National Defence Défense nationale

# Maritime Engineering Journal

June 1995

## CPF Construction — Experience Gained

## Also:

- *Readership Survey Results*
- *Incident at Sea: $O_2$ Explosion in* Cormorant

Canada


**Looking back**
**at HMCS *Fraser* …**
**… see page 24**

# Maritime Engineering Journal

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**OUR COVER**

CPF construction at Saint John Shipbuilding Limited: (*clockwise from left*) accuracy control personnel at work in the dock during erection of a bow-section megamodule; a crane manoeuvres a unit outside SJSL's enormous Module Hall; HMCS *Halifax* under construction. (*Photos courtesy of Saint John Shipbuilding Limited*)

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# Guest Editorial

## MAREs — Systems Engineers Bridging the Gap

*By Capt(N) J.R.Y. De Blois,*
*Director of Maritime Combat Systems*

In these times of downsizing and privatization it is germane to ask ourselves exactly what it is that MAREs provide to the navy — what is our "value added." Engineering services can be purchased, after all, so why maintain a naval engineering MOC? Clearly our worth must go beyond our engineering qualifications and parade-square skills.

Our value added is based on the combination of our particularized technical knowledge, our knowledge of the shipboard environment and our knowledge of the departmental material support system. Any single factor is hardly sufficient reason to justify a MARE classification. What is intrinsically valuable is the MARE's ability to bridge the gap between operations, technology and process. But how much of each element is required?

As far as operational exposure is concerned it is tempting to say there can never be enough. Without the operational end of the business there would be no need for any of us. At the other extreme, if a MARE were to spend an entire career at sea (presumably becoming very good at the job) the operational experience would never be applied to all those other jobs MAREs do, nor could other MAREs gain this experience. The correct answer is largely academic. Given the few platforms available for MSEs and CSEs, it is doubtful we will ever oversubscribe to this element.

And what about technical knowledge? How much and what kind? In one sense we need just enough to cost-effectively bridge the gap between the operational requirement and the suppliers of services. If the navy operated a fleet of automobiles instead of warships there would be no gap. There is a self-sustaining marketplace for cars, which drives performance up and prices down, offering some protection to the customer. For warships and associated systems this is not the case. The navy must therefore retain an indigenous capability to be a smart buyer, a smart user and a smart maintainer.

***"If you are thinking about becoming a specialist I would recommend you make a career change and make room for a real MARE."***

The MARE, then, must be first and foremost a systems engineer capable of drawing logically upon the specialized skill sets that are available. In this climate of downsizing we cannot afford to have specialists in uniform, people who expect to spend a career working exclusively in software or lubricants. Not that these skill sets are not required, but they are generally best provided by public servants or contractors. If you are thinking about becoming a specialist I would recommend you make a career change and make room for a *real* MARE. MAREs require the system-level breadth and the technical depth to gain access to the specialized services available to them. They need not know it all, nor do it all when cost-effective alternatives are available, but they must be smart buyers of these services.

And finally, how much experience does a MARE need with departmental materiel support? If you include industry and consider the whole as a system, once again the MARE's role is that of a systems engineer. Our value to the navy lies in our ability to understand how and why a system works so we can exercise it to the navy's best interest. As MAREs, therefore, we must gain experience and knowledge in all facets of materiel support. Imagine how dangerous it would be if the CSE of a ship were to become knowledgable about radars only, then make decisions based on radar considerations alone without considering the impact on the entire combat system. It would be equally disastrous for organizational elements of the material support system to become totally self-focused and ignore system impacts as they exercise their assigned roles. What's good for the radar may sink the ship; what's good for one unit may be bad for the navy. Junior MAREs are thus expected to provide systems expertise from a technical perspective, while senior MAREs are further expected to provide systems expertise from an organizational perspective. Such diversity of employment within the materiel support system is a major element of the MARE's value added.

Operations, technology, materiel support — these are just elements of a part of the system we call the navy, but it is our role to know how they fit together. The one-dimensional MARE has no more place at the materiel organization level than at the technical level. MAREs should guard against becoming organizational equivalents to the grommet expert, because when all is said and done the essence of the value we provide to the navy comes from our ability to make things work together.

# Commodore's Corner
## Cue cards for the future

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

In the last *Journal* I wrote about the changes that we were facing and our part in these changes. Since then, NDHQ has commenced full implementation of Operation Excelerate and MARCOM has begun its implementation of the Naval Engineering Maintenance Functional Review (NEMFR). Organizations are changing, processes are changing — nothing seems to be the same and it is all very confusing. Is there a master plan? Does anyone really know what is going on? Let me offer you the keys to what is happening — the common threads throughout all of these changes.

First and most importantly, there is the need to put in place the wherewithal to make the cost of what we do visible. Measure the benefit of something against its cost and you will get a pretty good idea of where it fits into your program. It doesn't matter if we are the information gatherer or the decision-maker, none of us can afford to operate in today's navy without this vital information.

Second, we need to put our support on a more businesslike basis to ensure that it is being offered in the most cost-efficient manner. Naturally, this assessment will only be possible if we understand what "effective" means and have the means of measuring its cost.

Third, we have to determine how much risk we are prepared to take in providing our support. Risk is a very important dimension of what we do — targeting zero risk drives up costs; too much risk is unacceptable. How many times do we have to review something before we sign it off? The right balance must be determined in every case.

Cost visibility, businesslike work practices, risk management — these are our cue cards to what is going on. Our job always has been and always will be to deal with change. (You see? Some things never change.) The challenge is to live within the constraints and use them to our advantage.

Our opportunity lies in making the change meet its objectives. That means picking up on how it relates to what is happening around us and running with it. We have to fully embrace this opportunity to shape our own future, because if we don't, Op Excelerate and NEMFR will go down in history as nothing more than personnel-reduction exercises and the navy will not be getting the support that it needs or that it could have.

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### Maritime Engineering Journal Objectives

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

### Writer's Guide

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

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

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

# Combat System Damage Control

*Article by* LCdr Bruce Grychowski

The Combat System Engineering department's Emergency Response Team has been in place for some time. It has a mandate to effect the repair of the combat system during all emergency and action station situations. It says so in the NEM Vol. 2, in the Damage Control Manual and in SSOs. Unfortunately, there is neither direction nor training provided on the conduct of this activity. Sea Training has conducted extensive exercises with the ERT in all classes of ship and there is a noticeable difference between repairing equipment in non-emergency situations and in emergency/action situations. The difference, which is time, drives the methods, considerations and information exchange.

When one thinks of the term damage control, a picture comes to mind of "engineers" battling fires and floods in darkness through clouds of smoke. Their speech is garbled by their Chemox masks as they drag charged hoses to the scene of the fire or work fiendishly in waist-deep water (always cold). Their motto is *Float, move, fight*. This is a valid portrayal of damage control, but not the only one. *Move* and *fight* are interchangeable, dependant upon one's point of view and the mission of the ship. Clearly, if you are not floating you are in a world of hurt. If you can move but cannot fight, you had best move quickly.

Combat systems damage control is the act of returning a maximum of capability, in a short time, after suffering equipment loss while the ship is at risk. This does not imply full repair of damaged equipment. The cause of the equipment loss can be directly from battle damage, fire or flood, shock, loss of services or from equipment failure. Whatever the cause, the damage must be identified, assessed, isolated, circumvented and, finally, repaired. The whole concept is predicated upon knowing the ship, the systems and the situation in detail. If this is not done effectively, the fighting capability of the ship will be affected and the ship will lie open to more damage.

Loss of air pressure, cooling water or cooling air can remove equipment from service. Interruption of power can not only take out high-value systems or equipment, but even after power is restored software must be reloaded and starting-time delays must be waited out. Fire, flood and physical stress will create numerous types of failure including cable/connector damage, electrical short-circuiting, thermal shutdown and physical damage. Effective plans, procedures and training are required to counter each situation and return as much capability as possible. In the short duration of modern attacks there may not be time to complete normal corrective maintenance, but there will be time to work around the problem and this is combat system damage control.

How do you train for CS damage control? What tools and equipment are required? Where is the guiding documentation and who is in charge? To my mind, the documentation should be contained within the NEM Vol. 2 and the Damage Control Manual. The controlling authority must be in a senior headquarters and be an active member of the Damage Control Advisory Committee (DCAC) and its working group (DCACWG). There should be a subcommittee to review CS damage control concerns, while keeping strong ties to the DCAC. Tools and equipment must be derived from detailed analysis of damage scenarios. Communications, ERT positioning, state boards, information storage/retrieval and manning must also be derived from scenario analysis. Training must become an integral part of career coursing for CSE officers, chiefs and PO1s, with occasional specific refresher training for all CSE department personnel.

Combat system damage control requires specific guidance to become a professionally competent activity. To date it has been purely up to individual ships' Combat Systems Engineering departments to come up with ad hoc systems and equipment to do the job. The results have been varying. As there is no standard, the utility of the ERT in its CS damage control role has met with some skepticism from commanding officers and Combat departments. Sea Training has effected minor advances which have improved effectiveness and established more of a team approach, but the advantages are lost with every major personnel change. It is therefore time to do something about the situation formally.

I am writing this article to identify a problem, not to offend any person or organization; the topic needs exposure. The CSE departments in ships are doing a fine job in isolation, but they need some assistance, training and tools to do their brand of damage control effectively and professionally. Functional warships are our reason for being and it seems that we, collectively, outside of ships, have not paid sufficient attention to an important part of the aim.

*LCdr Grychowski is the Sea Training Atlantic CSEO.*

# Canadian Patrol Frigate Construction — *Experience Gained**

*Article by* Capt(N) B. Blattmann *and* Cdr H.V. Archibald

*Photographs appear courtesy of* Saint John Shipbuilding Limited

(*Condensed from the authors' paper presented to the 1994 East and West Coast MARE Seminars.)

Saint John Shipbuilding Limited (SJSL) built the first Canadian patrol frigate (CPF), HMCS *Halifax*, in five and a half years. By comparison, the fifth frigate built by SJSL, HMCS *Fredericton*, took only three and a half years, with an incredible 45-percent reduction in construction manhours. SJSL predicts that the last CPF, HMCS *Ottawa*, will be built in just three years with fewer than 50 percent of the manhours used to build *Halifax*. As a result of this performance, SJSL will bring the CPF project to completion within budget and schedule.

This is a tremendous achievement for Canada's largest-ever government project, especially considering it takes nearly the same number of manhours to refit five steamers as it takes to build one patrol frigate. This article aims to demonstrate how advanced ship-construction techniques have been used to recoup initial overruns and make the Canadian Patrol Frigate project a success story. It will also draw some lessons from the experience which we in the naval engineering community can use to our benefit in future projects.

### SJSL Construction Experience: The Approach

In the traditional approach to ship design and construction, the various systems such as propulsion, ventilation, piping, electrical, etc., are designed and drawn separately. Production work packages are system oriented and the shipyard work-force is similarly split into speciality shops, with the majority of outfitting done after the ship's hull is erected.

In 1984, during the early stages of the CPF detailed design development, SJSL (with support from DND) revised this traditional approach by incorporating advanced ship-production techniques. Taking advantage of a broad application of pre-outfitting techniques, SJSL would employ a *product*-oriented approach (rather than a system approach) commonly referred to as "product by stage of construction," or P/SC.

In P/SC the ship is constructed as a series of building blocks. The ship design is divided into parts and subassemblies, or "interim products," which are then grouped according to their production requirements. Product similarity allows statistical analysis to be used to continuously improve product accuracy and the overall quality of the ship. The shipyard is organized into work centres or stages that cater to this process. The interim products are eventually merged to form larger assemblies and so on in a production-line process. The overall goal is to attain the least cost and the shortest possible construction period through optimization of the process of fabrication, assembly and erection of the interim products.

Maximizing the amount of outfitting done prior to the ship being erected is especially important in countries such as Canada where the weather is not always conducive to outdoor work. As a rule of thumb, if doing a job at the optimum time in the shop takes one hour, it will take three hours to do the same job at a non-optimum time, five hours in the graving dock and seven hours at the outfitting pier.

Still, it requires a major redirection of company resources to implement these techniques and accommodate the restructured build sequence from which these efficiencies are drawn. Such change places extensive demands on the engineering, planning and procurement functions since it requires their products earlier in the construction sequence. In effect, a new approach to design and construction must be implemented to transform the traditional system design into the products for a P/SC approach (*Fig. 1*).

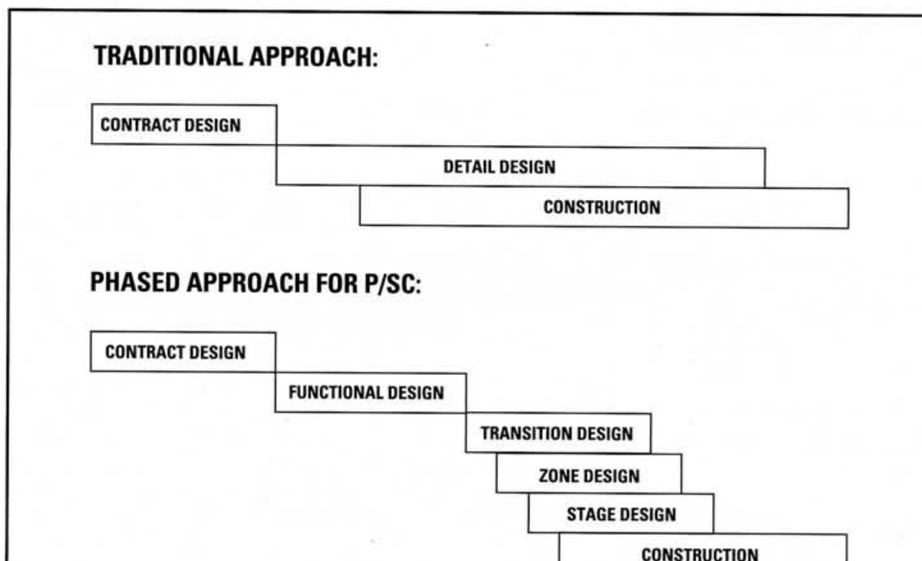


**Fig. 1. Ship Design Stages**

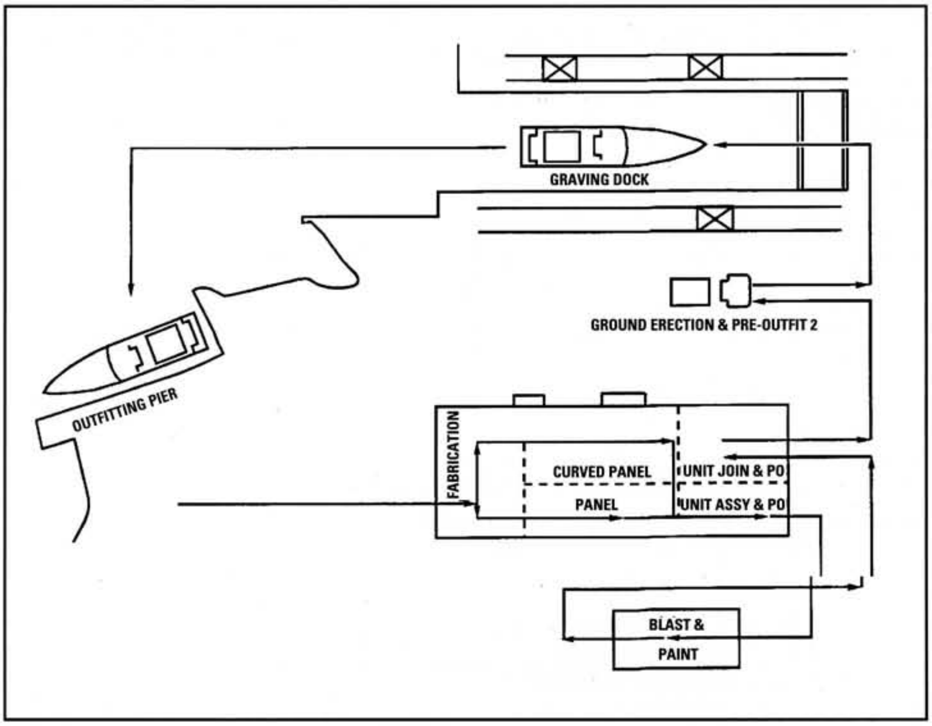


**Fig. 2. SJSL Facility Layout**

Designing a Canadian warship from scratch was not easy. Not only were the specification requirements stringent, but more than 20 years had passed since a major warship was last designed and built in this country. Not surprisingly, substantial delays were soon encountered in completing the various design phases (including final production drawings), especially once the decision was made to change to a P/SC approach midway through the design process. The delivery dates also suffered as construction of the first CPFs proceeded while the detailed design was still being finalized. To illustrate how SJSL was able to turn an initial, adverse situation around and make the CPF project a success, it is instructive to review the succession of construction techniques used during the project.

