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Maritime Engineering Journal

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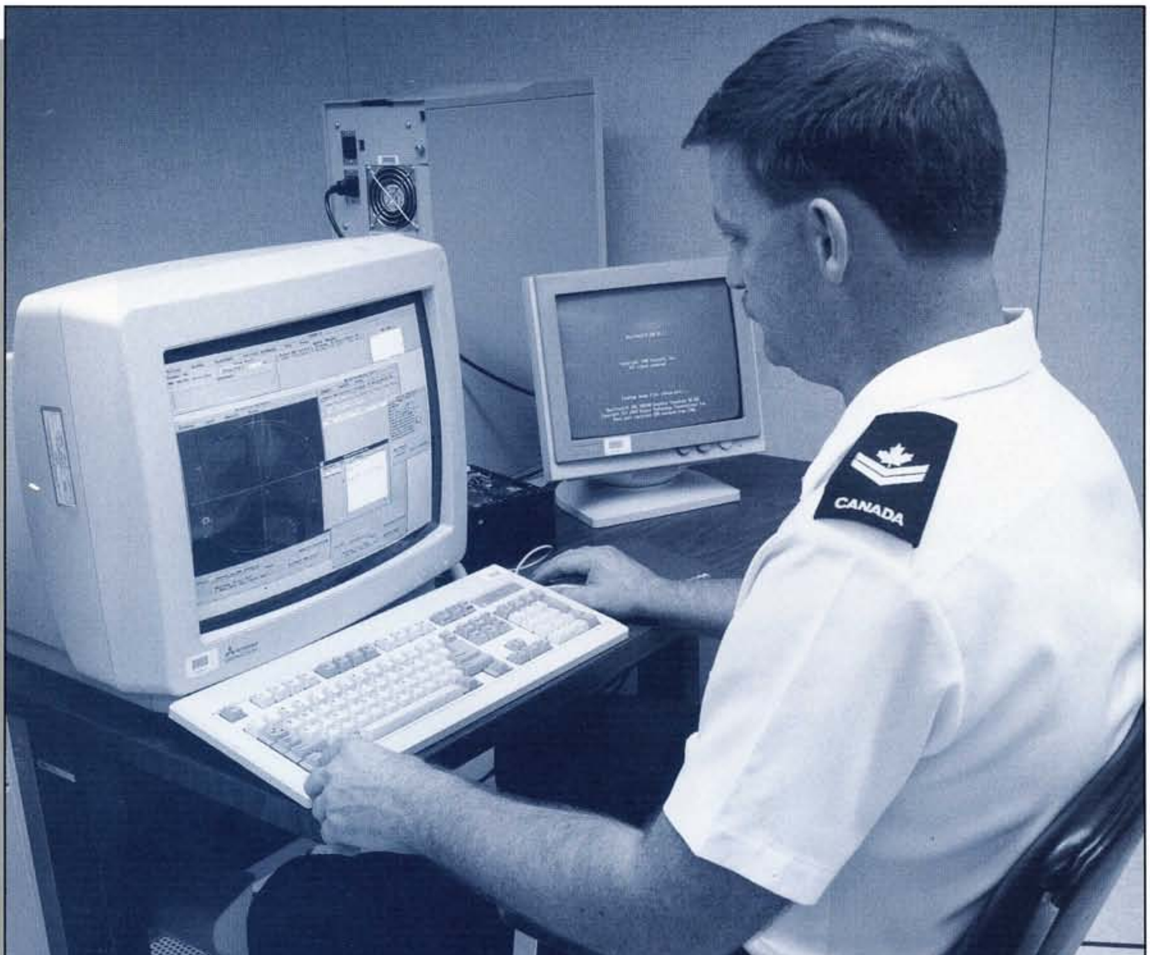


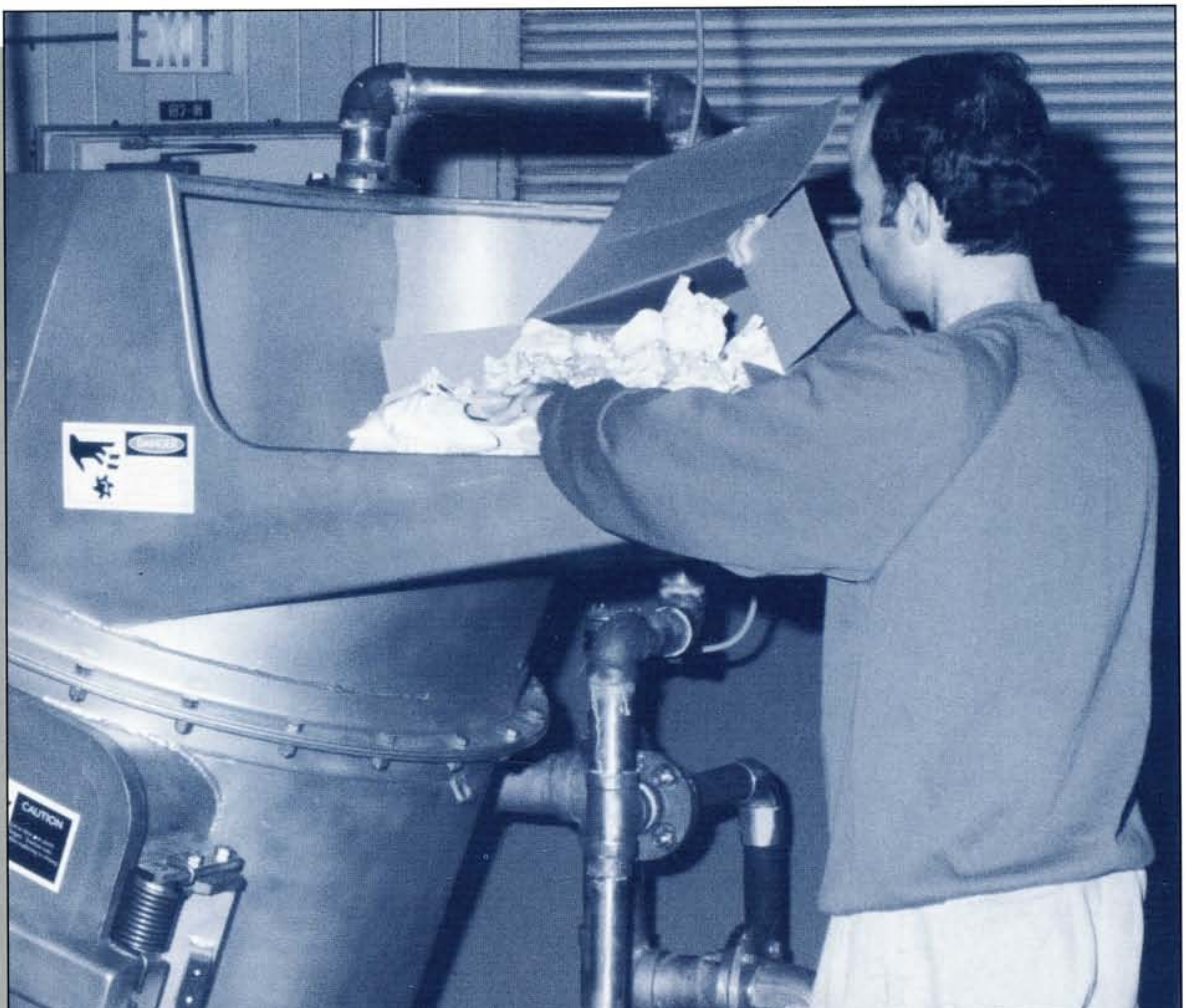
Designing effective ESM human/computer interfaces... Where does the end-user fit in?

Also:

- *Simple Steps for Effective Software Management*
- *A Readership Survey*

Canada

A veritable "green machine" is about to hit the waves – see page 21



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Maritime Engineering Journal

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DEPARTMENTS

FORUM

FEATURES

OUR COVER
Naval electronic warfare analyst MS Ed Campbell reviews the pre-production CANEWS 2 user interface being developed by Defence Research Establishment Ottawa. *(DREO photo by Bill Townson)*

The *Maritime Engineering Journal* (ISSN 0713-0058) is an unofficial publication of the Maritime Engineers of the Canadian Forces, published three 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

"Quick is Beautiful"

By Capt(N) Sherm Embree, CD, P.Eng., CIMarE
Director of Marine and Electrical Engineering

In these days of restraint it is as much the responsiveness of our DND processes that is being scrutinized as it is the cost of those processes. Cost is certainly a byword of any project, but so too are "schedule and performance." Customers demand satisfactory results, and they expect them quickly. If a supplier responds too slowly to a demand, conditions can change so drastically in the interim that the final output satisfies no one. This applies to DND's own processes of project management and engineering change. Unless these processes are made to function quickly, they tempt failure.

In his book, "*Infinite In All Directions*" (Harper and Row, 1988), Professor Freeman J. Dyson offers a more thorough discussion on the reasons why engineering projects fail. Dyson identifies some of the snags to be avoided when introducing new technologies. For instance, if we take too long to come up with a solution to a problem, he says, the conditions of the problem could well change enough in the interim to make the solution irrelevant. Do we fall into this trap in DND? When we go through the drawn-out process of establishing a business case for every change, are we certain that the financial conditions we started out with are still applicable at the end of the exercise?

A second concern of Dyson's is that regulations and requirements can change in less time than it takes to introduce a technology. What happens when everyone jumps onto a new-technology bandwagon and the wagon can't follow the major turns in the road? Our own experience with information and control systems may bring some lessons home to us in this respect.

Dyson also points out that we may be fooled into thinking there are economies of scale to be had with new technologies when, in fact, those economies may be lost if a big plant takes too long to build. "Small is beautiful" may not always be appropriate, but if your massive new maintenance information system is taking too long to establish, the economies of scale might very well be lost to interest and overhead charges. Never mind that a cumbersome system will suffer from its own inherent inflexibility as changing regulations and requirements outpace the system's implementation.

In my view DND has no choice but to adopt a "quick-response" work ethic to avoid these problems. We will have to see more off-the-shelf buys, streamlined once-only acquisitions and process reengineering if we are to ensure timely responses and customer satisfaction. "Quick is Beautiful" might not yet be recognized as a clarion call, but we might be well-advised to rally to it sooner rather than later.

Attention all readers!

....Speaking of keeping the customer happy, we have included a readership survey with this issue of the *Journal*. We last conducted a formal survey in 1987 and were delighted to receive replies from seven percent of the readership. This time we would like to do even better. Since the *Journal* is privileged with a worldwide readership, we would like to hear from anyone and everyone who reads the *Journal*, including our "extended family of readers" in the service of other countries.

Please take a few minutes to let us know how we can make Canada's MARE branch journal more responsive to your needs. Your feedback will guide the editorial committee in bringing about changes to improve the magazine, and we will report back on the results of the survey as soon as possible.

Letters to the Editor

A/HOD position on board ship a job

It has been just under a year since I first read the Forum article entitled "Assistant Head of Department: Should a job be an OSQ?" (*MEJ: July 1993*). After going over the article again during our transit through the Panama Canal (Operation Forward Action), and with the benefit of another year at sea as a CSE head of department, I feel it is time for a reply.

Lt(N) Pitre states that with respect to the A/HOD billet "it seems a bit unrealistic to affirm that it is not a training position." It's been my experience that this depends wholly on the person the A/HOD is working under. If an A/HOD's performance objectives are used as the sole basis by which he/she is employed, then yes, the A/HOD can turn into a trainee who runs around looking only for signatures. But in my opinion the performance objective package for an A/HOD is nothing but a guideline. I hardly ever looked at the packages for the three A/HODs I have successfully employed (one in HMCS *Qu'Appelle*, two in *Kootenay*). Merely completing the "reqs" does not by any stretch of the imagination mean that one will pass the HOD board or perform well as a HOD. What is important is that A/HODs be given increasingly important taskings and responsibilities, so that by the last four months of their employment they can be given the chance to fully function as the HOD.

While, as Lt(N) Pitre says, an assistant technically "cannot take responsibility for a department until the OSQ has been completed," as an A/HOD's experience grows he/she should be given the chance to take on this responsibility. Of course, the HOD is taking a chance by giving the assistant this role. Inevitably, mistakes will be made and will have to be answered. This can involve a lot of spilled blood in the CO's cabin, but I have been lucky enough to have had COs who (after the dust has settled) have generally agreed with my theory on the evolution of an A/HOD. The alternative is to produce an A/HOD with little experience or know-how in dealing with the pressures and responsibilities of being a HOD, and in learning how to interact with others (civilian and military) at this level.

LT(N) Pitre goes on to say, "Why do we allow newly sub-MOC qualified lieutenants to take on responsibilities ashore that sometimes exceed those of a department head in a ship, yet demand an OSQ for the job at sea?" Personally, I don't think you can compare the two. Who says a shore job at that rank level can match or exceed the responsibilities of a HOD at sea? Having spent one posting at NDHQ, I find it difficult to believe that there is a job a lieutenant(N) CSE or MSE HOD could have that is more important or challenging than ensuring a ship is technically ready and capable of performing the mission required of it. When all is said and done, is not the fleet the business end of what it's all about? And to say that the divisional responsibilities of a shore based lieutenant are the same as those of a HOD at sea is, for the most part, absurd. Except for the FMGs or the Fleet Schools, the vast majority of Lt(N) shore billets (from what I saw during my posting to DMCS) don't involve divisional responsibilities whatsoever, and those that do usually involve the ranks of PO1 and above. Being responsible for PO1s and above is far less time consuming and troublesome than being responsible for MS and below.

Finally, I totally disagree with the statement: "There is no need to make the A/HOD position an OSQ," primarily because I feel the A/HOD position is not one all sub-MOC qualified personnel are suitable for. Over the last three years I have successfully trained seven Phase VI candidates, but only four of them displayed the potential to succeed as an A/HOD (Yes, this was stated in their PERs). Good technical ability does not necessarily translate into good management ability or good leadership. If one does not display the potential, then one should not be given the A/HOD job. Definitely, the OSQ is needed to differentiate between those who are capable as a HOD and those who are not.

