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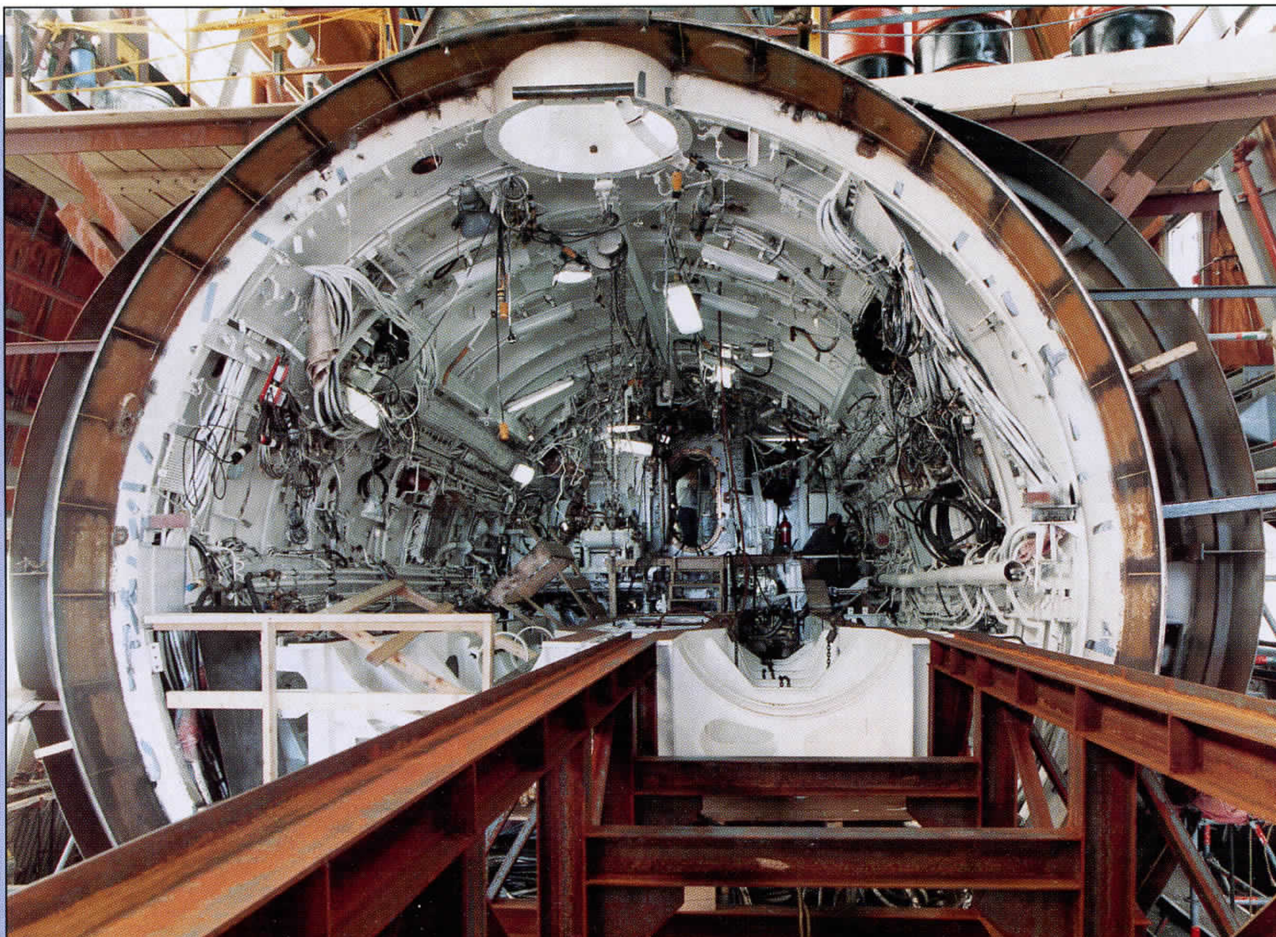
Maritime Engineering Journal

15th Anniversary Issue

CANADA'S NAVAL TECHNICAL FORUM

October 1997



Submarine Surgery: Radical refit procedure for the O-boats

Also:

- *Changes in Fleet Support*
- *Penetanguishene's "Discovery Harbour"*

Canada

Looking Back:

Discovery Harbour – A bit of naval history on the shores of Georgian Bay

Maritime Engineering Journal

15th Anniversary Issue

Established 1982

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DEPARTMENTS

FEATURES

Our Cover:
A rather unusual view of HMCS *Ojibwa*. Story begins on page 7. *(CF Photo)*

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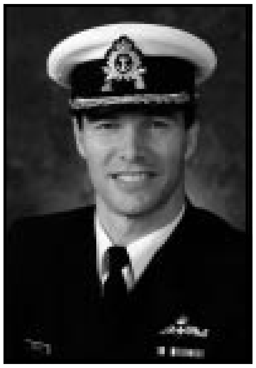


Editor's Notes

Fifteen years later, Canada's naval technical forum still going strong

By Captain(N) Sherm Embree, CD, P.Eng., CIMarE
Director of Maritime Management and Support
Editor

If someone were to ask me what the key element is behind the *Journal*'s longevity and success, I would answer without hesitation that it is "people." To many of you, the names of the people that appear in our masthead or alongside the articles we publish are familiar in and around the Maritime Engineering community. For the most part the names belong to shipmates and co-workers. What makes them special is that they share the distinction of contributing, in one way or another, to the continuance of Canada's best forum for the presentation of naval technical issues.

While many of our editorial contacts tend to be "one-time-only," we have been very fortunate in having enjoyed the long-term support of several major players. Production editor **Brian McCullough**, who has been with the magazine in one capacity or another since its launch in 1982, edits and produces the *Journal* through his company, Brightstar Communications. Brian's wife **Bridget Madill**, a journalism graduate of Carleton University and a former federal government editor, plays a much understated role in providing crucial assistance to our computerized desktop publishing process.

Two other key players deserve our gratitude. The first is the CFSU(O) Creative Services section, until recently headed by **Nicole Brazeau**. Thanks to her careful management and the ongoing skillful attention of production manager **Dave Doran** (now the section's manager and art director) and graphic designers **Ivor Pontiroli** and now **Ron Lalonde**, the *Journal*'s transition to DGMEPM in-house desktop production has been a resounding success. Another essential behind-the-scenes player is the PWGSC Translation Bureau. Under the direction of **Josette Pelletier**, the bureau calls upon the services of a wide range of dedicated administrators and skilled translators to ensure the *Maritime Engineering Journal* is available in both official languages. From both of these organizations the *Journal* has, over the years, received nothing less than exemplary, award-winning professional service.

In celebration of our 15^{th} anniversary, the *Journal* now has a new subtitle on the front cover of the magazine. After one false start with a motto contest, we finally received a wonderful selection of suggestions from a good military/civilian cross-section of ranks and occupations. True to form, the submissions ranged from the pessimistic ("*Always reengineering*") to the poetic ("*Ma mer, ma vie*"). We considered them all very carefully (as anonymous entries) during a spirited editorial session last March, before deciding upon "Canada's Naval Technical Forum." Congratulations go out to **Lt(N) P.J. Pope** of the DMCM/Subs section in DGMEPM for submitting the winning entry. As a reward for his success he was presented with a nicely personalized copy of Cmdre Duncan E. Miller's book, "*The Persian Excursion: The Canadian Navy in the Gulf War*."

On this upbeat note, I wish to close by thanking all of you who have supported the *Maritime Engineering Journal* since its inception in 1982. Your submissions, suggestions, technical assistance and moral support over the last 15 years have given this magazine a powerful sense of purpose and mission. Thanks to your involvement, the *Journal* continues to keep pace with the concerns and interests of Canada's maritime engineering community, and is able to share your viewpoints on these issues with a wide audience.

The *Journal* welcomes **unclassified** submissions, in English or French. To avoid duplication of effort and to ensure suitability of subject matter, prospective contributors are strongly advised to contact **the Editor, Maritime Engineering Journal, DMMS, 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. Letters of any length are always welcome, but only signed correspondence will be considered for publication.

Are you receiving enough copies of the *Journal*?

If you would like to change the number of magazines we ship to your unit or institution, please fax us your up-to-date requirements so that we can continue to provide you and your staff with the best possible service. Faxes may be sent to: **Editor, Maritime Engineering Journal, (819) 994-9929.**

Commodore's Corner

Teamwork & Building Bridges

By Commodore F.W. Gibson, OMM, CD
Director General Maritime Equipment Program Management

In his Forum article, "Nobody asked me, but ..." in our last issue, Cdr Paul Brinkhurst raised a concern regarding the tendency of various subgroups within the navy to isolate themselves, producing a segmented naval community. He also stated a need for a "unifying vision," and asked if we are going to improve relationships both within and outside the MARE community. In this current issue, Capt(N) Ian Mack continues the thread, pointing to the failure of trust as a cause of segmentation, observing that "teamwork is everything" and "tough issues require face-to-face discussion."

I am pleased to see that the *Journal* is being used as a forum to air this discussion, and would like to explore further the perception and reality of segmentation in our naval community. Let me offer my perspective.

Is it surprising that these separations can occur? No. The organization and occupational stovepipes that we see are not new. Dwindling budgets cause interservice rivalry for the limited resources available, while force reductions naturally lead to almost an instinctive move to close ranks against a perceived threat to the group. These pressures tend to exacerbate the organization and trade boundaries. The exceptions to this have been seen during times when we have been called upon to protect our country. Does this explanation make it acceptable? No. What is required to deal with these separations is a common vision to bind us together, short of actual conflict.

Do we in the navy have a unifying vision? I believe the answer is yes. One need only look to Maritime Command's stated "naval vision:"

> The Navy exists to protect Canadian interests in the ocean areas adjacent to the Canadian coast and beyond. To do this, we need a combat capable fleet, which entails far more than simply possessing modern warships. Achieving combat capability requires, above all, dedicated people, ashore and afloat, who have the opportunity to practice and develop their skills. The navy of the future must sail, it must sail often, and it must be ready. Our job is to make it so.

"Successful teamwork requires mutual trust, respect for each other's opinions and concerns, and a genuine willingness to listen..."

Is teamwork required? Yes! A vision by itself is not the complete answer. Teamwork is how we must execute the vision, given that there are various elements and organizations that must come together to do what the navy is being asked to do. The inefficiency and disorganization caused by segmentation cannot be diminished unless the energy of teamwork is added to the system. The fleet support plan, developed by DGMEPM in conjunction with the Chief of Maritime Staff and the formations, exemplifies how teamwork can be used to bridge the differences that otherwise separate these organizations.

What are the ingredients to teamwork? Successful teamwork requires mutual trust, respect for each other's opinions and concerns, and a genuine willingness to listen and discuss rather than ignore or dictate. Every effort must be made to understand the other's point of view. Likewise, there must be a willingness to understand the constraints that have been placed on each group. There must be no intent to prejudge one group versus another. Perhaps most importantly, there must be a willingness to "think outside the box." Teamwork is dependent not upon organizational structures, but upon sharing and reinforcing the unifying vision. It must always be recognized that a team requires more than one participant, and that all players must want to be part of the team.

There are difficult discussions that are still required. We cannot hide behind our respective organizations or trades. There must be free, open and honest discussion with no hidden agendas, other than what is best for the navy. Our unifying vision as the support community must be to provide the fleet with the best short- , intermediate- and long-term support possible. Our challenge is to bring the energy of teamwork to bear to increase the cohesiveness of our naval community in order to ensure our collective realization of the naval vision and our duty to serve the fleet.

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.

Forum

Speaking the Unspeakable: Reinstilling trust as a precursor to enhanced teamwork

Article by Captain(N) I.D. Mack

Well done to Cdr Brinkhurst for his recent submission to Forum! (See "Nobody asked me, but...," *Maritime Engineering Journal*, June 1997.) He has suggested that the issue of adversity between and within communities is unacceptable, and he has called for the MARE Council to lead the way in returning to the improved relationships which typify a team. Has he spoken of the unspeakable?

Though routinely written about in this journal, the MARE Council remains a poorly understood body. It is the venue in which matters important to the technical component of the navy's defence team are tabled for discussion, and from which DGMEPM and his team of sub-MOC advisers receive advice. Of note, the Council has rarely addressed technical issues not related to the personnel and training domains. Having been a member since 1989, I have routinely observed important personnel issues being widely consulted with the MARE commanders' chains in Ottawa and on both coasts before DGMEPM opened a dialogue at the Council. As well, except for a brief period while I was in the MARCOMHQ/N1 organization, Council meetings have regularly been attended by a senior MARS officer at the captain(N) level from the personnel and training branch. In many instances, members were tasked to obtain input from other bodies within the navy and the CF. I say this to inform all that the MARE Council is not meant to be an insular body, it is one whose primary approach is consultation.

And yet, many perceive that we are not unified in our support of some important subjects. Most never hear of the rationale for MARE Council decisions. How is this so? Would a broader Council comprised of MARS, MARE and SEA LOG senior officers better ensure a common vision and avoid time wasted fighting parochial battles which paralyze us? Would it lead to improved communications? An interesting hypothesis. I would offer another.

We are experiencing the same challenges all large institutions are faced with today — change. Change is an expensive business to do right in large conservative institutions such as our military. When implemented on a shoestring budget by organizations constrained to current allocations, those who are involved become busier and busier. I submit that all leaders everywhere are at war with "busyness," and that in recent years we have been losing this war.

"Leaders must tackle the big issues in full view of...the community. They must speak the unspeakable...expose issues for all the greyness that these tough questions really are."

The result is a lack of ongoing dialogue with MAREs and other officers across the navy. The word goes out to consult, but the discussion often is superficial due to time constraints. The tough issues involved are only effectively addressed through face-to-face discussion at all levels, and leaders are failing to get this job done. Junior officers are not being routinely engaged before decisions are taken, and are subsequently not getting "the word" to pass along. Is this why, in a recent MARCOM focus group, young sailors, POs and CPOs indicated that respect for superiors is low and leadership by example is disappearing?

The result is what Cdr Brinkhurst speaks of, in that we are not "carrying on a conversation with the situation," nor are we talking out important and controversial issues. Hence, we are not building like-minded thinking, we are not giving all members the opportunity to be heard, and thus we frequently fail to engender trust in the leadership to make the right decisions. This failure of trust is the root cause of the adversity Cdr Brinkhurst speaks of, and the team is suffering.

In the military, teamwork is everything and the very essence of "things military." So we *must* reinstill trust as a precursor to enhanced teamwork. Leaders must tackle the big issues in full view of all members of the community. They must speak the unspeakable in terms of doubts, and expose issues for all the greyness that these tough questions really are.

In our battle against busyness, leaders must place the right priority and focus on this requirement, as with all others. But if trust is at risk, as intimated by Cdr Brinkhurst, then I and all other leaders, not just in the MARE community but throughout the navy, must make time to restore with vigour the very essence of our military profession, the value of the team to the survival of the naval family.

In terms of practical application, MARE seminars need to be less on interesting presentations and more on workshops to talk out important questions facing the navy today. Naval officers and CPOs need to spend more time talking with each other in open forum sessions on a routine basis. Of course, civility and loyalty must guide such dialogue, but otherwise the floor must be open for all to speak their mind on any issue of interest.

In today's reality (as in any war), only overt leadership can have any impact whatsoever. And truly, it is the leadership team's priority calling, the MARE Council's most urgent task, to enhance the dialogue and transparency of important decisions taken. Trust may have been lost in some quarters through omission, but now it can only be regained by design.

Captain(N) Mack is the Base Commander of CFB Halifax.

The Equipment Change Dilemma

Article by L.T. Taylor

There is apparently a great deal of dissatisfaction with the EC process. It is said to be unresponsive, too complicated and bureaucratic, too costly and too slow. But let's put the process into perspective.

There are many EC proposals that are good ideas. The difficulty is in separating those that *meet a requirement* from those which create an upgrade but are outside the approved statement of requirements for the ship. The real failing in the EC process is that it does not require a proposal to be gauged against the original ship design requirement or a statement of capability deficiency for the class. With strict application of a comparison to the requirement, more ECs would be cancelled during the early stages. Good ideas should not be suppressed, but at the same time the EC process must focus on the few proposals which overcome deficiencies or bring the ship up to the *requirement*. Enhancements beyond meeting the design requirement need very careful screening in today's resource-limited environment.

The time spent processing EC proposals through even Part II consumes resources. If the Part I screening had cancelled the proposal as "No stated requirement or known capability deficiency," or "Enhancement beyond stated requirement for class," then resources would not be expended on staffing "good idea ECs" to just sit on the shelf as not affordable at this time. These resources could then be applied to the few "required" ECs, and the time needed to complete the process and have them implemented could be reduced.

"Enhancements beyond meeting the design requirement need very careful screening in today's resource-limited environment."

I titled this the EC "dilemma." The dilemma is how to ensure that we do not stifle the submission of EC proposals, which could result in one of the "few" not being put forward in the first place. Also, what do we do with the "good idea" proposals? A good idea may not be appropriate for follow-up at that moment, but it might be suitable for consideration later when other changes are being carried out or if a requirement changes. Another aspect of the dilemma is getting people (especially ships' commanding officers) to understand that the ships are not configured to their preferences, but to meet a *requirement*.

It would be nice to provide answers. Although I have opinions on some approaches, I wrote this more to get people thinking about what the EC process is really meant to accomplish.

L.T. Taylor is the Mechanical and Electrical Engineering Officer at FMF Cape Scott.

The Misuse of Technology

Article by Roger Cyr

Over the last few decades society has become technology-oriented, always seeking better, more advanced technology or devices to help bring about better productivity and efficiency. The feeling prevails that, without these advanced technologies, productivity would be hindered or even impaired. But is more advanced technology always needed, or is society just chasing the illusion that technology is the answer to all deficiencies? When seeking to apply a new technology, is due consideration given to "method," or is the new technology just applied to old and archaic ways, processes, activities?

The availability of new technology should be a magnificent chance to go back to the drawing board and rethink the way things are done. In most cases, however, new technology is merely applied to existing imperfect methods. The opportunity for radical change, for the reengineering of methods, processes and activities is ignored in the haste to correct deficiencies.

Will an improved faster computer increase the productivity or efficiency of someone doing word processing? Is there a requirement to produce texts faster? Is there a real need for someone to produce the texts at all? Can the activity be done differently? Simply acquiring a faster device to do the same activity the same way will likely result in little or no real gains in productivity and efficiency. Similarly, enhancing components of a system without taking due regard for the system as a whole will probably not produce significant gains in overall system performance.

Naval combat systems have seen great evolution in their technological make-up.

Yet, for the most part, the same methods that prevailed decades ago are still used with these systems. The opportunity to rethink naval operational processes and activities presented by the *availability* of the new technology was not seized.

Take, for example, the tracking of contacts in shipborne systems. This is indeed no longer done by a plotter using grease pencils on a Plexiglas table top. Instead, it is now done by a plotter on a computer screen. The (archaic) process of plotting tracks has been partially automated, but a more efficient method of performing this process or activity has not really been established. As to whether the activity needs to be done at all, or if it can be done differently, or if it can be done more efficiently by a machine than a person — these questions were not asked. Rather than look from a system perspective at improving methods and ways of doing things, new technology is used to partially automate archaic methods that are heavily dependent on human intervention.

It should be noted that the closest possible real integrated system is one human being. The integration process degrades exponentially as more human beings are introduced into the system because people are self-centred systems that do not communicate well. In groups they introduce mistakes, misunderstandings and misconceptions. Hence, any real integrated system must have as few human beings as possible, with the optimum number being one. Naval combat systems are vulnerable to these same human shortcomings because they are still heavily dependent on human intervention.For example the identification of threats, which could best be performed by a machine in today's complicated combat environment, has been subjected to greater automation, but the old ways and methods which are dependent on human input have been retained.

This heavy dependence on human intervention was retained because the old ways of operating naval systems, or naval doctrine and operating concepts have been maintained. The need to reengineer or rethink the combat system processes and activities before introducing improvements in automation was not realized, so there are still too many human interventions in the overall process, with the ensuing unreliability.

"The opportunity to rethink naval operational processes and activities presented by the* availability *of the new technology was not seized."