### *HMCS Halifax (Baseline)*

On June 8, 1986 when the first steel was being cut for HMCS *Halifax*, the SJSL facilities included the longest drydock in Eastern Canada (*Fig. 2*). The three cranes that serviced the dock were capable of lifting about 200 tonnes onto the building blocks. The major steelwork, assembly and pre-outfit activities were carried out in the steelwork assembly building, a 285-metre-long structure which had been recently upgraded with the installation of a plasma cutter, two MK automatic dual-head stiffener welders and better cranage. The pipe shop, one of several shops to be moved to new facilities on the other side of the dock, was upgraded with automated pipe-bending machines.

SJSL applied the P/SC principles in the construction of *Halifax* by dividing the ship into four zones — bow, machinery spaces, stern and superstructure — and determining the best point at which to do the work in each zone. The work itself was broken into eight stages corresponding to the work centres in the yard. The ship was then subdivided into groups of similar parts, or interim products, which could be manufactured and installed in batches at the most logical time and stage (*Fig. 3*).

*Halifax* was constructed of 57 assembly units, each typically one deck high with at least one major transverse bulkhead. The assembly units were joined into two, three and four deck levels to form 26 partially outfitted erection units (*Figs. 4 and 5*) which were erected in the graving dock to form the ship. Once erected, the ship was floated-up and shifted forward in the dock for final outfitting and to allow the next ship to start erection.

The construction phase (from start of fabrication until float-up) was originally scheduled to last 19 months. With *Halifax*, however, this phase lasted 23 months, the four-month slippage occurring during unit erection. Similarly, the overboard phase from float-up to delivery dragged on to 37 months from the scheduled 20 months, extending the scheduled three-and-a-half-year march to provisional acceptance to more than five years. The overriding difficulty, in our opinion, was that the developing design was not keeping pace with the overall schedule, resulting in a lower level of pre-outfitting, interference problems and problems with accessibility and maintenance. It all made for a significant amount of rework, such as when SJSL had to refigure cable transits that were already full because cables had been installed before the cable-run drawings were complete.

### *HMCS Vancouver*

The first steel for the second frigate, HMCS *Vancouver*, was actually cut two months ahead of schedule, close on the heels of that for *Halifax*, on Dec. 6, 1986. SJSL had learned from its

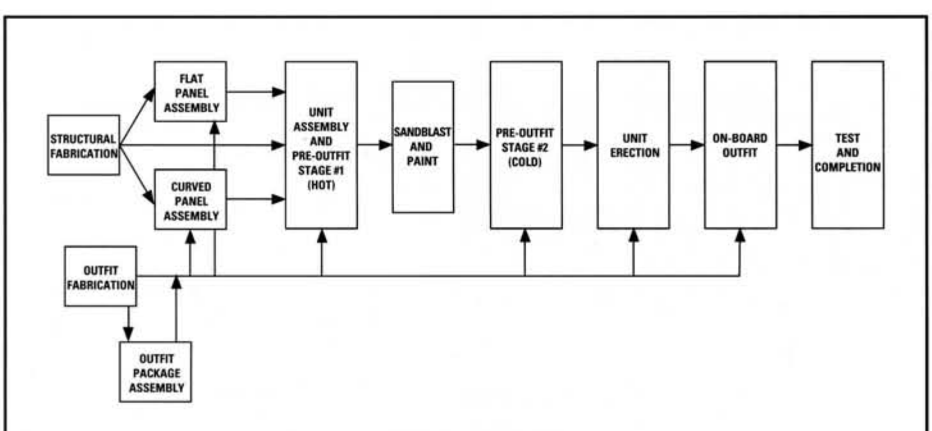


**Fig. 3. SJSL Production Flow**

experience with *Halifax* and wanted to extend the fabrication time to achieve a higher level of pre-outfitting. Unfortunately, because of the narrow separation between the two ships, *Vancouver* suffered from many of the same problems experienced by the lead ship. As problems were found in *Halifax*, so attempts were made to correct them in *Vancouver*, causing it to be delayed by six months in fabrication.

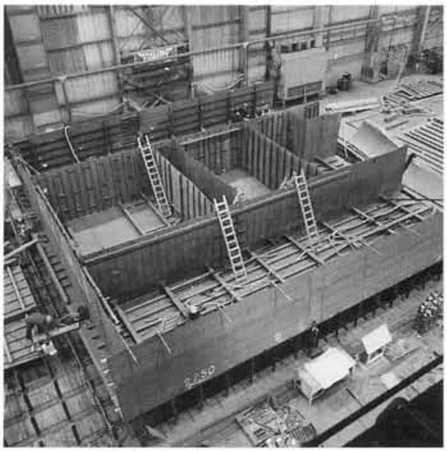

**Fig. 4. HMCS *Halifax* Assembly Unit**

It took 18 months before the keel was laid versus the 12 months originally scheduled, in contrast to the eight months for *Halifax*. Final erection and completion of the construction phase were delayed a further three months, making the ship a total of seven months late at float-up, even with the two-month head start. The additional pre-outfitting in *Vancouver* did, however, translate into significant manhour savings. The ship required some 12 percent fewer manhours than did *Halifax* (*Fig. 6*). Still, the amount of rework associated with design revisions made *Vancouver* two years late in delivery (*Fig. 7*).

### *HMCS Toronto*

Due to the problems being experienced with the construction of the first two ships and because *Vancouver* was taking longer to fabricate than expected, SJSL delayed the start of steel fabrication for HMCS *Toronto* (designated CPF-04; the third to be built by SJSL) to allow engineering and design to catch up. The first steel was finally cut for SJSL's third ship in January 1988, one year after that for *Vancouver*, four months later than originally planned.

About this time SJSL decided to expand its facilities and implement a "megamodule" concept. This, they hoped, would increase the level of pre-outfit and provide an opportunity to maximize the amount of work that could be done in a considerably more productive, controlled environment. In April 1988 work began on a module assembly hall (*see front cover*) that would replace the temporary shelters (*Fig. 8*) under which the erection units for the first two frigates had been completed. The building was in place by February 1990 and allowed the 26 erection units to be combined into nine megamodules (*Fig. 5*) in the assembly hall prior to erection. To get these new megamodules into the graving dock, SJSL leased two 350-tonne Scheurle transporters and a Manitowac ringer crane with a lift capacity of 600 tonnes. The yard was now able to build units in excess of 450 tonnes, a significant increase over the previous 200-tonne limit.

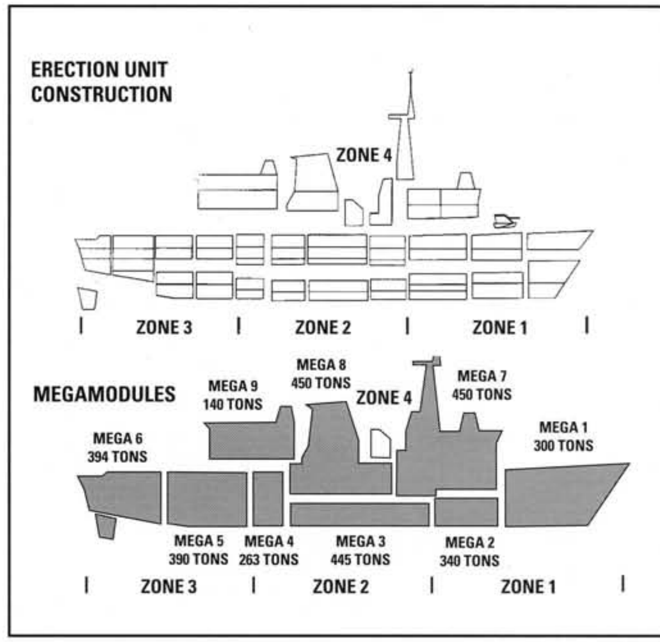


**Fig. 5. Megamodule vs. Erection Unit Construction**

Changing the building process so radically just as the yard was gaining experience in the erection-unit concept was a major risk, but one which senior management was prepared to take. They realized that without a radical revision of the process they would simply never recoup the delays that had already been experienced. *Toronto* became the first of the CPFs to benefit from the new process when four erection units forming the bow were combined into a 350-tonne megamodule. In October 1990 the megamodule was lowered into the dock on eight 125-mm-thick Kevlar slings — a first in shipbuilding. Until then, heavy lifts had always used conventional steelwire rope. To position the megamodule in the dock, a hydraulic control system was used instead of the slow, labour-intensive, chain-block method.

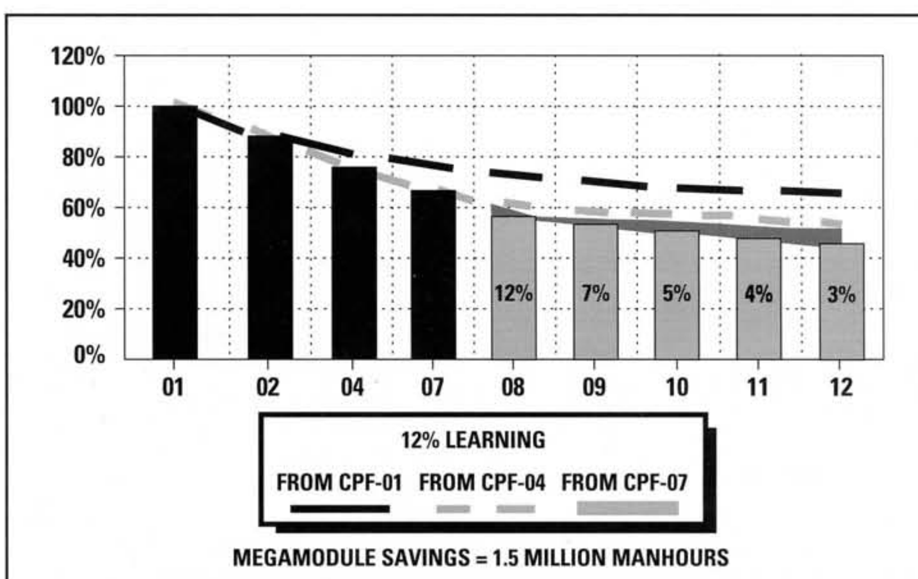


**Fig. 6. SJSL Learning Curve**

**CPF SCHEDULE**

| | | START FAB | KEEL LAYING | FLOAT-UP OR LAUNCH (L) | START SEA TRIALS | DELIVERY |
|---|---|---|---|---|---|---|
| CPF-01 HALIFAX | S. | 31-May-86 | 14-Mar-87 | 09-Jan-88 | 20-May-89 | 25-Oct-89 |
| | A. | 08-Jun-86 | 19-Mar-87 | 30-Apr-88 | 06-Aug-90 | *28-Jun-91 |
| CPF-02 VANCOUVER | S. | 14-Feb-87 | 06-Feb-88 | 10-Dec-88 | 12-May-90 | 24-Sep-90 |
| | A. | 06-Dec-86 | 19-May-88 | 08-Jul-89 | 10-Feb-92 | 11-Sep-92 |
| CPF-03 VILLE DE QUÉBEC | S. | 02-May-87 | 17-Oct-88 | 27-May-89 | 16-Jun-90 | 29-Jan-91 |
| | A. | 25-May-87 | 17-Jan-89 | 16-May-91 (L) | 16-May-93 | 23-Sep-93 |
| CPF-04 TORONTO | S. | 26-Sep-87 | 17-Dec-88 | 21-Oct-89 | 15-Dec-90 | 29-Apr-91 |
| | A. | 16-Jan-88 | 24-Apr-89 | 18-Dec-90 | 21-Sep-92 | 23-Dec-92 |
| CPF-05 REGINA | S. | 07-Nov-87 | 18-Jun-88 | 19-May-90 | 15-Jun-91 | 15-Oct-91 |
| | A. | 11-Aug-88 | 06-Oct-89 | 25-Oct-91 (L) | 27-Nov-93 | 02-Mar-94 |
| CPF-06 CALGARY | S. | 06-Feb-88 | 18-Jun-88 | 24-Feb-90 | 11-Jan-92 | 29-Apr-92 |
| | A. | 21-Feb-89 | 15-Jun-91 | 26-Aug-92 (L) | 19-Jun-94 | 30-Aug-94 |
| CPF-07 MONTRÉAL | S. | 17-Dec-88 | 13-Jan-90 | 29-Jun-91 | 19-Sep-92 | 29-Dec-92 |
| | A. | 14-Jan-89 | 08-Feb-91 | 26-Feb-92 | 20-Jun-93 | 27-Jul-93 |
| CPF-08 FREDERICTON | S. | 17-Mar-90 | 10-Nov-90 | 21-Mar-92 | 12-Jun-93 | 29-Sep-93 |
| | A. | 03-Jul-90 | 25-Apr-92 | 13-Mar-93 | 23-Jan-94 | 24-Feb-94 |
| CPF-09 WINNIPEG | S. | 15-Dec-90 | 24-Aug-91 | 19-Sep-92 | 12-Mar-94 | 29-Jun-94 |
| | A. | 02-Jul-91 | 19-Mar-93 | 11-Dec-93 | 06-Sep-94 | 11-Oct-94 |
| CPF-10 CHARLOTTETOWN | S. | 07-Dec-91 | 11-Jul-92 | 18-Sep-93 | 17-Dec-94 | 29-Mar-95 |
| | A. | 19-Apr-92 | 18-Dec-93 | 31-Oct-94 | (27-Mar-95) | (28-Apr-95) |
| CPF-11 ST. JOHN'S | S. | 26-Sep-92 | 22-May-93 | 11-Jun-94 | 16-Sep-95 | 29-Dec-95 |
| | A. | 26-Jul-92 | 24-Aug-94 | (4-Jul-95) | (13-Nov-95) | (10-Dec-95) |
| CPF-12 OTTAWA | S. | 05-Jun-93 | 29-Jan-94 | 18-Mar-95 | 15-Jun-96 | 29-Sep-96 |
| | A. | 31-May-93 | (27-Apr-95) | (24-Dec-95) | (27-May-96) | (30-Jun-96) |

NOTES:
S=CONTRACT SCHEDULED DATE (pre OAA)
A.=ACTUAL DATE
()=CURRENT TARGET DATES
*28 JUNE 91 was Provisional acceptance For CPF-01. Final Acceptance was 23 Dec 92.

