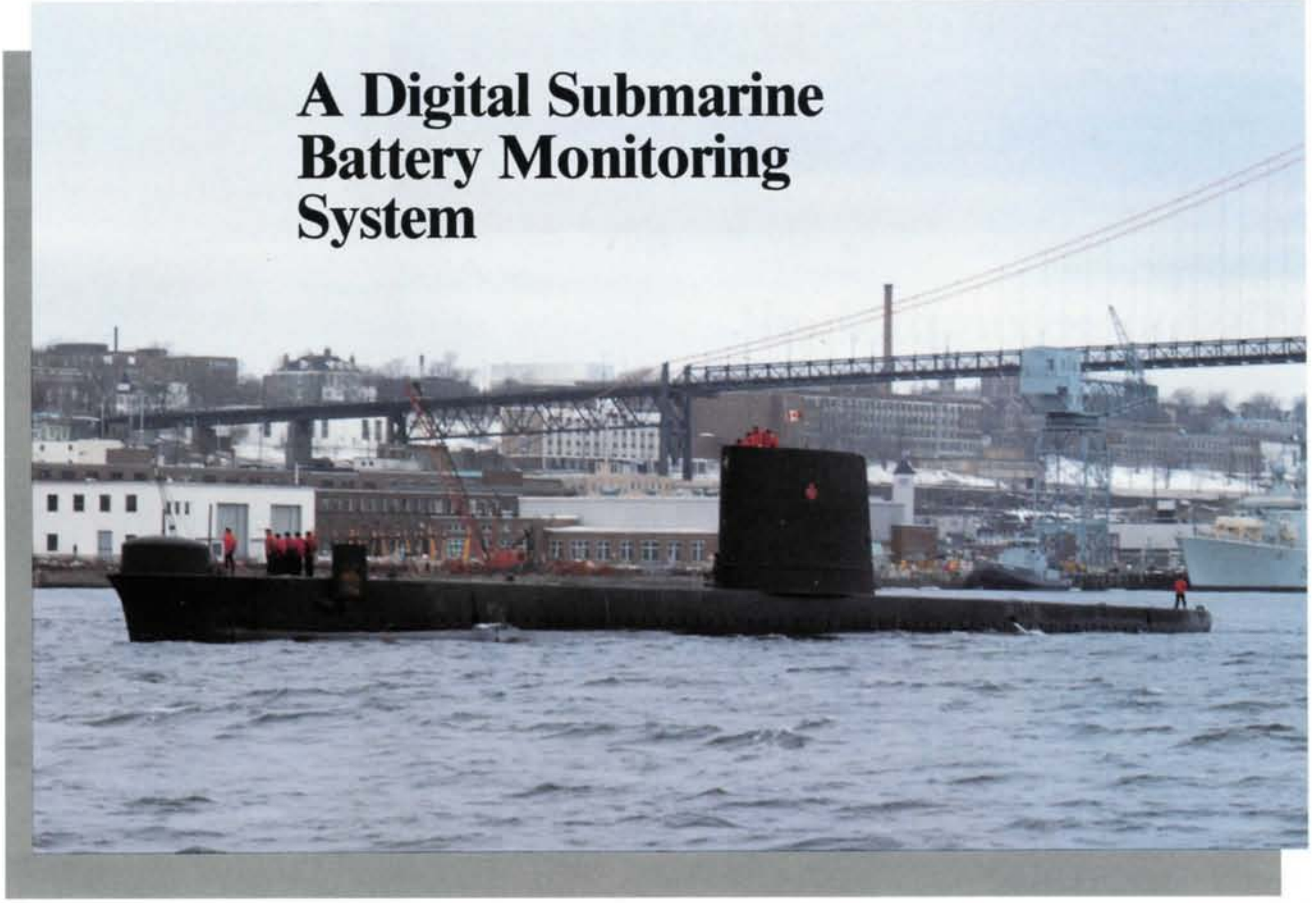
National Defence Défense nationale

Maritime Engineering Journal

October 1992

10th ANNIVERSARY ISSUE

A Digital Submarine Battery Monitoring System



Also:

- *Fibre Optics for Missile Guidance*
- *Halon Alternatives for the Canadian Navy*

Canada

PHOTO: PTE. CHRIS TUCKER, 418 SQN. EDMONTON

Mission accomplished!

American Robert Mantell, right, reported missing after dropping out from the Weber Expedition to the North Pole last May, was found 28 km north of the expedition's base camp by DREP's Arctic Acoustics Group *Iceshelf 92* personnel. Helicopter pilots Doug McArthur (talking with Mantell) and Leroy Dean (in front of the helicopter) prepare to refuel from a cache on Ward Hunt Island before returning to CFS Alert.

...page 24

Maritime Engineering Journal

Established 1982

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Maritime Engineering and
Maintenance
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OUR COVER
All three of Canada's Oberon-class diesel-electric submarines are wired for (but not with) the time-saving AN/BKK-501 digital battery monitoring system. At present, only *Onondaga* has been fitted. *(Base Halifax photo)*

OCTOBER 1992

DEPARTMENTS

FEATURES

The *Maritime Engineering Journal* (ISSN 0713-0058) is an unofficial publication of the Maritime Engineers of the Canadian Forces, published four times a year by the Director General Maritime Engineering and Maintenance with the authorization of the Vice-Chief of the Defence Staff. Views expressed are those of the writers and do not necessarily reflect official opinion or policy. Correspondence can be addressed to: **The Editor, Maritime Engineering Journal, DMEE, National Defence Headquarters, MGen George R. Pearkes Building, Ottawa, Ontario Canada K1A 0K2**. The editor reserves the right to reject or edit any editorial material, and while every effort is made to return artwork and photos in good condition the *Journal* can assume no responsibility for this. Unless otherwise stated, *Journal* articles may be reprinted with proper credit.

Editor's Notes

10th Anniversary Issue!

...with a little help from our friends

By Capt(N) D.W. Riis, OMM, CD
Director of Marine and Electrical Engineering

In the 10 years of its existence the *Journal* has grown to become what can be justly regarded as the authoritative journal of Canadian naval engineering you see before you today. It has been a tough haul at times, but never dull. Your steady supply of article submissions has seen to that. Five years ago on the occasion of the *Journal*'s 5th anniversary of publication, we expressed our view on the benefits of maintaining a professional journal. This month, as we celebrate our 10th anniversary, we feel it is an appropriate time to acknowledge the support of the people behind the scenes who have played key roles in making the *Journal* a going concern for a decade.

Producing something as complex as the *Journal* calls for a great deal of support, and in this we have been fortunate. For instance, word processing supervisor **Terry Brown** and her team have been with the *Journal* for years. In the days before writers were submitting articles on diskette, Terry's crowd (and before that, **Cathy Hunter**'s crew) keyed in an awful lot of manuscripts for us. Nowadays their involvement is pretty much limited to producing our mailing labels and, on occasion, fast tracking an article onto diskette. Less work, to be sure, but still every bit as important and deserving of our thanks. As far as translation work goes, **Josette Pelletier** at the Secretary of State's DND translation bureau has done much in recent years to accommodate the *Journal*. Thanks to her, turnarounds are quick (and always on schedule) and the quality of the translations is excellent.

On the graphics side of the house, the *Journal*'s 10-year association with **Nicole Brazeau** and her Graphic Arts section of DPGS has been both rewarding and satisfying. Under Nicole's careful management the *Journal* has weathered all manner of production headaches over the years, becoming something of a veteran in the process. The early design work of **Alan Birrell** gave our branch periodical a look that reflected the magazine's editorial message, and it is a design which we continue to build upon even today. Graphic designer **Ivor Pontiroli** took over the reins in 1985 and, since then, has worked closely with our production editor to produce what we hope is always an appealing, functional design. His experience with what works and what doesn't in page design has tempered some of our editorial zeal on occasion, but he has always come back with a *workable* alternative that is even fresher than our original suggestion for a particular layout. Ivor's "Why don't you leave it with me for a bit" is a good sign!

Over the years we have had the pleasure of dealing with a number of military photographers and base photo sections. To them we owe a debt of gratitude for their excellent service, especially on those occasions when they handled special requests for us on short notice.

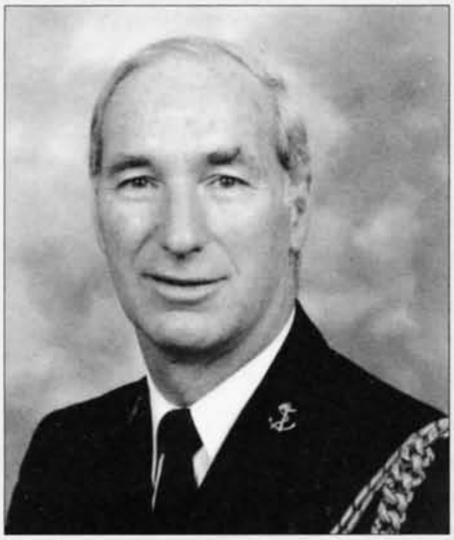
And a note of thanks and appreciation to a woman who has done more than anyone else to guide the *Journal* along the sinuous and often uncharted pathways from policy to production. Until last May **Lise Bailey** was Staff Officer (Periodicals) in the Directorate of Public Affairs, responsible for the publication of more than 40 authorized, unofficial DND periodicals. She has since moved on to editing duties in DPA, but for seven years Lise was our all-important connection to the policy-making DND Periodical Review Committee, and our contact for everything from production schedules to editor training. But there was more to her. She took a genuine personal interest in the welfare of her charges, and for this she earned the respect and admiration of many a DND periodical editor over the years. Officially she was SO Periodicals, but to us she was simply the "Den Mother." Lise has been (and continues to be) a good friend to the *Maritime Engineering Journal* and we wish her well.

Although I thanked our production editor in a recent issue, it would be totally inappropriate not to mention the work of LCdr Brian McCullough in this anniversary issue. For seven years Brian has done a stalwart job of pulling together our *Journal* and has been instrumental in developing both its spirit and high standard. Once again, thank you, Brian, for all you have done.

In closing, a word of thanks to all the people — about 200 of you at last count — who contributed articles, letters, news items, opinion pieces and story ideas to the *Journal* during the past 10 years. It is because of your efforts that we have been able to produce an engineering branch journal at all. Judging by the rate at which material continues to pour in, the *Journal* is assured of a long, thriving future. Keep sending those articles and news items our way, and we will continue to do our best to bring you a *Maritime Engineering Journal* you can be proud of.

In Memoriam

Captain(N) (Ret.) J.H.W. Knox, CD, P.Eng.
1928–1992



The naval officer's cap and sword resting on the White Ensign-draped casket told the story. It was Friday, August 14 and a sailor was going to his rest. As the six lieutenants carried the coffin up the steps of Ottawa's 160-year-old Anglican Christ Church Cathedral, preceded by a cortege of honourary pallbearers, some 200 mourners waited inside to pay their final respects to Captain Jim Knox, a family man and naval engineer who had earned the respect and admiration of his peers.

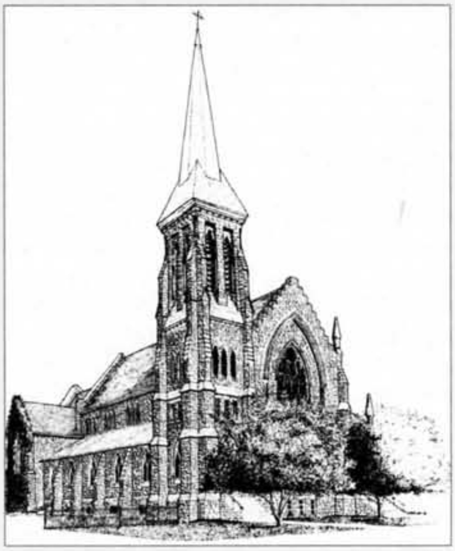
Captain Knox joined the RCN as a midshipman (E) in 1948, and during his 35-year naval career served at sea in HM ships *Victorious* and *Liverpool*, and HMC ships *Quebec*, *Huron* and *Bonaventure*. Ashore, he served as Commanding Officer of Ship Repair Unit Pacific; Director of Maritime Equipment Engineering in NDHQ; project engineer, and subsequently project manager of the FHE-400 hydrofoil program; and finally as Naval Adviser, Canadian Defence Liaison Staff, London, England. He retired from the navy in 1983 and went on to direct Ottawa operations for Saint John Shipbuilding Ltd.

Captain Knox was educated at Upper Canada College, the Royal Canadian Naval College Royal Roads, the Royal Naval Engineering College at Plymouth, the RN College at Greenwich, Queen's University, Kingston, and the Royal College of Defence Studies, London. From 1958 to 1962 he undertook graduate studies and field work in nuclear engineering at Queen's University; Atomic Energy of Canada Ltd., Chalk River; Naval Service Headquarters, Ottawa; and the Yarrows-Admiralty Research Department, Glasgow.

In 1985 Captain Knox's article "Origins of the Species MARE" appeared in the *Maritime Engineering Journal*. Some material in the article was taken from his much larger "An Engineer's Outline of RCN History," which was published in *The RCN in Retrospect, 1910 — 1968*, (1982, James A. Boutilier, ed.). He wrote the article to mark the 75th anniversary of the Canadian navy, and concluded it with a note of optimism on the future of the navy and its officer structure:

> That the process of development will continue is certain. The development will be influenced by the evolving character of the nation, by resources and by technological change. There are, however, some constraints among the influences. These include the versatility and resourcefulness of the people who are the navy, and the uncompromising demands of the sea, the element in which the navy must operate. Those responsible for the continuing development of the Canadian navy have exciting challenges to meet. They may, however, get both encouragement and inspiration if they cast an occasional glance over their shoulders as they carry the Canadian navy forward.

The *Journal* bids farewell to a fine naval officer, engineer and friend.



Letters

The CFR CSE — endangered? Maybe, but ...

Cdr Cyr's article "The CFR CSE — An Endangered Species" (*MEJ January 1992*) presented an interesting perspective on the issues of recruiting and training CSE CFR candidates. It is agreed that the branch-directed quota of an MOC composition of 20 percent is desirable, but to date has been difficult to achieve from a recruiting perspective. Some of the underlying statements and assumptions in Cdr Cyr's article, however, are based on perception and not fact, and the following corrections are offered.

The CFR entrant percentages quoted in the article lead one to believe the AERE and CELE classifications are doing much better with CFRs than MAREs. True, they may have over twice the percentage of CFR entrants, but what they do with them beyond that makes a difference. A quick check into either AERE or CELE shows that the majority of their CFRs progress only as far as major. In both cases, there are only one or two CFR lieutenant-colonels and no colonels. In the MARE classification, however, one could find at least three CFR commanders in Halifax alone, with at least that number elsewhere. And this is within a total commander population of a size slightly smaller than AERE or CELE. Relative to the other classifications, MARE CFRs would appear to have done as well, if not better, from the perspective of career progression.

In discussing his ideas about why there are so few CSE CFR applicants, Cdr Cyr stated that "officers from other classifications are brought in to serve as CSEs ... and frequently do not even undertake the basic CSE training." Fortunately, this is not the case. If it were true, then NETs might be a better source of CSE candidates. But for almost a decade all CSEs have gone through at least the CSE applications course and the afloat phase. In most cases, those who transferred from other MOCs have also done the CSE theory course to address their lack of "formal engineering background."

