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Maritime Engineering Journal

CANADA'S NAVAL TECHNICAL FORUM

February 1999

Engineering Incident: *Huron's* 1996 Gearbox Failure and Repair

Also:

- *Greenspace: "The Elusive Decibel"*
- *Canada and Hedgehog — The First Ahead-throwing ASW Weapon*

Canada

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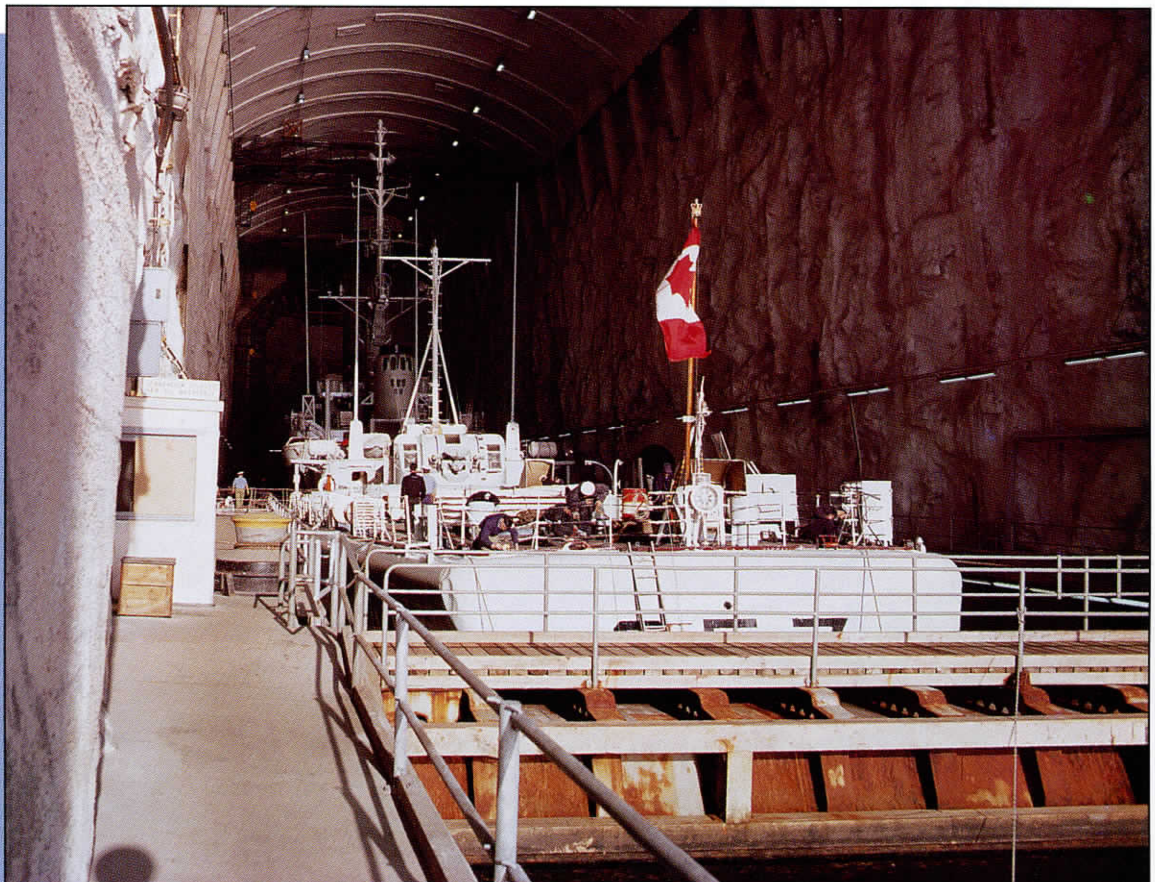

(Photo by Michael Young)

Check out our CNTHA Newsletter insert to find out what *Restigouche* was doing in this Norwegian grotto.

Maritime Engineering Journal

FEBRUARY 1999

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Director General
Maritime Equipment Program Management
Commodore J.R. Sylvester, CD

Editor
Captain(N) David Hurl, CD
Director of Maritime Management and Support (DMMS)

Editorial Adviser
Bob Weaver
DGMEPM Special Projects Officer

Production Editor / Enquiries
Brian McCullough
Tel. (819) 997-9355 / Fax (819) 994-8709

Production Editing Services by
Brightstar Communications,
Kanata, Ontario

Technical Editors
LCdr Mark Tinney (Marine Systems)
LCdr Marc Lapierre (Combat Systems)
Simon Igici (Combat Systems)
LCdr Chris Hargreaves (Naval Architecture)
CPO1 G.T. Wall (NCMs) **(819) 994-8806**

Print Management Services by
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Translation Bureau
Mme. Josette Pelletier, Director

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Our Cover:
This damaged flange attests to the destructive forces at work during the final stages of *Huron*'s 1996 gearbox failure. Story begins page 7. *(DND photo)*

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Editor's Notes

Focusing on Common Purpose

By Captain(N) David Hurl, CD
Director of Maritime Management and Support — Editor

After a number of years away serving the navy and the CF in the world of personnel, it's great to be back. I appreciated the opportunity to expand my horizons and gain an understanding of how the business we're in really *is* much bigger than material support, or even the fleet itself. I am especially thankful that I have been given the opportunity to return to the fold in a position that will allow me to influence naval readiness.

As Cmdre Mack points out in his own commentary, there have been amazing changes in just a few short years. We have a new, capable fleet, there are innovative and effective ways of providing material support, there is greater visibility into the expenditure of precious resources, and we are certainly operating in a more business-like manner. On the other hand, I see fewer people but don't yet see less work. There are well over a thousand active engineering changes in the bins (which for some reason doesn't feel quite right) and I sense that as a naval support community we may, at times, not always be pulling in a common direction.

As the Department's financial position continues to tighten it will be teamwork, a continuing desire to improve, a focus on common purpose and always our fine people that will allow us to provide our country with the most capable maritime forces possible. No doubt my first thoughts after only a week on the job will have to be revisited with more time on the plates, but one thing I am certain of — it is wonderful to be back.

Commodore's Corner

People, teamwork and the product — It's time to return to fundamentals

By Commodore I.D. Mack, CD
Director General Maritime Development and Operations — Assistant Chief of the Maritime Staff

Since last June I have had the opportunity to observe the Maritime Engineering community closely for the first time in nine years, and I am amazed at the achievements. Class desks, the Fleet Support Plan, equipment system management, two capable and results-oriented fleet maintenance facilities, and a modern fleet — all of these have been introduced in the past few years, and even now we are in the midst of introducing four ex-*Upholder*-class submarines into Canadian service.

What is remarkable is that all of this was being accomplished as we journeyed through a period of reduced funding. Change was the strategy, and the conservative, highly centralized and risk-adverse culture that typified the past was bombarded with incentives for transformation (with varying degrees of success). Today, everyone in the engineering community should be very proud of what they accomplished for the navy during the 1990s — even though our success has come at a price. Many of our experienced colleagues have left. Confusion exists over accountabilities for both units and individuals. There are doubts about a future characterized by liberal amounts of devolution and alternate service delivery. Trade-offs are more frequent in our world of diminishing resources, which inevitably leaves many good ideas unimplemented. There is discomfort with the perceived erosion of standards and with the frantic pace. As with the rest of Canadian society, trust in the leadership is tentative.

Well, it is when we are hurried, harried and confused that it is time to pause, and return to the fundamentals of people, teamwork and the product. Our slogan could be "People-R-Us." We are, after all, our most important resource, but we are also the first casualties of downsizing and devolution. The literature speaks of our human frailty when we are faced with dramatic change. We grieve the loss of what we have struggled to build and our self-esteem takes a beating, so we resist. Because we are all unique, we recover from the impact of change at different rates, but before we can adjust to one set of changes, another required change is upon us. It is continuous. We look for answers from those who lead, but there are fewer of them now, and they appear to be otherwise engaged in co-ordinating change in a labyrinth-like structure of diffuse accountabilities. We feel the tendency to turn inward, to stop worrying about others, to focus on our own duties. Less and less effort is made to communicate with each other, and relationships at all levels begin to break down.

It would be foolish to believe that this has not happened to some team members, given the renewal efforts of this decade. Teams are nurtured by the loyalty of members to one another, by their like-mindedness, and by a commitment to conform to a set of principles. Compliance follows. When we lose the time to communicate, to consult, to finish the exploration of concepts (like ASD and devolution), the team is weakened. Doubts can replace trust. If units and individuals start to rely on themselves alone, the team no longer functions as one.

And what is the effect of all this change on productivity? We have seen a general increase in efficiency and effectiveness throughout the team, but we have to be aware that there are still going to be imbalances across the team as individuals deal with the various organizational/procedural changes at their own pace. Furthermore, immature processes will tend to challenge the efficacy of the entire team, as can be seen in the aftermath (even three years later) of introducing the Regional Support Structure in MARLANT, in the absence of strong DCOS EM structures, and in the dramatic differences in coastal formation FMF and E&M structures.

As I glance through back issues of the *Journal*, people's concerns are very much in evidence: P.Eng. for MAREs, configuration control, employment of Certificate Four qualified PO1s, questions about the efficacy of decisions made during the frantic ship design days of the late 1980s and early 1990s. So too are the concerns apparent in comments I receive from members of DGMEPM and from the technical support communities on both coasts. What is the Maritime Staff doing about these challenges, I am asked, to ensure that we remain one naval engineering community, one team of people ensuring the technical readiness and sustainability of the fleet. Well, I have no panacea, only a few thoughts.

The first is that we all need to make more time to talk to one another — to the people who work for us, to those whom we work for, and to our co-workers. I reject entirely the suggestion that clear accountability structures eliminate the "wastefulness" of consultation. Where there is confusion, communicate on the issue. If addressing configuration change, even for EVALs or "mission fits," all team members need to be aware of what is transpiring, and must be given a chance to offer their input; it is the foundation upon which we all do our work.

My second suggestion is that we slow down. Mistakes in our business can be costly, as we saw in the tragic loss of life in the *Regina* RAS mishap some years ago, and more recently in a fire on board HMAS *Westralia*. It is when we are too busy and dealing with immature new processes that safety can be unintentionally sacrificed. As a senior leader I understand very well that doing "more with less" means doing it slower. But if on occasion our leaders (yours or mine) forget this, it remains our professional duty as engineers and technologists to remind them.

Third, accept that the practice of diffuse accountability (i.e. split among agencies) is here to stay. The Department of National Defence is part of a parliamentary system that is founded on checks and balances, and as such it will not soon evolve into an organization in which accountability assignment is singular and absolute. (Could that even exist?) Efforts to refine accountability frameworks and to clarify responsibilities will continue, but we will always be faced with what many interpret to be an imperfect situation. Learn to deal with it. The frustration it engenders only heightens the need for tolerance, mutual respect, positive thinking, focused goals and effective processes.

In this regard we are making headway. One of the tasks of the Director General Maritime Materiel — Capt(N) Bob Starchuk and his group — is to understand the team dynamics, identify imbalances, consult with the stakeholders in MARCOM and DGMEPM, and recommend interventions to VAdm Maddison. As the naval design authority, DGMEPM also monitors the situation, being responsible through ADM(Mat) to CDS for safe design and for maintenance standards. I also applaud the recent initiative to form the Naval Materiel Committee. These processes all take time and call for patience on everyone's part, but they are essential to the success of the team.

Finally, we should heed the advice of Kenny Rogers — "Know when to hold 'em, and know when to fold 'em." It may be human nature to resist change, but recognize that there are many ways to get a job done. Once the various arguments have been tabled, *let the leaders lead*. We are a very capable team, but we have been buffeted by the winds of change in recent times. Where we sense confusion, or even adversity, we need to slow down and talk it out, reach a decision and move on. At the same time we need to be aware of the human nature of those with whom we are in dialogue, and allow each of them to contribute their thoughts and ideas to the process. What it all comes down to is that we need to reinforce our ability to work as a team, and that means making it a personal goal to invest the time and effort to do so. To do otherwise is to risk failure.

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.

Letters

Dear Sir,

I read your Editor's Note in the October 1998 issue on MCDV procurement with interest, particularly your comments on the contractual construct for design and build of the vessels. The MCDV Project lessons learned will be important for all future warship projects. Commercial design rules are the wave of the future for warship design and construction.

In my position in the MoD Directorate of Naval Architecture I have seen similar methods applied to the design and construction of RN and RFA vessels. As in Canada, U.K. defence procurement policy leans heavily on commercial standards and classification society rules. The aircraft carrier HMS *Ocean* and the survey vessel HMS *Scott* are two recent ships built to class. Interestingly, they will also be maintained in class. The U.K. MoD has also climbed a steep learning curve to acquire the expertise to design and construct warships with the assistance of a classification society.

The relationship between the owner, the class society and the shipyard is a thorny issue in the U.K. as well as in Canada. One of the important lessons learned in the MoD is the need for the owner to involve the classification society early to assist in developing the design requirements. Classification society rules only provide a minimum level of design safety and they are often difficult to interpret for warships employed in non-traditional commercial roles. The owner must specify the additional requirements for a warship. Just meeting class does not ensure a warship is fit for purpose.

If oversight of vessels constructed under survey is primarily conducted by classification society surveyors, it is vitally important that the owner's requirements are understood and included. Owner's requirements address those aspects of ship design and performance that are above and beyond the basic design safety features offered by class. With poorly defined owner's requirements, the classification society surveyor is at liberty to determine what construction details are included in class. A shipyard can deliver a vessel that is not fit for purpose if no provision exists to ensure the owner's requirements are met during build.

The world is moving toward commercial standards and the classification societies are responding. As you probably know, Det Norske Veritas and Lloyd's Register of Shipping have rules for naval vessels currently under development. I have been involved in the MoD section managing the Lloyd's initiative to develop rules that will replace the current MoD design standards for structure. When Lloyd's rules are published (currently forecast for March 2000) they will provide much more comprehensive guidelines for warship construction and address many issues in class that would currently be considered owner's requirements. Modern design standards for ship structure will almost exclusively be supplied by classification societies. The MCDV procurement lessons are important and will prove valuable no matter what Canada's next naval vessel will be.
— LCdr D.B. Peer, A/NA111, Submarine Naval Architecture, Ash 0a #95, MoD Abbey Wood, Bristol, BS34 8JH

Forum

Response:

The Branch Advisor on P1 Cert Four Employment

Dear CPO2 Getson,

In your submission to the *Maritime Engineering Journal* [Forum, October 1998], you raised several concerns with respect to employment of PO1 Mar Eng Artificers who have achieved their Certificate Four qualification. As many senior members of your MOC can verify, the production of the required numbers of Certificate Four qualified personnel to meet the needs of the navy has long been a source of considerable concern and effort. In the past, the manning situation in Mar Eng MOCs dictated that promotion to a higher rank was virtually automatic upon achievement of the next appropriate watchkeeping certificate. However, this practice was symptomatic of an MOC that had very high flow-through rates caused by several factors. As you point out in your article, for the first time in many years our Certificate Four production in the past two years has significantly outpaced the promotion demand to the rank of CPO2.