Canadian naval combat systems have not yet proven to be fatally unreliable because of their dependence on humans. There are nonetheless striking examples of human failures, such as the unplanned firing of a second missile by HMCS *Vancouver* because the operator mistakenly pressed the fire button twice. There are many other examples in the world where the consequences of human beings attempting to cope with complex systems were fatal — recall the disastrous outcome of HMS *Sheffield*'s involvement with an Argentinean Exocet missile in the Falklands, and USS *Stark*'s inadequate response to an Iraqi-launched Exocet. The *Stark* incident report went so far as to state that because missile attacks evolve so quickly, reaction time must be cut by removing human intervention. Had the anti-missile defences been totally computer controlled, the proper reactions to the attack could have been initiated automatically and the ship would likely not have been hit. The old ways or methods, which are dependent on human intervention, were the weak link in the system.

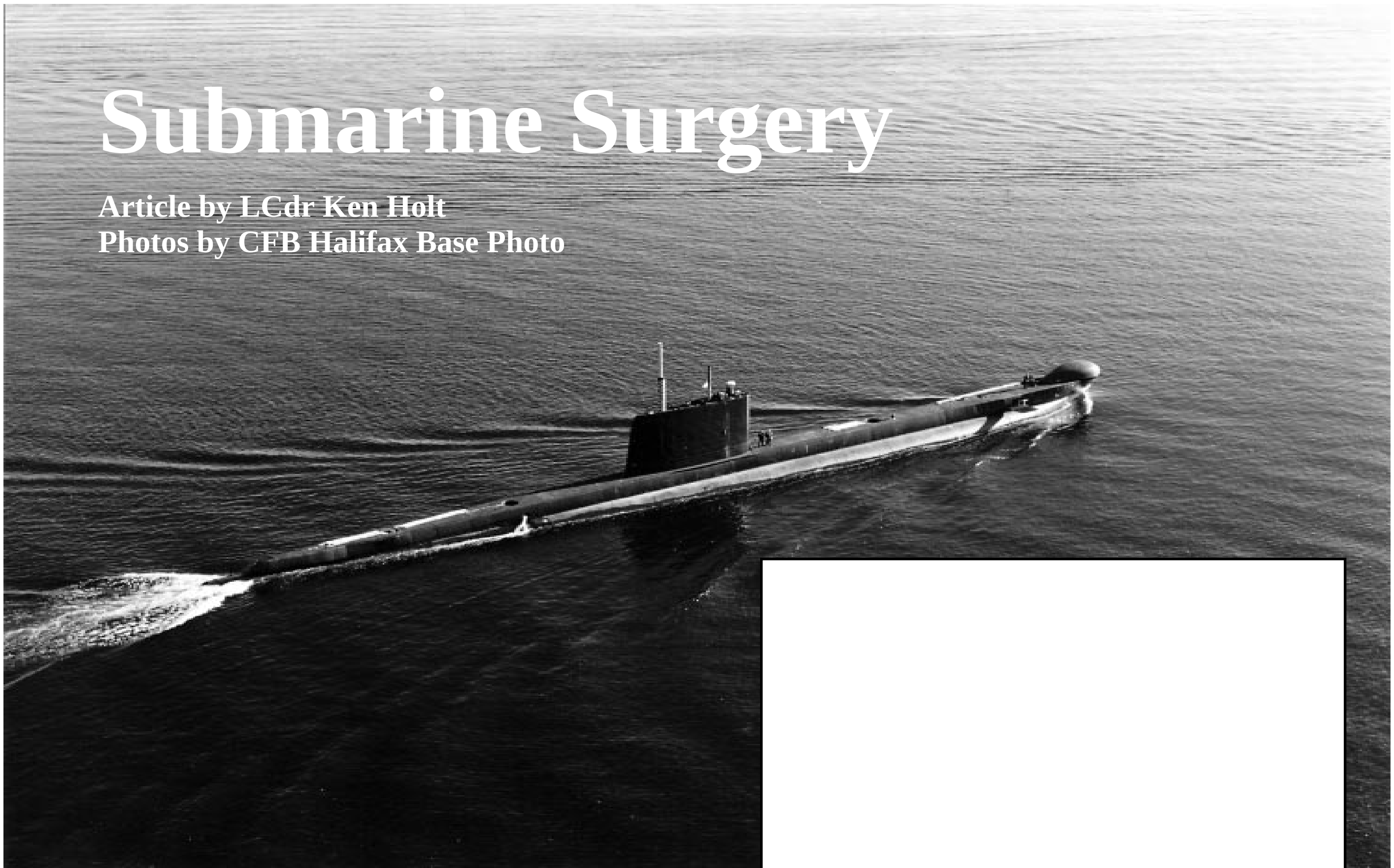
Although new technologies and devices could dramatically improve system performance, there is continuing resistance to fundamentally change methods and concepts. Technology is simply used to automate old methods, without taking due consideration to overall system requirements and performance. In the end, however, new technology combined with old ways will always result in automated obsolescence.

Cdr Roger Cyr (ret.) is the Chief of Quality Assurance at the NATO Maintenance and Supply Agency in Luxembourg.

Submission Formats

As a general rule, article submissions should not exceed 12 double-spaced pages of text. The preferred format is MS Word, or 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. If at all possible, electronic photographs and drawings should be in TIFF format. A photograph of the author would be appreciated.



Submarine Surgery

Article by LCdr Ken Holt
Photos by CFB Halifax Base Photo

The neatly severed stern section of an O-boat sits in the synchro-shed in Halifax.

During pre-refit surveys conducted for the 1993-94 refit of HMCS *Ojibwa*, fractures were discovered in the diesel engine bedplates. In addition, *Ojibwa*'s diesels were known to be in serious need of high-quality overhaul which could only be performed effectively in the shop. The prognosis was that serious engine damage could be expected due to excessive vibrations. Side-effects included lengthening of fractures, causing damage to neighbouring structure and increased noise which could potentially have adverse affects on submarine stealth. The situation was clearly unsatisfactory for operators and maintainers alike. Repairs were in order.

The diesel engines needed to be removed and replaced. In so doing, sufficient access would be gained to allow the bedplates to be properly repaired. The repair facility and engineering groups of the time — Ship Repair Unit Atlantic, Naval Engineering Unit Atlantic and the Directorate of Ship Engineering (DSE 5) — recognized that several options were available.

The standard approach developed by the *Oberon* class designers and builders in the United Kingdom was to remove the diesel engines through a so-called "soft patch" or "top hat" in the crown of the submarine pressure hull. This would be an extremely manpower-intensive and thus expensive undertaking, and would mean extending the refit period, thereby affecting operational availability. As the Canadian navy discovered during its experience with the Submarine Operational Update Project (SOUP) in the 1980s, removing the sizable soft patch presented considerable structural problems. In the interest of minimizing structural difficulties and improving production efficiency, an alternative engine-removal method was investigated for the refit of HMCS *Ojibwa* (and applied subsequently for the refit of HMCS *Onondaga* as well).

Planners eventually settled on a radically different approach. If the submarine were severed in two, diesel engine removal/replacement and bedplate repairs would be much simplified. Furthermore, other refit work would benefit from the increased accessibility. Technical investigations concluded that cutting the submarine hull into two sections would be both feasible and relatively efficient, realizing an estimated production saving of 12,000 designated labour hours. Key considerations revolved primarily around maintaining the structural integrity of the pressure hull, and the cost of reworking the electrical cables in the area of the cut. A plan was formulated and, once blessed by senior management, surgery commenced on HMCS *Ojibwa*.

The impending work was a new and novel approach for the Canadian navy and not without risk. This paper provides an overview of the technical considerations, as well as the reasons behind some of the decisions taken, in particular with respect to the pressure hull work. It is hoped that this brief account adequately portrays the work and recognizes the achievements of the many who contributed to these success stories. Since both *Ojibwa*'s and *Onondaga*'s pressure hulls were cut and reinstated in very similar fashion, no attempt has been made to distinguish clearly between either refit except where there were notable differences in the work.

Background

Pre-refit planning and surveys for *Ojibwa* revealed that the ASR1 engine and bedplate foundations required serious attention, engineers at NEUA and NDHQ immediately began to address the problem at hand. Preliminary investigations were conducted to determine whether it would be better to remove the engines for repair in the shop, or repair them in-situ. It soon became clear that the benefits of repair by replacement (RxR) significantly outweighed those of an in-situ operation. The RxR option offered:

- improved engine quality;
- easier engine alignment in the shop;
- significant productivity increase in the shop environment;
- engine repair and overhaul (R&O) would be removed from the refit plan critical path (thanks to the availability of replacement diesels from the ex-British submarine HMS *Osiris*); and
- potential gain for RxR of other components.

The problem then became one of how to remove the engines from the submarine and from the synchrolift refit shed itself. At the time, removal through the soft patch was thought to be the only solution. Unfortunately, the two synchro-shed cranes had a combined lift capacity of only 10 tonnes — the ASR1 engines weighed 33 tonnes each. A crane capable of lifting 200-300 tonnes could be contracted to lift the engines out, but this would mean cutting a five-metre-square opening into the roof of the synchro-shed.

But then the question was raised, Why remove engines through the pressure hull crown at all? During the SOUP project, refit teams had difficulty maintaining pressure hull circularity in the area of the soft patch because the frames were cut. Removing a much larger patch in the case of the impending *Ojibwa* refit would only magnify this problem because more frames would be affected over a larger arc. SRUA had equipment capable of rolling plate in excess of pressure hull plate thickness, but as this would have to be accomplished in several pieces, achieving top hat circularity would still be a major concern (and would involve fabricating replacement stiffeners to exacting specifications).

It was at this point that an alternative solution was put forward. As extreme as it seemed, the proposal to cut the submarine pressure hull in two would facilitate easy engine removal and effectively solve a good deal of the problems associated with the process envisaged to date. Radical surgery, however, would be required.

Technical Considerations

Obviously, a great deal of consideration was given to the safety implications and production issues *before* cutting the submarine pressure hulls in such dramatic fashion. Reinstating the boats such that performance capability was left undiminished was the real challenge. As NEUA put it in one of its briefing slides: "Business as usual is easier, but innovation is a lot more fun."

The primary concerns surrounded the question of pressure hull structural integrity (and its impact on submarine operations) and the significant cost of identifying, rolling back, severing and reinstating the electrical cables. A great deal of discussion ensued between the ship structures and materials experts in DND, their contractors and counterparts from other navies as the project team investigated the advantages and disadvantages of cutting the pressure hull. A corollary and most important question to resolve was where to make the cut — just forward of or just abaft the engines (*Fig. 1*).

It was eventually decided to cut abaft the engines, but exactly where to cut still had to be determined. Choosing a location to make a straight, 360-degree circumferential cut on the submarine pressure hull structure was a challenge. Not surprisingly, the team wanted a location in the vicinity of the diesels which would allow them access to the engines with the least possible disruption to other systems and equipment. This was a tall order, considering the high density of equipment and systems fitted in the engine-room, not to mention the external systems and casing structure.

Moreover, small imperfections in the steel were of concern since delaminations under locked-in stresses could potentially become large defects once released during the cutting process. To avoid this problem, extensive non-destructive examinations were performed to determine a location to cut the submarine where a minimal number of imperfections would be disturbed. In the case of *Onondaga*, the NDT survey uncovered a significant number of embedded laminations in a number of the plates. The team had to decide whether or not to repair these prior to proceeding with the pressure hull cut. Their decision to repair the defects after rewelding turned out to be the best course of action since negligible rework was later required.

Structure also needed to be considered. The work had to be accomplished without disturbing either the geometry or the material condition of the pressure hull stiffeners and plating. Circularity of the hull had to be maintained to within very stringent tolerances — plus or minus 0.5 percent of the pressure hull radius. In addition, rewelding could not occur too close to the pressure hull frames to ensure that a full-penetration weld could be performed and that stiffeners would not be distorted by the process. A location close

CUT LOCATION	ADVANTAGES	DISADVANTAGES
Soft Patch ("Top Hat" Cut)	• proven method • fewer removals • no engine alignment problems	• significant structural risk — (i.e., circularity of pressure hull, and higher stresses on longitudinal welds than on circumferential welds) • availability of material • more welding
Forward of Engines	• less electrical cabling • fewer removals • less welding	• engine/generator fit • higher shear/jacking loads • more structure to support aft end at docking
Abaft Engines	• easier engine removal • aft end lighter and thus easier to move	• more electrical cables • more welding • more removals

Fig. 1. A quick perusal of the pros and cons of the major cut location options reveals some of the technical complexity involved in the decision-making.

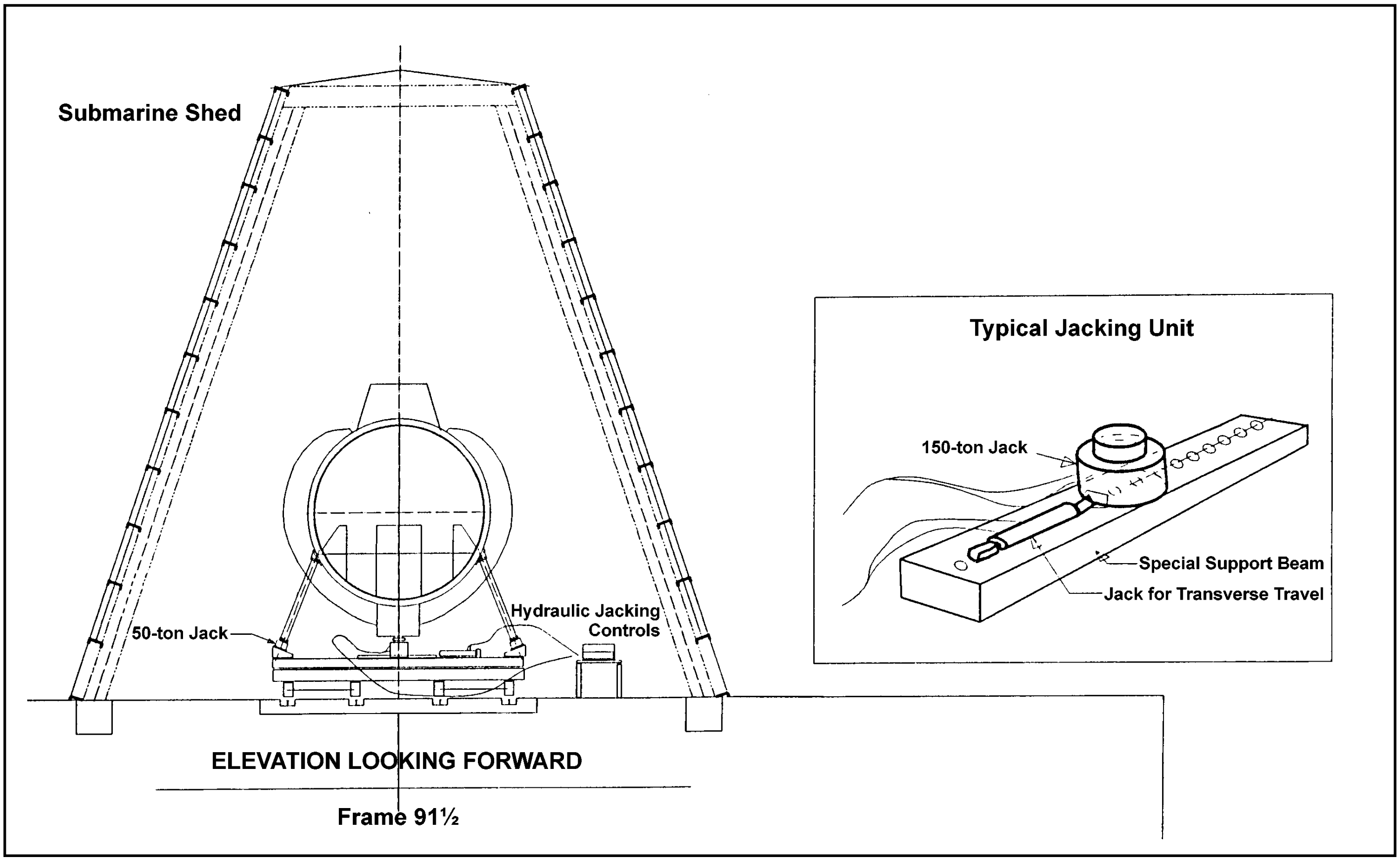


Fig. 2. Details of the docking and jacking arrangement.

to mid-bay between the pressure hull ring stiffeners at frame 91.5 was selected for both submarines.

A special dock block and jacking arrangement had to be designed to enable transfer and movement of the after end of the submarine as an intermediate step between cutting and rewelding the pressure hull. Four 100-ton, two 200-ton and two 50-ton hydraulic jacking units were mounted on existing trolley units to enable both vertical and transverse adjustment of the after end (*Figs. 2 and 3*).

Jacking operations were particularly tricky both during the cut and at fit-up when the submarine was being welded back together. While intact, the submarine could be likened to a beam resting on nearly continuous supporting blocks. The weight of the submarine varies along its length and is particularly heavy in the area of the engine-room, but the load is distributed relatively evenly to the dock blocks because of the stiffness of the hull. However, when the submarine is cut, the hull's ability to transfer load along its length is eliminated in the vicinity of the cut. The jacks therefore played a very important role in compensating for these load imbalances.

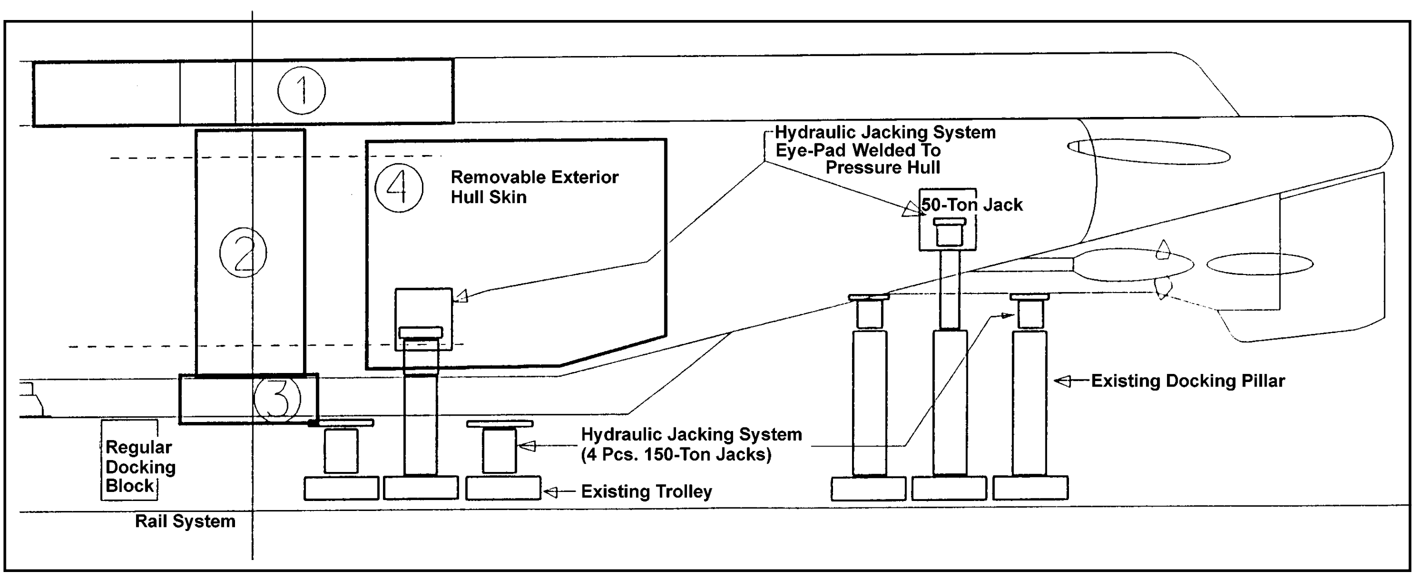


Fig. 3. Preparations for cutting the pressure hull included (1) removing the fibreglass casing; (2) cutting the outer hull sections with oxyacetylene torches; (3) cutting the keel plates; and (4) cutting away the removable exterior hull skin. Note also the arrangement of jacks and docking blocks.