In his article, Cdr Cyr talks about NETs being reluctant to consider the CFR route because of two reasons; namely, length of training and perceived career limitations. The length of training issue is being addressed. With today's steady state QL5/6A candidates being only a handful of credits short of being technologists, why should they attend Camosun College for three years to become something they already are? A proposal to eliminate this training was initiated by the Fleet School Halifax CSE Division and is before the sub-MOC advisor for consideration. CFRs will now undergo identical training to their ROTP, DEO and UTPNCM counterparts who don't hold electrical engineering degrees. Therefore, once in the training stream, the entry scheme under which the CFR entered would be both transparent and irrelevant. It could no longer be said that the CFR officer was "not accepted" or "not an equal member." From a career limitations perspective, promotion is on merit and CFRs are competing with some highly capable individuals.

The proposals in the article for UTPCFR are interesting. If RMC accepts the CFR candidates for entrance into third and fourth year programs, then a new source of electrical engineers has opened up. But like their CSE counterparts from other entry programs, these CFRs would still have to complete the CSE applications course and subsequent sea time. To say that the applications course is "for the most part a repeat of what was learned in the QL5 and QL6A courses" demonstrates a certain lack of understanding of the applications course. It has been under constant revision, and following a three-year intensive effort by the MARE Training Review Board, and a four-man training development team, it addresses the broad range of applications that a MARE 44C will see throughout his career. No CFR candidate, no matter how experienced, will possess equivalent experience in the areas of weapons, acoustics, communications and tactical systems, bound together under the auspices of C^3. The applications course also provides a venue for all CSE trainees to start establishing ties with other CSE officers and the community. To cut CFRs from this course would only deny them an essential step on their route to equitable status.

Cdr Cyr states that the present program for CFR CSEs is "unchallenging and unrewarding," and that, because of their proven track record undergoing QL5 and QL6A training, those selected for CFR are "virtually ensured success" in a program such as UTPCFR. This is not, unfortunately, the case. Notwithstanding suitable academic credentials, several CFR CSEs have failed to make it through the theory course or the applications course. The fact that, by percentage, a similar number of DEO and ROTP candidates have also failed the theory course indicates that all are treated the same. Student feedback, and successful 44C board completion show that the CSE training program is in fact both challenging and rewarding. It is the CSE CFR candidates who are willing to meet the challenges and succeed who will bring the necessary mix of backgrounds and experience to the classification.

The final point of disagreement with Cdr Cyr's article is his contention that the only way to succeed as a CSE is to be a graduate engineer. This statement will come as a shock to the 15 or 20 officers who comprise about 50 percent of the yearly CSE Division throughput, and who hold a degree other than electrical engineering. Although the basic education requirement of the MARE classification may be electrical engineering equivalency, the theory course addresses academic upgrading deficiencies. Because many non-EE CSEs have progressed through successful careers, CFRs need not worry about being graduates of "only" the theory course and the applications course.

In conclusion, it is hoped that this response has presented a different perspective on the CFR CSE issue. With new training initiatives and a better appreciation of the contribution that the CFR CSE makes, we may finally see the percentage mix of CFR CSEs that we need and want in our MOC. — **LCdr Michael Williamson, CSE Training Officer, Fleet School Halifax.**

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 five-and-a-quarter-inch 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.

Commodore's Corner

By Commodore Dennis Reilley, CD

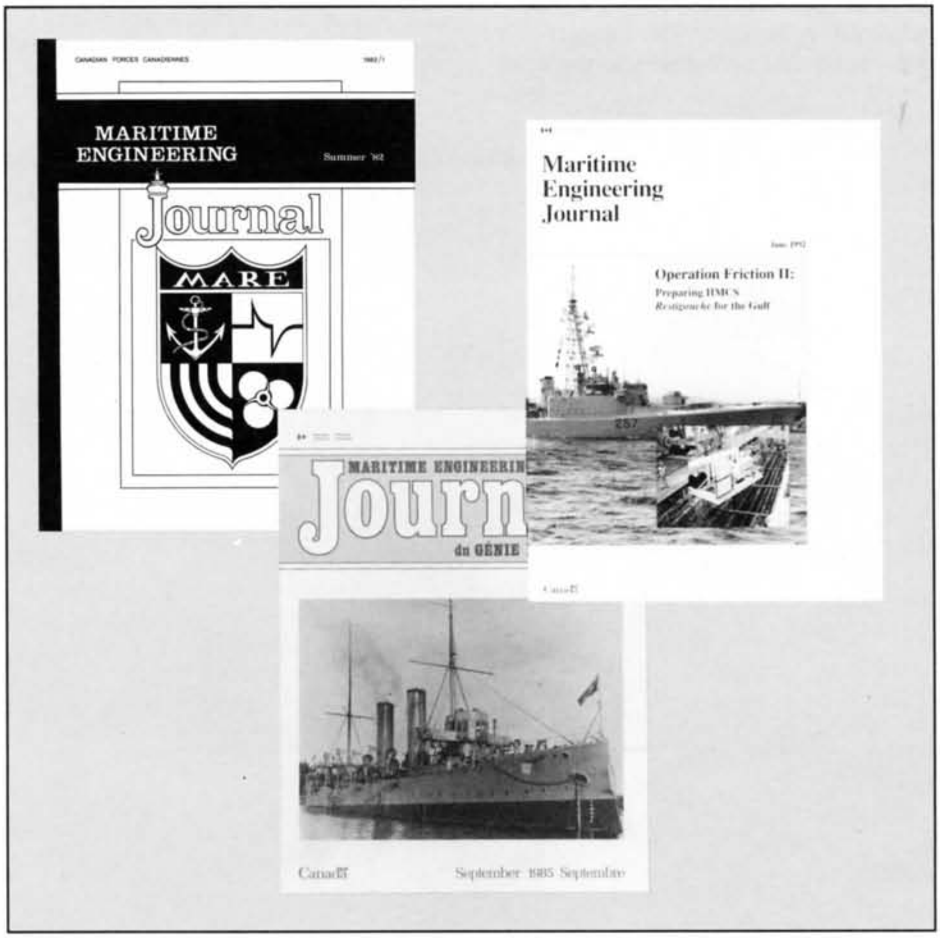
This issue will mark the tenth year of publication for the *Journal* and I have been asked to comment on its genesis. I undertake this request with a great amount of pleasure. However, I will broaden my remarks, as this will likely be my last opportunity to contribute directly to the *Journal* in this manner.

Back in 1977 the then Commander Maritime Command Vice-Admiral Andy Collier (now regrettably deceased) suggested in an issue of the *Maritime Warfare Bulletin* that there was a need for officers of all persuasions to contribute to the professional naval dialogue in some form of unclassified publication. At that time I was vice-commandant of Royal Roads (one of my several "green" incarnations) and I both sought and devoured any document that would sustain my naval and engineering interest. Short of perusing *Periodic Engineering Letters* there was little to feed my interest in marine engineering. Andy Collier's comments had struck a chord.

At that time naval engineering was in a very fragile and somewhat demoralized state. The Combat Systems Engineering subclassification was very recent and needed nurturing. Marine Systems Engineers were seen to be anachronistic in their predominantly steam pursuits. There was no focus to unite the CFRs (Constructors, MSEs) and postgraduate officers (Naval Architects, Dagger Es and so on) with the main stream. Perhaps most significantly, naval engineers perceived themselves as being the lesser among equals within the naval community. This was exacerbated by the tendency of engineers to play a passive consultative role rather than to actively participate in the professional naval debate and, more importantly, influence their own future. Something had to be done.

Between 1977 and 1980 (by which time I had become the Director of Marine and Electrical Engineering at NDHQ) I tried unsuccessfully several times to interest the *Maritime Warfare Bulletin* in embarking on a broader mandate that would support an unclassified version with engineering input. Some readers might recall the late seventies to early eighties was a period of intense professional reorientation, with engineers becoming eminently more involved in their own development. The MARE Study was one such activity. Another was the advancement of the digital integration concepts of SHINCOM, SHINMACS and SHINPADS. These projects would propel the navy to the leading edge of technology and, hence, capability, forcing a technological reorientation of MAREs toward the future. The advanced technology also forced a systems approach to our work and, indeed, has provided a common bond of understanding not only among all MAREs, but within the naval community as well. During this period the naval engineering community undertook other proactive branch adviser initiatives, such as the METTP which is just now bearing fruit ten years later as the TRUMPs and CPFs are coming on line. METTP and other personnel development programs modelled on it were very timely and have led, in my view, to what is the most capable body of naval technicians and technologists in the world.

Although the climate in 1980 was ripe for undertaking a professional MARE journal, the task of getting one going was not as easy as one might imagine. We in DGMEM at the time were not only involved in the initiatives just mentioned, but were also very heavily into developing the CPF specification; DELEX was in full swing, TRUMP was in its initial stages, the Oberon-class life extension was ticking along and we were somewhat distracted by



the Y-100 boiler fix which had "grounded" the fleet. On top of all this the NDHQ staffing situation within the naval community had not yet benefitted from the additional positions which would later flow with approved programs.

Development of a journal was supported by the director general of the day (Commodore Ernie Ball, also now very regrettably deceased) and the other three DGMEM directors besides me — Capt(N) Mac Whitman, Capt(N) John Gruber and Mr. George Blackwell. In usual fashion, the one who suggested the idea (me, in this case) got to implement it. Also in usual fashion, I delegated the task as a collateral duty to an already heavily loaded officer, but one who I knew would get the job done — Lt(N) "Robbie" Robertson.

Robbie had to accomplish four things before we could go into production — produce a model, obtain funding, define the editorial policy and solicit input for publication. Models for a branch journal already existed. As I recall, the ones which most closely approximated our version were the MILE and CELE periodicals. Because these and other works existed, the powers that be could hardly refuse a MARE initiative. However, funding was very tight and we had to plead our case somewhat over a period of about a year before getting approval. The editorial policy submitted by Robbie was approved with some adjustment by the *Journal*'s editorial board (DGMEM and the four directors) and remains largely unchanged to this day. Finally, we appointed "agents" in Halifax, Victoria and Ottawa to solicit input from their respective jurisdictions for publication. In reality, there had been very successful MARE conferences in 1980 and 1981 which provided a wealth of papers ready and waiting to be published. Professional input was not a great problem. Because I had started it all, DMEE was named editor-in-chief — an appointment still held by present incumbents.

While Robbie Robertson performed excellent work in pulling the package together, others attended to the myriad details involved in producing our first issue. Most notable was LCdr Ron Rhodenizer (now retired) who organized everything from articles to graphic arts assistance to distribution. And there were others. Like James Mimnagh, a resource manager in DGMEM/RM, who took on the task of proofreading the *Journal* during the critical early years up until 1984. LCdr Brian McCullough, who in those days was the DGMEM training co-ordinator, was active with the *Journal* virtually from the outset. He had advised Lt(N) Robertson on the initial production specifications for the magazine and, beginning with the second issue, helped out as a copy editor. He took over as full-time production editor in 1985 and remains so to this day, much to the benefit of all. The first issue was published in the fall of 1982 after I had moved on to Cornwallis as base commander. I am grateful for the manner in which now Commodore Eion Lawder, my relief at the time, picked up the traces, drove the first issue through to final production and nurtured the *Journal* during its early years of publication.

The *Journal* is now published in French and English and is both widely read and appreciated. Perhaps of greatest pleasure to me is that the *Journal* draws letters and articles from the entire naval community (MARE, MARS and civilian). In this context, I would hope that Naval Logistics and Training Development officers recognize the contribution they could make to the *Journal*, particularly in the area of integrated logistics.

My early fears that the *Journal* would become an insular periodical have, thankfully, proven unfounded as we have maintained a focus on the naval part of our profession. Well done and keep 'em coming for another few years at least!

Commodore Reilley was appointed Canadian Forces Naval Attaché in Washington in August.

A Digital Submarine Battery Monitoring System*

By Robert Laidley and Ralph Storey

***Condensed from a paper presented at the RINA Warship '91 Symposium on Naval Submarines held in London 13-15 May 1991.**

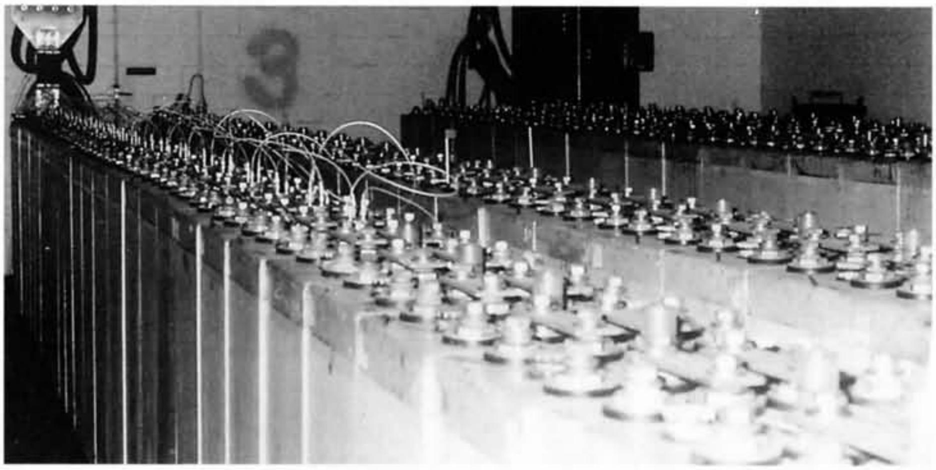


Fig. 1. Between 10 and 20 percent of the displacement weight of conventional submarines is carried in batteries. Canadian Oberon submarines typically carry two 224-cell batteries which may be operated either in series or in parallel.

Introduction

Diesel-electric submarines rely on large lead-acid batteries for their propulsion and hotel-load energy requirements when operating below snorkelling depth. Without a sufficient charge these batteries become just so much ballast, and the submarine becomes just another surface vessel (with poor defence and seakeeping capabilities.) Maintaining the battery cells and knowing at all times the state of the charge are therefore critical to a submarine's safety and its ability to meet operational requirements.

Unfortunately, submarine battery monitoring is a labour-intensive process. Canadian Oberon submarines typically have 448 cells interconnected into two batteries (*Fig. 1*) which may be operated either in series or parallel. The present monitoring system consists of using hydrometers to manually determine the electrolyte density in two of the 448 cells every two hours and in all cells every two months. In addition, the electrolyte level in all cells is visually checked every week. Overall battery voltage and charge/discharge current are monitored and recorded at appropriate intervals.

Some diesel-electric submarines use analogue instruments to monitor the voltage of all battery cells, but here too the process is laborious. Moreover, the effectiveness of the analogue instruments is bounded by their inherently limited accuracy. What is needed is a *digital* battery monitoring system that will allow submariners to know the full status of all cells on demand.

In 1991 the Canadian navy installed just such a system in HMCS *Onondaga*. Developed by the navy and SPD Technologies of Philadelphia, the computerized SPD BMS-100 battery health monitoring system continuously monitors four parameters on all 448 cells, monitors the flow of electrical energy into and out of the batteries, and provides complete information on battery health and charge/discharge capability. The system also allows for rapid calculation of the "time to run" before exhausting batteries (based on battery condition and an operator-selected discharge rate and time).

Background

In 1986 the Canadian navy began investigating new monitoring systems developed in Germany, Israel, the United Kingdom and the United States. Although some showed real promise, not one of these systems had been installed in an operational submarine. What was needed was a system that combined the best features of all the systems.