In closing, I have never had trouble convincing anyone that the A/HOD position on board ship is a job. I think this is mainly due to proper employment and the increasingly important tasks and responsibilities assigned, climaxing with being given the department to run for a period of time. It's never been a matter of just "signing the reqs off" with me. — **Lt(N) D. Wong, CSEO, HMCS *Kootenay*.**

Writer's Guide

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

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

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

Commodore's Corner

After the FRP: future for MAREs as good as ever

By Commodore Robert L. Preston, DGMEM

Since I last wrote an article for the Commodore's Corner there have been some significant events that continue to have an impact on the business in which we engage ourselves as Maritime Engineers. The world situation continues to develop in a more fragmented manner than we were used to in the 60s, 70s and 80s. Our members have, over the past few years, served in the Persian Gulf, the Adriatic, in Yugoslavia, Cambodia and Somalia. Our navy continues to enjoy a high standard of technical readiness, notwithstanding the challenges of introducing new and modernized classes of ships at the same time. One of the significant issues with which we must deal is the reduction of military activities in response to the financial problems (facing most developed nations today) enunciated in the February budget.

The budget announcement resulted in two personnel reduction initiatives, one being the Forces Reduction Program (FRP), the other being the Civilian Reduction Program (CRP). While action on the CRP was delayed until legislation could be put in place, the FRP (which affected the MARE classification along with 14 other classifications) has moved through a number of stages. By now, all those who applied for the program have been notified of the outcome of their application.

FRP 94 was effective in reaching its overall target of 963 releases. In fact, 933 CF personnel accepted the offer and will be released this fall. From the point of view of the MARE classification, the following numbers of MAREs accepted offers:

Capt(N)	3
Cdr	2
LCdr	7
Lt/SLt	25

While there were some problems getting information to those who were offered the FRP, I believe the program was generally well received. The FRP has provided immediate opportunities for some MAREs, and will open up a healthier promotion flow in a classification which would have otherwise suffered from throughput problems.

"The FRP...will open up a healthier promotion flow in a classification which would have otherwise suffered from throughput problems."

With the first phase of the FRP behind us we must look to some longer term solutions to the challenge of operating with reduced resources. The MARCOM Functional Review and NDHQ's Operation Excelerate are the initiatives which will define some changes to the way the navy does business. I anticipate even greater reliance on in-service support provided by the industries involved in building the Canadian patrol frigate and modernizing the Tribal class.

The big question now is, "How will all these changes affect our business as MAREs?" As I see it there will be little change to the early part of a MARE's career, which is oriented toward operating and maintaining the ships at sea. On the other hand, our new-equipment acquisition function will be affected, as will the in-service system and equipment support function we perform for the Maritime Commander.

The challenge will be to learn how to use and develop the capabilities of Canadian industry more effectively to provide the equipment and in-service support our navy needs. This challenge is not a small one and it will place tough, exciting demands on our members in the latter part of their careers.

In my opinion the future for the MARE is as good as it ever was. Service at sea as a Head of Department continues to be the focus of the early stages of the MARE career. It prepares our officers well for the demands they will face in providing effective technical support to the Maritime Commander. Although our classification will be smaller there is a great deal of change occurring and in that change there is opportunity for new approaches and exciting careers.

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.

SRUA
SHIP REPAIR UNIT ATLANTIC

SRUA in Transition — You Wouldn't Recognize the Old Place

Article by Capt(N) Roger Chiasson

Ship Repair Unit (Atlantic) has probably undergone more change in the last four years than it has since it was founded as a Royal Naval Dockyard in 1759. Much of that change has been self-imposed, by the introduction of a Continuous Improvement Program (our version of Total Quality Management).

Our reasons for embarking on this initiative were somewhat idealistic. We wanted to work smarter, and we wanted to empower our employees so as to reduce their frustration at being shackled by archaic rules and "systems." We also had an inkling that we needed to become "leaner and meaner," but little did we know how prophetic that gut feeling would be. SRUA, like everywhere else, continues to be affected by Department-wide budget cuts, and by a commitment in the naval engineering and maintenance community to drastically reduce the cost of doing business.

I have often compared the challenge of introducing a new management philosophy and employee culture in a unit like SRUA, which is so steeped in tradition and inertia, to that of changing the course of a 300,000-tonne tanker using a rudder the size of a briefcase. It's not a bad analogy when you consider it takes five to seven years for a TQM initiative to fully mature. Our "300,000-tonne tanker" has taken on a definite momentum, to the extent that most of us in SRUA are convinced the change of course has started and is irreversible.

The change of direction is clearly evident from the following significant achievements and/or initiatives which are attributable (either directly or indirectly) to our Continuous Improvement Program:

Adoption of Strategic and Business Planning

SRUA is now in its third business-plan cycle;

A cost-awareness and budget management philosophy has been adopted;

Goals and objectives are driven by customer and stakeholder needs.

Commitment to Improved Efficiency

A 7% reduction in the salary wage envelope (entirely out of overhead) has been achieved to date;

Further reductions are planned to achieve a mandated 20% reduction in the cost of doing business by April 1, 1996; more than half of this will be achieved through reductions in overhead.

"Somehow, the spark that had ignited the enthusiasm and pride for Operation Friction had to be relit."

Commitment to Increased Efficiency

The proportion of direct production person-hour effort has been increased from 42% to 49%;

Repair-and-Overhaul turnaround times for supply system components have been reduced by more than 50%;

SRUA's accident rate has been reduced by 17%; lost time due to accidents reduced by 35%;

Workforce flexibility (reduction of trade demarcations) and a team concept for major projects have been introduced;

ISO 9001 international quality assurance standard has been introduced; registration planned prior to August 1996.

Commitment to a People-focused Environment

Excellent labour relations exist despite the climate of wage constraint and downsizing;

There is mutual commitment to strategic alliances between management and labour;

Unions enjoy full consultative and participatory status in Human Resources Management, Continuous Improvement and Strategic and Business Planning committees;

An empowered workforce and a culture in which labour and management are amenable to and committed to change have emerged;

The representation of Employment Equity group employees has quadrupled;

Sensitivity and awareness training has been introduced to develop greater acceptance of a diversified workforce.

The decision to embark on a Continuous Improvement Program was made in the wake of SRUA's crowning achievement -- preparing three warships for deployment to the Persian Gulf in 1990. SRUA was awarded the Chief of Defence Staff Commendation for its part in Operation Friction, but enthusiasm levels soon waned. Somehow, the spark that had ignited the enthusiasm and pride for Operation Friction had to be relit.

Today, thanks to a great deal of slow-burning, enduring effort, these qualities are gradually beginning to reemerge. We still have some distance to go, but SRUA is well on its way to becoming the "leanest and the keenest" repair facility of its kind anywhere. You just wouldn't recognize the old place.

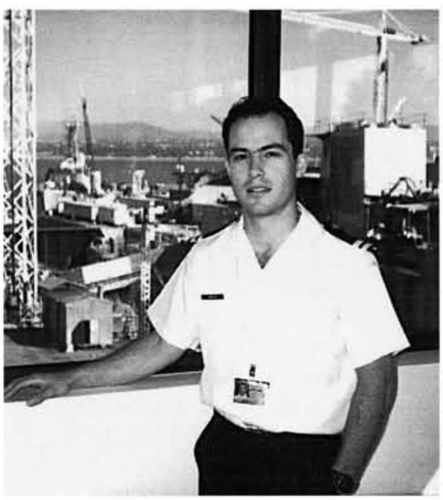
Capt(N) Chiasson was the Commanding Officer of SRUA from 1990 until this past July. He is now undertaking language training for his appointment as the Canadian naval attaché in Japan.

Forum

Life as a Junior CSE Officer*

Article by Lt(N) Pierre Langlois
(**First presented at the 1993 MARE Seminar in Halifax.*)

We all know how long it takes to get rid of the "U" in our MOC and replace it with an "A," and how long it takes to replace that with a sub-MOC designator. But obtaining that final, recognized qualification still only leaves us as "junior officers." So what is it like to be a junior officer in your first position? Most readers of this journal have been through that experience already, but I have been asked to give my own point of view, one not yet seasoned by broad experience in the MARE community.



I graduated from the Royal Military College in 1990 with a degree in Electrical Engineering. After training at *Venture* and in HMCS *Mackenzie* I completed the Applications Course at Fleet School Halifax and did my Phase VI on board *Algonquin*. I also had the opportunity to do some on-the-job training with Paramax in Montreal and with the Defence Research Establishment Atlantic in Dartmouth. I was posted to the TRUMP detachment at the MIL Davie shipyard in Lauzon in October 1992.

My first responsibilities in TRUMP were as D/CSEO. After benefitting from what has to be the longest turnover in the history of the Canadian navy (seven months), I became the CSEO — or, as my NCOs put it, "le boss." It is the responsibility of my office to verify and inspect all combat systems work performed by the shipyard. We evaluate trials, revise and approve unscheduled work proposals, provide technical assistance and generally liaise between subcontractors and DND agencies.

The position of CSEO involves a lot of responsibility, especially for a junior officer fresh out of training. My present supervisor was somewhat reluctant to take on a non-HOD-trained officer who did not have even a couple of years of experience. Not only did I have to prove that I was motivated to perform, but that I was capable of doing so. Being accepted by the other section heads was a great help, and I owe a debt of gratitude to the officer I replaced for all his support, encouragement and confidence in me.

What worried me most was how the senior non-commissioned members would react to me. These men had more sea time than I can ever dream of getting. I made it clear to them that even though I was a qualified CSE, I valued their opinions and recommendations highly. For their part they recognized my technical competence, and together we created a very efficient and powerful working relationship. Some of the shipyard employees, on the other hand, tried to take advantage of my inexperience during negotiations over contract work and inspection standards. The problems disappeared after I adopted a strong position on a few occasions.

My MARE training seemed to prepare me well for the CSEO position. The technical information it provided on the various areas of combat systems was excellent, and it gave me a good grasp of the concepts and a broad understanding of how the different systems interact on board ship. The training was also adequate in the broader naval engineering issues (especially in marine systems) and in general naval knowledge. In that last area, more time at sea would certainly help, though. If I could add anything to the training package it would be in leadership and the management tools to support it. Leadership seems to be a skill we are expected to develop on board ship, whether we have divisional responsibilities or not. I was *not* prepared for my first tour as Officer of the Day during Phase IV training.

From the position of CSEO in TRUMP Lauzon, I will take away excellent experience as a section head, as a Maritime Engineer in a major refit project and as a mediator in dealings between naval support agencies. There are some things that training alone cannot provide, and among these is the management of real resources to meet real deadlines.

"Leadership seems to be a skill we are expected to develop on board ship, whether we have divisional responsibilities or not."

As far as my outlook on a career in the navy goes, there are many interesting and challenging jobs available. The continuing training program of the Canadian Forces is certainly appealing, especially the postgraduate studies, but it seems the promotion opportunities will be limited as many excellent candidates fight for the extra gold. There is also an apparent contradiction in the absolute requirement to be HOD trained (to get ahead), versus the limited number of training billets in a fleet that is decreasing in size. Success, I have heard, is the combination of talent and opportunity. My classmates and I believe we have the talent, but will the opportunities be there?

Technical Specification for a CPO1 Engine Room Artificer

Article by Cdr G.L. Trueman

Author's Note: On April 28 a retirement farewell gathering was held at the C&PO's Mess in Halifax for CPO1 ERA J.L. MacIntosh and CPO1 ERA S. Jenkins. As the senior MSEO on the Coast I was asked to say a few words to mark the occasion. I wrote and delivered this "technical specification" as a tribute to the two chiefs, and to all CPO1 ERAs "worth their salt."

References:

A. BR2007 Marine Engineering Notes for Engine Room Artificers and Mechanicians Training (by Command of their Lordships of the Admiralty), 1952, Parts I-V.

B. BRCN 5521 (NEM).

C. Divisional Officers' Handbook.

General

1. The role of a CPO1 ERA is to be all things to all people: a confessor/confidante to his Engineer Officer, a father figure and idol to his "kids" on the plates, a tough man of action to his Captain and a fount of knowledge on all things mechanical to anyone outside his chosen profession. To fulfil this role, he must be able to recite verbatim all five parts of reference A on boilers, reciprocating machinery, turbines, auxiliary machinery and internal combustion engines. He must be on more intimate terms with the provisions of reference B than he is with his wife. He must be the living practical example of the provisions of reference C.

Performance Requirements

2. For a CPO1 ERA to be worth his salt, he must satisfy the following performance requirements:

   a. must always put his ship, his men and the welfare of his Branch before anything else;

   b. must be able and willing to go to sea and fight his ship, anytime, anywhere;

   c. must be able to slap a bearing on a triple-expansion steam engine without losing a finger, all the while whistling Hearts of Oak;

   d. must be a recognized expert on all things mechanical, pseudo-mechanical, remotely mechanical and nonmechanical, whether authorized or unauthorized for RCN use;

   e. must be able to extract a spare part anytime, anywhere, from the Pusser's shop, using the minimum amount of force necessary;

   f. must be able to manoeuvre at full power, either ahead, astern or sideways, preferably all at the same time, without propellers (read little to no pay), lacking lube oil (read lacking beer or beverage of choice) and lacking any form of closed-loop control system (read no direction and guidance); and

   g. must be able to lead his men from ahead and his officers from astern.

Physical Requirements

3. A successful CPO1 ERA must possess the following physical characteristics:

   a. big feet for motivating the backsides of wayward mechanicians;

   b. nerves of hardened, tempered, cold-rolled steel to AISI 4150 Standard, while all those around him possess nerves of pig iron or lesser grade materials;

   c. an intelligence quotient proportional to his Common Dog quotient and skin thickness; and

   d. the thermodynamic properties of an irradiated black body (i.e. can absorb all incoming heat, flack and abuse without retransmitting same).

Test and Trials Requirements

4. Besides satisfying the foregoing requirements and all of the tests and trials specified by reference B, a CPO1 ERA will satisfy the following tests and trials:

   a. wax eloquent for a minimum of 1 hour, without normalizing, on any topic of choice, in an unstabilized condition, to the standard specified by the Chairman of the Black Angus Society; and

   b. after a minimum of 35 years' service to the Navy recite, without error, the motto of his Engineering Branch, with a smile on his face.

Cdr Trueman retired from the navy in September to take up private business pursuits in Nova Scotia.

The Role of the End-user in the Design of Effective ESM Human/ Computer Interfaces

Article by Barbara Ford

Human/computer interfaces are often designed without direct input from the end-user. This is true especially of military systems where a headquarters unit determines the requirement for the human/computer interface (HCI), and assumes the operator (i.e. the end-user) will be trained to use the final product however it turns out. In fact, in cases where the end-user has not been involved in the design process, the operator tends to simply avoid those portions of the HCI that are too confusing, thereby reducing efficiency. Inevitably, this process leads to a spate of expensive engineering change requests.

