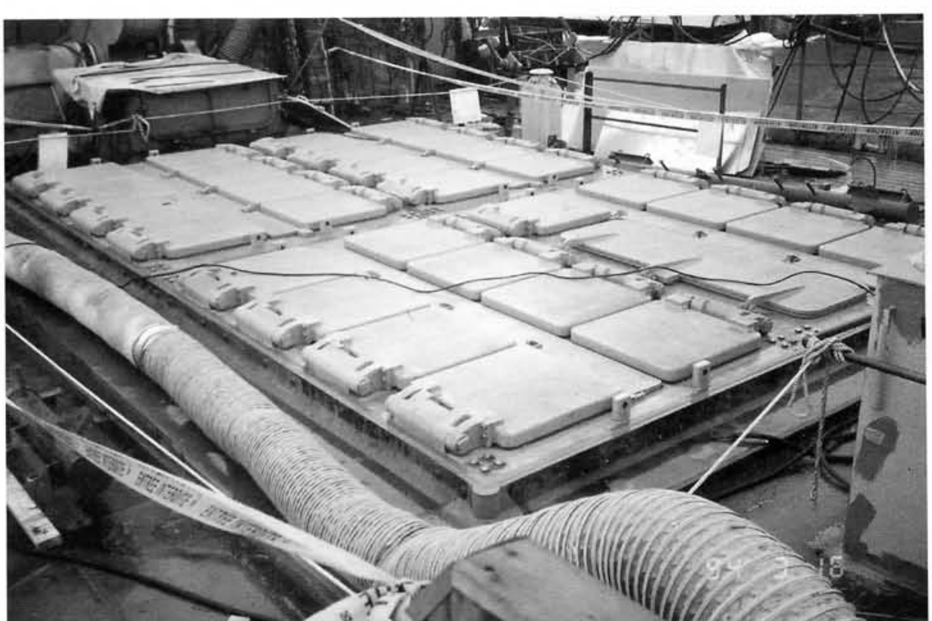

Fig. 9. Load-out complete: looking aft to the VLS launcher. The full coaming structure is not yet in place.

Conclusion

This paper has tried to convey some insight into the complexity of the integration of the VLS into the Tribal-class destroyers. The success of this engineering feat in HMCS *Athabaskan* and the other three DDH-280s attests to the integrity and professionalism of all the people involved in this massive engineering effort. From my perspective as the TRUMP detachment HSEO, I feel honoured to have played a part in this activity.

Acknowledgments

I would like to thank MIL Davie Ltd. for permitting me to take photographs in their shipyard. I also extend a special thanks to Cdr G.A. Buckingham and Mr. Y. Charron at PMO TRUMP for their assistance on this article.

Reference

[1]Interim CFTO C-70-328-000/MD-001, Vertical Launching System (VLS mk 41 Mod T) Introduction and Description, Feb. 1, 1989.

Lt(N) Brig Henry was the Hull Systems Engineering Officer with the TRUMP detachment in Lauzon, Quebec from 1992 to 1995. He is now serving with the ADP Group at Naval Reserve Headquarters in Quebec City.

Electric Propulsion — The Way of the Future

Article by LCdr Mark Tinney

Introduction

There are a number of new technologies under development which offer the potential to make greater usage of electric propulsion in future warships. These include permanent magnet motors and generators, high-frequency generators, inter-cooled recuperative (ICR) gas turbines and fuel cells. In this paper it is intended to provide a brief overview of these technologies as well as a few comments concerning the impact they will have on a ship's through-life costs, environmental impact and characteristic signatures.

Permanent Magnet Motors and Generators

The advancing technology of AC permanent magnet (PM) motors and generators can ultimately lead to electric propulsion designs which will be smaller and lighter than conventional plants. There are several types of PM motor under development, one being the transverse flux (TVF) motor.

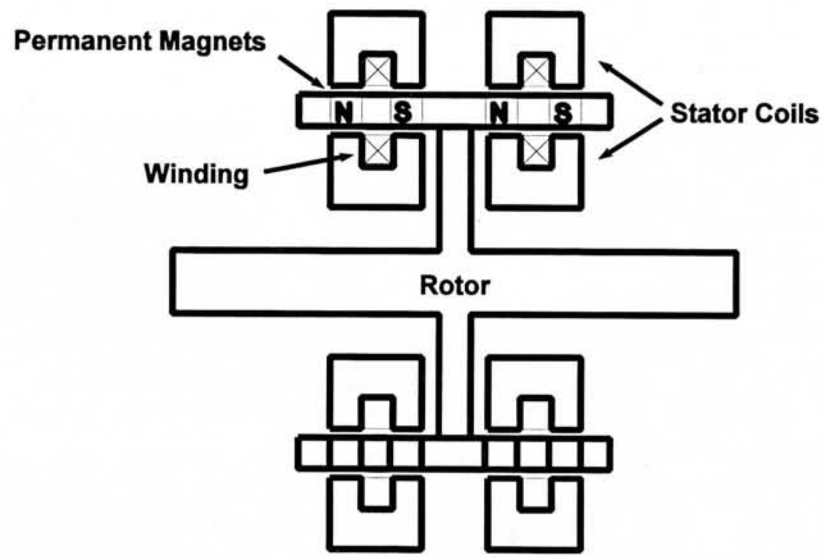

Fig. 1. Transverse Flux Motor Design

The TVF motor gets its name from the fact that the effective magnetic flux is transverse to the direction of rotation. As can be seen in *Fig. 1*, the rotor consists of radial discs supporting permanent magnets which extend out from either side at the outer diameter. The motor lends itself to a couple of topologies. One is a pancake design consisting of a single rotor disc, and the other is a long tubular design with multiple discs of small radius. The advantage is that the motor can be designed for use in either conventional, SWATH, or podded hull designs.

The design of the motor and the use of permanent magnets allows a large number of poles with large circumferential forces, yet with virtually no rotor losses. These factors result in an AC motor with high efficiency (*Fig. 2*), and a power density equivalent to motors designed around superconducting principles. Two 18-MW TVF AC motors could easily power a frigate, yet they would be smaller, and weigh half as much as the two 1.5-MW DC motors installed in the British Type 23 warship. As for costs, a British study calculated that a TVF motor would be cheaper to build than a similarly sized conventional motor[1]. Similar benefits would be achieved in PM generators.

Further weight and volume savings could be achieved if PM motors were used to replace standard induction motors throughout a ship. At one-quarter the weight, and less than half the volume of conventional AC motors, overall weight and volume savings per ship would be significant, although acquisition costs would be higher.

High-Frequency Generators

Interest in the use of higher frequencies is driven by the aim for higher power density in propulsion plant designs. Increasing the output frequency of propulsion generators in an electric ship is one way to reduce the size and weight of these components. This can be explained by referring to the following equation:

$$P = k \times T \times N$$

Where: P = power

k = constant

T = torque

N = speed

For constant power, an increase in speed (frequency) means a decrease in torque. This translates into a decrease in the size of the generator since rotor diameter is directly related to torque. This opens the door for small, high-power generators to be coupled directly to gas turbines.

The catch is that this requires rotor designs which can handle the higher speeds. The copper windings of regular rotor designs cannot withstand the high centrifugal forces produced by gas turbine speeds. Even with rigid support, the windings tend to cold-flow under the high forces. Permanent magnet-excited generators offer a solution since the magnets won't deform, and can be banded to the rotor to hold them in place.

Utilizing this technology, it is feasible to produce a 15-MW, 1767-Hz generator with an overall diameter of 101 cm, and an overall length of 91 cm[2]. The machine would be smaller than the generator end of a 400-kW turbo-alternator, and there would be no need for an intermediate gearbox. The high-frequency output would be converted to DC at the output of the generators and connected to the propulsion bus of an electrically powered ship. Power for the ship's service bus and the propulsion motors would be fed through pulse-width modulated, insulated gate bipolar transistor inverters. The technology required to switch such large amounts of power at the required frequency is already commercially available.

ICR Gas-turbine Engines

Compared to a diesel engine, the attraction of a gas turbine is its higher power density. Unfortunately, simple-cycle gas turbines have higher specific fuel consumption (sfc) at all powers, but most significantly at low-to-medium powers. The driving force behind the development of the ICR gas turbine is higher efficiency and reduced sfc. As can be seen in *Fig. 3*, the ICR engine has an sfc lower than simple-cycle gas turbines at all powers, and better than that of a medium-speed diesel for moderate-to-high powers. The amount of fuel that can be conserved depends on the installation, and the vessel's operational profile. For the USN's DDG-51-class destroyers with four ICR'd LM-2500s, fuel savings were estimated at $1.3 million (US) per year, in 1993 dollars.