PROCESS	ADVANTAGES	DISADVANTAGES
Flame Cut (Oxyacetylene or plasma)	• readily available equipment • common practice in yard	• high heat input — creation of a heat-affected zone • additional effort • loss in material (up to 2.5 cm) — buoyant volume reduced • measurement difficulties at end of cut sequence
Milling Machine Cut	• cut/edge preparation in one step • heat input lower than flame cut	• very expensive
High-Pressure Water-Jet Cut (i.e. water and garnet particle mixture)	• clean cut • no heat input • affordable • no significant loss of material	• requires screening • requires disposal of waste • learning curve — first time for production

Fig. 4. Cutting Process Comparison

The greatest fear was that the hull would be subjected to excessive shear from load imbalance while the submarine was only partially cut. With this in mind, the jacks were fitted with pressure gauges to provide instantaneous load feedback. Pressure readings were converted to load figures manually such that direct shear loads could be determined. Engineers monitored jack loads every half hour, making minor adjustments to compensate as necessary. This proved to be of great value both during the cutting and rewelding operations. In addition to the load cells, dial indicators were used to measure deflection of the hull and strain gauges were fitted to provide a second source of shear load indication (although the strain gauges proved not to be of real value).

Selecting the Cutting Tool

Standard practice for removing steel from a hull is to use a cutting torch, but this raised several concerns. First, high levels of heat applied locally would affect the metallurgical properties of the steel. The heat-affected zone in the remaining pressure hull steel would then require extensive preparation prior to welding to ensure against substandard metallurgical characteristics. A secondary concern and by-product of the cutting-torch method revolved around the shortening of the submarine and the subsequent effect on buoyancy. It was estimated that up to two and a half centimetres of the length of the submarine would be lost to a combination of the cutting process and, later, the edge preparation necessary to reconnect the two sections of pressure hull. Since this equated to something in the order of one tonne of lost buoyancy (the same as adding a tonne of equipment to the submarine) submarine manoeuvrability, particularly as it affected trim, diving and surfacing would need to be revisited. Measures such as solid ballast modifications would have to be taken to ensure that capability was not adversely affected.

Once again the question was raised as to whether there was a better way, this time in relation to hull-cutting methods. The NEUA naval architect duly set about investigating alternative cutting methods in preparation for the work on HMCS *Ojibwa*. The advantages and disadvantages of cutting by machine and by high-pressure water-jet were explored (*Fig. 4*).

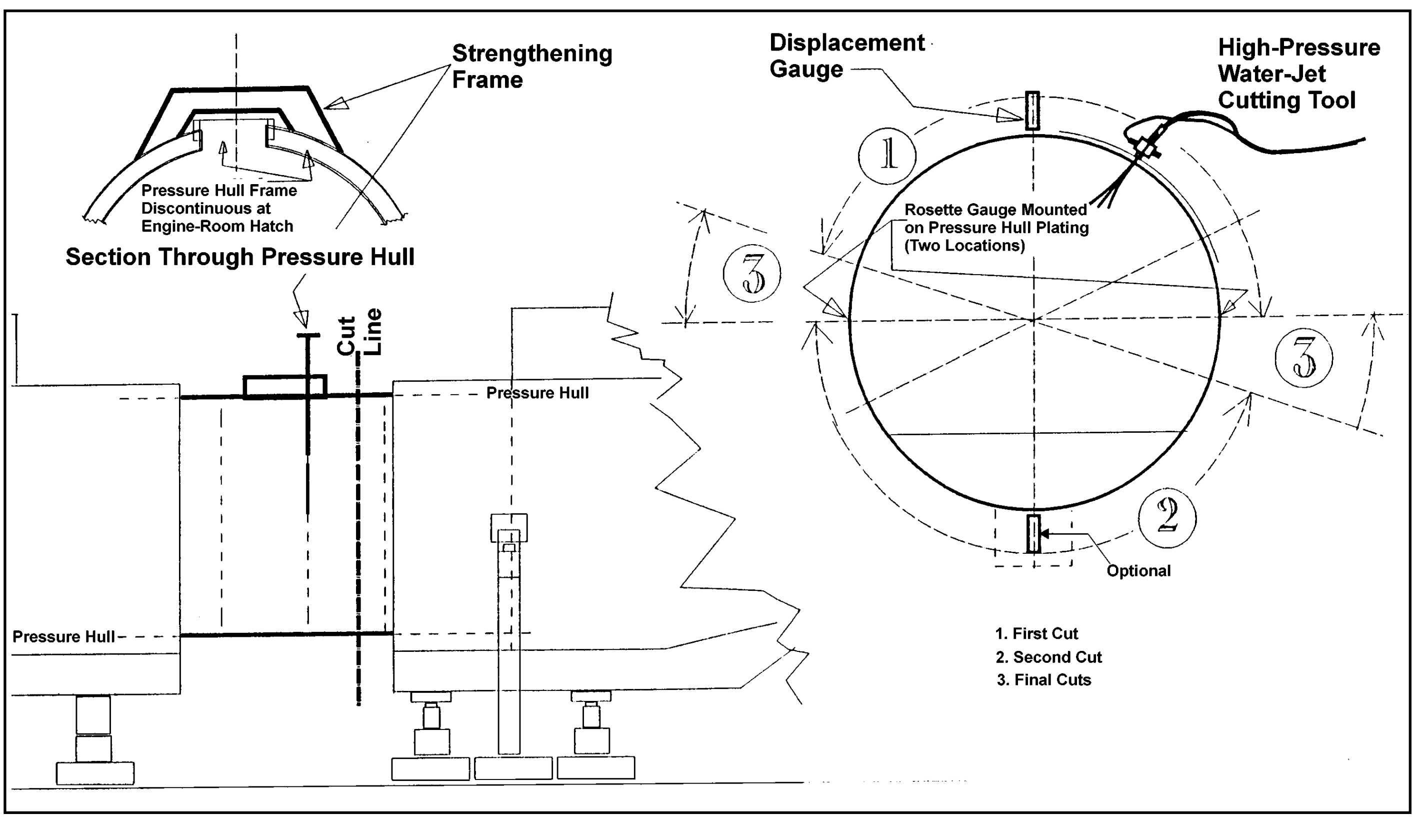


Fig. 5. Details of the Cutting Process

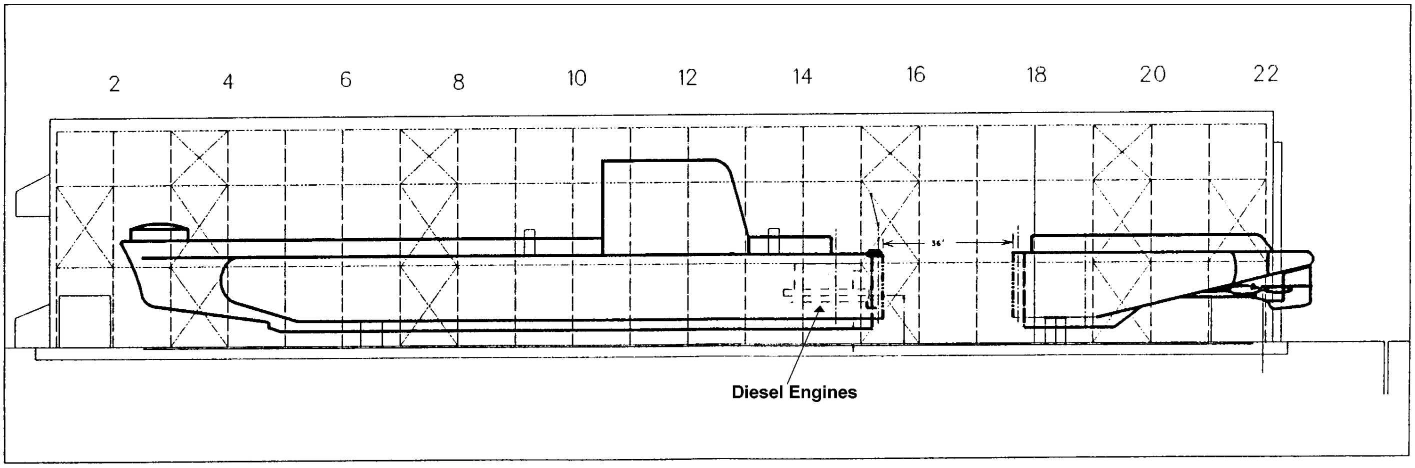


Fig. 6. Elevation, port-side view of the submarine after the stern section has been pulled back to allow access to the diesel engines.

A high-pressure (25,000 psi) water-cutting tool was found to be technically compliant and did not suffer the same drawbacks associated with the use of a cutting torch. There is no heat input and therefore no heat-affected zone to contend with. Also, the water-cutting method would not shorten the submarine by any appreciable amount (about three millimetres compared with roughly 25 mm if a torch were used) because it leaves a much narrower "kerf" and requires virtually no edge preparation apart from bevelling prior to rewelding. Measures would have to be taken to protect equipment inside the submarine from water and grit damage, but considering the small volume of water (4½-7 litres per minute) this did not pose a significant problem. Still, a temporary bulkhead was erected to contain all spray within one frame bay.

The Cut

With all of the preparations complete, it finally came time to do the actual cutting job. It was, for the most part, a rather boring experience. Until the after section was pulled away from the rest of the submarine, there was no obvious evidence of anything much happening. Magnetic tracks were attached to the pressure hull to guide the water-jet cutting head, which

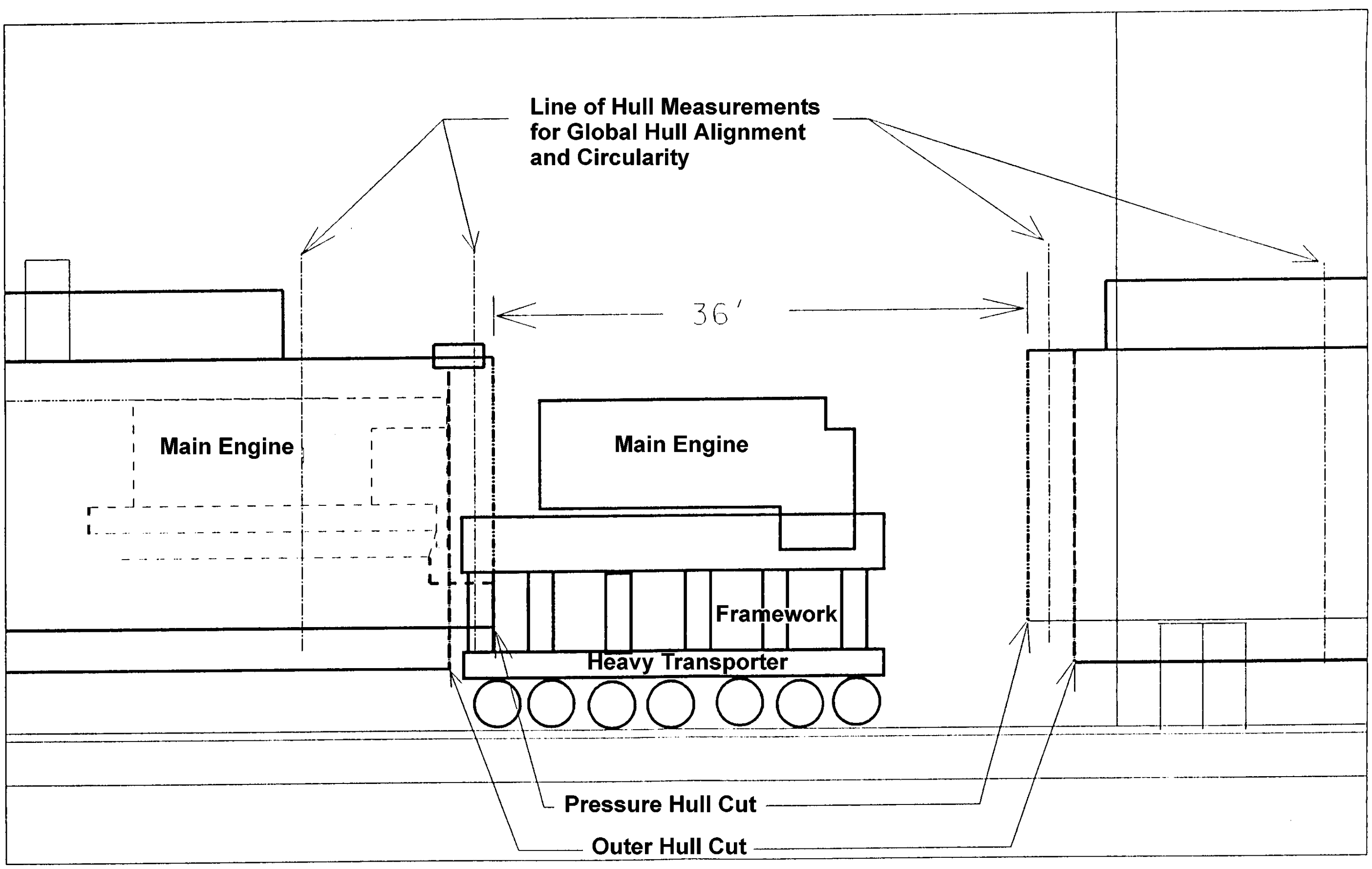
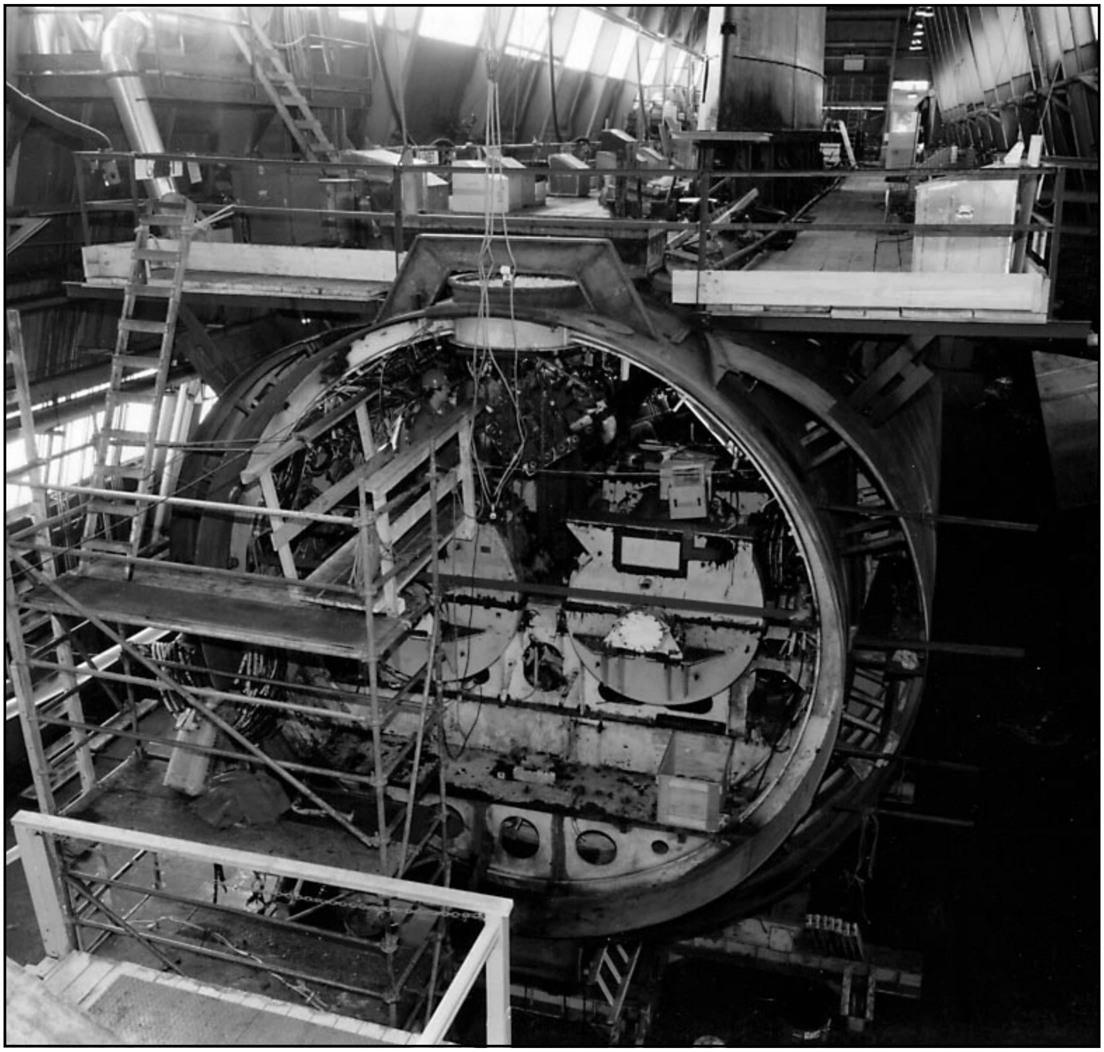


Fig. 7. Details of the main-engine removal set-up. Once the submarine sections were separated, a specially designed flatbed transporter was moved into place. One at a time, the engines were pulled back, then hoisted onto the transporter for delivery to the engine shop for overhaul.

proceeded along at approximately 2½ cm per minute.

During the cutting evolution, water-jet nozzles needed to be changed out relatively frequently. For *Onondaga* the contractor elected to use ruby-tipped nozzle heads rather than diamond-tipped heads as originally intended. This proved to be a problem since these heads degraded very quickly with the high-pressure flow of water and garnet particles. This resulted in the water-jet changing shape and thus increasing the cut width to maximum tolerances more rapidly than expected. To avoid too serious a step at the location where cutting stopped then recommenced, five nozzle heads were used to make the complete 360-degree cut.



As extreme as it seemed, the proposal to cut the submarine pressure hull in two would facilitate easy engine removal. *(Canadian Forces Photo)*

To avoid local overloading of the pressure hull, the cutting sequence was carefully established in advance to co-ordinate with the dock block jacking arrangements (*Fig. 5*). In the case of *Onondaga* the contractor elected to complete the first cut sequence in two parts. Rather than a single pass, cutting counter-clockwise past the pressure hull crown to about 280 degrees as was originally planned, the first cut was prematurely terminated in the area of the crown. The remainder of the first cut sequence was then completed in a clockwise direction from about 280 degrees to the crown. Around 2 a.m., as the water-jet approached to within about four centimetres of the crown to complete the first sequence, a loud "bang" was heard. It was the remaining steel suddenly giving way. One can well imagine the concern of Gord MacDonald, the FMF *Cape Scott* welding officer who was on site at the time. A seven-centimetre-long jagged fragment of steel left hanging from the after end of the submarine was cut away (it now resides on Gord's desk), and the subsequent repair was straightforward.

As discussed previously, jack pressures were measured and recorded every half hour throughout the cutting evolution. These figures were converted to forces and assessed to ensure that local loads on the pressure hull remained within acceptable limits throughout the evolution. Pressure gauges at the jacking locations were used to determine the final weight of the after section of the submarine once it was fully cut. These would eventually be used to assist in realigning the two sections in preparation for rewelding. *Ojibwa* load data was later used to initialize jacking pressures during the *Onondaga* evolution.

With the after end of the submarine pulled away (*Fig. 6*), a 3 x 6-metre flatbed trailer was manoeuvred into place. A transfer cradle (*Fig. 7*; see also *front cover photo*) built specially in the yard with twenty caterpillar type rollers enabled intermediate diesel movements to and from the trailer. The diesel engines were then slung via rigging onto the trailer for transport to the shop for some much needed R&O. (In the case of *Ojibwa*, replacement diesel engines from the ex-British submarine HMS *Osiris* were installed, eliminating the engine work from the refit critical path.)

Reinstating the Pressure Hull

As discussed previously, controlling distortion was extremely important in ensuring adequate structural integrity. Reassembly is a much more straightforward process if distortions introduced during cutting are minimized, but the forces involved are not trivial. Under normal docking conditions, *Oberon*-class submarines present dock block loads as great as eighty tonnes at any one of roughly seventy-five keel block locations along the length of the hull. Once the submarine has been cut and the diesel engines are removed, these loads are altered significantly.

The after hatch in close vicinity of the cut location at frame 91.5 was externally stiffened to control distortions. This did not prove to be entirely effective during the *Ojibwa* refit, however, so a much more satisfactory internal cruciform-shaped stiffening arrangement was designed and fitted for *Onondaga*.

Rewelding the submarine was progressed by applying normal pre-heat and post-heat to the pressure hull plating to ensure that the heat-affected zone (from the welding) would have sufficient metallurgical toughness to withstand service conditions, including low-temperature operations. The weight of the submarine was used to help align the forward and after sections of the pressure hull. The two sections were welded at the crown, then the jacks were lowered, gradually redistributing the load until the two sections came into alignment at the bottom (visual plate alignment techniques were used). The entire bevelled edges of the two joined sections were then welded inside and out and subjected to full non-destructive testing by radiography, magnetic particle investigations and ultrasonics.