As more and more HCIs are being designed, it is becoming clear that the end-users are valuable to the process of creating effective interfaces[1]. This particularly applies to military HCIs, since deficiencies in an interface could have catastrophic consequences. For instance, it is possible that lives could have been saved on board the USS *Stark* had the information on the ship's SLQ-32 been conveyed in a different way[2].

Designing a human/computer interface for an electronic support measures (ESM) system is not trivial. There is considerable information available about a potentially large number of pulses, emitters and platforms in the environment. The information is context dependent and of a critical nature. The effectiveness of electronic countermeasures and ship survival depend on the results of interpretation of the information.

Not only are the complexity and sophistication of the functions performed by an HCI increasing, but it is also essential to minimize development time and life-cycle costs. The achievement of these goals is dependent on the employment of effective system development methodologies. The Defence Research Establishment Ottawa (DREO) has formulated a development strategy for HCI systems that

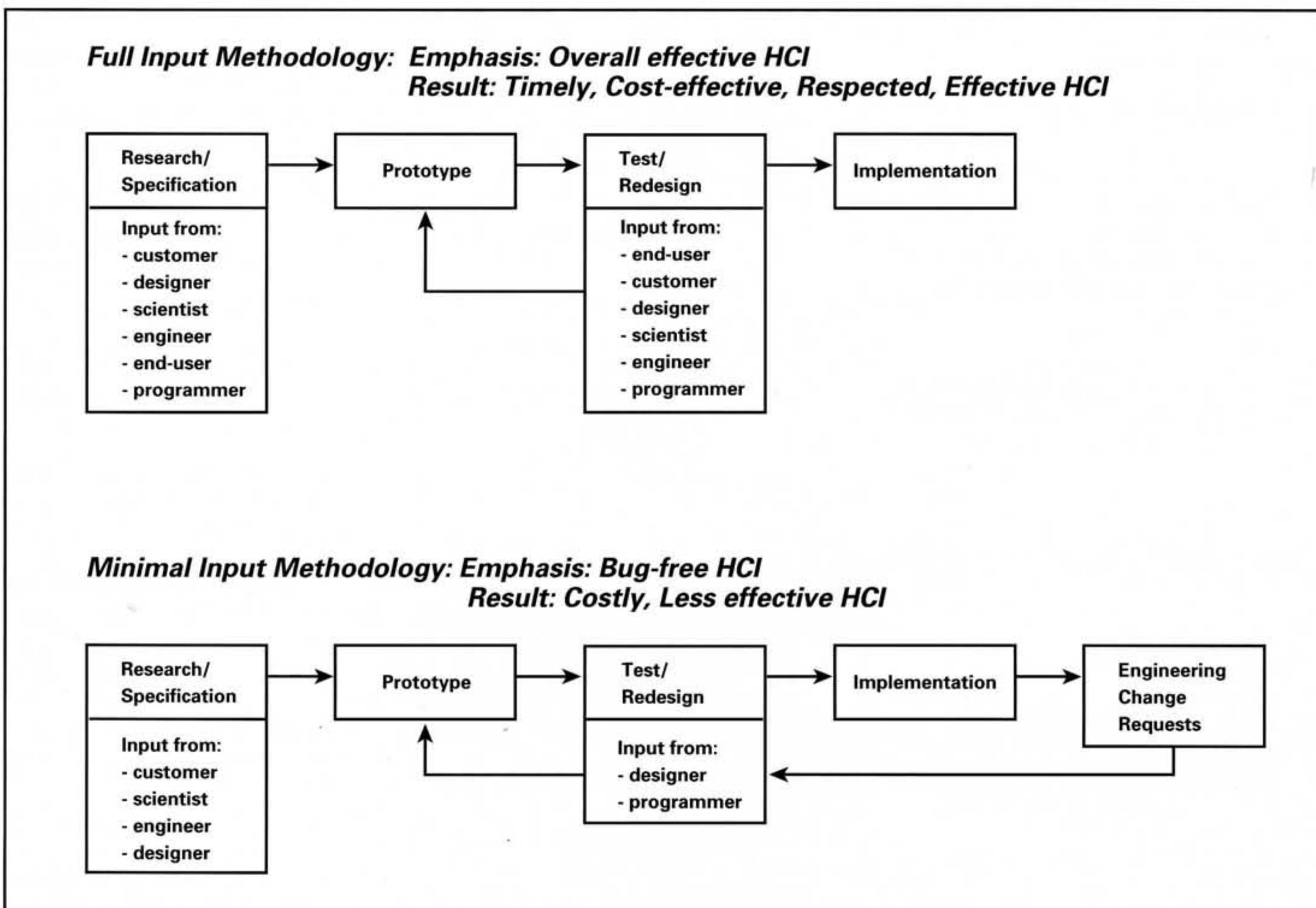


Fig. 1. Human/Computer Interface Strategies

borrows elements from concurrent engineering[3,4]. DREO's Full Input methodology minimizes the need for making design changes when the system development is nearly complete.

It does this by obtaining input from the intended users of the interface at various phases in the design process. In the older design methodology, which we refer to as Minimal Input, user feedback is obtained only *after* the HCI enters service. It is considerably more economical to identify and correct errors, and to implement and evaluate potential improvements at earlier stages in the system design. Consequently, the DREO methodology results in a more effective HCI, saving money and reducing the time required before the HCI is fully operational.

The phases of designing a human/computer interface are[5]:

Research/Specification — define the requirement, generate and analyze design ideas;

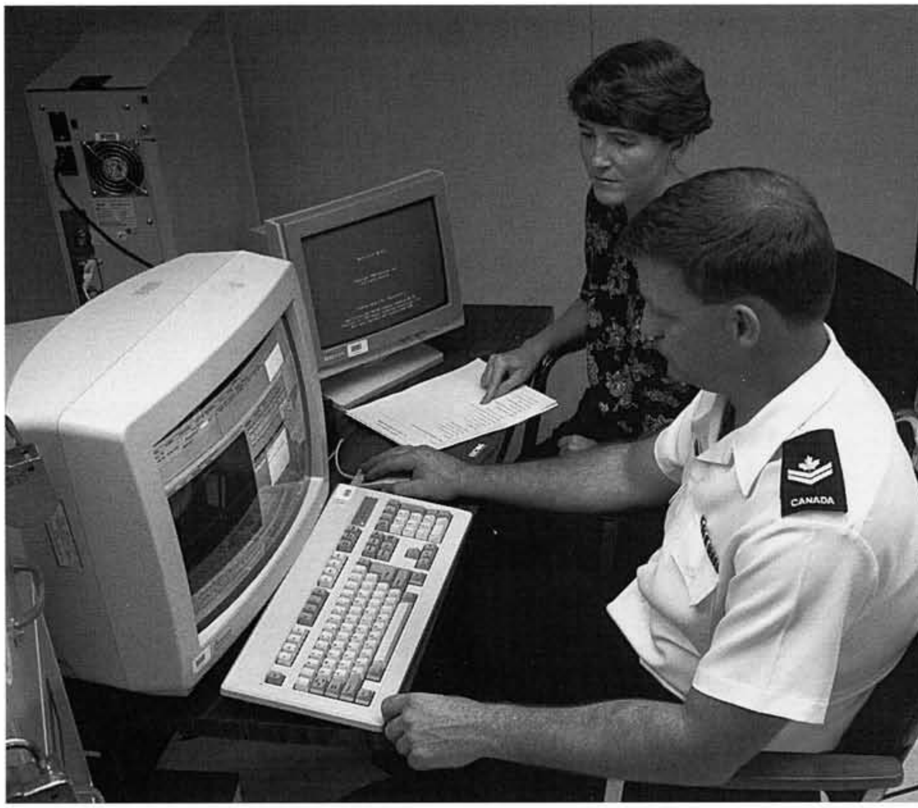
Prototype — build an experimental version of the specified design;

Test/Redesign — continue to try out and improve the design until it is effective and complete; and

Implementation — build the design to be fielded.

Input from the end-user is useful at the Research/Specification phase as well as the Test/Redesign phase. *Figure 1* shows these phases in both the Full Involvement and Minimal Involvement methodologies.

DREO is currently involved in designing the human/computer interface for CANEWS 2, the next-generation naval ESM system. DREO designed the CANEWS HCI currently in service in the Canadian patrol frigates and Tribal-class destroyers, and several of its features and functions are being maintained for the next generation. However, much has changed in the past decade: there is considerable additional information now available to the operator, and display techniques have advanced. The new HCI uses many windows, menus and buttons. The operator has considerable flexibility over what information windows he wishes to have visible. There is, however, a fixed window that cannot be removed or obscured since it contains critical information that must be displayed at all times.



DREO PHOTO BY BILL TOWNSON

Defence scientist Barbara Ford observes EW analyst MS Ed Campbell as he performs a fixed set of tasks on DREO's pre-production user interface for CANEWS 2.

The end-users, ESM operators, have contributed significantly to the design of the next-generation ESM system HCI. They have been useful in maintaining consistency with the old system interface, in determining which new features are most useful, and in identifying which new functions appear too complex. ESM operators were used at the Research phase to make sure all expected functionality was present, and during the Test/Redesign phase. The next section describes the process DREO used to test the design using the ESM operators.

Testing a Design using ESM Operators

Appropriate users must be selected for the test process. They should have an experience level typical of the expected end-users of the product, and should not be biased by the opinions of the designer[1]. DREO selected operators who had used other ESM systems, including the one the next-generation ESM system is to replace. They were, therefore, knowledgeable about what to expect from an ESM HCI[6]. These ESM operators had their own biases about what they like to use on ESM interfaces, but this was considered during the design test. Such bias was appropriate for the DREO application since progressive improvements on previous ESM interfaces are preferred over revolutionary changes.

The operators were told the purpose of the test and it was stressed that it was the product being tested, not them. They were told that if they had any difficulties it would indicate weakness in the design, not in their abilities.

The ESM system HCI is designed to be as intuitive as possible since the operator must react quickly to new information on the display, often under stressful conditions. Having an HCI that behaves as the operator expects it to can minimize errors in those critical moments. Due to this requirement, the operators were asked, one at a time, to use the system for five minutes without any training time. They were shown only the main menus and how to operate the input device. They were then observed to see how effectively the interface could be manipulated and which functions were accessed.

A short training period followed in which all interface functions and access procedures were explained. The operators were then given the opportunity to play with the system for 15 minutes. Although any questions would be answered during this time, the operators were left alone to explore and make mistakes without feeling inhibited by the presence of staff.

At the end of the training period each operator was observed performing a fixed set of tasks which included attempting functions, manipulating windows, and accessing menu items. To draw consistent conclusions about the design, it was important to use a fixed set of tasks when testing each operator.

By this time the operators had many opinions about the design of the ESM HCI. Any thoughts they expressed during the test were noted, and a wrap-up discussion among several ESM operators and the designer proved particularly useful. Everyone had a chance to bounce ideas off one another as the designer guided the discussion. Each function and window was put onto the display and discussed as to its usefulness and effectiveness. The operators were also asked to indicate if anything seemed to be missing from the interface.

The process just described constituted only one iteration of the Test/Redesign phase. Operators will be used again in further iterations for the design of the ESM system HCI.

How useful are the end-users?

The observations of the operators using the system with zero training helped to indicate the extent to which the design is intuitive. They demonstrated the effectiveness of the basic layout of the display, the accessibility of the functions through the menus and buttons, and whether the information the operator needs is where he expects to find it.

The fixed test showed whether the information the operator requires is easily accessible, and which display functions the operator is likely to use to obtain necessary information.

Many good ideas were presented in the wrap-up discussion, including ideas for changes to numerical units, additions to display options, and new graphs. The operators indicated areas where information or functions appeared to be missing, and pointed out which windows they would be most likely to use and in what form.

In general, consulting the end-users for this design test provided valuable insight into what they need in the design. Information from the operators contributed to consistency of terminology and usage among the various ESM systems. Consistency is needed for ease and comfort of use of the new interface. In any given day an operator is likely to use several ESM-related HCIs, so switching systems should be as easy as possible. The more familiar new tools are, the more likely it is the operator will use them effectively.

End-user design testing can be useful in determining how cluttered an interface can become. For instance, after using the interface for some time it may become cluttered with too many open windows. Operators will need to be trained to close windows that are no longer required. Restricting flexibility of the interface is possible, but is often not desired.

Conclusions

Operators should not be solely responsible for the design of a human/computer interface. They are not expected to be aware of all available system functionality and will show a tendency to initially reject what they are not used to. Still, it is important they be consulted.

The end-user, or operator, best knows the environment in which the HCI will be used and how the information will be interpreted. He knows best which information is presented in too complex a manner, and which aspects of the interface might rarely be used. He is also in the best position to enforce consistency between his various systems with respect to units of measure, and to how things appear, are used or accessed.

When the operator is consulted in the design of the interface, the changes he inevitably requires can be made *before* design implementation. This minimizes the need for costly, post-implementation engineering changes.

End-users should be in the loop for the design process of military HCIs. The use of the ESM operators at DREO for the design of the next-generation ESM HCI proved very useful. The operators enjoyed the exercise and were very enthusiastic. It is anticipated that the operators will have more respect for the final product, and confidence in it, knowing they were part of the design process.

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More Effective Software Management

Article by LCdr Doug Brown

Software is a pervasive element in today's complex society. It forms an essential component of virtually every control system, including those for all weapon systems. Yet the procurement and support of software is fraught with difficulty. Delivery of software on time, within budget and meeting initial requirements is the exception rather than the rule. Many of the problems encountered along the way stem from a lack of understanding of the software development process and its associated cost-drivers.

A great many software development projects are huge, and push technology to the limits. The command and control system for the Canadian patrol frigate, for example, will cost more than $200 million, but by today's standards this is not an unusually large undertaking. As complex as some development projects may be, managing the acquisition of software is not rocket science. The management principles involved are the same as for any other development project. It is the failure to apply these principles that causes many of the problems. The U.S. Defense Science Board recently stated that, "today's major problems with military software development are not technical problems, but management problems."

Even minor managerial oversights can involve large cost overruns. With software so crucial to naval operations, we cannot afford ineffective management of its development. To this end it is worth examining five key software management issues:

- life-cycle cost distribution of software,
- language of implementation,
- effects of hardware on software,
- changing requirements, and
- future technologies.

Life-cycle Cost Distribution

If software were to be characterized by one word, that word would likely be "expensive." Costs in the order of $200 to $300 per line of code are often quoted for weapon systems. As these systems frequently exceed one million lines of code it is not surprising that software development costs range in the hundreds of millions of dollars. Software and related costs can often be found in the range of 20-40 percent of total acquisition costs for weapon systems. Unfortunately, tracking software costs accurately can be difficult, especially when they have been buried within other costs (often for good reason). It is one thing to be unable to say in advance exactly how much your software is going to cost, but it is completely inexcusable at the end of the day to be unable to say how much you did spend. The first step in controlling software costs is to make them clearly visible so that they can be accurately measured and analyzed. Only then can norms be established and deviations dealt with.