The manner in which ICR engine efficiency is improved can be explained by referring to *Fig. 4*. The intercooler removes heat from the air as it leaves the low-pressure compressor (LPC) prior to entering the high-pressure compressor (HPC). This allows the HPC to compress the air more efficiently. The compressed air is then passed through the recuperator where it is preheated prior to combustion. The gas exiting the high-pressure turbine (HPT) passes through a variable area nozzle (VAN) prior to entering the power turbine.

The exhaust gas exiting the power turbine then passes through the recuperator where its heat is returned to the cycle to improve the engine's efficiency. At part loads the VAN serves to maintain the power turbine entry temperature at a constant value. This serves to increase the recuperator gas-side entry temperature at low load, thereby increasing the heat transfer to the combustion process.

For the most part, interest in the ICR gas turbine has been focused on its application as a propulsion engine in a conventional ship. But the technology has equal application in gas turbines driving generators of all sizes. In the case of the high-frequency generator previously mentioned, the use of an intermediate gearbox could be avoided if either an ICR or simple-cycle gas turbine were used as the prime mover, but the ICR engine would be the more efficient. In either case the speed of the prime mover and generator would have to be optimized to suit both machines, with the resulting size and weight dependent on the selected speed.

The reason that the ICR engine would be most effective as a generator prime mover can be found by referring again to *Fig. 3*. The region where a prime mover should ideally be operated is 65-90 percent power. It is in this power range that the ICR engine's sfc is lower than even that of a medium-speed diesel.

ICR engines are larger and heavier than their simple-cycle counterparts. For example, in the case of the LM-2500 propulsion engine, the weight (wet) will increase from 23 tonnes to 55 tonnes. This will be easily offset by savings in fuel weight which have been calculated to be 30 percent for the DDG-51 using ICR gas turbines rather than simple cycle gas turbines. For a given mission profile, a requirement for less fuel means smaller fuel tanks which can translate into a smaller ship design.

All things considered, the dual application of ICR engines and high-frequency PM generators in an electric propulsion design would provide the navy with the opportunity to develop small, high-performance, high-endurance and cost-effective ship designs.

Fuel Cells

Fuel cells in various forms are being developed by several countries, including Canada. There are a number of ways a fuel cell could be utilized in a ship — as ship service generators, as power supplies for UPS systems, or as propulsion engines in electric vessels such as submarines.

The driving force behind this effort is the quest for higher process efficiency. Fuel cells require hydrogen and oxygen to operate. In a shipboard application it is generally desired that hydrogen be reformed from conventional fuel. This reforming process will require a large amount of heat which will lower the system's efficiency. (R&D efforts are working toward a method for reforming standard shipboard fuels cost-effectively.) The oxygen can be supplied from either a liquid oxygen source, or from a compressed-air system.

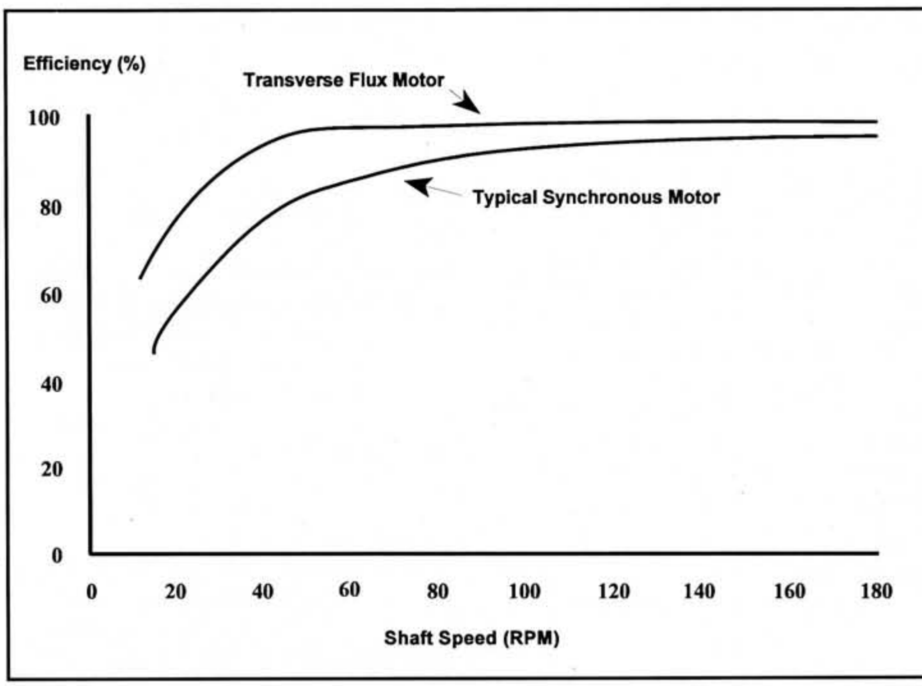

Fig. 2. Typical Efficiency Curves for Transverse Flux Motor and Synchronous Motor[1]

The energy required to supply air and reform hydrogen will drag the process efficiency down from the theoretical limit of 70 percent to roughly 45 percent. If liquid oxygen is used, the process efficiency is estimated to be in the low 50s. In either case, since these values are several points higher than those of conventional generators they will translate into significantly lower fuel consumption.

One method to return a fuel-cell generator's efficiency closer to theoretical values is to use fuel cells and gas turbines in tandem. This could be achieved by tapping off compressed air from the gas turbine compressor to supply oxygen to the fuel cell, and using waste heat from the gas turbine exhaust to reform the hydrogen. In this arrangement the fuel cell could be used to supply electricity and the gas turbine could be used as either a propulsion or generator prime mover. Either simple-cycle or ICR engines could be used for this purpose, but the ICR engine is better suited since the waste-heat temperature can be uniformly maintained throughout a greater range of the operating envelope, as explained earlier.

It is expected that fuel cell generators will not be any smaller than conventional diesel generators, but they will be lighter. And unlike conventional generators, they offer considerable flexibility in their placement on board since the fuel-cell stacks can be arranged to fit the available space (rather than the other way around). This, along with their requirement for less fuel, will have an effect on the size and design of warships.

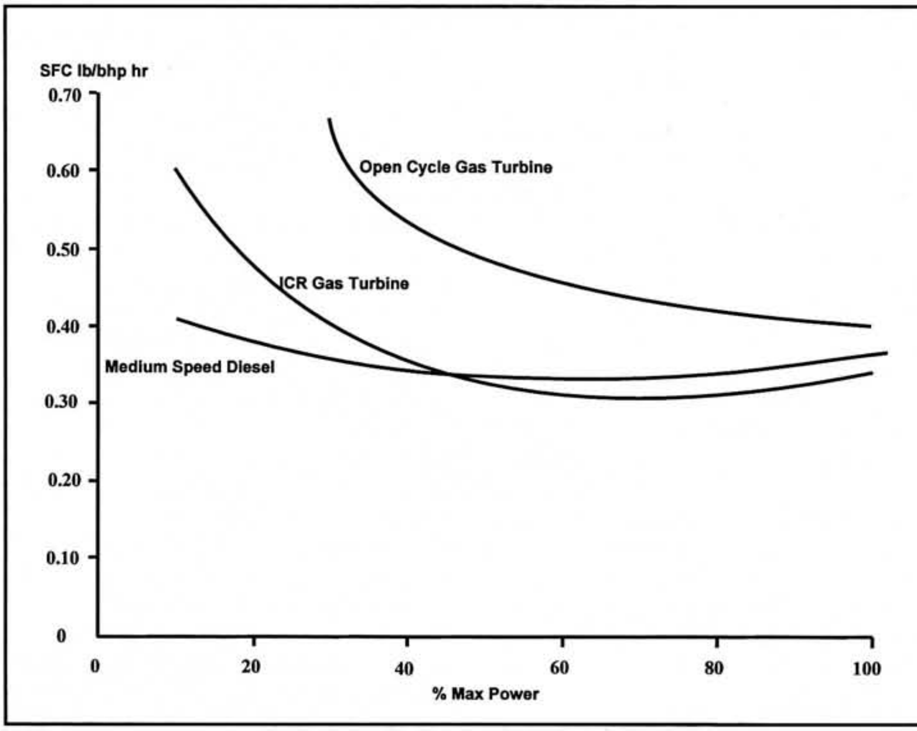

Fig. 3. Specific Fuel Consumption

Impact on the Navy

Through-life Costs

Electric propulsion on its own offers lower through-life costs. The Royal Netherlands Navy recently proved this in their evaluation of the life-cycle costs for a new 14,000-tonne amphibious transport ship. They concluded that life-cycle costs would be reduced by six percent in a conventional electric design. Included in this were the costs associated with a reduction of eight watchkeepers and maintainers in comparison to the engineering complement of a conventional plant.(3)

The technologies discussed herein, when integrated into an electric propulsion plant design will provide even further benefits. In any electric plant the ability to match the ship's power requirements to the generators' optimum output leads to improved operating conditions for the prime movers. This in turn leads to improved engine reliability, lower maintenance costs, and ultimately to savings in through-life costs.