Quality Control/Quality Assurance

Concurrent with the HMCS *Onondaga* refit, FMF *Cape Scott* was (and still is) undergoing significant change to its quality processes. ISO9000 status was subsequently bestowed upon the FMF at large. The quality process being developed was applied wherever possible to the specifications developed by the engineering division for implementation by production. Records of objective quality evidence were kept and used for the acceptance of physical work. These included:

• circularity measurements taken before and after using a “MANCAT” optical alignment system;

• strain and deformation data (from gauges fitted to the hull); and

• NDT records from before (material condition and cut location) and after (weld quality records, etc.).

Monitoring during the work provided further records (e.g., load cell measurement data from jack locations).

Conclusions

Both HMCS *Ojibwa* and HMCS *Onondaga* have now undergone major surgery involving cutting their pressure hulls into two sections. Worn diesel engines were readily replaced and bedplate repairs conducted. Technical risk regarding structural integrity, and the cost to renew electrical cabling were successfully addressed. Given the circumstances of the day, both evolutions must be considered as technical victories — the objectives of the refit were achieved by methods not envisaged until the ingenuity of the DND technical support community came into play.

Following the *Ojibwa* work, NEUA offered these thoughts in the way of lessons learned:

• Senior management is willing to adopt novel and potentially risky approaches if there is a perceivable payoff (in this case, reduced refit time).

• Business as usual is easier, but innovation is a lot more fun.

• Novel approaches can boost morale (as this one did in the dockyard).

• Such a project can foster stronger working relationships between the agencies involved.

Should the O-boats be cut to remove diesel engines during future refits? Now that two submarines have successfully undergone radical surgery of this nature, the technical feasibility has certainly been proven. The decision therefore rests as a business case issue.

Acknowledgments

A special thanks is extended to LCdr Doug O’Reilly, Mr. Gord MacDonald, Mr. Roger Barakett and Mr. Jean Paul Ayotte (Yogi) at FMF *Cape Scott* for providing the scribe with sufficient material and anecdotes with which to write this paper. LCdr Wayne Nesbitt, LCdr (Ret.) Xavier Guyot and staff at the former Naval Engineering Unit Atlantic and Ship Repair Unit Atlantic are commended for their role in engineering the HMCS *Ojibwa* refit and for having the courage to pursue this novel approach. Technical material presented in this paper drew heavily upon documentation which they produced.

LCdr Holt is the DMSS 2-3 Ship and Submarine Hull Structures Officer at NDHQ.

FMF *Cape Scott* — Changes in Fleet Support

Article by LCdr David Peer

The maintenance and repair of warships has been a part of the Halifax waterfront since the 18th century. Many changes have occurred in the relationship between the fleet and the dockyard. From the Royal Navy and wars of the British empire to the Royal Canadian Navy and two world wars the relationship constantly evolved. Placed in this context, the current changes to naval engineering and maintenance (NEM) during the 1990s represent just a small evolution in the support to the fleet.

The most recent changes to the fleet NEM support organization on the East Coast trace back to 1991 when our ships were being prepared for duties in support of Operation Friction. The achievements and accomplishments of Ship Repair Unit Atlantic (SRUA), Naval Engineering Unit Atlantic (NEUA) and Fleet Maintenance Group Atlantic (FMGA) during the rush to prepare ships for deployment to the Persian Gulf resulted in two unit commendations. Though the NEM organization proved extremely effective, the Gulf War experience made everyone realize that more efficient methods existed to support the fleet. The ship repair and naval engineering units seized the opportunity and both units embarked on continuous improvement programs to change their business practices.

In 1994, external political, budgetary and industrial pressures combined to accelerate the pace of change. Maritime Command (MARCOM) initiated a complete functional review of naval engineering and maintenance that reevaluated how SRU, NEU and FMG provided support to the fleet. The goal of the functional review was to reduce support costs by 20 percent and allow MARCOM to shift resources to sustain operations.

The East Coast NEM units were able to take an aggressive approach to the functional review because of the continuous improvement initiatives in SRUA and NEUA and a labour-management strategic alliance in SRUA. The Continuous Improvement Program had changed labour and management working relationships and provided a framework and reference for those participating in the functional review. The strategic alliance was — and remains — a cornerstone of the co-operative approach used to manage change in the newly formed Fleet Maintenance Facility *Cape Scott*. Over a period of three years in SRUA, labour management evolved from a conventional, confrontational approach to a collaborative, win-win approach.

The navy's NEM organization was facing major challenges. Its ability to meet fleet operational requirements was proven, but it was not cost-conscious and could not demonstrate cost-effectiveness. Measuring unit performance and cost-effectiveness was impossible. Management and service delivery functions were mixed, cost visibility was absent, and the whole support organization was driven by consumption. With no effective feedback on cost, the system of fleet support lacked accountability and often experienced problems when operational priorities between ships came into conflict. In a time of reducing resources, change in fleet support was inevitable.

Restructuring NEM Support

In 1994, the East Coast NEM units employed more than 2,200 military and civilian personnel with direct and indirect expenses of over $150 million annually. FMF *Cape Scott* stood up April 1, 1996 with about 1,500 personnel. Though the functional review authorized a maximum establishment of 1,700 people (222 military and 1,478 civilians), it set actual personnel levels to match the forecast work.

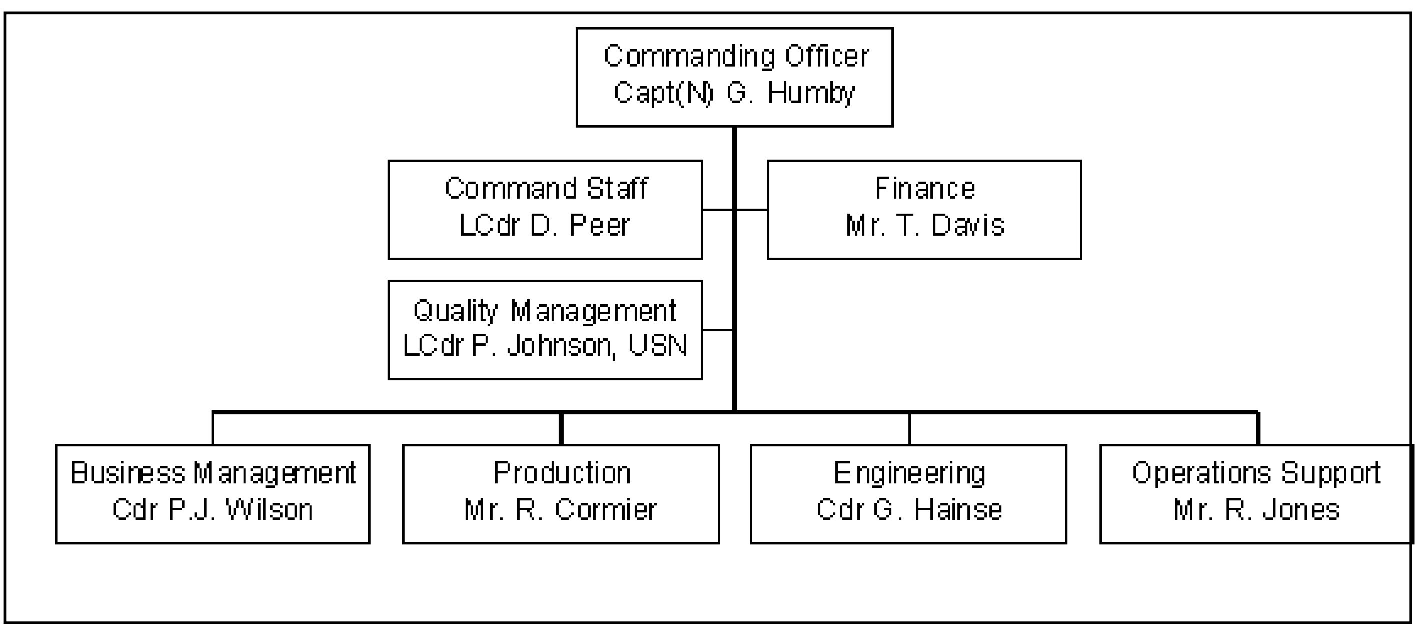


Figure 1. FMF Cape Scott Organization

Cape Scott entered fiscal year 97/98 with just under 1,400 people (200 military and 1,200 civilians). The manning level continues to reduce to match the anticipated workload.

In forming *Cape Scott*, the functional review concentrated major changes in management and support areas. *Figure 1* shows the new organization. The two line departments — Engineering and Production — were formed around the legacy organizations of NEUA, FMGA and SRUA. The line departments now operate with considerably less management and support overhead.

The Operations Support department consolidated the NEM administration, safety and environment, information technology, and industrial engineering functions. The department streamlined, consolidated and significantly reduced all support areas. The Business Management, Quality Management, and Finance functions are new. They manage FMF business operations, the quality management system, and the accounting and financial systems.

FMF *Cape Scott* stood up with engineering maintenance and repair capabilities similar to the former NEM units, but with 36 percent less overhead. For example, when the functional review established the production department from SRUA and FMGA, the SRUA production organization eliminated two levels of supervision and reduced material support personnel by over half.

The functional review exceeded the target and achieved a 23-percent reduction. The overall resource reduction in *Cape Scott* included more than 500 civilian employees (representing $13 million in salary costs); 17 percent of all military positions; and 10 percent of all Operations and Maintenance costs. An internally funded facility rationalization project (managed internally and run in parallel with the functional review) consolidated *Cape Scott* real estate on both sides of Halifax Harbour. The rationalization resulted in additional annual savings of $1.4 million.

The facility rationalization project reduced East Coast NEM requirements by about 45,000 square metres. Shops moved from the Naval Armament Depot in Dartmouth to Halifax, eliminating facilities and equipment duplication. The shop moves also increased efficiency by reducing travel time and delays.

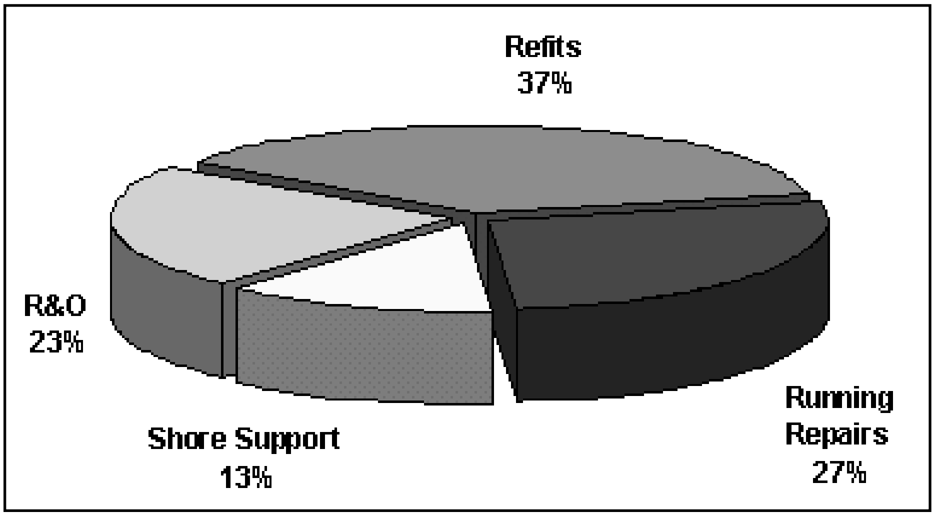


Figure 2. Work Distribution FY 95/96

The First Year

Over the past year everyone has worked hard to stand up and run FMF *Cape Scott* during a period of significant change and resource reduction. Since the implementation phase of NEMS:

• one hundred more civilian positions have been eliminated;

• performance measurement has begun;

• the direct production ratio — or the portion of all hours available used to deliver a service — has increased from 42 percent to 53 percent;

• accidents have been reduced by 50 percent;

• time lost due to accidents has been reduced by 60 percent;

• R&O turnaround time has decreased by 50 percent;

• overtime has decreased by over 80 percent, saving $1.6 million;

• *Cape Scott* has gone on-line with self-funded information technology improvements; and

• customer feedback and surveys have indicated a noticeable improvement in customer satisfaction.

Last year, the Maritime Forces Atlantic (MARLANT) operating budget funded *Cape Scott* to provide over one million productive person-hours to support MARLANT units and the navy. The breakdown is shown graphically in *Fig. 2*. Services in support of NDHQ tasks (R&O and refits) have recently reduced from 70 percent to 60 percent of the total productive capacity. Current projections indicate NDHQ allocations could be reduced to as low as 50 percent. This trend may continue as the navy places increased reliance on in-service support contracts for entire ship classes, and shifts toward more third-line support in industry.

The other significance of *Fig. 2* to *Cape Scott* is not readily apparent. Although Formation Halifax funds 100 percent of *Cape Scott*'s salary wage envelope, it consumes less than half the resources. Funding and division of work occasionally become a source of conflict when *Cape Scott* is caught between Formation priorities and NDHQ tasks. The conflict started in 1993 when NDHQ devolved 100 percent of the NEM salary wage envelope to the Formation. At that time Formation only consumed 30 percent of the NEM resources. Although from the Formation perspective NDHQ tasks may seem to consume a disproportionate share of the MARLANT operating budget, the percentage of NDHQ work has reduced significantly.

For *Cape Scott*, NDHQ tasks are critical to cost-effectiveness. A steady flow of work from non-Formation sources allows *Cape Scott* to load-level work around the cyclical availability of operational ships. Unfortunately, the MARCOM functional review focused almost entirely within the Command for solutions. The reduction in service to NDHQ — placed on *Cape Scott* by the functional review, subsequent budget cuts, reengineering and other Formation initiatives — occurred without significant NDHQ input. This has created some misunderstandings and mistrust and left some significant issues unresolved.

Though the functional review accomplished a significant feat by reducing MARLANT engineering maintenance and repair costs by over 20 percent, it was never more than an 80-percent solution. The functional review missed the broader aspects of fleet support outside the context of MARCOM and did not significantly affect the legacy service delivery processes of NEUA and SRUA.

Today's Challenge

Cape Scott has a new challenge to reduce capacity and balance the production and engineering work force with the current workload. Unit capacity must match the decreased demand so *Cape Scott* can provide support to the fleet cost-effectively. Reserve time has doubled from last year and has now reached levels four times traditional norms. An overall reduction in demand has created excess capacity because our work force is primarily indeterminate. *Cape Scott*'s ability to quickly adjust its work force eroded when the functional review reduced term and casual employee numbers to insignificant levels.

Excess permanent employee capacity reduces the unit's overall cost-effectiveness. To remain more cost-effective *Cape Scott* must quickly address over-capacity issues affecting cost performance, and reduce the work force in FY 97/98 to match our current, permanently reduced workload. This human resource issue will strain labour-management relations in *Cape Scott*.

Since *Cape Scott* stood up in April 1996, six major factors have developed that define the new challenge:

• By fiscal year 98/99, based on known budget reductions, *Cape Scott* will see demand reduced to 66 percent of the forecast workload established in 1995. Unfortunately, the external political, budgetary and industrial pressures on naval engineering and maintenance continue to restrict the flexibility of the unit to identify additional work to use current capacity.

• The government direction on increased partnership with industry and the contracted engineering and maintenance for new ship classes such as MCDV have permanently decreased demand for engineering and maintenance work in *Cape Scott*.

• *Cape Scott* is organized to support running repairs for 1960- and 1970-vintage warships and submarines. As the navy's older steam-powered destroyers paid off, demand on *Cape Scott* changed. Capability and capacity do not match the current demands of a modern fleet. For example, the traditional backlog of manufacturing for the supply system (national inventory) to support steamers has been cleared and will never reappear.

• Federal budget decisions made in previous fiscal years will continue to reduce DND's budget each fiscal year in the near future. In FY 98/99, MARLANT's operating budget will decrease by $11 million (*Cape Scott*'s share will be $6 million). The real impact will be a reduction in our direct labour work force as *Cape Scott*'s operating budget moves from $57 million to $51 million in FY 98/99.

• *Cape Scott* must consider the possibility that a decision in late 1997 not to proceed with the last scheduled Oberon refit could drastically change the demand on the unit. Submarine support, including refit activity, consumes about one third of the total capacity output of *Cape Scott*. This would further reduce the work force requirements in FY 98/99 to 55 percent of FMF *Cape Scott*'s original 1995 capacity.

• Within DND, Maritime Command and Maritime Forces Atlantic the pressure to shift budgetary resources from support to operations increases as budgets reduce. MARLANT considers *Cape Scott* a support unit and has directed a 15-percent improvement in efficiency by FY 99/2000. This efficiency gain means either increased service from the same size work force, the same service with a smaller work force, or some combination of increased service and a smaller work force. With the pressure to keep the fleet at sea, the Formation commander could direct some combination of the two. Improving efficiency will further reduce *Cape Scott*'s operating budget and our direct labour capacity. Where permanent employees solely provide excess capacity, a reduction in the size of the permanent work force will be necessary.

These major factors represent only the immediate quantifiable impacts on *Cape Scott*'s future. The full impact of additional issues that could reduce overall demand on *Cape Scott* is not known. These issues include:

• Maritime Command's implementation of the Department's readiness and sustainment policy;

• The implementation of delegated maintenance budgets and user pay;

• The increased use of credit cards for local purchase rather than FMFCS manufacture; and

• The analysis of all *Cape Scott*'s activities and capabilities for alternate service delivery by March 1998.

To respond to all the major factors and additional issues, FMF *Cape Scott* critically reexamined how it provided services to the fleet. In the fall of 1996, *Cape Scott* established a Continuous Improvement Project to explore opportunities in the service delivery process. Phase 1 of the project was an extensive activity-based cost (ABC) analysis of the service delivery process. The analysis quickly determined that reengineering was necessary to reduce costs and achieve additional efficiency gains. It was clear that legacy service delivery processes from NEUA and SRUA were still effectively in place. It was also clear that no effective performance measures existed to manage a business-like service to the fleet.

The *Cape Scott* response to the ABC analysis was to immediately start planning for the phase 2 reengineering project.

FMF2000 — *Tomorrow's Opportunity*

FMF2000 is *Cape Scott*'s response to the service delivery challenge and the second phase of the continuous improvement project; it will match our capabilities and capacity to our customers' needs. *FMF2000* will improve the service delivery process within the broad context of the navy's fleet support plan (FSP), and make the service delivery process more cost-effective. Combined with other continuous improvement initiatives to improve work force flexibility, it will also reduce fleet support costs, make the unit more efficient, and position *Cape Scott* for the future. Phase 2 project definition started last spring and the project commenced in May of this year. The design phase will complete in the fall.

The goal of *FMF2000* is to redesign *Cape Scott*'s service delivery process by using best practices and exploiting our newly developed activity-based costing (ABC) model from phase 1. Once *FMF2000* defines a new service delivery process, the implementation of project design recommendations will begin this fall and complete in fiscal year 98/99.

FMF *Cape Scott* formed in a consolidation process that reduced the cost of providing naval engineering and maintenance and repair services by 23 percent over FY 93/94 baselines by reducing management and management overhead. While there may be some additional savings possible in our management and support costs, the bulk of the unit's costs are now tied up in the service delivery process. This process will provide the focus for *FMF2000*. Any further efficiency with a constant or smaller work force will have to come through reengineering service delivery. This critical issue with service delivery is realigning and modernizing capabilities, activities, practices, processes and capacities to improve cost-effectiveness, efficiency and flexibility.

The process issue is critical to the unit. Support to the current and future fleet must:

• cost less;

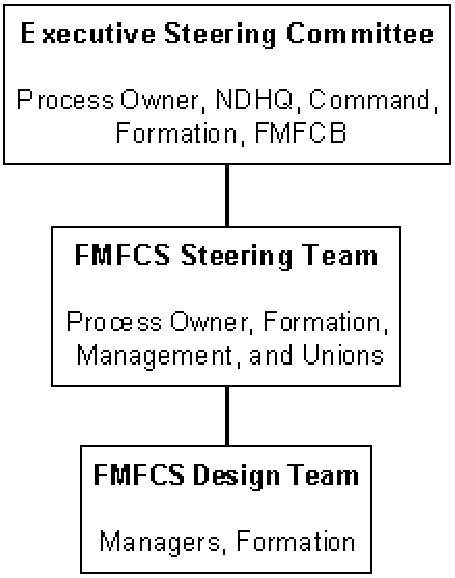


Figure 3. FMF 2000 Project Structure

• increase customer choice and satisfaction; and

• provide services that are so competitive that the cost-effectiveness of the unit will no longer be in question.