**Fig. 7. Schedules: Contracted, Actual and Projected**

By float-up the initial four-month delay on *Toronto* had increased to 14 months, mainly because of resource limitations as *Halifax* and *Vancouver* were both undergoing final IMCS and combat outfitting and trials. Still, SJSL made good use of *Toronto*'s lengthened construction phase to improve its construction techniques and set up the planning for megamodule construction, further increasing the level of pre-outfitting. For example, the almost 25-percent rejection rate of randomly X-rayed welds on *Halifax* was reduced to five percent on *Toronto*. Although the ship was 20 months late when delivered on Dec. 23, 1992, *Toronto* required about 18-percent fewer manhours than *Vancouver*.

### *HMCS Montréal*

Having demonstrated the feasibility of using and safely handling megamodule units, SJSL proceeded to build HMCS *Montréal* (CPF-07), using six megamodules and 11 conventional erection units (*Fig. 9*). Fabrication started a year after *Toronto* on Jan. 14, 1989, only a month behind the original schedule, but erection did not begin until Feb. 8, 1991, almost 13 months behind the original non-megamodule schedule. In contrast to *Toronto*, this delay was primarily due to SJSL instituting new processes and maximizing its opportunities to push more and more work into the construction phase versus the overboard phase.

Of the six megamodules used in *Montréal*'s construction, perhaps the most interesting to engineers is mega one, the bow unit. Building on their experience, SJSL investigated the feasibility of installing the entire gun in the shop (*Fig. 10*) before moving the megamodule to the graving dock. This was a radical move, as gun installation and alignment had always been done after erection. SJSL's bold step became a world "first." The concern had always focused on being able to meet final gun alignment, but SJSL succeeded thanks primarily to its accuracy control department.

Accuracy control holds a unique and critical position within SJSL by virtue of its involvement throughout the shipyard. The accuracy control team monitors nearly every process from steel cutting to megamodule erection. The numerical database the team collects provides statistical information which the planning, welding and production departments use to implement innovative production methods. For instance, this data was used to improve welding sequences and reduce distortion and subsequent out-of-tolerances between units, providing the shipyard with the necessary confidence to initiate megamodule construction.

In addition to incorporating six megamodules in *Montréal*, SJSL also moved as much work as possible into pre-outfitting. For instance, they recognized that grinding, painting and other rework caused by hot work done after blast and paint contributed significantly to construction costs and represented an area of large potential savings. This was but one of the many items addressed just prior to *Montréal*'s construction by SJSL's Continuous Improvement Program, a program similar to the Total Quality Management initiatives going on in the navy. As a direct result of this program, a number of producibility improvements were introduced during the construction of *Montréal*.

*Montréal* thus became the first ship to benefit significantly from megamodule construction and the Continuous Improvement Program. When the first unit was erected the ship was about 13 months behind schedule but by float-up on Feb. 6, 1992 five months of that slippage had been picked up. For the first time the company was also able to make up schedule in the overboard phase, so that by delivery on the July 27, 1993 *Montréal* was only seven months behind a schedule that had been established six years earlier. These schedule improvements marked a turning point in the project and were the harbinger of things to come. SJSL was once again able to post a reduction in production manhours, this time more than 14 percent compared to *Toronto*.

### *Fredericton, Winnipeg and Charlottetown*

The trend continued with HMCS *Fredericton* (CPF-08), the fifth patrol frigate from SJSL. The ship was the first to be built almost entirely of megamodules (eight of them) and required about 12 percent fewer manhours to build than did its predecessor. One of the new megamodules, number seven — bridge, ops room, galley and mast — weighed a whopping 450 tonnes, the limit of SJSL's lifting capacity (*Fig. 11*). Pre-outfitting reached a new level in mega eight: uptakes were now fully lagged, spaces were painted and final inspections were done prior to erection in the graving dock.

From the start of fabrication to delivery the total time was just over three and a half years, an excellent achievement. For the first time SJSL had also reduced the construction phase (*Fig. 12*), and believed it could shorten construction enough on future CPFs to catch up to schedule by CPF-10 (HMCS *Charlottetown*) and deliver the last two ships early.

SJSL instituted additional improvements with *Winnipeg*'s (CPF-09) pre-outfit, especially on the hangar module (*Fig. 13*). The CIWS, torpedo handling equipment, after STIR and communication antennas were all installed as pre-erection work, thereby negating the need for Paramax to perform these tasks outdoors. By the time the hangar was erected it was 85 percent complete.

**Fig. 8. HMCS *Halifax* Temporary Shelter**

Another improvement was the finalization of the main ring butt welds on all megamodules in the shop, allowing main ring welding to proceed as soon as the megamodule was positioned in the dock.

By the time *Winnipeg* was delivered in late 1994 the manhours had been reduced again by nearly eight percent, substantiating SJSL's claim that, beginning with the true megamodule approach on *Montréal*, a new 12-percent learning curve for ship construction had begun. The difference between a typical 12-percent curve starting from *Toronto* and the current projections starting from *Montréal* (*Fig. 6*) are attributable directly to megamodule construction and amount to a substantial 1.5 million manhours! Thus the daring initiative undertaken by SJSL in the early nineties is quite clearly paying off.

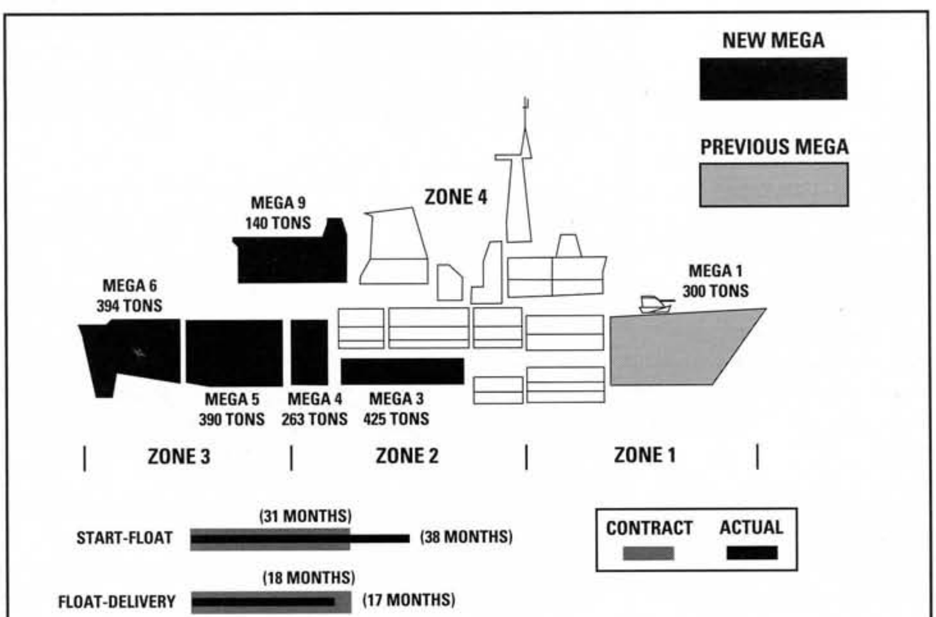


**Fig. 9. HMCS *Montréal* Construction and Schedule**

SJSL has continued to subject the megamodule methods to reviews aimed at maximizing efficiency. For example, beginning with HMCS *Charlottetown*, SJSL's seventh ship, mega three has been enlarged to include the forward auxiliary machinery room, saving a month of dock time per ship. The move significantly improves the installation of pipe work, cabling, etc., from the diesel generators, auxiliary boilers, ROD units and other equipment through to the forward engine-room (*Fig. 14*). To save more time, *Charlottetown*'s tanks were, for the first time, air-tested in the module hall instead of water-tested. Also, the DRES Ball was installed in the uptakes prior to erection of mega eight. By the time *Charlottetown* was floated-up in October 1994 the ship was estimated to be 69.3-percent complete — the highest level of finish achieved by that stage at that point in the CPF building program. As a result of these improvements *Charlottetown* is

**Fig. 10. Megamodule 1 with Gun**

expected to be delivered to the navy by April 1995, only one month after the date projected back in 1987.

Even though the project is now drawing to a close, SJSL has not eased in its drive to improve. An additional Manitowac ringer crane will be installed in the spring of 1995 to increase the yard's lifting capacity to 800 tonnes. Current plans are to increase the size of the megamodules for HMCS *Ottawa*, our twelfth and last CPF. These plans include combining megas four and five, as well as installing the gearbox, gas turbines and raft in mega three prior to erection. A further proposal to create two "super" megamodules out of megas two, seven and eight is also being studied (*Fig. 15*). These changes are designed to improve productivity and reduce construction time and should help SJSL avoid the "last-ship syndrome" common in other multiship programs.

**Lessons Learned**

***Benefits of Advanced Ship Construction***

The most obvious lesson to be learned from the SJSL CPF experience is that there are significant benefits to be gained by maximizing pre-outfitting in a shop environment. SJSL clearly demonstrated that these benefits — reduced construction cost, improved quality and reduced construction time — are not limited to a yard with an experienced work-force. Rather, they can be attained through rigorous planning and a motivated management cadre implementing good, basic industrial engineering concepts. By successfully implementing these techniques and practices, SJSL has established itself as a competitive force in the world shipbuilding marketplace.

***Design Process***

The second lesson involves the way we do business. As many people are aware, the procurement strategy for the CPF project was a significant departure from previous experience. A Total Systems Responsibility (TSR) approach was adopted whereby the contractor was responsible for all aspects of the project, including contract and detailed design. The intent was that the contractor would produce frigates meeting our performance requirements in a "turn-key" project. To ensure the government's independence, a policy called "negative guidance" was followed during the project definition phase. It is this negative guidance approach which needs a second look since the fallout was that government and industry did not proceed as partners, but almost as independent entities during the early phases of the project.

**Fig. 11. Megamodule 7 Superstructure**

Such an environment is not conducive to the implementation of producibility concepts involved in a P/SC approach. These require co-operation between the navy and the shipbuilder from the earliest stages to provide a receptive atmosphere for the necessary trade-offs to be made and implemented fully.

The benefits of incorporating producibility concepts and strategies from the earliest stages was amply demonstrated in the CPF project. But with the significant savings being realized only after the delivery of CPF-07, *Montréal*, the real disappointment is in not achieving the full potential that might have been possible had the new concepts been incorporated during the earliest stages of the design process. Several other initiatives might also have been considered, such as the "robust ship" with its heavier, but simpler structure, but these require the shipbuilder's early participation in the design process to foster concurrent product and process design. In the case of CPF the design of the construction process did not start until well into the actual detailed design and did not really conclude until after the seventh ship. Producibility and construction-process considerations are required in all design phases prior to construction.

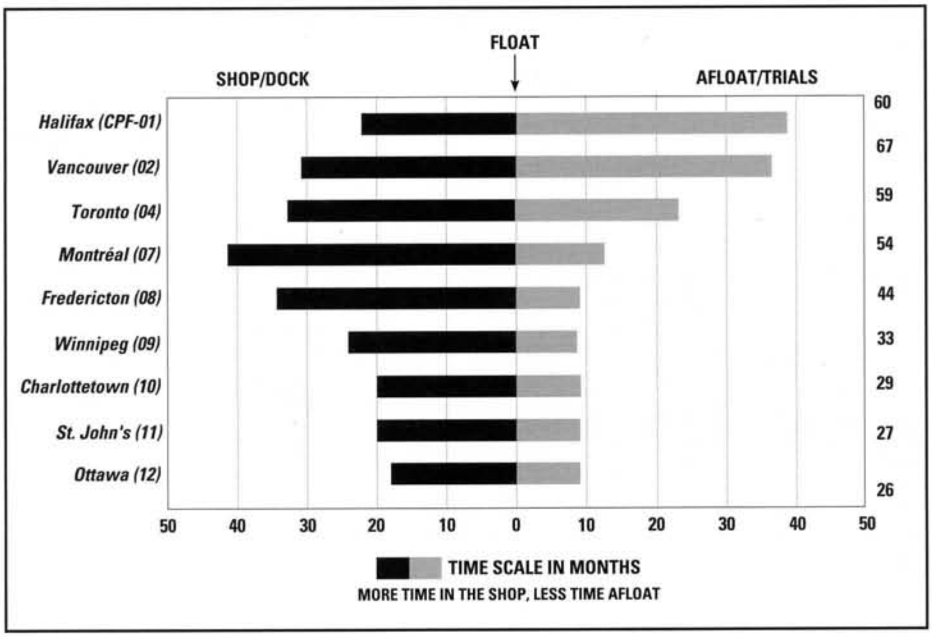


**Fig. 12. SJSL Shipbuilding Durations**

The concept of involving the shipbuilder earlier in the design process is one which the USN is currently pursuing in its quest to improve the efficiency of its ship design and construction process and make that process both shorter and cheaper. Our navy is also considering it in the initial concepts for a multi-role support vessel (*MEJ June 1994*) process including a combined design team of contractor and naval personnel. Nonetheless, there also needs to be a consistent, systematic approach to measuring the impact of producibility concepts. Criteria must be developed to enable producibility trade-offs to be made so that the navy is assured of getting the end product it desires. If this is to succeed, it will require training for both naval and contractor engineers.