In 1989 SPD Technologies of Philadelphia was contracted by the Canadian navy to design and supply a computerized submarine battery health monitoring system for installation in HMCS *Onondaga*. The system (*Fig. 2*) has been assigned NATO designation AN/BKK-501. The contract described the parameters that were to be monitored as well as the computations to be provided. The parameters to be monitored were:

a. cell electrolyte level;

b. cell electrolyte specific gravity;

c. cell electrolyte temperature;

d. cell voltage;

e. battery overall voltage; and

f. battery charge or discharge current.

All the information was to be displayed in real time and was to be printed for logkeeping. To be included in these displays was a bell curve of the number of cells at each cell voltage. The system was to calculate, display and record the ampere hours charged, discharged and owed using a charge (efficiency) factor. Also, based on the battery voltage and discharge current, the system was to calculate the time to run at the present discharge current and at any input future discharge rate.

The contract also specified the environmental conditions for shock, vibration, temperature, humidity and EMI/EMC. Detailed design of hardware and software components was conducted co-operatively by SPD Technologies and DND during the two-year contract period.

AN/BKK-501 Monitoring System

The SPD BMS-100 battery health monitoring system for the "O" Boat consists of two communication links each containing 224 battery probes, an interface module to interrogate the links and a host computer.

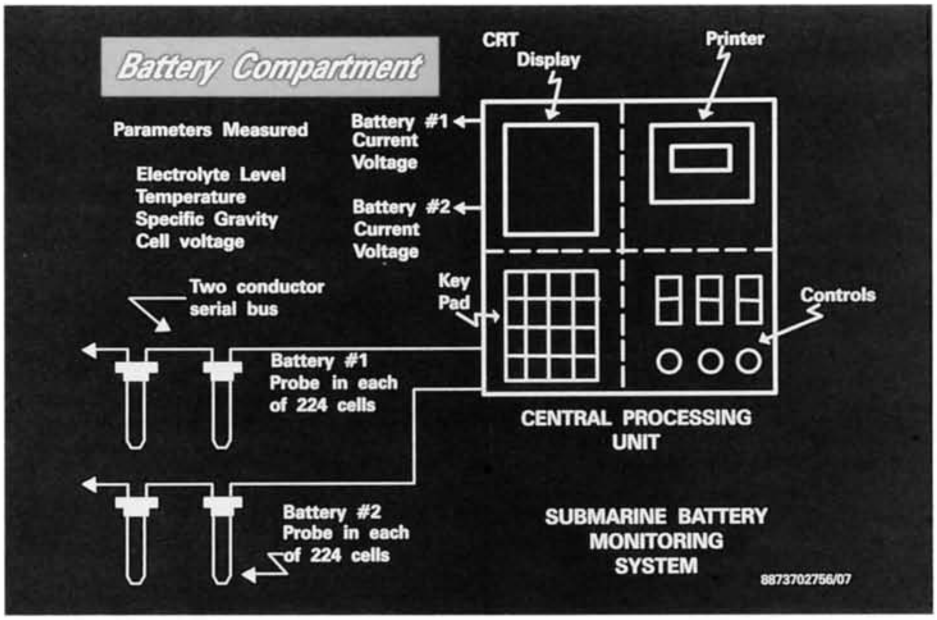


Fig. 2. The AN/BKK-501 Battery Monitoring System

Fig. 3. Battery Sensing Probe

Sensing Probe

The sensing probes for each of the battery's 448 cells are powered by the individual cells. Each probe is approximately 12 inches long (*Fig. 3*) and fits almost entirely inside the cell, with only the cable connection enclosure protruding several inches out of the top of the cell (*Fig. 4*). Each probe contains the following sensors:

a. Six discrete density floats (range = 1.000 - 1.320 g/cm^3; accuracy = +/- 0.002 g/cm^3);

b. Electrolyte temperature detector (range = -5 to 75 deg C; accuracy = +/- 1 deg C);

c. Level sensor (Low/OK);

d. Voltage sensing (range = 1.000 - 3.000 volts; accuracy = +/- 0.01 volts).

The probe electronics consist of an analogue-to-digital converter, a microprocessor, memory, power supply and communications interface. Should a probe fail, a latching relay will shunt it out of the circuit and an LED in the top of the defective probe will activate.

Communication Links

A two-conductor shielded cable connects each probe in a series link with the interface module located in the central control unit. There is one link for each of the two batteries of 224 cells. All communications from the interface module to the probes and back to the interface module travel one way, with the data being passed from probe to probe. Incoming and outgoing communication cables are connected to the probe through plug connectors so that a defective cable or probe can be easily replaced or jumpered out. Optical isolators in each probe's communication circuit reduces the transmission of electrical noise.

Interface Module

The interface module is located in the central control unit and interrogates the probes by transmitting a request for data. The command is passed from probe to probe, with each one adding the requested data from its memory. The last probe passes on the original command and the data from each probe to the interface module. The address of any probe which fails to answer is also noted. The interface module also communicates with the battery switchboard to collect data on overall battery voltage and charge/discharge current. This data is processed and stored by the interface module (which operates autonomously from the host computer most of the time).

Host Computer

A host computer in the central control unit provides the operator-system interface. Battery cell parameters are updated every 30 seconds, or when requested by the host computer/operator. Under normal conditions the computer monitors operating parameters (for electrolyte temperature, density and level, as well as cell voltage) in all 448 cells and alarms and prints a report whenever any preset parameter is exceeded. (The limits are a percentage of the average value of all the cells.) The system will also alarm and report any self-failures. When the cause of an alarm is corrected or self-corrects, this too is recorded by the printer.

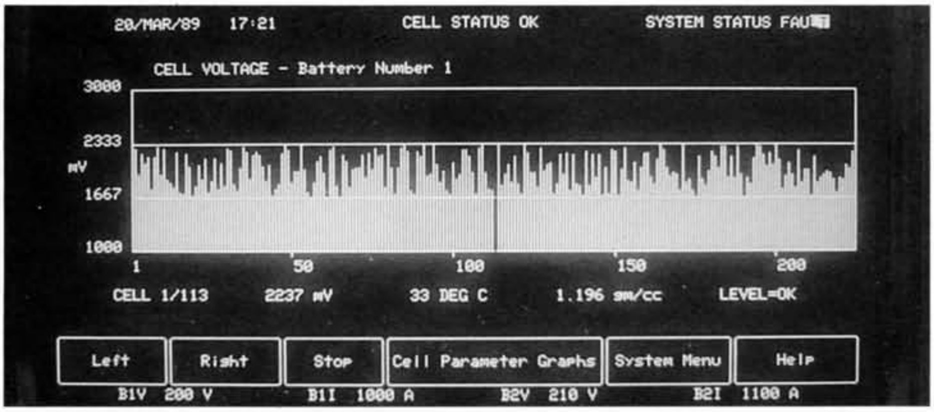
Fig. 4. A battery probe installed in a cell.

System Display

The operator interface with the system is through a menu-driven electroluminescent touchscreen display. The screen always displays both of the batteries' voltages and charge/discharge currents as well as system and battery status. The interface screen, communication system and printer are all enclosed in the control module.

On start-up, the main menu offers the operator the major functions of the battery monitoring system:

> ***Battery Status*** — information on the ampere hours charged, discharged and owed to fully charge the battery;


20/MAR/89 17:21 CELL STATUS OK SYSTEM STATUS FAU

CELL VOLTAGE - Battery Number 1

CELL 1/113 2237 mV 33 DEG C 1.196 gm/cc LEVEL=OK

B1V 200 V B1I 1000 A B2V 210 V B2I 1100 A

Fig. 5. Cell voltage bar graph

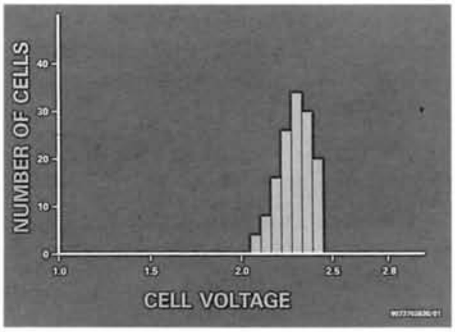


Fig. 6. Cell voltage distribution curve

Cell Parameter Graphs — a submenu of graphic displays of voltage (*Fig. 5*), temperature, electrolyte level and specific gravity/density for all battery cells;

Cell Voltage Distribution — (*Fig. 6*) a quick and effective graphic method of determining the health of the overall battery. Represented as a bell curve, the narrower the bell, the less the spread in cell voltages and therefore the better the health of the battery;

Faulty Cells — a faulty cell/system indicator on the main menu; printout and fault table provide full details on location, extent and status of the fault; and

Time-to-Run — determines and displays the length of time the boat can operate at present or anticipated speeds before the battery is discharged. Battery performance for a series of future manoeuvres at different discharge/power levels and durations can be determined.

The display also offers a system self-diagnostics function for on-line testing, and help screens for menu items. A keyed access input function allows system configuration and default data (eg. parameter fault-level alarms) to be entered or modified. The main menu also contains a print function to produce hard-copy reports of cell parameter values, battery cell voltage distributions and faulty cell data.

Conclusion

The AN/BKK-501 submarine battery health monitoring system provides real-time status reports which will enable a crew to better maintain the battery and its associated systems. Also, the accurate and instantly available data on time to run will be of significant value for the tactical operation of the submarine. The recorded battery data will be useful to design engineers and battery manufacturers. One system modification currently under way is the addition of a disk drive for automatically logging parameters at regular intervals and when conditions change.

Prior to its installation in an O-boat, the system underwent extensive trials, debugging and modification in the Halifax battery shop. Trials were satisfactorily concluded and the system is now installed and operational in HMCS *Onondaga*. The boat's operators are already so confident in the AN/BKK-501 battery monitoring system that they would like to discontinue manual logkeeping. Nonetheless, the system is being operated in parallel with manual logkeeping of battery readings for at least the first year. Should the AN/BKK-501 continue to meet expectations, it could provide a model for all future submarine battery monitoring systems, including those for the small, emergency battery system in nuclear-powered submarines.

References

[1] CF Technical Order C-24-521-000/MS-002, *Technical Manual for a Propulsion Battery for the "O" Class Submarine*, December 1988, produced by Varta Batterie AG for the Canadian navy.

[2] CF Technical Order C-24-556-000/MS-001, *SPD BMS-100 Battery Health Monitoring System Technical Manual*, June 1989, produced by SPD Technologies for the Canadian navy.

Robert Laidley is an electrochemical engineer in DMEE 6.

Ralph Storey is the former DMEE 6 senior engineer for shipboard electrochemical and electrical motor-drive propulsion systems. He is now senior engineer for Tribal-class systems in DSE 7.

Fibre Optics for Missile Guidance*

By LCdr "Rogie" Vachon

***Adapted from the author's MSc thesis paper: "Long Haul Fibre Optic Bidirectional Communication Link for Guided Missile Systems," by LCdr W.F. Vachon, RMCS Shrivenham, U.K. November 1989.**

Significant growth in the demand for guided weapons over the last twenty-five years has pushed the development of these systems to the forefront of military technology. Missile guidance requirements have become so complex that engineers today must regularly look to what might be called "ambitious" solutions to meet specific requirements. As always, though, the feasibility of any new system depends as much on the merit of its financial considerations as on the strength of its technical plan.

In their search for new guidance systems engineers and scientists have been hampered by the inescapable fact that guided-missile systems are expensive. Enormously so. An autonomous missile system, for example, commands a huge price because the missiles' sophisticated onboard computers, autopilots and signal processing equipment are lost with each round fired. It all comes down to how much system you want to pay for.

The search for a sophisticated, yet inexpensive, guidance system that is immune to electronic countermeasures has been a major preoccupation with engineers, and for the most part fruitless. But things have changed. The recent exploitation of fibre optic technology has thrown just such a system into the arena — the fibre optically guided (FOG) weapon.

Optical fibre is used routinely throughout the telecommunications industry as an inexpensive, high-bandwidth, lightweight communications medium. But now that high-strength, ultra-low-loss fibre the thickness of a human hair is available in continuous lengths of tens of kilometres, it has become increasingly appealing for application in long-range missile communication systems. The use of optical fibre as a transmission medium and, more specifically, as a guidance data link between launch platform and missile allows the tactician to achieve critical aims in battle. FOG missiles can be used to:

a. pinpoint and engage targets with minimum reaction time;

b. engage over-the-horizon targets;

c. locate a target's point of maximum vulnerability to maximize weapon effectiveness;

d. counter the threat from cruise and other anti-ship missiles; and

e. collect valuable intelligence during flyout.

A guided missile system, with a secure, bidirectional fibre optic communication link between the missile and ship, provides accuracy and flexibility, with considerable advantages (including cost) over other guidance methods.

The Pros and Cons of Fibre Optic Communication Links

An optical fibre transmission medium has significant advantages over wire or RF command links. For example:

a. a wide usable bandwidth, allowing high bit-rates (Gbits/s);

b. resistance to electronic countermeasures (ECM), i.e. it cannot be jammed or spoofed and does not emit electromagnetic radiation;

c. new lightweight and small-diameter uncladded fibres provide low volume for longer range missiles;

d. minimal operator hazards — the fibre insulates against water and power lines;

e. small bending radius is possible;

f. negligible crosstalk;

g. high tensile strength compared to wire;

h. bulk material costs are lower than other media such as copper;

j. high-tensile rotary couplers are now available;

k. reduced limitations on missile speeds in comparison to wire-guided missiles. Optical fibre can be despooled at speeds up to 682 metres per second — Mach 2;

l. more efficient laser sources with higher output power and smaller spectral widths are available, making long-range FOG missiles practical; and

m. system flexibility for planned product improvement.