For *FMF2000* to be successful, the unit recognized early that the reengineering effort must extend beyond *Cape Scott* to include a broader perspective of naval engineering and maintenance. Though the unit mission is primarily within the MARLANT business and operational environment, NDHQ demand represents a significant portion of output. Unfortunately, the link between NDHQ work and Formation objectives is currently weak. *Cape Scott* can be caught between conflicting requirements when NDHQ demands on the unit do not align perfectly with Formation priorities.

FMF2000 will consider all aspects of the fleet support plan process and involve stakeholders from NDHQ, Command, Formation and *Cape Scott*. It will redesign *Cape Scott*'s service delivery processes by examining best practices in outside industry and using the ABC model and job and cost data available from the unit's management information system. Some of the goals of the project against which *Cape Scott* will measure success include:

• improving end-to-end plan process management of fleet support;

• validating FMF capabilities;

• improving the service delivery process to reflect best practices and position *Cape Scott* to be the best naval shipyard in North America;

• reducing fleet support costs and meeting efficiency targets;

• examining, and as necessary redefining, how capacity is provided based on government policy and business case analysis; and

• developing process performance measures.

The *FMF2000* project will operate at three levels (*Fig. 3*) to provide a forum to address the issues outside *Cape Scott*'s control. Of particular concern is the goal to improve end-to-end process management of the fleet support plan. The executive steering committee deals at the strategic level and provides all FSP stakeholders and the process owner a place to address pan-naval issues. The process owner is Capt(N) Gerry Humby, Commanding Officer of FMF *Cape Scott*. The executive steering committee deals with strategic issues such as what the service delivery process will produce and what external constraints will apply to the reengineered service delivery process.

The steering team operates at the Formation and unit level and deals with the tactical issues of how the design team will meet the strategic direction. The steering team is the usual arbiter of issues floated up from the design team. As the *Cape Scott* process owner, the commanding officer provides the link between the steering team and the executive steering committee.

The working level team actually conducting the project will be led by *Cape Scott*'s engineering department head, Cdr Gilles Hainse. The design team will rely on continuous improvement project teams to deal with specific issues like workforce flexibility and shop compression. The project will follow a very tight time line. The project began in May and will complete a final report by October.

This project is not the only change activity under way at *Cape Scott*. Some significant initiatives will be progressing in parallel with *FMF2000*:

• revising the ABC model to reflect the last fiscal year;

• registering the quality management system to ISO 9001;

• benchmarking all capabilities by cost for alternate service delivery;

• re-opening collective agreement negotiations (*Cape Scott* has already successfully completed one collective agreement); and

• installing a new management information system.

These initiatives will place challenging constraints on project resources and limit design flexibility, but then no project would be complete without constraints.

Conclusion

Cape Scott is committed to excellence in naval engineering and maintenance services. To achieve excellence, *Cape Scott* must work in partnership with all stakeholders in fleet support to maintain the navy's operational tempo in a climate of declining resources, a changing workload and government outsourcing policy.

Cape Scott has had to take decisive action to ensure resource reductions do not jeopardize its mission to support the fleet. The unit understands where it was, where it is and where it needs to go. *FMF2000* will fundamentally change how the fleet receives support.

LCdr David Peer was the Industrial Engineer at Ship Repair Unit Atlantic and the Staff Officer at FMF Cape Scott during the Formation and stand-up of the new NEM organization. He is now serving on exchange with the Royal Navy.

Integrated Machinery Control System Operator Training Tools for the Canadian Navy

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(This paper was presented at the 11th Ship Control Systems Symposium in Southampton in April 1997, and appears here in abridged form courtesy of Computational Mechanics Publications, Southampton SO40 7AA, United Kingdom.)

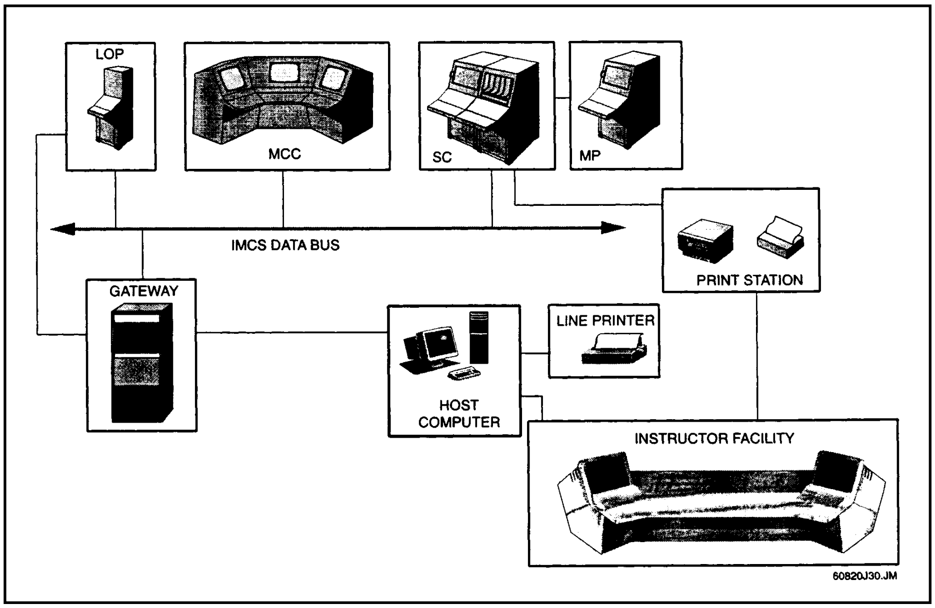

Fig. 1. TRUMP Shore Based Trainer — Block Diagram

The installation of the Integrated Machinery Control System (IMCS) in the Canadian navy's new patrol frigates and updated Tribal-class ships has prompted a rethinking of the way marine operators and technicians are trained. CAE Electronics Ltd., in conjunction with the Canadian Department of National Defence, has developed new training platforms to allow the navy to properly train its ship crews in an effective and efficient manner. These platforms consist of classroom trainers and on-board training systems which share simulation models, instructor facility interfaces, utilities and IMCS software.

As systems become more integrated, training programs must be capable of incorporating seamless simulations of several pieces of equipment to be effective. Similarly, the accidents at the Three Mile Island and Chernobyl nuclear power stations have resulted in more stringent requirements being imposed on the fidelity of the systems used to simulate full-replica nuclear power plants. The software models must be able to accurately respond under all normal and abnormal conditions. The growing power of computers, coupled with a reduction in their costs, has made it possible to bring the fidelity of full-scope simulators into the classroom, as well as to individual workstations, in order to help meet some of these stringent requirements.

Several years ago, CAE Electronics Ltd. developed its Real-time Object-oriented Software Environment (CAE ROSE™) as an internal, software productivity tool in response to changing requirements in the training field and the evolving computing power available from workstations. It was felt that a graphical, icon-based, object-oriented software environment would allow modellers to more easily and accurately translate their knowledge of a particular process into a simulation than traditional methods allowed at that time. It was also determined that modular, object-based simulations would be much easier to maintain and would provide greater reusability than traditional software code. Additional benefits included automated code and documentation generation, requirements traceability and greater ease of use. CAE ROSE™ allows a user to model a system by assembling schematics using objects found in predefined functional libraries. The environment is unique in that it allows the user to connect schematics across different types of environments (i.e. hydraulic, electrical and control) so as to provide a high-fidelity, integrated representation of an actual system.

The Canadian Navy's Situation

With the arrival of Canadian patrol frigates (CPF) and the update of the Tribal-class ships (under the Tribal-class Update and Modernization Program — TRUMP) in the late 1980s, the Integrated Machinery Control System was introduced into the Canadian navy. An important aspect of IMCS development for the navy was how to effectively train the sailors to use these highly automated control and monitoring systems. Initially, shore-based trainers for each class of ship were introduced to provide the necessary training, ranging from basic IMCS familiarization courses to advanced certificate training. It quickly became evident that the "throughput" of these single-seat, team-type trainers was inadequate and that additional training tools were required.

In addition to the critical throughput training requirement, two other major issues also needed to be considered:

(a) The Canadian navy is mainly a two-coast navy, separated by a vast distance of over 5,000 km. With TRUMP shore-based trainers located on the West Coast and CPF shore-based trainers located on the East Coast, trainees had to travel from coast to coast for the necessary training. Training options which would result in the reduction in the cost of travel and living expenses were being sought.

(b) The throughput of certificate training at sea was severely affected by the very limited number of training bunks allocated to the Marine Engineering department in CPF ships. This problem was further compounded by an inability to provide sufficient emergency drill training at sea without affecting a ship's operational schedule. For this reason, many certificate trainees were unable to complete their on-the-job-training package within the prescribed time frame.

As a result of the given constraints, CRT-based classroom trainers and subsequently on-board training systems were acquired to satisfy the training requirement. The CRT-based trainer was initially developed internally by the navy, making general IMCS familiarization training possible. The Canadian navy has since contracted CAE Electronics Ltd. to upgrade both the hardware and software of the CRT-based trainer and enhance its existing training functionality. CAE is also in the process of upgrading the CPF Shore Based Trainer. To address the limitations of conventional on-board training as noted above, all Tribal-class ships are currently fitted with an on-board training system, while an option for fitting an on-board training system in CPF ships has recently been exercised by the navy.

IMCS Trainers

IMCS trainers are mainly divided into two categories — shore-based and on-board. In the Canadian navy, shore-based trainers consist of a full mission trainer known as the Shore Based Trainer (SBT), and a part-task trainer known as the Marine Systems Trainer (MAST). The trainer embedded in the control system is called an on-board training system (OBTS). These trainers are designed to allow maximum reusability and commonality of software components on both types of trainers. This methodology reduces development cost and enhances maintainability. The plant/ship systems simulation models, the instructor facility software and the IMCS software are the main software components common to these trainers.

Shore Based Trainer

The SBT is a full-mission trainer designed in a specific configuration to provide all IMCS training, ranging from basic IMCS familiarization to advanced certificate training for fleet school students and shore support personnel. This training encompasses both individual and team training. Individual training aims to develop skill in console functions, while team training aims to develop co-ordinated, procedural skills for certificate trainees.

One of the many advantages of a trainer over other methods is that it can reproduce the sequence of events and time scale of an actual ship performance. Operators register information from a wide range of sources, making it important for the information to be consistent in all aspects in order to maintain the operators' concentration in the virtual reality. It is for this reason that the Shore Based Trainer incorporates a simulation model designed on the basis of first-principle modelling techniques. Electrical, thermal-hydraulic, mechanical and control aspects of the ship systems are simulated in this manner using CAE's ROSE™ software

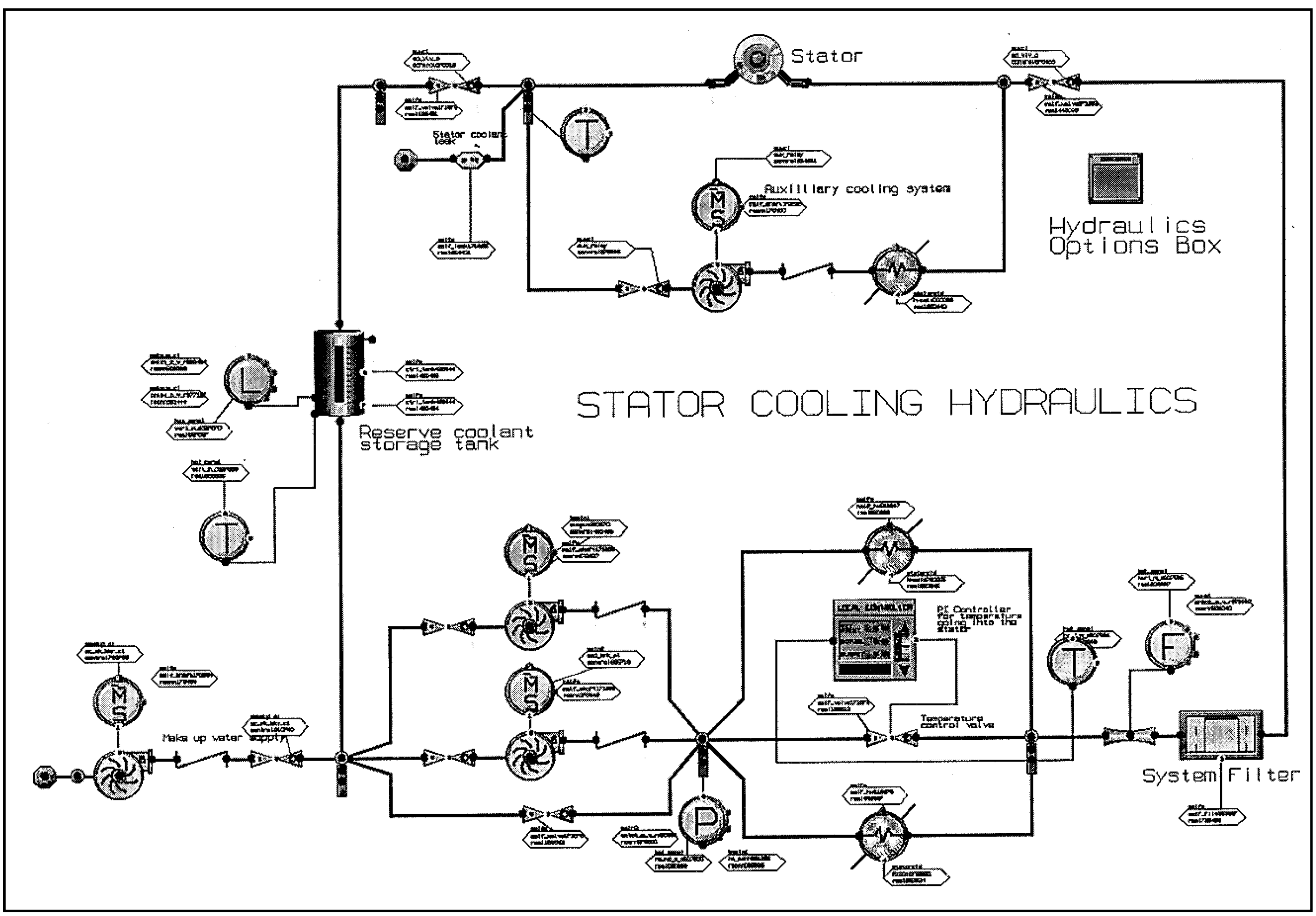

Fig. 2. Typical CAE ROSE™ Hydraulics Schematic

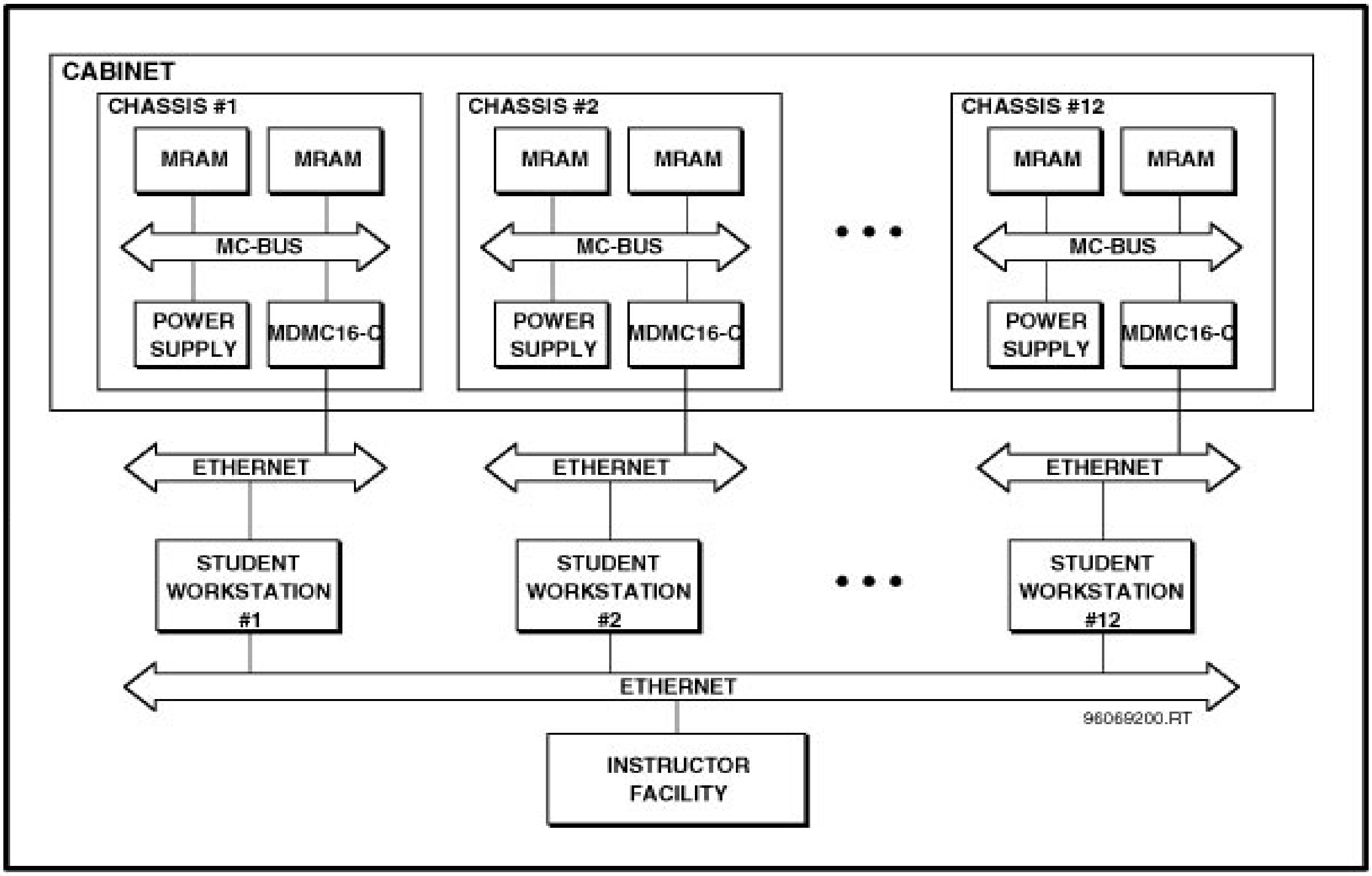

Fig. 3. Marine Systems Trainer — Block Diagram

package. All simulation models are developed from the ship's system configuration and fine-tuned with performance data from actual sea trials.

To ensure a realistic training environment, the TRUMP Shore Based Trainer consists of components that are identical to the actual ship installation in terms of console functions. In fact, the trainer represents a subset of the actual IMCS. These components include the machinery control console, supervisory console, maintainer's panel, local operating panel, digital propulsion controllers, the health monitoring subsystem, and even the data logger and colour hard copier, all functioning exactly as the ones on board. Remote terminal units and the bridge console are the only IMCS components not included in the Shore Based Trainer. To complete the trainer, an instructor facility, a host computer and a gateway were incorporated (*Fig. 1*), allowing full control and monitoring of all training sessions. Communication between the IMCS components and the simulation models is achieved via the gateway, which also hosts the gas turbine management processes. The gateway is also responsible for the stimulation of the local operating panel's hardwired lamps and gauges.

Compatibility with Actual IMCS

A necessary requirement of the Shore Based Trainer was that none of the IMCS software be modified. This means that the software (resident in the firmware) of the consoles, the health monitoring subsystem and the digital propulsion controllers would be unchanged as compared to the software installed on the ships. The consoles themselves are functionally the same as shipboard equipment; however, commercial-grade structures have been used for the training system.

In order to guarantee the authenticity of the system's performance, the actual IMCS control software is used for the trainer. This has the added benefit of making the maintenance of the SBT software components independent from updates in the IMCS control software, as modified IMCS software can be plugged into the SBT without any changes to it. The SBT platform has also proven to be a valuable IMCS support facility for reproducing and testing scenarios which have been observed on board ship, but for which it is not practical to try to reproduce at sea. For this reason, the SBT can serve as a test bed for final qualification testing of IMCS software modifications prior to shipboard installation.