All of the technologies described in this paper offer improvements in efficiency. In some cases the improvements may appear small, but considering that the power levels under discussion are in the range of megawatts, even a small increase in efficiency can dramatically reduce a vessel's through-life costs. Higher efficiency means less fuel which can translate into smaller ship's with smaller crews, both of which would have a beneficial impact on the costs to build and operate a ship.

Environmental Impact

If carefully designed, electric ships can be more environmentally friendly than conventional plants for several reasons. First, since it is possible to match the ship's electrical load to the optimum generator output, fewer engines (on average) will be operated. Second, generator prime movers are less polluting than their variable-speed counterparts at partial load. Further benefits stem from the technologies described in this paper, which can lead to smaller ships with smaller crews, and a corresponding decrease in the amount of waste generated.

Another aspect to consider is the worldwide trend toward new, stricter air-emission regulations which will be difficult, and very costly to meet. Fuel cells in an electric propulsion design offer one solution since they are virtually pollution-free. For example, because their operation does not rely on the burning of fossil fuels, they do not produce hazardous by-products such as nitrous oxide.

One can envisage fuel cells being used to replace some or all of the conventional generators in an electric-ship design. These generators could supply power for either ship's services or propulsion at any time, but would be most useful for propelling the ship when transiting areas where strict environmental controls are in effect. Two single-megawatt fuel cells could provide all the propulsion and ship's service power requirements to drive a medium-size frigate through such an area at speeds up to eight knots. A study currently under way in DMEE will provide some insight to the size and weight of such a system.

The environmental impact of ICR engines will be roughly the same as that of simple-cycle gas turbines. The higher combustion temperatures will give off

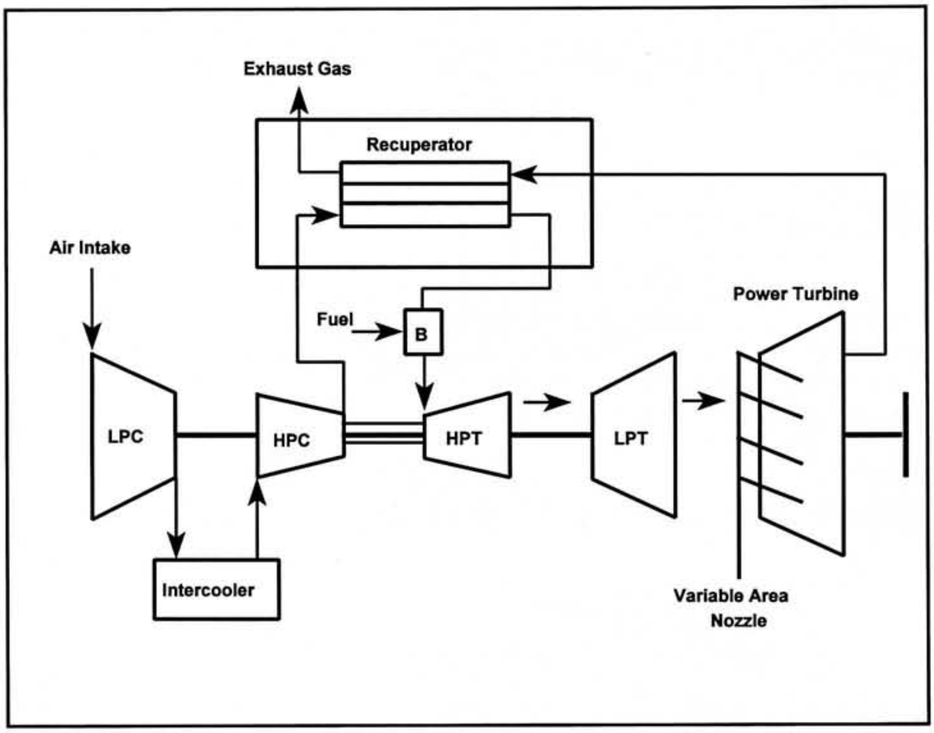

Fig. 4. ICR Cycle

higher levels of nitrous oxide, but the improved efficiency will reduce the quantity of exhaust gases. The net effect will be roughly equal.

Signature Reductions

Noise/Vibration

Fuel cells are quiet, static devices, with the only moving components being the ancillary fuel, air and cooling pumps which can be easily mounted to prevent noise and vibration transmission to the hull. Overall, fuel cells can be positioned almost anywhere on the ship without concern for noise transmission to the water.

Low vibration and ease of resilient mounting have resulted in good underwater noise and vibration characteristics for gas-turbine propelled ships. This will not change with the adoption of the ICR engine as long as the associated auxiliary systems are carefully mounted and isolated from the hull. The vibration characteristics of a gas turbine operated as a prime mover for a high-speed generator will be a known quantity and easily tuned out through careful mounting. In addition, with the direct connection of the gas turbine to the generator, gearing noise will be eliminated. Finally, except for very high power units, there will be considerable flexibility in positioning the generators throughout the ship to minimize noise and vibration transmission to the water.

Close attention will have to be paid to the design of the drive train of any AC electric propulsion system since harmonic-induced shaft vibrations are a characteristic of AC drives, including PM motors. The harmonics are created by solid-state switching action in the frequency converters and can be transmitted down the propulsion shaftline in the form of a ripple-torque which can be transmitted by the propeller as measurable noise.

Under some circumstances these ripples can actually be amplified by the shafting. This occurs because marine shaftlines are lightly damped rotating systems with natural frequencies in the bands where one or more harmonics could be present with appreciable amplitude. It is therefore essential to carry out a thorough resonant analysis at the design stage to identify where this might be a problem. If problem areas are identified there are a number of design solutions which can be adopted. Phase-shifting techniques in co-operation with either tandem motors or double-wound motors could be utilized as a way to cancel the dominant harmonics. The effects could also be reduced by adjusting the shaft stiffness to move the resonant frequency outside of the operating envelope.

IR Signature

Both ICR engines and fuel cells have much lower exhaust stack temperatures than conventional propulsion systems, and therefore their infra-red signature will be lower. The exhaust temperature of an ICR engine will be limited to around 350°C, which is 175°C lower than either a simple-cycle gas turbine or a highly rated high-speed diesel engine. This is a significant reduction considering that an infra-red signature varies with the fourth power of the temperature difference.

Conclusions

Considerable improvements are being achieved in the efficiency, and power density of the components that make up electric propulsion systems. New technologies and concepts are opening the door for even further improvements. The benefits that can be realized from these include lower life-cycle costs, signature reductions and reduced environmental impact. It is suggested that for these reasons all of the technologies mentioned in this paper will find their way into navy ship designs in the foreseeable future.

References

[1] A. J. Mitcham International Research and Development Ltd., and Lt Cdr B. Dullage, RN, "A Novel Permanent Magnet Propulsion Motor for Future Warships," INEC 94.

[2] Thomas B. Dade, "Advanced Electric Propulsion, Power Generation, and Power Distribution," *Naval Engineers Journal*, March 1994.

[3] Cdr C.H.J. van Norden, RNLN, and Cdr R.J.A. Kints, RNLN, "Reduction of Life-Cycle Costs for an Amphibious Transport Ship," INEC 94.