According to the 1998 Annual Military Occupation Review of Mar Eng MOCs, over the next five years there will be a need to make 56 promotions from PO1 to CPO2. Given the present and forecasted Cert Four production, there should be three Cert Four qualified PO1s competing for every promotion to CPO2. The Mar Eng MOCs have now reached a point where promotion to CPO2 can be based on a broader set of competitive criteria, vice selectivity predominantly based upon qualification.

In your letter you raised a concern with respect to having personnel qualified for positions higher than they are authorized to fill. This is in part true, but does not address the full scope of what is required. Those who have obtained Certificate Four qualification have demonstrated their technical competence in front of a board of superiors. However, one's leadership skills are also of paramount importance, and one's day-to-day activities provide the best opportunity to hone and demonstrate these skills. Our Personnel Appraisal System provides the process to identify those with the necessary leadership skills to complement our technical qualification process. For those PO1s who have achieved their Certificate Four qualification, the journey is not over. Although they may be employed at sea as EOOWs, there is ample opportunity for them to assume more demanding roles to improve and polish their leadership skills, and hence, improve their chances of promotion.

Is this too much to expect from these individuals? I think not. Their future role is to lead sailors in a very demanding environment. Our sailors deserve the best leaders we can produce, and it is the Cert Four qualified PO1s who have demonstrated the necessary leadership skills who will be selected for promotion to assume the demanding jobs that CPO2s fulfil at sea and ashore. This is a good situation for the navy as well as the Mar Eng MOCs. In essence, our efforts over the past decade to stabilize the structure and flow-through rates of the MOC are starting to pay dividends.

You suggested that without some form of immediate reward upon achievement of Cert Four there is no motivation to acquire the qualification. I do not agree. All qualifications simply open the door to new opportunities for individuals, and there are many motivational factors to consider — such as the opportunity to gain greater job stability through selection/acceptance of an IPS offer; the opportunity for promotion and increased take-home pay/retirement package; the opportunity to stop standing sea watches for the rest of one's naval career; to spend more time with one's family (due to the difference in sea/shore ratios between PO1 and CPO2 ranks); the opportunity to lead the engineering section of the Marine Systems Engineering Division as Chief ERA; and to have a greater influence on MOC career and technical decisions.

For those who focus on and understand the importance of leadership, there are many rewarding opportunities to vie for, such as becoming one of the five most senior NCMs in a ship, including coxswain — the CO's advisor on sailors' matters; or becoming a Formation CPO; the Navy CPO, or the CF's most senior ranked CPO. None of these monetary, quality of life or new employment opportunities is available unless the combination of demonstrated leadership capability and Certificate Four has been achieved. It is from these larger aspects that PO1s must look at the achievement of a Certificate Four qualification. It is not an end in itself, but a preparatory step leading to the assumption of greater responsibilities within the navy.

You are to be commended for raising your concerns. It is my hope that with this information you can better understand and support the manner in which the Mar Eng MOC will be managed in the future. **— Capt(N) D.G. Dubowski, CMS/DMMPD, Branch Advisor, MARE and Sea Technical MOCs.**

Life After the Forces

When Serge Lamirande left the Canadian Forces after 22 years of naval service to join the private sector as a project manager for Securiplex in Montreal, it didn't take long for the reality of civilian employment to make its mark. Now, a year and a half later, he looks back at working life on both sides of the fence.

Article by LCdr (ret.) Serge Lamirande

It really hit home that I wasn't working for the government anymore in the first week of my new civilian employment. During my very first section meeting as a project manager in the private sector, my new supervisor called a follow-up meeting for five o'clock that afternoon. I decided I had better draw my line in the sand right away to show where I stood with this kind of "business" behaviour, and proceeded to tactfully tell my supervisor that I was a "retiree" and that in my previous employment everybody was at home at 1700 hrs on a Friday afternoon. A thunderous laugh from all the section members was the only response I got. They thought I had quite a sense of humour (and still do).

Well, you often hear the dictum that you don't realize how good you have it (a car, a relation, or even a job) until it's gone. In my case, I truly enjoyed my 22 years with the navy because of the wide range of responsibilities I was challenged with throughout my career, and more importantly because of the great people (officer and non-officer, alike) that I served with. I knew then, as I know now, that I would never have as much fun in any other workplace as I had in the navy. However, the navy is a young people's outfit and I was getting to that age where what remained for "maturing personnel" like me was the administrative drudgery of life behind a desk. Hence my decision to jump ship. Now, a year and a half after leaving the navy, I would like to offer some of my observations on the "cultural" differences between public and private sector employment.

Rule #1 — The "Prime Directive"

In my first week at work I was taught the prime directive — the customer is "God" (within reason). Quite simply, when dealing with the customer, you have to meet his expectation of the end product. As an engineer officer in a ship I was used to keeping my commanding officer happy, but now with our DND customers I was in the unusual position of having to look at my former colleagues and peers as the gods I had to satisfy! This was the first cultural difference I noticed between the two systems.

Rule #2 — Profitability

The second major cultural difference for me was the idea of profitability. We have to make profit to survive in the corporate world. No matter how good our product is, our success will be measured by the amount of profit that is made. This is in stark contrast to the paradoxical world I was used to in the navy. When you are at sea, the aim is quite simple and the mission is clearly defined at the start (whether it's a fishery patrol or a NATO exercise), but the measures of success are more intangible (and profitability is never one of them).

Rule #3 — Meet Deadlines

We must meet deadlines for the simple reason that we have invoiced the customer on time. Not doing so has the following impact on the company:

• Rule #1 is contravened because the customer's expectations have not been met;

• The chief accounting officer starts spending an increasing amount of time in your office (counselling/advising/nagging/threatening) because his "cash flow" has been disrupted;

• Rule #2 is jeopardized because you have indicated on your time sheet that you (and your team) will need to spend more time than planned to complete the project.

By comparison, the sense of urgency to meet deadlines in the navy is certainly there in operations. However, at the headquarters level it's another story. There, the milestones are often more intangible and the customers (the ships) are seldom in your face.

Sense of Purpose

Private Sector Sense of Purpose: It is quite simple — refer to Rule #1 and Rule #2.

Canadian Navy Sense of Purpose: In the navy, the sense of purpose is, I believe, much higher. The private sector perception of the navy is one of an exciting life (in operation). It is often with extreme pride that co-workers will mention that they installed a system on a particular ship that made the news the night before. There is deep respect (envy) for the professionalism and competence of the personnel serving at sea. I acknowledge that life at sea is not easy for the sailors (no paid overtime), but I like to think that ultimately there is a higher purpose of serving in the navy, which is serving our country (and its citizens). Although some of my civilian co-workers sometimes work long hours of paid overtime, the financial benefit does not seem to fully compensate them for their perceived loss of personal time. I truly believe that working for a higher purpose can compensate for a lot of sacrifices that an individual has to make.

Working Conditions

You will never get rich in the navy. Let's face it, you are a multipurpose expendable asset owned by the government — not a hockey player. At sea the working conditions can be quite gruelling (e.g. workups) and the deadlines are very tight at times. However, shore postings are often viewed by some as a "payback time." It is a world of paradoxes, the stress is certainly there in operations, but once the mission is over, or when you are posted ashore, the working conditions are usually somewhat better. There is a level of security and comfort that can quite easily lead to complacence.

The private sector looks at Forces personnel with envy for two reasons:

• the exciting life they appear to enjoy (perception true or false), and

• the apparently unlimited security they seem to have.

I am often reminded how good the conditions are in the public sector when I receive a voice mail from a customer at NDHQ asking me to call him back prior to his departure for home at 1500 hrs that afternoon. In the private sector you are just getting warmed up by the time three o'clock rolls around!

Measurement of Competence

Tolerance of incompetence in the private sector is inversely proportional to the level of responsibility held by the individual; i.e., the level of tolerance decreases very quickly with the increasing level of responsibility held by an individual. There are three reasons why incompetence compromises the success of the company:

• Rule #1;

• Rule #2; and

• Rule #3.

In the public sector, however, most individuals are not bound by Rule #1 (they *are* God), they don't care about Rule #2 (profit just isn't a factor), and Rule #3 is more often than not loosely established (Deadlines? Let's do another study!). Incompetence is, therefore, perhaps more difficult to measure and deal with.

Conclusion

Any regrets? Both systems, the public service and the private sector, have advantages and disadvantages. At the end of the day, nobody has the insight to judge for you whether the decision to "stay or go" is the right one. The only person who can judge that is you, and the test is to ask yourself "Am I happy with this?" The worst decision is to not take any decision at all.

Serge Lamirande's last navy appointment was as Commanding Officer of the Naval Engineering Test Establishment in LaSalle, Quebec.

Our Photo Contest Deadline is April 30th!

(See the October 1998 Issue for Details)

1996 Engineering Incident:

HMCS *Huron* Gearbox Failure and Repair

Article by LCdr Darren Rich, CD

Part I — The Incident

On the afternoon of Wed., April 24, 1996, HMCS *Huron* (DDH-281) was in the midst of Week Three of workups. At approximately 1551 that afternoon she was running on both cruise engines when the bridge ordered a normal speed increase from 10 to 15 knots. At that time, the port cruise engine tripped out due to a gas generator N2 overspeed trip. At the same time, the machinery control room (MCR) watchkeeper reportedly heard what sounded to him like a low-flying jet aircraft. The engineering officer of the watch (EOOW) immediately assumed power on the port main engine and sent a roundsman to the main machinery room (MMR) to investigate. When the door to the MMR was opened, a loud banging noise could be heard from the vicinity of the port main gearbox. The EOOW rang engineering emergency, the ship was stopped and the problem was investigated.

The investigation revealed that the cruise engine extension shaft had been displaced. Nine bolts — or portions thereof — were observed lying loose in the port main gearbox. The port shaft was ordered locked and *Huron* sought technical assistance from the Technical Officer, Maritime Operations Group Four (MOG 4 TO) and staff from Maritime Forces Pacific Headquarters (MARPACHQ/N42-2). *Huron* was advised to remove the loose debris, but to leave the remainder of the gearbox intact until it could be viewed on the ship's arrival in Esquimalt the next morning. Stephen Bobyn, the NDHQ life-cycle material manager for transmissions, was immediately informed and he arranged for MAAG to dispatch field service representative (FSR) Bert Jost to arrive the following Monday. Mr. Bobyn would also meet the ship in Esquimalt. Upon *Huron*'s return to Esquimalt, it became evident that the gearbox covers would have to be removed to uncover the extent of the damage. That was completed by Saturday morning.

The initial reaction in MARPAC was to ensure all concerned were aware of the failure. Repairs were initially estimated at anywhere from two weeks to two months, depending on the degree of damage. Commander Mosley (MOG 4 TO) conferred with the Commander MOG 4 who had discussed the issue with the Commander Sea Training. It was agreed that workups would be terminated and concluded at a later date. The immediate assistance of staff in DGMEPM was sought and MARCOM/MARLANT engineering authorities were advised of the situation. The failure of *Huron*'s gearbox raised the possibility that this might be a class-wide problem, but a review of her gearbox operating hours muddied the picture. She was the "low time" ship and the last out of the TRUMP modernization refit program.

Discussions with both DMSS 3 and MARLANT concluded that the only other ship in a potential position of immediate danger was *Huron*'s sister ship, HMCS *Algonquin* (DDH-283), then at sea on passage to Inchon, Korea. A flurry of telephone calls between MARPAC N42 and J3 staffs and DMSS 3 late Friday afternoon concluded that it would be prudent to impose engineering restrictions on *Algonquin*, at least until the exact cause of *Huron*'s failure could be determined. *Algonquin* was contacted via Inmarsat that afternoon and advised not to exceed 15 knots while on cruise engines, and not to change speed by any more than two knots per 30 seconds while maneouvring on cruises. The restrictions were not well received. By Sunday afternoon it became apparent from the message traffic that neither *Algonquin* nor the Commander MOG 2 (who was em-

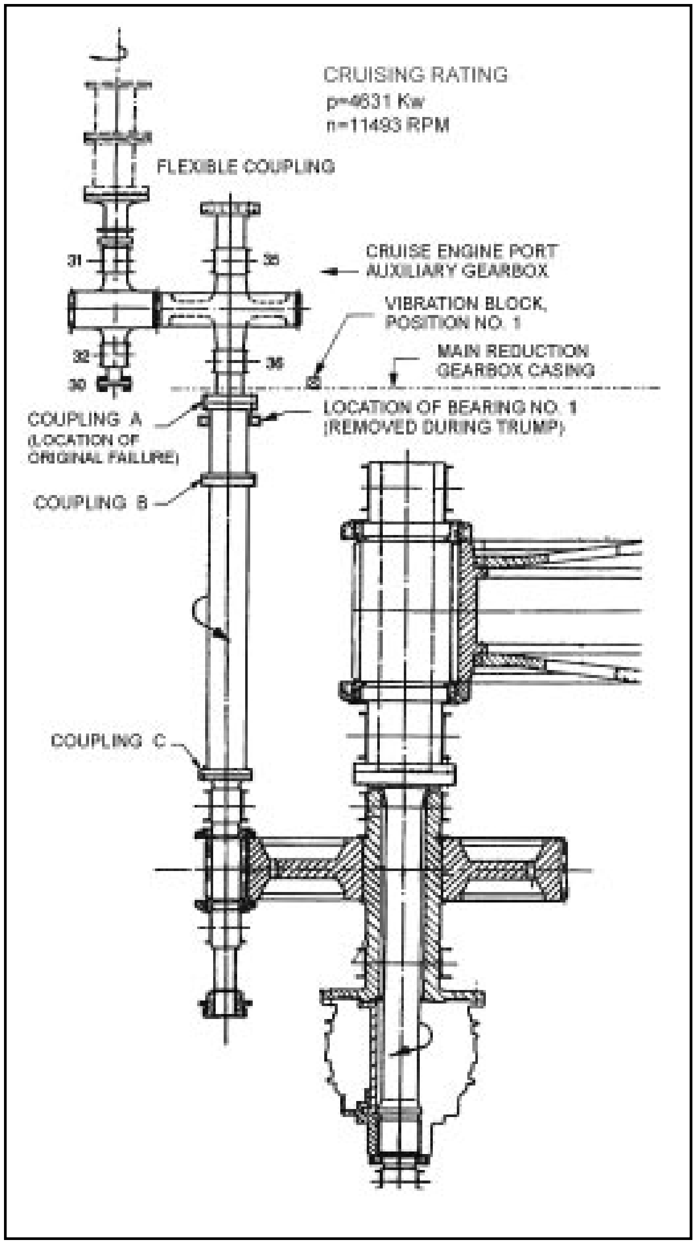


Fig. 1. HMCS *Huron* Port Gearbox Arrangement ***(Diagram courtesy S. Bobyn and G. Jette, DMSS 3)***

barked in the ship) concurred with the restrictions. Both had sent messages indicating their extreme displeasure at having a speed restriction imposed upon them by MARPAC N42 staff. Nevertheless, they complied.