IMCS Emulations

As stated earlier, the remote terminal units and bridge console were not included in the suite of SBT IMCS. The actual remote terminal units (RTUs) serve as the connection points between the control system and machinery sensors and actuators. They acquire plant input/output information, process this information to check for an alarm or warning status, and transmit the information onto the data bus for distribution to the other subsystems. In the case of the Shore Based Trainer, the host computer scans the simulated plant and reports statuses and values through the serial link to the IMCS components. In this way it emulates the functionality of the actual remote terminal units. The emulated RTUs also include all alarm processing capabilities.

The bridge console emulation is such that the instructor has the ability to change and request speed changes, trip the engines and perform all bridge station-in-control functions. The purpose of this emulation is not to train a bridge operator, but to present to the machinery operator realistic demands from the bridge. From the students' perspective at the consoles, they will not be able to dis-

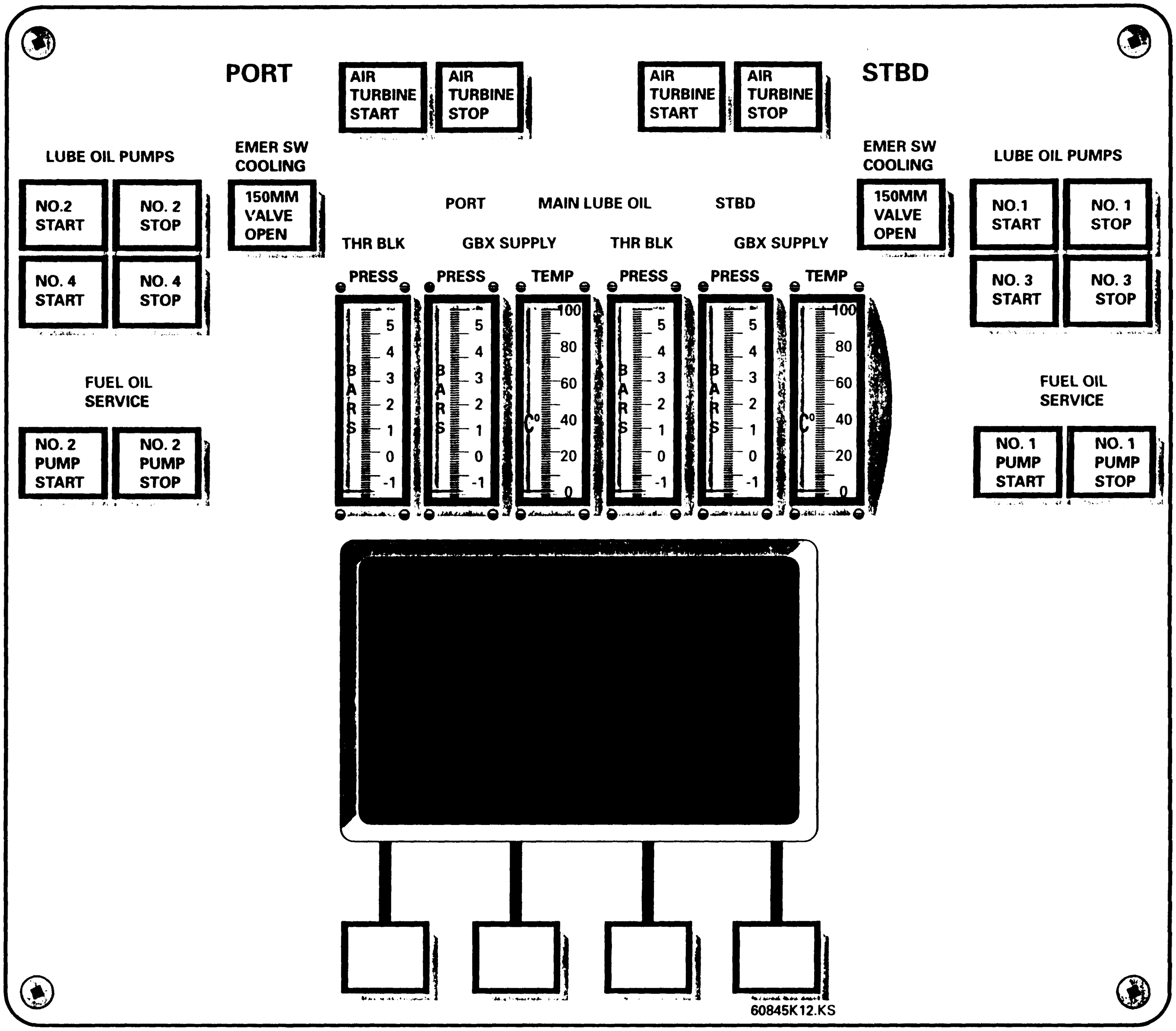

Fig. 4. Man-Machine Interface using TIGERS™

tinguish any difference between these emulations and the IMCS.

Plant/Ship Systems Simulation

The simulation of the plant/ship systems is divided into propulsion and hull systems, ancillary systems, auxiliary systems and electrical systems. Modelling software development is performed using CAE ROSE™ simulation, which uses uniquely identified icons, along with their associated codes, to represent the various types of hydraulic, electrical and control devices of a typical plant (*Fig. 2*). Once a schematic is drawn using CAE ROSE™, its associated software code is automatically generated based on its topology. Standard routines were developed for most components of plant equipment, ensuring a uniform simulation for all common devices in the plant (e.g., tanks, pumps, heat-exchangers, valves, etc.). Modules of all the different systems are then linked to produce an integrated real-time, high-fidelity simulation of the machinery plant required for the trainer. The same plant/ship models which are developed on one trainer are also used on the other types of trainers of the same shipset. This means that only two sets of plant/ship systems simulation software were required to be developed — one for the Tribal-class shipset and one for the CPF shipset.

Instructor Facility

The instructor facility (I/F) is a graphical, highly user-friendly, point-and-click man-machine interface for monitoring and controlling training sessions. It can also be used by the instructor to prepare lesson plans (predetermined sequences of operations) that are later executed upon command.

All system information and plant data is displayed via CRT pages, or point templates. Instructor functional pages (control points, scanpoints, malfunctions, local control, instructor command pages) are provided for each machinery component. A point template contains all the point-related information or attributes (point identification, alarm/warning status, current value/state, etc.).

The following is a more detailed description of the features available to the instructor at the I/F:

(a) **Malfunctions** (failures of devices that result in a deviation from normal ship performance) are predefined for the instructor, and may be selected as either a Boolean type (ON or OFF), such as an ENGINE HOT START, or as an analogue type, which may be scaled from a minimal to a maximum effect, such as a PIPE break.

(b) **Local controls** allow the control and simulation of devices which are re-

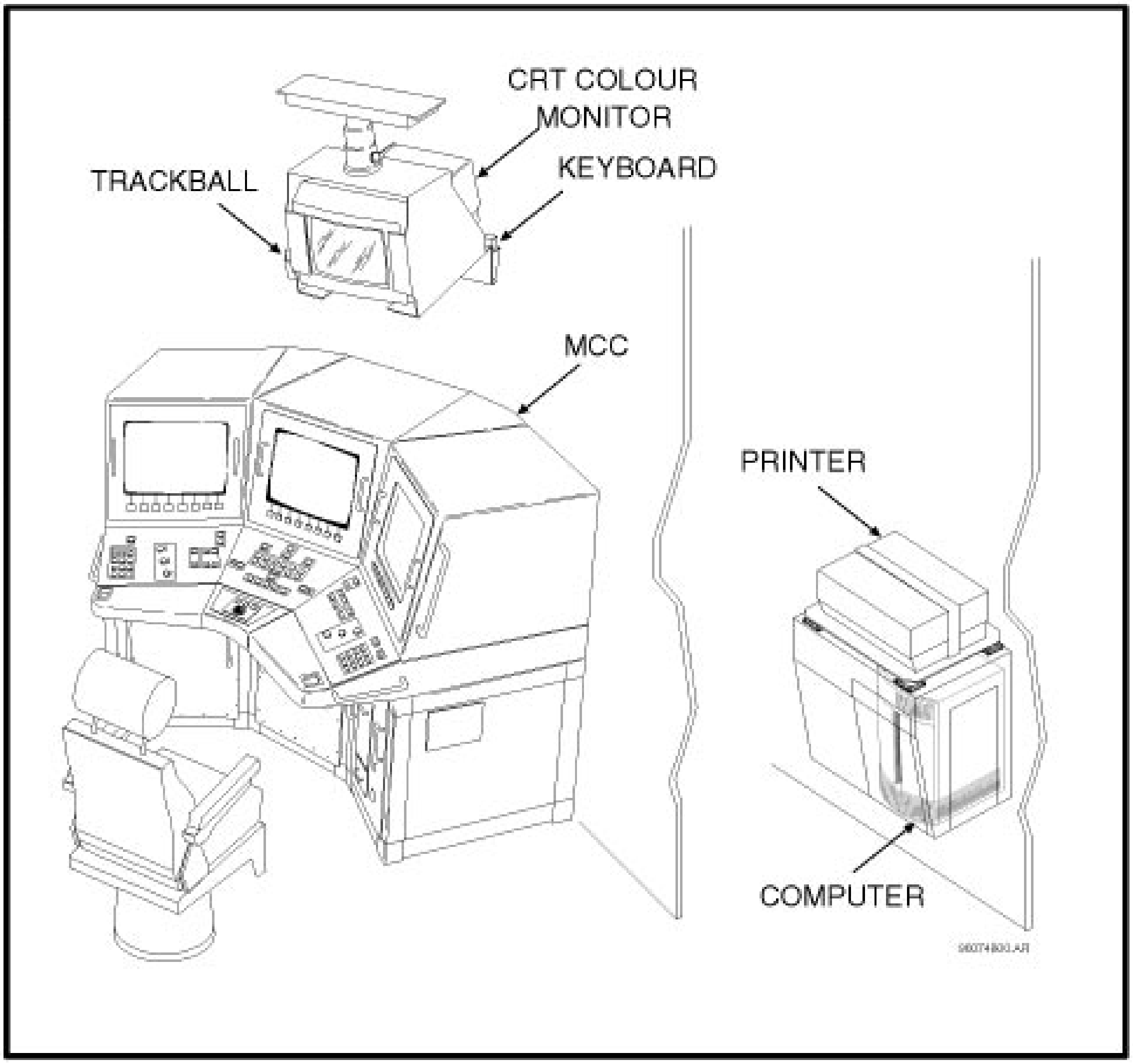

Fig. 5. TRUMP On Board Training System — Ship Installation

quired for training purposes, but are not accessible from the IMCS. These include manual valves, local pump controls and other input which cannot be controlled from the IMCS.

(c) **Environmental controls**. The instructor can change the environmental parameters of the training session. Sea and air temperature, wind and sea conditions can all be changed dynamically.

(d) **Event logging/performance monitoring**. The event logger of the I/F is a tool which the instructor can use to monitor a student's performance. The event log provides a quantitative measure of a student's performance, and an on-line tool for monitoring the IMCS and the plant simulation.

(e) **Signal override**. From the I/F the instructor can override any signal in the IMCS database. The value overwritten is seen by the student at the console or local operating panel.

(f) **Storepoints**. The trainer is capable of being returned to a specific preset ship state by selecting a storepoint and restoring it. A storepoint is created by saving a snapshot of the entire plant status and IMCS settings. A base set of storepoints is delivered with the Shore Based Trainer, which includes a "dead ship," "alongside/shore power," "ready to start," and specific engine driving environments. The I/F also allows other storepoints to be easily created as required by the instructor.

The instructor facility is able to access CAE ROSE™ schematics during training sessions, enabling the monitoring and logging of any parameter accessible from the schematics.

Marine Systems Trainer

The Marine Systems Trainer (MAST) is a high-fidelity, CRT-based classroom trainer with high-resolution graphical displays of the man-machine interface (IMCS consoles and local operating panels). The MAST is used to train Marine Systems Engineering personnel to operate and manage the ship's IMCS using standard watchkeeping practices. It is also used for introductory IMCS maintainer training.

The MAST consists of one instructor facility, 12 independent student workstations, and one commercial enclosure containing a computer processing unit (MDMC) and two memory cards (MRAM) for each student station (*Fig. 3*). From the instructor station, the instructor selects a student station and then an MMI emulation (one of the emulated consoles or local operating panels). The instructor then downloads the selected MMI emulation to the IMCS enclosure RAM card for the chosen station. The student station would contain the ship simulation and the instructor facility software. From the instructor station, the instructor is able to control the instructor facility software for each student station.

The ship simulation software originally developed on the Shore Based Trainer is used for the MAST, and subsequently reused on the On Board Training System. The MMI emulation gives the student the same interface capabilities and options as on the real consoles and local operating panels (LOPs), including the operation and location of all instruments such as pushbuttons, indicator lights, meters and keyswitches (*Fig. 4*). The high-fidelity, graphical emulation of the MMI is produced using The Interactive Graphics Environment for Real-time Systems (TIGERS™), a CAE-integrated software environment for developing real-time, graphical, dynamic displays of consoles and panels. It is also used for the development of CAE ROSE™ objects and simulation schematics, including hydraulics, electrics and controls systems. As the simulation is executed, the instrumentation on the TIGERS™ schematics (MMI emulation) can be manipulated using a mouse and keyboard, and indicators such as lights and meters will respond dynamically in real time.

On Board Trainers

The On Board Training System (OBTS) is a trainer embedded in the actual IMCS that can act as an extension of the Shore Based Trainer, allowing for a comparable level of training while at sea. The core to the concept of the OBTS is the ability to convert the shipboard machinery control console (MCC) into a training console and run training scenarios while actual control of the machinery plant is maintained by the rest of the IMCS. Once this is accomplished, a trainee can practice IMCS drills and procedures at sea without interfering with ship operations.

The TRUMP On Board Training System has been functionally implemented as shown in *Figures 5* and *6*. A second computer processing unit (MDMC) was added to the machinery control console. This slave MDMC is responsible for maintaining a serial link to a host computer. It is also host to the gas turbine management processes for certain remote terminal units of the training session, and the digital propulsion controller. During this time, the machinery control console is not connected to the IMCS data bus, and can only communicate through a shared memory interface to the MMI MDMC (master MDMC) of the machinery control console.

The development of the On Board Training System has gone through an extensive evaluation process to ensure it is safe for use with the IMCS. To reflect the intended use of the OBTS in a shipboard environment, the following safeguard features have been incorporated:

(a) Only the machinery control console is able to operate in training mode.
(b) The machinery control console is prevented from changing to training mode if it is the station-in-control, or if the supervisory console is unavailable.
(c) When the machinery control console is in training mode, all operating IMCS MMI stations are notified by a system-wide message appearing on the operator status page. In addition, pages displayed at the machinery control console are visually distinguished to reflect IMCS status as “Training.”
(d) Control actions performed at the machinery control console while in training are sent only to the simulation computer and will not impede the ship’s systems or the rest of the IMCS.
(e) The machinery control console will automatically revert to normal operation within 15 seconds if the supervisory console becomes unavailable, if the serial link between the machinery control console and the simulation computer is lost, or upon request by the operator.

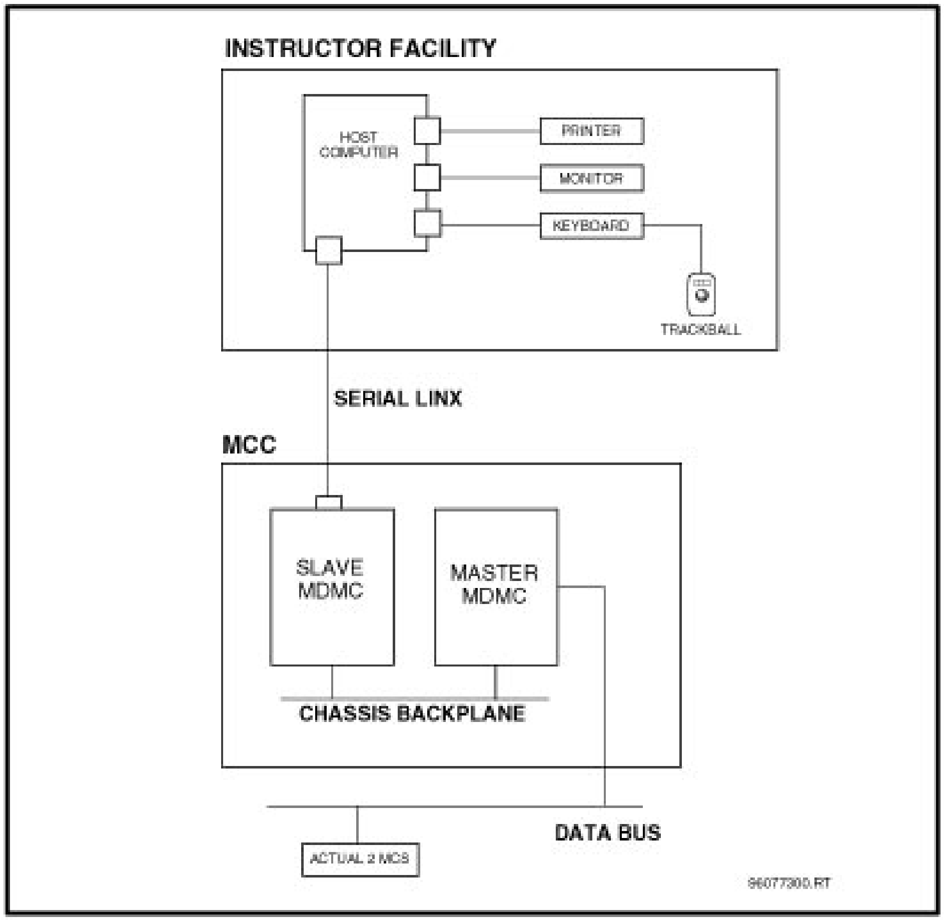

Fig. 6. TRUMP On Board Training System — Block Diagram

When the machinery control console converts to a training console, it disconnects itself from the rest of the IMCS to ensure that no information generated during training is seen by the rest of the IMCS. The last information transmitted by the machinery control console is a message indicating that it has entered a training session. The border of the machinery control console pages also changes from the standard green to an amber colour, and the time and date field reflect that the console is in training mode.

The On Board Training System also includes an instructor facility with the same capabilities as that of the Shore Based Trainer. The OBTS can be operated alone or with the assistance of an instructor. The instructor facility has been installed so as to occupy minimal space in the machinery control room. The host computer is in a separate room and the instructor facility becomes simply a monitor and trackball. The monitor hangs from the deckhead above the machinery control console and can be swivelled out of the students’ view or controlled by the students themselves. The trackball allows for table-free use of the instructor facility. The keyboard may be used, if preferred, but is not necessary for the normal operation of the instructor facility.

Summary

The capabilities of the described trainers may vary, but all serve as excellent devices and meet the specific need of IMCS training. Perhaps the greatest disadvantage to a full mission trainer is the device’s inability to handle the throughput requirement. Technically, the Shore Based Trainer is the most complete, but it is a “one-seat” trainer restricted to a specific type of training for a specific individual at any given time. Also, its cost is many times that of the Marine Systems Trainer (MAST) due to the extensive hardware requirement. On the other hand, the MAST is a multiseat trainer. The number of students that can be trained at a time is restricted solely by the number of student stations connected to the network server. Due to its limitation, however, of having only a single screen in which all system simulations and various control panel emulations can be displayed, the MAST does not provide realistic training in real time for emergency operation of the machinery plants, and the type of training that can be provided is limited to basic familiarization of the IMCS. The greatest advantage of this type of trainer is that it allows students to repeat each step at their own pace and as often as desired to learn about the control system and, subsequently, the ship's operation.

Finally, the On Board Training System can provide each ship with an environment to conduct on-the-job training at no risk to the actual plant at a fraction of the cost of the Shore Based Trainer. It offers a relatively inexpensive, but highly effective means of satisfying on-board training requirements with no disruption to ship's operations and without endangering the ship's equipment. It is very attractive in terms of reduced travel and living costs, training benefit and trainer availability.