### *Lead-ship Strategy*

Another lesson which stands out is the need to separate the lead ship from follow-on ships. The original contract allowed a gap of only one year between the delivery of the first and second ships. The problems caused by this small separation were compounded by the fact that the original schedule allotted only three years to build each ship. We know now that the time needed to construct a typical lead frigate is about five years and even in the best of times the first follow-on ship will require about four years. Thus, from the lead ship to the follow-on ships, the stage was laid for the repetition of engineering and material problems and attendant rework charges. The situation got worse as the detailed design began to slide to the right into the actual construction period of the follow-on ships. The result was that the early portion of the contract schedule soon became completely unrealistic and the contractor had difficulty predicting delivery dates and the man-hours required to complete each ship.

Changes and rework must be expected on any new construction project, but a significant number of man-hours might have been saved if there had been more separation between the first two ships. Based on the CPF experience, a case could easily be made for supporting a prototype approach. With an appropriate gap between the delivery of the lead ship and the first of the follow-on ships, the majority of construction and design faults could be identified and eliminated before full production was undertaken. Certainly, if not a separate contract, which might be impractical for reasons of shipyard employment continuity, then completing the detailed design prior to fabrication and maintaining a significant separation are mandatory. This might well be the most important lesson of the CPF project.

### Conclusion

The original project objectives were to (a) build new multipurpose warships to meet naval requirements, (b) establish industrial benefits for Canada, and (c) create a shipbuilding centre-of-excellence in Canada. The CPF design and performance are indeed a success story. HMCS *Halifax* has now sailed over 40,000 nautical miles and is highly capable of extended operations at sea in all weather conditions. *Halifax*, *Toronto* and *Montréal* have been deployed on UN peacekeeping duties in the Adriatic Sea, while *Vancouver* has served in the Far East as an integrated component of a task force. As one CPF commanding officer remarked on his return from his first extended deployment, "It is becoming apparent that the CPFs are going to be equal to or better than any comparably sized multipurpose warship in the world."

The Canadian Patrol Frigate project has generated significant industrial benefits, with over 70 percent of the work done in Canada. At the height of production the prime contractor and its principal subcontractors alone were employing more than 6,000 people directly on the project. Of the more than 200 Canadian companies supplying equipment to the ships and support facilities, many became success stories in their own right.

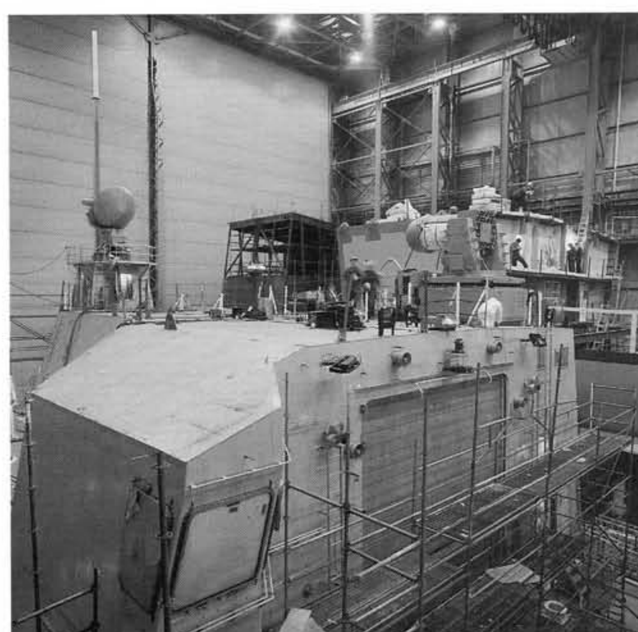

**Fig. 13. HMCS *Winnipeg* Hangar**

Perhaps most importantly, SJSL now has a modern shipbuilding facility and the proven capability to design and build first-class ships efficiently and economically. There were many examples where the navy and SJSL worked together to make changes beneficial to both parties. This capability is not only nationally important, but is now recognized internationally. SJSL is presently pursuing a number of foreign marketing opportunities, any one of which could put Canada back on the map as a shipbuilding nation. Thus, through leadership, innovation and achievement SJSL has rightly earned the title of Shipbuilding Centre of Excellence, for which we as Canadians can justifiably be proud.

**Acknowledgment**

We would like to acknowledge the support received from Saint John Shipbuilding Limited and from the CPF Project Management Office in Ottawa. In particular, we would like to thank Mr. Derry Oke, Mr. Daniel Cyr and Ms. Mary Parsons, all of whom assisted with comments and suggestions that were invaluable in the preparation of this paper.

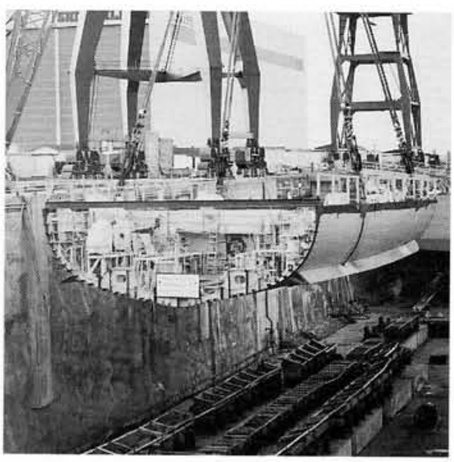

**Fig. 14. HMCS *Charlottetown* Keel-laying**

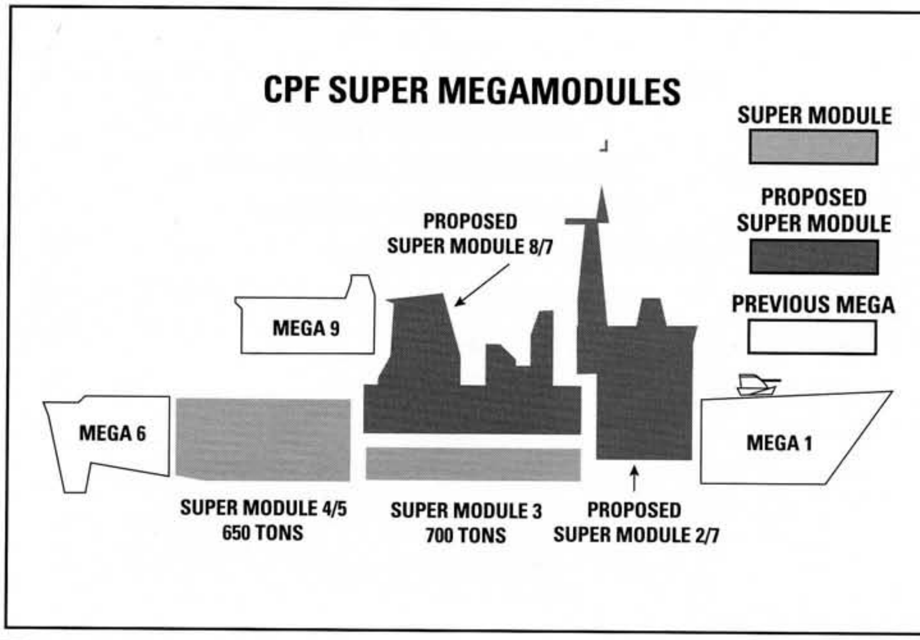


**Fig. 15. The proposed "super" megamodules for CPF-12, HMCS *Ottawa***

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# Incident at Sea: Oxygen System Explosion in HMCS *Cormorant*

*Article by* LCdr Jim Muzzerall, Stephen Dauphinee *and* LCdr Kevin Woodhouse

On Nov. 18, 1992 the navy's diving support ship HMCS *Cormorant* was conducting local operations off Nova Scotia when the ship suffered a small explosion in her diving-gas flask stowage compartment. The ship had just completed diving operations with the submersible *SDL-1*, and was preparing to refill the submersible's oxygen tanks when the explosion occurred. Refilling tanks is a normal post-dive procedure, but this was the first such oxygen transfer to be made since *Cormorant*'s refit six months earlier.

The flask stowage compartment contains 28 oxygen flasks and 20 helium-oxygen flasks, storing diving gases at 1,650 psi. The gases are used by the divers, the two submersibles (*SDL-1* and *Pisces*) and the ship's recompression chamber. The diving gases and compressed air are delivered throughout the ship via the manifolds and piping of the diving-gas distribution system.

As personnel prepared to refill *SDL-1*'s oxygen tanks to 3,000 psi, the necessary valves were opened to pressurize the gas-transfer booster pump. This would allow oxygen stored at 1,650 psi in the flask stowage compartment on 2 deck to pressurize the line up to the inlet of the gas transfer booster pump located outside the compartment. The pump outlet was to be connected to the SDL-1's oxygen tanks, but one valve was inadvertently left closed. As the booster pump increased the oxygen pressure from 1,650 psi to 3,000 psi, an explosion occurred inside the flask stowage compartment.

Fortunately, the personnel conducting the oxygen charging were at the booster pump just outside the compartment. They heard a loud bang, but thought it was the relief valve lifting. (The relief valve was set only 50 psi above 3,000.) They shut the pump down and upon seeing thick, grey, rusty smoke quickly raised the alarm. The Rapid Response Team arrived and manually activated the halon extinguishing system. When the attack team finally advanced into the flask stowage compartment, they discovered the fire out and the bulkheads and deckheads scorched (*Fig. 1*).

At first the scope of the reported fire incident and the potential hazard to personnel and equipment were not recognized. On arrival in Halifax, *Cormorant* was met by SRUA pipe fitters ready to remove damaged parts, NEUA spec writers trying to assess the scope of the repair job and squadron technical staff looking for a first-hand damage assessment. It was then that squadron staff realized the fire incident was in fact an explosion resulting from a catastrophic failure of a component of the oxygen system. The area was immediately quarantined. No repairs would commence until a technical investigation had been carried out.

**HMCS *Cormorant***

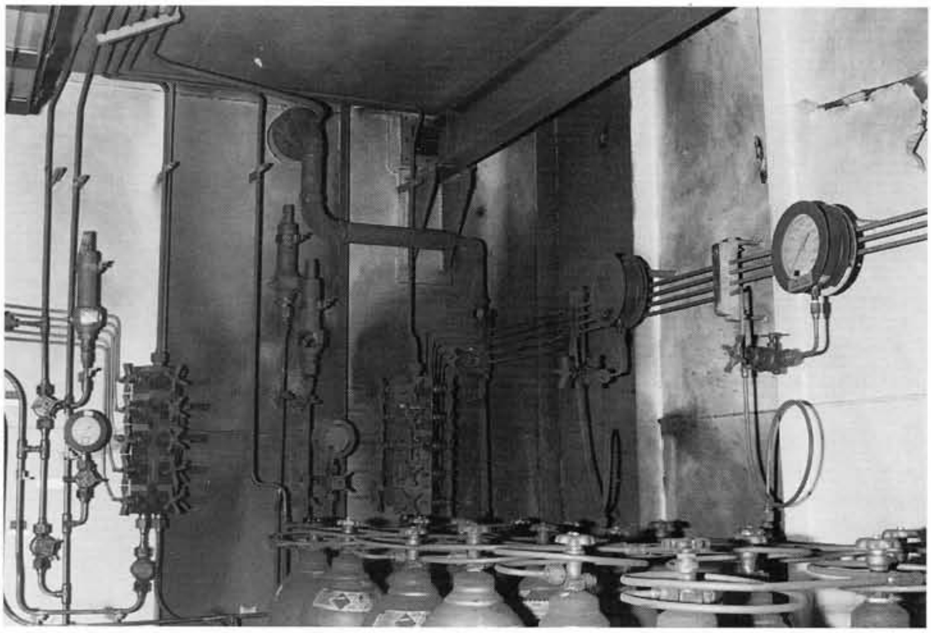


PHOTO BY LCDR G.R. TWEEDIE

**Fig. 1. The fire-damaged flask stowage compartment on board the diving-support ship HMCS *Cormorant*.**

The technical investigation discovered an exploded relief valve and a burned transfer hose (*Fig. 2*). A quick inspection of an undamaged transfer hose in the system revealed a polyvinyl chloride dust plug (*Fig. 3*) that should have been removed prior to installation. The possibility that a similar plug had also been left in the damaged hose seemed likely. In addition, an excessive amount of silicone grease was found in the oxygen bank manifold unions. Since the presence of such contamination implied negligence, or possibly sabotage, the technical investigation was terminated with a recommendation that a summary investigation be conducted. The summary investigation would attempt to determine the cause of the explosion and whether or not gross negligence played a part. It would also recommend measures to prevent recurrence.

### Summary Investigation

The summary investigation led to the following conclusions:

- The diving-gas system had been neither certified clean, nor functionally tested;
- Certain system valves and unions had been extensively lubricated with silicone — a substance known to act as a fuel in an oxygen enriched atmosphere;[1] and,
- A PVC dust plug had been inadvertently left in a stainless steel transfer hose. Such a plug in a pressurized oxygen line can act both as an obstruction and as a fuel.[2]

The silicone contamination was a possible cause of the explosion. Silicone grease found in the system "is more likely to ignite and will release more heat than fluorinated greases once ignited."[3] The PVC plug found in the system pointed to another likely cause of the explosion. "Presence of a similar plug in the transfer hose (which was) destroyed could have provided the fuel necessary for the fire to start and destroy the relief valve and transfer line."[4] Except for procedural error, the closed valve did not change the outcome of the charging. It only made the relief valve lift sooner. The investigation concluded that the explosion in the oxygen transfer system was probably caused by maintenance-induced contamination (i.e. the PVC plug or the silicone grease) acting as the fuel, with oxygen as the oxidizer and high-pressure oxygen under adiabatic compression as the ignition source.

As a review, adiabatic compression occurs when high-pressure gas is rapidly introduced into a low-pressure system and strikes a barrier. The increase in pressure causes a dramatic increase in temperature. Theoretically, oxygen under adiabatic compression caused by 3,000 psi entering a system at one atmosphere and 20°C, will reach a temperature of 1,066°C. PVC in pure oxygen at one atmosphere ignites at about 390°C.[5] Clearly, the theoretical temperature caused by adiabatic compression well exceeded the PVC dust plug's ignition temperature.