We must also understand that there are two distinct phases in the software life cycle: the acquisition/development phase and the maintenance/in-service phase. Weapon system software is historically long-lived; service lives of 15 to 20 years and longer are normal. Inevitably, maintenance costs will more often than not exceed development costs. The United States Department of Defense has found annual maintenance costs as high as 10-15 percent of the total development costs. Over the lifetime of a system, maintenance costs can reach 70-80 percent of

I'll find out what they need. The rest of you start coding!

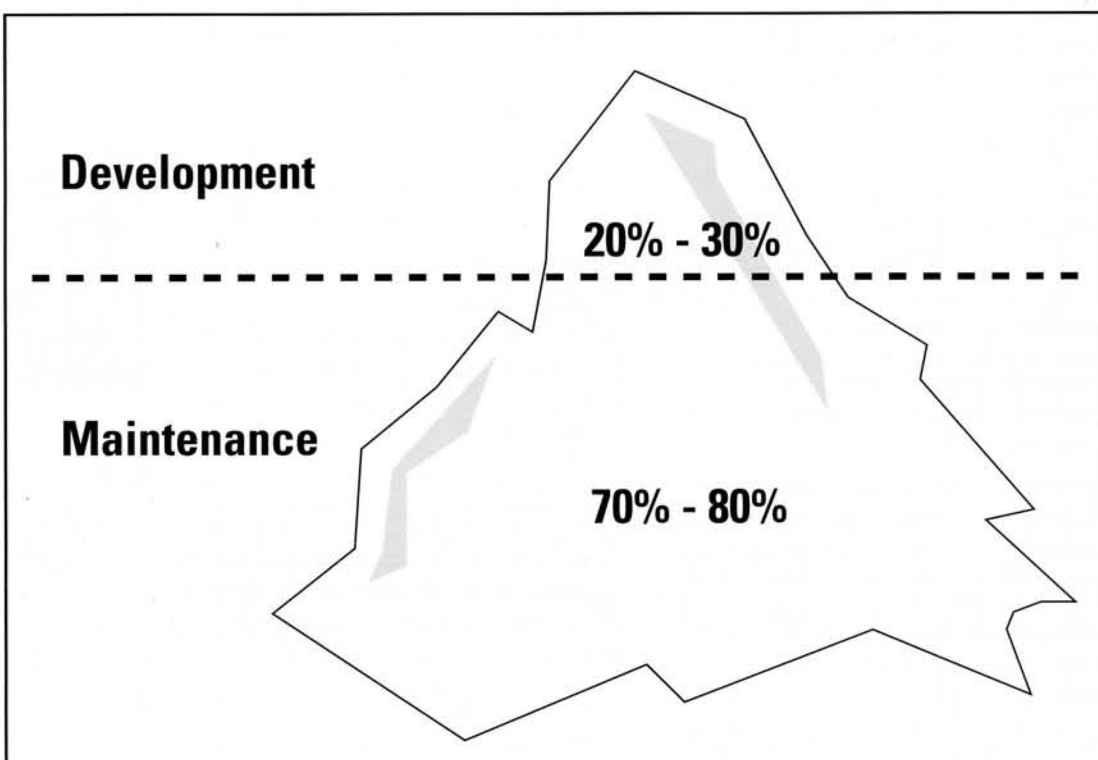

Fig. 1. Software Life-cycle Cost Distribution

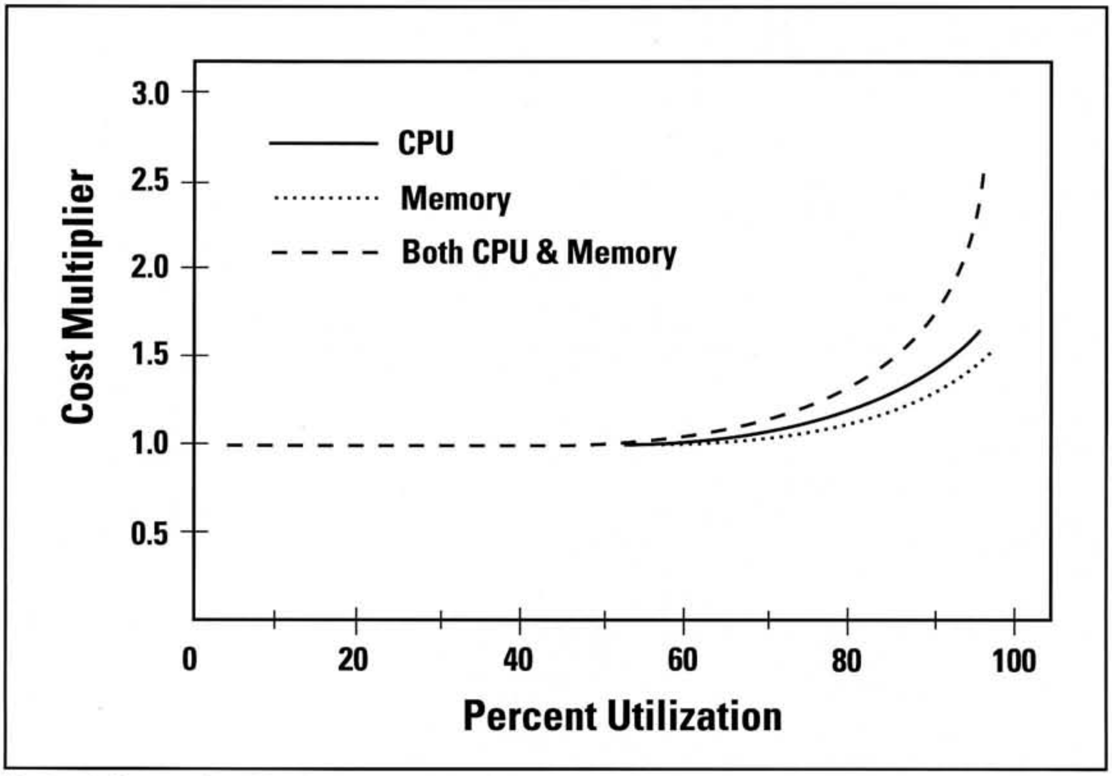

Fig. 2. Software Cost Escalation resulting from High CPU and Memory Utilization.

An experiment conducted here in Canada serves to highlight the effectiveness of Ada. Two teams were given identical requirements and equal time to implement a small utility. One team used C-language; the other, Ada. In use, the Ada code was found to be more robust, requiring less than one-third the effort to implement a change. A similar experiment by the USAF found the Ada maintenance effort to be less than half that of C. While savings of this magnitude are unlikely to be found on large systems, savings of even a few percent cannot be ignored when annual maintenance costs are in the tens of millions of dollars.

the total software-related costs. For this reason, software development costs are often compared to the tip of the software cost iceberg (*Fig. 1*).

To date, much effort has been focused on reducing software development costs. Little effort has been focused on reducing maintenance costs, where the greatest expenditures lie. It is a well-known maxim that the largest target is easiest hit. Perhaps economic necessity will finally force us to focus on the target with the greatest potential for savings. It doesn't help that maintenance costs are often inadvertently increased by misinformed decisions made during development. When a project is late or over budget, considerable pressure is often exerted to get the software "out the door" at any cost. In the rush, essential design documents may be ignored, or short-cuts taken, which can easily double the subsequent maintenance costs.

The problem stems from the nature of software itself. Software is largely an intellectual artifact and must be understood before it can be modified. Short-cuts in development are achieved at the price of understandability and reliability, which increases the level of effort and the cost associated with maintenance. It makes better fiscal sense to expend extra effort in development to achieve a quality product to help reduce the larger maintenance costs.

Language of Implementation

The language used for implementation can also significantly affect life-cycle costs. Unfortunately, selecting a suitable language is difficult. The world is full of self-professed "experts" who praise one particular language and trash all others. Also, the mandate to use Ada is frequently resisted, often for no other reason than people don't like to be told what to do. Project managers can easily find themselves at a loss as to which language might be the best for their project.

When the issue is examined rationally, Ada can be found to be the most beneficial and economical language to use over the life cycle of a weapon system's software. It must be acknowledged, however, that although Ada has been adopted as the standard high-order language for weapon systems in the Canadian Forces, it does have a number of deficiencies. Many of these faults apply equally to every other language in use today, but few people understand that the primary advantage of using Ada is not reduced development costs. Ada's intimacy with sound software engineering principles leads to the development of high-quality software that is easier to maintain. The primary advantage of Ada, therefore, is reduced life-cycle costs through reduced maintenance effort. Unfortunately, developers often base their recommendations on software development costs alone.

Impact of Hardware Selection

Systems with embedded computers have traditionally had their hardware selected first. The software was then made to fit the hardware. This may have been cost-effective 40 years ago when hardware was expensive, but no longer. Today, the choice of hardware can be a significant cost-driver for software development and maintenance. U.S. DoD analysis indicates that software-related costs form about 90 percent of the cost of embedding computing resources in a system. But even though it forms a very small percentage of the total cost, the selection of hardware is crucial.

Curiously, attempting to utilize all available CPU and memory capacity can substantially *increase* software costs (*Fig. 2*). While there is apparently no impact below a threshold of 60-percent utilization, once this limit is breached the cost of developing software to fit the available resources increases rapidly — by more than two and a half times at 95 percent capacity than at 60 percent.

None of this has been lost on the maintainers who will spend days and even weeks trying to devise new algorithms that are just a few bytes smaller or a few cycles faster. Understandably, many of the algorithms and control structures devised to cope with limited resources are arcane. Thus, future maintenance activities become progressively more complex and expensive.

In a similar vein, we must also examine our embedded computer hardware procurement practices. Twenty years ago military computers were on the leading edge of technology. Today, most are obsolete before they even get off the drawing board. The half-life of a modern CPU is very short and declining. With procurement lead times of 10 years and longer, we can no longer afford to develop specialized military computers. We are also faced with a dilemma: do we specify current technology and guarantee obsolescence, or do we increase the risk by specifying undeveloped technology?

The solution is to specify the interface and not the hardware. While the hardware interface remains well defined, the hardware and software can be developed in isolation and integrated with minimal difficulty. We need to emulate the model of the PC. Although the PC has many technical limitations, it does have well-defined architecture and interfaces. This allows PC software to be developed in isolation so successfully that it is not even given a second thought.

The PC model has another attribute worthy of emulation. It is possible to easily upgrade the CPU, add more memory, or any other needed resources and not worry about software compatibility. We can even replace one PC with a completely different model. We are finding that this flexibility is increasingly needed for weapon systems. Just as application programs for the PC are growing in size and resource demands, so too is the software in our weapon systems. We must be able to cater to software growth approaching an order of magnitude during a system's 20- to 30-year life cycle. It is relatively easy to physically change a processor, but we must also be able to move our considerable software investment as well. We rightly demand to be able to migrate a $200 word processing package from an older PC to the latest model without modification. We must demand the same for a $200-million command and control system.

Changing Requirements

Software requirements frequently are allowed to be changed in mid-development. Most people view software as being something akin to gold: simple in structure and easily shaped by anyone. In reality it is like crystal — very complex and liable to shatter if mistreated. Although software can accommodate most any change during the development process, it is seldom simple and almost never cheap. Uncontrolled change can easily double the cost of software development. Fortunately, it is one of the most preventable causes of cost escalation, and thus merits special attention. Not surprisingly, all successful software projects share the common attribute of rigorous control over requirement changes.

Software development is frequently initiated with incomplete requirements. Perhaps the three most common letters found in a requirements specification are "TBD" (to be determined). While there are some cases where requirements are best sorted out after development has begun, all too often this is used as an excuse to truncate requirements definition and "get on with the job." This is a mistake. This does not imply that requirements should never be allowed to change (which would present an impossible situation). Rather, requirements should be rigorously controlled such that the potential impact of every proposed change is carefully examined and understood.

Future Technologies

Software, like all leading-edge technologies, has a number of innovations that show great potential. It is prudent, though, at this point to interject two words of caution. Fred Brooks stated in 1986 that there is no silver bullet that will magically increase software productivity. This remains true today, despite claims to the contrary. The second point to remember is that all new technologies are attractive. We must not let this cloud our judgment. The acquisition of new technologies must help fill bona fide requirements and should not be ends unto themselves. After all, many of even the most innovative software products are destined to spend their lives on a shelf.

Three emerging technologies seem to be most relevant to weapon system software: CASE, software reuse and prototyping. CASE or Computer Aided Software Engineering has been touted as many things and has been greatly oversold. If half the marketing literature were to be believed, a novice with a CASE tool could develop practically

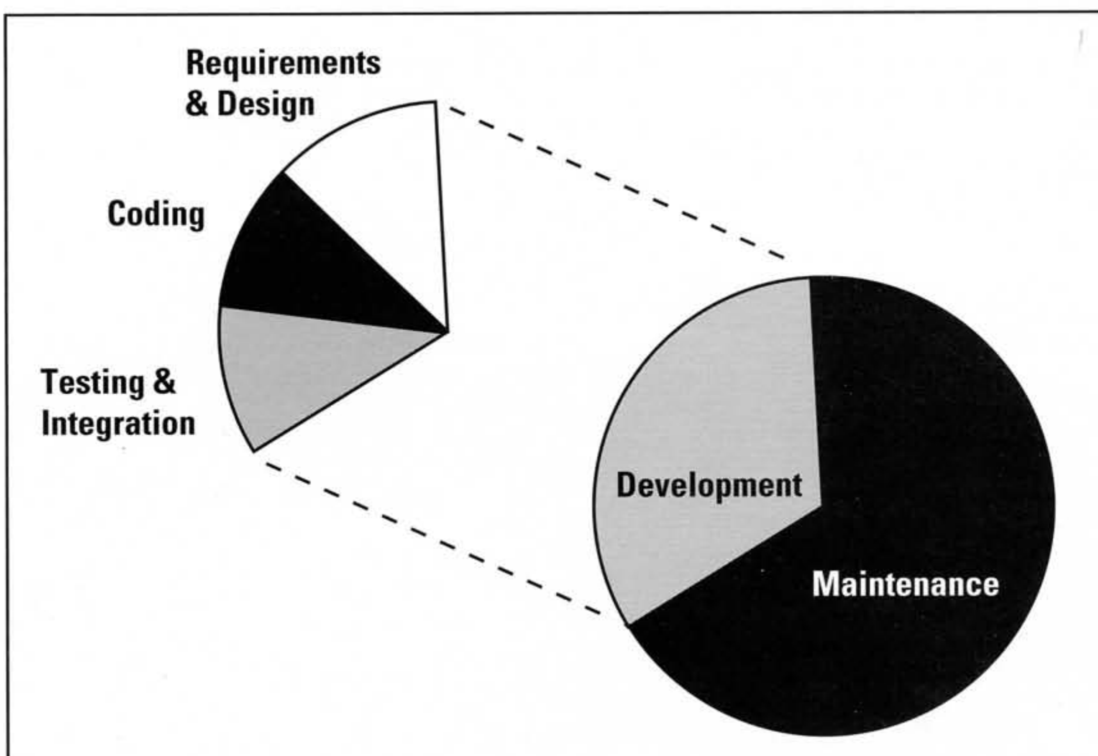

Fig. 3. Applicability of Software Reuse

any real-time application to the most exacting military standards. This just is not so. CASE technology can be beneficial, and when properly applied can achieve substantial economies, but the underlying methodologies must first be understood. A fool with a tool is still a fool.