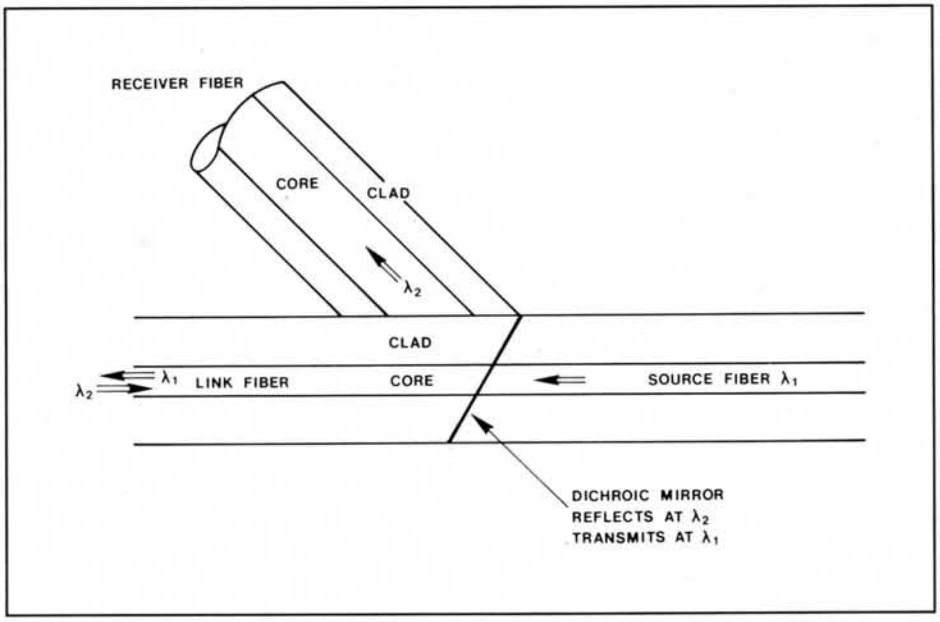


Fig. 1. An Optical Fibre Dichroic Coupler

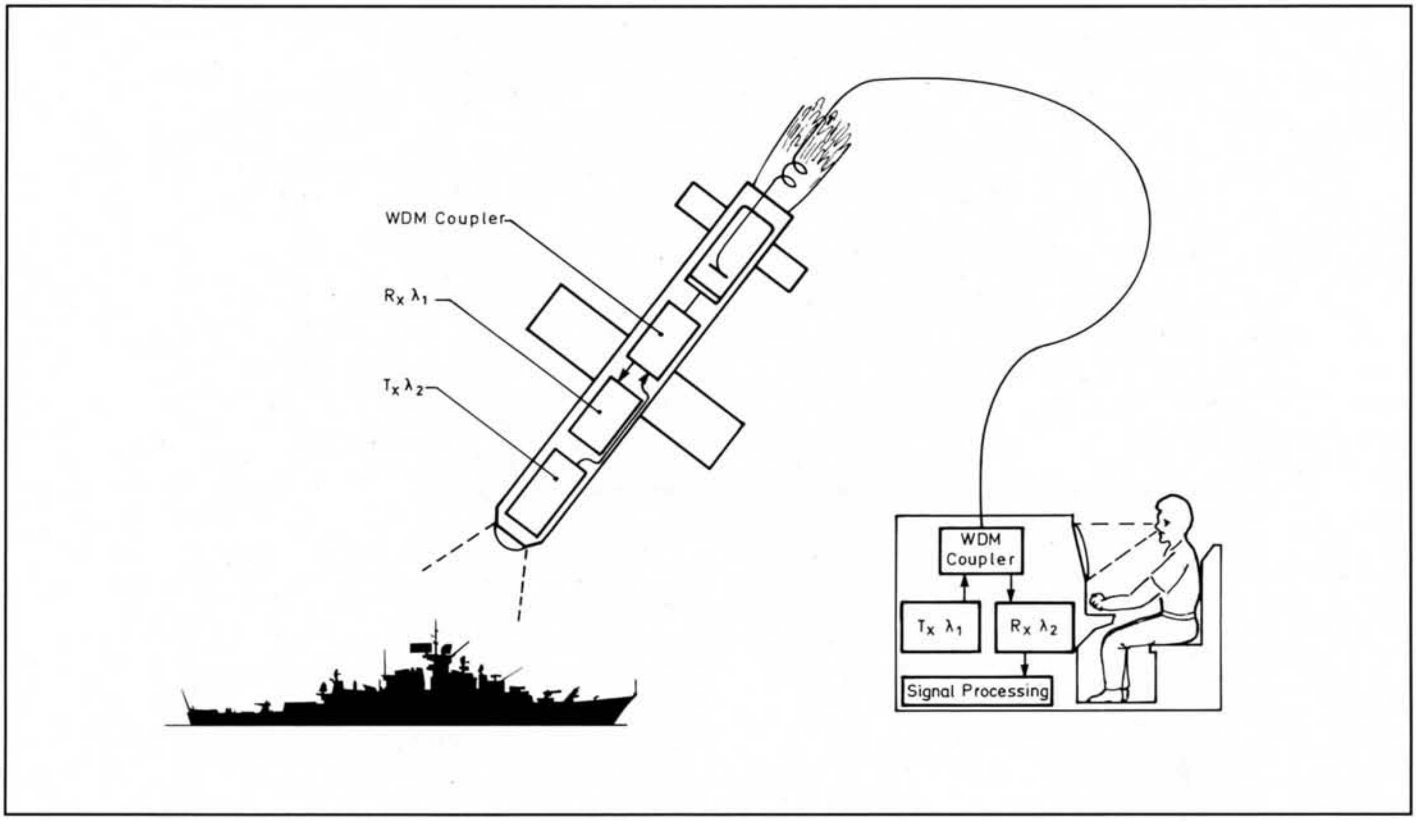


Fig. 2. Fibre Optic Bidirectional Communication Link

Disadvantages include:

a. susceptibility of the fibre to water seepage where hydroxyl ions can reduce efficiency. This is of concern for long-term storage and would necessitate controlled climatic conditions provided by a container;

b. fibres are not suited to multi-access use, making it difficult to implement multi-access data bus. Each firing channel needs a dedicated fibre optic link; and

c. not suited to anything greater than binary signalling.

The most fundamental advantages of fibre optics over wire are its wide bandwidth and its immunity to electronic countermeasures. The increase in fibre optic data transmission capacity and decrease in fibre volume and mass are considerable improvements over wire guidance. Also, depending on the design of the missile's propulsion system, the fibre optic cable may even be despooled through the missile's efflux[1] (exhaust). But the most important advantage in the guided-weapon context is the practical application of positive guidance over long ranges, at minimal cost, with minimal susceptibility to ECM.

The FOG Missile

Consider the FOG missile with an effective range of 50 kilometres. A single-mode optical fibre would be needed to support bidirectional communications between the ship and missile, using time-division multiplexing (TDM) to sequence the information into data words for transmission. Although the uplink and downlink are transmitted at two different wavelengths, they are able to function simultaneously through wave-division multiplexing (WDM). Dichroic couplers designed to be transparent at one wavelength and reflective at the other (*Fig. 1*) preserve the message integrity of each optical carrier for subsequent conversion to an electrical signal.

The downlink from the missile consists of a video signal from either an imaging infra-red (IIR) or radar seeker (*Fig. 2*), and signals from the missile's sensor monitors. At the same time, a lower data-rate signal comprising several command channels is uplinked to control the missile's flight. The video image is presented on the operator's screen for target identification, weapon assignment and possible intervention. The system has the capability of being completely automated, but can be controlled by an operator "flying the missile on a joystick" during the terminal phase of the missile's flight.

Bidirectional Signal Processing

Shown in more detail (*Fig. 3*), the key components that convert electrical signals into light energy and vice versa are the modulators and demodulators in the electro-optical transceivers. The uplink begins with a number of pulse-code modulated command data words (the output of the analog-to-digital converter). These words are fed into the TDM to generate a coded bit-stream that is, in turn, fed to a laser modulator to produce the optical signals for transmission. The optical signals are reflected up the optical fibre via the coupler to the missile. The optical bit-stream is then demodulated and subsequently detected by an avalanche photo-detector (APD) sensitive to the wavelength of the corresponding laser transmitter. The signal is decoded before being demultiplexed and converted (digital to analog) for the seeker and autopilot circuits.

Simultaneously, video optical pulses together with sensor and seeker data are downlinked to the ship at approximately 360 Mbits per second. These words contain data resulting from the monitoring of control surfaces, seeker position and missile attitude, and are sent to the multiplexer to be combined with the video. From this point the signal processing is similar to that of the uplink. On board ship

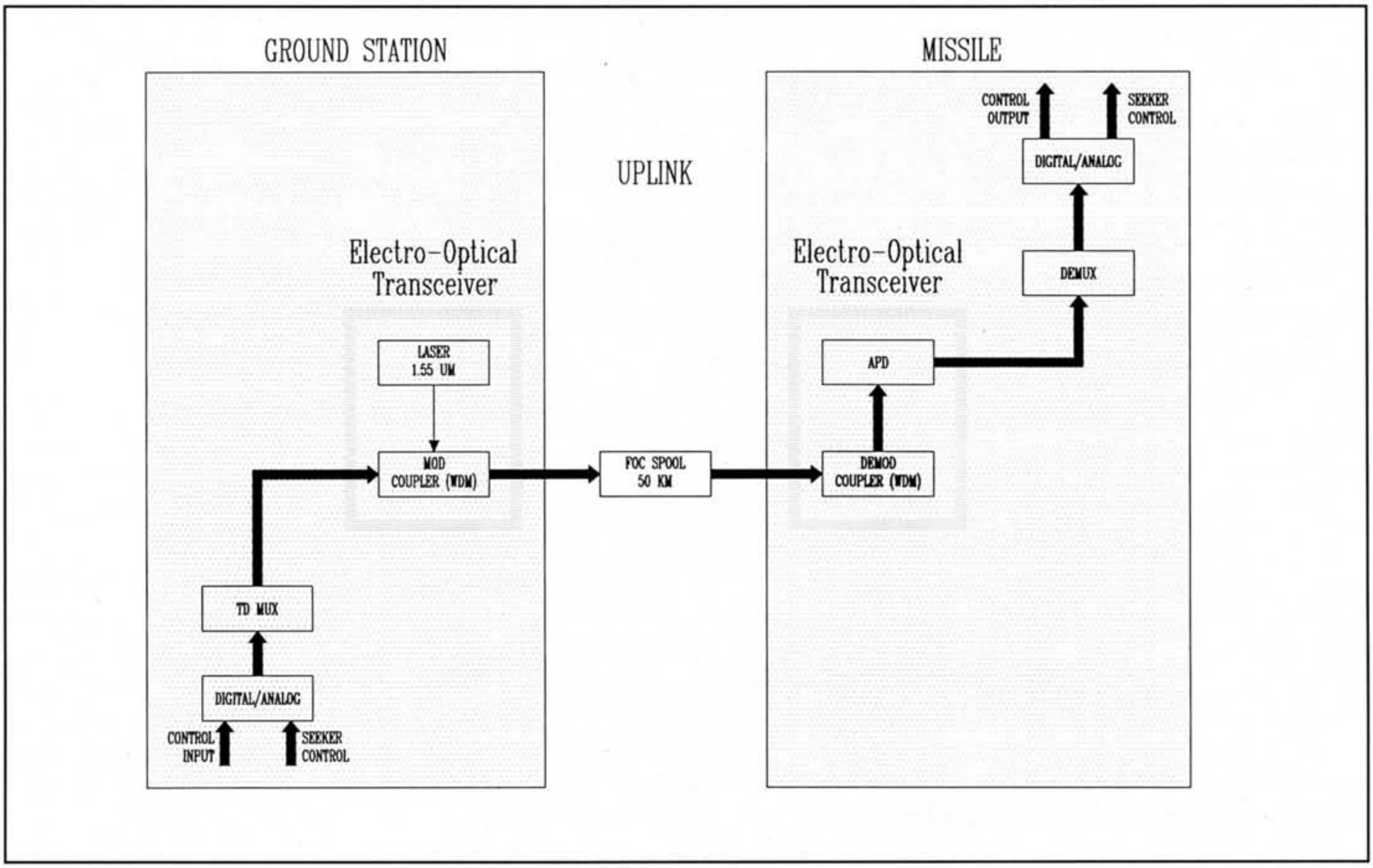


Fig. 3. Key Components in the Electro-optical Path

the video is presented on the operator's display, while the sensor signals provide feedback for the autopilot.

Bobbin Winding and Packing

Winding optical fibres the thickness of human hair onto a bobbin is a highly technical and critical process. Two methods are considered by industry to be the state of the art — "cotton reeling" and winding by "orthonormal precision" (*Fig. 4*). The type of fibre packing, whether it be tapered with variable pitch angles or square-packed (*Fig. 5*), is also critical when minimization of signal attenuation loss is essential.

Each of these methods for winding and packing has its advantages, depending on the specific application, but the combination of orthonormal precision-wind and square packing seems best for missiles requiring longer lengths of fibre optic cable. Although this format is difficult to achieve, the bobbin volume and signal attenuation from pressure stresses are kept to a minimum. It is also extremely critical that the correct despooling tension be maintained on the fibre. Too little adhesive holding the fibre optic cable onto the bobbin will cause the cable to despool too rapidly and snarl; too much adhesive and the minimum bending radius (and therefore the fracture toughness) of the fibre will be exceeded.

Advances in the construction of small-diameter fibre cable offer hope for significant space- and weight-saving benefits. For example, compare the bobbin dimensions of two fifty-kilometre cables for use in a missile having an outside diameter of 216 millimetres (*Fig. 6*). One cable is 250 microns in diameter, the other a newly designed[2] 170 microns. Each has been orthonormally wound and square-packed, but note that the bobbin length of the 250-um cable is more than twice that of the 170-um cable. Without the smaller fibre design and, hence, the smaller bobbin in this computer-generated example, significant design changes to the missile would have been necessary.

Fibre Optic Link Survivability

The single most-often asked question is, "Won't the fibre optic cable break?" In fact, documented results show that the fibre optical communication link experiences a lower breakage rate than a wire link.[3] Should the cable settle back to earth while the missile is still in flight the communication link could be disrupted. However, the settling rate in still air for a 170-um cable has been calculated to be in the order of 0.7 metres per second. Considering the flight profile of a missile

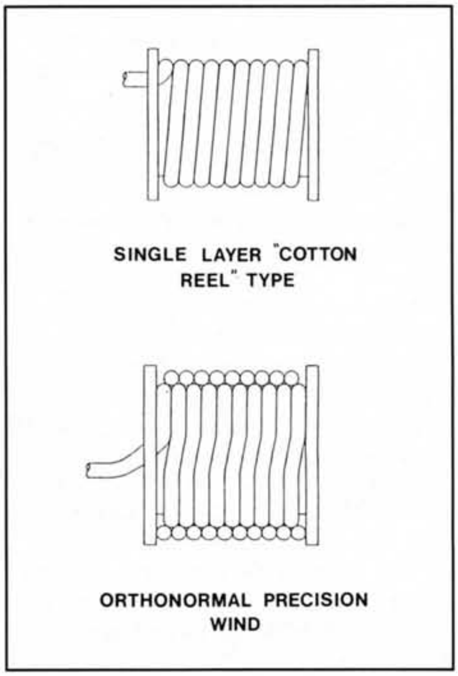


Fig. 4. Dispenser Coil-winding Types

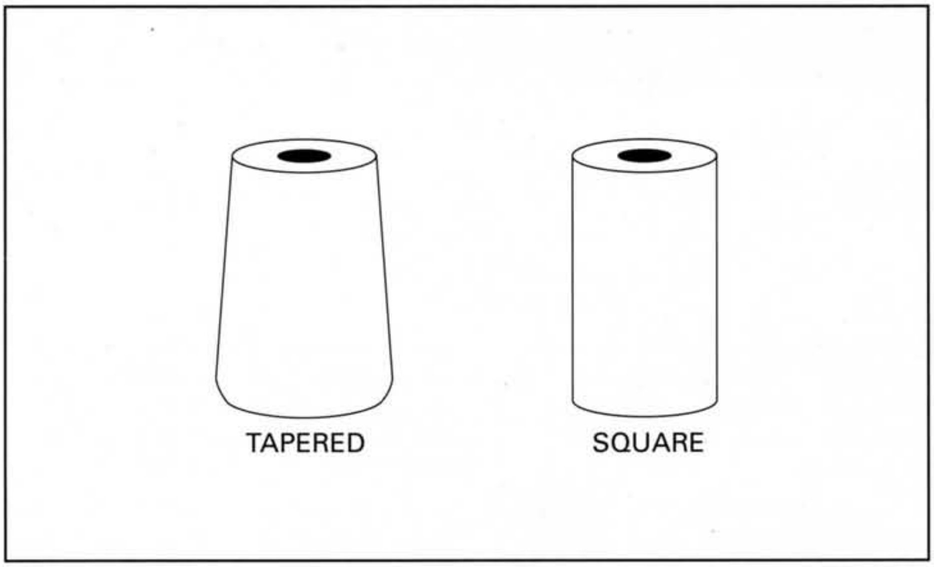


Fig. 5. Bobbin Packing Types for Optical Fibre

travelling at 200 metres per second at an altitude of 200 metres, the cable would not settle to the ocean surface (except near the launcher) before missile impact.