When the contaminated oxygen system was pressurized the relief valve lifted, allowing 3,000-psi gas to strike the PVC plug. It was only a matter of an instant before the adiabatic compression

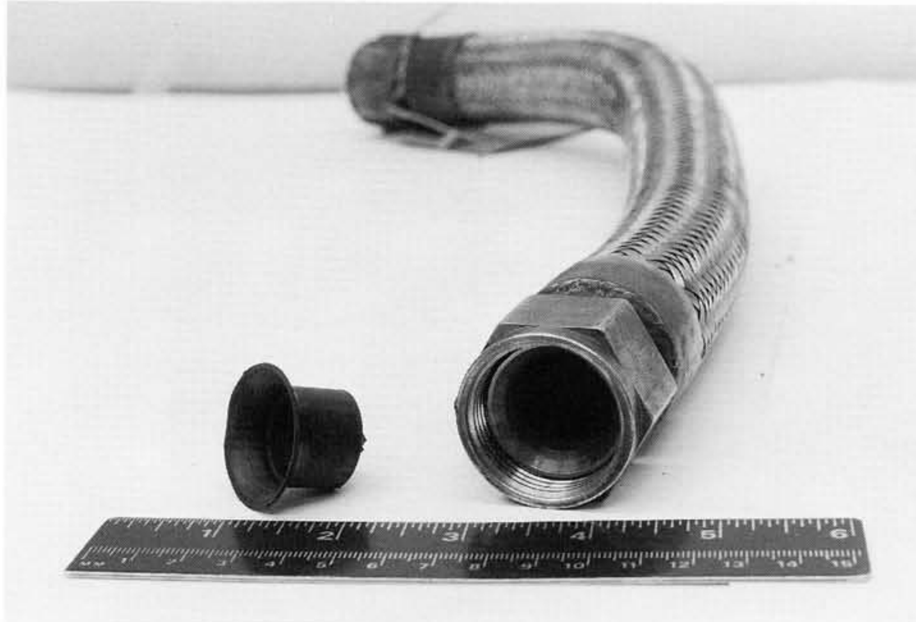
PHOTO BY LCDR G.R. TWEEDIE

**Fig. 2. The damaged relief valve and transfer hose in the flask stowage compartment.**

of oxygen raised the temperature sufficiently to ignite the PVC plug. Once started, the fire drew on the supply of pure oxygen and like a cutting torch burned through the stainless steel transfer hose (*Fig. 4*) using the stainless steel itself as a fuel. The fire continued to burn in the body of the open relief valve, weakening the valve body, resulting in mechanical failure and subsequent explosion. This sprayed slag and scorched the surface of bulkheads, deckheads, gas-transfer piping and associated fittings in the flask stowage compartment.

At some point the fire must have run out of fuel since the heat from the flame and the oxidizer were still present. (Oxygen continued to vent from the flasks until the Rapid Response Team entered the compartment and closed the oxygen bank valves.) The fire must have burned for perhaps only a few seconds. The intense heat dissipated so quickly in the compartment that it did not activate the halon extinguishing system. The minimal damage indicated that the fire was out well before the Rapid Response Team activated the halon extinguishing system.

Why did this happen? How did the contamination enter *Cormorant*'s oxygen system? How did it go undetected? How could the diving-gas system have been approved for use? These were some of the questions that led to the revelation of several oxygen system maintenance problems.



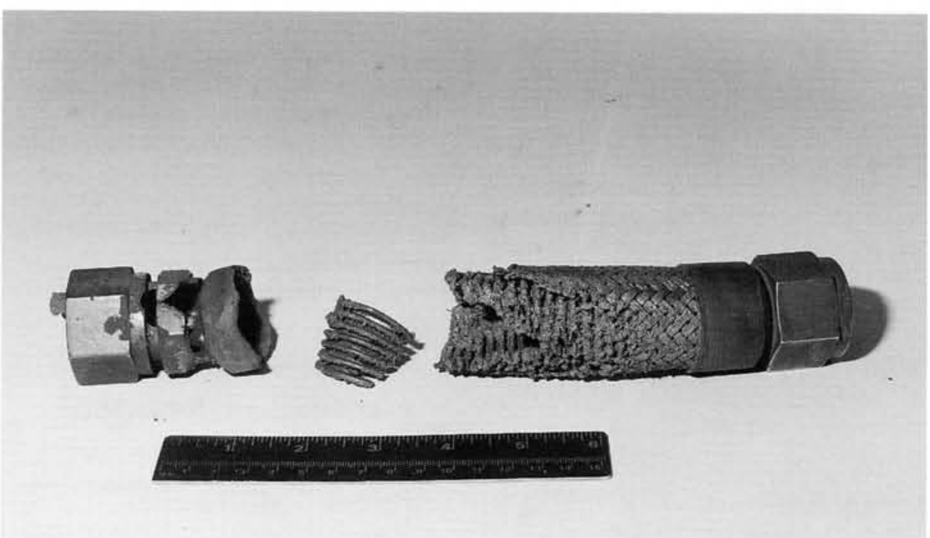
CF PHOTO BY BASE PHOTO HALIFAX

**Fig. 3. This PVC plug was found in the undamaged transfer hose which was not pressurized during the explosion.**

### System Contamination

The PVC plug in the stainless steel transfer hose was there because someone forgot to remove it. New hoses from the manufacturer are delivered with "plugs in" to keep the hoses clean. Evidently, a PVC plug was left in and QA did not find it.

Excessive silicone grease, which is not approved for use in oxygen systems because of the fire hazard associated with its ignition characteristics, was found in some oxygen bank piping. (The only grease approved for diving systems is Christo-lube MCG III.[6]) The unapproved grease in the diving-gas system could have been introduced during refit or maintenance. Hence, routine ship maintenance might have been a contributing factor. The investigation found that first-line maintenance of diving-gas systems was being conducted not by the engineering department, but by divers who might not be aware of common engineering procedures relating to tests and quality assurance.



CF PHOTO BY BASE PHOTO HALIFAX

**Fig. 4. This stainless steel transfer hose was destroyed during the explosion. Its purpose was to connect a relief valve to the oxygen pressure relief dump line.**

Yet, even if a diving-gas system were contaminated during maintenance, the system tests and trials should have revealed the problem. Unfortunately, as *Cormorant*'s oxygen system work was still incomplete at the end of her refit, the tests were not conducted. A system retrial/retest was neither observed as a deficiency in the CF 1148 Record of Inspection, nor recorded as having been conducted. It should be noted that the functional test specified in the refit did not require the relief valves to be tested in situ. As a consequence of this, the in-situ operation of these valves is proven at the first six-monthly maintenance routine or, as happened in this case, at the first actual lifting of a relief valve.

In the final analysis it is unclear who was responsible for the PVC or silicone contaminants. What *is* clear is that insufficient quality assurance played a role, whether on the part of the contractor, CFTSD, SRUA or ship staff. The production of unclear maintenance and

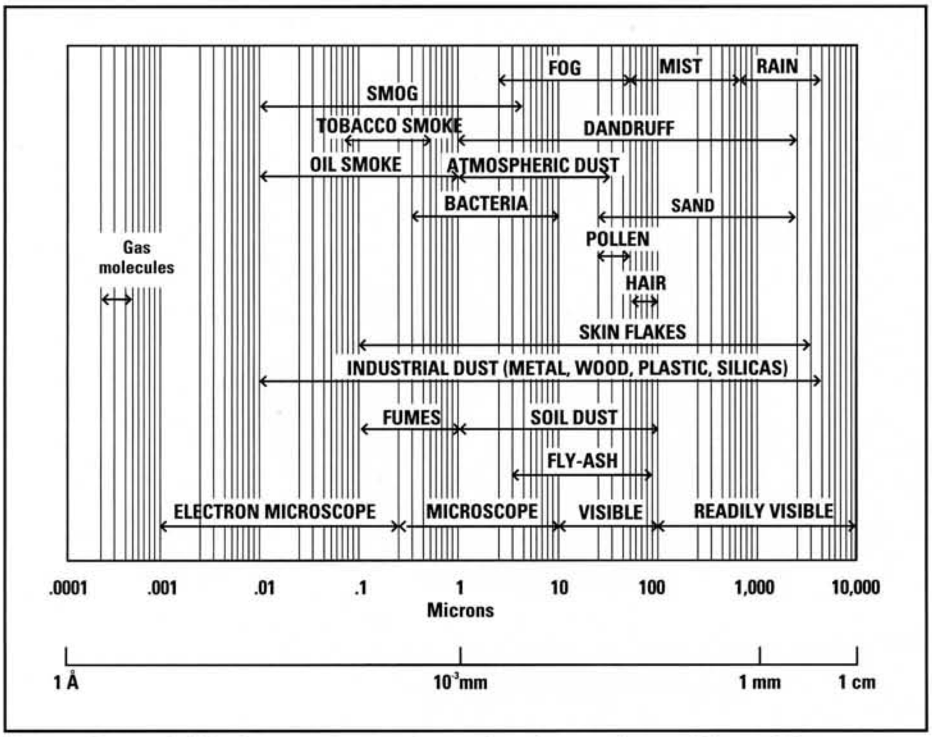



**Fig. 5. Potential $O_2$ System Contaminants[7] — Approximate Sizes of Common Particles**

repair deliverables also played a part. The existence of these deficiencies was an indication of the naval engineering community's lack of appreciation of the hazards associated with oxygen systems.

### Repairs

A month after the explosion, on completion of the summary investigation, a 30-page job instruction (which closely resembled the original refit instruction) was prepared by NEUA. SRUA would be tasked with the repair work, while *Cormorant* divers would provide the QA function.

The basic valve and pipe repair and overhaul procedure would involve:

- removing the valves for cleaning;
- flushing the piping with jumpers at valve locations;
- reassembling the valves to the piping;
- conducting pressure tests;
- taking a gas sample; and
- functionally testing the system.

Once removed from the piping the valves were disassembled to separate metal and plastic components. The metal components were cleaned with Freon in an ultrasonic bath, then all components were washed with a surgical detergent and rinsed in water. The parts were inspected under black light to ensure no hydrocarbons existed, then were reassembled and pressure tested with either pure nitrogen or helium. Finally, end caps were installed, the valves were sealed in heavy plastic bags and certification tags were attached. The valves were then returned to the ship for installation.

On board the ship the pipes of the diving-gas system were flushed with circulating Freon for 30 minutes, then reflushed for 15 minutes with a fresh supply of Freon. A sample of the Freon was then collected in a petri dish and taken to a Clean Room where it was inspected for hydrocarbons under a black light. The Freon was then evaporated so the petri dish could be inspected visually for residue under a black light. Once certified clean, the pipe circuit was purged of Freon using hot nitrogen gas, after which the pipe ends were capped and covered with heavy plastic and a certification tag was attached.

The newly cleaned system components were reinstalled and pressure tested for strength and tightness (i.e. leakage). The pressure test was uneventful except for the helium test on some flexible hoses which allowed some helium gas molecules to effuse through the Teflon hose material. Although the hoses all passed the strength test, certain ones could not pass the tightness test. Spare hoses fared no better, but were granted temporary waivers to allow the system to be used until full-spec replacement hoses could be installed (five months later).

The final part of the repair process involved sending a gas sample to Mann Labs in Toronto for analysis. On the strength of the results, DCIEM certified the gas safe for diving. The ship's staff reviewed the SRU documentation for completeness and everything was a go for a dive. Off they went at the end of May 1993. A few days later we got a message to say the function test was successful, nothing blew up and the air tasted great.

### Problems

The repair process was not without its obstacles. To begin with, the Freon proved ineffective in removing the silicone contamination. Thus, the valves had to be chemically cleaned and the pipes steam cleaned, which added significantly to the repair time.

Second, with the silicone removed, the initial flushes still showed signs of hydrocarbon. After much head scratching it was decided that the workspace was the major contributing factor. It seems the system and samples were open to a wide range of potential contaminants (*Fig. 5*). Although CFTOs do not specifically say so, it made sense to establish clean areas for conducting valve cleaning, pipe flushing and testing. Gas system cleanliness is important both for providing the divers with clean air and for preventing an explosion hazard. To ensure cleanliness, a number of CFTOs exist which describe the general requirements and procedures for maintaining diving-gas systems and taking gas samples. But if the gas must be pure, how clean do the valves and pipes have to be? Essentially, *very clean*. There must be:

- no hydrocarbons;
- less than 5 ppm residue in the cleaning fluid; and
- no residue inside the components.

What is interesting is that even particles that are less than 10 microns in diameter (all the invisible stuff) can cause contamination. Clearly, the DND standard white glove test would not be good enough to screen these out.

Accordingly, a clean work area was established in the ship. The sealed off area was fed by filtered air and maintained at a positive pressure to repel airborne contaminants. The Freon flushing agent and Freon samples were carefully protected from contamination. A Clean Room was also set up ashore in building W7 in Dartmouth, containing a secure work area, a work bench and a pressure test facility. At *Cormorant*'s suggestion the place was cleaned like a hospital operating room. Access was limited by rigging plastic curtains at all entrances and by posting No Trespassing signs. Anyone entering either of the clean areas had to wear white, lint-free coveralls. When we resumed flushing, the contamination disappeared.

Finally, we ran out of Freon refrigerant during the flush. With all the contamination problems, SRUA had been going through 45-gal. drums of the stuff and Freon was in desperately short supply everywhere. What to do? We could try using Trisodium Phosphate, but we felt the technical risks would be too great. In the end we decided to recycle the Freon. It was amazing how quickly the Pipe Shop constructed a "Down Home" style still to evaporate the refrigerant. We were soon back in production.

### Lessons Learned

Broadly speaking, we split the lessons learned into two categories: those specific to *Cormorant*, and those applicable to all hyperbaric diving-gas systems. In general, the single-most important lesson stemming from this incident was the need for a knowledgeable user-maintainer (one of *Cormorant*'s ship's staff) to be dedicated to the refit work on the ship's diving-gas system. After all, someone whose life will later depend on the system will likely focus intently on all aspects of safety and security.

Due to the inherent dangers associated with high-pressure oxygen relief valves, we recommended that heavy steel shielding be installed around the valves to minimize injury or damage in case of an explosion. We also recommended that some method for isolating the gas supply from the flasks be fitted *outside* the compartment. During the incident the crew had to enter the compartment to do this. The relief valve lift pressure also came under scrutiny. Having it set only 50 psi above the 3,000 psi maximum was obviously much too close for comfort, especially since the compressor pressure cutout switch operated above this setting. The oxygen relief valve was reset to lift at operating pressure plus 10 percent — 3,300 psi. So now, not only will the compressor cut out well before the relief valve is set to lift, but the valve will only lift if the compressor does not cut out.

The explosion and damage, the result of a routine operation, forced a reexamination of diving-gas system maintenance procedures used by the Canadian navy. The repairs to *Cormorant*'s diving-gas system were successful, thanks in great part to the fact that a single agency — SRUA — was responsible for all aspects of the repair and certification. They disassembled the system, cleaned the valves, cleaned the pipes, reassembled the system, took air samples and certified the system clean. Many problems occurred during the rebuild, but these were resolved by the combined efforts of SRUA, *Cormorant* staff, squadron staff, the Environmental Diving Unit in Toronto and NEUA.