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Career Manager's Update on MARE Positions

Article by LCdr Derek W. Davis *and* Lt(N) Spencer Collins,
Personnel Careers Officers (MARE)

The February issue of the *Journal* contained a list of "alternative" MARE posting opportunities — those outside the more traditional command and headquarters billets. Since that list was produced, there have been many additions. Some are new MARE positions, others are positions being filled by MAREs for other MOCs.

Billets not associated with traditional DGMEPM/Command Headquarters/FEMU positions

Type of Job	Rank	Location
Research and Development	LCdr, Lt(N)	Ottawa, Esquimalt, Halifax, Valcartier
Naval Reserve Associated (including CO/XO positions)	LCdr, Lt(N)	Ottawa, Quebec City, Sept Isles, Vancouver
Director General Quality Assurance	LCdr, Lt(N)	Ottawa, Halifax, Nicolet (Quebec)
UN Associated	LCdr, Lt(N)	New York (USA), Kigali (Rwanda)

Non-Traditional MARE Filled Positions in Ottawa

Organization	Rank	Job
DG Policy Planning	LCdr	Analyst — Director Nuclear and Arms Control Policy
Director Military Traditions and Heritage	LCdr	Staff Officer — Dress, Insignia and Administration
DG Official Languages	LCdr	Staff Officer — Director Official Languages Policy
DG Information Management Development	Lt(N)	Project Officers — Information Management Policy and Architecture, and Information Technology Security
DG Maritime Development	LCdr	Director of Naval Requirements, Major Platform and Combat System Requirements
Chief Personnel Careers and Development	LCdr	Staff Officer to Chief Military Personnel
PMO Reserve Integrated Information Project	LCdr	Project Officer
DG Reserves and Cadets	LCdr	Staff Officer — Director Reserves
Narrow Band Secure Voice Equipment Replacement Project	LCdr	Project Manager
Military Personnel Information System Upgrade Project	Lt(N)	Project Officer
DG Information Systems Delivery and Support	LCdr, Lt(N)	Project Officers and Managers — Electronic Warfare Operational Support Centre, Pay Systems, Tactical Secure Voice Project, Remoting of Naval Radio Stations Project, Space Systems, Information Systems Support

Active Jammers in Anti-ship Missile Defence: Onboard or Offboard?

Article by Lt(N) Sylvain Carrière

Introduction

There is speculation in the fleet about the navy's intentions with respect to replacing the AN/ULQ-6 noise-deception repeater jammer fitted on board the Tribal-class (TRUMP) destroyers. Suggested replacements for the AN/ULQ-6 include the fitted RAMSES noise-deception repeater and expendable offboard jammers such as the Australian NULKA decoy system[1].

The primary intent of this article is not to focus on the technical aspects of these two jammer systems, nor to discuss issues linked to their integration with the TRUMP command and control system. Rather, the article will evaluate the respective merits and the stand-alone tactical employment of onboard reprogrammable noise-deception repeater jammers and offboard active decoy systems against radar-guided anti-ship missiles.

Reprogrammable Noise-deception Repeater

An onboard reprogrammable noise-deception repeater such as RAMSES appears, at first glance, to be the logical AN/ULQ-6 replacement in the TRUMP ships for two main reasons. First, being reprogrammable, the system offers flexibility in that it can be reconfigured to meet changing threats. Second, since RAMSES is already a standard fit on board the Canadian patrol frigate, fitting it on board TRUMP ships will economize the required fleet maintenance, training and operational support.

A major drawback that is often overlooked, however, is the time and effort required to provide effective operational support to an onboard reprogrammable jammer. It is absolutely critical to have an in-depth understanding of the internal functioning of the missile seeker head that is intended to be countered. This knowledge is often only acquired by obtaining an actual missile seeker, examining it in a laboratory and testing it on a range against possible electronic countermeasure (ECM) jamming techniques. Such "exploitation" allows a reprogramming team to generate jamming techniques to counter that specific missile seeker type.

Unfortunately, the proliferation rate of missile family variants makes it almost impossible for the exploitation process to keep pace. Countries such as Taiwan, North Korea, China, Iran, Iraq, etc. either design entirely new anti-ship missiles, or else reengineer and redesignate known systems purchased from arms suppliers. The Russian SS-N-2 and French Exocet anti-ship missile families are perfect examples of weapons in worldwide use that have had a wide variety of modifications made to their original design. As a consequence, it is becoming more and more difficult for traditional onboard jammers to provide adequate defence against every type of radar-guided missile.

In addition, this proliferation makes it very difficult for intelligence staff to identify the specific missile variants front-line units can expect to encounter in a theatre of operations. This knowledge is critical since even minor modifications to hardware components or software logic targeted by a jamming technique can reduce or neutralize the jammer's effectiveness or, worse, make it act as a homing source for the missile.

Offboard Active Decoy

In an attempt to reduce the resources involved in supporting onboard reprogrammable noise-deception repeater jammers, some countries have embarked on programs designed to evaluate the use of offboard jammers. In the air world, the United States and United Kingdom, with their respective Raytheon AN/ALE-50 and GEC-Marconi ARIEL systems, are planning to make operational use of active jammer decoys towed behind aircraft for self-protection against missiles[2,3,4].

In the naval world, offboard jammers such as the United Kingdom's SIREN system and Australia's NULKA will soon be available on the market. Australia has already awarded a contract for the purchase and installation of the NULKA offboard expendable radio-frequency and infra-red decoy system for its FFG-7 class frigates[5]. The U.S. Navy has also shown interest in this decoy system and is looking at the feasibility of integrating NULKA into the self-defence systems of selected vessels[6].

Offboard active decoy systems work on the principle that if they produce a strong enough level of RF energy to reach a pre-set threshold in a missile seeker, the missile will go into a home-on-jam mode and prosecute the decoy. The NULKA rocket-propelled decoy, which has a fully programmable and controllable flight path[7], stays aloft by hovering on its rocket thrust. SIREN is launched much the same as a chaff round, with its descent controlled by parachute.

In principle, these decoys require only limited technical knowledge of the threat systems since they take advantage of the inherent home-on-jam feature of most radar-guided missiles. If used properly, such decoys could significantly increase the level of self-protection against missile threats for which exploitation data is limited or unavailable.

Benefits of operating two active ECM systems

Having a fleet of patrol frigates and TRUMP ships equipped with a mix of active ECM systems such as RAMSES and NULKA (or some other offboard decoy system) would provide real advantages to Canada. Ships could be sent to theatres where missile threats exist for which no effective jamming techniques have been programmed in RAMSES. It would also give a task group commander the flexibility to deploy ships according to the self-protection capability offered by their active jammer fit. For example, in a multiple missile threat scenario, RAMSES-equipped ships could be deployed such that they could counter missile types for which jamming techniques have been validated; ships fitted with an offboard decoy system could be positioned to counter those threats for which RAMSES is known to have little or no capability.

Conclusion

The key issue in the debate of onboard reprogrammable noise-deception repeaters versus offboard active decoys is to understand the operational support that is required to make an ECM system effective in countering anti-ship missile threats. Onboard reprogrammable jammers attempt to seduce a missile and thus require an in-depth knowledge of the specific threat missile seeker. Offboard active decoys exploit the inherent home-on-jam feature of almost all modern radar-guided missiles.

People involved in the decision-making process for the ULQ-6 replacement must weigh the pros and cons of RAMSES, NULKA and other possible offboard decoy systems. Onboard reprogrammable jammers should be able to counter a finite number of the active anti-ship missiles presently in existence. The remaining radar-guided missiles could then be effectively defeated by proper deployment of expendable offboard active decoys. An offboard active decoy system for the TRUMP ships, in conjunction with RAMSES, could thus give the fleet the flexibility it requires to fulfil its missions.

References

[1] Cdr M.R. Bellows, Directorate of Naval Requirements — Combat Systems DNR(3), AAW Conference Halifax, Jan. 12, 1995.

[2] Gerald Green, "Five Tactical Aircraft Could Get ALE-50," *Journal of Electronic Defense*, March 1994, p.16.

[3] "Industry readies bids for F/A-18 ECM," *Aviation Week and Space Technology*, Oct. 10, 1994, p.149.

[4] Martin Streetly, "Ariel Comes in out of the Black," *Journal of Electronic Defense*, October 1994, p.20.

[5] "Headline News," *Jane's Defence Weekly*, July 9, 1994, p.5.