A video produced by the author and *Huron*'s engineering officer was shown at the MARPAC Monday morning brief, whereupon it was discovered that the speed restriction agreement had not been passed up the operations chain within MARPAC. An e-mail address group was subsequently created to include everyone up to and including the MARPAC Chief of Staff, and was used successfully on many occasions to provide up-to-date information to both coasts and DGMEPM staff within a matter of minutes. Events then returned to some degree of normalcy, if you can call a major gearbox failure anything approaching normal. Several hours later the MAAG FSR arrived and shortly thereafter came the pronouncement that took everyone by surprise.

The FSR's Discovery

Prior to Mr. Jost's arrival, preliminary examination of the gearbox and its casing by Command Gearing Inspector Richard Mills uncovered signs of corrosion and rust in the vicinity of the old No. 1 bearing housing, where the initial failure took place (*Fig. 1*). A cursory examination of the bolts by Esquimalt Defence Research Detachment (EDRD) pointed to stress corrosion cracking being the mode of failure, but on early Monday afternoon Mr. Jost dropped his bombshell — the failed bolts did not appear to be MAAG products, nor were they in compliance with MAAG bolt design (*Fig. 2*):

- the copycat bolts were etched with a two-digit number, whereas the MAAG bolts were stamped with a two- or three-digit number;
- the copycat bolts appeared to have been machined and finished by lathe, unlike the MAAG bolts which had a high-quality finish;
- the heads of the copycats were 15 mm in diameter, as opposed to the 18-mm diameter of the MAAG bolts;
- the copycat bolts had a countersunk hole drilled deep into the head; and
- the copycat bolts featured a smaller 7.5-mm neck diameter immediately under the bolt head, as opposed to the 9.0-mm diameter of the MAAG bolts.

DMSS 3 and MARLANT were contacted immediately. MARLANT ordered a check of *Iroquois* (DDH-280) and *Athabaskan* (DDH-282) first thing Tuesday morning (*Athabaskan* was scheduled for a full-power trial Wednesday morning, while *Iroquois* was in the midst of an alongside maintenance period).

Fig. 2. The non-spec bolts: the upper bolt in the top photo; the bolt on the left in the lower photo.

Algonquin's engineering officer was also informed of the problem and requested to immediately inspect the input flange bolts for the irregularities.

By Wednesday morning it had been determined that both East Coast tribals had had the non-compliant bolts installed. It was then that NDHQ imposed an immediate ban on the use of the cruise engines pending replacement of the suspect bolts with MAAG-supplied, or compliant, bolts. That left only *Algonquin* to check in. Much to everyone's relief, *Algonquin*'s bolts were reported to be compliant and the restriction was subsequently removed from her plant. (It was later discovered that four of the MAAG bolts on the starboard side had been ground, and that three of them had what appeared to be microscopic cracks on the neck of the side opposite the ground sections. Also, the removal torque on these bolts exceeded that expected for the recommended installation torque. As a result, all 32 bolts were replaced with manufactured bolts from FMF *Cape Scott* in September 1996. The bolt holes of the two mating flanges were rebored, similar to those on the other three tribals, and ground to fit bolts were installed.)

Extent of the Damage

Once *Huron*'s gearbox was opened, it was found that the bolts connecting the port cruise auxiliary gearbox output shaft to the port main gearbox cruise input shaft had failed (*Fig. 3*). Indentations from bolts passing through the gearing mesh were found on the main bull wheel (*Fig. 4*), and on both the upper and lower main engine input pinions and the cruise engine input pinion. The cover photo on this issue of the *Journal* illustrates the damage to the port cruise engine reduction gearbox output flange. Subsequent surveys of the sump and other areas of the gearbox resulted in the recovery of all but 20 grams of the total estimated weight of the failed components. This missing amount would figure prominently in future events.

With the MAAG FSR on site, a plan was set in motion to conduct the majority of the repairs in-situ. The cruise engine extension shaft was removed to EDRD for non-destructive testing and inspection at FMF *Cape Breton*. The port cruise engine auxiliary reduction gearbox was removed and returned to MAAG for overhaul and repairs. It was returned and reinstalled in November 1996. The plan was to hone the high spots on the most seriously damaged teeth with the expressed hope that *Huron* would be ready within two weeks.

The lube oil was changed, the gearbox was closed up and a basin trial was attempted on Wed., May 8. Unfortunately, a "gravel truck" sound was clearly audible and it was clear that a more complex repair process would have to be undertaken. At that point there were three options to consider:

- grind and hone all the teeth as completely as possible in-situ;
- remove the gears and send them back to MAAG to be fixed; or
- contract MAAG to manufacture replacement gears.

The last two options would ultimately involve removing and replacing the bull

Fig. 3. Note the sheared off bolt heads on the connection between the auxiliary gearbox output shaft and the main gearbox cruise input shaft. ***(Base Esquimalt photo)***

Fig. 4. Not a pretty sight. Aftermath of bolt passage through the gearing mesh. ***(Base Esquimalt photo)***

wheel and the associated pinions. At this point the Naval Architect section in FMF *Cape Breton* was tasked to determine the optimal removal route, considering costs and disruption to the ship's routine. The tasking was not an easy one. The bull wheel measured approximately 2½ metres (eight feet) across and weighed more than eight tons. Removing such a large object from the ship was not a low-risk proposal. [In fact the lead time to produce a new bull wheel was 10-12 months, at a cost of almost $450 K CDN, which further precluded this option.]

Second Repair Attempt

After carefully considering the options and discussing the degree of risk and potential for success if the in-situ regrinding process was followed, it was agreed that it would be prudent at least to attempt it. If all went well, the ship could possibly be back in service within a month. If not, we could not be reasonably criticized for not following a graduated response process.

In order to turn the gearbox more easily using the turning gear motor, the Vulcan coupling was disconnected as was the main engine input coupling. Under the watchful eyes of either the MAAG FSR or the Command Gearing Inspector, personnel from Shop 133 began grinding the nitrided tooth surfaces using a dremel tool, and finished the work using handheld diamond hones. Not only was this a painstaking process, but it was further complicated by the exhaustion of local supplies of diamond hones which then had to be special-ordered from the United States. The work involved inspecting both sides of the 293 teeth on the bull wheel, the 53 teeth on each of the two secondary pinions, and the 39 teeth on the cruise pinion. Production staff, the MAAG FSR and Command Gearing Inspector worked double shifts and through the weekends to complete this work in just under a month.

On Thurs., June 6 we attempted a second basin trial, which did not go well. But this time there was an unexpected wrinkle. Immediately upon assuming power on the port side, a loud, thumping noise was heard coming from the gearbox. The inspection port covers were removed and additional damage to the gear teeth was readily evident. It was then reported that several foreign objects had been discovered by ship's staff during the final flushing of the gearbox, but were dismissed as the missing 20 grams of debris.

Subsequent investigation revealed that two foreign mild steel small bolts (similar to those found on the IMCS cable trunking), a round metal disc and a larger foreign mild steel bolt of unknown origin had passed through the gear meshes. *Huron* contacted the military police to investigate how these objects could have been introduced into the gearbox, especially considering the degree of "open gearbox" discipline invoked by *Huron*'s engineering officer from the outset.

Third Repair Attempt

Keeping the old adage of "third time lucky" in mind, it was agreed that the second attempt at repairs would have been successful if these objects had not been in place. Therefore, a third repair attempt was mounted.

Another two weeks of grinding and honing was required to repair the damage. The third basin trial was attempted on Thurs., June 20, and sound readings and vibration analysis readings detected no appreciable difference in readings from before the failure. The ship immediately slipped and proceeded to sea to conduct an at-sea trial devised by FMF *Cape Breton*, the MAAG FSR and the LCMM.

While repairs were being conducted in *Huron*, DMSS 3 LCMM and FMF *Cape Breton* engineering staff were working on a post-repair trials agenda that would provide all concerned parties with the necessary assurances that the port main gearbox was fit for service. It was felt that, as the helical teeth are progressively loaded in a similar fashion to those in the Y-100 main gearboxes, working the ship up to full power would allow for any noise increases to be detected. Due to the location of the "zone of repairs," that is, the general area along the tooth surface where the damage occurred, it was agreed that the gearbox would be loaded along this zone by the time it reached 70 percent full power. *Huron* was slowly brought to 70 percent full power with no appreciable increases in noise or vibration readings, at which point she was stopped and the meshing patterns of the teeth were verified and inspected. *Huron* was then brought to full power without incident.

Although problems with her torductors prevented the ship from fully completing the trial, the trials staff was satisfied with the readings and *Huron* was given a clean bill of health. Sound rangings conducted the following day proved equally satisfactory. FMF *Cape Breton* issued *Huron* with a report stating that her gearbox was certified for full power, with the exception of crash stop manoeuvres which would be tested at a convenient opportunity. Her torductors were successfully calibrated on Sept. 23, 1996.

Part II – The Investigation:

Back during the morning watch on April 24, the EOOW had noticed an unusual noise originating from the port main gearbox. The Data Trap was used to take readings from four of the 15 blocks, but unfortunately this task was never completed due to a change in speed; nor were the readings reviewed prior to the failure that afternoon. What the limited Data Trap data showed was a reading approximately 26 to 32 decibels above the fleet average. A spectrographic plot indicated high vibration at rotational speed and the associated harmonics. While we will never know for sure, this was almost certainly an early indication of the onset of the failure.

The initial investigation found evidence of saltwater ingress and subsequent corrosion in the vicinity of the old No. 1 bearing housing. Signs of reddish deposits on some of the failed bolts were also taken to be rust until the Esquimalt Defence Research Detachment determined they were not. What they did confirm, however, was that at least three of the 16 bolts had failed due to corrosion fatigue. (The EDRD investigation of the failed bolts had in fact uncovered three distinct failure modes — corrosion pitting fatigue, cyclical tensile loading fatigue, and ductile failure — all of which contributed in one way or another to the damage suffered in this incident.) This made it possible, it was hypothesized, for the remainder of the weakened and non-spec undersized bolts to subsequently fail due to increased stress.

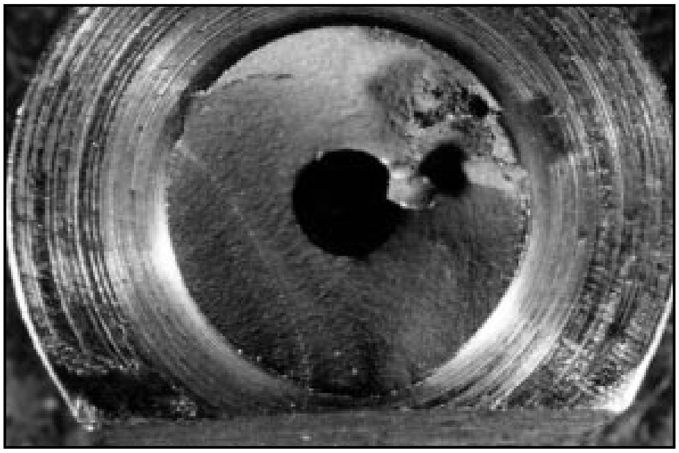


Fig. 5. The centre-drilled hole in this bolt head, coupled with the smaller diameter of the neck, resulted in a significant loss of material and a corresponding loss of strength. Microscopic analysis revealed many small beach (clamshell) marks, in addition to the large beach mark, which were indications of cyclical tensile loading stresses leading to progressive cracking.

The first step in solving the puzzle was to analyze the reddish substance seen on some of the failed bolts. Although no match was found with any substances commonly used in Esquimalt, it was determined that this was an organic compound, most likely a lubricant, and that it had been present since installation. Furthermore, it was determined that using the MAAG dry torque on a lubricated bolt would lead to an installation torque more than double that called for by MAAG and a resulting load 120 percent higher than design. It was subsequently discovered that, of the three ships having non-spec bolts, *Huron*'s port gearbox was the only one that was torqued to these levels, and the only gearbox found with this organic compound on the bolts.

Fig. 6. Silent witness: this collection of bolt and nut material was recovered from the sump.

In determining the failure mechanism of bolt numbers 1, 9 and 10, the issue of corrosion came to the fore. As previously mentioned, evidence of saltwater ingress and the subsequent initiation of pitting corrosion in the vicinity of the failure site led to the initial speculation of stress corrosion cracking initiated by pitting corrosion in the neck area of the three bolts. The non-MAAG bolt dimensions were also a factor in that the smaller diameter bolt head failed to provide an effective seal of the bolt holes, and the smaller diameter neck reduced factors of safety. This allowed continuous access for sodium, chloride, potassium, calcium and magnesium, thereby accelerating the corrosion process on the smaller-diameter neck. Ironically, if all the bolts had been coated with the organic compound mentioned previously, the corrosive effects of the salt-laden moisture in the gearbox might not have affected these three bolts. On the other hand, the higher torque on these bolts due to the compound may have reduced the cyclic stresses required to initiate fatigue cracking by a factor of three. *Huron* had clearly been in a no-win situation.

While pitting corrosion was a factor in the failure of three bolts, the main mode of failure was cyclical tensile loading failure (*Fig. 5*). The centre-drilled hole, coupled with the smaller diameter of the neck, resulted in a significant loss of material and a corresponding loss of strength. Microscopic analysis of this bolt head revealed many small beach marks (i.e. clamshell marks), in addition to the large beach mark, which were indications of cyclical tensile loading stresses leading to progressive cracking. This process continued to a point where the material was sufficiently weak for a final, catastrophic ductile (tearing) type of failure to occur.

Fig. 7. The after flange (centre) — minus its bolt heads! *(Base Esquimalt photo)*

In its report, EDRD stated:

> Corrosion appears to have played a key role in the initiation and the growth of the cracks in three of the sixteen bolts and it is conceivable that it was only after these three bolts failed by a corrosion fatigue process that the stresses in the remaining bolts became sufficiently high to initiate fatigue cracks without the aid of pitting corrosion. It has been well established that in martinsitic steels the presence of a chloride containing environment significantly reduces the stresses necessary to initiate fatigue cracks.