How long did all of this take? The total down-time was six months. One month was taken up by the technical and summary investigations. If the repairs had been confined to explosion damage only, the time to repair would have been approximately 1½ months. The extensive silicone contamination added about 3½ months to the repair.

Why this interest in diving systems? Well, to begin with, SCUBA charging systems are found in all ships and submarines. And contrary to popular belief, it is the engineer officer who is responsible for the maintenance of these diving-gas charging systems — *not* the divers. You could find yourself posted to a Fleet Diving Unit where your major responsibility would lie, not with the main engines in diving tenders, but with diving-gas system problems. So if nothing else, remember that cleanliness is critical to the success of a diving-gas system.

### Acknowledgment

The *Cormorant* diving-gas incident presented some fairly specific requirements in terms of maintenance and repair procedures. We figured we could handle the engineering side of things, but we needed someone who could provide the practical knowledge gained through hands-on experience. What we needed was a diver who had done everything according to the rules. In fact, we found two — **LCdr Paul Morson** of the Experimental Diving Unit in Toronto and **Lt.Cdr. Jack Copes**, USN, who had recently joined Cormorant. The cooperation and expert assistance of these two officers was fundamental to achieving the repair, and for that we thank them.

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[4] DREA/DL 3715 PR1AL-3-1.973, Dec. 4, 1992.

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[7] American Society for Testing and Materials G93-88.

CF PHOTO BY CPL C.H. ROY

*LCdr Muzzerall (left) is the Group Assistant Technical Officer for CMOG1 in Halifax. He conducted the summary investigation to determine the cause of the oxygen system explosion on board HMCS* Cormorant.

*Stephen Dauphinee (centre) is a design engineer with Naval Engineering Unit Atlantic. He directed the repair effort on board* Cormorant.

*LCdr Woodhouse (right) is the Group Technical Officer for CMOG5. He conducted the technical investigation surrounding the* Cormorant *oxygen system explosion.*

# Survey says!

## *The results from our October 1994 readership survey are in. Can we talk?*

*Article by* Brian McCullough

*"More combat systems!"*

*"Down with combat systems! More marine systems content!"*

*"Too technical!"*

*"Not professional enough!"*

Ever get the feeling you're in the middle of a bunfight? When the returns started coming in from last October's readership survey our first inclination was to run for cover. Especially when the high-tech guys on the next floor up from our offices started *faxing* their returns to us. Happily, we survived the experience to tell about it.

To begin with, we were thrilled with the response. We heard from a good sampling of our readership and received enough bouquets and buckshot to keep us busy for a long time to come. Our respondents sometimes let their school colours show, but they did manage to agree in a few important areas. We found that people for the most part were satisfied with their *Maritime Engineering Journal*, but were ready to blow safety valves over our ineffective distribution.

Of the 1,550 copies of the *Journal* we mailed out, 303 people took time to answer our questionnaire. Of these, 53 (mostly junior ranks) submitted "nil returns" that made no comment other than to say they had never heard of the magazine (duly noted). Two others (a leading seaman and a lieutenant) expressed themselves with less than Neanderthal wit in their demands for the immediate demise of the *Journal* on money-saving grounds (also noted), but otherwise had nothing constructive to say.

Therefore, to ensure a more accurate survey and in fairness to those who were able to make informed responses, we based the rest of our findings on the remaining 248 returns — still an impressive 16-percent response. (During our 1987 survey we received 93 replies — a seven-percent return — from the 1,400 copies we mailed out.) Based on what people told us in this survey, a *conservative* estimate places the total readership of the *Maritime Engineering Journal* at about 3,100 people — that is two readers for every copy we mail out.

**Survey Who's Who**

Our respondents reported in from bases and headquarters (58%), training centres (16%) and dockyards and ships (15%). The majority of the rest hailed from other government departments and project offices. Sixty-two percent of those who participated in our survey were military, three-quarters of them being MSE and CSE lieutenants and lieutenant-commanders. There was also a solid 23% representation from our senior non-commissioned members (NCMs), virtually all of whom were PO1s or PO2s in the engineering technical occupations. Of the 38% of respondents who were civilian, we identified engineers (25%), technologists (18%) and a smattering of QA managers, financial managers, project officers, administration support officers and clerks.

On the language front, 87% of our respondents reported they read the *Journal* in English, 3% said they read it in French and 7% said they read it in both languages (in some cases to practice their French). Just to confound us, one person who apparently reads the magazine in French chose to answer the questionnaire in English. Another diabolical mind took the opposite tack — claimed to be an English reader, yet answered the survey in French and in the same breath professed no ability to judge the quality of the French content! Hmm. (Of the 41 people who did rate the translation, 14 pegged it as Very Good, 26 as Good and one as Poor.)

**Magazine Content**

Readership interest across all sections of the *Journal* was encouraging, with any one section being read on average by 67% of readers. An amazing 52% reported reading the magazine from cover to cover (with another 12% saying they read everything except for one article or column). As far as favourite sections went, nearly half the respondents said they preferred the articles (no favourite subject emerged), 21% liked the News Briefs best, 19% most enjoyed the Forum section and 18% preferred the Looking Back feature. The other sections received approval ratings of between 12% and 15%. Although most people refused to identify a *least* favourite section, each of our regular features received a few raspberries.

People were generally happy with the complexity of the articles — 70% said the articles were just right, while the rest were evenly split on whether they were too technical or too general. Similarly, two-thirds expressed satisfaction over the general interest articles, but in this case the majority of the remainder considered the non-technical content to be too shallow. Respondents were more definite (83%) in telling us they liked the mix of articles in each issue.

Readers responded to the "How often should we publish?" question with everything from twice a month (*yikes!*) to never (*oh, pooh*). One person even suggested we publish "as often as required." By far the most popular request was for a quarterly (34%), followed by our present three issues a year (19%), monthly publication (13%) and six issues a year (10%). With respect to subscription fees, *extreme* caution was the word of the day. Fifty-eight percent flat out said No, but a surprising 30% said Yes to fees (depending, of course, on how much they were).

And if you think the Hubble Space Telescope had a case of bad optics, we didn't do our own public relations any favours when we (that is, I) inadvertently omitted civilians and most of the NCM engineering occupations from the list of target audiences in question 11. One miffed respondent refused to continue the survey. Fair enough.

What we learned in the end is that there is strong support out there for directing the *Journal* to all areas of the Canadian naval engineering community, including the commercial sector. We were specifically asked to include more articles and commentaries written by (or, of interest to) NCMs in the naval technical trades and civilian contractors involved with naval engineering support.

### *Journal* Objectives

We were perplexed by the number of people who asked us what the magazine's objectives were. We publish them in every issue. Maybe it's a case of people not noticing the wallpaper any more. At any rate, sixty-eight percent of respondents said the objectives should remain as they are, while 21% offered no opinion.

Several people told us the magazine is too light on the technical side to be a professional engineering branch journal. Our primary concern, another said, should be to promote interest, knowledge and awareness. Still others suggested we broaden our outlook to include our place in industry and internationally. A number of people said we should be gearing the publication more toward the NCMs who make up most of the branch. One engineer questioned our having a senior MARE named as editor. "As long as the stated editor is a Capt(N)," he wrote, the *Journal* "will not be an open forum. Lesser ranks will feel intimidated." In a similar vein, another person said we do not offer a proper forum where all viewpoints appear welcome — "too much party line."

### Reality Check

Asking readers to rate the usefulness of the *Journal* was instructive. While 67% said they found it useful, 27% reported they had little or no use for it. Some people didn't like our choice of words, saying they considered the magazine to be more educational than useful. (Perhaps we should have polled readers as to the *importance* of maintaining a journal.) As far as overall impressions went, 17% said they were Very Favourably disposed toward the *Journal*, 56% said Favourably and 3% said Unfavourably. What bothers us is the 19% who gave a Neutral response. Put all of this in the context of the entire survey and it seems clear that (a) people want a more current and work-oriented journal; and (b) our hit-and-miss distribution is killing us.

So where do we go from here? The bottom line, of course, is to make the *Journal* better for you the reader. We received a good number of suggestions, some widely popular, others delightfully contradictory. What impressed us most was the depth of your interest in the *Maritime Engineering Journal*. Here is a taste of what you told us:

***Policy & Production***

- ensure regular delivery;
- institute "Article of the Year" awards to promote excellence in article writing;
- expand the *Journal* to represent all naval MOCs;
- get more input from commercial maritime organizations and universities;
- make the *Journal* more accessible, more fun to read;
- make the magazine more suitable for junior ranks (eg. establish NCM technical editors and NCM Corner);

***Format***

- provide an electronic edition (e-mail and CD-ROM);
- separate the English and French sections to save $$;
- emulate the *Journal of Naval Engineering*, *Proceedings*, IEEE journals, *Popular Science*;
- print on recycled, recyclable materials;
- use more colour and more photos;
- adopt a newspaper tabloid format to save $$;

***More News about...***

- project updates, advances in industry;
- engineering trends and problem areas;
- conference and seminar schedules;
- organizational changes (eg. Op Excelerate);
- branch interests (eg. NCM training, MARE OA);
- Who's Who and Who's Where in Canadian naval engineering;

***Editorials/Opinion Pieces***

- establish regular departments for major engineering organizations and MOC advisers;
- more open discussion of *controversial* issues — less pap, less process;
- more Way Ahead articles by senior officers;
- more leadership discussion;
- create a question and answer column;

***Articles***

- more professional interest (eg. case studies);
- report current technical policy issues;
- more ship systems and "dirty hands" type of articles;
- more emphasis on engineering and project management;
- more historical technical subjects;
- more CSE and software engineering articles;
- more humour (eg. cartoons, funny photos, anecdotes);
- publish "Notes from Sea;"
- publish summaries of master's theses;

***In General...***

- do nothing — it's so bad now...;
- it's great, keep it coming — don't change a thing;
- no more surveys!

So there you have it. Thanks to your excellent response the editorial committee can now forge ahead with more informed decisions regarding the magazine's purpose and direction. This was only the second readership survey in the *Journal*'s 13-year history. Our aim this time is to refocus the *Journal* to meet the needs of the Canadian naval engineering community during this new era of more responsible fiscal management.

By the time you read this we will have already taken steps to get a handle on our Number One priority — the distribution problem. There are bound to be glitches, but with your assistance and continued good humour we can get the machine working smoothly again as soon as possible. Thank you for your very kind words of encouragement and, yes, for your biting criticisms as well. (Perhaps one day we can return both.) We look forward to all your submissions to the *Journal*.

See you around the farm.

*Brian McCullough has been Production Editor of the* Maritime Engineering Journal *since 1985.*

# Interference Suppression using an HF Adaptive Antenna Receiving System (HFAARS)

*Article by* Lt(N) Michael P. Craig

## Introduction

Major advances in digital signal processing (DSP) have affected all areas of military combat systems. The increased throughput, reduced size and lower power consumption of DSP chips have permitted the development of subsystems which improve overall system performance. One such subsystem is the High Frequency Adaptive Antenna Receiving System (HFAARS).

Adaptive antenna receiving systems are used to suppress signal interference in radio communications. Interference can originate from other transmitters in the same frequency band, man-made noise, or from natural phenomena like thunderstorms. In the particular realm of military communications, interference can also take the form of enemy jamming signals. Adaptive antenna array processing counteracts interference by forming a composite antenna pattern that greatly reduces the gain in the direction of an interference source, while enhancing the gain toward a desired signal (*Fig. 1*).

In the simplified system description shown in *Fig. 2*, the signal from each antenna in the array is received by independent HF receivers, digitized and passed to a DSP for filtering, frequency shifting and generation of complex data. The filtered data is then examined to detect the onset of the communications signal and to synchronize to it. Adaptive weights are calculated to enhance the known reference features embedded in the communications signal and at the same time to suppress other (interference) signals. The weights adjust the phase and amplitude of the received signal from each antenna. Finally, the signals are combined to cancel the undesired interference signals and to obtain a maximum signal-to-interference ratio.

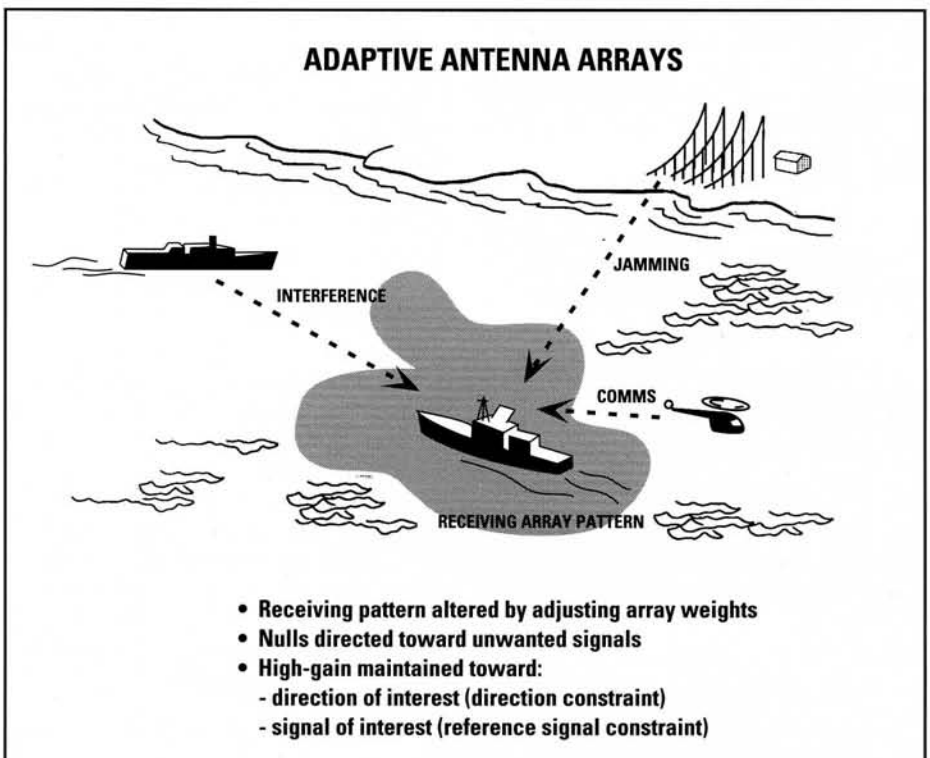


**Fig. 1. Typical scenario for adaptive antenna arrays**

## DND Research and Development

The AN/FRQ-26 HF receiving system built by the Andrew Corporation features adaptive interference-cancelling techniques using four identical HF receivers and antennas. It can suppress up to three independent jammers to enhance the reception of Link 11 and FSK (frequency shift keying) signals. This particular system (the only one of its kind known to be in production) was purchased in 1991 under an R&D project managed by DMCS 6 and sponsored and funded by the Chief of Research and Development (CRAD).