[6] J. Knowles, "Australian Navy Buys New Missile Decoys," *Journal of Electronic Defense*, August 1994, p.20.

[7] Jane's Radar and Electronic Warfare Systems 1994-95, 6th ed., *Naval ECM Systems*, Jane's Information Group Inc., p.491.

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1995 Central Region Naval Engineering and Maintenance Seminar

Article by Lt(N) Michael P. Craig

The 1995 Central Region Naval Engineering and Maintenance Seminar was held at the Government Conference Centre in downtown Ottawa April 5 and 6. The theme for this year's conference was "The Next Millennium — The Challenge and the Opportunity," and was supported by interesting presentations on a wide variety of naval engineering topics.

Master of ceremonies for the first day was **Capt(N) J.R.Y. De Blois**, Director of Maritime Combat Systems, who began the seminar by introducing **Cmdre F.W. Gibson**, Director General Maritime Equipment Program Management (formerly DGMEM). The commodore welcomed everyone, acknowledged the seminar theme and encouraged active participation during this yearly opportunity to learn and develop in the naval engineering community.

The opening speaker, **Capt(N) D.C. Morse**, Director of Naval Requirements, gave a straight-talking address on the *Defence Services Program and the DND Budget* which was very well received. A spirited question-and-answer period followed. Captain Morse's presentation was such a crowd-pleaser that it was recommended as the opener for next year's seminar. Just before the break, **Bill Grayson**, CAE Ottawa's director of business relations, presented **SLt Dan Riis** with the CAE Award for highest academic score during Phase V of Marine Systems Engineering training.

The seminar's Organizing Committee *(from left to right)*: LCdr Rob Quaia, Dave Morris, Cdr Rick Marchand (Chairman), Mike Belcher, LCdr John Fisher, Lt(N) Mike Craig (Secretary) and CPO1 Craig Calvert (absent).

The seminar's first-day keynote address, *"Industrial Development and Security,"* was delivered by **Dr. John MacDonald**, co-founder and chairman of the board of MacDonald Dettwiler and Associates. A polished and entertaining lecturer, Dr. MacDonald shared his perspective on the importance of industry and its relationship to the national debt. He was especially concerned, he said, about the rate of growth of the debt and presented some convincing arguments as to why this thorny issue should be addressed immediately. Dr. MacDonald also stressed the need to build and maintain an industrial base in Canada which would greatly aid in controlling and managing the large national debt. Where the military is working on the physical defence of Canada, he said, Canada's employers and exporters are working on the "economic defence" of the country. Dr. MacDonald said we need to learn to exploit (as well as export) our technology more efficiently if we are to continue to grow as a nation.

LCdr Serge Garon presented an interesting overview of the management, preparation and conduct of the *CPF Shock Trial*. Of particular note were the extensive public affairs involvement and environmental controls. Day one was rounded out with presentations by **Cdr Mark Eldridge** on the *Naval Engineering and Maintenance Function Review*, **LCdr A.B. Smith** on *Evaluating the Cost and Military Effectiveness of Marine Projects*, and finally **LCdr Steve Rudnicki** on *COTS vs. Mil-Spec: The Myth and the Reality*. In the spirit of comradeship, a meet and greet was held at the Conference Centre immediately following the final paper of the day.

Day two saw a new master of ceremonies in the person of **Mr. R.A. Spittall**, Director of Maritime Engineering Support. Starting the morning was a presentation by **LCdr Xavier Guyot** on the *HMCS Ojibwa Cut* — when the O-boat was cut in half to facilitate engine removal during refit last year. An initial presentation was made at the East Coast MARE Seminar while the work was still in progress. This was the subsequent and final report and included a stimulating 20-minute video. Other presentations included **Bob Laidley** on *Fuel Cells — Where we are from, where we are going* and **Lt.Cdr. Roland Hooley, RN** and **LCdr Keith Dewar** on the *Naval Environmental Challenge*.

VAdm D.N. Mainguy (ret.) was invited as the keynote speaker for day two, with the topic of *Security in the Modern World*. His wealth of experience, from commanding officer of several ships through to vice-chief of the defence staff, provided him with the basis to comment on the need for the continued use of the military to support national objectives. He spoke on the difference between peace keeping and peace *making* and how each has its place in the global situation.

Concluding the seminar were presentations by **Mike Belcher** on *Canadian Participation in Large-Scale Blast Trials*, **James Menard** on *Shifting the DPMS Toward Human-System Integration*, and **Jim MacLean** on the *Wrangel Bay Clean-up*. Cmdre Gibson gave the closing remarks, thanking the presenters and the organizing committee, thus signalling the end of the 1995 Central Region Naval Engineering and Maintenance Seminar.

In summary, the seminar was an excellent forum for those involved in naval engineering and maintenance to present topics relative to their area of expertise. Judging by the questions and comments, it also served to broaden people's horizons across a wide range of subjects, from the effects of fiscal restraint to the influences of the world political situation. Perhaps this will allow us to look at our own work with a new perspective and to appreciate the broad variety of functions that comprise naval engineering.

Greenspace: Maritime Environmental Protection

Blackwater Tanks — New Issues for Confined Space Entry

Article by LCdr David Peer

The arrival of blackwater tanks on board HMC ships and auxiliaries has led to new issues for confined space entry. The health risks posed by chemical agents, in particular hydrogen-sulphide gas, were discussed in the last issue of the *Maritime Engineering Journal*, but until recently little has been done to address the risks of biological contaminants.

Blackwater systems on our ships are self-contained and do not pose a general health risk. However, a risk does exist for workers *inside* a contaminated tank since blackwater can remain on board long enough to allow considerable bacterial growth. When organic substances and microorganisms are present in blackwater sludge it can become septic. Human feces, a major component of domestic waste, has long been implicated in the spread of bacterial, viral, protozoan, fungal and worm diseases.

The most likely modes of transmission of any of the bacterial agents are aerosol inhalation and hand-to-mouth contamination. Standard confined space entry procedures limit the risk of aerosol inhalation and proper hygiene will reduce the likelihood of oral contamination. However, workers inside a contaminated area cannot completely discount absorption through the skin, especially if the skin is cut, scraped or even sunburned. Concentrations of bacteria, viruses and parasites in sludge can never be considered truly safe.

Due to the hazardous nature of blackwater tanks, any work conducted within them is quite properly subject to regulation. Unfortunately, the existing procedures which were based on Canadian Occupational Safety and Health regulations, departmental safety policy and years of experience were not designed to protect against all hazards in a blackwater tank. No regulations and few guidelines or procedures specifically dealt with the biological hazards.

SRUA blackwater tank entry procedures

In 1994 safety inspectors from Ship Repair Unit Atlantic (SRUA) sought to correct this shortcoming by revising and developing procedures for confined space entry to blackwater tanks on board Canadian naval ships, submarines and auxiliaries. With the assistance of Canadian Forces medical authorities, SRUA developed procedures and identified personal protective equipment that would guarantee an acceptable level of risk to the health and safety of workers. The new procedures would provide better protection during inspection and better clean-up of sludge residue.

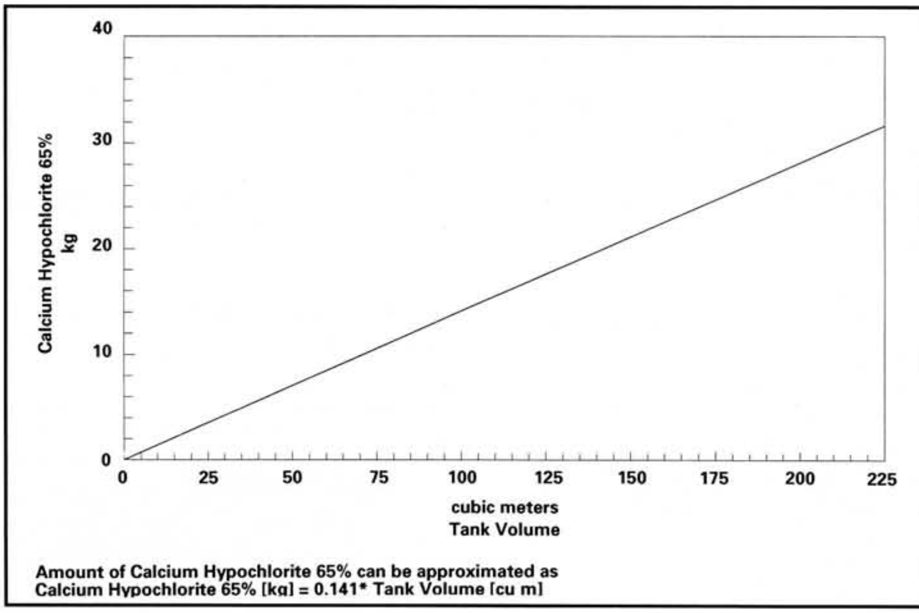

Fig. 1. Amount of calcium hypochlorite 65% required to achieve 100 ppm chlorine solution.