The other failure discovered was the loss of a portion of the port cruise auxiliary reduction gearbox output flange (*see cover photo*) which had been torn away during the failure. Analysis of this item revealed that the failure initiated on the side closest to the mating flange and fractured most of the way through the thickness before arresting. Final failure occurred more progressively as evidenced by a number of beach marks. This piece was broken off in the final stages of the failure as one of the remaining bolts was drawn through the then existing gap between the flanges, forcing this part to break off.

Once the forward flange was free of the cruise flange, it continued to flail about until the gearbox was stopped. The after bolts, installed by MAAG, were then subject to cyclical stresses and broke at their weakest point, the reduced section adjacent to the threads. The shaft rotation coupled with the elastic energy of the bolts as they snapped was sufficient to send the pieces flying through the gearbox at which point they passed through the mesh. *Figure 6* shows the collection of the bolt and nut material initially recovered from the sump, while *Figure 7* shows the after flange minus its bolt heads.

Concluding Material

This was, without a doubt, one of the most technically challenging repair and investigation efforts undertaken by the Canadian navy since the superheater header scare of the early 1980s and the turboblower mystery of 1987-88 [see "The Trouble with Turboblowers," *Maritime Engineering Journal*, Jan./April, 1990)]. Discussing the *Huron* incident later, Mr. Jost said that while MAAG had made similar in-situ repairs for smaller warships in the Far East, this was the first time they had attempted in-situ repairs of this magnitude.

DGMEPM staff continued to investigate this issue as they attempted to determine how these bolts made their way into three ships. There were still many unanswered questions, such as:

- How did the bolts get there?
- Why were there differences in the installation torques between *Huron* and the two East Coast tribals? and
- Why the difference again in *Algonquin*?

Acknowledgements

I would like to acknowledge those individuals whose expertise, knowledge and advice helped ensure this repair was satisfactorily concluded. The list is extensive, but includes everyone from the following organizations who assisted in any way with this project: DGMEPM, MARCOM, MARLANT, MARPAC, FMF *Cape Breton*, FMF *Cape Scott*, EDRD and MAAG.

At the time of the Huron *gearbox incident, LCdr Rich was head of the Marine Systems section in the Engineering Division of Fleet Maintenance Facility* Cape Breton*. He is currently attending the Canadian Forces Command and Staff College in Toronto.*

[This article accurately describes the sequence of events regarding the *Huron* gearbox incident, up to the completion of the in-situ repairs required to get the ship back to sea as soon as possible. It should be noted that at this stage (September 1996), *Huron* was operational, but with only the starboard cruise drive train available, as the port auxiliary gearbox had been removed and sent to MAAG in Switzerland for factory repair. At this time the failure analysis for the incident was thought to be accurate and conclusive, with the complete failure mechanism known and accounted for.

A continuation article by the LCMM in DMSS 3 will chronicle the subsequent activities regarding this incident. It will include the technical investigations for the source of the nonconforming bolts, the factory gearbox repair, postrepair installation of the auxiliary gearbox, postinstallation alignment of the port cruise drive train, postrepair trials and postrepair secondary incidents(!). The article will show that the subsequent activities revealed additional causes for the initial failure, and will summarize the effort required to restore *Huron* to full operational capability. **— Stephen Bobyn, DMSS 3-7-2**]

Naval Maintenance for the New Millennium

Article by Lt(N) David Evans

In the tumultuous downsizing, rightsizing and reengineering of the 1990s, the black art of naval maintenance has lost its focus. Organizations have lost significant numbers of people, and additional responsibility and accountability are being devolved to those who remain. In an attempt to bring naval maintenance back into focus for us all, we need to look beyond the fire in the hole to the "whole of the fire." This article examines how we got to where we are now, and by emphasizing the current naval maintenance policy, shows that the Naval Maintenance Management System (NaMMS) is alive and well.

Evolution of the Naval Maintenance Management System

Following World War II, maintenance of ship's equipment was mainly directed to the repair of defects. Destroyers were docked annually and refitted every two years. Refit maintenance and repair lists consisted of known defects, mandatory inspection of certain equipment and a number of "open and rectify defects found" items.

During the operational periods between refits, engineers and technicians applied their own system of preventive maintenance to that equipment for which no preventive maintenance requirements had been stated. Maintenance efforts were based on specific maintenance directives where they existed, guidance provided in maintenance manuals, experience and good engineering practice. In the absence of a formal maintenance management system, maintenance of HMC ships was carried out in an ad hoc manner and to no particular fleet standard.

With the increase in complexity and number of equipment fitted in the *St. Laurent* and later destroyer classes, it was recognized that preventive maintenance must be planned, organized and directed if degradation of equipment performance was to be kept to a minimum. In 1958 Naval Headquarters approved the RCN Planned Maintenance System which provided maintenance schedules and performance tests for equipment and systems, a managerial system for directing and controlling the shipboard preventive maintenance effort, and an information system.

Promulgated in BRCN 6429, the RCN Planned Maintenance System was a significant step in the evolution of naval maintenance policy and practice. It incorporated manufacturer recommendations into standard maintenance routines, established naval authority requirements and generated maintenance practices of the day. The objective of the planned maintenance system was to keep systems and equipment in like-new condition.

Build-up to the Present Day

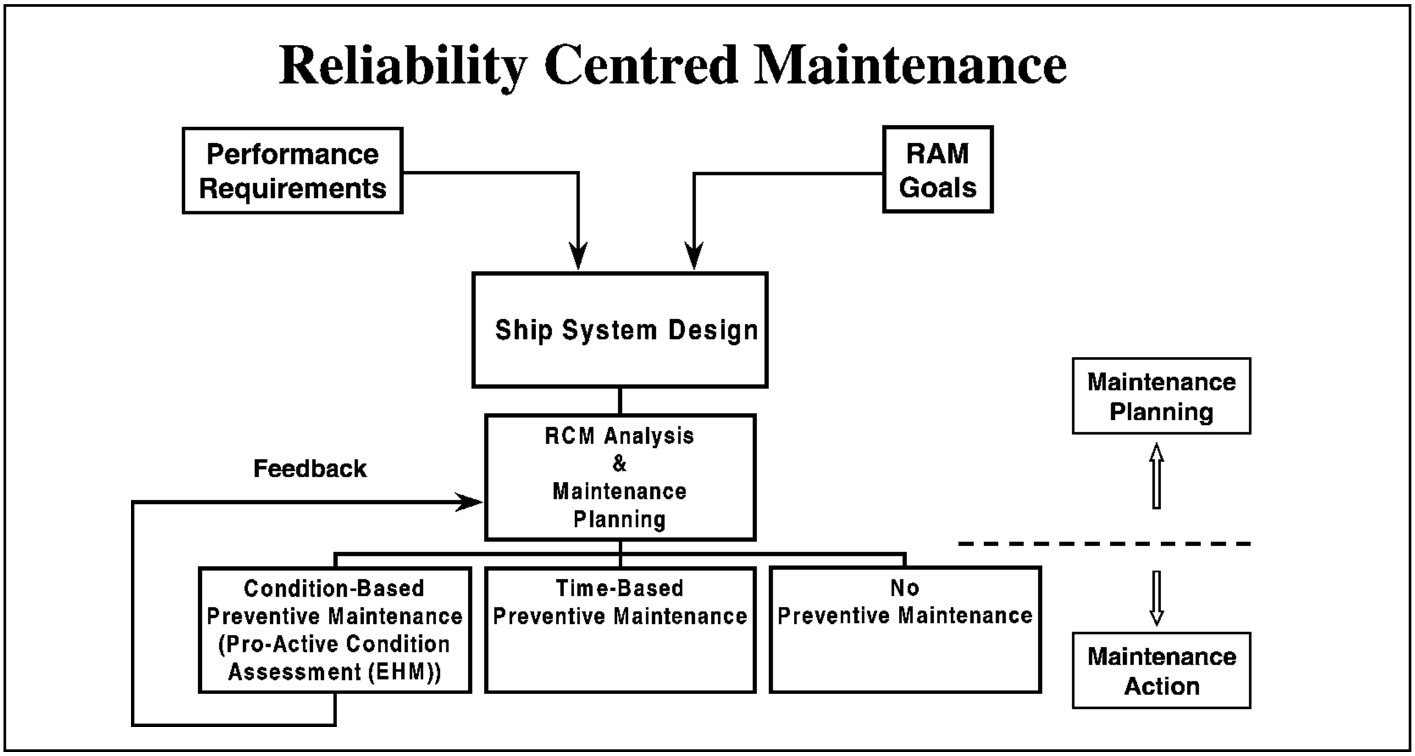
In the late 1960s a series of reports and policy decisions, as well as the emergence of automated data processing as a management device, contributed to the scope of the naval maintenance system as it was constituted in 1974. Preventive maintenance activities continued to be time-based, and considerable resources were expended maintaining and overhauling equipment whether its condition warranted it or not. Life-cycle management was introduced into the Materiel group in NDHQ in 1977 with activities that included research, design, production, evaluation, acquisition, installation, maintenance, logistic support, configuration management, modification and, finally, disposal. Although life-cycle management is not a part of a naval maintenance system, it has significant interaction with it.

The drive in the early 1980s to ensure that optimum benefit was being realized from the maintenance effort brought about a change of maintenance concept. Naval maintenance went from being a time-based process to one centred on reliability. The reliability centred maintenance (RCM) requirements and the application of resources to satisfy those requirements were promulgated in the 1984 naval maintenance policy statement which introduced NaMMS. The change in maintenance concept was predicated on the achievement of a balance between available resources and the degree of operational availability that was desired. Using analytical techniques it could be determined whether preventive maintenance would be done at all, and if so whether it would be time- or condition-based, and what work would be performed. Time-based maintenance was retained only where safety requirements dictated that every precaution be taken to prevent failure, where continued availability of the system was operationally essential and for systems which did not lend themselves to condition-based maintenance.

Throughout the early-to-mid-1990s significant changes were made to functional responsibilities and resource accountability in the maintenance arena due to the considerable downsizing and restructuring that was occurring. Many organizational changes took place, including the stand-up of the fleet maintenance facilities (FMFs), and the transformation of MARCOM into the Chief of Maritime Staff (CMS) organization (and its subsequent move to NDHQ). The maritime engineering and maintenance (DGMEM) division also evolved to become DGMEPM, embracing a philosophy of maritime equipment program management by placing procurement officers, materiel managers, class managers and support personnel in one division. A business management discipline was introduced and business planning was applied at each divisional level. Through all of this, the fundamental and essential elements of the existing maintenance policy remained the same.

The Naval Maintenance Management System (NaMMS)

The task of naval maintenance is to use resources effectively to provide operational commanders with ships, submarines, minor war vessels and auxiliary vessels in a state of technical readiness that will enable them to meet their commitments. To accomplish this, a systematic approach to naval maintenance is necessary to ensure maximum ship and equipment availability and to guarantee the most effective use of limited manpower and resources. If the maintenance task is to be accomplished successfully, it must be well managed. Co-ordinated action is therefore required within each ship and submarine, within each squadron and its supporting repair facility (whether that be the fleet maintenance facility or a civilian contractor), and within the Chief of Mari-



time Staff and National Defence Headquarters.

The purpose of NaMMS is to maintain our equipment and systems ready for use within the required notice, to assist and support operations by promoting effective use of available manpower, materiel, money and maintenance opportunities, and to provide comprehensive information upon which materiel readiness and maintenance effectiveness can be evaluated and management decisions made. Elements in the management of naval maintenance include maintenance policy, organizational roles and responsibilities, equipment identification, information management, reliability centred maintenance, work period management, test and trials, quality management, and configuration management.

Policy Objectives

Maintenance policy is the foundation for what we do in the ships. We all need to understand the requirements for and follow the precepts of the reliability centred maintenance philosophy that has been adopted. To this end we should be aware that the primary objectives of NaMMS are to:

• provide direction on maintenance philosophy and administration;

• ensure that the required equipment and system maintenance is specified;

• ensure all pertinent maintenance information is captured and analyzed;

• ensure that appropriate techniques to monitor the condition of equipment and systems are conducted;

• ensure work packages are controlled using approved resources; and

• ensure appropriate quality and configuration management programs are applied.

Naval Maintenance Policy Statement

Naval maintenance policy consists of the following essential principles:

• *Cost-Effectiveness* — Naval maintenance should be conducted in a cost-effective manner to meet the required ship performance and life-expectancy, and use the maintenance and work resources that are identified in the Fleet Support Plan and respective class plans.

• *Reliability Centred Maintenance* — Maintenance requirements should be determined using RCM, emphasizing condition-based maintenance supported by an effective equipment health monitoring program.

• *Maintenance by Exchange and Repair by Replacement* — To increase system availability, reduce on-board repair time, and minimize ship's staff maintenance requirements, where possible, preventive maintenance should be conducted through a maintenance by exchange process, and corrective maintenance should be conducted through repair by replacement.

• *Information Flow* — Maintenance monitoring depends on an effective flow of maintenance information.

• *Work Period Essentiality* — Work periods are an essential component of maintenance management, with work requirements determined by a condition-based assessment.

Conclusion

Implementing procedures necessary to ensure full compliance with existing naval maintenance policy will be an evolutionary process within the new organizations of DGMEPM and CMS. Equipment and maintenance managers should take direction from this policy in the preparation of work packages and maintenance plans for all new or replacement systems. As well, they are encouraged to improve maintenance procedures during a continuing review of maintenance schedules for in-service systems. DMMS 3 staff stand ready to assist.

The success of this maintenance policy will be critically dependent on the effective use of feedback to allow verification of the technical state of the fleet, to permit performance assessment of systems, and to adjust maintenance plans accordingly. The future of naval maintenance is in our hands. We all need to recognize the massive team effort that is required to conduct naval maintenance correctly and effectively. Together, we will make it work to support the navy of today and tomorrow.

Lt(N) Evans is a maintenance policy analyst in DMMS 3.

Condition Based Maintenance — The Solution for the Next Millennium?

Article by Peter MacGillivray, P. Eng.

[This article first appeared in condensed form in CaseFILE, the newsletter of GasTOPS Ltd. This full-length text is reprinted here with permission.]

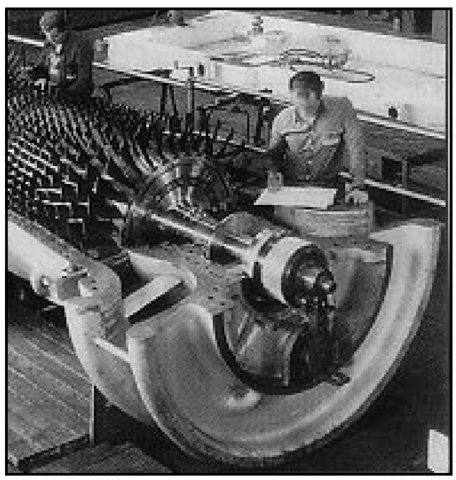
Most organizations with large investments in sophisticated capital resources are experiencing spiraling increases in both the cost of systems maintenance, and the increased nonavailability of production resources. Navies and nuclear power plants, process industries and power cogeneration sites all suffer on the horns of a modern dilemma: the sophistication of the machines used to produce their resulting products, from ship's propulsion to electrical power, have resulted in enormous increases in the cost of maintenance.