Research into interference suppression by DMCS 6 began in mid-1990 with the goal of investigating and developing an advanced HF adaptive antenna system at the Communications Research Centre (CRC) at Shirley's Bay near Ottawa. Thus far, the signal processing techniques and real-time software have been developed primarily for naval use. It has been demonstrated that the system can provide reliable communications in the HF band in the presence of virtually any type of interference or jamming signal. The processing techniques can be extended to other military and civilian applications, such as land mobile cellular radio.

The continuing focus of the HFAARS research and development project has been on developing DSP algorithms to counteract intelligent jammers to maximize HF data rates in hostile environments. Work accomplished at CRC so far has resulted in the writing of tailored DSP algorithms for taking advantage of specific HF data protocols used in friendly communications. The aim is to automatically detect and synchronize with the onset of a friendly signal in a hostile communications environment in real time. The messages are then separated from the jamming signals, demodulated and decoded.

Two newly developed HF protocols were selected for the initial algorithm and software development. They are the NATO STANAG 4285 waveform and the U.S. Mil-Std-188-110A waveform. Both are HF serial tone waveforms for digital data transmission and are designed to take advantage of optional error-correction coding. Antijamming algorithms developed by CRC for use in an HFAARS system contain the following basic processing procedures:

- detection of and synchronization to the communications signal;
- suppression of interference signals of various waveforms, including time-varying or pulsed jamming;
- de-interleaving data and error-correction; and
- demodulation and decoding.

Work completed to date on the HFAARS system has resulted in the capability to enhance the reception of the STANAG 4285 waveform in the presence of various types of jamming. Most of the research has been in the area of software algorithm development and in upgrading the digital signal processing hardware. Due to the increase in processing capability, the HFAARS system can automatically recognize the STANAG 4285 waveform and reject other interference signals without operator intervention. Some of the interference signals which have been tested against the HFAARS system include: fixed tone, chirp, continuous noise and pulse noise jamming.

Adaptive antenna receiving system requirements for the naval environment are particularly demanding. A system must be able to adapt quickly to ship motions which tend to veer the antenna pattern null away from the interference. Additional complexities in the naval environment are the RF harmonics and intermodulation noises generated by the ship itself. The directions of the jamming signals and shipboard noises are unknown in practice and can change quickly. These undesired signals may also be statistically non-stationary — i.e. behaving as impulsive noise.

The signal processing algorithms developed at CRC have been demonstrated in field trials to achieve very high signal detection rates and very low bit-error rates in the presence of the most severe types of interference (i.e. jamming-to-signal ratios exceeding 30 dB). Of the various types of jamming, pulse noise jamming is considered to be one of the most severe and difficult to defeat.

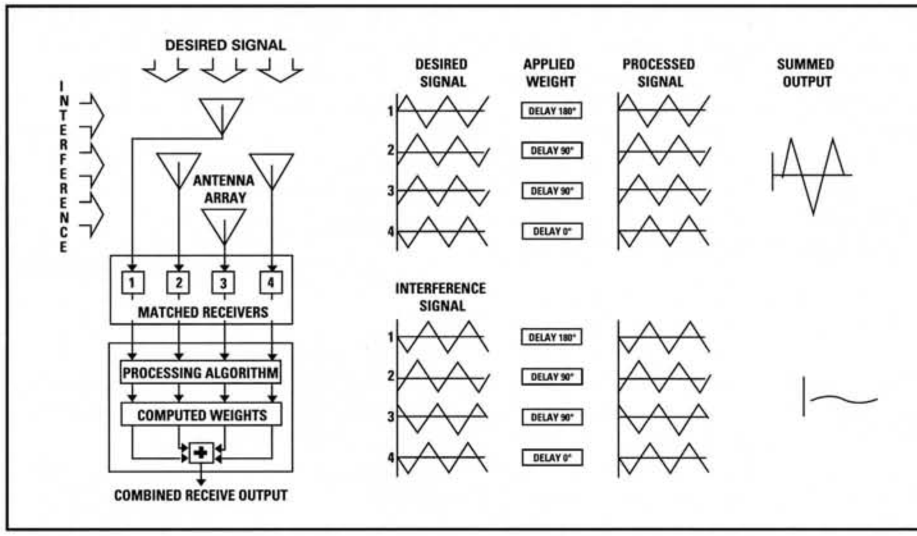


**Fig. 2. System description — adaptive antenna array processing**

HFAARS's four HF receivers are well matched in phase and amplitude, which is essential for good interference suppression performance capability. The heart of the system is the programmable DSP processor. This DSP chip is where the real-time adaptive signal processing and data processing are performed. The original HFAARS hardware from Andrew contained transputers for the signal processing, but these have been replaced by a single Texas Instruments TMS320C40 (C40 for short) digital signal processor. Although the STANAG 4285 algorithms require only one C40, future algorithms requiring more processing power can be accommodated by simply adding more C40 chips.

### Techval S/859 HMCS *Saskatchewan*

By the end of 1993 research on the HFAARS system had progressed to a point where a shipboard technical evaluation (techval) became necessary. The evaluation would validate the work done by CRC and determine further development needed to transform the system into an end product. In February 1994 a week-long HFAARS techval (S/859) was conducted on board HMCS *Saskatchewan*. The techval took place alongside and at sea in the Gulf Islands and Georgia Strait. Assistance came from HMCS *Restigouche*, acting as an enemy jamming ship, and CFS Aldergrove (Matsqui) which transmitted the source message signals.

The techval showed conclusively that the HFAARS running the STANAG 4285 waveform antijam algorithm can perform effectively in a hostile operational environment using *existing* ship's antennas. It also demonstrated that the FSK antijam algorithm provides significant benefit against a jamming signal. It should be noted that this was the first time Aldergrove transmitted messages at a data rate of 2400 baud to an operational unit at sea. The use of serial tone waveforms (i.e. RF-5710 modem capabilities) in conjunction with HFAARS will greatly increase the reliability and throughput of message traffic at sea.

### The Future of HFAARS

Further development work will increase the capabilities of HFAARS by producing new software algorithms which include updating FSK and Link 11 antijamming capabilities, as well as enhancing the reception of the new Mil-Std-188-110A waveform. Improvements to the reception of HF signals via sky-wave transmission paths, with their associated Doppler spread and multipath delay distortions, are also planned.

The algorithms and software are currently designed to run on the Andrew Corporation's AN/FRQ-26 HF Adaptive Antenna Receiving System. Although the AN/FRQ-26 is used at CRC as a test bed to validate the performance of the signal processing algorithms and software in a laboratory setting, it is fairly large for its function and uses older DSP technology (transputers). Clearly, a new hardware architecture will be needed to run the software algorithms. Since the new software is written in "C" it is logical to make the minor modifications necessary to transport it to other similar signal processing platforms.

Thus, with the advent of new electronic technology, future versions of the adaptive antenna receiving system will be much smaller and cost significantly less. The envisioned host architecture for the C40 DSP chips containing the anti-jamming algorithms is the new VXI (VME Extension for Instrumentation) standard which is an RF version of the VME bus architecture. HF receiver modules, DSP modules containing C40 chips and 486-based computer controllers, all of which are VXI compatible, are commercially available today. Development work would require the software integration of these modules and implementation of the adaptive receiving algorithms.

A contract has recently been awarded to SED Systems of Saskatoon to build a prototype HFAARS system (which will be based on the VXI architecture). The contract is expected to be completed in early 1996, followed by up to six months of operational evaluations of the new prototype, including feedback from the users. It is then planned to purchase production units for each major war vessel. It is possible the adaptive antenna receiving system will eventually evolve into a multichannel, multiband, multifunctional, fully programmable radio system. Such a system would satisfy most naval communications requirements for peacetime and wartime well into the next century.

*Lt(N) Craig is the R&D officer for DMCS 6.*

# Greenspace: Maritime Environmental Protection

## Hydrogen Sulphide Gas — A Deadly Shipmate

*Article by* Lt(N) K.W. Norton

Most naval engineers are familiar with the dangers posed by confined spaces. However, a new threat has emerged with the advent of national and international pollution prevention regulations. Changes in operating procedures and the installation of black, grey and oily wastewater systems in response to these requirements have increased the tendency for the onboard generation of toxic hydrogen sulphide ($H_2S$) gas.

Although a "rotten egg" smell is readily associated with low levels of hydrogen sulphide gas, few people are aware of the dangers it presents. Fatalities due to $H_2S$ gas inhalation have been documented by the USN and RAN, as well as by civilian agencies. A recent accident in the maintenance support ship HMAS *Stalwart*, involving $H_2S$ gas generated in an oily water sullage tank, resulted in the death by asphyxiation of three sailors and the hospitalization of 56 others.

Hydrogen sulphide is an asphyxiant gas generated when iron sulphide reacts with dilute sulphuric or hydrochloric acid. It is also formed when sulphate-reducing bacteria (SRB) anaerobically metabolise the sulphur components of organic matter such as petroleum products, detergents, sewage, food debris and treatment chemicals. This anaerobic condition can occur at the interface between water and organic matter in conditions as diverse as oil, fuel and sewage. Although SRB are common in the marine environment, and thus in the bilges of ships, growth of these bacteria in significant quantities occurs only when several important factors are met simultaneously:

a. Since sulphate-reducing bacteria grow only in an anaerobic environment, the absence of oxygen is essential. In an environment rich in biodegradable organic matter this can be readily and rapidly achieved by the growth of aerobic bacteria that consume the oxygen.

b. An adequate source of sulphate (or other reducing form of sulphur) is also required for SRB growth. Since sulphate is a significant component of the salts in sea water, sulphate is usually present in significant quantities in bilge water and gravity blackwater systems. It should be noted, however, that the upper limit of the $H_2S$ hazard will be governed by the amount of usable sulphur that is present.

c. Growth of SRB and other bacteria in waste water also requires the presence of an oxidizable carbon source. This is required to produce energy for the bacteria and for growth of cellular matter. Biodegradable detergents present in both bilge and blackwater systems can satisfy this need either directly or indirectly through partial breakdown by other bacteria in the waste.

| | | |
|---|---|---|
| | 0.05 ppm | detectable by odour |
| | 0.10 ppm | irritation of eye and upper respiratory tract |
| | 10 ppm | threshold limit value (8 hrs exposure) |
| | 30 ppm | very strong smell but not unbearable |
| | 50 ppm | casualty complains of painful eye irritation, a halo around lights, headache, loss of sense of smell, nausea, rawness in throat, cough and respiratory difficulties |
| DANGER ZONE | 150 ppm | rapid olfactory fatigue occurs (loss of sense of smell) |
| DANGER ZONE | 300 ppm | unconsciousness after a few minutes' exposure |
| DANGER ZONE | 500 ppm | rapid onset of unconsciousness after a few breaths, respiratory centre stimulation and rapid breathing |
| DANGER ZONE | 600 to 1000 ppm | single breath causes immediate respiratory arrest and unconsciousness |
| DANGER ZONE | 4300+ ppm | explosive range — ignition temp. 500°F |

**Table 1: Effects of Varying Concentrations of Hydrogen Sulphide Gas**

d. Other minor components, including phosphate, trace minerals and vitamins are also essential for bacteria growth. These can enter bilge and blackwater systems through addition of chemical formulations such as cleaning agents and detergents and by the discarding of food scraps and rubbish.

A lag time of several days is generally required before hydrogen sulphide begins to generate, after which the rate of $H_2S$ production increases rapidly. The time to achieve an anaerobic state (and subsequent increased risk of $H_2S$ generation) is accelerated under higher temperature conditions, with most SRB microbial activity favouring an ambient temperature range of 20 to 40°C. As the SRB multiply, a microbial film (sludge) accumulates on the surface. This creates an increasingly anaerobic environment consistent with the consumption of oxygen by aerobic bacteria, even if the bulk of the mixture is oxygenated. This anaerobic decay can occur at any interface between water and organic matter.

Oily and blackwater wastes are now routinely stored on ships for periods well in excess of the lag time. Additionally, conditions ideal for SRB growth exist in bilges, black/greywater tanks and oily water collection and storage tanks. The hazard of gas being released by disturbing the sludge blanket in these spaces is not widely appreciated.

Hydrogen sulphide gas is heavier than air and can reach high concentrations in poorly ventilated areas. Although $H_2S$ is not toxic at low concentrations (< 10 ppm) it has a characteristic pungent rotten egg odour at these low levels that seriously degrades the quality of the working environment. Unfortunately, odour is not a good guide to the presence of toxic levels of $H_2S$ in the air. As the data in *Table 1* shows, hydrogen sulphide cannot be detected by smell (as a result of olfactory paralysis) at concentrations where it presents a severe toxic hazard to personnel. The olfactory nerves rapidly become fatigued and desensitized at moderate concentrations. In environments where $H_2S$ is known to reach high concentrations, or where accidents involving hydrogen sulphide asphyxiation have occurred, the presence of this smell in the air should not be dismissed lightly. Such conditions should be investigated with appropriate monitoring equipment to determine the extent of the hazard.

Minimizing the generation of hydrogen sulphide in shipboard waste is essentially a "housekeeping" problem, best solved by prevention. The generation of $H_2S$ will be retarded if the wastewater environment can be prevented from supporting the growth of sulphate-reducing bacteria. The best treatment for minimizing $H_2S$ generation in the bilges is to keep them clean, using only *approved* cleaning agents. Most detergents contain the nutrients necessary for SRB growth. More importantly, oily wastewater should not be stored any longer than necessary, especially in warm climates.

The bilges, of course, are just one location where hydrogen sulphide gas can form. It can also be generated in ballast tanks and in fuel and lubricating oil systems. An incident has even been reported of hydrogen sulphide being generated in the crankcase of a diesel engine. Wastewater tanks are very susceptible, the conditions there being ideal for sludge blanket formation. It is absolutely essential that preventive maintenance instructions governing the washing down and emptying of these tanks be strictly observed.

Sound judgment and intimate knowledge of the hazards associated with hydrogen sulphide gas are necessary if dangerous situations are to be avoided. Good housekeeping, established routines for entering spaces with non-Chemox breathing apparatus, and use of a gas detector such as the Exotox-50 will offer an adequate level of safety.