Conclusion

The procurement of the Shore Based Trainer, Marine Systems Trainer and On Board Training System has enhanced the navy's capability in achieving its training objectives by providing students with hands-on experience using IMCS man-machine interfaces. The student is not inhibited by a fear of causing machinery or personnel damages. The device, therefore, provides an ideal learning environment for operators to familiarize themselves with the control system and the associated ship systems. Feedback from students at all levels has been positive.

The effectiveness of this learning environment depends on the degree of realism presented by the training equipment. One common feature of these trainers is the ability to accurately simulate all modes of operation in real time for various conditions by inputting the necessary pre-defined parameters. For this reason, the ship's staff and the technical authority have used these trainers for troubleshooting purposes which has helped them to better understand system responses under various conditions. With the introduction of the On Board Training System, on-board training is no longer restricted by the ship's operation schedule. On-board certificate trainees now have a better opportunity to conduct engineering emergency procedures and are able to finish their training within the prescribed time frame.

Students do hands-on operation of the IMCS in various modes ashore as well as at sea. In doing so, they become more familiar with the operation and performance of the equipment and therefore are better trained to fulfill their duties aboard ship in normal and emergency situations.

Over the years, the training philosophy in the Canadian navy has evolved with the acquisition of highly automated, computer-based systems. A combination of classroom lectures and hands-on training has proven to be an effective means of training personnel. Installation of IMCS aboard Canadian naval ships has shifted the emphasis to appropriate hands-on training. Without the appropriate training aids or training billets, the navy's current training requirements could not be effectively fulfilled.

Although the training philosophy in the navy has evolved to include the use of cost-effective, "high-tech" trainers in addition to the traditional hands-on training, these new tools are not meant to replace the actual hands-on training itself. Hands-on training remains an essential requirement for IMCS certificate training in the Canadian navy.

Acknowledgments

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Firm Requirements: The Number One Misconception about Software Development

Article by LCdr S.W. Yankowich

LCdr Tinney's article, "Surviving the Tar Pit: A Few Things to Consider when Acquiring Development Software," (*Maritime Engineering Journal, June 1997*) accurately identifies several fundamental aspects of the developmental software acquisition process. The author's inference, however, that software system requirements should be "locked in" prior to proceeding with development, is a matter of some controversy and as such, is worthy of further discussion. The purpose of this article is to clarify some persistent misconceptions associated with the software requirements specification process and to propose alternative proven approaches to software requirements specification.

The Elusive Firm Requirements Specification

Traditional thinking dictates that users must thoroughly and accurately define their requirements prior to the commencement of development and implementation work. This approach is based on the "waterfall" paradigm (*Fig. 1*), wherein requirements specification is a discrete step which is a necessary and sufficient precursor to the subsequent design and integration steps. It is demonstrably effective in both small and large-scale projects where a similar job has been done before and the requirements are already well understood vis-à-vis their technological implementation. In cases where the software system is first of its kind, and no previous project can be used as a basis for comparison, a thorough and accurate user-supplied requirements specification is extremely difficult to obtain. This is because requirements specification is tightly linked to the human perception of how the required tasks should be implemented. "First of kind" software requirements, by their very nature, cannot be firm because it is impossible to anticipate all the ways the tasks will change once they are automated.[1] Strict adherence to the "waterfall" process inevitably leads to the users being forced to firmly state their requirements before they can fully grasp the nature of the implementation. Since requirements changes must be frozen in order for a contract to be negotiated, errors in the initial specification usually result in delivery of a less than optimal product requiring extensive and expensive retrofits.

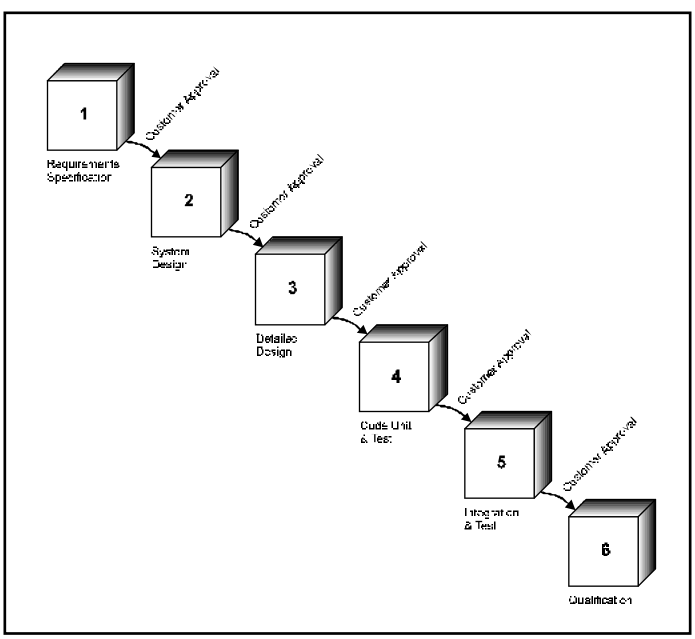

Figure 1. "Waterfall" Development Paradigm

Software requirements definition and validation is a learning process, and as such, should proceed in small incremental steps as part of the project definition or initial software development activity. There are no definitive guidelines for how to best achieve this objective. However, depending on factors such as system size, complexity, purpose and contractual obligations, an oft-used rule of thumb is that 20 percent of the total development effort should be applied to system requirements analysis.[2]

Spiral Development

One effective approach to the requirements specification conundrum is to abandon the "waterfall" paradigm in favor of the "spiral" paradigm (*Fig. 2*). In the "spiral" paradigm, the software development process begins with a minimal set of requirements that are well understood by both the developer and the user. From these requirements an application is designed, implemented, tested and used in trial form. Experience and lessons learned from this process are then applied as additional requirements are defined and implemented in the same manner. Thus, the final solution is gradually evolved in a way that is much more likely to meet the user's needs. Though effective, the spiral development paradigm does have its drawbacks. It is resource- and schedule-intensive, and does not readily facilitate accurate estimation of the total cost of the project prior to contract award (as is required for Treasury Board approval). Moreover, design decisions made early in the spiral development process may preclude the implementation of newly specified requirements in future iterations.

OOA, OOD and Prototyping

The need for an up-front, firm-fixed-price contract with well-defined deliverables, costs and schedule constraints renders the "spiral" paradigm impractical for most software development projects. However, its iterative model of define, design, code, integrate and test can be effectively applied to an expanded project definition or requirements specification phase. The established mechanism for accomplishing this task is prototyping (*Fig. 3*). The use of prototyping as a software requirements discovery technique is well established in industry. Paper documents representing requirements are static and passive, but a software prototype is a functional and dynamic visual model of the user's requirements. Applied as an

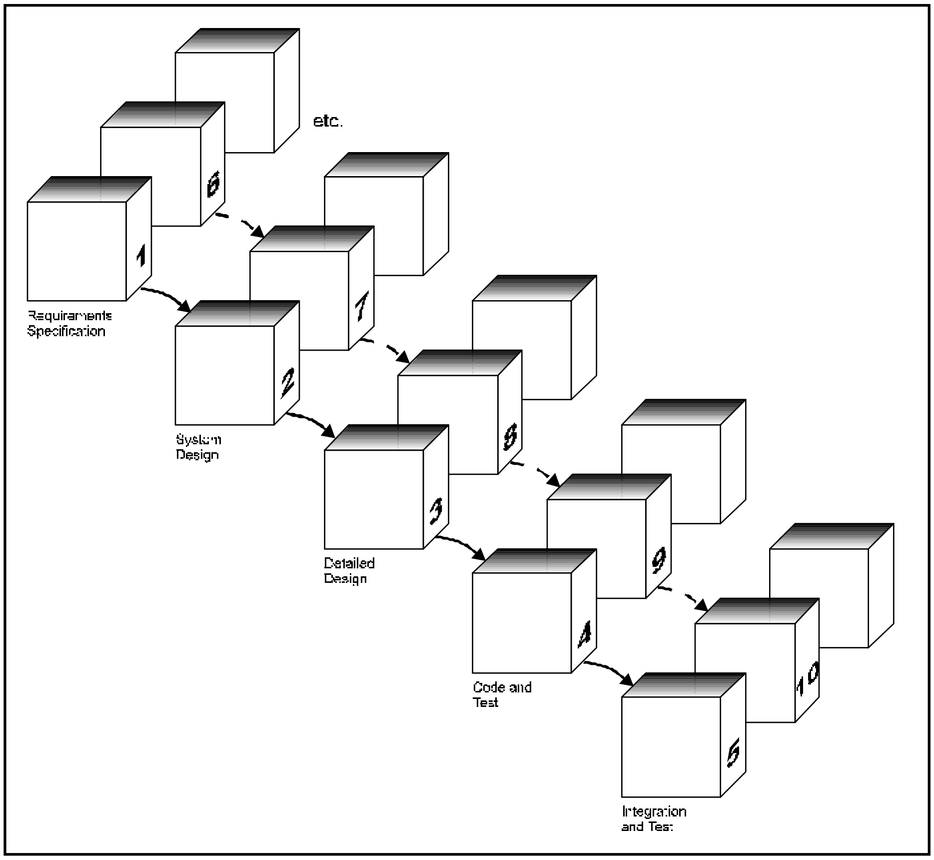

Figure 2. "Spiral" Development Paradigm

integral component of the requirements definition process, the prototype provides a basis for dialogue between developers and users that is far more effective than text alone. By applying a mini "spiral" development process as the model from which to implement successive prototypes during the project definition or requirements specification phase, a refined, accurate and comprehensive requirements specification, satisfactory to both user and developer, can be generated.

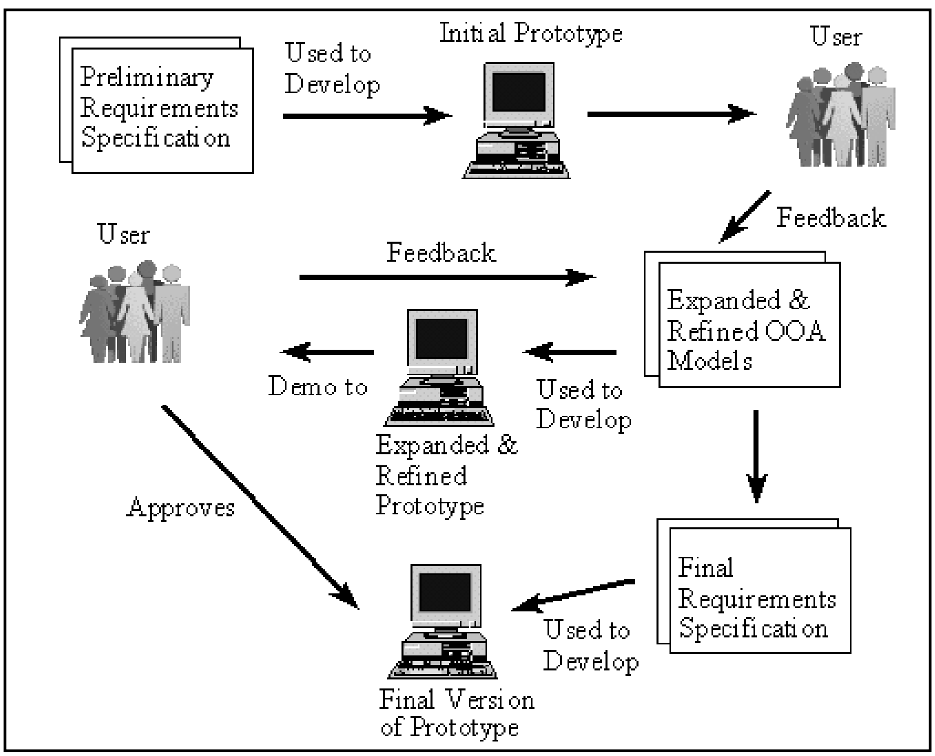

Figure 3. "Spiral" Development Process Applied to Prototyping

The traditional knocks against prototyping are its cost and the general belief that the prototypes themselves are "throwaway" (i.e., not suitable for integration into the final product) due to software rapid prototyping methodologies. While prototypes can be expensive, the gain in terms of a solid, workable requirements specification, is often well worth the up-front expense. Moreover, modern object oriented analysis (OOA) and development (OOD) techniques facilitate easy integration of legacy prototypes into a functional product (either as part of, or separate from, the end deliverable). The discussion of the merits and applications of OOA and OOD methodologies is beyond the scope of this paper. However, object-oriented-based prototypes have proven extremely cost-effective in the requirements specification, design, and implementation of the Operations Room Team Trainer (ORTT).

Conclusion

With software acquisition projects, the challenge is to balance detail and quality of the requirements specification with the business need for a firm contractual relationship. Since accurate and thorough requirements cannot be determined by the user alone (irrespective of the technological implementation), it is essential that a structured, dynamic dialogue between the user and developer be initiated as soon in the project development process as possible. Whether this requires the use of the evolutionary "spiral" development paradigm, or the application of OOA, OOD and prototyping, the resultant understanding will provide a solid foundation for the entire project.

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The Admiral's Question

Author unknown

*(*This article appeared in the Dec. 22, 1981 edition of the Maritime Command *Trident*, and is abridged and reprinted here with their kind permission.*)*

The admiral of a fleet of galleys manned by slaves reached for a sheet of papyrus one day and dashed off a note to one of his captains: "How fast can your ship go?"

Captains take seriously the questions of admirals, and this captain, a graduate of the Tyre Naval College and of the Byzantine Business School at Constantinople, prepared to give the admiral's question top priority. Being action oriented, he called in his systems engineers and hired outside consultants and gave them mission-oriented orders. Meanwhile, he conferred on a less scientific basis with some of his colleagues, for a number of tension-producing questions sprung to mind:

- Why is the admiral asking such questions?
- Does he doubt my ability to obtain optimum results from my ship?
- Is he considering the trade-off benefits of switching from galley to sail?
- If this happens, what is the future of galley captains, such as *me*?
- How can I influence any decision that may be made?
- Who are the real decision makers?
- Who do I know at CinCMed?
- Who was that guy in the Commander's office I bought Greek wine for last year?

While the captain wrestled with these questions, his engineers went to work. The first step was, of course, the definition of the problem. The galley, they say, was a homo-mechanical system comprising, basically, a number of homogenous subsystems which were also homo-mechanical. The man-machine mix had to be examined and quantified. Statistics on the average weight and age of the slaves were compiled and the importance of these factors was mathematically computed. Materials control specialists provided data on the length and weight (wet and dry) of the oars. The psychological effect of atmospheric conditions on the slaves was a variable to be taken into consideration. Sea conditions provided another variable. Acceleration measurement problems posed doubts about the prevailing state of the art.

Socio-economic and political considerations were not very relevant, but it was thought that this input (provided by consultants from Phoenicia University) might be useful in answering follow-up questions and, in any case, would demonstrate the thoroughness of the analysts.

The admiral, not receiving a quick answer to his question, repeated it, adding, "What the Hell is going on down there?"

This mild expression of irritation caused whiffs of panic to swirl through the galley. Tensions increased, tempers grew shorter, and there was much burning of midnight oil and flogging of slaves. The Greek slaves, toiling over their whirling abacuses, had a particularly hard time. However, within 62 hours, an interim report was ready for the captain's signature. It was long and included several appendices, but it gave a clear picture of the progress made on Phase 1, defined the area of inquiry, explained the difficulties being encountered, outlined the nature of future research, praised the self-dedication of those working on the task, and assured the admiral that all concerned were confident of the ultimate success of the project. One of the appendices detailed the costs incurred so far and gave refined estimates of future costs.

The admiral was taken aback when this report — 832 pages of legal-sized papyrus — arrived on his desk. The son of a fisherman, he had come up from the ranks and had not had the advantage of attending either Tyre or Constantinople. He had been out chasing pirates when it had been his turn to go to staff college, so he missed that too. The admiral looked at the captain's report and decided to turn it over to one of his brighter staff officers for evaluation. What he told the staff officer was, "Boil this crap down to two pages."

Within a week, the admiral was given a neat, two-page report, though there was a one-page appendix which the staff officer could not resist including, which contained a fascinating graph of his own construction that vividly illustrated the big picture of the entire project. The report told the admiral that the captain was certainly tackling the project energetically, that he had the correct approach, that all concerned organizational elements had been plugged in, and that all technical aspects had been considered. The staff officer added his personal conviction that the captain and his people would succeed. He also noted that there were a few errors in some of the original equations, but added that these had been corrected and that the appropriate people on the captain's staff had been notified.

In submitting his report, the staff officer told the admiral that he had put a thousand scribes to work producing the report and that copies had already been sent to the department heads and technical people. He asked the admiral what further distribution he would like to make.

The admiral, feeling the forces of higher education closing in on him, did not reply, but stared out the window at the sea. It had never seemed so far away. The staff officer, thinking that his chief wanted to consider his options, quietly left. The admiral continued to stare out the window, then he arrived at a decision (on his own and by a process involving some emotional factors and irrational thinking). He went fishing.

By the time the second interim report, elegantly bound, was submitted, the admiral had been replaced by a younger naval officer who had immediately made a clean sweep of the old admiral's programs and the entire project was scrapped.

Attitudes toward the Environment

Article by LCdr Mark Tinney

Sean Gill of GEO-Centers of Pittsburgh, PA briefs Protecteur's maintainers (E Techs and Mar Eng Techs) on maintenance aspects of the ship's new plastic waste processing equipment. *(Photo courtesy of Sean Gill)*

I recently had the good fortune to be assigned as project manager for the Maritime Environmental Protection Project (MEPP). One of the tasks that goes along with the job is to provide updates on the MEPP for the Greenspace section of the *Journal*. So, for my inaugural article in this space I would like to move the discussion away from all the tangible goodies such as equipment, publications, and drawings, and discuss one of the intangible aspects of the project. Attitudes! Specifically, I want to discuss the attitude of the people who will be expected to operate and maintain the equipment so that our ships can meet national and international environmental regulations — the ships' crews.

Individual attitudes toward the environment can't be dictated, but they certainly can be influenced. On board ship this influence starts with the commanding officer and the senior heads of department. If they set the tone for the ship with a positive attitude, and implement a waste management regime which is easy to follow, the ship's company will adopt the new way of doing business with a positive outlook. The MEPP is not just a matter of installing new equipment so that we can pulp and compact our waste. It is also about finding ways to reduce, reuse and recycle the waste that we generate.

A perfect example of this in action can be found in SLt Charles Brown's article, "Waste Not," in the January 1991 issue of the *Maritime Engineering Journal.* The article describes how Capt(N) James Steele of HMCS *Protecteur* had a remarkable influence in shaping his crew's attitude toward the environment. Capt(N) Steele set the tone for the entire ship by personally getting involved and challenging his crew to find new ways to reduce and recycle. Actually, what seems to be clear from reading the article is that many members of the crew already harboured concerns about dumping trash in the ocean. They just needed someone to chart the way for them to do something about it. Since then, the ship has adopted a commendable waste management organization (as witnessed during a recent visit to the ship by MEPP staff).

The same sort of attitude was found on board HMCS *Montreal* when MEPP staff visited to tell them we would be installing their solid waste handling suite during their docking work period. It must be appreciated that what we are doing via the MEPP is installing additional equipment on our ships, and this equipment is going to translate into more O&M for ships' companies that are already overburdened. Telling crews that you are giving them *more* work isn't exactly a morale booster, so it is especially encouraging to see that they are very receptive to the task of doing something positive to prevent waste from being dumped into the sea.

Overall I feel very confident that the Maritime Environmental Protection Project is going to be a tremendous success story both for the navy and the environment. Not just because we are giving people the tools to do the job, but because their positive attitude is making the task at hand as effective as it can possibly be.

Discovery Harbour: Penetanguishene's Naval Connection

Article and photos by Mike Belcher

When you think of historic naval bases in Canada, Penetanguishene, Ontario doesn't usually come to mind. However, a family holiday this summer in the Midland area 150 km north of Toronto met up with a surprising bit of naval history when we visited Discovery Harbour on the shores of Georgian Bay.