Traditional maintenance practice has failed to address fully the requirements of these enhanced technologies. The maintenance activities — often defined once at plant design and never revisited — have come to be looked upon as "necessary evils." A plant down for maintenance is not viewed as a good thing; it interferes with production. This has led to a constant struggle of wills between traditional operations and maintenance staffs.

This issue is exacerbated in most organizations by the lack of a continuous maintenance improvement cycle. Statistics across a broad range of industries indicate that, on average, maintenance crews spend over 50 percent of their time on corrective (unscheduled breakdown) maintenance. It is worth noting that original maintenance plans typically call for — and resource for — 10 percent corrective maintenance. As a direct consequence, vital preventive (scheduled) maintenance is often deferred, which in turn leads to further corrective maintenance, which in turn is often costlier in operational and maintenance resources due to unacceptable outages and catastrophic failures.

While condition-based maintenance (CBM) is itself not the only solution to address the rising cost of maintenance, it is certainly a vital element of an effective reliability centred maintenance (RCM) program. RCM is simply that — a maintenance program that focuses on reliability of machinery and systems to perform at a given level to ensure minimization of unscheduled and costly damage. It consists of preventive maintenance (both scheduled and condition-based) and corrective maintenance.

To successfully implement CBM, one must be able to identify clear, unique and repeatable condition indicators that will track the health of various critical machinery components. The advent of highly sophisticated computer-based sensor and surveillance systems greatly enhances the potential for effective application of CBM. By establishing reliable and automated condition indicators for critical system component health, it is possible to provide a prognostic element to maintenance planning. If it is possible to predict the imminent failure of a component, unplanned outages and catastrophic damage will be less likely to occur.



Of course, CBM is not the solution for all components. For example, a component which in a failure mode will cause neither system degradation nor significant economic impact is probably a candidate for nothing but corrective maintenance. "Run-to-failure" is often avoided as a maintenance practice based solely upon historical or cultural aversion to "things breaking." However, there are always those noncritical components whose consequence of failure is so limited that they should be selected for corrective maintenance only.

Scheduled maintenance must be performed whenever failure is unacceptable and it is not feasible to maintain "on-condition." Scheduled, or time-based maintenance is by far the norm for any traditional preventive maintenance program. In most cases, schedules are driven by equipment manufacturers using statistical analysis to ensure zero failures in service, and are thus always extremely conservative in nature. However, if an appropriate and economical condition indicator can be used to establish machinery health, scheduled maintenance should be eliminated. Only in those cases where CBM indicators cannot be established should time-based maintenance be performed, and then with a view to specific failure histories. This drive to avoid unnecessary maintenance is supported by studies that suggest that up to 50 percent of breakdowns are the direct result of errors made during scheduled (time-based) maintenance.

A disciplined RCM program that incorporates CBM can significantly improve the maintenance statistics and bottom line of any organization. Surveys indicate that organizations taking a serious approach to RCM and CBM have brought corrective maintenance below 20 percent, and are able to apply CBM to some 20 percent of their overall maintenance activity. The ability to then complete virtually all preventive maintenance is a direct outcome, and the reduction in outages, downtime and related breakdown maintenance costs is nothing short of dramatic.

It is unlikely that a near-term technological breakthrough will result in sudden reductions in maintenance costs. In fact, as the next millennium begins, costs of traditional maintenance programs will continue to spiral upward. Unless organizations begin a disciplined approach to control maintenance costs through CBM/RCM, their economic viability will be in question.

Cdr Peter MacGillivray (ret.) manages the GasTOPS Machinery Protection Division.

The Elusive Decibel: Thoughts on Sonars and Marine Mammals

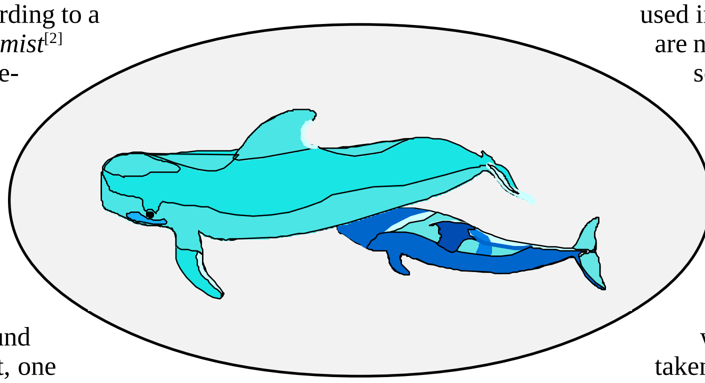
Article by David M.F. Chapman and Dale D. Ellis

[This article first appeared in *Canadian Acoustics / Acoustique Canadienne*, 26(2) 29-31 (1998).]

A few years ago there was considerable controversy over the effects of a proposed global acoustic experiment designed to measure the temperature of the world's oceans[1]. The focus of concern was the possible effect of the acoustic signals on whales and other marine life. There is continued interest in the effects of underwater sound on marine animals, according to a recent news item in *The Economist*[2] based on related scientific correspondence in *Nature*[3]. The thesis is that loud signals from experimental sonars harm marine mammals, or at least harass them enough to unacceptably alter their behaviour patterns. In the various discussions of this important issue that can be found in the press and on the internet, one often sees questionable comparisons being made, such as the acoustic output of a naval sonar being compared with the noise from a jet aircraft. Some misunderstandings between professionals in different fields can be traced to the multiple uses of the term "decibel." Acoustical terms can be confusing, even for experts. It is not at all surprising that well-intentioned articles sometimes fail to present situations clearly.

By definition, the decibel is a relative unit, not an absolute unit with a physical dimension; unless the standard of comparison is cited, the term "decibel" is to all intents and purposes useless. The confusion is not helped by the use of the decibel to specify distinctly different physical quantities, or the same physical quantity with different reference levels. Some reporters — and even some scientists — are getting their "apple" decibels mixed up with their "orange" decibels, as it were.

The decibel (abbreviated dB) is simply a numerical scale used to compare the values of like quantities, usually power or intensity. Acousticians introduced the decibel to devise a compressed scale to represent the large dynamic range of sounds experienced by people from day to day, and also to acknowledge that humans (and presumably other animals) perceive loudness increases in a logarithmic, not linear, fashion. An intensity ratio of 10 translates into a level difference of 10 decibels[4]; a ratio of 100 translates into a level difference of 20 dB; 1000 into 30 dB; and so on. (The term "level" usually implies a decibel scale.) In a uniform acoustic medium, the magnitude of the acoustic intensity is proportional to the square of the pressure for a freely propagating sound wave. Accordingly, the level difference in decibels associated with two sound pressure values (measured in the same medium) is determined by calculating the ratio of the pressures, squaring this number, taking the logarithm (base 10), and multiplying by 10[5]. If one chooses a standard reference pressure value, then sound pressure levels can be specified in decibels relative to that reference, but this should be stated along with the number, for clarity[6].



The following is a typical erroneous statement found in the press, on radio, on television, and on internet discussion groups. Referring to an experimental sonar source that produces very loud low-frequency sound, *The Economist* wrote: "It has a maximum output of 230 decibels, compared with 100 decibels for a jumbo jet." Regardless of the author's intention, the implication is that a whale would experience an auditory effect from the sonar that would be substantially greater than that of a person exposed to the jet aircraft. However, this type of comparison is misleading for at least three reasons: (1) the reference sound pressures used in underwater and in-air acoustics are not the same; (2) it compares a source level with a received level; and (3) there is no obvious connection between an annoying or harmful sound level for a human in air and an annoying or harmful sound level for a marine animal in water. In the remainder of this note, we will expand on these topics somewhat, attempt to correct the mistaken impression, and try to direct attention to the real issue at the heart of the controversy.

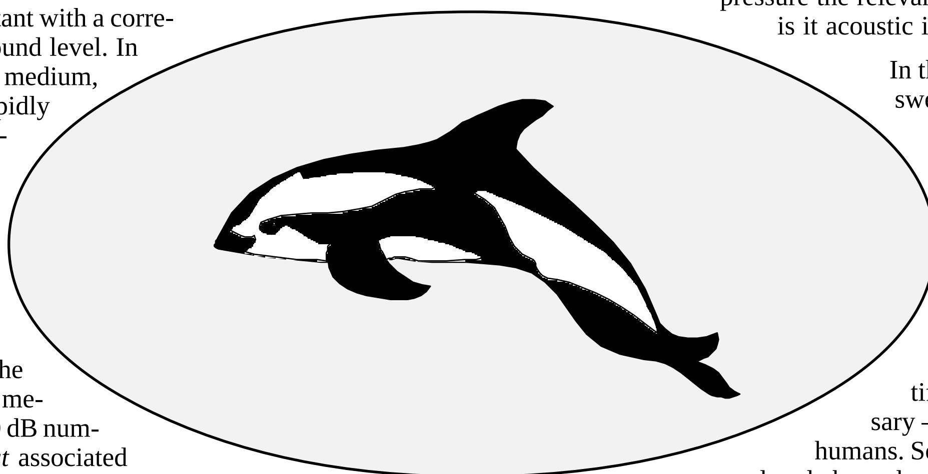
1. Standard References

The standard reference pressures used in underwater acoustics and in-air acoustics are not the same. In water, acousticians use a standard reference sound pressure of 1 micropascal (i.e. 10^{-6} newtons per square metre), abbreviated µPa. In air, acousticians use a higher standard reference sound pressure of 20 µPa. The in-air standard was chosen so that the threshold of hearing for a person with normal hearing would correspond to 0 dB at a frequency of 1000 Hz. Adopting different standards for air and water inevitably leads to a confusing consequence: the same sound pressure that acousticians label 0 decibels in air would be labelled 26 decibels in water. Presumably, both factions of acousticians had equally good reasons for proposing their respective standards, and this dichotomy is now entrenched in an ANSI standard[6], which is unlikely to change. Accordingly, the following dictum should always be observed, especially when dealing with cross-disciplinary issues: *It is essential that sound levels stated in decibels include the reference pressure.*

2. Source Level and Received Level

The erroneous statement compares a source level with a received level. In underwater acoustics, a source level usually represents the sound level at a distance of one metre from the source, while a received level is the sound level at the listener's actual position, which could be considerably more distant with a correspondingly reduced sound level. In an unbounded uniform medium, loudness decreases rapidly with increasing source-receiver distance, 6 dB less per doubling of distance. For example, *The Economist* (and even *Nature*), in referring to the 230 dB sonar source level, neglected to mention the reference distance of 1 metre. In contrast, the 100 dB number that *The Economist* associated with a jumbo jet is not a source level at all, but is typical of a received noise level measured during jet airplane take-off, averaged over several microphones situated several hundred to some thousands of metres from the runway[7]. It is incorrect to compare a source level at 1 metre with a received noise level at an unspecified (and probably much larger) distance.

Combining these two remarks, the output of the sonar source should have been written as 230 dB re 1 µPa at 1 m, while the jumbo jet noise level should have been written as 100 dB re 20 µPa. The inclusion of the reference values shows that these are not like quantities, and that the numbers are not directly comparable. *The Encyclopedia of Acoustics*[8] offers 120 dB re 20 µPa as a typical noise level associated with jet aircraft take-off measured at 500 m distance (although there is sure to be a wide variation about this number, depending on the type of aircraft, etc.). With the assumption of spherical spreading, referencing this level back to 1 metre distance adds 54 dB. Switching to the 1 µPa standard reference adds another 26 dB. Accordingly, the source level of a large jet looks more like 120 + 54 + 26 = 200 dB re 1 µPa at 1 m, compared with 230 dB re 1 µPa at 1 m for the sonar. Both of these are loud sources, but now at least the comparison is sensible. The ratio of sound pressures is around 32, rather than over 3 million, as some commenters would have you believe!



There are other minor issues that could be discussed. The signal from the sonar source is narrowband, and the concentration of all the signal at one frequency may be particularly troublesome for an animal who has a cavity that resonates at that frequency. On the other hand, the jet noise is broadband, and the acoustic signal was probably passed through a filter that approximately matches the sensitivity of the human ear before the measurement was made, so this measurement would be meaningless for an animal with a different hearing sensitivity curve. Much more could be said about these issues, but the principal reason for raising them is to underscore the message that the sonar/jet plane comparison has little validity.

3. What Hurts?

There is no clear connection between a harmful sound level for a human in air and that for an animal in water. All creatures have evolved and adapted to their respective environments and there is no reason why human hearing characteristics should apply to any other animal, including whales. If a given sound pressure hurts a human, would the same sound pressure level in water hurt a whale (or a fish, or a shrimp)? Is the threshold of pain higher? Is it lower? Particularly when comparing acoustic effects in media of widely different impedance, is acoustic pressure the relevant acoustic quantity, or is it acoustic intensity?[9]

In the end, it is the answers to these and related questions that really matter, not juggling decibels. To properly answer these questions and to determine the "community" noise standards for marine animals, scientific research is necessary — just as it was for humans. Some of this work has already been done, and an excellent review[10] of the state of knowledge up to 1995 is a good starting point for acousticians and biologists interested in deepening their understanding. A single example cannot represent the whole range of species under consideration, but it is typical: The response threshold (determined through behavioural studies) of a beluga at 1000 Hz is just over 100 dB re 1 µPa. Of course, this says nothing about the beluga's threshold of pain, and says nothing about what sound level would unacceptably alter its behaviour. It is unwise to assume that the auditory experience of any animal would be the same as that of a human exposed to the same sound level.

Conclusion

As sonar engineers, marine biologists and environmentally conscious citizens continue to discuss these important issues, we should at least agree to use the same acoustical units to convey our points of view, to avoid confusion and

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misrepresentation. Some sensible acousticians have advocated abandoning the use of the decibel (which is partly to blame for our woes) in favour of good old SI (i.e., metric) units for sound pressure, acoustic intensity, power, etc. Until that happy day dawns, let us include reference values with our decibels, so we don't end up with fruit salad dBs. Ultimately, what is important is to determine what underwater sound levels are harmful to marine life. We must develop mitigation measures to allow underwater acoustic systems to be operated while ensuring the protection of the marine environment with due diligence.

Acknowledgement

The authors thank Harold M. Merklinger for his helpful comments on the manuscript.