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*Lt(N) Norton is the DMEE 5 project engineer for liquid waste systems.*

# HMCS *Fraser* — Last of the ISLs

***When she paid off on Oct. 5, 1994,* Fraser *became the last of Canada's "original seven"* St. Laurent*-class anti-submarine escorts to be retired from service. Thanks to a heritage group, the venerable ship could find new life as a floating exhibit in Kingston.***

*Article by* Brian McCullough

The times they are a'changing, and so are the ships. The Canadian navy closed an important chapter in its history last October when HMCS *Fraser*, the last of the *St. Laurent*-class ASW escorts, was decommissioned for the final time after 37 years of service. Named for Canadian rivers, the 2,400-tonne *Fraser* (DDH-233) and her six sisters, *St. Laurent* (205), *Saguenay* (206), *Skeena* (207), *Ottawa* (229), *Margaree* (230) and *Assiniboine* (234), were the first major warships to be designed and built in Canada.

When they were commissioned into the Royal Canadian Navy in the mid-1950s the *St. Laurents* were regarded as the state of the art in ASW surface-ship technology. Their unique combination of available speed, Canadian-designed sonars and effective ASW armament (mortars and torpedoes) put them in a class of their own. With their gas-tight, positive-pressure citadel and distinctive rounded hull the ships were designed to survive and operate in a nuclear or biological warfare environment.

During the early sixties the ships were converted to carry a Sea King helicopter and variable-depth sonar, vastly increasing their effectiveness in the ASW role. Redesignated *Improved St. Laurent (ISL)* DDHs, the ships became operational proof of Canada's hugely successful pioneering work in teaming up small ships with large ASW helicopters.

Although HMCS *St. Laurent* was declared surplus in 1974, the rest of the class went on to give decades of service.


**In this photo of HMCS *St. Laurent*, probably taken in 1956, note the twin mounts of triple-barrelled Limbo ASW mortars lying horizontally in their secured/loading positions in the well aft, and the absence of fibreglass gun houses on the forward and after gun mountings.**

In the early 1980s the ships received Delex life-extension refits to bridge the gap until the *Halifax*-class patrol frigates could join the fleet. As the CPFs arrived, one by one the *ISL*s were paid off.

Today, *Fraser* is the last intact example of her kind. With the exception of *Saguenay*, which was stripped of her fittings and sunk as an artificial reef near Lunenburg, N.S. early last year, the rest of the *ISL*s have already been, or are in the process of being scrapped.

For Dave Matts, Greater Kingston-area director of the Canadian Naval Heritage Foundation, it has all been a little frustrating. The Foundation has been trying for years to save one of the "cadillacs" from the wreckers and preserve it as a heritage memorial in Kingston, Ont. The group finally worked out a loan agreement to purchase *Fraser* for a reported $200,000. For the moment, the ship has been "locked down" to preserve the artifacts. The Foundation will still have to raise $100,000 to tow the destroyer to Kingston.

"We're plugging away," said Matts. "The sooner we get (*Fraser*) up here (in Kingston), the sooner we can get showing her to the public and let her start carrying herself."

Life as a floating exhibit would make an honourable final career for the venerable *Fraser*. As the sole remaining representative of the illustrious *St. Laurent* class, she would join the select company of Canada's few other preserved naval historical vessels — the corvette *Sackville* in Halifax, the Tribal-class destroyer *Haida* in Toronto and the hydrofoil *Bras d'Or* in Bernier, Que. As Dave Matts put it, "*Fraser* is the last (of the *St. Laurents*), which makes her all the more important." ⚓

*As a young naval reserve officer Brian McCullough joined an ice-bound HMCS* Margaree *in Montreal for two weeks of familiarization training in the spring of 1976 — just long enough to get "TSQ'd" the hard way when a brutal 48-hour influenza swept through the ship's company.*

**HMCS *Fraser* (233) with *Margaree* a year or two after their mid-sixties conversion to DDHs. When these *St. Laurent*-class escorts were built in the 1950s they represented the state of the art in ASW surface-ship technology.**

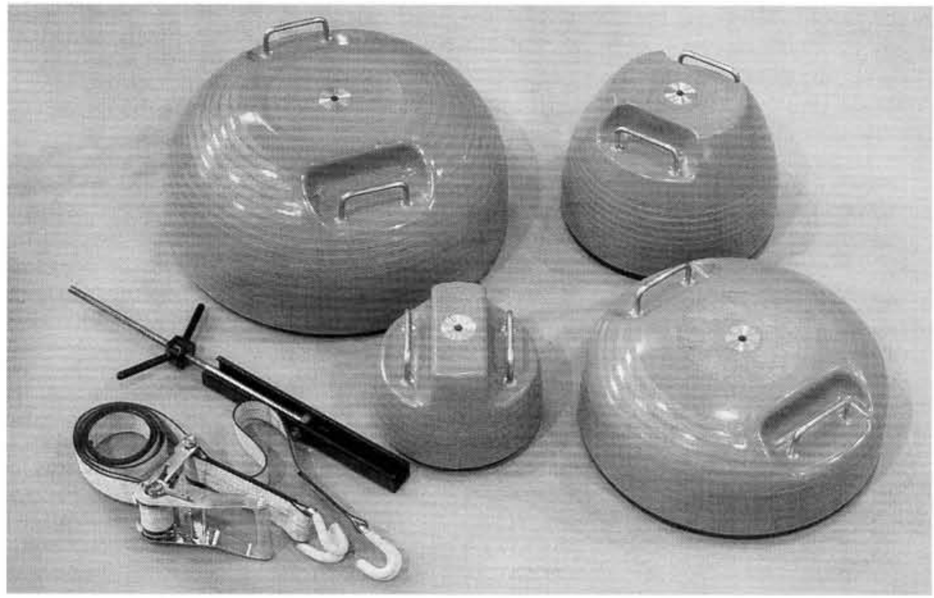
## *Updated design for DC splinter boxes*

An improved system of damage control splinter boxes will soon be available to Canadian warships. The glass-reinforced plastic (GRP) splinter boxes will be built to a design developed in Canada from a Royal Navy concept.

Warship DC teams use splinter boxes to cover projectile and shrapnel holes in a vessel's hull, decks and bulkheads to minimize compartment flooding. The steel splinter boxes currently in use in the Canadian navy are square with sides 305 mm to 457 mm long and 150 mm high, and weigh between 15 kg and 29 kg.

As the Royal Navy found with similar units during the Falklands War, steel splinter boxes are heavy and difficult to handle, especially when water-filled in rough seas. Because of this experience, the RN went on to develop lighter GRP splinter boxes, taking advantage of the material's excellent strength-to-weight ratio.

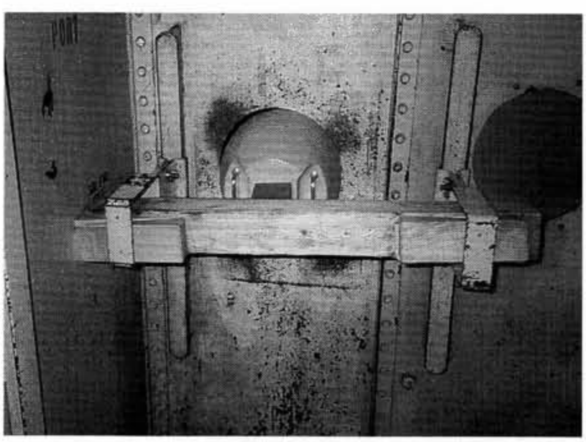
A prototype unit based on the RN concept was fabricated and tested at Canadian Forces Naval Engineering School Esquimalt CFNES(E). Initial evaluation indicated that, though not ideal, the concept was an improvement over the existing steel design. The Naval Engineering Test Establishment (NETE) in LaSalle, Que. was tasked by DMEE 4 to refine the design by evaluating the prototype design and incorporating other known desirable features.



NETE PHOTO BY MICHAEL BERGIN

**Fig. 1. This new system of glass-reinforced plastic splinter boxes features many improvements over the steel units presently used in shipboard damage control.**

A preliminary design for an improved splinter box system was developed and the first prototypes were fabricated and tested at NETE. Full-scale operational tests were performed at the Damage Control divisions of CFNES(E) and CFNES Halifax. As a result of the testing, further refinements were made and the final splinter box system design incorporated most of the features desired by DMEE 4, CFNES DC staff and NETE.




NETE PHOTO BY COLIN SMITH

**Fig. 2. A 350-mm GRP splinter box undergoing evaluation at the Damage Control division of CFNES Esquimalt.**

The final system configuration comprises four sizes of splinter box and two securing systems (*Fig. 1*). The splinter boxes range in size from 250 mm to 550 mm in diameter, weigh between 3 kg and 8.5 kg and are stowed as two nested pairs. They are fitted with recessed handles, feature non-slip surfaces and have deep, flexible seal elements which are easily replaced.

Depending on the situation, the boxes can be secured using traditional wooden shoring (*Fig. 2*), or one of the other securing systems for which the splinter boxes are configured. The first, a toggle bolt assembly, consists of a pivoting strongback, bolt and wing-nut. The second, a securing strap, consists of a quick-ratchet cargo strap fitted with non-slip wire hook-ends.

The new, lighter system has proven to be easy to handle and quick to install. The system is adaptable and, in many situations, the splinter boxes can be installed by one person. The new GRP splinter box system is expected to be available in the fleet in early 1996. **— Colin Smith, Project Officer, MSI Section, NETE, and LCdr A.J. Lafrenière, DMEE 4-2.**

## *CAE Award*

**SLt Dan Riis (DMES 6) receives the CAE Award for academic excellence in Marine Systems Engineering from Bill Grayson, CAE Ottawa's director of business relations. (*Photo by Lt Chuck Doma)***

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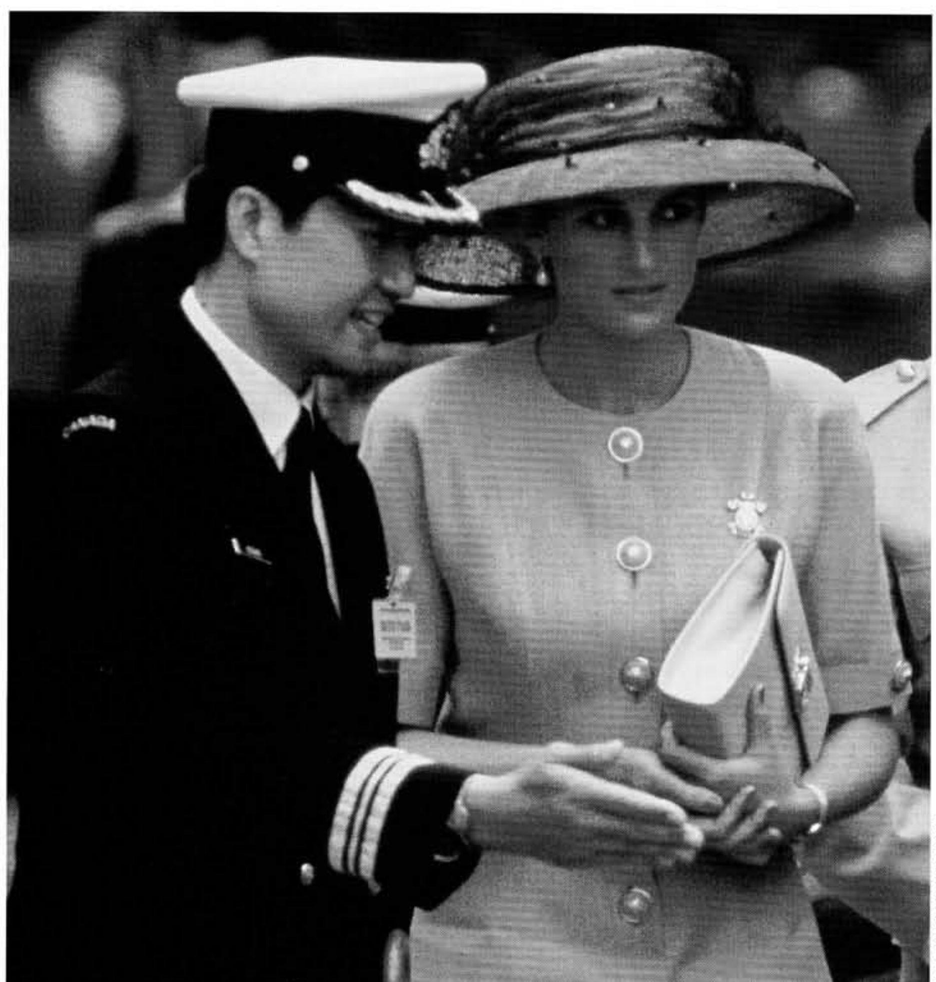
## *The Engineer and the Princess*

**HRH Princess Diana was escorted during the June 1994 unveiling ceremony at the Canadian Memorial in London by a Canadian Maritime Engineer. LCdr Ted Dochau, an MSE with DSE 9 at NDHQ, spent four months in England as special assistant to Capt(N) E. Davie, Naval Adviser at CDLS(L), co-ordinating Canadian D-Day activities in England.**



NUNN SYNDICATION PHOTO

# News Briefs

## *Merit awards*

Congratulations go out to the following people who have been recognized by Canada, the Chief of the Defence Staff, ADM(Mat) or DGMEPM for their various outstanding efforts:

**John Porter** and **Danny Morehouse** of DREA for their work with **Doug Nickerson** of NEUA in isolating the cause of premature turboblower failures and formulating a plan to rectify the problem.

**James Moores** of DREP for his outstanding performance in solving corrosion-related problems in naval ships.

**Kevin Chadwick** of DMCS 4 for 20 years of outstanding performance in the fields of radar systems and naval command and control; particularly for his work in resolving technical problems with the AN/SPS-503 radar.

**LCdr Jamie Quathamer** of DMES 6 for his superb achievements as the Deputy Project Director of the Naval Maintenance Management Information System Project.

**Lt(N) René Hatem** of DSE 2 for his outstanding work as Ship Disposal Officer.

**LCdr Dave Ashling** of DSE 3 for his work as the NDHQ project officer for the HMCS *Protecteur* West Coast refit.

**Bob Laidley** of DMEE 6 for his outstanding work in the area of electrochemical power sources and AIP technology.

**Bob Coren** of DMEE 4 for his outstanding work as the LCMM responsible for diving and hyperbaric systems.

**Cdr Peter MacGillivray** (retired from DMEE 7) for his superior achievements in organizing the 10th Ship Control Systems Symposium; also noted for their outstanding work on this event were the **military and civilian members of the 10th SCSS organizing committee** and also **Melanie MacGillivray** for her "gracious presence, remarkable skill and energy" in hosting the spouse program.

*Military Merit*

**Cdr Richard Houseman** of DSE (who as Naval Architecture Officer at NEUP prepared HMCS *Restigouche* for Op Friction) — appointed Officer of the Order of Military Merit.

**CPO2 Wayne McIsaac** of PMO MCDV (founding member of the Naval Electrical Society) — appointed Member of the Order of Military Merit.

# TRUMP VLS Installation

## *Coming up in October*