One of the problems with CASE tools is that developers must adopt the method espoused by the tool; it is very difficult to mould the tool to match existing practise. Many software developers are still trying to refine their processes, and find that CASE tools constrain and hamper development rather than enhance it. Widely accepted standards that allow the output of one CASE tool to be used as the input to the next are still being developed. The level of effort presently required to provide this intertool interfacing could easily negate any potential savings from automation. It is often forgotten that CASE tools are meant to be used by people, meaning that the most important factor in successfully implementing a CASE product is adequate training. CASE without the training is a waste of resources.

Finally, CASE technology cannot yet be applied retroactively. A large portion of the naval software now in service was developed without benefit of modern methodologies. Adapting this software to modern methods is proving to be very challenging. Still, all is not doom and gloom. CASE technology holds great promise for automating the repetitive tasks and busy work associated with software development. Part of the challenge will be avoiding inappropriate CASE applications which can lead to expensive "shelfware," or even a loss in productivity.

Software reuse is also gaining prominence as a potentially attractive means of reducing costs. Considerable effort — such as with the U.S. DoD's STARS and CAMP initiatives — has been expended to develop repositories of reusable software components. To put this into perspective, consider that software development typically breaks down to 40-percent effort defining requirements, 30 percent developing source code, and 30 percent testing and integrating (*Fig. 3*). Limiting reuse to source code, as is frequently envisaged, constrains its impact to only 30 percent of development effort, which itself is only a small portion of the total life-cycle costs. Clearly, a large-scale economic breakthrough will not be achieved in this fashion.

Some firms are achieving considerable success with reusing design, code and integration software across a limited product line. Thompson CSF of France, for example, is achieving 60-80 percent reuse rates with the code and design for its air-traffic control systems. While these high levels of reuse represent only modest cost savings, the biggest benefit is the substantial reduction in the risk normally associated with completing a software project on target. Reuse has much promise, but it is still immature and there are many technical and legal issues that need resolution.

The last of the new technologies to be considered is prototyping. Prototypes are useful in many development situations to further refine requirements, especially in areas such as the user interface. User interfaces are historically subject to very high levels of maintenance activity, mainly because users often don't know exactly what it is they want. They seem to follow the rules of "IKIWISI" — I'll know it when I see it!

Developers are asked to provide a production interface, and user input is often limited to negative feedback, being received late in the development process. A great deal of effort can be wasted trying to define user requirements. Modern prototyping tools allow designers to easily and rapidly build software functions so the user can provide meaningful positive feedback before extensive effort is wasted delivering an inappropriate product. In this situation, a picture truly is worth a thousand words. A word of caution, however: prototypes are *meant* to be disposable. Prototyping yields low quality code that should not be considered for use in production software.

Conclusion

Software has become an essential component of weapon systems in a remarkably short period of time. To support its increasing importance, software must be managed cost-effectively. Taking some simple steps will help achieve this.

Most importantly, all software-related costs must be tracked. It is important to know exactly how much is being spent on software development and support. To control life-cycle costs, software must be developed with a view to easing maintenance. This includes using appropriate languages such as Ada, and completing all required documentation in a meaningful and useful manner. This might even entail extra effort during the development phase. Requirements must be meticulously analyzed, and changes rigorously controlled. Hardware has to be selected judiciously to ensure it does not increase software development and maintenance costs. Interfaces need to be specified so that appropriate hardware can be selected and then upgraded as required, while maintaining any software investment intact. Finally, new technology must not be allowed to override common sense. It must be shown to be useful, cost-effective and to satisfy a specific outstanding requirement.

Software can be very impressive in operation, providing flexibility and greatly increasing the capability of our systems. But it is not without cost. Managing weapon systems is complicated and intolerant of mistakes. Any attempt to suspend common sense and good managerial practice will always be disclosed in the bottom line.

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Fuel Cells and the Navy

Article and Illustrations by: LCdr M.J. Adams, CD, MEng, P.Eng.

For the past several years the navy has been supporting Canadian industry in the development of electro-chemical technologies. *Figure 1* depicts the three basic types of electro-chemical power systems, which depend on anodes, cathodes and an electrolyte to enable their respective reactions. They are:

the **battery**, which stores energy within itself through electro-chemical potential between an anode and cathode;

the **Semi-Fuel Cell**, which produces energy from a chemical reaction between a fuel (stored internally as the anode) and an oxidant (stored externally and fed to the cathode); and

the **Fuel Cell**, for which a hydrogen-based fuel and oxidant are stored externally and fed to the fuel cell's anode and cathode, respectively, to react and provide energy.

DND's efforts have focused on the development of two of these technologies: the **proton-exchange membrane fuel cell** (PEM FC) and the **aluminum/oxygen semi-fuel cell** (sFC). The rationale for DND interest in these emerging technologies can be distilled to a single element: process efficiency. Both technologies promise system efficiencies in the 50-percent region, compared to the average 25-percent overall system efficiency of thermal systems. Theoretical fuel-cell efficiencies can reach as high as 70 percent.

PEM Fuel Cell

Figure 2 shows a basic proton-exchange membrane fuel cell. A fuel cell combines hydrogen and oxygen (in a process which is the opposite of the electrolysis of water) to produce energy, with its by-product being water. It works as follows. A catalyst at the anode causes the following reaction:

$$H_2 \longrightarrow 2e^- + 2H^+$$

The protons (H^+) migrate through the membrane, which is an electron insulator. This forces the electrons (e^-) through the external path, i.e. the load. At the cathode, the electrons recombine with the protons and oxygen to form water:

$$2e^- + 2H^+ + 1/2O_2 \longrightarrow H_2O$$

There are several options for storing the hydrogen fuel. It can be stored in its pure form as a high-pressure gas, a cryogenic liquid or in a metal hydride. Another option is to derive the hydrogen from a hydrogen-rich substance such as methanol (CH_3OH), one litre of which contains 1.4 times as much hydrogen as the same amount of liquid hydrogen.

It is for this reason that we have selected the latter method for hydrogen storage. Methanol is catalytically broken down, or reformed, into hydrogen for the fuel cell, with carbon-dioxide as the by-product. This method has much simpler storage requirements and gives the highest system energy density, even though the presence of a "reformer" reduces potential system efficiency from 70 percent to 50 percent. This still equates to twice the fuel efficiency of a corresponding thermal system. For instance, a fuel-cell generator would require only half the fuel and oxygen of a comparable diesel generator to produce the same power, and would produce only half the carbon dioxide.

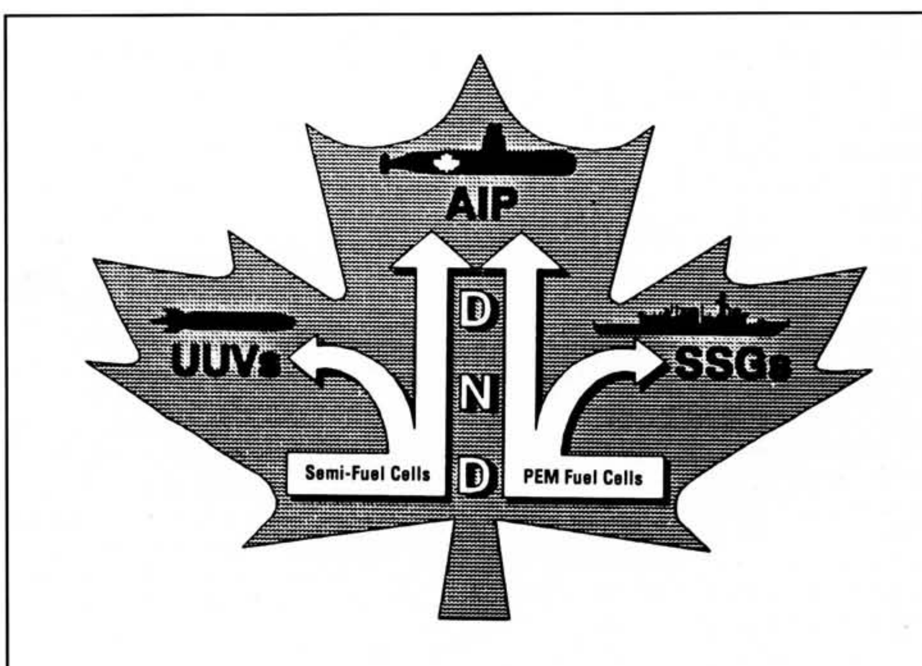
Since the fuel-cell system does not actually *burn* the fuel, there are certain additional benefits:

- the reforming process is cleaner and does not produce hazardous by-products, such as nitrous oxides;
- the reforming process does not need high-calorific-value fuel; this permits a much wider range of fuels for a fuel-cell system, making it easier to design a multifuel-capable system; and
- the ability of the fuel cell to use methanol greatly enhances its environmental appeal, since methanol is a synthetic, hence renewable, fuel.

Al/O_2 Semi-Fuel Cell

The basic aluminum/oxygen semi-fuel cell can be described as a hybrid between a fuel cell and a battery. A helpful way of understanding this system is to envision the aluminum as an electron storage device in which electrons are stored in the metal during the refining process and released during the oxidation process.

Figure 3 illustrates this relationship. Bauxite is refined into aluminum, using large quantities of power. An intermediate stage in the refining process produces aluminate ($Al(OH)_3$) which is then further refined into a pure aluminum alloy. This alloy is used as the fuel in the semi-fuel cell, where it undergoes controlled corrosion, releasing about 50 percent of the energy used in the refining process. The aluminate by-product can be re-refined back to aluminum. The aluminate,



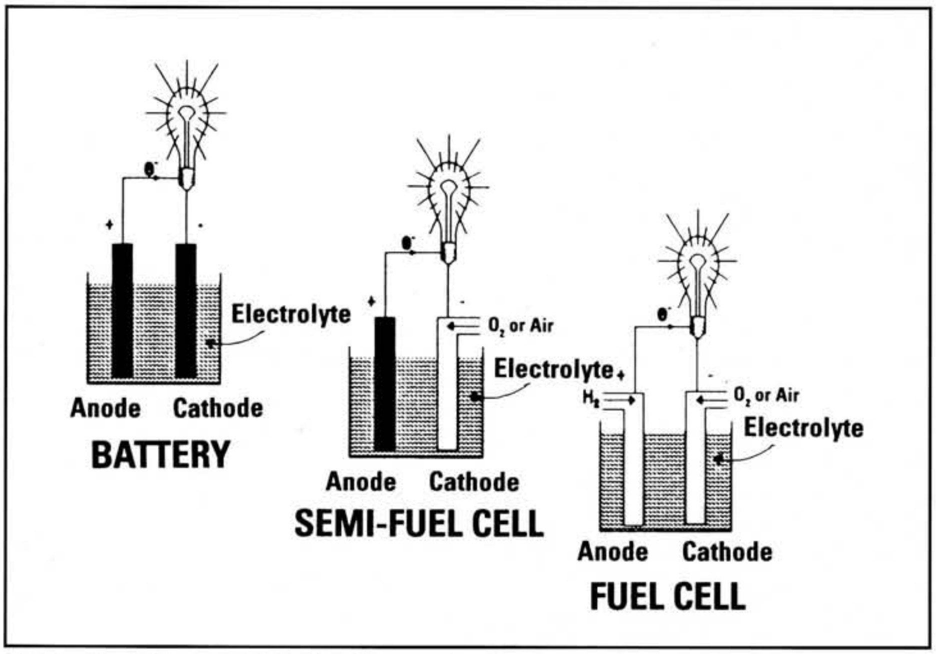


Fig. 1. Basic Electro-Chemical Power Systems

by the way, is an inert product which, among other things, is used as a main ingredient of tooth paste.

Figure 4 shows a basic Al/O_2 semi-fuel cell. The abbreviated mechanism of the aluminum/oxygen energy conversion process consists of a catalyst at the cathode, reducing water in the electrolyte and the supplied oxygen into OH^-, or hydroxyl, ions:

$$3O_2 + 6H_2O + 12e^- \longrightarrow 12OH^-$$

The electrolyte passes these ions to the anode where they react with the aluminum to provide the electrons, hence the power to the load:

$$4Al + 12OH^- \longrightarrow 4Al(OH)_3 + 12e^-$$

The aluminate by-product can either remain in solution in the electrolyte, or precipitate out of solution. Since the management of the electrolyte has a direct impact on the overall system energy density, three management systems are currently under development.

Figure 5 summarizes these three versions. The simplest system consists of maintaining the aluminate ions in solution in the electrolyte. This **solids-free** system is basically a pumped system whereby the electrolyte is stored in a common reservoir and pumped to each cell. There is sufficient electrolyte volume to prevent the aluminate ions from precipitating out of solution.

One way to increase the energy density of this type of system is to deliberately precipitate the aluminate out of solution. This has the effect of maintaining electrolyte conductivity, hence power production, while reducing the required volume of electrolyte. One variant of this strategy being developed is an unpumped **self-managed** system, whereby each cell contains its own electrolyte and reservoir. As each "self-managed" cell is discharged, the dissolved aluminate ions supersaturate and self-precipitate out of solution to settle at the bottom of the reservoir.

A second precipitating system variant, the solids-managed system, is a pumped process that actively precipitates the aluminate out of solution. It does this by seeding the electrolyte, which increases the size of the aluminate precipitate particles. A settling tank is incorporated to provide sufficient settling time to enhance higher packing densities.