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[2] "Quiet, please. Whales navigating." *The Economist*, March 7, 1998, p. 85.

[3] R. Frantzis, "Does acoustic testing strand whales?" *Nature* 392, March 5, 1998, p. 29.

[4] In fact, this defines 1 bel, named after Alexander Graham Bell. The bel turned out to be too large for practical purposes and the decibel, which is 1/10 of a bel, is the preferred unit. Also, one decibel is about the smallest incremental change of sound pressure level a person can sense.

[5] Mathematically, this is equivalent to taking the logarithm of the pressure ratio and multiplying by 20, but knowing when to multiply by 10 or 20 in such calculations is an endless source of confusion to the neophyte, so we advocate the definition in the main text.

[6] American National Standard Preferred Reference Quantities for Acoustical Levels, ANSI, S1.8, 1969, p. 8.

[7] Malcolm J. Crocker, ed., *The Encyclopedia of Acoustics* (John Wiley and Sons, Inc., New York, 1997), p. 1095.

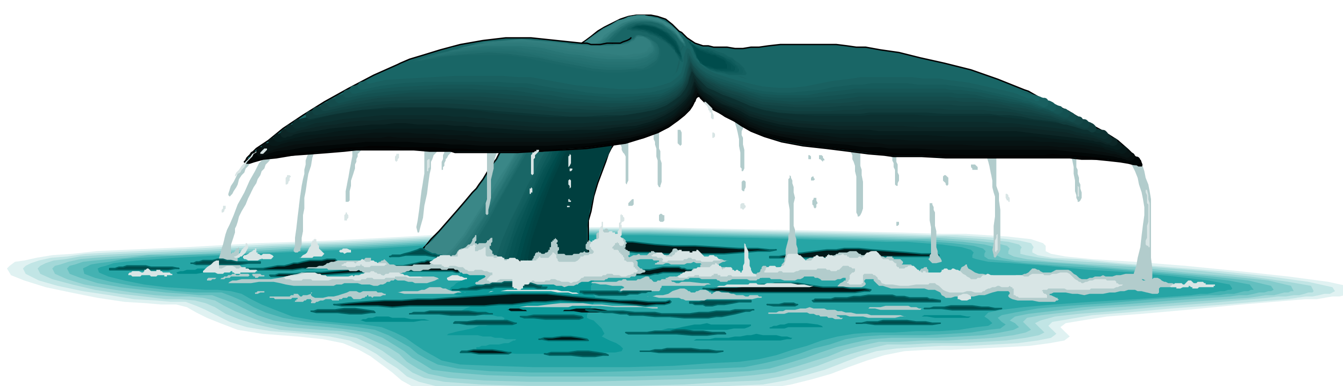
[8] Ibid., p. 11.

[9] The suggestion that acoustic intensity has more bearing than sound pressure in this context has been seriously proposed by some acousticians; however, the available evidence gives the nod to sound pressure, not intensity.

[10] W. John Richardson, et al., *Marine Mammals and Noise* (Academic Press, New York, 1995).

David M.F. Chapman is head of the Naval Sonar section and Project Manager Towed Integrated Active-Passive Sonar Project at Defence Research Establishment Atlantic (DREA) in Dartmouth, N.S.

Dale D. Ellis is the leader of the Maritime Systems Analysis Group at DREA.



Looking Back

Canada and Hedgehog — The First Ahead-throwing Anti-submarine Weapon

Article by Dr. W.A.B. Douglas

This is a note on documents to be found in the Churchill Archive, Churchill College, Cambridge, England, specifically in two collections of papers: the Stephen Roskill Papers and the Sir Charles Goodeve Papers. Captain Stephen Roskill was the official historian of the Royal Navy in the Second World War. He became keeper of the Churchill Archive and acquired a superb collection of naval documents. Sir Charles Goodeve was a Canadian scientist who went to England before the Second World War. He served in the RCNVR before leaving Canada, and joined the RNVR in England, where he advocated the recruitment of scientists for the Navy. Goodeve went on to become one of the leading scientists working for the Navy during the Second World War, as Director, Miscellaneous Weapons and Development.

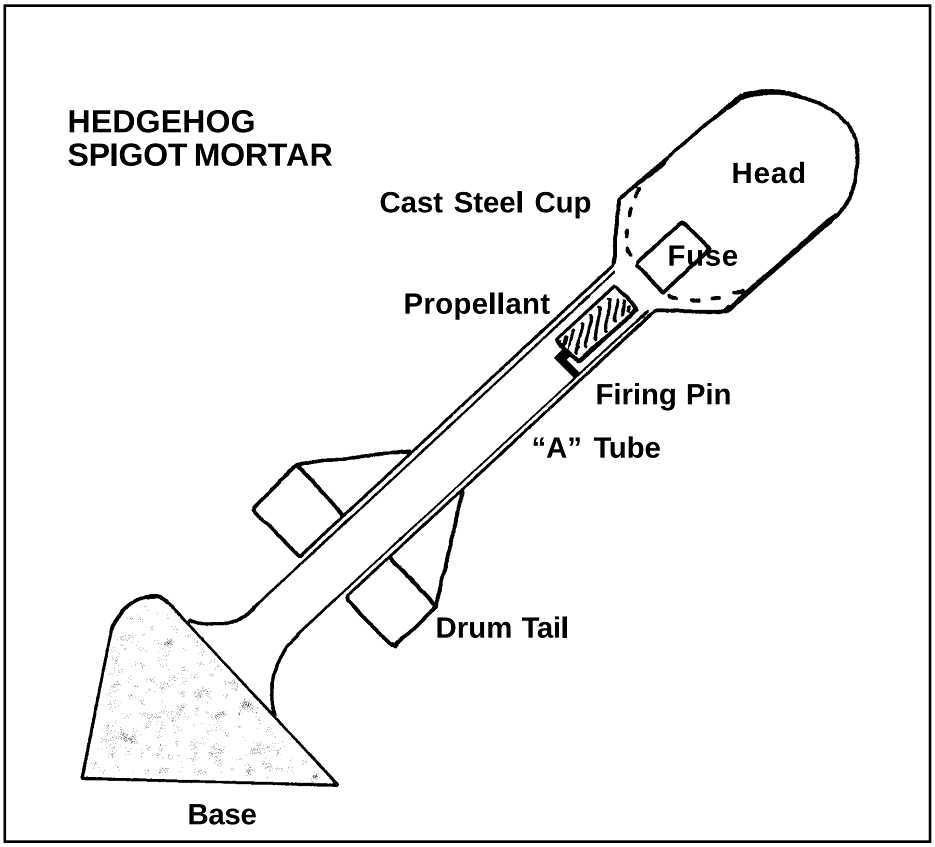
The technological backwardness of the RCN during the Second World War has been the subject of much discussion in books and articles by Marc Milner, David Zimmerman, Doug Maclean and others. It had significant influence on the part played by Canadian ships, and the reputation they had in other navies of the Allied powers. In anti-submarine warfare the lag time between Canadian and British ship modernization was something like eighteen months. There is no need to belabour the point that, until Canada caught up with the RN and USN, lives and ships were lost that might otherwise have survived. One of the weapons that Canadian warships used to advantage when they did catch up, in 1944, was Hedgehog, the first ahead-throwing anti-submarine weapon. The origins of Hedgehog, as noted in the October 1998 issue of *CNTHA News*, had a Canadian connection in Commander C.E., later Sir Charles, Goodeve.

The ancestry of Hedgehog is of more than passing interest. It was a spigot weapon that can be traced back to the German granatenwerfer of 1915-16. In 1939 the British army adapted the idea both for anti-tank and general purposes. In 1940 the Royal Navy latched onto the concept, and in 1942 began fitting escort vessels with the weapon. The RCN could not install Hedgehog without complete modernization of the Flower-class corvettes, and both because of the limited capacity of Canadian shipyards and shortfalls in modern Asdic (sonar), this presented an acute problem. It was only by carrying out a prototype refit on the corvette HMCS *Edmunston* that one Canadian warship had Hedgehog by June 1943. The RCN program for fitting the weapon would eventually be overtaken by events, because new construction ships in 1944-45 were receiving the next generation in ahead-throwing weapons, Squid. Nevertheless, in 1944-45 Hedgehog was proving itself in Canadian as well as British and American ships, and was still the principal A/S weapon in most RCN escorts when the Second World War came to an end.

By 1945 the ahead-throwing contact weapon Hedgehog was the principal ASW armament in most RCN escorts. ***(National Archives of Canada photo R-634)***

A lot of people in both services, and probably Winston Churchill himself, deserve the credit for applying the spigot mortar to anti-submarine warfare. The explanation given in 1942, however, that "a large number of ideas and knowledge of a variety of technical officers were collected together and built up into the final result," ignores the large egos, bitter rivalries and political manoeuvring that tend to accompany weapon development.

In the early 1960s Captain Stephen Roskill, official historian of the Royal Navy, began to look into the question. He never found the opportunity to publish the whole story, but the correspondence he generated on the subject gives us some useful insights into the early evolution of this highly significant weapon. All Roskill's informants agreed that Colonel L.V. Blacker (and not, as had been suggested elsewhere, Lord Lindemann, Winston Churchill's scientific adviser) played a major part in the process. Blacker



The Hedgehog operated as a "spigot mortar," which was about 2½ cm in diameter and 38 cm long and rigidly attached to a heavy base or to a recoil system. A drum tail gave it areodynamic stability. A brass cartridge case fitted into the "A" tube contained cordite propellant. The head could be of almost any shape and securely or weakly fixed to the cast steel cup at the forward end of the spigot.

himself told Roskill he had "...succeeded in forcing ten weapons and equipments into all three services over a period of fifty years of hard struggle against the ultra Dervish like fanatics of the bureaucracy." He took full credit for Hedgehog:

> The original germ of the Hedgehog came painfully into my mind in the Fokker fodder period of 1915. We in the Royal Flying Corps were mounted on aircraft of state design. We could not shoot ahead but only… feebly out to either side. Fokker's private enterprise machines which could fire dead ahead shot us out of the sky until the Admiralty came to the rescue of the Army with their Sopwiths and their Scarff Dibowski armament. So naturally when I had developed the spigot weapon I emphasized the need to make it shoot dead ahead, in the anti-submarine war.... I was rudely rebuffed for quite a time, by the Director of Torpedoes and Mining, but I think I suffered in a good cause.

Blacker in 1961 was still inventing and still complaining — this time about "the quite satanic Ministry of Aviation" — and finished his letter by saying "...let me take my hat off once more, as a pretty old Pongo, to all ranks and ratings of the Royal Navy and marines & MN [Merchant Navy]...."

In fact, before they had the benefit of Colonel Blacker's ingenuity, the naval boffins had been examining various ways of using contact charges rather than depth charges against submarines. According to G.H. Oswald, who in 1940 was Director of Naval Ordnance (L) in the rank of commander, when the Director of Torpedoes and Mining apprised the Ordnance Board of a need to have ahead-throwing weapons, they started designs for Shark, a weapon with underwater performance and a hydrostatic fuse to be fired from 4" and 4.7" guns. This took too long to develop and had too small a charge, so they consulted Commander Goodeve, then attached to the Inspector of AA Weapons and Development.

Goodeve had won a reputation for his remarkable work in the rapid development and fitting of degaussing equipment. It so happened that in the fall of 1940 the Navy was considering the use of a spigot mortar, because of its light weight and seaworthiness, to carry up anti-aircraft wires.

In November 1940 the Navy came to the conclusion that nothing less than a mortar would do for firing A/S contact charges, and credit for the suggestion goes to a Major Jefferis of the War Office. Commander Oswald recollected:

> Jeffries [sic] was the Head of the so-called Ministry of Defence (Buckinghamshire), a strange set-up with Winstonian backing [i.e. with Prime Minister Winston Churchill's support and encouragement] occupying a lovely Queen Anne country house in Buckinghamshire. I stayed a night there in 1940 in enormous luxury. They produced several devices such as delay action fuzes, saboteurs gear &c. I do not know how they got the money — perhaps from Ministry of Supply votes — but they had plenty of it & were all great enthusiasts & had never heard of red tape, which was most useful in production of a new weapon who nobody wanted to father! An invalided N.O...was working there as a draughtsman & worked like a trojan in Hedgehog drawings.

Goodeve put together a team — which came to be known as the Department of Miscellaneous Weapons and Development — and began work without delay. The minutes of a meeting on Dec. 12, 1940, suggest how this team went about its task:

> An informal discussion took place between D.S.R. [Director of Scientific Research], Commander Oswald (D.N.O. -L), Commander Farquhar (D.A/S.W.) and Commander Goodeve (I. A/A.W.& D.) on the evening of 12 December to consider possible lines of development of the spigot mortar as a thrower for A/S contact charges. This mortar has been designed...and is in production for War Office requirements.
>
> Part of the history of the contact charge method of A/S warfare was reviewed and it was pointed out that

the method had been under consideration for some time, but only recently have definite requirements been laid down....The spigot mortar should be able to meet these requirements both for range (600 yards) and charge (20-30 lbs. H.E.) And in addition has the advantage of being simple in construction, seaworthy and with a dynamically stable shaped charge. The requirements as to elevation and training can be met if the spigot is fixed to an existing gun either axially at the muzzle or alongside nearer the trunnion.

It was decided to recommend to D.N.O. that Major Jefferis (M.D.1) be invited to discuss possible methods of fixing one or a pair of spigots to a gun with D.N.O. officers at Bath.

Discussion also took place as to the possibilities in a multiple mounting firing 20 rounds more or less simultaneously. It was pointed out that this could be done with a comparatively simple arrangement provided D.A/S. W. was prepared to accept fixed training and elevation, say for 300 yards.

At the same time the Admiralty Science and Research Establishment (ASRE) at Fairlie, in Scotland, was working on that other ahead-throwing weapon, Squid, but Squid needed sonar (Asdic) with depth indication, something not yet developed. This meant that Hedgehog, which did not need depth indication, could provide a quicker answer to the need for an ahead-throwing weapon, providing the establishment was forthcoming in support.

Establishment support was anything but a foregone conclusion. The Director of Naval Ordnance said that if a mortar solution were adopted the whole scheme must go back to DTM, (Torpedoes and Mining), but that the Ordnance Board must be closely associated with the ammunition. The fuze was so novel that five years would be required for design and test. That left Commander Oswald, who as an electrical officer had no standing in the Board, out on a limb. Fortunately Admiral Sir Bruce Fraser, who provided wholehearted backing to anybody he trusted, and who was getting on with a vital job, gave Oswald the necessary authority to continue in the work. ASRE at Fairlie was also reluctant to co-operate. The head scientist at ASRE, said Oswald, "was an obstructionist....He was the most pig-headed scientist I met in the war, and that is saying a good deal." When the team met at Fairlie on Jan. 17, 1941, he refused to make the underwater range in the River Clyde available. Goodeve and company therefore used the entertainment pier at a seaside resort (Weston-super-Mare) from which to conduct their hydrodynamic trials.