Exploitation of Fibre Optic Technology

Fibre optically guided weapon systems are now considered to be at the leading edge of technology. Recent advances in fibre optics, high-speed despooling techniques, high-power lasers and signal processing have all paved the way for using optical fibre as a large-capacity, bidirectional missile guidance transmission medium. FOG missiles offer a significant tactical advantage in anti-ship and anti-air operations, and in a variety of other naval and non-naval applications. Coastal defence, naval gunfire support, submarine-launched weapons and land-based anti-tank operations can all benefit from the technology.

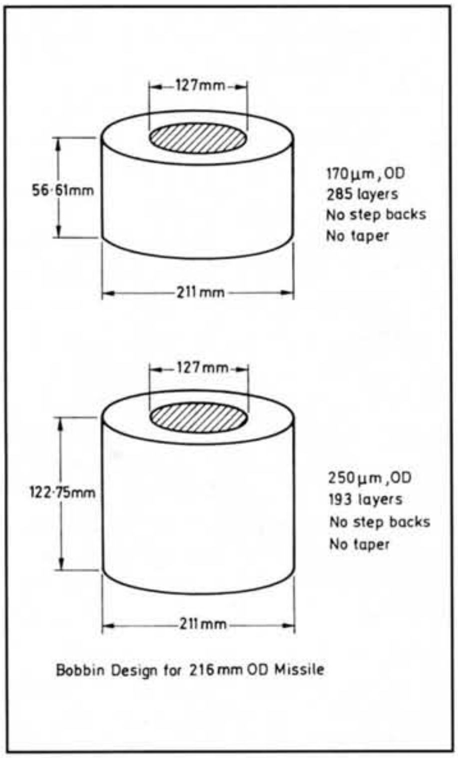


Fig. 6. Optical Fibre Square Packing for 50-km Length

Interest in long-range fibre optic missile guidance is definitely on the upswing. Euromissile of France has received funding from the French and German governments to develop a surface-launched, medium-range Polyphem 60 FOG missile that will be effective to 60 kilometres. And MBB of Germany has even developed a FOG missile which can be launched from a 21-inch torpedo tube against hovering aircraft!

Although the optical fibres being manufactured today offer a maximum range of about 80 kilometres, ranges from 100 to 120 kilometres should be possible very soon. The USN, for example, has already carried out successful link trials on a FOG Navy Sea Ray missile out to a range of 63.5 kilometres and expects to conduct trials out to 120 kilometres in the near future.

There is no doubt that optical fibre communication link technology can play a significant role in meeting modern missile guidance requirements. By turning to fibre optics and such sensors as IIR, millimetric wave radar and low-level-light TV, and doing away with the expensive processors and autopilots in the missile airframe, the full advantages of secure, bidirectional guidance communications can be realized.

The FOG missile's greatest strength lies in its capacity to engage targets with pinpoint accuracy beyond the visible horizon, yet remain virtually immune to electronic countermeasures — exactly what is needed in a high-density threat environment. That it should outperform an autonomous missile system and cost less makes it all that much more attractive as a system of choice.

Notes

1. Modelling and experimentation at the Royal Military College of Science in Shrivenham, U.K. has shown that despooling the cable through the efflux would not cause unacceptable fibre damage or optical attenuation either from thrust or temperature.
2. In development at Corning Glass Works, U.S.A.
3. Silica glass has a Young's Modulus (stress/strain) approaching that of steel.

LCdr Vachon, now at Staff College, is the former DMCS 2 project officer for the NATO Seasparrow missile system. In 1989 he completed postgraduate studies in guided weapons at the Royal Military College of Science at Shrivenham, U.K.

Forum

The Duality of MARE

By LCdr Mike Adams, CD, P.Eng

It used to be so simple. MAREs were naval engineers — engineers who went to sea. Shore jobs existed to support the ships at sea by maintaining the ships, by engineering improvements to the ships and by procuring new ships. Tangible links between MAREs and their dual naval and engineering professions were solidly in place.

But times have changed. As the MARE occupation evolved, the conflicting pressures of budgetary restraint, training-time reduction, sub-MOC evolution and other transient pressures have all had an effect upon the links holding together the dual identity of naval engineers. The result has been a weakening of the naval connection and a resultant drift in favour of the engineering profession. We have lost the focus of our MARE duality.

What exactly is this "duality of MARE?" Simply put, it is the dual professional status of a Maritime Engineer — the synergetic composite of the *naval officer* profession and the *engineering* profession. The links to these professions are imbedded in the MARE occupation Specification[1], which states:

> The MARE occupation is an integral part of the Navy. Accordingly, every Maritime Engineer must have sufficient experience at sea to enable each to understand shipboard equipment, ship construction and the needs of the personnel who fight in Naval ships and submarines. ... Members of the MARE occupation are all, at the same time, Canadian Forces General List Officers, Naval officers and members of the engineering community. The relationship is complementary and the compulsion to duty is equal.

This duality of function is clearly a fundamental precept of our calling as MAREs. Our naval bond grants us credibility within the naval community. Our engineering ties enable us to perform our duties as engineers. No other engineering occupation in the Canadian Forces has this distinction of professional duality. If the MARE link to the naval profession were allowed to atrophy, the MARE occupation would become "just another engineering occupation." We would become *EMARs* (Engineers, Maritime), left to join the ranks of the other support-engineer occupations.

So what should our role be ... MARE or EMAR? Over the past decade or so the MARE training system has leaned relentlessly toward the engineering profession. In the mid-'80s, MS and CS sub-MOC at-sea time was reduced by 63 percent, with the Head Of Department (HOD) qualification relegated to an Officer Specialty Qualification. In 1991, the MARE Basic Qualification (44A) at-sea time was reduced by 33 percent. Today, the MARE just starting a career is already at a disadvantage where the links with the naval profession are concerned.

"Today, the MARE just starting a career is already at a disadvantage where the links with the naval profession are concerned."

As more and more MAREs are indoctrinated in the "engineer-first" approach to maritime engineering, our ties to the naval profession continue to weaken. This affects the priorities that MAREs assign when dealing with issues that affect both the naval and engineering communities, usually to the detriment of the former. Prime examples of this are the reduction of MARE shore billets requiring the sea-experienced HOD-qualification, the temporary prohibition in the late 1980s against promoting the at-sea route as the "preferred" course for MARE progression, and the current move afoot to minimize MARS involvement in the MARE sub-MOC qualification process.

If this drift toward engineering preeminence continues we could well find ourselves isolated from the naval community, having become nothing more than token naval officers. How this would influence the effectiveness of our dealings with the MARS hierarchy is anybody's guess, but it likely would not be for the better.

And what a time for this to be happening. The fleet is in the throes of fundamental transition. While the introduction of state-of-the-art frigates, destroyers, minor war vessels and, hopefully, submarines is certainly refreshing, it brings with it some revolutionary concepts in maritime engineering that bear consideration. For instance:

- What role will MAREs play in operating and supporting the new fleet?
- What effect will the reduction of sea time and "on-the-plates" experience have on the MARE role?
- What effect will software have on the MARE role in the new ships?
- What will be the effect of replacing planned maintenance with condition-based maintenance?
- How will the navy and the yards adapt to the reduction or elimination of ship refits?
- How will the ever-increasing participation of industry in matters once the sole purview of the navy affect MAREs?

The fleet transition exacerbates the potential drift toward engineering dominance in the MARE profession. Our familiar linkages to naval engineering are disappearing, and their absence weakens our bond to the naval profession. If we are to maintain our professional duality we must ensure that new linkages replace the old familiar ones as the navy adapts to the new fleet.

This requires action on our part. To begin with, we must clarify our role in the new fleet and confirm that the duality concept is still the fundamental essence of the MARE. The next step is to ensure the naval community is made aware of the fact that we are MAREs, and not EMARs. We must be *seen* to be promoting the engineering and naval professions equally, not pushing one at the expense of the other. In that sense we cannot afford any further lessening of our involvement with the ships.

There is no question that the MARE occupation will continue to evolve — as it must. However, current trends indicate the occupation is drifting away from its naval roots and is in danger of regressing from a front-line engineering occupation to a support engineering occupation. In my opinion, this is detrimental to the MARE occupation and should be corrected. The effectiveness of the current evolution of the MARE training plan won't be known until the first class of the latest generation of MAREs is sub-MOC qualified in mid-'93 and enters the fleet. Until such time as we can confirm that this new training is meeting our needs, no further attempt should be made to change MARE training.

> ***"If this drift toward engineering preeminence continues we could well find ourselves isolated from the naval community, having become nothing more than token naval officers."***

A meeting of the minds is required to evaluate the dilemma of the MARE duality issue and to chart a course for the MARE occupation. It is therefore proposed that a special committee of key MAREs be established by the MARE Council for this purpose. Once the problem has been formally acknowledged, we can begin taking positive action to direct the MARE occupation toward meeting our dual naval engineering requirements of the future.

Reference

1. A-PD-150-002/PP-002 Maritime Engineering Occupation Specification.

LCdr Adams was the Marine Systems Section Head at NOTC until his posting to DMEE 3 in June.

Seminar Report

East Coast MARE Seminar 1992

By LCdr Robert Craig

This year's East Coast MARE Seminar, held in Halifax from 22 to 23 April, was based on the theme "The Fleet in Transition — The MARE Community, Present and Future." The organizers succeeded in generating an introspective look at the MARE community, including its strengths, problems and challenges. In spite of the current atmosphere of restraint, reduction and reorganization, and having to "do more with less," a positive spirit grew out of the proceedings. In his opening address, Maritime Command Chief of Staff RAdm R.C. Waller acknowledged the appropriateness of the seminar theme and encouraged a spirit of communication throughout the naval community.

Following the theme of the seminar, three central issues were highlighted in presentations: customer service, resource management and MARE ethos (community spirit). The presentations gave rise to spirited syndicate discussions on these issues during day two, which in turn generated continued discussion outside the forum.

Capt(N) Roger Chiasson (CO SRUA) opened the subject of customer service with a presentation on total quality management (TQM). Rapidly being adopted in work environments around the world, TQM is a management philosophy based on having teams of working-level employees (with support from the top) resolve problems in their own work environment. Both SRUA and NEUA have implemented TQM programs with some success.

In the area of resource management, Cdr Al Kennedy (DSE section head for naval support cost reduction) outlined the NCSR Study into new ways of doing business to reduce operating and maintenance costs. Command Comptroller Capt(N) Peter Estey presented an overview of the budgeting system and suggested how support units might secure their fair share of resources. He also reviewed some new resource management initiatives and indicated how they might affect us.

PHOTO: CFB HALIFAX

Cmdre R.L. Preston, RAdm R.C. Waller and Cmdre (now Rear Admiral) M.T. Saker brought their experience to this year's East Coast MARE Seminar in Halifax.

LCdr Barry Munro, the DSE project officer for minor warships and auxiliary vessels, spoke on the philosophy behind the in-service support contract (ISSC). Developed as a pilot project for the MSAs, an in-service support contractor has been engaged to respond to MSA 2nd- and 3rd-level maintenance demands. Keynote speaker Guy Veronneau, President and CEO for MIL Davie Ltd., defined the relationship he believes must exist between the navy and industry, and suggested change is necessary on both sides. He said that improved communication with industry is required if an adequate industrial base is to be maintained.

LCdr Doug Brown, who is currently developing a software manager's course, spoke on software as an integral part of systems engineering. Addressing his remarks to all MAREs, not just CSEs, he stressed the need for a total systems engineering outlook (properly emphasizing software), increased software training and improved skills to work with software specifications. Doug was congratulated on his presentation by Cmdre M.T. Saker (DGMEM), who noted that he personally had two action items to take away.

On a different note, LCdr Bruce Grychowski and LCdr Ken Winch (CSEO and MSEO of HMCS *Halifax*) offered some insight into the transition for engineers fortunate enough to be posted to a patrol frigate. They outlined some of the differences being faced by engineering department heads in our newest warships.

To promote a more introspective look at the classification, NEUA Planning Officer Cdr Mark Eldridge initiated an emotional look at MARE ethos. He pressed the forum to debate whether or not there is a characteristic spirit within the MARE community, what it is, how it is generated and how to enhance it. MARE ethos appeared to mean different things to different people, but there was definite evidence of community spirit.

MARITIME · ENGINEERING · SEMINAR
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Cmdre M.T. Saker and his senior MOC advisers — Capt(N) Tom Brown (DMCS), Capt(N) Dave Riis (DMEE) and Capt(N) Roger Westwood (DNASE) — addressed sub-MOC issues. They were later joined by MARE Career Manager LCdr Bob Chenier, and the floor was opened to questions.

Closing remarks by Cmdre Saker emphasized the need for finding new ways of doing business so that we may continue to satisfy requirements at less cost. He stressed the need for teamwork, the development of more effective cost reduction and a greater awareness of software. He said the MARE community has much to be proud of, adding that our status as part of the Naval Operations branch is a key element of our strength and character.

Cmdre R.L. Preston (COS Mat) closed the seminar by asking, Is there a future for individual MAREs in the navy today? He affirmed his strong belief that there is, citing past and current naval successes (such as the introduction of the *St. Laurent* class, helicopters at sea, CPF, TRUMP and the MCDVs) as the basis for his enthusiasm. He suggested that change and challenge imply opportunity, and urged junior officers to be patient and take a long-term view. In interesting times, he said, there is scope for growth and development.

Overall the seminar provided a refreshing introspective of the MARE community. The MARE mess dinner, hosted by Fleet School, offered a fitting end to the seminar. The achievements of outstanding MARE students were recognized (*see News Briefs*) and a spirited social exchange continued.

LCdr Craig is the CSEO for the CPF Detachment in Halifax.

Some General Comments on Active Sonar Performance with Applicability to the AN/SQS-510

By Dr. A.T. Ashley and LCdr P.J. Lenk

Introduction

The intent of this paper is to discuss some of the principles involved in modern active sonar. Some technical details of the AN/SQS-510 sonar are included, but are mentioned only as examples to emphasize the potential performance gains that can be achieved through application of the principles.

The paper begins with a review of 25 years of active sonar development in Canada to indicate some of the advances that have been made in technology and to establish a baseline against which we can compare performance. The bulk of the paper is a discussion of several of the environmental factors that limit active sonar performance, and the types of pulse waveforms that can be used in each case to counter the degradation. This should be instructive to the engineer and operator alike. Finally, a brief discussion of several other ideas that can be used to improve effectiveness is included.