These modifications result in a significant increase in system energy density. A typical aluminum-air sFC, for example, has more than ten times the energy density of an equivalent bank of lead-acid batteries. In other words, an sFC system requires only one-tenth the volume of a bank of lead-acid batteries.

The fuel cell and the semi-fuel cell systems both have the added advantages of low-noise operation, reduced infra-red signature, modular design and fuels which are either recyclable (sFC) or renewable (methanol). The systems are Canadian, and the two companies involved in developing them are world-leaders in their respective technologies: **Alupower Canada Ltd.**[1] of Kingston, ON (aluminum-oxygen semi-fuel cell); and **Ballard Power Systems Inc.** of North Vancouver, BC (proton-exchange membrane fuel cell).

Fuel Cell Applications

The navy is currently developing these electro-chemical technologies for use in:

- unmanned underwater vehicles;
- ship's service generators; and
- air-independent power.

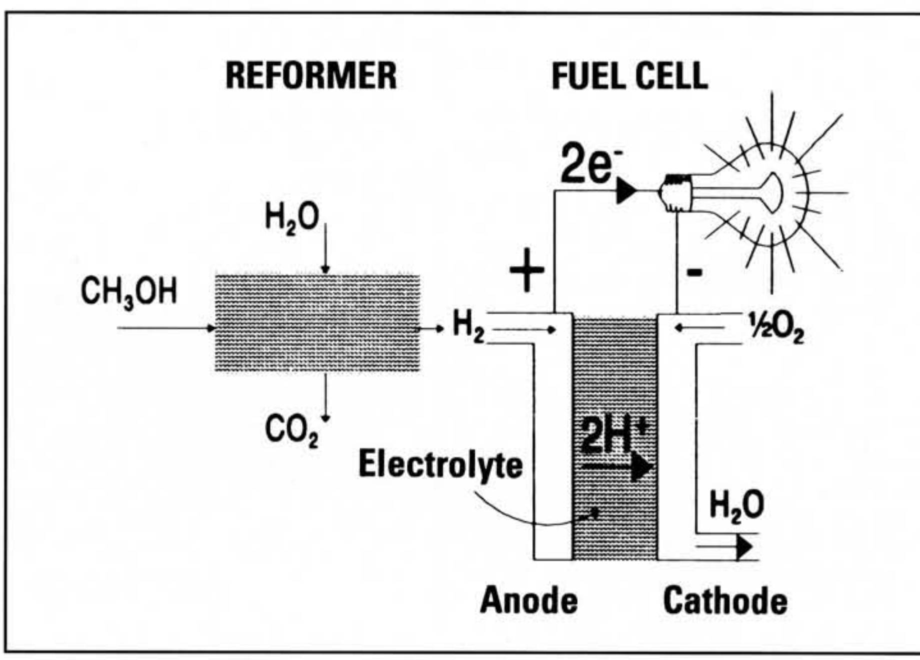


Fig. 2. Basic PEM Fuel Cell

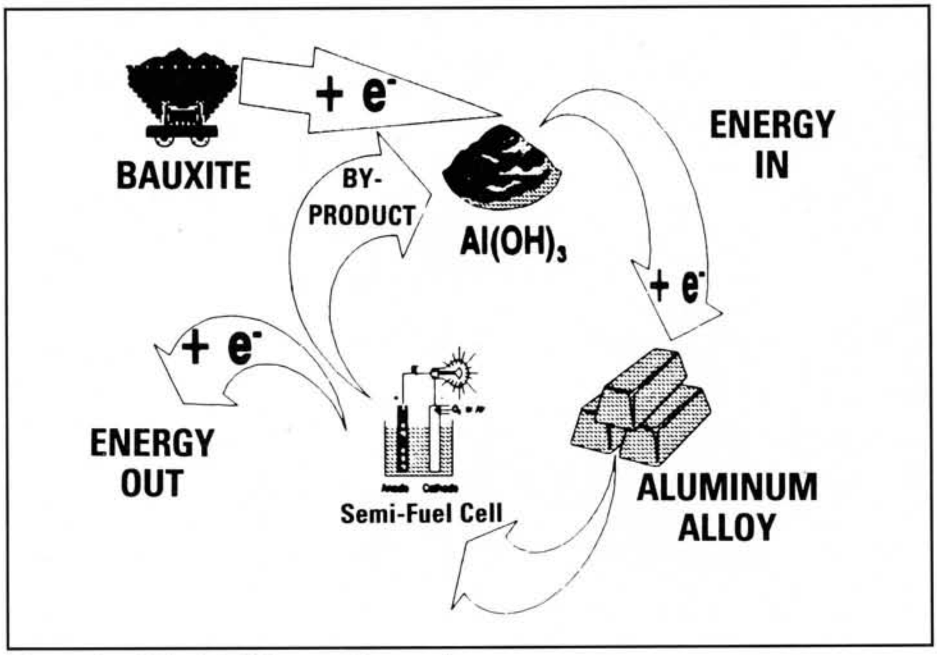


Fig. 3. Semi-Fuel Cell Energy Conversion

Unmanned Underwater Vehicles

Unmanned underwater vehicles (UUVs) and autonomous underwater vehicles (AUVs) are becoming more and more important to naval forces. UUVs typically have an umbilical cord for electrical power and/or communications (*Fig. 6*), and an onboard power source. The more versatile, free-swimming AUVs are entirely self-contained. As the technological capabilities of these vehicles increases, so does their suitability for longer duration missions which require a greater onboard supply of energy.

Most AUVs operate on lead-acid or nickel-cadmium batteries, which severely limits their submerged endurance. Although higher performance batteries, such as silver-zinc batteries, are becoming available, they have limited cycle life, are extremely expensive and are difficult to charge. To fully utilize the increased capabilities of modern AUVs, a enhanced endurance power system is required.

To this end the navy has been supporting Alupower in developing a power system for small underwater vehicles. Alupower has developed a 2-kW, 54-kWhr system for the navy's Autonomous Remote Controlled Submersible (ARCS) AUV, using decomposed hydrogen peroxide as the oxygen source and a "solids-free" electrolyte management system. The ARCS submersible, which is 27 inches in diameter and 15 feet long, operates on ni-cad batteries which give it a maximum endurance of six hours. The Alupower system was successfully trialled at sea in June 1994, achieving a 30-hour endurance (a five-fold increase). Alupower has also modified the current ARCS power system into a "solids-managed" system. A bench-top version of this system trialled in March 1994 delivered 54 hours of power — a nine-fold increase in endurance.

Figure 7 shows a comparison between typical UUV power sources. The densities shown represent installed weights and volumes for the Alupower systems, and best estimates for those of other power sources. It quickly becomes apparent that aluminum power sources have much to offer UUV developers. Gravimetric energy densities are between six and 10 times greater than lead-acid, and five to eight times that of ni-cad batteries. Volumetric energy densities are two to four times better than lead-acid.

Investigations are currently underway to determine how the navy can best continue the development of this promising technology. Assuming the technology remains in Canada[1], it is tentatively planned to further develop the "solids-managed" ARCS power system and perform another set of sea trials as resources permit.

Ship's Service Generators

The second area the navy is investigating is the application of PEM fuel cells to ship's service generators (SSGs). We are approaching this application from two angles — technology and requirements.

On the technology side Ballard is studying how much better a fuel-cell ship's service generator would be over a diesel SSG. The efforts are being focused on an 850-kW SSG that will be directly compared to the 850-kW diesel SSG fitted in our patrol frigates. The study, which is expected to be completed by March 1995, will address such issues as the use of multifuel operation: i.e methanol, for when the ship is in waters controlled by stringent discharge restrictions; and JP-5 or marine distillate for more relaxed operating conditions. Hardware development projects are being planned

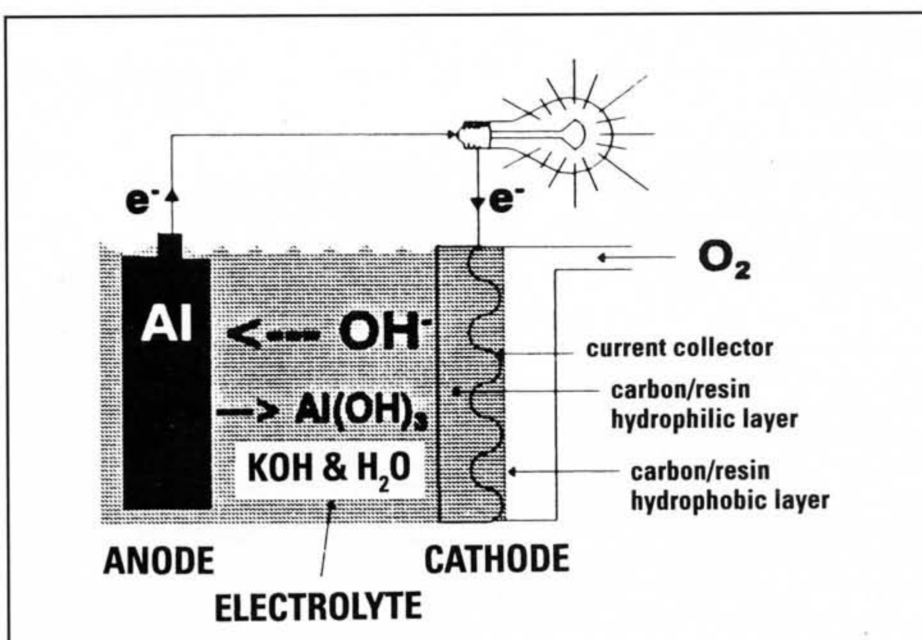


Fig. 4. Basic Al/O_2 Semi-Fuel Cell

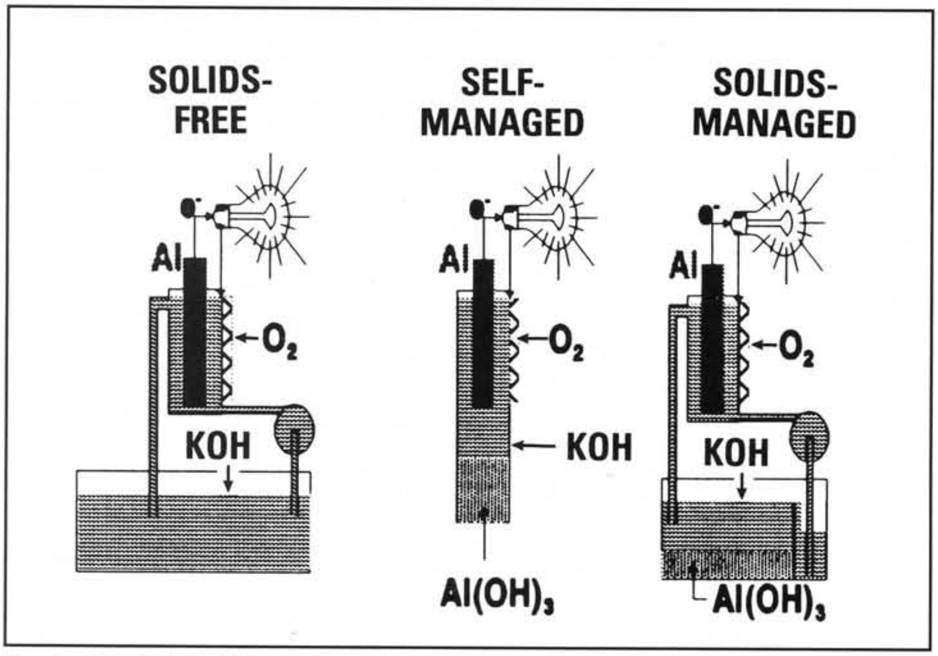


Fig. 5. Electrolyte Management Systems

for after the study to refine the PEM technology for SSG applications.

On the requirements side DMEE 6 will commission a study next spring to develop a ship-configuration optimization program for patrol frigate SSGs. The study will quantify how much better a fuel-cell SSG has to be to justify the expense of changing-out one or more diesel generators, and investigate the impact of replacing one or more SSGs. The study will enable us to play out "What if?" scenarios to determine the optimal configuration and associated cost benefits.

Air-Independent Power (AIP)

DND began its proactive role in AIP development by commissioning Alupower and Ballard to report on the feasibility of applying their technologies to AIP. The studies, which were completed in March 1992, showed that both technologies were feasible and that neither technology was clearly superior to the other in the AIP application.

In the two years that followed we continued to fund the development of these technologies and prepared for a major R&D project for an AIP exploratory development model, or XDM. Involved is the development of two 40-kW AIP technology demonstrators: a proton-exchange membrane fuel-cell system using reformed methanol for its fuel, and an aluminum/oxygen semi-fuel cell system. Unfortunately, Alupower's sale to a U.S company eliminated them from the XDM project. A $3.7-million XDM contract is now in place with Ballard Power Systems Inc., with a December 1996 completion date.

One novel application of an AIP system using PEM fuel cells is a regenerative power system being developed by NASA for a manned moon base. DND is contributing 20 kilowatts of Ballard fuel-cell stacks to the system, the basics of which are shown in *Fig. 8*. During the two-week lunar day a solar array will power the moon base and electrolyse stored water into hydrogen and oxygen for storage and later use. During the lunar night the fuel cells will use the stored hydrogen and oxygen to produce power for the moon base. The water by-product will then be stored for use during the next lunar day, and so on. The Ballard stacks are ready for delivery to NASA and it is expected that this system will be up and running at the Jet Propulsion Laboratory in Pasadena by early 1995.

Related Projects

Several other related projects are supporting our fuel-cell application work. Royal Military College has been working closely with DMEE to enhance our understanding of these exciting technologies. Another project consists of the development of the Hybrid Submarine Propulsion System software model, which will model the integration of an AIP system with a conventional submarine propulsion system. We want to get an idea of how these two active power systems will interact.

Conclusion

The DND approach to the development of these promising technologies has obviously paid dividends. Both companies are recognized as world leaders in their respective technologies and DND now has several opportunities to refine cutting-edge technologies for implementation into the fleet.