This 1944 view of the Hedgehog mounting on board the minesweeper HMCS *Fort Francis* shows just what a modest affair it was. *(DND photo HS-0374-3, courtesy the Directorate of History and Heritage)*

These and other trials determined the need for high deck thrust and consequent stiffening, with combined training and roll correction rotating on the fore and aft axis, and a slung beam system, known as the "porcupine," that provided strength "in a rather unorthodox manner of letting the beam bend until it hit an arc on the deck," a system that Major Jefferis converted into the more practical proposal eventually adopted. Goodeve's team designed the spigot electrics, the ripple switch that governed the sequence of firing, two types of fire control, a projectile that would work with both electric and percussion spigots, rejection of the idea of a cartridge case and the decision to use fixed ammunition (thanks to Sergeant Major Tillesley of Major Jefferis' staff), and the fuze. After the Ordnance Board proposed a fuze that had 127 parts, Goodeve picked the brains of scientific establishments across the U.K. and his team chose a swash plate type of fuze with external actuating ring and the propeller arming with a tumbler release. The Hall telephone company worked on what came to be known as the 420 fuze, with strong input from officers on Commander Goodeve's staff at I.A/A/.W. & D. Lieutenant I. Hassall first proposed the name "Hedgehog."

It is quite remarkable that all this was accomplished in nine months. The "Winstonian backing" enjoyed by the Ministry of Defence (Buckinghamshire) certainly helped. Of course, although the first Hedgehog was undergoing trials at sea in a V-class destroyer by September 1941, it took much longer than that to convince sailors of its worth. It lacked the satisfying bang produced by a depth charge whether or not the target was hit, something that commended Squid to the fleet a few years later. As late as 1943 the C.O. of a Captain-class frigate at Argentia told Oswald "...the silly asses have given me this idiotic contraption which, if I fire, I will run over the top of the subs and blow myself up." It took two hours, wrote Oswald, over many drinks, to disabuse him of that notion. But years after the war, when this author was interviewing Rear Admiral P.W. Burnett, one of the most distinguished anti-submarine warriors of the Second World War, a different prejudice became evident. It was his view that

Looking Back

Bombs away! The Hedgehog threw its twenty-four bombs ahead of the ship to land in a circle whose diameter was about two-thirds the length of the U-boat. They fired on contact only. ***(National Archives of Canada photo R-707, courtesy the Directorate of History and Heritage)***

the Admiralty spent too much time and effort on Hedgehog, to the detriment of Squid. Possibly the scientists at ASRE would have agreed, but the fact remains that thanks to the disregard of red tape, the ability to work with army scientists, and the capacity to win the support of influential leaders both in uniform and out (including the prime minister himself), the Royal Navy produced the first ahead throwing anti-submarine weapon in a very timely fashion when it was most needed.

It is ironic that although a Canadian was the principal figure in the weapon's original development, Canadian escorts were the last to be fitted with it. Canadian inventiveness was not lacking — the Canadian Anti-acoustic Torpedo (CAT) gear, for example, was in action before the RN had developed the more complicated Foxer late in 1943 — but Canada had too much catching up to do. In other technological fields, such as radar and HF/DF, Canada found itself in the same situation, with the result that Canadian escorts had great difficulty reaching the same degree of operational efficiency as their opposite numbers in Allied navies.

Dr. W.A.B. Douglas is a former Director General of History at National Defence Headquarters. He is now retired and living in Ottawa.

News Briefs

Navy's Y2K Ship Systems Project in full swing

Article by LCdr Richard Gravel and Lt(N) Erick DeOliveira

Long before the champagne was ever uncorked for the latest New Year's festivities, the Year 2000 issue pertaining to computers was a popular subject of discussion. Media analysis and individual conversations alike teem with speculation over which computer systems might malfunction, and what form those malfunctions might take. In May 1998, the Chief of Maritime Staff and the Director General Maritime Equipment Program Management jointly stood up the Year 2000 Ship Systems Project (Y2K SSP) to identify and address potential malfunctions in the *Halifax*-class, *Iroquois*-class, *Kingston*-class (including other auxiliary vessels), and *Protecteur*-class ships.

The Y2K SSP has been mandated to ensure that systems fitted in naval platforms will function during the clock transitions through sensitive calendar dates related to the millennium rollover. System stability must be investigated for more than just operation on Jan. 1, 2000. In fact, there are many calendar dates which could pose problems.

The Y2K issue can be described in its most fundamental form as a date ambiguity problem — certain dates will present computers with more than one interpretation. January 1st of the year 2000 is at once the most famous and troublesome (because so many systems are potentially affected, and will be affected simultaneously). Systems which read a two-digit year may interpret '00 as either 1900 or 2000, but successfully interpreting 2000 may not be enough. Because the year 2000 is a leap year, and the year 1900 was not, Feb. 29 has also become a key test date. Computer systems may also have additional internal rollover problems which are unrelated to a calendar, but which may be triggered by the presence of certain information in the date field. *Table 1* lists key dates, as well as their significance.

An Ounce of Prevention…

Within the Y2K Ship Systems Project a program has been established to certify individual naval systems for Year 2000 compliance, and to validate this compliance through a program of high-level functionality testing of integrated combat and marine systems.

The certification process within DGMEPM consists of LCMMs submitting evidence of system compliance to a certification review board (CRB). The Board comprises DGMEPM and CMS representatives who ensure that the evi-

Table 1. Some Key Dates in Y2K Compliance Testing

Date	Importance
Jan. 1, 1999	First appearance of "99". Newspapers report taxi meters in Stockholm and Singapore all collectively malfunction.
April 9, 1999	For systems that read the calendar in a Julian format (nth day of the year), the 99th day of the 99th year will produce a 9999 date field that some computer systems will read as an "end-of-tape" or "end-of-file" command.
Aug. 20, 1999	GPS satellites will experience a non-date-related, but predictable, autonomous internal rollover on the 1024th week of their operation.
Sept. 9, 1999	The 9th day of the 9th month of the 99th year may create a problem similar to that of April 9th.
Jan. 1, 2000	First appearance of "00" in two-digit year date codes may be interpreted as a 100-year jump back to 1900.
Feb. 29, 2000	2000 is a leap year — 1900 was not.
Dec. 30, 2000	The rollover to Dec. 31 will test the 366th day of the year (leap year) for Julian formats. Julian formats only recognize Feb. 29th as the 60th day of the year, and won't notice that it's a leap year until they try to roll over from the 365th day to the 366th.
Jan. 1, 2001	Millennium transition from the 366th day of 2000 to the first day of 2001.
Feb. 29, 2004	First leap year after 2000.

dence, including manufacturer's claims, test results, and LCMMs' detailed assessments meet the requirements of Year 2000 due diligence. Presently, some 1040 of 1150 systems have been certified.

The Naval Engineering Test Establishment (NETE) in Montreal has been tasked to conduct high-level integration testing of *Halifax*-, *Iroquois*- and *Kingston*-class systems. This will ensure that compliance is preserved when systems which are individually compliant are integrated and share date information. Testing has progressed from land-based trainers, to alongside testing and, finally, to at-sea dynamic trials. *Table 2* summarizes this validation testing effort.

	Halifax Class	*Iroquois* Class
Shore/Trainer	Oct. 31 - Nov. 16, 1998	Nov. 16-19, 1998
Alongside	Jan. 13-16, 1999	Nov. 30 - Dec. 4, 1998
At Sea	Jan. 20-22, 1999	Feb. 1-5, 1999
International Exercise	Feb. 24 - March 6, 1999[1]	

[1]HMCS *Regina* predeployment system integration test (Y2K environment) with the USS *Constellation* battle-group.
[2]*Kingston*-class trials to be scheduled for spring/summer 1999.

Table 2. Y2K Ship Validation Trials

The impact of the Y2K Ship Systems Project has been widespread: from LCMMs' laborious task of preparing CRB submissions, to the lengthy hours and frequent coast-to-coast travel demanded of the NETE trials staff, to the necessity of disturbing ship agendas and formation schedules through onboard testing. Recognizing these disruptions, the Y2K SSP is making every effort possible to ensure the cure does not prove worse than the disease. In upcoming issues of the *Maritime Engineering Journal*, Y2K SSP staff will seek to bring you the results of the certification review process, the trials program, and further news of the Y2K readiness of the Canadian fleet.

LCdr Gravel (DMSS 8) returned to Canada from a three-year position as a trials officer with the RN to assume duties as Project Manager for the Year 2000 Ship Systems Project. He has extensive experience in software design and programming, and established the West Coast Iroquois*-class software support facility while at Naval Engineering Unit Pacific. LCdr Gravel is a former Fleet CSE, and was CSEO in HMC ships* Saguenay *and* Nipigon.

Lt(N) DeOliveira (DMSS 5-6) is Test and Trials Manager for the Year 2000 Ship Systems Project. He was seconded to DMSS 8 from the Submarine Air Independent Propulsion Fuel Cell Project for the purposes of the Y2K effort.

Obituary:

Rear-Admiral S. Mathwin Davis, CD, Ph.D.

RAdm Davis was born in Birkenhead, England, April 18, 1919, and died of cancer in Kingston, Ontario, October 28, 1998. This appreciation is drawn from material contributed by his friends.

Three days before he died, Sam Davis, though ill, chaired a meeting of the Queen's University Institute for Life-long Learning. It is typical of this exceptional man that his distinguished public service continued almost to the end of his life, and that his last activity should have been one so close to his heart. For Sam was not only one of Canada's most notable maritime engineers, rising to the peak of his profession, but an example of life-long commitment to learning and service as a scholar, public servant and community leader.

His naval career began in 1940 when he joined the Royal Corps of Naval Constructors, having just graduated from the University of Liverpool in naval architecture. As a Royal Navy constructor-lieutenant, he was present at the sinking of the German battleship *Bismarck* in 1941 (*see "The Bismarck Action...," Maritime Engineering Journal, Feb. 1998*). He later served in shore appointments in England and with the British Admiralty Technical Mission in Washington.

After the war ended, Sam Davis left the RCNC — which he thought somewhat stuffy — to emigrate to Canada, and practiced naval architecture with the Montreal firm of German and Milne. He was persuaded by Constructor Captain Rowland Baker, then Naval Constructor-in-Chief, to join the RCN Reserve in 1949, rising to the rank of constructor-commander in 1953. He then transferred to the RCN, serving as Assistant NCC in Ottawa and as the senior constructor in Halifax dockyard. In 1956, he became Principal Naval Overseer (Montreal Area), and, in 1958, the working head of the Nuclear Submarine Survey Team. In 1959 he was selected for the National Defence College course. He returned to Ottawa in 1960 as Deputy NCC.

This was a time of great challenge for senior maritime engineers. The former technical branches had just been abolished, and Naval Technical Services were in the throes of a major reorganization along functional lines. Davis became the first Director General Ships in the new organization in May 1961, and for over four years guided the new directorate through what was perhaps the most difficult and demanding period ever faced by RCN engineers. Beside the pressures of a busy shipbuilding program, it was a period of much policy uncertainty and extensive political and organizational change.

Sam didn't believe in the "indispensable man," but that is what he was. He brought to the job broad experience as an innovative designer and a practical manager. He was a pragmatist with sound common sense, not overawed by gold lace, blessed with a sense of humour and able to see the vexatious moments (of which there were many) in perspective. He had an incredible capacity for work, usually beginning in the very early morning, a practice he continued throughout his life. We soon became used to his greeting us as "Master So-and-So," occasionally promoting us to "Friend," or even "Brother," and were delighted when we discovered that our (and his) seniors were similarly addressed.

But, most importantly, he was a leader who could build the teams needed to deal effectively with rapid technical and organizational change. He quickly gained the respect and liking of his counterparts on the Naval Staff and the other technical divisions. He didn't have much patience with second-rate work, but was always ready to take advice. He was generous in giving credit to his juniors, often insisting that they should make presentations to senior bodies when he might well have done so himself. He encouraged new ways of thinking and acting, and piloted the results through the confusion that followed the headquarter's integration with great skill and tact.

Sam was by no means infallible, but he could take difficult and far-reaching decisions carefully and honestly, and then move on to the next one without looking back. On the important issues, he was right far more often than he was wrong.

He was a good companion, but not one for the social whirl, preferring the company of his family and his academic pursuits. By his own account, his time at the NDC opened up "whole vistas of knowledge that I had previously barely recognized." He thus began a life-long program of graduate study in areas he found interesting — adding this to his already heavy responsibilities. He was delighted when, after a senior staff appointment from 1965 to 1969 that he did not much enjoy, he went back to NDC in 1969 as rear-admiral and commandant. He brought a fresh outlook to the college, always challenging its students and extending his own understanding of the larger world by continuing study.

When he retired from the navy in 1974, he embarked on a doctoral program at Queen's University, concentrating on issues in public administration. In 1980 he became chief executive officer of the Kingston Health Science Complex Council, a position he filled with distinction until 1985. He then returned to Queen's as an adjunct professor in the School of Policy Studies to set up a specialized program in health care policy. Here his generosity of spirit and wide experience made him a popular graduate supervisor, particularly of mature students balancing professional and family responsibilities with their studies. He combined this with extensive volunteer work in the Kingston community. Fortunately, he was able to continue in all this until only a few weeks before his death.

We who were lucky enough to have worked closely with Sam — the naval officer, maritime engineer, administrator, scholar and friend — will remember him with admiration and affection. **— Dr. H.W. Smith, Cdr (ret.), University of Victoria.**

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CNTHA News

The *Journal* welcomes **unclassified** submissions, in English or French. To avoid duplication of effort and to ensure suitability of subject matter, prospective contributors are strongly advised to contact **The Editor, Maritime Engineering Journal, DMMS, National Defence Headquarters, Ottawa, Ontario, K1A 0K2, Tel. (819) 997-9355**, before submitting material. Final selection of articles for publication is made by the *Journal*'s editorial committee. Letters of any length are always welcome, but only signed correspondence will be considered for publication.

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National Defence / Défense nationale

FEBRUARY 1999

News

CANADIAN NAVAL TECHNICAL HISTORY ASSOCIATION

RAdm Sam Davis:
Remembering a Man who Lived to Serve

In this issue of *CNTHA News* and the *Maritime Engineering Journal* we are paying tribute to the memory of RAdm (Ret'd) "Sam" Davis, who passed away last October. I had the honour of attending his funeral service in Kingston, and during the service a number of people spoke warmly of how Sam had touched their lives. Although I had only worked with Sam for the past few years in connection with the Canadian Naval Technical History Association, I knew that he had done great things both in and out of the navy. I was quite overwhelmed, however, to learn the full measure of the man.