History

In the early 1960s the Canadian navy undertook the development of a medium-frequency, active sonar for use in either hull-mounted (HMS) or variable-depth (VDS) configurations. The basic system design was produced within DND, with engineering design and construction of the system being undertaken by a number of Canadian companies including Westinghouse, Sperry, Edo and Fleet Engineering. At the time it was a very ambitious undertaking that resulted in several firsts in various areas of technology. Specifically, the major achievements of the AN/SQS-505 development were:

a. a completely solid-state transmitter and receiver;

b. an analogue 16-doppler-channel matched filter tuned to the 40-ms, 25-Hz CW pulse; and

c. a triple-rotating directional transmission mode, effectively increasing the omnidirectional source level by about nine decibels.

The AN/SQS-505 has been in service in the Canadian navy for well over 20 years and has been the chosen sonar for every new class of ship built in Canada since the late 1960s. It has also been retrofitted into most older classes under DELEX or other conversion programs. The AN/SQS-505 has been very successfully marketed abroad and systems are now in service with the Dutch, Belgian and Hellenic navies. Including those fitted in the 12 new Canadian patrol frigates, there will ultimately be about 50 systems in service worldwide.

Although the capability of the AN/SQS-505 has been continually improved since its initial production, advances in technology have made many of its basic components obsolete. As far back as the mid-1970s it was realized that significant portions of the sonar would have to be replaced if the full benefits of new technology were to be reaped. A study was therefore undertaken by the Defence Research Establishment Atlantic (DREA), with the assistance of the Directorate of Maritime Operational Research, to examine options for improving the AN/SQS-505 in light of advances in digital computer technology and submarine technology. The study concluded that the most cost-effective way to capitalize on the success of the AN/SQS-505 was to replace the aging analogue receiver and display with a modern digital signal processor and modern raster-scan display. The study made the following specific recommendations:

a. use new waveforms employing longer pulses and wider bandwidth;

b. develop a new-generation, high-speed digital signal processor capable of implementing a matched filter for detecting a wideband FM pulse;

c. utilize extensive postprocessing capabilities such as computer-aided detection (CAD) and automatic tracking to assist the operator;

d. replace the display with a modern raster-scan display; and

e. retain the transmitter and transducer portions of the AN/SQS-505.

The gains in relative average performance predicted by the study are summarized in *Tables 1 and 2*. Using the AN/SQS-505 performance as a baseline (averaged over a one-year period and over all water masses in which the Canadian navy might be expected to operate), the figures represent the performance increases that could be expected from the various options examined. The numbers quoted in the tables represent average increases in initial detection capability; the exact performance on any given day may show significant variation depending on actual acoustic conditions encountered. The values shown in *Tables 1 and 2* do not include corrections for non-ideal implementation of the signal processing algorithms. If these were included, the approximate improvement provided by a modern digital implementation, such as is used in the AN/SQS-510, would be even greater.

Based on the DREA study, a decision was made to proceed with development of a new sonar. An advanced development model incorporating DREA-specified signal and data processing was developed by Computing Devices Company (CDC) and put to sea for trials in HMCS *Nipigon*

AN/SQS-505 at 7 kHz	1.0
AN/SQS-510 at 7 kHz	1.4
AN/SQS-510 at 5 kHz	1.6

Table 1: HMS AN/SQS-510 Improvement Factors

	TOW DEPTH (feet)		
	500	1000	2000
AN/SQS-505 at 7 kHz	1.0	1.1	1.1
AN/SQS-510 at 7 kHz	1.6	1.9	2.3
AN/SQS-510 at 5 kHz	1.7	2.1	2.5

Table 2: VDS AN/SQS-510 Improvement Factors

in the spring of 1985. The new sonar, the AN/SQS-510, incorporated new waveforms which increased the energy in the pulse, or the bandwidth of the pulse, or both. It also incorporated extensive postprocessing capabilities such as CAD and used an advanced display (SHINPADS) to optimize operator performance over extended time periods. The trials were considered an outstanding success, and development and production contracts for the AN/SQS-510 were signed with CDC in 1987 and 1988, respectively.

It is interesting to note from *Table 2* that in the VDS option very little is to be gained by simply using a deeper tow. However, by using a deeper tow in combination with some of the advanced signal processing and other techniques available in the AN/SQS-510, ranges can be more than doubled.

The two tables clearly illustrate the advantages of reducing frequency to five kHz. At present no effort has been expended to exploit these advantages. They remain an interesting option, particularly as the Royal Netherlands Navy operates a five-kHz version of the AN/SQS-505, designated the AN/SQS-509. The transmitter and transducer portions of the AN/SQS-509 sonar could be readily adapted to operate in a hull-mounted, low-frequency variant of the AN/SQS-510. The drawback is that installation would likely require extensive structural modification of any Canadian ship because of the larger transducer size.

Active Sonar Performance

The sonar problem is inherently complicated because of the spatial and temporal variability of the environment. Performance is affected by many factors, including temperature and salinity variations within the water mass, the size, depth and acoustic characteristics of the target, the ambient or background noise in the ocean, the reverberation noise present due to scatterers in the water mass, and surface and bottom reflections. Since no one waveform will give optimum performance under all conditions, it is highly desirable to have a variety of waveforms available to the sonar operator. Given current knowledge of the environment and threat, the operator can then select appropriate pulse characteristics to optimize sonar performance.

Generally, sonar performance is considered to be limited by one of three factors: noise, reverberation or refraction. In this section we will briefly consider the types of waveforms that can be used to gain advantage under various circumstances.

Noise-limited Performance

By "noise-limited performance" we understand the limiting factor in sonar performance to be the level of background noise that is present. This noise is caused by various mechanisms such as wave action (a function of sea state), maritime traffic, flow noise around the ship's hull and sonar dome, and electronic noise in the circuitry (chiefly in the initial stages of the electronics).

Noise of this type is normally assumed to be white, that is, it has equal power at all frequencies across relatively small frequency bands. The noise power spectral density (joules), is constant with frequency, f, with a level given by $N_0/2$:

$$N(f) = N_0/2 \quad (1)$$

Under these conditions, the performance of a matched filter receiver is entirely a function of received signal energy. If the transmitted energy in a pulse is E_s (joules) and the received echo energy is k_sE_s, then the signal-to-noise ratio, S/N_{OUT}, at the output of the matched filter can be shown to be:

$$S/N_{OUT} = 2k_sE_s/N_0 \quad (2)$$

where k_s is a factor which accounts for propagation, interaction with the target and other losses.

This is an interesting result. Since for a rectangular pulse the transmitted signal energy E_s is simply described by SL T, where SL (watts) is the transmitted source level and T (seconds) is the time duration of the transmitted pulse, the performance of the system can be improved in one of two ways: either the source level or the pulse length can be increased. As the source level is generally limited by cavitation (especially in hull-mounted systems) and by restrictions on the physical size of the transmitter and transducer, the only viable option is to increase the pulse length. For example, if the AN/SQS-505's 40-ms pulse were increased tenfold to 400 ms, a theoretical 10-dB increase in the signal-to-noise ratio could be achieved.

The performance of the matched filter depends on the fact that all of the returned echo energy is coherently processed. However, media such as the ocean will not sustain pulses of arbitrary length coherently. A parameter used to describe the maximum pulse length that can be transmitted and expected to be received coherently is known as the coherence time. It is a measure of how quickly the environment is changing with time. To adapt to different coherence times, the AN/SQS-510 allows for arbitrary pulse lengths from 10 to 500 ms (in the FM mode).

Reverberation-limited Performance

Reverberation energy is the result of energy being scattered from any inhomogeneity in the ocean, including microscopic marine organisms, the surface of the ocean and the bottom, to name but a few. The result of this scattering is a level of unwanted energy, in the band of the transmitted signal, which is extremely large just after transmission and decays approximately exponentially with time. This unwanted energy tends to obscure the target echo of interest and often forms the limiting factor in active sonar performance. If we assume that all the scatterers act independently, then, for our purposes, we can model the reverberation as white noise over some bandwidth BW_r (Hz). The total reverberation energy, E_r, is given by:

$$E_r = k_r SL\,T \quad (3)$$

where k_r is a parameter that depends on the environment, the beam patterns, etc. Then by analogy with Equation 1, the reverberation spectral level, $N_r/2$, can be modelled as:

$$N_r/2 = E_r/(2BW_r) = k_rSLT/(2BW_r) \quad (4)$$

Figure 1 illustrates the spectrum that may be expected for reverberation. Effectively, we are modelling reverberation as a band-limited white noise with a bandwidth similar to that of the transmitted pulse. The bandwidth will in fact be slightly larger due to frequency shifts induced by own-ship doppler and by doppler shifts caused by motion in the medium such as wave action, the movement of fish, etc. We will not account for this spectral spreading in our simplistic model.

Performance is said to be "reverberation-limited" if $N_r/2 > N_0/2$. Notice that, since $N_r/2$ is proportional to E_r, which is in turn proportional to the transmitted energy E_s, any increase in transmitted energy results in a proportional increase in reverberation. Intuitively, we may conclude that increasing pulse energy level will not result in any gains in performance in reverberation-limited conditions.

We will consider two cases, and in each case assume that performance is reverberation-limited; however, we will treat the circumstances of high and low target-doppler separately. Let us first consider the case of a slow-moving target, in which we may assume the target echo and reverberation energy occupy the same band since the target echo will have little or no doppler shift. From our previous assumption of independent scatterers, we infer that the noise will be approximately white over this band. We therefore may use our formula (Equation 2) for the signal-to-noise ratio at the output of a matched filter in the presence of white noise:

$$S/N_{OUT} = 2k_s E_s/N_r = 2(k_s/k_r)BW \quad (5)$$

Close examination of Equation 5 shows that the performance in a reverberation-limited environment is a function of the target and environment, through k_s and k_r, and the transmitted signal bandwidth BW. Since k_s and k_r are beyond the control of the sonar operator, the only mechanism available to improve the performance is an increase in transmitted signal bandwidth, BW. Note that an increase in the transmitted signal energy via an increase in source level, SL, or pulse length, T, is totally ineffective under these conditions.

For a CW pulse the bandwidth can be increased by decreasing the pulse length since the pulse length and bandwidth have a reciprocal relationship. For an FM signal we can independently control both the time duration and the bandwidth of the pulse. The FM pulse of the AN/SQS-510 has a nominal bandwidth of 300 Hz and nominal pulse length of 320 ms. This large bandwidth will result in a gain of about 11 dB over the 40-ms (25-Hz) CW pulse of the AN/SQS-505.

It may appear that an even wider bandwidth would provide even greater performance advantage, but, again, the environment establishes a limitation. The ocean is known to be a dispersive medium in that all frequencies do not propagate with the same velocity. Thus, the echo cannot always be processed coherently and some potential processing gain may be lost. The maximum bandwidth over which we can consider the energy to remain coherent is known as the coherence bandwidth. The AN/SQS-510 allows for some flexibility to adapt to different conditions by permitting the bandwidth of the FM pulse to be varied anywhere from 100 to 750 Hz.

Let us now turn our attention to the case where we have a fast-moving target and the sonar's performance is reverberation-limited. Since the target echo and the reverberation do not necessarily occupy the same frequency band because of the doppler shift of the returning echo, we can achieve better results if we find a way to completely separate the two spectra (reverberation and target echo). This will be easier to accomplish if we use a narrow bandwidth signal.

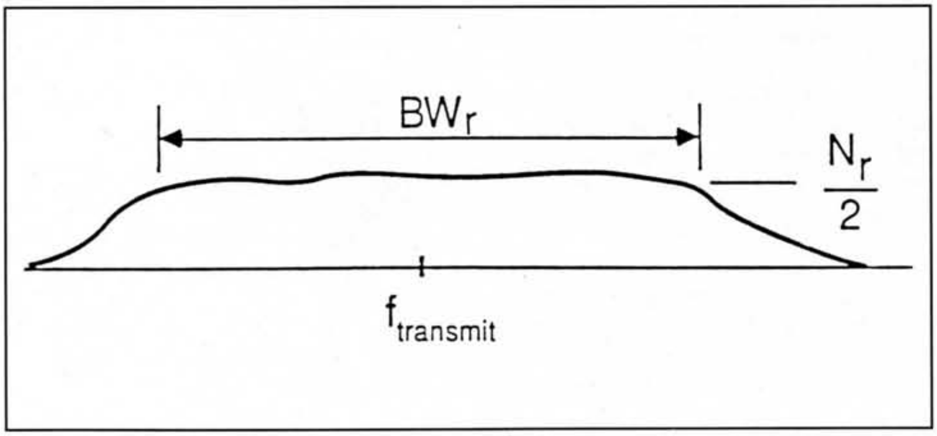

Fig. 1. Reverberation Spectrum

Compare the situations depicted in *Fig. 2*. The narrowband signal of *Fig. 2b* clearly allows the two spectra to be completely isolated. If the bandwidth is narrow enough and the target doppler is sufficient that this separation occurs, the performance is equivalent to the performance of the system under noise-limited conditions. The conclusion in this case is that a long CW pulse will give the best performance. The AN/SQS-510 provides a 400-ms CW pulse which has a bandwidth of only 2.5 Hz (0.5 knot at seven kHz.) The performance gain over the AN/SQS-505 is around 10 dB.

Refraction-limited Performance

Performance can also be limited by refraction. If a strong negative sound velocity gradient exists, all transmitted energy will be sent toward the ocean bottom. With a hull-mounted sonar little can be done to improve the situation other than to increase the pulse energy, which provides marginal improvement at best. The only way to realize significant gains in this situation is to use a variable-depth sonar. The sonar transducer can then be positioned at the desired depth and, depending on the conditions present, considerable gains may result. The actual sound velocity profile present will determine the precise gain that can be achieved.

In summary, the AN/SQS-510 is designed to allow the operator to deal effectively with a variety of environmental conditions. The wide choice of modes and selectable parameters allows near-optimum performance at all times by allowing the sonar to be tuned to the particular operational scenario and environmental conditions at hand. In future implementations it may be possible to include an on-line monitoring system (which will actually be capable of measuring the coherence of the medium) to provide the required input to allow the pulse characteristics to be adapted on-line.

Postprocessing

Once the data has been processed by the matched filter receiver it can be passed directly to the display subsystem, or subjected to additional data and display processing to further enhance system capability.

Computer-aided Detection

Anyone familiar with previous generations of sonar equipment knows how difficult it is for an operator to make a detection solely on the basis of information presented on a plan position indicator (PPI)

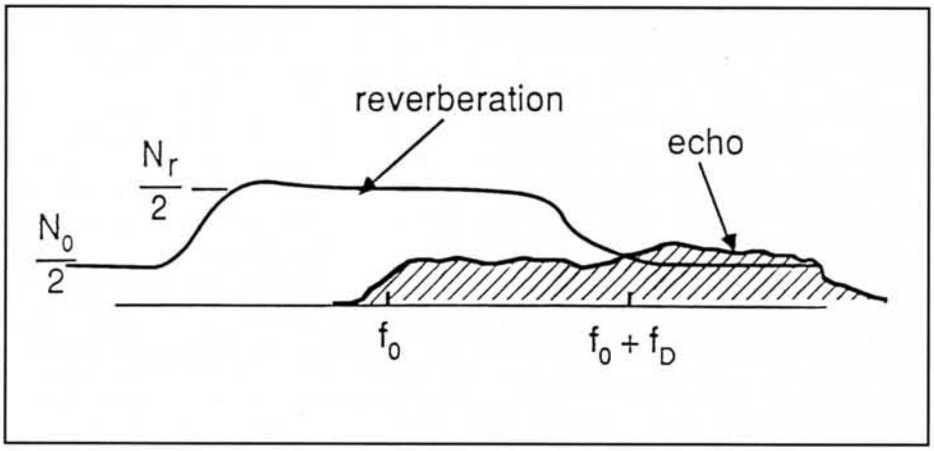

Fig. 2a. High-doppler target in reverberation — wideband signal.