The SRUA safety section, with the assistance of the Canadian Forces Hospital in Halifax, modified the blackwater tank procedures recommended in the new *Naval Engineering Manual*. Where the *NEM* recommends two wash-and-pump-out cycles to clean a tank before initiating entry procedures, the modified procedure introduces an additional soak with a 100 ppm chlorine solution after the double wash-and-pump-out cycle and before space venting. The solution is left in the tank for a contact time of at least two hours to reduce the risk of biological contamination. The tank is then drained as low as possible through the distribution system, refilled with water and drained again to flush the chlorine solution.

Chlorine solution is obtained using calcium hypochlorite 65%, which is available through the CF supply system. (This is the same chemical used to disinfect freshwater tanks, except that blackwater tanks require a higher concentration of chlorine.) The amount of calcium hypochlorite required to achieve 100 ppm depends on the size of the tank (*see Fig. 1*). The solution is mixed in a pail of water to form a slurry before being introduced to the tank.

The personal protective equipment identified in the procedure is intended to protect against contamination through the skin. Rubber gloves, rubber boots, vapour masks and water-resistant chemical suits — all disposable — are worn when sludge residue is present. SRUA uses PE-TYVEK Polycoat-Yellow polyethylene-coated coveralls which conform to ANSI Spec 1985-101 and are available through the supply system.

SRUA now uses the modified entry procedure for all blackwater tanks. The CF's preventive medicine section has evaluated the procedure and determined that a significant reduction in biological activity results. When the procedure is combined with good personal hygiene workers can significantly reduce any risk to health posed by biological contaminants. A draft MARCORD based on the SRUA procedure for cleaning and working with sanitary tanks and systems is now under development for the fleet.

References

[1] C-02-040-009/AG-000, *DND General Safety Standards*, pp. 7-1 to 7A-15.

[2] L. Parmeggiani, ed., *Encyclopedia of Occupational Health and Safety*, 3rd ed. (revised), (Geneva: International Labour Office, 1983), pp. 600-604.

[3] Lt(N) K.W. Norton, "Hydrogen Sulphide Gas — A Deadly Shipmate," *Maritime Engineering Journal*, June 95, pp. 22-23.

[4] R.J. McCunney, "Health Effects of Work at Waste Water Treatment Plants: A Review of the Literature with Guidelines for Medical Surveillance," *American Journal of Industrial Medicine*, 9 (1986), 271-279.

[5] M. Lundholm and R. Rylander, "Work related symptoms among sewage workers," *British Journal of Industrial Medicine*, 40 (1983), 325-29.

[6] C-03-005-033/AA-000, *Naval Engineering Manual (Advance Notice Copy)*, pp. 4-1-17 to 4-1-20.

[7] SRUA Safety Order 3.04.7 – Procedure for Cleaning and Working in Sanitary Tanks.

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1992: Hurricane Relief Operations

...or the founding of the HMCS *Protecteur* Construction and Odd Jobs Company (International)*

Article by LCdr N. Leak, Lt(N) F.T. Tait *and* LCdr W.R. Mack

*(*Condensed from HMCS* Protecteur *post-deployment reports.)*

In the wake of Hurricane Andrew in the autumn of 1992, HMCS *Protecteur* (AOR-509) was dispatched to conduct emergency relief operations in southern Florida and the Bahamas. Under the command of Capt(N) D.J. McClean, the 25,000-tonne supply ship sealifted transport and construction materials to the stricken areas and provided naval parties to assist in the reconstruction.

The two relief efforts — in Miami, Florida (Sept. 10 to 28) and on Eleuthera Island, Bahamas (Oct. 15 to 25) — demonstrated Canada's ability to conduct effective, "non-traditional" AOR sealift operations at short notice (*see the Forum section in this issue*). The successfulness of both operations was a testament to the inherent flexibility of the Canadian Forces and to the dedication and resourcefulness of its members.

Operation Tempest in Florida was conducted as a joint operation between units of Maritime Forces Atlantic (MARLANT) and Air Command (AIRCOM) under the operational command of NDHQ/J3. Command of the Canadian contingent fell to Captain McClean in *Protecteur*. The Bahamas operation on the island of Eleuthera was also conceived as a joint effort, but this time the AIRCOM engineering units were employed only during the reconnaissance phase. The operational phase of the mission was conducted by MARLANT, with AIRCOM acting in a supporting airlift role.

Miami, Florida

HMCS *Protecteur* was formally tasked with the Miami relief operation on Sept. 9, 1992, one day before the required sailing date. Fortunately, effective liaison between NDHQ, MARCOM and MARLANT allowed the ship to interrupt a pre-refit short work period and begin contingency prepara-

HMCS *Protecteur's* LSHT Bertolo, MSHT Gagne, C2ER Barklay and LSER Ryman offload construction materials from a CF aircraft in the Bahamas.

tions on Sept. 4. This, and the solid support of the Halifax support agencies across the Labour Day weekend enabled *Protecteur* to meet its commitment.

The major challenge in the early phases of the operation was for units to become familiar with the mission requirements and with each other's capabilities. Even with little opportunity for advance planning, the units quickly formed a cohesive and effective force. The teams performed very well despite their unfamiliarity with this type of operation. For the newly formed Air Engineering Squadron (AES), the learning curve was somewhat steep as Tempest was their first operational deployment.

The Canadian relief teams plunged into the reconstruction of two storm-damaged schools — a junior high and an elementary school. The ship had embarked nearly twice the requested amount of building materials, but much more had to be purchased locally. Both buildings were re-roofed and weather-proofed, walls were reconstructed and repairs were made to the sanitary, heating and air-conditioning systems. *Protecteur*'s NE Techs even managed to salvage a $450,000 (US) computer lab.

Work days started well before sunrise and ended long after sunset, with the teams enduring 30°C (plus!) temperatures and 95-percent humidity (as they would later in the Bahamas). Workers rested frequently, drinking up to 20 litres of water per day.

Our garrison and naval combat dress quickly proved its ill-suitedness for construction work under these conditions. We even had to replace our sea boots with proper safety footwear procured locally. Ship's ball caps, approved as official headgear, became a valuable commodity for generating good will and obtaining favourable consideration for mission-related services.

Since the pace of the work could not be maintained indefinitely, a rotation schedule of site work, shipboard duty and time off was established. Many people still chose to work at the sites on their days off. *Protecteur*'s medical officer kept a weather eye for signs of heat prostration and dehydration. (The MO's presence alone had a positive effect on team morale.) A shuttle service to local beaches and entertainment centres was available, but with the long working day few people had the energy to venture ashore. The ship's infamous flight-deck swimming pool (which did *not* compromise mission resources, contrary to some reports) became a favourite place to relax prior to retiring for the evening.

Operation Tempest had its share of problems. During the initial phases command and control became an area of some confusion as NDHQ, MARLANT and AIRCOM promulgated their own operation orders. As well, supply administration, which had performed well during the preparatory phases, proved too rigid to handle local purchases effectively during the deployment. There were also some co-ordination difficulties with Base Supply, but once these problems were ironed out the reconstruction proceeded smoothly, exceeding even the most optimistic predictions.

The Bahamas

Although the first warning order for the Bahamas arrived just 18 hours prior to sailing, the experience we gained during Tempest and the working relationship we had established with the reconnaissance leader paid great dividends. Once the recce reports were reviewed it was decided that it would be well within *Protecteur*'s capability to construct four hurricane relief houses (ten would eventually be built).

Base Supply Halifax supported the mission admirably. Most of the construction material was supplied by the Bahamian government, but tools and equipment were in short supply. The construction sites also had no access to electrical power or potable water. Fortunately, these shortfalls had been identified by the reconnaissance team and a CC-130 Hercules aircraft was tasked to transport the additional supplies and equipment needed. Base Supply Halifax went to extraordinary effort with their many short-notice local purchases.