The next challenge is to maintain the momentum in the development of these technologies and their application to

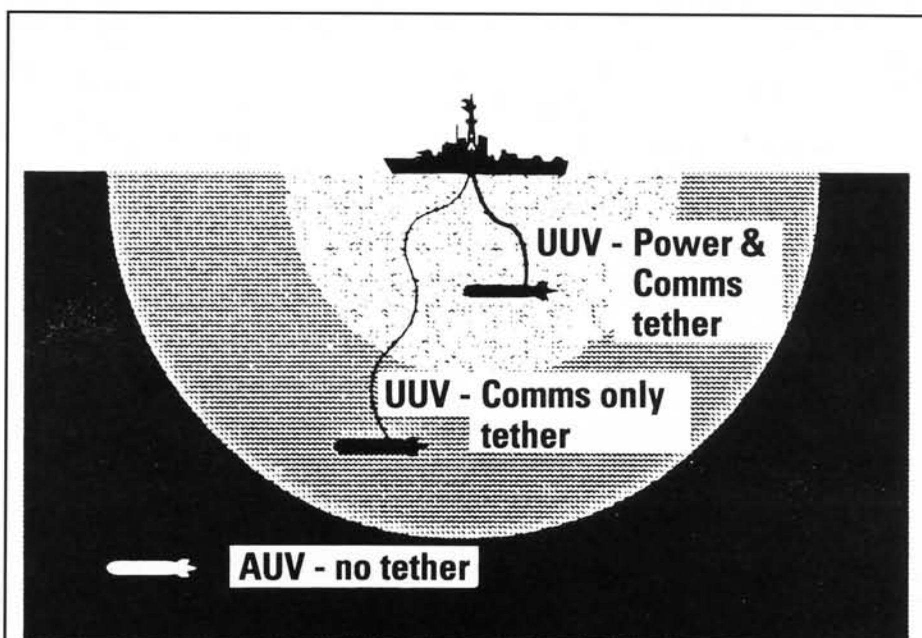


Fig. 6. UUV/AUV Relationships

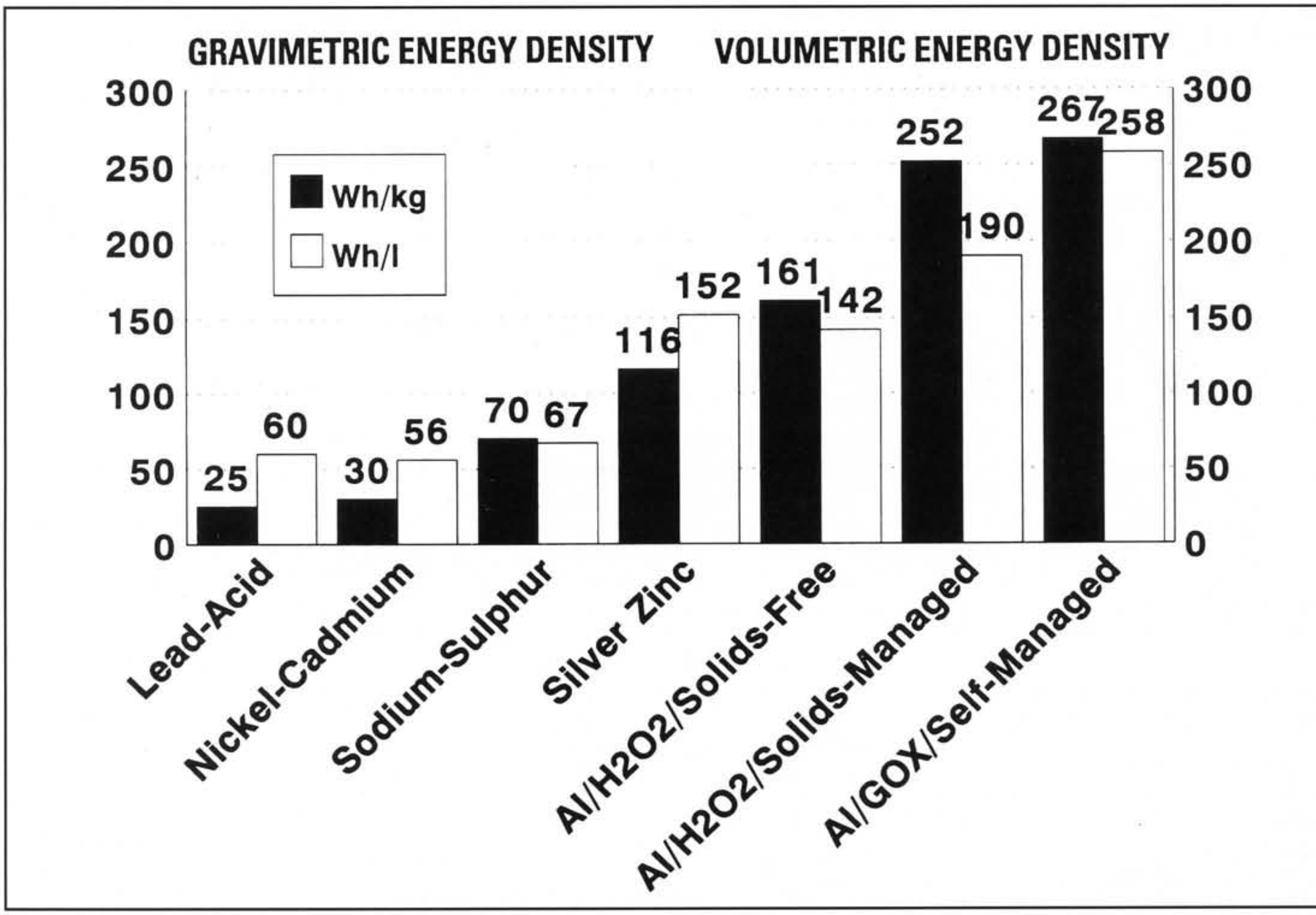


Fig. 7. UUV Power Source Energy Densities

DND requirements. While the commercial sector can now maintain the development of these technologies, DND must still participate to ensure DND's requirements are addressed.

Note

[1] At the time of writing, Alupower was in the process of being sold by its parent company, Alcan International, to the U.S. battery firm, Yardney. It is not yet known if or how DND can continue its Canadian developmental efforts of the sFC system.

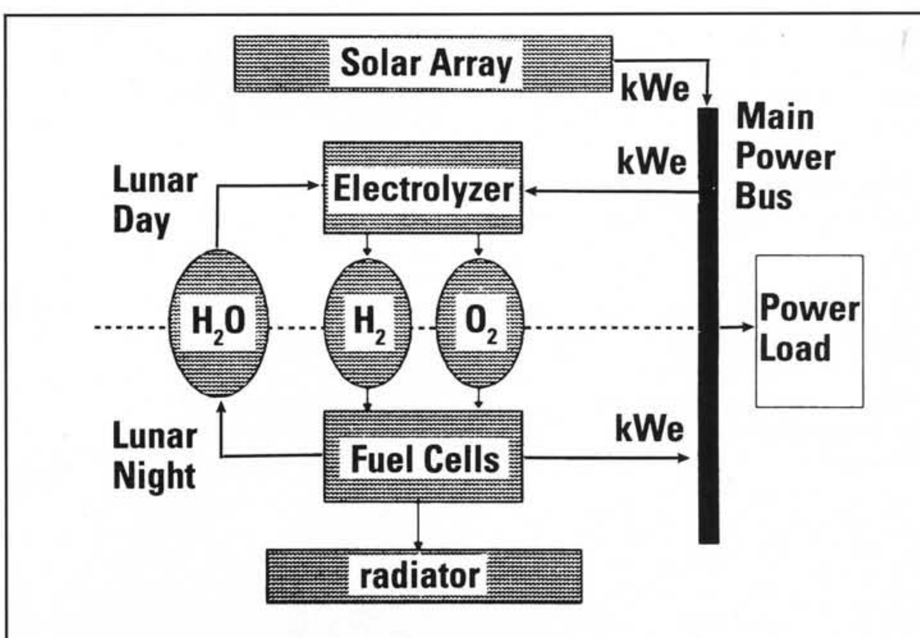


Fig. 8. Regenerative Power System

LCdr Adams is the DMEE 6 project officer for air-independent power.

East Coast MARE Seminar 1994

Article by Lt(N) Brad Yeo

The East Coast MARE community held its annual seminar at the Ramada Renaissance Hotel in Dartmouth on April 20 and 21. The theme for this year's seminar was "Lessons Learned." Each of the presentations shed new light on a major engineering event as we looked at what happened, what went wrong and how we could avoid a repeat occurrence.

During the opening remarks **RAdm L. Mason**, Commander MARLANT, said the challenge for the navy was to become critically self-analytical in everything it does. In a similar vein, **Cmdre D.G. Faulkner** (MARL N4) challenged us to examine our leadership responsibilities toward NCMs, both individually and as a community. From an NDHQ perspective, **Cmdre R.L. Preston** (DGMEM) highlighted the critical introspection his division must face in dealing with DGMEM's downsizing and restructuring, and with the expected associated reduction in engineering change.

Capt(N) R. Buck (D5) presented an operator's viewpoint, suggesting the challenge to the engineering community is to become flexible and innovative. In a controversial presentation he suggested MAREs should learn to overcome their perceived tendency to avoid risk. Risk avoidance, he said, will be unacceptable in the face of reduced resources, short-notice operations, a higher operational tempo and a focus on core operational capacity. As we begin to accept some risk in the way we do business, the change process will have to become more flexible to define requirements and respond to them more rapidly.

On the materiel management side, **Maj Marty Burke** (DMAS 5) described the cost-avoidance value of effective transition management in major capital equipment projects. Citing from the files of a number of major projects, he reviewed some of the difficulties encountered in transferring system management responsibilities from a project management team to the matrix.

CPF Construction: Experience Gained

Capt(N) B. Blattmann and **Cdr V. Archibald** described how CPF's advanced ship-construction techniques and strategies have recouped initial overruns to make the project a success story. They reviewed the lessons learned regarding the design and contractual processes, focusing on the benefits of advanced ship-construction methods, the hindrance of negative guidance in the design process and the need for a realistic lead-ship strategy.

The presenters took us through the progression of methods and design changes — from the 26 construction units of HMCS *Halifax* to the nine megamodules of HMCS *Charlottetown* — associated with CPF construction. They also explained how negative guidance impedes a team approach, and how too short an interval between the start of lead-ship construction and that of follow-on ships does not allow enough time to profit from lessons learned from the first of class.

Algonquin Flood

In a lively, humorous presentation, **LCdr S. Lamirande** described the events surrounding the incident of November 15, 1991 when HMCS *Algonquin* accidentally flooded during a heeling trial. The ship's EO at the time, LCdr Lamirande punctuated his remarks with personal, witty observations as he shared the human and technical lessons of the incident.

The human lessons focused on the failure by all agencies to recognize the problem, the lack of a clear understanding of who was in charge during the trial, the distraction of secondary duties during the preparation phases, the excellent value of damage-control and section-base team training, and the personal risks taken to save the ship.

Technically, it was relearned that submersible pumps are not interchangeable between steamships and tribals, and that the tribals have no overboard discharge for submersibles on No. 2 and No. 3 decks. Also, the messdeck centreline drains could not be used to draw water from those spaces when the ship was listing. The TRUMP ships, LCdr Lamirande said, could benefit from a cross-connect for the pre-wet pumps.

New Submarine Engine Overhaul Procedures

After a brief commercial message for the U.K.'s new Upholder-class submarines, **LtCdr P.J. Southern, RN** entertained us with a presentation prepared with **LCdr W. Nesbitt** on the new engine-overhaul procedures for submarines. The highlight was the technical description of how HMCS *Ojibwa* was cut in two to remove her main engines and generators for overhaul. LtCdr Southern showed the first part of a video being produced by Base Photo to document the procedure, as well as a video of a similar repair in the U.K. He thoroughly discussed the risks associated with the RxR of the main engines in a submarine.

The seminar also included well-received presentations on: the Naval E&M Functional Review (LCdr Findlay — MARCOM); ICEMaN and Configuration Management (Lt Bedard and Lt Boulet — FMG, and Debra Burke — DMES 6); Accountability: Case Study of ECPs (LCdr Guyot — NEUA); Apocalypse II: The UNTAC Experience (Lt Doma — DMCS, and Lt Mack — CFFSH); and the *Cormorant* breathing gas incident (Mr. S. Dauphinee — NEUA, and LCdr Woodhouse and LCdr Muzzerall — FTO).

In his closing remarks Cmdre Faulkner emphasized the need to critically analyze our leadership in these times of restraint. He also took time to rebut Capt Buck's comments regarding risk-taking, reminding the community of its function to minimize the risks our MARS brethren face when they sail into harm's way.

Lt(N) Yeo is the Machinery Control Systems Software Officer for the MSE Division of NEUA.

A Solid Waste Pulper for the Navy

Article by Mario Gingras

A ruggedized solid-waste pulper has been procured for operational evaluation by the Maritime Environmental Protection Project (MEPP). The pulper will be fitted on board HMCS *Preserver*, likely this fall, to test the system in the marine environment and to establish a standard for future permanent installations. A dedicated compartment will be constructed in the after, starboard side of *Preserver*'s dispersal area on 01 deck. The MEPP will eventually purchase solid-waste handling equipment for the fleet.

The pulper, which was designed and developed by the U.S. Navy, processes organic solid waste (food, paper and cardboard) into a negatively buoyant slurry for overboard discharge in accordance with international regulations. The pulper is a marine version of a commercial unit and works like a giant garborator. The operator dumps waste into the feed tray and pushes it into a pulping chamber where it is mixed with sea water and drawn down to be pulverized by a number of cutting blades fitted to a rotating impeller. The oatmeal-like slurry is evacuated through a screened ring surrounding the blades by a drainline suction induced by an eductor.

The unit is designed to resist damage in case trash sorting errors allow metal, glass or other non-pulpable material into the machine. Metal and glass debris are shunted to a "junk box" which must be emptied manually. Plastics are partially shredded and, to some degree, retained within the pulping chamber for manual removal. During trials a metal office wastebasket thrown into the pulper made it through without so much as scratching the cutting blades. (The wastebasket didn't fare nearly as well.) The unit incorporates numerous safety features to prevent sailors from "processing" themselves.

The pulper is an improvement over the presently fitted garborators, and also permits the processing of paper and cardboard. The large feed tray and tank opening allow bulky waste to be disposed of with a minimum of pre-processing. The unit can pulp 450 kg/hr of food waste, or 225 kg/hr of paper and cardboard, which amounts to handling the normal *daily* output of an AOR in just over an hour of operation. A smaller unit is also under consideration.

Pulping solid waste will improve operational flexibility, as well as minimize health and safety hazards for ship's companies by allowing most organic waste to be safely and legally discharged even in restricted waters. The pulper represents a step toward eliminating the discharge of unprocessed solid waste material into any body of water.

Mario Gingras is the DMEE 5 project engineer for the navy's solid-waste pulper.

PHOTO COURTESY U.S. NAVY

A pre-production prototype of a shipboard solid-waste pulper is put through its paces at the U.S. Naval Research Laboratory in Annapolis, Maryland.