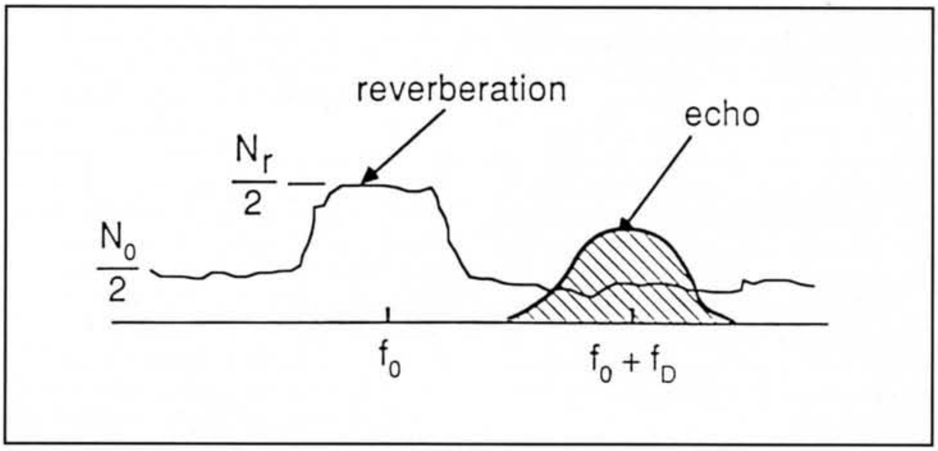

Fig. 2b. High-doppler target in reverberation — narrowband signal.

type of display. In the AN/SQS-505 this was recognized as a problem, so an "A-Scan" display with a five-ping history was added. This limited capability for performing ping-to-ping correlation made it easier for an operator to make a detection and isolate the target's range. The PPI display could then be used to determine the contact's bearing.

The AN/SQS-510 provides a significantly enhanced version of this functionality and builds upon it with the addition of a computer-aided detection capability. CAD will do automatic ping-to-ping correlation and alert the operator when it has received a consistent echo over a number of transmissions. Following initial detection the algorithm will track the contact, generating an estimate of its position, course and speed. CAD is not designed to enhance the performance of the best operators at their peak. Rather, it is designed to aid the tired or overloaded operator, thus improving overall average performance. An equivalent increase in signal-to-noise ratio of about five dB has been estimated for CAD processing.

Man-machine Interface

A sonar as complex as the AN/SQS-510 can generate vast quantities of data during a multi-ping prosecution of a submarine target. Since operators must interact with this great mass of information, it is critically important they be provided with a well designed man-machine interface where all unnecessary functionality has been stripped away. The AN/SQS-510 offers an extensive array of display formats, each one tuned to a particular phase of the scenario from initial detection through to target classification and tracking.

Conclusions

In order for sonar operators to make optimum use of their equipment they must understand and recognize the factors that limit system performance. They must also be familiar with the capabilities they have at their disposal for countering the limitations. As the equipment becomes more complicated, operators will need even greater knowledge of the principles and limitations under which it is operating. In addition, extensive data and display processing is required to reduce the operator's workload and to display the data in a manner which allows the operator to get on with the job.

To provide the flexibility that is required, an adaptation mode has been included in the AN/SQS-510 which allows the system to be tuned to maximize performance under many different environmental conditions. For instance, trials have proven that the 510 sonar can be given a useful mine-detection capability through a simple adjustment of system parameters. Production units were not available in time for the Gulf War, but it is this type of inherent flexibility that is the 510 sonar's chief strength. Unmatched in any other production sonar, this unique ability to adjust capability to meet specific and sometimes unforeseen threats should allow the AN/SQS-510 to consistently outperform all other medium-frequency active sonars, including the AN/SQS-505.

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Greenspace: Maritime Environmental Protection

Halon Alternatives for Firefighting in the Canadian Navy*

By PO1 T.J. Hanrahan

***Condensed from a paper prepared by the author for the C7 Chief ERA course in October 1991.**

Introduction

Halon, one of the most effective fire extinguishants in use today, has been linked to the depletion of the Earth's ozone layer. By 1995 Canada will ban the importation of ozone-depleting substances controlled by the Montreal Protocol, which includes the halogenated hydrocarbons, or specifically halon 1211, 2402[1] and 1301. Although halon use in the Canadian navy may continue for some time under an essential-use exemption, the search for replacements and alternatives should continue since the importation ban will cause halon stocks to dwindle rapidly and force a sharp rise in their cost.

Background

In October 1986 an ozone trends panel was formed by the National Aeronautics and Space Administration, the National Oceanic and Atmospheric Administration, the Federal Aviation Administration, the World Meteorological Organization and the United Nations Environmental Program (UNEP). The panel, which was made up of more than one hundred scientists, including scientists from the Atmospheric Environment Service of Environment Canada, reported in the spring of 1988 that the level of source gases important in controlling stratospheric ozone levels were increasing at a rate significant enough to cause serious damage to the ozone layer through uncontrolled emissions [1].

Some months prior to this, in September 1987, 24 nations had signed the Montreal Protocol, a pact to regulate the production of ozone-depleting substances. Ratified and entered into force on January 1, 1989, the Montreal Protocol currently applies to two primary groups of substances: chlorofluorocarbons (CFCs), and halogenated hydrocarbons or halons. It was thought that the initial controls laid down by the protocol would be sufficient to protect the stratospheric ozone layer, however more recent scientific evidence has concluded that the rate of ozone depletion is far greater than earlier predicted [2].

The parties to the Montreal Protocol met again in London in June 1990 to consider a more stringent phase-out schedule for ozone-depleting substances. The proposed London Amendments call for a freeze in the production of halons at 1986 levels by 1992, a 50-percent reduction from 1986 levels by 1995, and a 100-percent reduction from 1986 levels by January 2000 (with possible exemptions for essential uses).

The ramifications of this are of particular importance to the Canadian navy since the FFH-330 (CPF) and TRUMP DDH-280 classes are extensively equipped (or being equipped) with halon 1301 fire-extinguishing systems and halon 1211 portable fire extinguishers. Even though naval ships will likely be considered essential users, application of the Canadian Environmental Protection Act (which prohibits the manufacture of halons in Canada) and growing public concern for the environment might well decide the course of action DND takes.

Aim

With a growing number of halon alternatives available to choose from, it is in the best interest of the Canadian navy to consider these options as soon as possible. This paper discusses the viable alternatives and the steps the navy could take to implement the preferred option(s) and reduce dependency on halons for firefighting.

Halon Use

For clarity, two terms must be defined. A "replacement" agent is a halon-like, gaseous or volatile, clean fire extinguishant, explosion suppression agent and/or inertion agent. "Alternative" agents are defined as being not-in-kind, non-halon-like agents such as carbon dioxide, water, foam and dry powder extinguishants.

Presently, most HMC ships are using either halon 1211 portable fire extinguishers, or halon 1301 total flood fire-extinguishing systems. The FFH-330-class ships rely heavily on halon 1301 systems, having 37 compartments protected by these systems. The DDH-280-class ships are also being fitted extensively with halon 1301 systems as part of their TRUMP refits. There is very limited use of halon 1301 systems in the remainder of the fleet, although almost all classes use halon 1211 portable fire extinguishers.

Chemical Replacements

The most desirable halon replacement agent would be a chemical agent possessing similar fire-extinguishing properties,

BASE HALIFAX PHOTO

Fire protection at what environmental cost? The DDH-280 and FFH-330 classes rely heavily on halon 1301 systems such as this one on board HMCS *Halifax*.

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[1] The Canadian navy does not use halon 2402, but it is included in this discussion for completeness.

BASE HALIFAX PHOTO

Back to basics. Water could once again become the fire-protection agent of choice in shipboard fitted systems — but with a difference. Fine water-spray systems now under development overcome the problems of equipment damage and reduced ship stability associated with conventional sprinkler systems by supersaturating combustion air with significantly less water.

without the negative environmental impact. A "drop-in" type of agent, which could be substituted without altering existing distribution and storage arrangements, would be ideal because of the minimal cost and time required for conversion. Research companies, only too aware of the market potential for such an agent, are attempting to develop drop-in chemical replacements for halon 1301 and halon 1211. Success, however, is likely still some time off.

Du Pont de Nemours & Company and the Great Lakes Chemical Corporation are now offering chemical replacement agents for halon 1301 and halon 1211. However, these agents possess some inferior qualities to halon and require further testing to prove them acceptable fire extinguishants. The U.S. National Institute for Standards and Technology has produced a comprehensive report detailing a number of replacement and alternative chemical agents with potential for fire-protection applications.

Alternative Agents

Of particular interest in recent years has been the development of fine water-spray systems (not to be confused with conventional sprinkler systems) as a halon alternative. Unlike conventional systems whose major drawback is the great amount of water they discharge into a space, fine water-spray (waterfog) systems supersaturate the combustion air in a space to extinguish a fire through cooling and oxygen starvation. Discharging water droplets 20 times smaller than those discharged from conventional sprinklers, and at a lower rate, the fine water-spray system overcomes the serious problems of equipment damage and reduced ship stability associated with conventional systems.

In Ottawa, the National Fire Laboratory (a unit of the National Research Council) has begun investigating the use of fine water-spray fire suppression systems for shipboard machinery spaces through a project co-sponsored by DND. It is anticipated that fine water-spray systems will be an effective alternative to halon 1301 extinguishing systems in certain applications. Further research is still required to fully understand the concepts and to engineer a system for shipboard use.

Obviously, the environmental impact of fine water-spray systems is nil. The space and weight characteristics are not expected to increase significantly from those of equivalent halon 1301 systems. However, the installation of a fine water-spray fire-suppression system may prove to be expensive since the cost of first removing the halon 1301 system must be taken into account. Once installed, though, the cost would be minimal as the extinguishing agent — water — would be readily available.

Alternative Selection Approach

Since no "drop-in" replacement agent for halon 1301 will be available in the foreseeable future, and new technology alternatives such as fine water-sprays have not yet been fully developed, consideration should be given to a structured option selection approach to satisfy fire-protection requirements. Instead of trying to find general-purpose replacement agents for the halons, each particular requirement should be assessed and assigned its own agent/system that can adequately protect the compartment without harming the environment.

In its final report [3], the UNEP Technical Options Committee detailed a method for scoring and comparing the best alternatives to halons for fire-protection purposes. The Canadian navy could easily use this method to reconsider many of the fire-protection systems used before the advent of halon. For example, where in-cabinet and subfloor carbon dioxide systems might prove feasible for computer rooms, early warning detection systems and fine water-spray systems could very well be appropriate for engine rooms.

The alternative selection approach recognizes that, while halons are arguably the most versatile extinguishants and in certain instances would be impossible to replace without giving something up in return, they are not the only agents that can extinguish a fire. At the very least the alternative selection approach will guide fire-protection engineers in selecting the best possible alternatives that will sacrifice the least.

Conclusion

The Canadian navy currently uses halon 1211 portable fire extinguishers in most ships; halon 1301 total flood systems are seeing widespread use in the FFH-330 and DDH-280 classes. As the halon phase-out schedule proposed by Environment Canada is in advance of that being proposed by the Montreal Protocol, Design Authorities for naval ships must begin to examine current halon installations with a view to reducing the navy's dependency on halons to the absolute minimum. To this end, it is recommended that a co-ordinator be appointed to monitor and evaluate the various options that the navy could pursue as the availability of halons decreases. It is also recommended that the Canadian navy fund research projects specifically related to eliminating halons in HMC ships.

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[1] Environment Canada, *Preserving the Ozone Layer: A First Step*, May 1988, p. 2.

[2] Mauzerall, Denise, "Protecting the Ozone Layer", *Fire Journal*, Sept/Oct 1990, pp. 23-24.

[3] United Nations Environment Program, *Final Report of the Halons Technical Options Committee*, 11 August 1989, p. 21.

METTP graduate PO1 Terry Hanrahan completed the C7 Chief ERA course last year. A Marine Engineering Artificer, he served in HMCS Protecteur *until his posting to 303 CFTSD in Hamilton last July.*

News Briefs

Pisces IV joins the navy

After 22 years of going it alone, the navy's SDL-1 submersible diver lockout is getting a messmate on board HMCS *Cormorant*. The manned research submersible *Pisces IV*, which has been operated by the Department of Fisheries and Oceans (DFO) since 1972, was turned over to the navy late last year.

Pisces IV will be maintained primarily as a rescue support vehicle, covering off the navy's requirement for a 72-hour standby rescue capability for SDL-1. This is not a new role for the 12-tonne submersible. For some years, now, *Pisces IV* has been earmarked as the sole standby rescue vehicle for the navy's 15-tonne SDL.

This arrangement came into jeopardy in 1990 when federal research cuts forced DFO's Institute of Ocean Sciences (IOS) to suspend manned deep seabed operations. The submersible was offered to other government departments, but DND was the only one to express interest. Unfortunately, the estimated $1.4 million acquisition cost was out of reach for DND. This was a blow to the navy. If *Pisces IV* were sold out of government, rescue support for SDL-1 would depend on the good will and availability of foreign military or commercial resources.

Pisces IV

DFO itself came to the rescue. Wishing to maintain access to the vessel, the Department offered to refit *Pisces IV* to American Bureau of Shipping (ABS) standards prior to any transfer. This reduced the acquisition costs to the navy to a manageable amount and, under the terms of the transfer agreement, gave DFO continued access to the submersible for research purposes.

Apart from the diver lockout sphere on SDL-1, the two submersibles are similar. Both were built to ABS standards in the early 1970s by the now defunct International Hydrodynamics Co. Ltd. of Vancouver, BC. Although *Pisces IV* was designed for a maximum operating depth of 2,000 metres — three times that of SDL-1 — the three-man vehicle is presently certified for a maximum depth of 650 metres.

"SDL and *Pisces* are similar," said DSE *Pisces* Project Manager **LCdr Garth Taylor**. "But these are experimental vessels — each one is unique." Experimental or not, the two submersibles have each provided 20 years of safe service. "They have a very good safety record," Taylor said.

Although the submersible is structurally sound, a technical audit conducted by NEU(A) last February highlighted deficiencies in the vessel's technical and logistic support documentation. But according to LCdr Taylor, upgrading the documentation to DND standards should not prove troublesome. "I don't see it as a problem," he said.

During post-refit trials in November 1991, five naval personnel from HMCS *Cormorant* underwent two weeks of operator-maintainer training on board the submersible. More training was scheduled for the summer of 1992, after which the implementation plan would be put into effect.

A major part of *Pisces IV*'s operational mission will include underwater surveys and salvage operations for the Canadian Forces. In 1990 the submersible was used by DND to retrieve the flight recorder from a downed CF-18 fighter off the west coast of Vancouver Island. However, the vessel's primary role remains as a standby rescue vehicle for SDL-1.

Whether it is pulling a black box from a downed aircraft or attaching a rescue cable to a stricken SDL-1, *Pisces IV* with its on-board crew is superbly suited to the task. As sophisticated as unmanned, TV-equipped remotely-operated vehicles (ROVs) are today, LCdr Taylor said the better definition of the human eye can give an edge during complex, high-value rescue or salvage operations.