The absence of a suitable anchorage around Eleuthera Island meant we could not support the operation from seaward. Instead, *Protecteur* went alongside in Nassau to act as a command and support platform for the naval work parties. Because of the remoteness of Eleuthera from the ship, a core group of 32 people was billeted in a hurricane-damaged hotel on the island, while another 40 were flown in each day by charter aircraft. Relaxation facilities for the crew staying on Eleuthera were minimal. The hotel's pool was returned to partial service during the evenings, but people were more interested in following the World Series.

The two major stumbling blocks at the start of operations were the lack of a reliable air shuttle and inadequate communications with the deployed parties. We solved the transport problem by block-booking the daily commercial

Touring the Site (Bahamas): LCdr Leak and Capt(N) McClean discuss relief operations with the Bahamian prime minister.

shuttle and chartering local light aircraft. The communications problem, which we estimated to be costing us 25 percent of available work time, was easily fixed by procuring cellular telephones (as we did during Tempest).

Slow-ups in the preparation of house foundations by local officials left us time to help construct the components for the prefab houses. We also assisted with repairs to existing structures, the biggest problem here being deciding where to stop. A roof repair would uncover a dangerous electrical circuit, which would lead to another problem, and so on. Most of the repairs were not directly attributable to hurricane damage.

"Max Flex"

While an overall mission could be defined ahead of time, detailed planning was not feasible until the teams were on site. Naval parties were generally briefed in very broad terms as to what job was to be performed, and the unit supervisor was left to "get on with it." Control and co-ordination were achieved by roving supervision on the part of the on-site command team, which also ensured everyone was kept apprised of the overall situation.

Mission requirements were the principle drivers in how taskings were managed — requirements were never altered to fit a particular style of management. In the Bahamas, for example, reports were made using laptop computers that were hand-carried between the ship and site. This ensured rapid transmission of information and notes could be entered at any time by supervisory personnel for daily summaries, thereby reducing the need for formal daily staff meetings.

Such flexibility showed itself in another positive way, as well. The initial employment plan had segregated the ship's company into technical and general labour work parties, which very quickly created friction among the crew. The problem was defused by adopting a "best sailor" approach, whereby people's "hidden talents" could be put to best use. The radio operator who had built his own house could now bring that experience to the team, while the junior officer with limited construction skills could be better employed hammering nails than supervising. The benefits of this concept in terms of morale and crew cohesiveness were immediate. This willingness to adapt, which the navy often takes for granted, was the main reason for the extremely high morale, team effectiveness and success of both operations.

The two humanitarian relief operations had a tremendous impact on morale. The locals were generally very appreciative of the Canadian effort, and this turned into something tangible for us. A successful military exercise with high levels of simulation can be vital to a unit's effectiveness, but it is not quite the same as being directly involved in building a new home or repairing a school. Certainly both types of operations and their resulting influence on morale and team cohesiveness can be complementary with respect to improving overall unit operations.

LCdr Nick Leak was the MSEO in Protecteur from 1990 to 1993. During Operation Tempest he was responsible for on-site naval work parties and served as principle adviser to the site commander. He was the on-site commander in the Bahamas. LCdr Leak is now N42 (Engineering and Maintenance) in MARLANTHQ.

Lt(N) Rick Tait, deck officer in Protecteur from 1991 to 1992, was the on-site naval 2 i/c during Operation Tempest, and the on-site executive officer in the Bahamas. He is now serving in HMCS Vancouver.

LCdr Rob Mack was the CSEO in Protecteur from 1991 to 1993. He was the site 2 i/c during Operation Tempest, with specific taskings relating to the salvage of a new computer facility. In the Bahamas he was in charge of operations in the settlement of Lower Bogue on Eleuthera. LCdr Mack is now the Group Assistant Technical Officer for CMOG 1/7 in Halifax.

Capt. MacGougan of the CFB Halifax Base Construction Engineering section works alongside LSET Burke and Pte (Storesman) Pye.

Canadian Maritime Network

Canada's Department of National Defence (DND), Coast Guard (CCG) and Department of Fisheries and Oceans (DFO) spend considerable resources developing and maintaining an up-to-date maritime picture. Until recently, pooling their information was difficult. The three agencies do not identify vessels in the same manner, they locate ships differently (by latitude and longitude, or by zone), and they don't share a common time format (i.e. GMT or local time). On the East Coast, the three agencies all use different data formats.

The concept of a Canadian Maritime Network (CANMARNET) was created in 1993 so that existing maritime information could be pooled to optimize departmental resources. In April 1994 the Naval Engineering Test Establishment (NETE) in LaSalle, Quebec was tasked to investigate common departmental requirements for establishing such a network. At the same time, MARLANT HQ was tasked with testing an East Coast prototype network for pooling vessel information. The prototype network — a one-way flow of information from CCG and DFO to DND — proved successful. NETE identified the requirements for the joint use of data and by Dec. 1994 the Director of Naval Requirements was developing a four-phase plan to further the CANMARNET project.

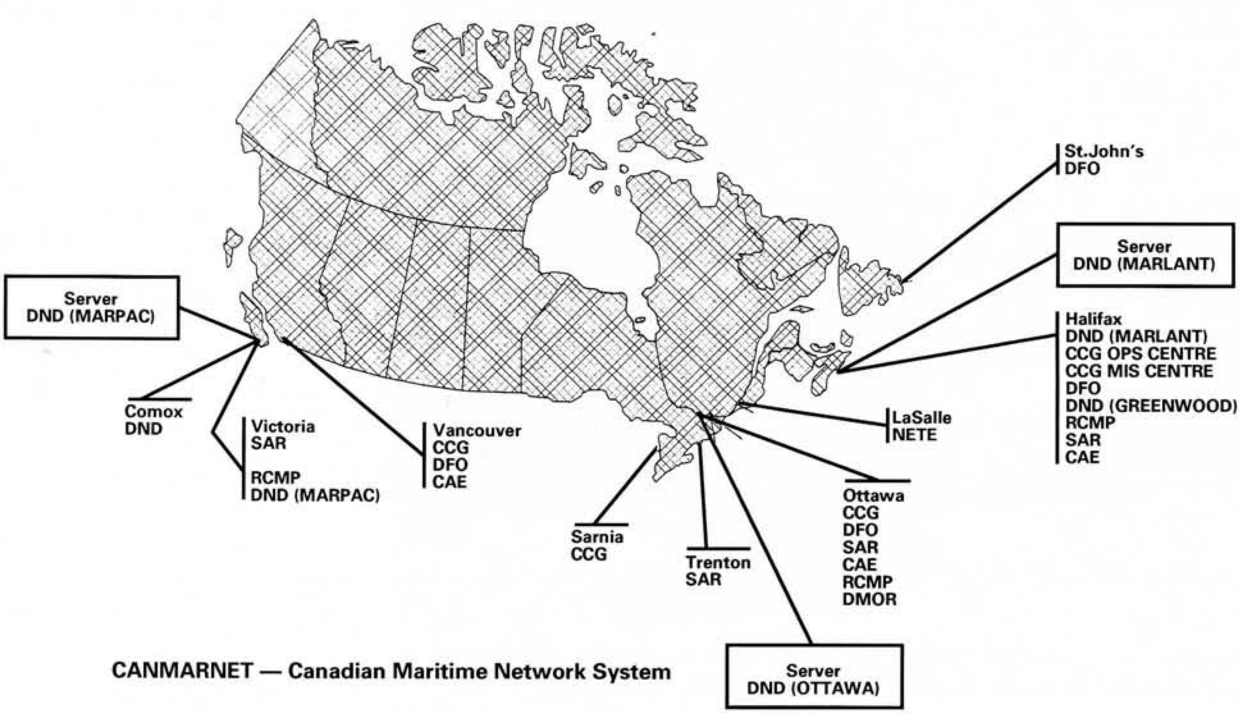
The first phase of the plan was to create an E-mail system for exchanging electronic data between DND, DFO, the Coast Guard and the Royal Canadian Mounted Police. Information could then be extracted from existing departmental networks and retrieved without translation or data manipulation. By May 1995 a EUDORA E-mail system was in place. Since CANMARNET exchanges the data in any form, unmodified, the agencies can now use their own formats and standards and there is little chance of corrupt data. The whole process is transparent to users. The system is capable of handling attachment files such as binary and ASCII, and exchanging digitized photos and graphs. As the image files become larger, however, the transmission bandwidth will have to be upgraded. Shipboard remote nodes are also being planned for Phase One implementation.