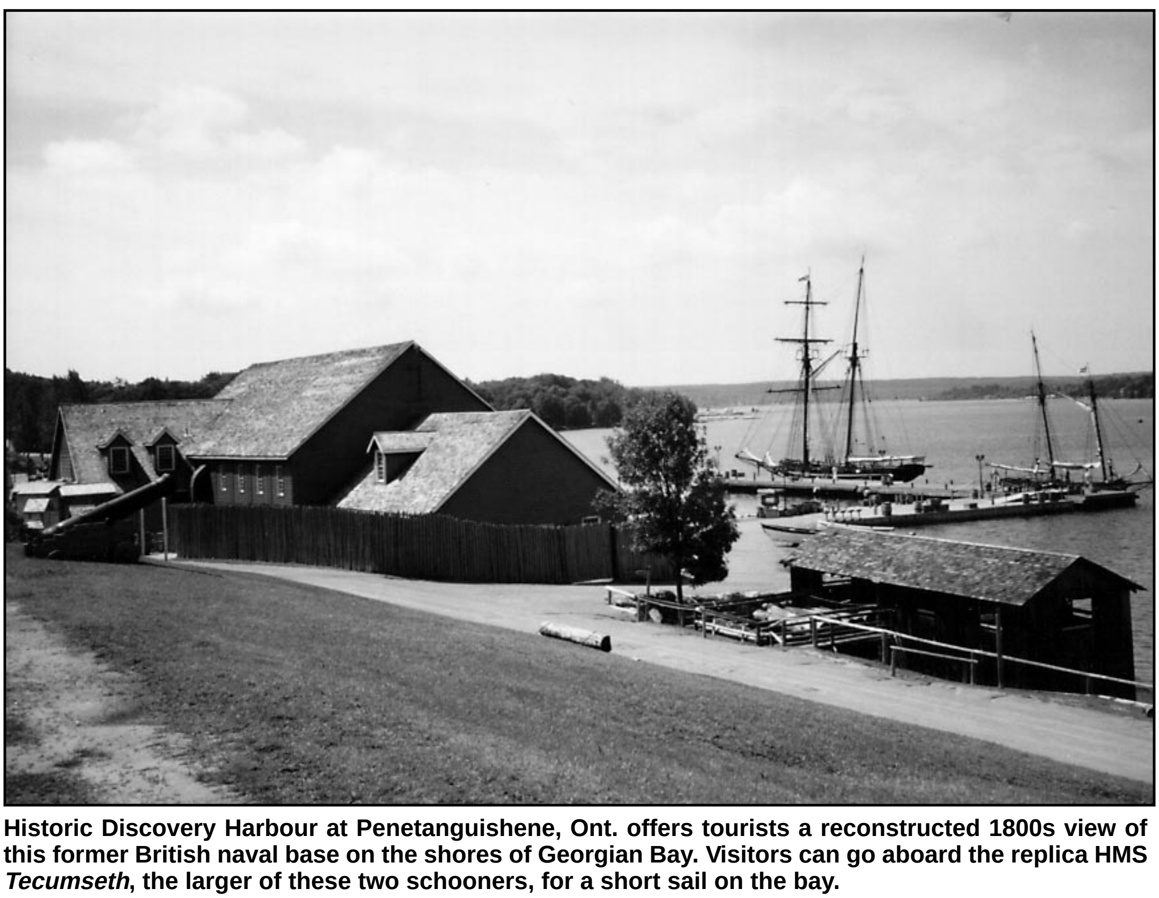
His Majesty's Naval Establishment at Penetanguishene was established in 1817 as a naval dockyard and base for British navy warships charged with protecting the upper Great Lakes. With the War of 1812 still in recent memory, the location offered a deep, sheltered harbour with access to Georgian Bay and a rough road to York (now Toronto). Two warships, HMS *Tecumseth* and HMS *Newash*, were moored there "in ordinary" (masts, sails, rigging and armament removed and stored) in case they should ever be required. Numerous other small craft were based there for supply duties. The base also served as the winter home of Lt. Bayfield, a naval hydrographer who surveyed and mapped much of the upper lakes.

As it turned out, the warships were never required. They eventually broke up and sank at their moorings as the need for the dockyard diminished. By 1857 the base was no longer active and the land was used for a military prison and later, a psychiatric hospital. Today, the hospital and a maximum security prison occupy the site.

Discovery Harbour is a recreation of the site as it was in the early 1800s. In addition to the visitor's centre and Kings Wharf Theatre, a number of heritage buildings have been reconstructed. Tours of the site with guides in period costume provide a flavour of the harsh conditions on the base at the time. The life of a sailor posted to Penetanguishene was no sea story. Men spent the winter cutting wood in the bush and the rest of the year constructing the buildings at the site and maintaining the ships in storage.

The highlight of our visit to Discovery Harbour was the opportunity to take a sail in one of the two schooners based there, both modern reconstructions. HMS *Bee* is a small cargo schooner, while HMS *Tecumseth*, built in 1995, represents one of the base's original warships. The reconstructed *Tecumseth* is a "reverse iron-clad" (steel construction with wood sheathing to represent the original hull), and boasts a few features not seen on period ships, including diesel auxiliary propulsion and a bow-thruster! Modern trimmings notwithstanding, tourists sign on as temporary crew and get to handle the ropes as the ship heads out for a short sail on Georgian Bay. Under the direction of a small crew of experienced officers and seamen (some of them navy retirees), our pressed crew of landlubbers got a chance to experience life under sail, if only for a short time.

Mike Belcher is a survivability analyst in DMSS.



Historic Discovery Harbour at Penetanguishene, Ont. offers tourists a reconstructed 1800s view of this former British naval base on the shores of Georgian Bay. Visitors can go aboard the replica HMS *Tecumseth*, the larger of these two schooners, for a short sail on the bay.

Book Review

Operation Friction — The Canadian Forces in the Persian Gulf, 1990-1991

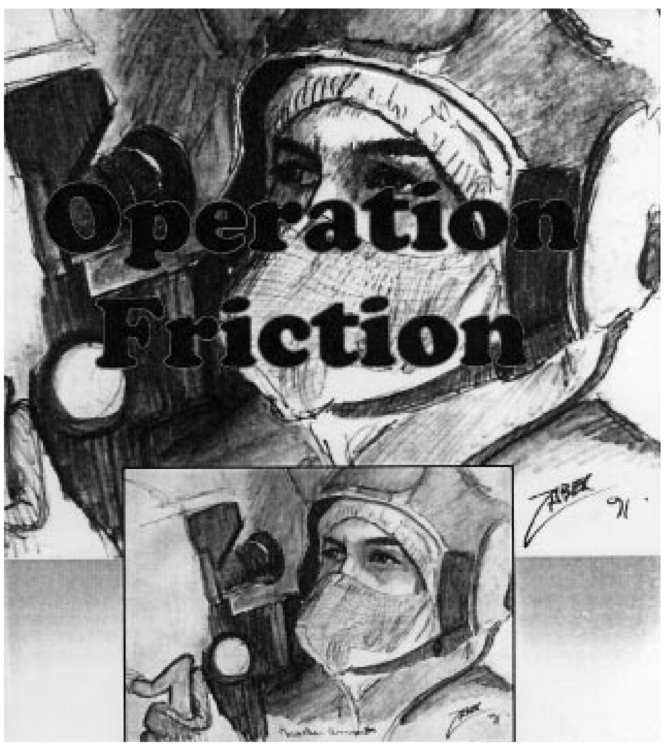
Reviewed by LCdr Doug Burrell

"Operation Friction — The Canadian Forces in the Persian Gulf – 1990-1991"
Maj Jean H. Morin and
LCdr Richard H. Gimblett
A co-production of the Dept. of National Defence and University of Toronto Press
280 pages, 30 illustrations
$36.99 (cloth) 1-55002-256-3
$19.99 (paper) 1-55002-257-1

It was a summer of discontent. In late June, the Meech Lake Accord floundered and left the nation divided, its fate uncertain. The Oka crisis exploded on the national scene in mid-July. And then a war broke out. This book tells the story of how Canada participated in that war.

Written by two historians, Maj Jean Morin and LCdr Richard Gimblett, "OPERATION FRICTION, 1990 - 1991" is the official history of Canada's role in the Gulf War. It chronicles the events leading up to the outbreak of the Gulf War and the decisions taken at the highest political and military levels that determined Canada's involvement in that war. Starting with the early political decision to support the United Nations Resolution 660, the authors trace the preparation of the ships and helicopters of Task Group 302.3 in Halifax and its deployment to the Arabian Gulf. The book also details the considerable effort to develop the logistics support and command infrastructure that was essential to maintaining the task group in the Gulf.

The activities of the task group and the development of its role in the multinational intercept force up to November 1990 are discussed in considerable detail. The authors then repeat essentially the same pattern in discussing the preparation, deployment and activities of the Canadian Air Task Group. Finally, there is some discussion of the creation of the Canadian Forces Middle East Headquarters (CANFORME) in Manamah. As events rushed toward armed conflict, the naval and air task forces roles began to be redefined. The authors describe in detail how the transition came about and the response of Canada to the men and women in the Gulf. Finally, the war itself and Canada's performance in it are described and analyzed. Of considerable interest was the final section of the book, detailing the Canadian medical effort and other ancillary operations.



The book is more than a simple chronology of Canada's role in the Gulf War. It also describes the interaction between the allied forces and its impact on the employment of both task groups and the field hospital. This is the strength of the book — its ability to convey to the reader an understanding of all the background interactions and their effects on the decisions made with regard to our involvement in the war.

The book is not is a definitive work of Canada and the Gulf War. Frequently, the authors start what could be an interesting bit of anecdotal material or analysis only to stop short of fully developing it. From time to time, this caused moments of frustration and imparted a certain dryness to the narrative. There were also several instances when their conclusions and/or comments were debatable.

Would I recommend this book? Most emphatically! It is a concise and highly readable account of events and actions at the national and command levels. My only regret is that the book is too concise. At twice the length it would have been a superb work of military history.

LCdr Burrell saw Gulf service as the Combat Systems Engineering Officer in HMCS Athabaskan. *He is currently on posting to Colorado Springs, Colorado.*

Orders for "*Operation Friction — The Canadian Forces in the Persian Gulf, 1990-1991*" can be placed by contacting: University of Toronto Press, 5201 Dufferin St., North York, Ontario, M3H 5T8, Tel. (416) 667-7791, Fax (416) 667-7832.

DGMEPM News Roundup

The following are updates concerning a number of noteworthy news items from the desk of Commdore Wayne Gibson, Director General Maritime Equipment Program Management (DGMEPM):

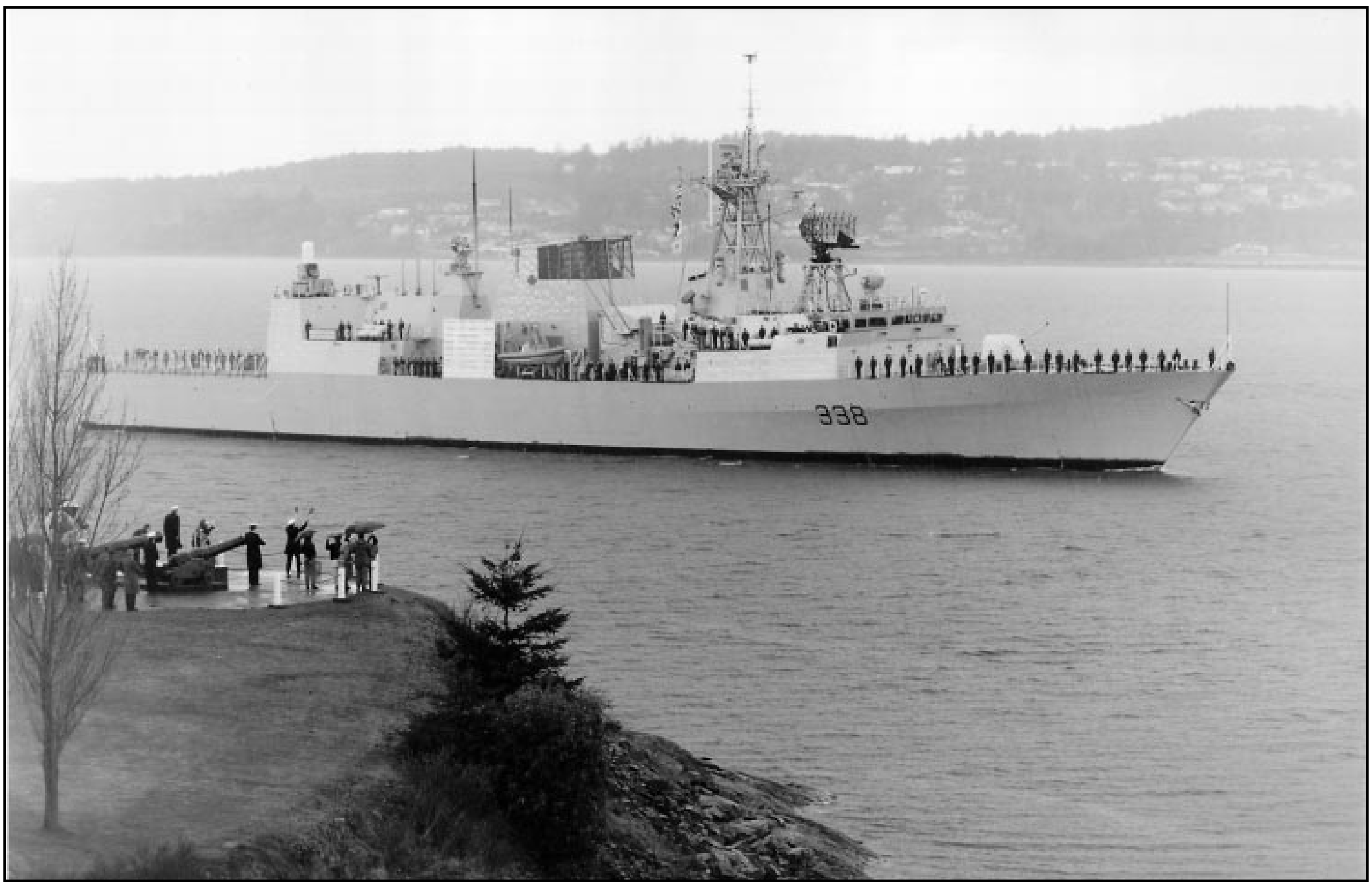
CPF

A major milestone in the Canadian Patrol Frigate (CPF) Project was completed when HMCS *Ottawa*, the twelfth and last CPF, was transferred to operational status on the West Coast on July 11. The project management office (PMO) is now nearing the completion of its mandate, and establishment is being reduced accordingly. CPF detachments at Halifax, NS and Esquimalt, BC were stood down in August.

One area of continuing work is in support of CPF training. The Maintenance Procedures Trainer (MPT) is a multimedia system, developed by PMO CPF and produced under contract by Lockheed-Martin Canada using COTS hardware and software. It provides CPF combat system functionality at each student workstation, thus reducing the requirement to work on the real equipment. The MPT is now being used in the Canadian navy, and its success has been noticed south of the border. The USN has recently contracted Lockheed-Martin Canada to provide a simulation for USG-2 maintenance and operations training based on the Canadian MPT (USG-2 is an add-on to AEGIS, and is part of the system that provides an enhanced network for co-operative engagement capability).

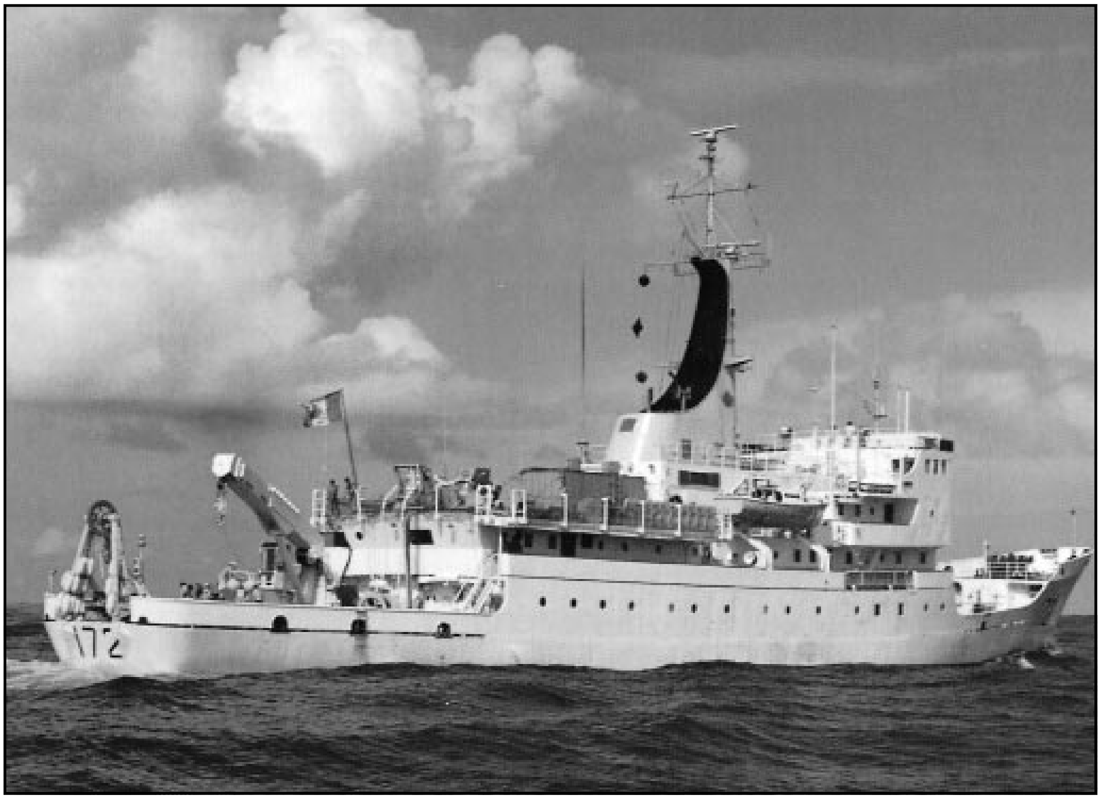
MCDV

The Maritime Coastal Defence Vessel (MCDV) Project is progressing well, with six of 12 vessels now delivered to the navy. Four more are in various stages of construction or trials. HMCS *Whitehorse* (MCDV 06) departed Halifax on Aug. 25 en route to her home port of Esquimalt. HMCS *Goose Bay* (MCDV 08) was named and launched by her sponsor, Mrs. Doris Saunders, on Sept. 4. On the following day, Captain(N) D.S. Mackay (MARLANT N3) laid the keel of the tenth MCDV, the future HMCS *Saskatoon*.



HMCS Winnipeg: CPF Project nearing completion *(CF Photo)*

News Briefs



CFAV *Quest (CF Photo)*

Quest

Since June 1997, Marystown Shipyard of the Burin Peninsula in Newfoundland has been progressing the implementation phase of the mid-life refit of the Canadian Forces oceanographic research vessel CFAV *Quest*. The ship was built at Burrard Dry Dock in Vancouver, and entered service in 1969. *Quest* has had most compartments stripped, and the majority of hazardous material has been removed. The main engines and generators have been landed, as has the large quarterdeck crane and traction winch system. *Quest* is now docked on the Marystown synchrolift. The refit project remains scheduled to complete in August 1998.

CFMETR

The Province of British Columbia has informed the Minister of National Defence that it intends to cancel the licence of occupation for use of the seabed at the Canadian Forces Maritime Experimental and Test Range (CFMETR) at Nanoose. The province has provided the Government of Canada the required 90-day notice under the terms of the licence, and on Aug. 21 informed Ottawa that it is trespassing on provincial land but does not intend to “evict the Federal Government at the present time.” In response to this action, the Department of Justice has filed a claim in BC Supreme Court disputing the validity of the cancellation. The basis of the federal government position is that the reasons forwarded by the province for cancellation are outside the terms of the licence. The federal government has stated that it will take whatever measures are necessary to sustain normal operations at the range. As such, operations at CFMETR are continuing as scheduled.

MARI-TECH ’98

MARI-TECH ’98 and the Annual General Meeting and Technical Conference of the Canadian Institute of Marine Engineering (CIMarE) will be held in Ottawa, June 17-19, 1998. The theme of the conference is “Partnership in Support of the Fleet,” and will be addressed in the context of the Canadian political scene, government policy and the marine industry.

The venue for the 1998 conference will be the Citadel Inn, in the heart of the nation’s capital. Registration will take place the evening of Wed., June 17. The AGM will be held on June 18, with technical papers being presented June 18 and 19.

Conference information is available from Gerry Lanigan at MSEI Services, 201-1150 Morrison Drive, Ottawa, Ontario K2H, 8S9; Tel. (613) 828-1319, fax (613) 828-7907, e-mail services@milsystems.com