"With today's (sophisticated) technology," he said, "you'd have to have something pretty damned important (on the bottom) to send a human down."

Arctic search!

Personnel from DREP's Arctic Acoustics Group got more than they bargained for when they conducted their *Iceshelf 92* research exercise at CFS Alert last May — a call to search for missing North Pole expeditioneer **Robert Mantell**.

Found! His back turned to the helicopter's rotor wash, missing Arctic adventurer Bob Mantell waits for Exercise *Iceshelf 92* search personnel to land on the pack-ice north of Ellesmere Island. Mantell became the subject of a search when nothing was heard from him 12 days after aborting his trek to the North Pole.

PHOTO: PTE. CHRIS TUCKER, 418 SQN. EDMONTON

As was widely reported in the media, the RCMP mounted a search for Mantell 12 days after he dropped out from the three-man Weber Expedition's attempt to ski unaided nearly 1,500 km to the North Pole and back again. Mantell, an American, left the expedition 39 days into the trek to return to the base camp 157 km away on Ward Hunt Island. He reportedly had with him a tent and enough food to last 10 days.

Iceshelf air resources — a Twin Otter from 440 Squadron in Edmonton and a Bell 212 helicopter chartered from Remote Helicopters Ltd. of Slave Lake, Alta — were asked to participate in the search. Control over the aircraft and search co-ordination were exercised from CFS Alert by DREP *Iceshelf 92* personnel **Steve Taylor**, **Gary Hare** (of Arctic Hare Enterprises) and CSE **LCdr Peter Lenk**.

After almost 48 hours of continuous searching, a break came on May 5 when the helicopter crew reported finding the trail of what was apparently one person heading south. Over the next several hours and again that night they followed the tracks for more than 84 km. Pilots **Doug McArthur** and **Leroy Dean** often had to fly their helicopter only feet above the pack-ice at speeds under 20 knots just to keep the trail in sight. Finally, at 0904 GMT on May 6, the crew located Mantell on the pack-ice 28 km north of the expedition's base camp on Ward Hunt Island. He was in good health.

The search was conducted in what is perhaps the remotest location in the world — the polar ice cap. That it was successful at all is a direct consequence of the team effort of civilian and military employees of DND, members of the RCMP and employees of Canadian commercial companies. Particular credit is due the two pilots of the Bell 212. Without their extraordinary skill and perseverance the operation would certainly have failed**...by LCdr Peter Lenk.**

Canadian navy first with mil-spec ROD

Just as the Royal Navy pioneered commercial reverse osmosis desalination (ROD) units during the Falklands War, the Canadian navy has claimed the first successful operation of a fully mil-spec ROD plant in wartime. Performance data on the navy's new DDH-280 ROD plant installed in some Canadian ships for Operation Friction has been so positive that several navies are now showing interest.

Attracted by the plant's successful performance in the Gulf and by its relatively low cost, the U.S. and South Korean navies have approached Canada with requests for technical details and performance data. This is a remarkable display of confidence, considering the first production model of the 33.3-tonnes(t)/day plant was rushed to Bahrain to be fitted in HMCS *Terra Nova* in September 1990. The two-stage DDH-280 ROD plant was designed by DND and manufactured by Zenon Environmental Systems Inc. of Burlington, Ontario.

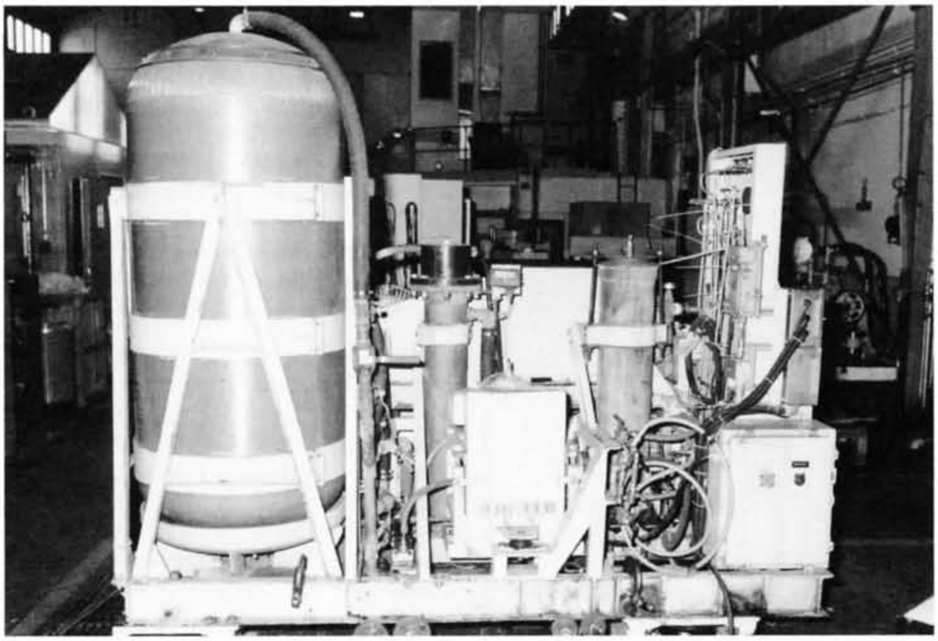
From the outset of Operation Friction it was apparent that evaporators alone would be no match for the anticipated demands on fresh water for personal showers and equipment washdowns. ROD plants, which consume 25 times less energy, are well suited to tropical operations as their efficiency and output increase with sea temperature.

The decision to go with reverse osmosis desalination was a natural outcome of the navy's longstanding involvement with the development of this technology (*see box*). Selecting the DDH-280 ROD plant for three of the four destroyers deployed to the Gulf certainly made sense from an operational standpoint, but it was also a golden opportunity to prove the units at sea before installing them in the modernized Tribals and in the second batch of patrol frigates.

Thanks to their nearly self-contained design, ROD units can be installed virtually anywhere in a ship. In *Terra Nova* (Op Fric I), *Restigouche* and *Huron* (Op Fric II) the DDH-280 ROD plant was installed quite handily in the mortar well, below the Phalanx CIWS. (HMCS *Athabaskan* received a commercial ROD unit as the first DDH-280 units were not yet available in August 1990. A 20.5-t/day ROD unit earmarked for the naval research vessel *Quest* was fitted in *Athabaskan*'s auxiliary machinery room.)

The situation for the supply ship HMCS *Protecteur* was drastically different because no suitable ROD plant, commercial or otherwise, was immediately available at the time of her Op Friction work period. In an incredible display of ingenuity and resourcefulness, personnel from the NEU, SRU and Dockyard in Halifax designed, assembled and installed four, seven-t/day "mini-ROD plants" in the ship's engine-room — in under 72 hours.

The only apprehension surrounding the DDH-280 ROD units came when the Iraqis spilled millions of litres of crude oil into the Gulf. To prevent contamination of ROD plants and freshwater systems, plans were made to fit the plants with oil content monitors (OCMs). The war ended before they could be fitted, but the threat underscored their importance in system design. OCMs are now a standard design feature of ROD plants**...by Lt(N) Joël Parent, DMEE 5-2-2-3.**



This DDH-280 ROD plant, removed from HMCS *Terra Nova* on her return from the Persian Gulf, was designed and manufactured in Canada for TRUMP and the last six CPF ships.

ROD in the Canadian Navy

Positive claims made by early users of shipboard ROD systems, notably the Royal Navy during the Falklands War, led the Canadian navy to investigate the feasibility of changing over to ROD technology for fresh and feedwater production on board ship. Following a succession of technical and operational evaluations of simple prototypes in the 1980s, DMEE 5 secured a contract with a Canadian manufacturer to develop a ROD plant for installation in a Tribal-class destroyer. The prototype was modified extensively at NETE to meet military specifications and to improve the unit's performance and reliability.

The resulting two-stage, mil-spec DDH-280 ROD plant produced an average daily output of 33.3 tonnes of potable water at less than 500 ppm total dissolved solids (TDS), and eight tonnes of boiler feed water at 7.3 ppm TDS. Two units are scheduled for installation in each of four DDH-280 ships, *Huron* being fitted first as part of her TRUMP refit. The second batch of six Canadian patrol frigates will also be fitted with this design (two units have already been installed in HMCS *Montreal*).

NETE has since developed a 4.5-t/day (potable water) military-qualified ROD prototype for O-class submarines which has already been installed in HMCS *Onondaga*. A production unit of the same design will be fitted in *Okanagan* during her current refit. (*Ojibwa* will retain her commercial ROD plant installed as a TECHVAL in 1988.)

And more development projects are under way. DREP, in conjunction with Hi-Tech Enterprises Ltd. of Victoria, BC, has designed, built and shore-tested a centrifugal ROD prototype for minor warships and auxiliary vessels. The new design does not use a reciprocating pump and so offers substantial reductions in power consumption, noise and vibration. The prototype is being installed in CFAV *St. Anthony* for its development evaluation.

J.P.

El "SID"

The Canadian navy has a new computerized database for recording and tracking ship structural defect information. Eleven months in the making, the Structural Inspection Database (SID) is but one component of the naval structural maintenance program that will formalize the process of maintaining the structural integrity of HMC ships (*see MEJ: June 1992, p.19*).

In addition to tracking defects, the computerized database will be useful in monitoring the progress of compartment surveys and the status of ships' Statements of Structural Integrity. It will also be invaluable in conducting long-term research aimed at minimizing structural flaws in future ship designs.

For the present, SID's database will be accessed by surveyors at the two naval engineering units and by the SID system manager in the Directorate of Ship Engineering (DSE). Surveyors working from a graphic representation of a ship's general arrangement (GA) can record specific defect information relating to a particular compartment or element of the ship.

"You give up a bit of realism (with the GA)," said DSE SID manager **Lt(N) Garry Pettipas**, "but it becomes very efficient in representing the model." Detailed descriptions of defects are stored in such a way that the database can be queried for similar faults throughout the ship, class or fleet. The system is so user-friendly that even non-specialists can enter defect data provided by a surveyor.

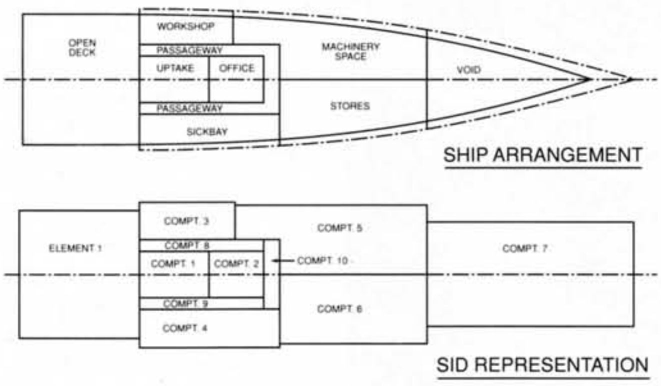
The $75,000 SID was designed by MIL Systems Engineering Inc. of Ottawa to hold information on up to one million defects. Once captured, data will rarely be deleted. The system operates with db VISTA software in Windows on 386, 33-MHz computers which feature a 660-Mbyte hard drive and 250-Mbyte tape and disk drives. For now, tapes and disks containing database updates will be traded monthly between the NEUs and headquarters.

The database has great potential for expansion. SID has been successfully demonstrated to the United States and Great Britain who are members with Canada in an Information Exchange Program on ship structures. Their active interest in SID (or development of a similar system) is matched by Australia, who is seeking to join the IEP — all of which could lead to a "global" research database of structural defects.

SID is very much in line with the structural maintenance requirements for Canada's new fleet of patrol frigates. Pettipas said that the 12-year refit cycle for CPF demanded certain changes be made to the structural maintenance policy. "We've got to start a new way of doing business to accommodate that," he said.

By all accounts SID's defect tracking capability will fit the bill. According to Pettipas the Structural Inspection Database will provide feedback on structural maintenance in the fleet, thereby helping to ensure operational readiness and safety.

Queries regarding the Structural Inspection Database should be directed to SID Manager **Lt(N) Garry Pettipas, DSE 5-5-2, NDHQ, 101 Colonel By Drive, Ottawa, Ontario K1A 0K2 (Tel. 819 997-0687)**.



The graphic representation of a ship's general arrangement in the Structural Inspection Database might not look like a ship, but the simplified compartmentalization system is highly efficient for identifying the location of defects.

Suggestion Awards

DMEE 6 engineers **Art Antopolski** and **Bob Laidley** received certificates and cash awards this summer for their participation in the government's Suggestion Award Program. Laidley suggested a method for cutting down on the duplication of effort in creating high-usage forms on computers. Antopolski wrote a refit data management computer program that reduces certain aspects of refit data assembly by 30 times.

1991 CSE Awards

Bravo Zulus go out to four Combat System Engineers who were recognized for achievements in training at this year's MARE mess dinner in Halifax on April 23rd. **SLt Andy Strong** was presented with the Paramax Award for top CSE officer achieving MARE 44C qualification in 1991. The award, which recognizes performance in MARE 44C training ashore and afloat, was presented by **Gen (Ret.) Paul Manson**, president of Paramax Systems of Canada.

Three officers — **SLt Scott Acker**, **SLt Marcel Losier** and **SLt Darren Stadel** — received the Westinghouse Award for professional excellence in CSE training in 1991. The award is presented to a graduating officer of the CSE Applications Course taught at the CSE Division of Fleet School Halifax. **John Alsop**, general manager of the Information Services Division of Westinghouse Canada Inc., presented the awards.

SLt Andy Strong receives the Paramax Award from Gen (Ret.) Paul Manson. A prize of a naval sword accompanied the award for top CSE achieving 44C in 1991.

SLt Scott Acker, CSEAC 9101, receives the Westinghouse award for professional excellence in CSE training from John Alsop.

SLt Marcel Losier, CSEAC 9102, receives the Westinghouse award for professional excellence in CSE training from John Alsop.

SLt Darren Stadel, CSEAC 9103, receives the Westinghouse award for professional excellence in CSE training from John Alsop.

MSE Awards

In May **SLt E.H. DeOliveira** was presented with the CAE Award by Fleet School Halifax MSE Division Commander **Cdr S.A. Lowrie**. For the past five years CAE Electronics Limited has sponsored the award for the MSE graduate having the highest combined marks from both the Marine Engineering Application Course at RNEC Manadon and the MSE Phase 6 Ashore Course at Fleet School Halifax (commonly referred to as the EOPC — Engineering Officer Power Course). SLt DeOliveira placed top of his class on both courses.

CAE Award — SLt E.H. DeOliveira

Lt(N) Richard Baxter, HMCS *Yukon*, received the Peacock Award in April for being the top MSE candidate achieving MARE 44B qualification in 1991. A CAE Award winner in 1991, Lt(N) Baxter was presented with a sword and plaque by Peacock Vice-President **Rod Morrison** at this year's West Coast MARE mess dinner.

Peacock Award — Lt(N) Richard Baxter

News Briefs

Order of Military Merit!

Congratulations go out to **Cmdre Wayne Gibson** (PM CPF) and **Cdr Roger Cyr** (DMCS 6), recent recipients of the Order of Military Merit.

Cmdre Gibson

Cdr Cyr receives his OMM from Governor General Ray Hnatyshyn.

Artificial Intelligence — The Threat Evaluation and Weapon Assignment Problem

Coming up in our next issue