To make CANMARNET accessible to a larger number of users, one possible scenario is to connect it to the various departmental networks by networking a CANMARNET PC node (i.e. acting as a gateway) to the local site network and enabling access from any node on the network. This, however, raises questions concerning security and data classification. The current system is unclassified, but adding data from certain networks would change that. For instance, the vessel information supplied to the Coast Guard on a voluntary basis is sometimes industry sensitive. The system would have to adopt authentication devices and other protective measures.

CANMARNET of the future could include a distributed database that would allow agencies to receive real-time graphical map displays of vessel locations. The database, controlled according to a user's security classification, could be expanded to include more detailed information as required. The current E-mail system creates a foundation by encouraging user interest. The system will build on this foundation with inexpensive technological advances. — **Satya Roy, Computer Systems & Software Section, NETE, and LCdr R. Lambert, DNR 4-3.**

NETE photo lab goes digital

The Naval Engineering Test Establishment has maintained a conventional photographic laboratory in support of test and evaluation taskings for more than 10 years. In the interest of environmental friendliness, workplace safety and cost-effective operation, NETE re-



CANMARNET — Canadian Maritime Network System cently upgraded its photo lab by introducing digital photographic technology.

Since the technology is all computer-based, it does not require the use of chemical processing agents common in a conventional photo lab. Hence, chemical waste-disposal costs, as well as those associated with a clean-up in the event of an accidental discharge into the environment are eliminated. The conversion has also allowed NETE to drop more than 50 regulated products from its inventory. This negates any possibility of chemical exposure to our employees and has dramatically reduced the hazards and costs associated with the storage and transportation of dangerous goods.

The adoption of digital photography at a time when resources are shrinking is a clear demonstration of the commitment by DGMEPM and NETE to improve both the environment and the workplace, while enhancing the support services provided to the navy. – **Boyd Hamilton, Traffic & Safety Co-ordinator, NETE.**

Construction of a new NETE test cell

Since its construction in 1968, the NETE gas turbine and diesel engine test cell has been in constant demand by DND and private industry. The test cell has one test bed, and is fitted with a low-speed Froude dynamometer which has the capacity to absorb up to 9,000 h.p. Historically, the test cell has been used for major investigational and developmental programs, such as testing various diesel engines for Bombardier, the development of the Solar shipalt 308 for DMEE 2 and the redesign of the No. 1 Solar package for PMO TRUMP. The test cell is currently being used to assess a new gas-turbine combustor for the Allison 570 KF cruise engine.

The decision to expand the existing facility came as a result of the increased population of diesel engines in the fleet, and in anticipation of future work in testing diesel engine systems and subsystems. Under the auspices of DMEE a project was initiated in late 1994 to erect a second test cell adjacent to the gas-turbine test bed. The construction of the new cell was completed at the end of March 1995. The two test cells are controlled from a common elevated control room. The new test cell is 15m x 7m x 7.6m high, which is capable of accommodating any generator set in the fleet. The cell has one 12m x 3.6m test bed and a five-tonne overhead crane. It is anticipated that the cell will soon be furnished with a 2000-h.p. dynamometer, where a prime mover engine may be tested on its own. – **Ahmed Abdelrazik, Section Head, Marine Systems Investigation, NETE.**

Naval E&M Functional Review

Questions abound regarding the implications of Maritime Command's Naval Engineering and Maintenance Functional Review (NEMFR). They are being asked by military and civilian tradesmen and officers at all levels and they reflect more than a passing interest in what we are doing.

The NEMFR is a product of the pressure being placed on DND to reduce costs and of the need to re-allocate resources in line with the changing disposition of the fleet between coasts. There is a real need for the maritime commander to reduce engineering and maintenance costs and yet satisfy the navy's ongoing support requirements. The strategy to deal with this is relatively simple. The process, on the other hand, is long and anything but simple.

The strategy calls for the fleet maintenance group, ship repair unit and naval engineering unit on each coast to join to form an entirely new unit, with accompanying reductions in overhead and management. The NEUs and FMGs are not being absorbed by the SRUs, or vice versa. In essence, three separate units, each having a wealth of corporate technical knowledge, are combining to create a new and distinctly separate fleet engineering and maintenance unit (FEMU). The move will eliminate duplication of services, reduce inefficiencies, improve effectiveness and establish a "single process owner" (i.e. one CO) in each formation. "Stand-up" of the new units is scheduled for April 1, 1996.

The FEMUs will enjoy totally integrated work-forces, with military and civilian technicians working side by side toward common goals. There is certainly nothing unique about the concept. Joint mil/civ working relationships of one form or another are common practice throughout the DND. Partial integration of military and civilian work-forces is expected to begin this fall, with full integration in place by next spring. Since the changes will directly affect the employment and training of naval and civilian technical personnel, indoctrination and ongoing training are seen as key elements in establishing understanding between the two work-forces.

Teams of military and civilian representatives have been working for months to iron out areas of difficulty. Concerns relating to performance reports, the divisional system, service dress, hours of work and trade jurisdiction have been deliberated upon and resolved. For example, FEMU(A) and FEMU(P) will have well-established and clearly defined divisional systems, with civilian supervisors playing an integral role. Every effort will be made to provide military and civilian supervisors with the information and training they need to write proper assessments on their personnel.

Opposition to change is perfectly normal. Every large-scale restructuring has its pros and cons, but in the case of the NEMFR the positives will far outweigh the negatives. The navy is bringing together three extremely professional, motivated and highly trained engineering and maintenance work-forces, each having a history of pride and commitment that has grown from the single objective of keeping our ships at sea. If the FEMUs hold to the same forward-looking course that the NEUs, FMGs and SRUs have charted in the past, we have the ingredients for a long and successful relationship. — **CPO1 H.L. Benson, NEMFR Halifax.**

Merit awards!

Jim MacLean of DMCS 3 received the SrADM(Mat) merit award for "outstanding performance" during the restoration of the Wrangel Bay acoustic data gathering site on Ellesmere Island. The work was in association with the Arctic Subsurface Surveillance System Project.

LCdr Jody Curran of DMEE 7 received the ADM(Mat) Certificate of Merit for "his endeavour in developing the support and training infrastructure" for the integrated machinery control system installed in the DDH-280s and Canadian patrol frigates.

Bravo Zulu

Congratulations go out to **LCdr Ted Dochau** and **LCdr Rob Mack**. Their articles on the Forces involvement in Cambodia (*Cambodia — The Forgotten Mission*), which appeared as the cover feature in the February 1995 issue of the *Maritime Engineering Journal*, have been selected as course study material by the Lester B. Pearson Canadian International Peacekeeping Training Centre in Clementsport, Nova Scotia. The Centre was established in 1994 as a division of the Canadian Institute of Strategic Studies and is funded in part by DND and the Department of Foreign Affairs and International Trade.

MacDonald-Dettwiler Award

The first-ever MacDonald-Dettwiler Award for top MARE HOD candidate was awarded to **Lt(N) Karl Seidenz**, a communications theory instructor at CFNES Halifax. Presented at this year's West Coast naval engineering conference, the award was for the top MARE 44B/C HOD candidate for 1994. *BZ!*

Westinghouse Awards

Capt(N) J.R.Y. De Blois (DMCS) presents the Westinghouse Award for professional excellence during Phase VI (Ashore) CSE training to SLt R.D. Pederson (course 9401), *right*, and SLt M. Drews (9402), *below*. Candidates were assessed by their peers and instructors on attitude, potential, professionalism, officer-like qualities, grades, work ethic and the respect earned from classmates and instructors. Bravo Zulu to both officers. *(CF Photos by Cpl G. Andrews)*

Unisys Award

SLt D.K. Fenton receives the 1994 Unisys (formerly Paramax) Award from Unisys GSG Canada representative Capt(N) (Ret.) Bruce Baxter. The award recognizes the top CSE candidate achieving MARE 44C qualification in the previous year. Bravo Zulu to Slt Fenton and the other four finalists. *(CF Photo by Cpl G. Andrews)*