Canada's first astronaut (and MARE) in space

Update by Brian McCullough

The date was Oct. 5, 1984. The vehicle — the NASA space shuttle *Challenger* (Mission 41-G). The astronaut, of course, was Cdr Marc Garneau.

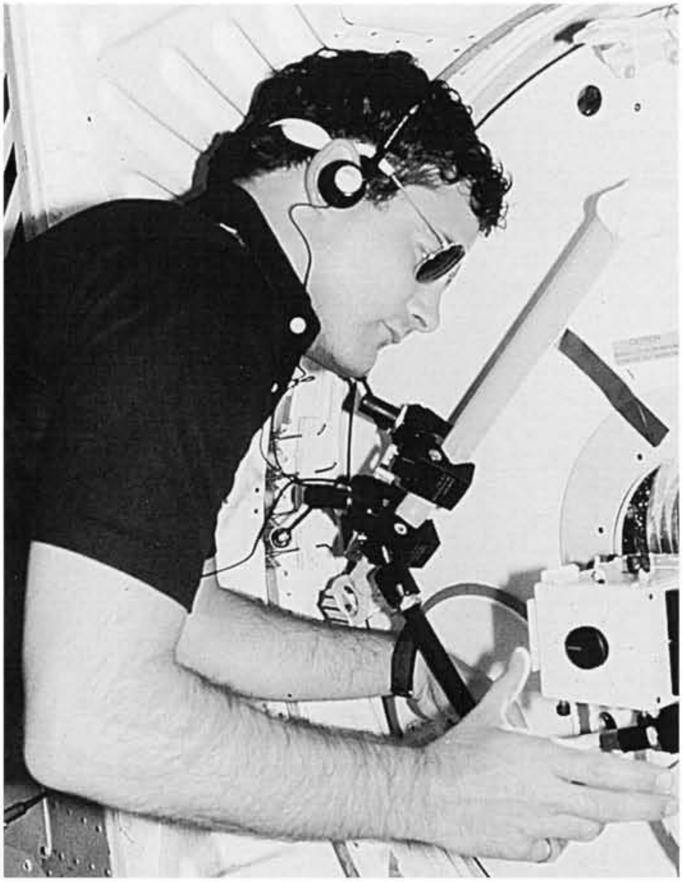
Ten years ago this month Garneau, who was a navy Combat Systems Engineer at the time, made headlines by becoming the first Canadian to be launched into Earth orbit. He flew as a payload specialist on board the shuttle *Challenger*, which made headlines of its own a year and a half later when it exploded on January 28, 1986, killing all seven of its crew.

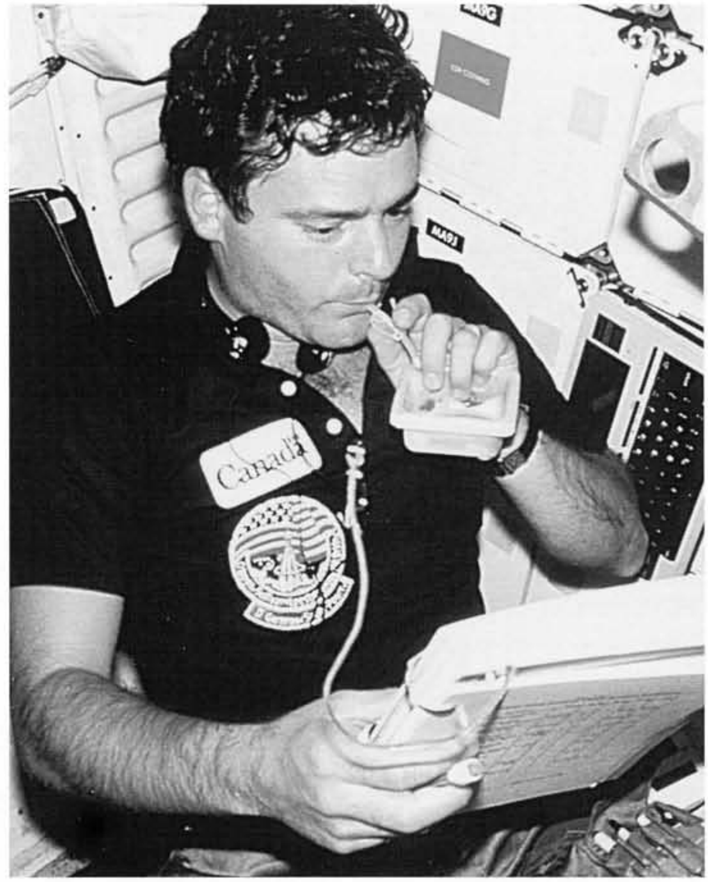
"I can't believe ten years have gone by," Garneau, 45, said during a telephone interview from Houston a week before the anniversary of his flight. "I'm ten years older of course," he chuckled. "They (the Canadian Space Agency) are going to make a bit of a fuss and I'm thrilled," he said of plans for him to make publicity tours to Montreal, Ottawa and Toronto in early October. Garneau said he enjoys living in Houston, but misses the change of seasons. "Weatherwise, I'm a Canadian to the core," he said.

Garneau remained with the Canadian Astronaut Program following his flight, but retired from the navy as a captain in 1989 (see MEJ January 1989, page 30). In August 1993 he and colleague Chris Hadfield became the first Canadians to qualify as mission specialists, whose prime responsibility would be the in-flight operation and repair of orbiter systems including the Canadarm. Garneau himself has now been trained on the Canadarm, as well as in rendezvous operations and extra-vehicular activity (spacewalking).

"By some quirk of circumstance I've completed all the optional training," Garneau said. "They (NASA) take the approach they want everybody trained in everything." The former MARE has the distinction of being the oldest person to start training as a mission specialist in the history of the program. "I think for

Looking Back





Canada it's increasing our credibility to have our people trained (to professional levels)."

With a mission specialist qualification under his belt Garneau can expect to receive a flight assignment in three to four years. "I think that's in the cards," he confirmed. "I might get assigned to a mission." It helps, he said, that he has already flown a mission. Hadfield is scheduled to fly on mission STS-74 next year.

Garneau is currently working on technical issues for the Astronaut Office Station-Exploration Branch. As a member of the Robotics Information team he has technical input to a space station remote manipulator arm, and said he is very proud of the Canada's role in that. "It's very important to have a Canadian presence down here," he said.

Garneau is the first non-American to assume the duties of Capcom (capsule communicator) — the sole voice-link between astronauts in an orbiting shuttle and scientists and mission controllers on the ground. "I've been assigned to Capcom for missions through to next summer," Garneau said. He will be the lead Capcom for Mission STS-66.

Garneau's enthusiasm for his work with the manned space program is infectious. "It's a fabulous job," he said. "It's an exciting business to be in if you're an engineer...It's a great place to be working — it's exhilarating."

And what's the best part of it all? "The chance to rub shoulders with some very interesting people."

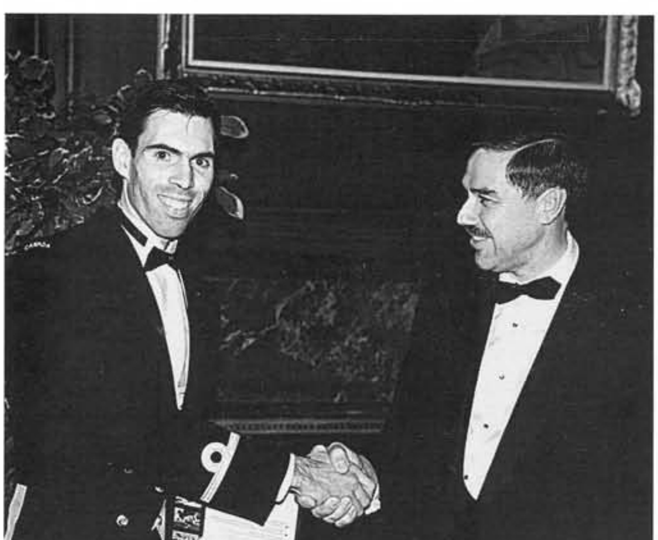
1993 MARE AWARDS

Submitted by LCdr Jim Dziarski, CFFS/NES Halifax
CFB Halifax Photos by Cpl. C.H. Roy

CAE Awards

Congratulations to CAE Award winners **Lt(N) Bruce Trayhurn** (right) and **Lt(N) Eric VanGemeren**. Both officers received a plaque and two-volume Marine Engineering Reference Library, donated by CAE Ltd., for taking top marks in the shore phase of their respective MARE 44B applications courses in 1993.

Westinghouse Awards



SLt J.P. Laroche and **SLt Eric Tremblay** receive the Westinghouse Award from company representative Robert Dufault in recognition of their professional excellence during Phase VI (Ashore) CSE training in 1993. The presentations included a plaque and a set of binoculars. Congratulations to both officers.

Paramax Award

Lt(N) Norbert Duckworth receives the 1993 Paramax award from Capt(N) (Ret.) Bruce Baxter of Paramax Electronics. The award recognizes the top CSE candidate achieving MARE 44C qualification in the previous year. Bravo Zulu to Lt(N) Duckworth (who received a plaque and naval sword) and to the other finalists.

Peacock Award

METTP graduate **Lt(N) Ken Squire** receives the 1993 Peacock Award for excellence in MARE 44B training from Peacock Inc. president and CEO Brian Emo. The award of a plaque and naval sword is made to the MARE 44B graduate who demonstrates the best overall performance in a calendar year during sub-MOC training. Bravo Zulu, Ken.

News Briefs

How careful are you with grounds?

OPIs should ensure that the requirements for electrical interfaces are carefully defined in procurement and installation specifications for new systems, equipment or modifications. The cruise engine controls on the TRUMP ships have had to be modified to correct a power ground and to isolate the digital signals from the analogue signals. A good number of stand-alone relay boxes have been installed in the TRUMP ships to get the correct interface between user equipment such as the Allison 570 Electronic Control Unit and the Integrated Machinery Control System.

Unlike utility power systems, or some commercial marine power systems, the power systems on navy ships are designed to be electrically ungrounded (i.e. isolated from the hull) to enhance reliability (see General Electrical Specifications D-03-003-005/SF-000). Any user equipment that causes a ground during normal operation will degrade the reliability of the power system to which it is connected. Problems in the past have been largely confined to diesel or gas turbine controls which, if of a manufacturer's standard, may be based on the industrial practice of using the engine structure as a power return.

Also, digital and analogue signals to an external system must be electrically isolated from one another and from the power circuits. Such isolation allows the signals to be connected to the external control and monitoring system without running the risk of ground loops (coupling between different signals) or grounding the ship's power supply. Ground loops due to a difference in ground potential, or inadvertent coupling, can cause malfunction of not only the offending equipment, but of other equipment or systems as well. Problems of this type are difficult to identify, particularly if they are infrequent and occur in a ship-wide system controlling a large inventory of user equipment. — **W.A. Reinhardt and G. Swamy, DMEE 6.**

Long Service Awards!

CFB OTTAWA NORTH PHOTO BY CPL GABRIEL LECLERC

Long-service award recipients **Maureen Collins** (44 years of service) and **Cdr (Ret.) Bob McNeilly** (39 years) worked together in DSE 5 before retiring earlier this year. Cmdre Robert L. Preston, DGMEM, presented the awards last May 11. Congratulations to both for their years of dedicated civilian and military service.

IMDEX 95: March 28-31, 1995

The International Maritime Defence Exhibition and Conference, sponsored biennially by the U.K. Defence Research Agency, resumes March 28-31, 1995 at the Greenwich National Maritime Museum. The theme of the conference will be: Creating the Naval Task Force.

Seven nations have already committed to sending ships to London for IMDEX 95, with several more likely to follow suit. No Canadian ships are scheduled to attend.

According to Capt(N) Edward E. Davie, naval adviser to Canada's High Commissioner in London, the exhibition and conference provide "excellent opportunities to demonstrate Canadian equipment, technology and ideas, while pursuing joint venture possibilities." At IMDEX 93 held at Brighton, Canadian defence industry, in co-operation with the naval staff and the High Commission's Commercial section, had the second-largest contingent.

Bravo Zulu

The Maritime Engineering community congratulates **Capt(N) Gerry Humby** on his recent promotion. Capt(N) Humby took command of Ship Repair Unit Atlantic in June.

UNTAC – Mission to Cambodia

Coming up in our February issue

Maritime Engineering Journal – Readership Survey

You can help us make the *Journal* better for you by taking a few moments to answer these questions.

1. What is your rank and MOC, or civilian occupation?

   ____

2. Where do you work?
   a. Canada
      Abroad (please specify)
   b. Ship/Dockyard
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      Other (please specify)

3. Which sections of the *Journal* do you usually read?
   a. Cover to cover
   b. Editor's Notes/Letters
      Commodore's Corner
      Forum
      One article
      Two or more articles
      Greenspace (environmental protection)
      Looking Back
      News Briefs

4. Which sections do you enjoy most?

   ____

5. Which sections do you enjoy least?

   ____

6. On average, the articles are:
   Too technical
   Too general
   Just right

7. The ***non-technical*** and general interest articles are usually:
   Too detailed
   Too shallow
   Just right

8. Do you think there is a good mix of articles in each issue?
   Yes No

9. What would you like to see covered by the *Journal*?

   ____

10. Would you rather the *Journal* were mailed to units, or to individual subscribers?

    ____

11. Which audiences should the *Journal* target?
    MARE officers/cadets
    Mar Eng chiefs & petty officers
    Mar Eng master seamen and below
    Engineering branch retirees
    Non-engineering MOCs (please specify)
    Military/government agencies
    Commercial marine organizations

12. Do you retain back issues for reference?
    Yes No

13. How many people read your copy of the *Journal*?

    ____

14. How useful is the *Journal* to you?
    Very useful
    Somewhat useful
    Of little use
    Of no use

15. What is your overall impression of the *Journal*?
    Very favourable
    Favourable
    Neutral
    Unfavourable
    Very unfavourable

16. In general, do you think the magazine meets its stated objectives?
    Yes No (Why not?)

    ____

17. What should be the objectives of the *Journal*?
    a. As published
    b. Other (please specify)

18. Do you read the *Journal* in English or French?

    ____

19. How would you rate the quality of the French translation?
    Can't say
    Very good
    Good
    Poor
    Very Poor

20. How often should the *Journal* publish?

    ____

21. Can you suggest a better format for the *Journal*?

    ____

22. Would you pay a subscription fee to receive the *Journal*?
    Yes No

23. How can we make the *Journal* better for you?

    ____

    ____

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