Perhaps the most poignant message came in the homily delivered by the Very Reverend A.V. Bennett, Dean of St. George's Cathedral in Kingston. Of particular note were his thoughts (excerpted below) on the idea of service and a person's sense of duty, virtues that seem to have fallen from favour in these modern times:

> *We live at the end of a millennium in a society dominated by individual self-actualization. That is, we live at a time in which selfishness is a virtue. Whether big faceless governments have made us insensitive to others, or advertising has focused so much on the self, it is not clear. But we have lost a sense of community. We have lost a sense of responsibility. We have lost a sense of duty beyond ourselves. Where is the passion to serve others?*
>
> *Sam Davis was not an outwardly passionate man. He was, after all, an Englishman. But beneath his dignified and gracious façade was a burning heart. Sam believed in those things that have gone out of style. He was a patriot in his new home of Canada. He kept a wider vision of the commonwealth of nations. But most importantly, as a sailor, a scholar and a man, Sam had a marvelous sense of duty. He served the common good. He served others.*
>
> *Sam had a heart that was consumed by the honour of service. His sense of duty flowed from the belief that to whom much is given, much is, indeed, expected. From that belief came his courage, his dignity and his heroic confrontation of a terminal illness. It was an illness he would not allow to debilitate him.*
>
> *Sam Davis embodied the best in a life of service. In a world without heroes, he was indeed heroic. In a time where self-service is the creed, he served others. In a society in which most struggle for wealth and power, he was a Christian gentleman, a scholar and signpost pointing beyond the self.*
>
> *This was an admiral who served. A scholar who pursued knowledge. A civic person who served humanity.*

Food for thought. RAdm Sam Davis made a significant contribution to the CNTHA, and for that we are grateful. As the Very Reverend Bennett said in his closing, "We will miss you, Sam. You will be remembered."

Mike Saker

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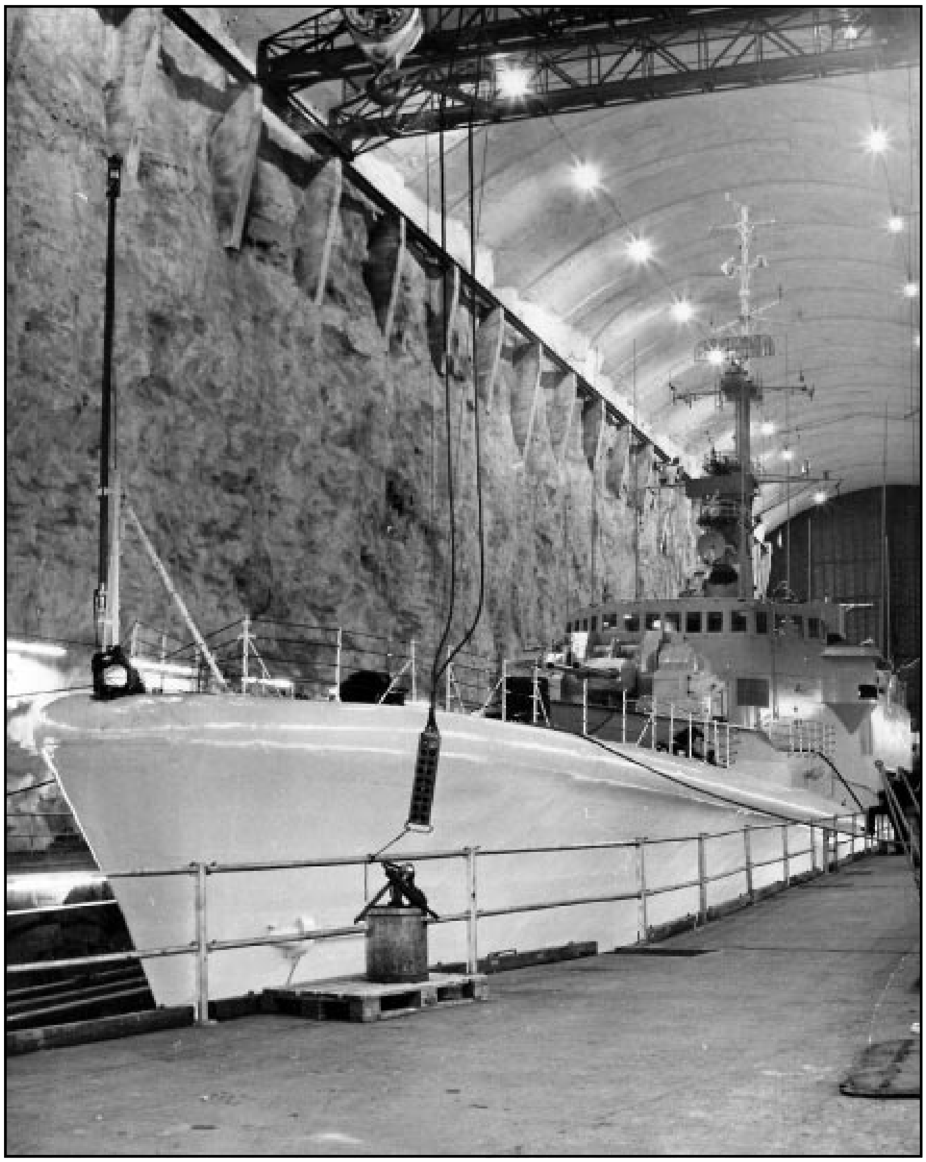
Docking with a Difference — or How *Restigouche* Went Underground

Article by Michael Young
(All photos courtesy of the author)

A drydock is a drydock, right? Perhaps, unless that dock happens to be surrounded on three sides by solid Norwegian rock! This is the story of how a Canadian destroyer ended up in that very different dock.

In January, 1970, HMCS *Restigouche* (DDE-257) sailed from Halifax to join the Standing Naval Force Atlantic — STANAVFORLANT — in Lisbon. This was the first time the squadron would be commanded by a Canadian, Commodore



Restigouche **in the "barn" on completion of paint ship, March 18, 1970. This is the largest dock of its type. The Germans built smaller ones for submarines and E-boats throughout the fjords during their wartime occupation of Norway. The overhead hoist was invaluable as was the high level of lighting. The bullring at the bow was painted blue to recognize the ship's crossing of the Arctic Circle earlier in the deployment.** ***(SNFL photo)***

About the CNTHA

The Canadian Naval Technical History Association is a volunteer organization working in support of the Directorate of History and Heritage (DHH) effort to preserve our country's naval technical history. Interested persons may become members of the CNTHA by contacting DHH.

A prime purpose of the CNTHA is to make its information available to researchers and casual readers alike. So how can you get to read some of it? For the moment there is only one copy of the Collection, situated at the Directorate of History and Heritage located at 2429 Holly Lane (near the intersection of Heron and Walkley Roads) in Ottawa. DHH is open to the public every Tuesday and Wednesday 8:30-4:30. Staff is on hand to retrieve the information you request and to help in any way. Photocopy facilities are available on a self-serve basis. Access to the building requires a visitor's pass, easily obtained from the commissionaire at the front door. Copies of the index to the Collection may be obtained by writing to DHH.

With the entrance to the enclosed dock lying ahead, *Restigouche* is manoeuvred into position by tug. Note the uniforms! Although this was 1970, the then-new green uniform was not yet widely available. *(Photo by the author.)*

D.S. Boyle, and the first time that Canadian ships would participate for the full year. *Restigouche* was the lead flagship.

The tempo of operations in the first two months was very high and the weather generally poor. The effect of all this on the external appearance of the flagship was such that *Restigouche* began to resemble her nickname of "*Rustyguts*." But what to some was a look of hard work, to the commodore was plain scruffiness!

In mid-March the squadron arrived at the Norwegian naval base at Haakonsvern, near Bergen, for a two-week maintenance period. One of the tasks was to paint ship, which had not been possible since well before departing Halifax. But even if clear weather prevailed, the idea of painting ship in near-freezing temperatures did not seem to be very bright. The Norwegian navy solved the problem by making available their relatively new drydock for a short period. What few in the ship realized, was that this "drydock" was carved into the side of a small mountain!

Norway had several such caverns in various parts of the country. Although this particular one was built on a NATO/Norwegian cost-sharing basis, the Germans during their wartime occupation had built smaller ones for their submarines and E-boats throughout the fjords of Norway.

Checks revealed that the mast was three feet too high to clear the roof, but we resolved that problem by removing the DAU direction-finding antenna at the masthead. On March 16, 1970 *Restigouche* was cold-shifted into the dock and the outer doors were closed (the dock was not drained). The ship's company was organized into painting parties and the round-the-clock work began. In the "barn," as it came to be called, the temperature was controlled and night turned into day. Under such conditions, painting ship was relatively easy.

Forty-eight hours later the job was complete and the ship was shifted back to a regular berth. The ship's company earned their Easter break and, eventually, the compliments of the commodore.

Restigouche steamed for six months in European waters without major defect and did not miss any operational commitment due to equipment problems. (Even the 3"/70 gun performed magnificently and, once, the airborne early warning radar display came *tantalizingly* close to displaying the full picture being transmitted from the airborne Gannet AEW aircraft!) The ship paid off into IRE conversion refit after her return to Halifax.

Michael Young was Weapons Officer in Restigouche *in 1970 (pre-Combat Systems Engineer days) when she served in STANAVFORLANT.*

The Collection

A recent submission by Cdr Ralph Fisher, RCN (Ret'd) has provided a unique insight into the personnel relationships of the late 1940s as they led up to the Mainguay Report. Using HMCS *Magnificent* as the vehicle, Ralph has laid out the facts and problems for posterity.

Following on this theme, it should be noted that the "Technical" in CNTHA is not an inhibiting factor. Articles concerning personnel and organization are welcome as they round out the picture of what was done, and why we did it. We even have a personal history category (PRS) in which resides the memoirs of several retired naval officers.

If any readers have a yen to scribble a few words for the collection, don't hesitate; we welcome all and sundry inputs. Send to:

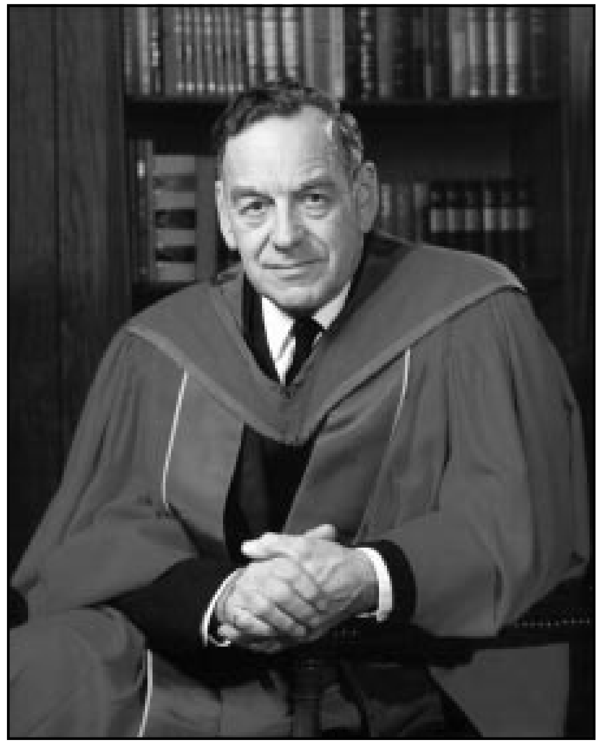
673 Farmington Ave.,
Ottawa, Ont., K1V 7H4

fax: (613) 738-3894
e-mail: as436@freenet.carleton .ca

Phil Munro

Sam Davis — Historian

One aspect of Rear Admiral Sam Davis' life and work that seems to deserve comment here, is his great service to naval history in this country, and to the Canadian Naval Technical History Association (CNTHA) in particular.



Sam was among the first to realize (nudged a bit by Dr. Alec Douglas, then Director General of History in DND) the importance of technical matters to the history of the navy of the 50s and 60s, and his formal publications are an important part of the record. When the gathering of personal recollections was first suggested in 1992, he was a strong supporter of the scheme, and served as a member of the CNTHA committee until just before his death. His sage counsel, often pungently expressed, will be greatly missed.

Perhaps his most engaging historical work remains unpublished. In 1985, while holding a postdoctoral fellowship at Queen's, he prepared an account of his experiences in the navy between 1953 and 1965. [This paper, "Technological decision-making in the RCN, 1953-1965," is held by DHH. The rest of Sam's unpublished work is in the CNTHA collection.] Sam held some of the most important posts of the time; he knew the events and the senior people (naval officers, civil servants and politicians) who were the players. This mammoth work (500 pages, or so) is recommended reading for anyone who wants to get the true flavour of how the technical side of the navy worked back then. His anecdotes are frequent and inimitable. It's serious history, but written with Sam's keen eye for the ridiculous. No one escapes his gentle irony — including Sam himself in this anecdote from the 1950s:

A destroyer escort is commissioning on the St. Lawrence on a sunny summer day. The "quality" is in attendance — senior officers in whites with swords and medals, elegantly dressed ladies — and the band is playing. The ship's company, also in whites, is about to be marched on board when the ceremonies are rudely disrupted by the piercing shriek of a boiler safety valve which has lifted. As stokers scramble to shut off sprayers, billowing geysers of steam and soot are ejected into the air, all to fall back on the assembly as hot black rain. Definitely not the best of days for the principal naval overseer!

Sam lives on in the work he has left behind — a fitting reminder of a very remarkable man, and an example to us all.

Hal Smith

Crusader and VDS

A short comment on VDS in our last issue that mentioned *Crescent* as a trials ship has brought some comments on the lines of "I thought it was *Crusader*." Both are right. In 1955, when a high-speed ship was needed to complete VDS development, *Crusader* was assigned the role of a trials and experimental ship for many new developments in naval technology besides towed sonar, although that was the most visible. The RCN evaluation of Naval Research Establishment's experimental CAST-1X sonar in *Crusader* in 1958 was critical in gaining navy acceptance of what many thought to be a harebrained scheme. The service equipment evaluated in *Crescent* two years later was the engineered result.

Thank you...

To Charles Gunning, DGMEPM, and Brian Redding, formerly of Fleet Manufacturing Ltd., for their response to a request for help with variable depth sonar. They both have given us valuable leads to information on VDS handling gear used with the SQS-504 and SQS-505.

We'd love to hear from you…

If you have information, documents or questions you'd like to pass along to the Canadian Naval Technical History Association, please contact the Directorate of History and Heritage, NDHQ, MGen George R. Pearkes Bldg., Ottawa, Canada K1A 0K2 Tel.: (613) 998-7045/Fax: (613) 990-8579